UNIVERSITY OF NOVI SAD, FACULTY OF TECHNICAL SCIENCES
DEPARTMENT OF CIVIL ENGINEERING AND GEODESY
Novi Sad, Serbia

HIGHER EDUCATION TECHNICAL SCHOOL OF PROFESSIONAL STUDIES
Novi Sad, Serbia

EUROPEAN YOUTH PARLIAMENT
Belgrade, Serbia

SERBIAN NATIONAL FIRE PROTECTION ASSOCIATION
Belgrade, Serbia

BOOK OF PROCEEDINGS

1st INTERNATIONAL SYMPOSIUM
S-FORCE 2018
Students **FO**r **R**esilient so**C**i**E**ty

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PREFACE

University of Novi Sad, Faculty of Technical Sciences from Novi Sad, in cooperation with Higher Education Technical School of Professional Studies in Novi Sad, National Fire Protection Association and European Youth Parliament, organizes first international symposium Students For Resilient soCiEty - S-FORCE 2018, within Erasmus + K-FORCE project.

Climate change, fast urbanization and new technologies, in interaction with irresponsible human activities, cause the need for multidisciplinary and interdisciplinary engineering competencies, knowledge and skills. Considering these, available higher education is insufficient and unsustainable at regional level without modernizing and further development.

Numerous human causalities, significant material damages and negative environmental impact of natural and manmade disasters and fires in the Balkans are the warning calling for change of approach to these issues.

Resilient societies are based on knowledge and training, as well as preparedness. Building synchronized regional capacities in higher education in Disaster Risk Management and Fire Safety Engineering, according to regional needs and contemporary trends, is a first trend towards building resiliency of our region.

1st part of the symposium is reserved for presentation of students' papers. This part of symposium is intended as a forum for PhD students and master students who aim to pursue PhD studies in Disaster Risk Management and Fire Safety to have an opportunity to present the results of their scientific research.

2nd part of Symposium will be in line with the methodology of European Youth Parliament (EYP-workshop). The aim of the Workshop is to introduce to WB students with working procedures of EU Parliament.

The symposium will be dedicated to current issues in education, profession, science and practice in the field of Disaster Risk Management and Fire Safety Engineering.

Editors

ORGANIZERS OF THE SYMPOSIUM

The Faculty of Technical Sciences in Novi Sad is an institution of higher education and scientific research founded in 1960. Faculty consists of 13 Departments implementing 88 study programs at the undergraduate and postgraduate level. The Department of Civil Engineering and Geodesy offers a comprehensive study programs in the field of civil engineering, geodesy and disaster and fire risk management: Disaster management and Fire Safety B.Sc. Honours and M.Sc. Qualification levels.

HIGHER EDUCATION TECHNICAL SCHOOL OF PROFESSIONAL STUDIES IN NOVI SAD

The Higher Education Technical School of Professional Studies in Novi Sad, Serbia is founded in 1959. It educates engineers at 4 Department in 20 accredited study programs of professional bachelor and specialist studies. In the Department of Protection Engineering the following areas are studied: Fire Protection, Occupational Health and Safety, Environmental Protection and Civil Protection & Emergency Rescue.

EUROPEAN **YOUTH** PARLIAMENT
PARLEMENT EUROPÉEN DES **JEUNES**

EYP is a youth non-governmental, non-partisan organization that exists in 40 European countries. EYP simulates decision making process of European Parliament and is established as a non-formal educational programme with the aim of providing the young with a possibility for education, exchange of opinions and in order to encourage them to take an active role in their societies. EYP SERBIA was established in 2006.

НУЗОПРС
SERBIAN NATIONAL FIRE PROTECTION ASSOCIATION

NUZOP RS is the unique professionals' association of active working experts. It is a regionally oriented organization and represents a wide platform for gathering of experts dealing with emergencies situations and fire safety. Programs and initiatives are designed to assist institutions and national fire authorities in creating fire safety system, as well as fire, security and safety, and other relevant professionals to achieve and maintain the very highest standards of fire safety management.

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FLOOD RISK AND INDICATORS OF SOCIAL COHESION IN THE WESTERN BALKANS

Abstract: The study investigates a hypothetical relation between social cohesion and a major flood event affecting parts of the Western Balkans region. Using state-of-the-art bibliometric techniques, we show the historical evolution of research on social cohesion and disasters, its multi-disciplinary composition resulting in competing definitions of what constitutes social cohesion as well as the relations among the different knowledge domains in the form of network cluster maps. We use the maps as the basis for objectively selecting variables representing social cohesion constituents and relevant control variables. We find that despite the high uncertainties associated with the quantity and quality of the data set, a linear relationship between social cohesion and disaster response does indeed exist as an empirical phenomenon. We discuss implications of the results with regard to a possible trade-off between the individual and collective dimensions of social cohesion and how complementing the model results with a cultural analysis based on grid-group theory could facilitate policies on social cohesion, which are in tune with cultural preferences for systems of governance.

Key words: community resilience, disaster risk management, social cohesion

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1. INTRODUCTION

The present research is conducted as part of the EU Erasmus project Knowledge for Resilient Society (K-FORCE) wherein a consortium of universities from the Western Balkans, two central European universities and three Scandinavian universities are working together to exchange and build new knowledge in the area of resilience and disaster risk management, with particular focus on educational activities. The Western Balkan countries have a leading role in the project as they are the primary beneficiaries of the outcomes. The role of Aalborg University as a partner is to faciliatate the knowledge exchange process and build awareness of frameworks, methodologies and best practice as well as provide learning-teaching materials, relevant learning strategies and platforms to deliver them. In what foolows the preliminary results are presented on a hypothetical correlation between flood disaster response and social cohesion. The primary aim of the study is to enhance awareness of the concept of social cohesion and its relation to natural hazards among disaster management academic audiences of students, teachers and researchers.

At the onset of the K-FORCE project, it became evident that many of the Western Balkan partners perceive resilience to natural hazards from two main perspectives: disaster insurance and structural protection measures. Both education and practical work related to disaster risk management thus comes mainly from the knowledge domains of Civil Engineering and partly from Economics and actuary practice. A concept such as social cohesion and how it might relate disaster response is poorly understood. We take our study as the starting point in building educational material around this hypothetical relationship by looking at the historical evolution of research on social cohesion, competing definitions and perspectives from the different knowledge fields where it has been applied, and ways to measure the effect of social cohesion on disaster recovery.

From a research point of view a study of the dynamics of social cohesion and natural hazards in the Western Balkans is both theoretically and methodologically challenging and complex. In terms of physical exposure, the region as a whole is exposed to a number of natural hazards from floods to landslides and mass movements to earthquakes. One hazard can trigger other ones (e.g. floods and earthquakes can trigger landslides and other mass movements). Upstream and downstream consequences often transcend the national boundaries of these very small nation states. In addition, due to regional climate change predictions, the Western Balkans are expected to become increasingly vulnerable to both extreme temperatures and floods (IPCC 2014).

In terms of societaly related challenges, the Western Balkans‘ coping capacities are influenced by the success of transitioning from planned to market economies and from totalitarian to democratic systems of governance. The social complexity as a result of historical, political and cultural dynamics, including a series of violent conflicts, has given birth to the term „balkanized“ to describe systems or processes that are disjointed or disunited – in effect, the very opposite of social cohesion. Yet at the same time, the region and its individual constituents can be characterized by many of the ingredients considered necessary for social cohesion as expressed in terms of informal individual relations or social capital, e.g. strong informal relations among family and friends, largely homogeneous cultures and shared values. These contradictory dynamics between individual-individual relations and individual-group relations make the Western Balkans a uniquely intersting case study in defining, measuring and analyzing social cohesion.

Following the introduction in section one, section two outlines the methodology and decsribes the data used to populate the subsequent linear multiple regression model. In section three the results of a bibliometric analysis of the scientific literature on social cohesion are presented, including the historical evolution of research, the multi-disciplinary composition of the research and the relations among the different knowledge domains in the form of a keyword co-occurrence analysis. In section four we take basis in the network representation of the co-occurrence analysis to justify the selection of variables chosen to measure the correlation between social cohesion and disaster response. In section five the results of the regression analysis for four Western Balkan countries, together with a sensitivity analysis for each individual country are presented and discussed. Section six draws preliminary conclusions about the model's validity and some implications for future research.

2. METHODOLOGY AND DATA

The present study uses mixed methods research design, combining state-of-the-art bibliometric techniques and linear multiple regression analysis.

While the phenomenon of social cohesion is so old as to be considered part of human nature by thinkers as early as Aristotle[1], the term social cohesion itself has only in the past three decades been used by a small number of academics and a somewhat larger body of policy analysts to describe the ephemeral quality of social systems that keeps a system's integrity, preventing its physical tendency toward disintegration, chaos and collapse. Social cohesion and resilience of social systems are intimately related concepts. Both have been subject to much academic speculation on how to define them, what constitutes them, what causes them, what consequences ensue as a result of their presence or absence, and what indicators best capture their dynamics.

A comprehensive literature review is provided by Schiefer and van der Noll (2016) who trace the conceptual development of social cohesion from liberal political philosophy in 17th century Britain, which saw social cohesion as a natural result of collective willingness to cooperate and exchange goods in order to satisfy individual interests to French 19th century functionalism, particularly Durkheim's idea of solidarity based on shared loyalty and mutual interests, to late 18th century German romanticism, based on biological metaphors of organicism, where individuals and society form one holistic organic body, to contemporary formulations stemming from the social policy domain, addressing social cohesion from a plethora of applied policy areas such as security, integration, welfare, etc. As the purpose of this study is to quantitatively assess a possible correlation between social cohesion and disaster response, we do not strive to provide a comprehensive definition of social cohesion nor to explain how it relates to semantically similar concepts such as social capital or solidarity. Instead, we focus on providing an experimental operational definition, which we base on a selection of variables we derive from a bibliometric cluster analysis.

In Schiefer and van der Noll (2016) no mention is made of grid-group cultural theory developed by anthropologist Mary Douglas (1970, 1978), which we consider a serious omission in the body of research on social cohesion over the past 30 years. The only direct reference to Douglas' cultural theory in the context of social cohesion we found in Melton (2003) who tests the validity of selected questions from the World Values Survey as indicators of the grid-group. An operational definition of social cohesion developed by Chan et al. (2006), however, bears a strong indirect reference to Douglas' functionalist methodology as a whole and to her grid-group model in particular. There social cohesion is defined as "a state of affairs concerning both the vertical and the horizontal interactions among members of society as characterized by a set of attitudes and norms that includes trust, a sense of belonging and the willingness to participate and help, as well as their behavioural manifestations."

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[1] For a discussion of Aristotle's designation of man as social/political animal (πολιτικὸν ζῷον) as a way to distinguish between membership in civic society and social institutions vs private sphere membership such as a family household, see Mulgan (1974).

In our study, we come close to the operational definition of Chan et al. (2006) whereby we distinguish between perceived and observed elements of social cohesion, which apply to both relations between individuals in society and relations between individuals and institutions (what Chan et al. label ‘horizontal’ and ‘vertical’ respectively). Like Chan et al. we exclude a number of socio-economic conditions from our definition as we see those as causes and consequences, not essences of social cohesion. However, we argue for their inclusion as control variables as we believe they provide an opportunity for a more nuanced analysis, where situational factors may significantly impact the model results. In section 6 we suggest that Douglas’ group-grid scheme might be an appropriate complement to the regression model as a way to achieve a culturally nuanced comparison of the four countries under consideration, wich would in turn facilitate social cohesion policy tailored to the preferences for social organization of individual countries.

Our selection of social cohesion variables is further aided by a keyword co-occurrence analysis of the literature on social cohesion. A keyword co-occurrence analysis is a statistical datamining method. The relatedness of items is determined based on the number of documents in which they occur together. We used the VOSviewer software to construct keyword maps of the 6000+ records we extracted from the Web of Science on the topic of social cohesion. The methodology is described in detail in Van Eck and Waltman (2017).

To analyze the correlation between the selected social cohesion variables and a major flood event affecting the Balkans region in 2014, we adapted a multiple linear regression model from a study by Calo-Blanco et al. (2017) on social cohesion and earthquake disaster response in Chile, which is the only other study we are aware of that attempts to quantify the dynamics between social cohesion and disaster response, using at least partially objective indicators.

Data for the model was collected from sources listed in Table 2. The availability, quantity and quality of the data differs considerably among the countries as well as among the different variables. Most of the data pertains to perceived elements of social cohesion, collected through stated preference type of surveys. Observed elements of social cohesion could be found in data of the revealed preference type, of which only data on marriage, divorce and reported intentional homicide could be collected. A significant omission in our model is therefore data related to observed social-institutional relations such as actual participation in civil society and public decision-making. Further lacking is data on the individual dimension of suicide.

3. BIBLIOMETRIC ANALYSIS OF SOCIAL COHESION

3.1. Evolution and disciplinary distribution of research

The birth of the concept of social cohesion can be traced to the early 1990s. The evolution of research over the past 3 decades shows that while interest in social cohesion has progressively increased in the last 10 years, the concept is still a rather marginal subset of the broader concept of social capital (Fig.1). In our literature review we found that in academic publications social capital and social cohesion are for the most part distinguished. The former concerns only relations between individuals; the latter encapsulates the collective relations between individuals and social institutions additionally. In the policy-oriented literature on social cohesion the distinction is rarely made. The total number of records for social capital from 1900 onwards is about 23,000, more than 95% of which were published during the last 3 decades. Social cohesion records come to around 6000 for the same period.

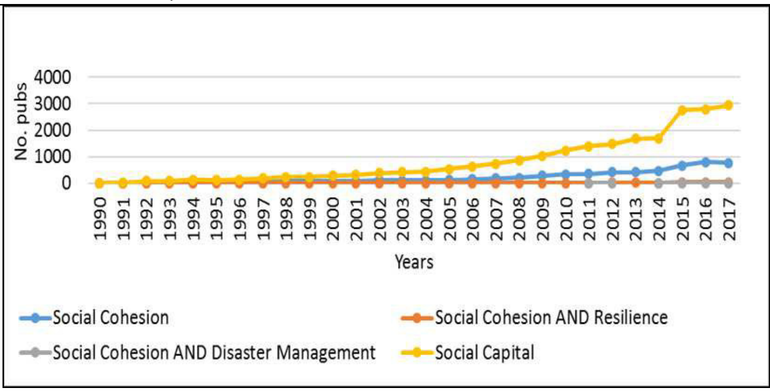

Figure 1- Evolution of research on social cohesion 1990-present

Even more marginal is research on social cohesion, which focuses on combing disaster risk and resilience, with a total number of records just over 100, mostly published in the last several years.

Social cohesion is a budding area of academic inquiry that has spurred interest from a number of different academic domains. In Fig. 2 it can be seen that social cohesion is studied in different application areas and from a number of different disciplinary perspectives. The two dominating knowledge areas are Psychology and Sociology and Social Sciences. Psychology research on social cohesion focuses primarily on the individual, while Sociology, Anthropology and Political Science study social cohesion from the collective perspective of social groups or society as a whole. The Social Sciences produce mostly theoretical research, whereas research in the areas of Psychology, Public & Environmental Health, Business and Government and Law tend to be more problem-oriented and focus on empirical research.

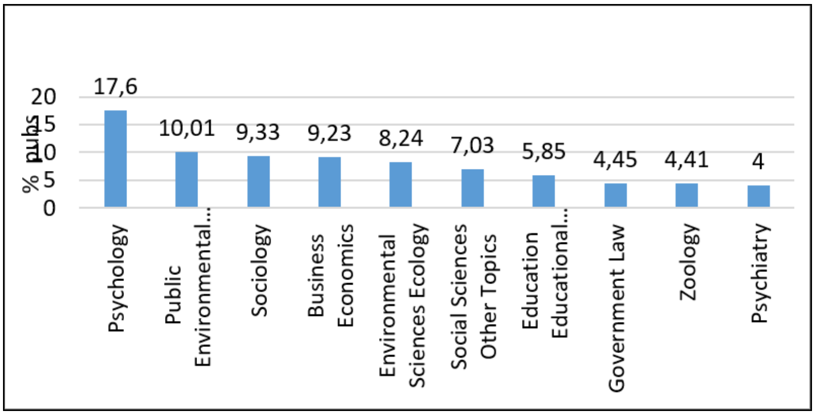

Figure 2- Social Cohesion Top 10 contributing research areas

3.2. Keyword co-occurrence analysis of social cohesion

As a qualitative literature review yielded a large number of contradicting definitions of social cohesion, largely stemming from different disciplinary camps, we used a quantitative data mining technique, namely keyword co-occurrence analysis, to attempt to strip some of the subjectivity and polemicism from the debate what constitutes social cohesion. In Fig. 3 the results based on the 6000+

records extracted from the Web of Science is visualized as network composed of keywords and links. The larger the circle, the more frequent the keyword occurrence. Links are connections or relations between two keywords. The stronger the link, the thicker the line. Keywords are also grouped together into clusters. A cluster represents a set of keywords strongly linked together.

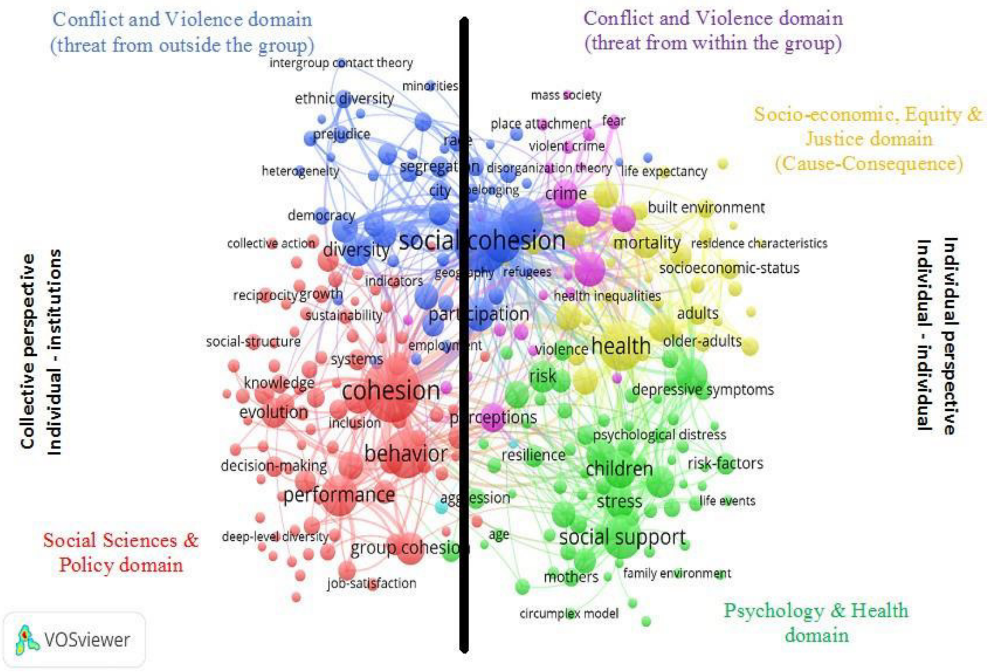

Figure 3 - Network visualization of social cohesion 1990-present

The five clusters in this network correspond to the dominant disciplinary perspectives on social cohesion. The red cluster contains items pertaining to the Social Sciences and Policy domains. Here dominant elements are behavior and performance, decision-making, systems, social structure, diversity, and elements such as reciprocity, collective action, and sustainability. This cluster is clearly about collective rather than individual relations and behavior.

The blue and pink clusters are about social cohesion from the perspective of conflict and violence. We believe that we see a difference between them in that the blue is more oriented toward collective threat by outsiders of a group while the pink represents more an individual level of violent crime from within a group.

The yellow cluster is what we call the "cause-consequence" cluster where we see different socio-economic and demographic indicators, such as life expectancy, inequality, health, age, etc. They may be individual or aggregate but we argue that they are conditions for or results of social cohesion rather than essential elements of social cohesion.

Finally, the green cluster is clearly the domain of psychology, family and health and represents exclusively the individual dimension.

3.3. Keyword co-occurrence analysis of social cohesion in the context of disaster risk management

While the co-occurrence analysis of social cohesion helped to narrow down some elements we could consider in defining and measuring social cohesion, it was too broad for the problem context, namely the link between social cohesion and disaster response. A second co-occurrence analysis based on the 100+ records combining social cohesion and disaster in the titles and abstracts facilitated a further comparison between the broader and narrower terms (Fig. 4)

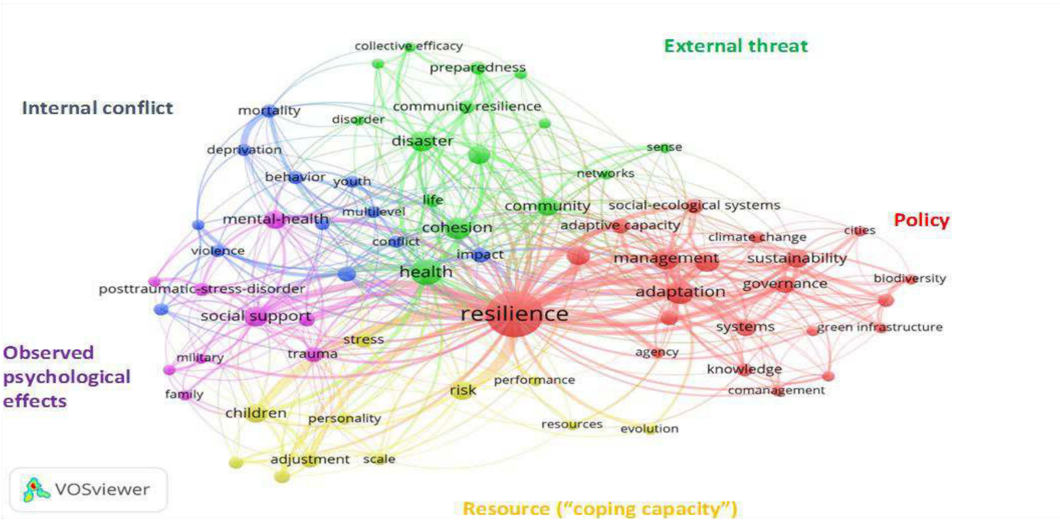

Figure 4 - Network visualization of social cohesion in the context of disaster risk management 2000s – present

In this network visualization there are 5 clusters again. The dominant one is the red one, which represents more or less the Policy domain, only here Social Science has been replaced by Environmental and Ecological Sciences, e.g. adaptation, adaptive capacity, social-ecological systems, biodiversity, green infrastructure, systems, etc.

The green cluster is clearly the external threat cluster, in this case pertaining to the natural hazards domain. The blue is internal conflict and violence probably more linked to socio-economic conditions, e.g. deprivation and mortality. It merges together with the pink cluster of observed psychological effects of social break down on the individual level such as trauma, post-traumatic stress, mental health. We could ascertain here relation to suicide, the available statistical data for which is very poor or non-existent.

The yellow cluster is the „resource“ cluster of psychology and health at the individual level, which we label „coping capacity“.

4. SELECTED VARIABLES

Based on the qualitative literature review and the bibliometric analyses, we selected a number of variables, for the subsequent regression analysis. The variables are divided into three types: flood exposure variables, social cohesion variables and control variables.

The flood variables relate to a major, so-called 100-year flood event that occurred in May 2014 and severely affected two of the countries in the region – Serbia and Bosnia and Herzegovina – for the purpose of determining variations in the social cohesion outputs before and after this event. Albania and Macedonia were not affected by this flood event. We are further interested in comparing variations in the variables we have chosen to represent the state of social cohesion between the affected and unaffected countries in the region (Table 1). According to an impact and needs assessment report of the Serbian government, prepared under the guidance of European Union, the United Nations and World Bank, the highest impact of the disaster was in terms of production and access to social services (1,312 million EUR or 86% of the total) while infrastructure damages amounted to 192 million EUR or 12% of the total). Economic consequences of the disaster were predicted to include decline in real economic growth, worsening of the current account of the balance of payments and a decline in the fiscal position as a result of lower tax revenues and higher expenditures for recovery and reconstruction. Social consequences were predicted to include temporary loss of employment and a decline in the country's HDI score due to GNI decline and limited access to education and health services. All socio-economic impacts were expected to have higher effect on the poor, ethnic Roma, women, and disabled persons.

In a similar needs assessment report prepared by the government of Bosnia and Herzegovina and the guidance of the international organizations listed above, the event was estimated to have caused the equivalent of nearly 15% of GDP in damages (9.3% of GDP) and losses (5.6%), amounting to 2.04 billion EUR. The report refers to the event as the most serious natural disaster experienced by the country in the past 120 years, affecting approximately one million people of the total 3.8 million population and in particular, families, small, medium and large businesses, agricultural producers, and an undefined number of vulnerable sectors of the population.

Table 1- Exposure variables

Exposure Variables	**Note**
POSTt	1 if t>=2015 (the occurrence of the major flood event in 2014); otherwise, = 0
Influ by Flood2014	if the country is influenced by the major flood event in 2014, it will be 1 for t>=2014; otherwise, = 0
POSTt x Influ by Flood2014	interaction between the above two variables

To represent the multi-facetted concept of social cohesion, the social cohesion variables (the model's outputs) are grouped into three thematic domains: (i) Trust and Social Relations, (ii) Altruistic Behavior and (iii) Compliance (Table 2). In our classification, we further distinguish between factors positively or negatively influencing social cohesion as well as whether a variable measures perceived or observed behavior.

Table 2 - Social cohesion variables

Dimension	Social Cohesion Variable	Note	Pos (+)/ Neg (-)	Individual (I)/ Collective (C)	Perceived (P)/ Observed (O)
Trust and Social Relations	Trust in Fellow Citizens	"Generally speaking, would you say that most people can be trusted or that you need to be very careful in dealing with people?" (V23/V25 World Values Survey)	+	I	P
	Government Effectiveness	Perceptions of the quality of public services, the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. (World Bank - Worldwide Governance Indicators)	+	C	P
	Marriage	Crude Marriage rate per 1000 population (Eurostat)	+	I	O
	Divorce	Crude Divorce rate per 1000 population (Eurostat)	-	I	O
Altruistic Behavior	Giving Money	A composite country score for charity based on data from Gallup's WorldView World Poll. The survey question is "Have you donated money to an organization in the past three months?" Incl. political parties/organisations as well as registered charities, community organisations, and places of worship. (World Giving Index)	+	C	P
	Volunteering Time	Same as above. The survey question is: "Have you volunteered time to an organization in the past three months?"	+	C	P
	Helping a Stranger	Same as above. The survey question is: "Have you helped a stranger or someone you didn't know in the past three months?"	+	I	P
Compliance	Rule of Law	Perceptions of the extent to which agents have confidence in and abide by the rules of society, and	+	C	P

		in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. (World Bank - Worldwide Governance Indicators)			
	Corruption	Perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. (World Bank - Worldwide Governance Indicators)	-	C	P
	Crime	Intentional homicides per 100,000 people (World Bank – World Development Indicators)	-	I	O

The socio-economic and demographic conditions relevant for social cohesion have been included as control variables (Table 3). In here, variables related to health, wealth and inequality as identified in the bibliometric analysis are deemed to be causes and/or consequences of the presence or absence of social cohesion. They are implicit in the HDI and Gini country scores. Variations in the Gini could be taken as a proxy indicator on the grid axis of the cultural grid-group model, which represents a range of societal acceptance for social assymetry of roles and the degree of hierarchy in a given society. The HDI we believe is a proxy indicator for quality of life in that it aggregates economic purchasing power, health and education. The majority of models measuring social cohesion include quality of life or life satisfaction as an indicator of social cohesion. We take a position that it can be both a cause and a consequence but it is not a necessary condition for social cohesion.

Unemployment is a widely accepted cause of social unrest and breakdown. Particularly interesting in terms of the interplay between the individual and collective dimesnions of social cohesion is informal employment or shadow economy, which is alledgedly very high in the Balkans region. While informal employment may be said to undermine community resilience in that it hinders socio-political institutions to accumulate resources that may be distributed as relief and reconstruction efforts after a disaster event, informal employment may also be seen as a proxy indicator for social cohesion on the individual scale of informal relations between individuals, which are important in determining co-operative and altruistic behavior that fosters community resilience. Ineffective governance and corruption decrease trust in institutions and people’s willingness to contribute to public goods in the form of taxes. These potential contributions remain or are exchanged in an informal way between individuals, which strengthens the individual dimension of social cohesion while at the same time weakening the collective. If a hypothetical society is culturally prone to be low grid and low group, i.e. place value on individualism and freedom expressed negatively as freedom from control, it will show a political preference for social structure where the individual, not the collective institution is the dominant actor. By contrast, a high grid high group society will seek to convince its members that absolute institutional control is necessary to ensure the availability of equal public goods.

Table 3- Control variables

Control Variables	Note
Gini	Gini index measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution. A Gini index of 0 represents perfect equality, while an index of 100 implies perfect inequality. (World Bank)
HDI	The Human Development Index (HDI) is a summary measure of achievements in three key dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions. Data inputs for the HDI index include: Life expectancy at birth, Expected and mean years of schooling, and GNI per capita. (UNDP)
Unemployment	Unemployment (age 15+) per 1000 persons, 1 year period average (SEE Jobs Gateway database, based on data provided by national statistical offices and Eurostat)
Informal Employment	Informal employment as a percentage of total employment. Data on informality are collected by the labor force surveys of Albania, the FYR Macedonia, and Serbia only; no data is available on Bosnia and Herzegovina. All countries use the comprehensive International Labor Organization (ILO) definition for informal employment, covering (1) Self-employed in unregistered businesses, (2) Wage workers without written contract and, (3) Unpaid family workers. (SEE Jobs Gateway database, based on data provided by national statistical offices and Eurostat)

5. REGRESSION ANALYSIS RESULTS AND DISCUSSION

We build on the work of Calo-Blanco et al. (2017) who conducted a similar study of social cohesion and earthquake disaster recovery in Chile. While in principle the same regression model, the exposure, social cohesion and control variables were changed to fit both the different type of natural hazard and the different socio-cultural elements relevant for the Balkans region. Our model is written as:

$$\gamma_{ct} = \alpha + \beta_1 \mathrm{POST}_t + \beta_2 \mathrm{Influ\ by\ Flood\ 2014}_c + \beta_3\ \mathrm{POST}_t \times \mathrm{Flood\ 2014}_c + \gamma X_{ct} + \varepsilon_{ct}$$

where,

y_{ct} is an indicator of social cohesion in a country c at time t

β_1 -shows the average increase or decrease in the indicator between the period before and after the 2014 event for the unaffected countries

β_2 shows the difference between affected and unaffected countries before the 2014 event

β_3 shows the average difference in the evolution of the indicator between affected and unaffected countries from before the event to after the event

γXct is a vector of control variables

α represents regional fixed effects

ε_{ct} represents an error term

Our main interest lies in the parameter β3 which estimates the average difference in the evolution of the indicator between affected and unaffected countries from before the event to after the event.

Typically, the two important values to consider are the R-square value and the p-values. The R-square value expresses how much variation is explained by the model. The greater R-square value indicates high correlation and a good model fit. The p-value is an expression of the statistical significance. If the p-value is less than the significance level (0.05) then the model fits the data well. In general, the best scenario is a combination of high R-square and low p-value. However, due to the very limited data we were able to obtain (7 or 8 observations per variable, and in the case of some variables the data was statistically interpolated), the 0.05 p-value cut off criteria cannot be justified in our model. We focus therefore on comparing the R-square values, which give us a good preliminary indication of the relevance of our hypothesis, namely that a linear correlation exists between social cohesion and disaster response while keeping in mind the uncertainties associated with the correlation values. In Fig. 5 the solid lines represent the R-squared values or the regression; the punctuated lines show the p-values, or the uncertainties of the model. The higher the correlation of a given variable, the closer the uninterrupted line is to the outer boundary of the spider diagram. The higher the uncertainty associated with a particular variable, the larger the surface of the punctuated lines. The best fit for a variable, i.e. high correlation with small uncertainty is therefore a combination of a solid line value residing on the outer boundary and a punctuated line value residing closest to the center. For Bosnia and Herzegovina no data could be collected for the variables Marriage and Divorce.

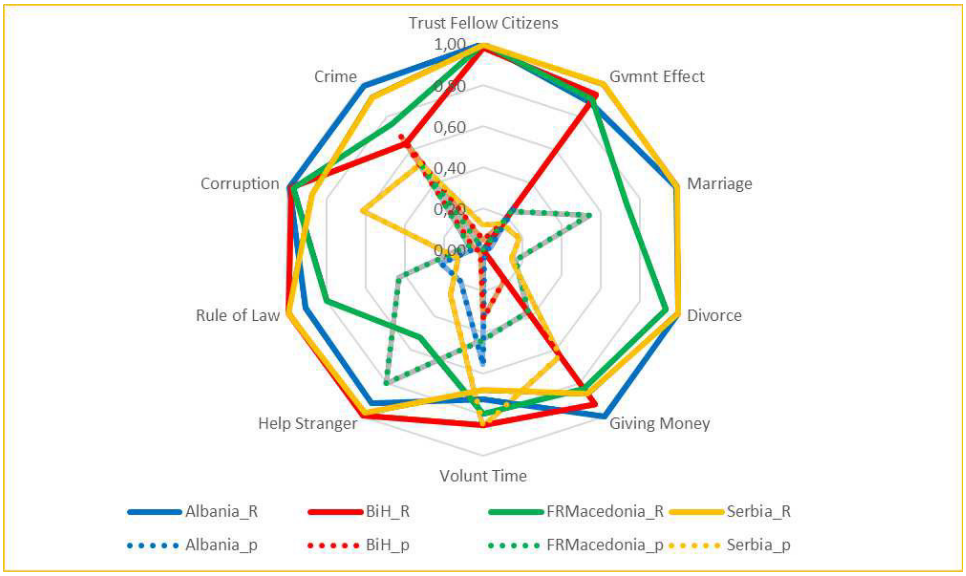

Figure 5 – Comparative correlation results for Albania, BiH, FR Macedonia, and Serbia

While most variables show high correlation irrespective of country, the uncertainty associated with the results is smaller in the case of Albania and Bosnia and Herzegovina and significantly larger for the FR Macedonia and Serbia. To compare, the results between the two countries affected in the 2014 flood event – Bosnia and Herzegovina and the two that were unaffected – Albania and the FR Macedonia we compare the values of the root mean squared error (RMSE) of the regression, which express the average model prediction error. RMSE ranges from 0 to ∞, where a lower value indicates a better model prediction. Fig. 6 shows that the two unaffected countries show an almost perfect fit to the data, while the affected ones show less certain results.

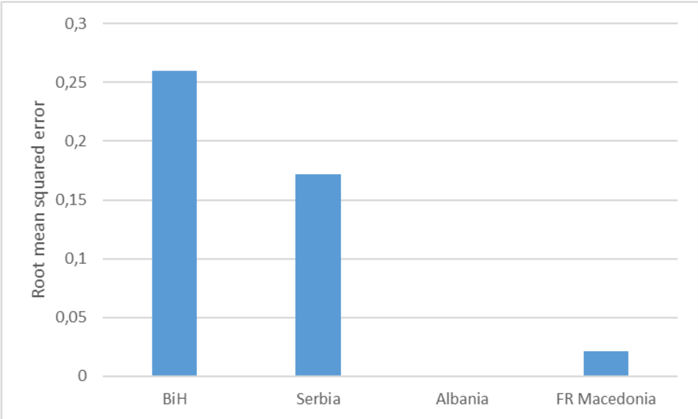

Figure 6 – Comparative root mean squared error results for the affected and unaffected countries

The choice of control variables when dealing with social phenomena is very subjective. A dependency among the control variables could result in multicollinearity, which in turn can invalidate the model prediction of how well each independent variable can be used to describe changes in the dependent variable. In our case, there might be linear relation between HDI and Gini or between the variables representing the flood events. However, our goal is to be sure whether there is a multiple linear relation between the social cohesion variables and the explanatory exposure and control variables. The high R-square values indicate that the relation is strong, so we can conclude that the linear relation is valid.

In the social sciences a principal component analysis (PCA) is typically performed to identify the principal, i.e. most important components of the data. This is especially relevant for multiple regression with a large number of independent variables as the method helps to decide which less significant components can be eliminated and whether some of the omponents can be grouped together. PCA uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. If there are n observations with p variables, then the number of distinct principal components is no larger than min(n-1,p) (Jolliffe and Cadima (2016). For our problem at hand, we do not have sufficient data points, e.g. in our case n and p are equal to 8 and 7 respectively, and in some instances we even rely on statistical data interpolation. For this reason we conclude that a principal component analysis is not of relevance for our case.

We turn instead to engineering reliability analysis, where a sensitivity analysis helps to identify the influence of change the value of an independent variable x (for our problem all exposure and control variables) has on the change of reliability y (for our problem - social cohesion) by calculating the value of the derivatives dy/dx (or $\partial y/\partial x$ for multi variable cases precisely). For our multiple linear model here, the value of $\partial y/\partial x$ for different independent variables x is the corresponding coefficient that was calculated. In Fig.7 the sensitivity results for the four countries are shown based on the standardized regression coefficients for each independent variable.

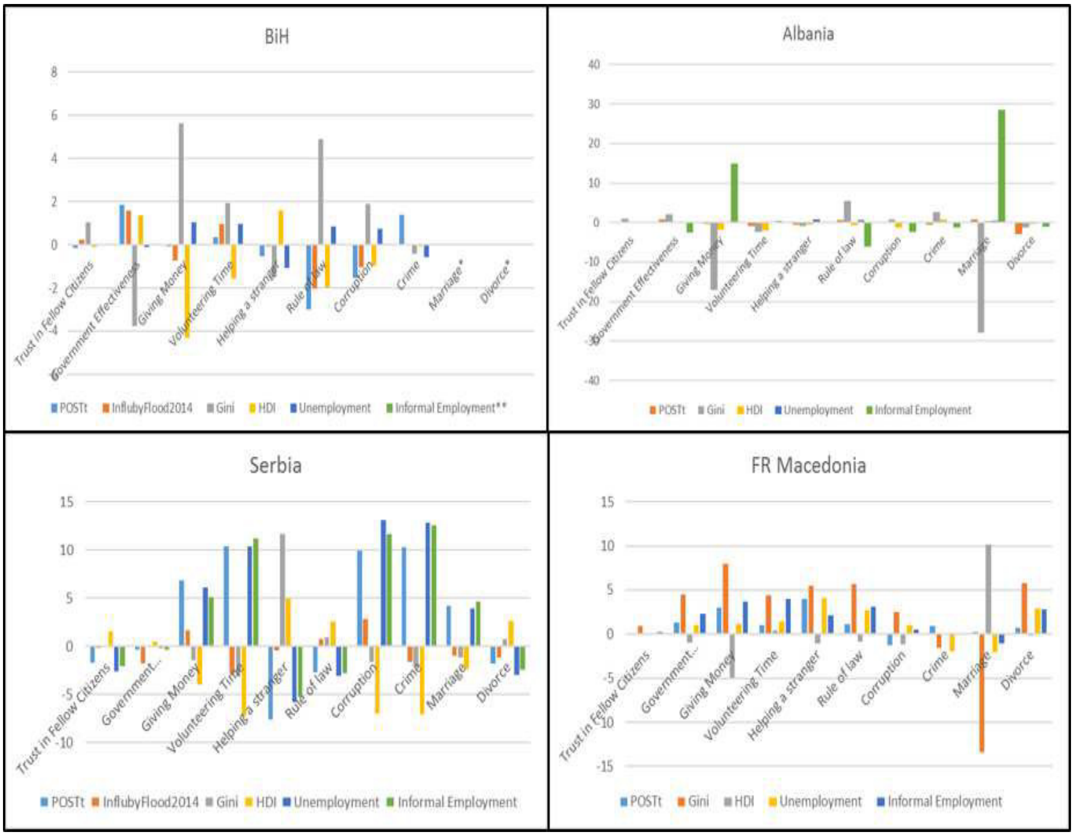

Figure 7 – Sensitivity results for Albania, BiH, FR Macedonia and Serbia

** No data could be obtained for Marriage and Divorce for Bosnia and Herzegovina*

*** No data could be obtained on Informal Employment for Bosnia and Herzegovina, however various grey literature sources estimate that its labor market is also characterized by a substantial informal economy. Estimates of its size vary between one third and one half of total employment. A report by the ILO (2009) based on a 2006 labor force survey, informal employment makes up around one third of all employment.*

The results of the sensitivity analysis appear similar for all the countries except Serbia. For Bosnia and Herzegovina the most significant variables are the Gini and the HDI; for Albania – Gini and Informal Employment; for the FR Macedonia – Gini and the HDI; for Serbia, the weight of all control variables as well as the exposure variable POSTt are similar and significant. In most cases, the absolute value of the coefficients of GINI is bigger than that of the others while Informal Employment has significantly higher values for Albania and Serbia. Potentially, this could be indicative of Bosnia and Herzegovina if we are able to support the qualitative information we obtained on informal employment in BiH from grey literature with a dataset. From the mathematical point of view, we propose that the multiple linear model describes the relation between the social cohesion and all independent variables (control and exposure), meaning that the model, itself, is formulated here independent of the occurrence of the flood events.

6. CONCLUSIONS AND FUTURE OUTLOOK

The goal of this study has been to investigate whether there is multiple linear relation between social cohesion and a major flood event affecting parts of the Western Balkans region. We find that despite the limited and often highly uncertain data, a linear relationship does indeed exist. While our model cannot be statistically verified with the present amount of observations, it nevertheless points to the fact that a hypothetical correlation between disaster response and social cohesion could be an empirical phenomenon of the world and not simply of the model. The need for a better data set on all the identified variables will be indispensable in the further calibration of the model.

The generally accepted 0.05 p-value as a criteria for the model's goodness of fit is in our problem context too strict to justify due to the high uncertainty in the data and also the insufficient number of the data points. We have therefore proposed other statistical measures to investigate the hypothesis: R-squared to test the preliminary indication of the relevance of our hypothesis; root mean squared error to compare the results for the affected vs the unaffected countries; and standardized regression coefficients for each independent variable as a sensitivity measure.

The differences in the value of the correlation coefficients across the countries as shown in the sensitivity analysis might further come from cultural or historical factors that are not captured in the variables we have selected. To examine such effects the functional grid-group model developed by anthropologist Mary Douglas in the 1970s could shed additional light on how homogeneous or heterogeneous the Western Balkans region is with regard to the dynamics of social cohesion in the aftermath of a natural hazard event. In the social sciences, functionalism is a theoretical perspective arising from the influence of the biological conceptualization of organisms as holistic systems, where the whole is greater than the sum of its parts. The first theory of social cohesion stemming from this perspective is Durkheim's theory of *organic solidarity* which is what makes a society maintain its internal stability over time, or in present days words, what makes a 'resilient society'. Functionalist methods rely on emprical data („social facts“) to describe objective social conditions that influence human behavior at the macro scale of a collective or whole society. Douglas' grid-group models social organization on a two dimensional axis, where the vertical grid dimension is a measure of the degree of social hierarchy within a given society and the horizontal dimension is a measure of the group's cohesiveness, expressed as a degree of individual or group centeredness (Douglas 2007). While conducting a grid-group analysis is outside the scope of the present study, we believe that the model could be a relevant complement in the context of providing a culturally-nuanced policy advice because the relative position of a country on the grid-group axis will give an indication of the societal preference system for governance and whether this preference supports the collective institutional dimension exemplified by a system of strong state political and economic institutions or the individual dimesion exemplified by a system of private contracts and informal arrangements.

7. REFERENCES

[1] Calo-Blanco A, Kovářík J, Mengel F, Romero JG (2017) Natural disasters and indicators of social cohesion. *PLoS ONE* 12(6): e0176885.

[2] Chan, J., To, H. and Chan, E. 2006. Reconsidering Social Cohesion: Developing a Definition and Analytical Framework for Empirical Research. *Social Indicators Research* 75: 273-302.

[3] Douglas, M. 1970. *Natural Symbols: Explorations in Cosmology*. London: Berrie & Rockliff.

[4] Douglas, M. 1978. *Cultural Bias.* London: Royal Anthropological Institute.

[5] Douglas, M. 2007. *A History of Grid and Group Cultural Theory*. Toronto, Ontario, Canada, University of Toronto. Retrieved from http://projects.chass.utoronto.ca/semiotics/cyber/douglas1.pdf

[6] Durkheim, E. (1982 (1895)). *The Rules of the Sociological Method.* The Free Press. Retrieved from https://monoskop.org/images/1/1e/Durkheim_Emile_The_Rules_of_Sociological_Method_1982.pdf

[7] Government of Serbia. 2014. Serbia Floods 2014. Retrieved from Reliefweb https://reliefweb.int/sites/reliefweb.int/files/resources/20140715-serbia-rna-report_0.pdf

[8] Government of Bosnia and Herzegovina. 2014. Bosnia and Herzegovina Floods 2014. Retrieved from Reliefweb https://www.gfdrr.org/sites/default/files/BiH-rna-report.pdf

[9] International Labour Organization (ILO). 2014 Country employment policy review: Bosnia and Herzegovina. Retrieved from https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/publication/wcms_250997.pdf

[10] IPCC 2014, {WGI 2.6.2, WGII 3.2.7, SREX SPM B}, https://www.unisdr.org/files/1741_SouthEasternEuropeDRMitigation.pdf

[11] Jolliffe, I. T., & Cadima, J. 2016. Principal component analysis: a review and recent developments. *Philosophical Transactions. Series A, Mathematical, Physical, and Engineering Sciences*, 374(2065), 20150202.

[12] Melton, J. 2003. Measuring Culture and Cultural Change. *Res Publica, Journal of Undergraduate Research*. 8, 119-150.

[13] Mulgan, R. 1974. Aristotle's Doctrine That Man Is a Political Animal. Hermes. 102. Bd.H. 3(1974). 438-445. Retrieved from https://www.jstor.org/stable/pdf/4475868.pdf

[14] Schiefer, D. and Van der Noll, J. 2016. The Essentials of Social Cohesion: A Literature Review. *Social Indicators Research*. Vol.127. 1. 1-25.

[15] Van Eck, N.J and Waltman, L. 2017. VOSviewer Manual. Version 1.6.6. Retrieved from http://www.vosviewer.com/documentation/Manual_VOSviewer_1.6.6.pdf

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MODELLING APPROACH OF STRUCTURAL FIRE PERFORMANCE

Abstract: Numerical modelling of structural fire performance is a powerful tool in assessing the behavior of structures subjected to extreme loading conditions. It is not a replacement for experimental testing. On the contrary, experimental studies are inevitable and essential part for performing verification and validation of proposed calculation models. The process of model development needs to be validated step-by-step. This paper presents the course of finite element model development for assessing the structural behavior of reinforced concrete members subjected to nominal fire exposure, using commercially available software ANSYS. The model has been verified and validated based on the comparison between the predicted response and the results of numerical benchmark studies, different numerical codes and experimental tests.

Key words: numerical modelling, structural fire performance, verification and validation

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1. INTRODUCTION

Experimental studies provide the most comprehensive knowledge on the behavior of structures in fire. However, in addition to the experimental setup and equipment needed to perform tests at ambient temperatures, specialized furnaces and instrumentation are necessary to provide standardized (or parametric) fire exposure and to adequately capture the thermal and structural response at elevated temperatures. Given the limitations in size of the furnaces, and the costs of providing the equipment, as well as the large amounts of energy for each conducted test, the need for more sustainable approach has resulted in the development of numerical procedures, namely using finite element method, as a robust tool in support of time and cost consuming experiments.

Modelling the behavior of structures in fire is a very complex process. Numerical models should be based on fundamental physical behavior to provide a reliable approximation of the expected behavior of structural components under fire condition. The complexity is reflected in determining the temperature field in time, and coupling it with the structural response, which includes nonlinearity of the material behavior and is able to include the degradation of mechanical properties at elevated temperatures.

There are several computer programs capable of calculating the thermal and mechanical behavior of structures in fire, such as ANSYS [11], ABAQUS [2], SAFIR [10], VULCAN [12], OPENSEES [15], etc. Since numerous nonlinearities are included, it is imprortant to perform verification and validation steps of the proposed models. Verification is usually based on the engineering judgement, sane checks, hand calculations and numerical error checks. However, those can only provide the information whether the chosen mathematical model is solved correctly using numerical solution, but not whether the mathematical model is a reasonable representation of the physical phenomenon. Validation of the advanced numerical models should be made based on comparison with experimental results or analytical solutions. In the absence of such results databases, additional checks could be made by comparison with other numerical models, but only to a certain degree of confidence.

2. STRUCTURAL FIRE PERFORMANCE

The governing phenomenon influencing the thermal response of structural elements in fire is the heat transfer, by means of conduction, convection and radiation. A comprehensive analysis would incorporate thermal, hydral and mechanical analyses in a fully integrated coupled model capable of predicting the water migration and pore pressures, influencing, for example, the explosive spalling of concrete. However, in most practical cases, simpler methods, omitting, i.e. mass conservations, energy and momentum conservation equations, are adequate for the analysis of structures in fire. [3] Based on the experimental results from tests at ambient and elevated temperatures, the input parameters influencing heat transfer are empirically proposed in the Eurocode standards. Influence of the moisture content in materials such as concrete or wood is introduced through modifications of the specific heat and material density, to account for free water evaporation and loss of mass, implicitly.

Thermal and mechanical analysis could be coupled in a weak or strong manner. Unlike strong coupling, weak coupling assumes that the heat transfer is not influenced by the deformations of elements and, therefore, can be solved separately. Such approach can provide reasonably accurate predictions of the thermal response and a computationally less expensive solution, given that it reduces the number of degrees of freedom (DOF) that need to be determined in each substep of the analysis. The results of the thermal analysis, in terms of temperature evolution in time, are transferred to the subsequent structural analysis, as internal time-dependent body temperature.

Structural mechanical analysis must include material nonlinearity and degradation at elevated temperatures. Coefficient of thermal expansion for structural materials, such as concrete or steel, is temperature-dependent. For concrete structures, thermal expansion is dependent on the type of aggregate being used for the concrete mix design. The physical-chemical changes that occur in concrete, such as the loss of free and physically bounded water, followed by the loss of chemically bounded water at higher temperatures, are implicitly accounted for through the temperature-dependent relationships of thermal strains and stress-strain relations at elevated temperatures. The influence of endothermic process of changing the crystalline structure of carbon based steel is reflected in the peak values of specific heat, as well as the thermal strain at the temperatures of interest. The process of wood burning and forming a protective charring layer for the remaining part of the structural element, is implicitly accounted for through modification of the thermal conductivity of wood and assuming zero-strength and stiffness of the charred layer.

Numerical models need to be able to incorporate nonlinear calculations, and to address the changes in material properties at high temperatures, both thermal and mechanical. As the numerical models tend to provide mathematical solution to the physical representation of the structural fire performance with reasonable accuracy, based on the provided assumptions, the process of verification and validation should be performed step-by-step during the model development. In this paper, the process of model development in a general purpose computer program ANSYS has been presented, to evaluate thermal and mechanical response of the structures subjected to fire.

2.1. Thermal Model Response

Eurocode 2, part 1-2 [9], provides guidelines for verification of thermal analysis results for concrete members, such as slabs, exposed to fire from one side (Fig. 1) and beams and columns, exposed from all sides to standard ISO 834 [13] fire (Fig. 2). Developed ANSYS [1] finite element model is composed of 8-node 3D SOLID70 elements, with a single degree of freedom, temperature, representing concrete part of members, and surface elements SURF152, which are used to apply thermal loads in terms of convection and radiation. Convection coefficients α_c=25 Wm^{-2}°C^{-1} and α_c=9 Wm^{-2}°C^{-1} are adopted for exposed and unexposed surfaces, respectively, while emissivity related to concrete surface is adopted as ε_m=0.7. Fig. 1 presents comparative temperature results in a concrete slab with a thickness of 200 mm, after 30, 60, 90, 120, 180 and 240 minutes of fire, providing proper temperature distribution through the slab thickness in time.

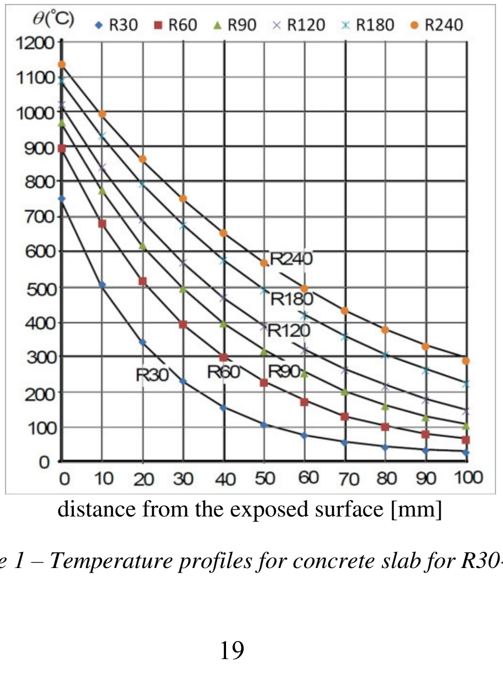
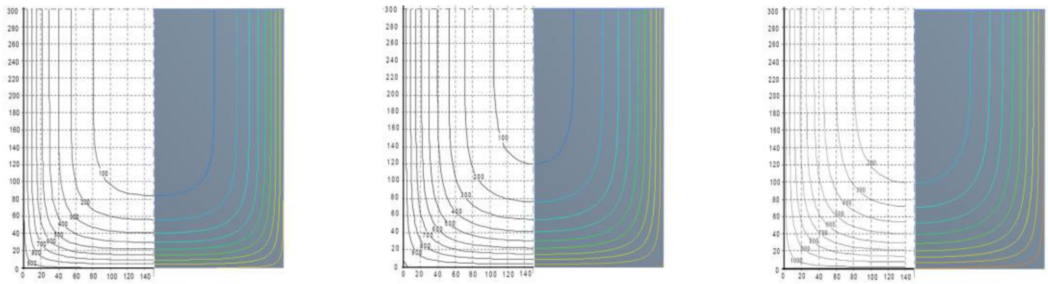


Figure 1 – Temperature profiles for concrete slab for R30-R240

Based on the member geometry and external thermal loading, if the thermal response is symmetrical, corresponding boundary conditions could be applied, thus reducing the number of elements, i.e. number of DOFs, which would shorten the computational time by more than proportional to the node number reduction. In Fig. 2, comparison of isotherms in concrete beam (*b*/*h*=30/60 cm) is presented, after 60, 90 and 120 minutes of standard fire, between Eurocode and ANSYS numerical model values.



R60 R90 R120

Figure 2 – Isotherms after 60, 90 and 120 minutes, according to EN 1992-1-2 (left) and ANSYS (right) [6]

Validation of the thermal model of reinforced concrete beam is performed by comparing the results of the predicted thermal response with measured data in fire test performed by Dwaikat and Kodur [4] and numerical model developed in ABAQUS by Kodur and Agrawal [16]. The above discussed model is expanded to include steel reinforcement, both longitudinal and transverse, as line bodies, using 2-node line element LINK33, coupled at the corresponding nodes with surrounding concrete elements. Temperature evolution in reinforcement and concrete at specified locations of previously installed thermocouples, as well as predicted temperatures at exact locations, is presented in Fig. 3, showing good agreement between measured and calculated results. [5]

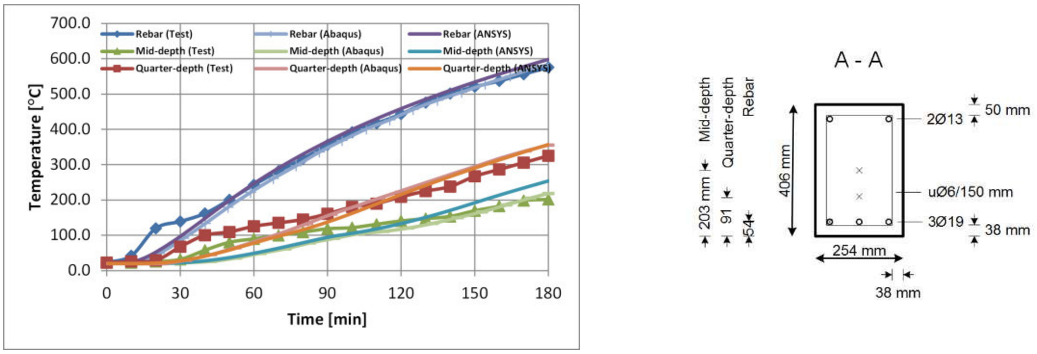


Figure 3 – Comparison of measured and predicted temperatures using ANSYS and ABAQUS [5]

2.2. Structural Model Response

Transient structural response in fire is influenced by the thermal response, previously calculated, and the external loading acting on structure. According to Eurocode, these should include self-weight and additional permanent load and 50% of imposed load. Temperature-dependent material mechanical properties for advanced calculation method are proposed in corresponding Eurocode standards. The developed numerical simulation consists of two load steps. In the first step, external mechanical load is applied, which remains constant during the second load step, that includes thermal loading for the whole expected duration of fire, transferred from the results of the thermal analysis.

During the model development, verification of the correct implementation of material degradation properties at elevated temperatures is achieved by conducting separate analysis using different numerical codes. For this purpose, a theoretical example of a simply supported steel beam, subjected to standard fire exposure, is calculated comparing the model created in ANSYS and in an open source code software OpenSEES. [14] Developed primarily as the computational platform for research in performance based earthquake engineering, the software framework is focused on providing advanced computation tools for analyzing non-linear response of structural frames subjected to seismic excitation. Since 2009, a research team at the University of Edinburgh has started developing structures in fire modelling capacity in OpenSEES, adding new classes for defining temperature-time relations and modifying existing classes to account for the effect of thermal load.

ANSYS structural finite element model is consisted of 8-node 3D SOLID185 elements, representing steel elements, with three degrees of freedom at each node: translations in the nodal x, y and z directions. The element has plasticity, stress stiffening, large deflection and large strain capabilities. In the comparative analysis, temperatures obtained using ANSYS thermal model are imported in OpenSEES model, in 30 time points (every 8 minutes) and applied to the model in 9 points across the height of the cross-section. Time step for the mechanical analysis in OpenSEES is defined as Δt=10s, assuming linear interpolation of temperatures. Displacement-time curves of the beam mid-point for different values of external point load are presented in Fig. 4. Comparing the results, somewhat smaller displacements are calculated using OpenSEES beam element than in the 3D analysis using ANSYS, but the member failure, in terms of deflection rate, practically happens simultaneously, providing confidence for the correct implementation of the steel mechanical properties.

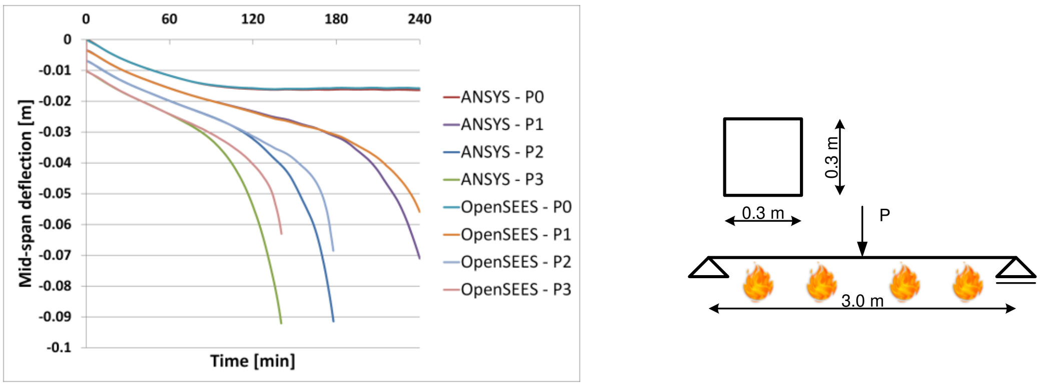


Figure 4 – Comparison of deflection-time curves using ANSYS and OpenSEES [8]

Unlike modeling steel, a homogeneous isotropic material, concrete numerical modelling is more complex, given that concrete is a brittle material with different behavior for compression and tension. ANSYS element library includes an 8-node 3D SOLID65 element, capable of cracking in tension and crushing in compression. Material is modelled using constitutive concrete model of William and Warnke (1974) [17] which can be combined with multilinear isotropic hardening plasticity, following stress-strain relations provided in EN 1992-1-2. In a tensile zone, the presence of a crack at an integration point is represented through modification of the stress-strain relations by introducing a plane of weakness in a direction normal to the crack face. The same element could also be used to model reinforcement implicitly, by smearing the stiffness over the concrete element. Another approach is using discrete uniaxial 2-node line element LINK180, with three translational degrees of freedom at each node. Care must be applied when defining the finite element mesh, as to align the reinforcement element nodes with the surrounding concrete element, to enable node coupling and provide composite action. Multilinear isotropic hardening plasticity is assumed, since large strains are expected to develop.

Reinforced concrete simply supported beam with a point load at the mid-span is analyzed. [7] The beam is exposed to standard ISO 834 fire from all four sides. Since the thermal model is previously verified [6], the aim is to verify the structural model, namely concrete and reinforcement material degradation at elevated temperatures. Results, in terms of the beam mid-span deflection in time, the stress and strain distribution (total mechanical, plastic and thermal strain) are presented and discussed in [7], providing confirmation of the expected physical behavior of the beam.

Validation of the structural model is performed using test results from the same test used to also validate the thermal model. The 4-point bending test setup, as well as the measured and predicted mid-span deflection during fire, are presented in Fig. 5. Although numerical models predict somewhat lower temperatures than measured in the first 100 minutes of test, resulting in a bit stiffer structural response than measured, which could be attributed to a slower degradation of mechanical properties, the numerical model failure at around 180 minutes shows good agreement with experimental results.

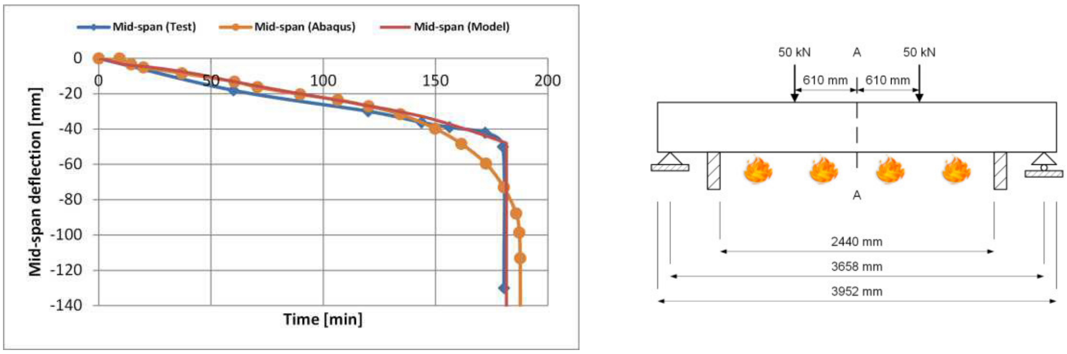


Figure 5 – Comparison of measured and predicted mid-span deflections using ANSYS and ABAQUS [5]

3. CONCLUSION

Numerical model creation is a step-by-step procedure. The behavior of structures in fire depends on numerous parameters influencing the response, which need to be incorporated adequately. The proposed model developed in ANSYS has been

There is a wide range of software, both specialized and commercial, that are capable of predicting structural fire performance. As the computational power increases and the cost of hardware decreases, advanced calculation methods become more and more favorable in determining the behavior of structures in fire. Reliability, however, is not necessary an inherent property of such software, regardless of their level of sophistication. Structural fire performance is a highly nonlinear numerical problem, reflected in the changes of material properties by high temperatures, both thermal and mechanical, as well as in the nonlinear temperature distribution at the element cross-section. Therefore, in the process of model development, for the simulation of thermal and structural response in fire, it is essential that special attention is given to the verification and validation of the numerical model. The experimental fire tests still remain the most useful source of knowledge on different fire resisting assemblies, but are also very valuable for providing data for verifying computer models, which can then be used for a wider range of application.

The proposed three-dimensional finite element model developed in commercially available software ANSYS has been verified and validated to assess the behavior of reinforced concrete members subjected to nominal fire exposure, based on numerical benchmark results, other numerical codes and experimental results from the available literature.

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4. REFERENCES

[1] ANSYS® Academic Teaching Mechanical. (2015). *ANSYS Help Documentation, Release 16.0.* Canonsburg: ANSYS, Inc.

[2] Bailey, C., & Ellobody, E. (2009). Whole-Building Behaviour of Bonded Post-Tensioned Concrete Floor Plates Exposed to Fire. *Engineering Structures, 31*, 1800-1810.

[3] CEB-FIP. (2007). *Fire Design of Concrete Structures - Materials, Structures and Modelling* (T. Bulletin 38). International Federation for Structural Concrete (fib).

[4] Dwaikat, M., & Kodur, V. (2009). Response of Restrained Concrete Beams under Design Fire Exposure. *Journal of Structural Engineering, 135*(11), 1408-1417.

[5] Džolev I., Cvetkovska M., Lađinović Đ., Radonjanin V. (2018). Numerical analysis on the behavior of reinforced concrete frame structures in fire, *Computers and Concrete, 21(6)*, 637-647.

[6] Džolev I., Cvetkovska M., Lađinović Đ., Radonjanin V., Rašeta A. (2015). Thermal analysis of concrete members subjected to fire according to EN 1991-1-2 & EN 1992-1-2, 13th International Scientific Conference iNDiS 2015, Novi Sad, 25-27 November, 708-715.

[7] Džolev I., Cvetkovska M., Lađinović Đ., Radonjanin V., Rašeta A. (2016): Fire analysis of a simply supported reinforced concrete beam using Ansys Workbench, 8th Symposium 2016 Association of Structural Engineers of Serbia, Zlatibor, 15-17 September, 322-327.

[8] Džolev I., Radujković A., Cvetkovska M., Lađinović Đ., Radonjanin V. (2016). Fire analysis of a simply supported steel beam using Opensees and Ansys Workbench, 4th International Conference Contemporary Achievements in Civil Engineering, Subotica, 22 April, 315-322.

[9] EN 1992-1-2. (2004). *Design of Concrete Structures, General Rules, Structural Fire Design.* European Committee for Standardization.

[10] Franssen, J.-M. (2005). SAFIR: A Thermal/Structural Program for Modeling Structures Under Fire. *Engineering Journal - AISC, 42*(3), 143-158.

[11] Hawileh, R., & Naser, M. (2012). Thermal-Stress Analysis of RC Beams Reinforced with GFRP Bars. *Composites: Part B, 43*, 2135-2142.

[12] Huang, Z. (2010). The Behaviour of Reinforced Concrete Slabs in Fire. *Fire Safety Journal, 45*, 271-282.

[13] ISO 834. (1975). *Fire Resistance Test - Elements of Building Construction.* International Standard 834.

[14] Jiang, J. (2012). Nonlinear thermomechanical analysis of structures using OpenSees, The University of Edinburgh, Edinburgh.

[15] Jiang, J., & Usmani, A. (2013). Modeling of Steel Frame Structures in Fire Using OpenSees. *Computers and Structures, 118*, 90-99.

[16] Kodur, V., & Agrawal, A. (2016). An Approach for Evaluating Residual Capacity of Reinforced Concrete Beams Exposed to Fire. *Engineering Structures, 110*, 293-306.

[17] William, K., & Warnke, E. (1974). Constitutive model for the triaxial behaviour of concrete. *Concrete structures subjected to triaxial stresses*, 1-30.

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IDENTIFICATION AND CHARACTERIZATION OF DESIGN FIRES TO BE USED IN PERFORMANCE-BASED FIRE DESIGN OF CERN FACILITIES

Abstract: CERN operates the most complex particle accelerator facility built until today. Several different hazards, including fire, are present in these facilities and need to be reduced to a tolerable level.

This paper is aimed at characterizing and better understanding of the potential fire behaviour of most common combustible items present in CERN's facilities. After a detailed literature review of fires in electronic cabinets, an Excel calculator for obtaining a design fire in any number of cabinets/racks is developed.

Second part of the paper is dedicated to experimentally characterizing smoke produced by the most common cables and insulating oils used at CERN. Particle size distribution is obtained by using DMS500 fast particle analyser (Cambusiton), coupled with cone calorimeter (FTT).

Key words: CERN, design fires, electrical cabinets, insulating oils, cables, smoke characterization, DMS500, Cone Calorimeter

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1. INTRODUCTION

CERN (French "Conseil Européen pour la Recherche Nucléaire"), or European Organization for Nuclear Research, is the largest particle physics laboratory in the world. As CERN consists of numerous buildings and underground areas having tens of kilometres of tunnels and other complex constructions, the whole facility represents a great challenge from any standpoint. Having kilometres of wiring, thousands of electrical components and a huge number of various combustible materials present in facilities (electrical cabinets, klystrons, detectors, vehicles, cable trays, racks etc.) – fire safety obviously represents a concern that should be paid special attention to.

Long term objective of CERN is to develop a catalogue, containing detailed descriptions of combustible items present at CERN with their single and combined design fires, and the modes of fire propagation and other relevant characteristics (CO and CO2 yields, smoke particle size distributions etc.). This paper, thus, aims at contributing to this catalogue.

1.1. Overall objective

The first objective of this paper is to assess the fire hazard imposed by electrical cabinets and racks used at CERN, and to address them with appropriate design fires. Second objective is to characterize smoke particles caused by fires in most common cables and insulating oils used at CERN.

Deeper insight into the smoke characterization of the most commonly used cables in tunnels and of the most commonly used oils in klystrons will be obtained by conducting experiments.

To reach these objectives two main goals have to be fulfilled:

1. Exploring all the existing research papers done on electrical cabinet fires. Finding the most appropriate cases to be compared with the CERN electrical cabinets. Gathering the specifications and pictures of the most common cabinets present in CERN. Developing an Excel calculator giving the expected design fires for any number and distribution of electric cabinets.

2. Conduct small scale experiments on oils and cables using cone calorimeter coupled with particle analyser in order to characterize the smoke.

2. ELECTRICAL CABINETS AND RACKS

2.1. Methodology

Several experimental campaigns on fires in open and closed electrical cabinets have been performed by now in France, Finland and USA. The results of the experiments are presented in [1], [2], [3],[4] and [5]. The goal of the experiments was to examine: the potential for a cabinet fire to ignite; the rate of development of a fire in a cabinet; the resulting room environment produced by a fire and the potential for a fire to spread to other cabinets. The effects of the following variables on fire development were investigated:

a) Different ignition sources, b) cabinet styles, c) cabinet ventilation, d) fuel types, amounts and configuration

In cases when cabinets were attached to each other fire could propagate to adjacent cabinets and mode of propagation was conduction, whereas in case of cabinets separated by air gaps, fire did not propagate to adjacent cabinets. Key role of ventilation conditions in peak HRR values reached is shown. Each of the experimental campaigns resulted in models for peak HRRs.

After a visit to some key CERN facilities, it is observed that electrical cabinets and racks can be distributed in any possible way – from a single closed cabinet to a set of 2 rows x N columns of combined racks and open and/or closed cabinets (figures 1). Therefore, an excel calculator for calculating design fire is developed in order to cover the common and possible fire scenarios.

Figure 1 - Open/closed cabinets + racks in a row – picture from one of CERN facilities

Electric Power Research Institute (EPRI) and U.S. Nuclear Regulation Commission [6] made a summary of the state of the art in nuclear power plant fire safety in the US, including the analysis of all the fire experiments done up to the moment of publishing. They gave values for peak HRR for open and closed cabinets, obtained as a 98th percentile from the previous experiments. The results represent an envelope case for all the fire experiments done on electrical cabinets. The values found in this paper were used to develop the Excel calculator for CERN, and they will later be compared with values obtained by models from experimental campaigns conducted in France and Finland. Exact values are – 1004kW for open, and 464kW for closed cabinets, but values of 1000kW and 500kW are taken for the sake of simplicity. Rounding down 1004 to 1000kW is acceptable as it is in the uncertainty range, and rounding 464 to 500kW, still leaves us on the safe side.

Growth and decay were described by simple exponential laws given respectively in equations 1 and 2:

$$\dot{Q} = \alpha * t^2 \tag{1}$$

$$\dot{Q} = \dot{Q}_{(td)} \exp\left[-\left(\frac{t - td}{\tau}\right)\right] \tag{2}$$

Where:

α - growth factor [kW/s2],

t - time from established ignition [s]

$\dot{Q}_{(td)}$ - heat release rate [kW]

t_d - time at the start of the decay phase [s]

τ - decay time constant [s]

Now that we know peak HRR values for both closed and open cabinets, and we also know how to address growth and decay, we only need to define the duration of burning at peak HRR.

In the case where the amount of fuel is not known, the duration of burning at the peak heat release (steady burning - ts) will be taken to be ts=12 mins for open cabinets. [6] recommends ts=8 minutes to be taken, but due to the fact that some extreme cases of 17-20 min were observed, it is decided to be on the safe side, and take a 50% higher value than the recommended 8 mins, so ts=12min is taken. In the case of closed cabinets, as their peak HRR is 50% smaller than peak HRR of open cabinets, it is assumed that duration of steady burning ts will be 2 times longer than ts of open cabinets. Thus, ts for closed cabinets is taken to be ts=24 minutes. This is decided according to the engineering estimation that the same amount of fuel will take 2 times longer to burn if the peak HRR is 2 times smaller.

Now that we have completely addressed a single cabinet burning (growth, peak HRR, duration and decay) we only need to describe the spread in order to obtain a full excel calculator. Fire spread to the adjacent cabinet in 11-16 minutes according to the experiments done in [7] and [2]. To be on the safe side, it is assumed that the fire will spread to the adjacent cabinet after 10 minutes. The mode of fire spread is conduction.

2.2. Results

Snap of Excel calculator for design fires in electrical cabinets in CERN facilities is presented in figure 2. User is required to specify the number of rows and columns of cabinets, and to specify for each position if the cabinet is open or closed. In case the amount of combustibles inside of the cabinet is known, user can specify the amount of combustibles in order to get a more precise estimation of the duration of burning. Final output – design fire for any number of cabinets is given. All the assumptions used are listed in order for user to be aware of the boundaries of this calculator.

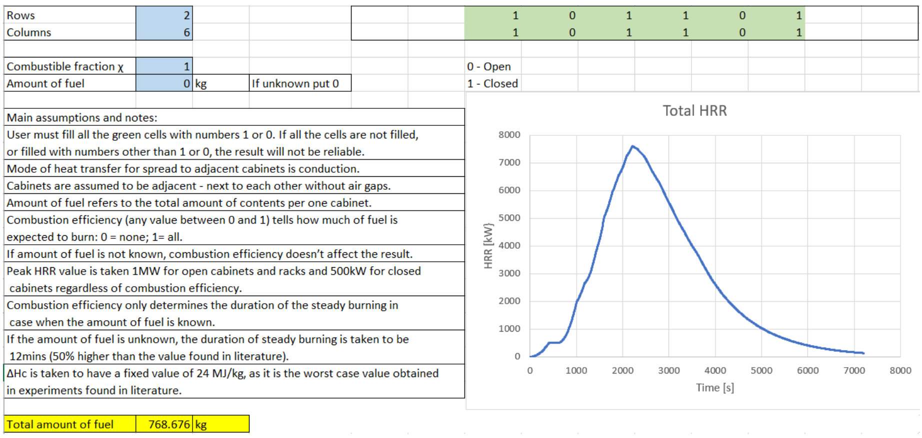

Figure 2 - Excel calculator for design fires in electrical cabinets in CERN

Comparisons with models for peak HRRS developed in France and Finland has been conducted and it was proven that the values taken form [6] were conservative and left us on the safe side, which was the goal.

3. PARTICULATE MATTER ANALYSIS

3.1. Methodology

The second part of this thesis was dedicated to smoke particulate matter analysis of three most common types of cables used in CERN, as well as two insulating oils used in transformers and klystrons. In fire models, the accurate prediction of aerosol & soot concentrations in the gas phase, as well as aerosol & soot deposition thicknesses in the condensed phase, is important for a wide range of applications, including human egress calculations, heat transfer in compartment fires, and forensic reconstructions of fires. [8] Apart from those general applications, CERN in particular is interested in obtaining a deeper insight into smoke particle size distribution and concentration for a special reason. In case of a fire in one of CERN tunnels during experiments, it is expected that smoke particles, produced by burning activated materials, will be radioactive too and will further carry and deposit the radiation, which is a serious threat that has to be addressed and solved properly. For the sake of that, CERN has a need of obtaining a detailed smoke particle concentration and size distribution. This project will be used with the aim of validating the current state of art in Fire Dynamics Simulator (FDS), but also for further advancing and expanding the FDS code.

3.2. Experimental setup

As the goal of the experimental campaign was to assess general fire behaviour of the samples, but also their smoke particle size distribution, it was decided to couple the standard Cone Calorimeter produced by Fire Testing Technology (FTT) with the DMS500 Fast Particulate Analyzer (Camsution).

The major output from the cone calorimeter is heat of combustion. It is further correlated with the oxygen, CO2 and CO measurements to obtain the value for Heat Release Rate, according to the equations proposed in the standard [9]. Apart from that cone calorimeter also provides measurements for smoke obscuration and CO and CO2 yields measured bz SERVOMEX gas analysers.

The device used for sampling and analysing smoke particle matter is a Fast Particle Analyzer DMS500 (Cambustion Ltd., Cambridge, UK). Major feature of this device is that it tracks the Particle Number (PN) and measures the particles size distribution in the size range of 5nm -1 μm. For the sake of getting an idea of how precise this device is, it should be compared to a well-known and broadly used Dekati Low Pressure Impactor, that gives particle size distribution in 14 size fractions in the range of 16nm to 10μm, whereas DMS500 gives 38 size fractions (classes) between 5nm and 1μm ((4.87, 5.62, 6.49, …, 749.89, 865.96, 1000 nm). Apart from being so precise, another even greater advantage of this device is that it does the measurements live – i.e. gives real time results. It represents a huge advantage in comparison to the traditional offline devices - impactors, soot samplers and other gravimetric, filter-based devices, that post-analyse the particles, allowing them to further coagulate, agglomerate and change their concentrations due to the aging process.

DMS500 works on the following principle: High voltage discharge is used to charge each particle proportionally to its surface area. Charged particles are introduced into a classification section with a strong radial electrical field. This field causes particles to drift through a sheath flow toward the electrometer detectors. Particles are detected at different distances down the column, depending upon their aerodynamic drag/charge ratio. Outputs from the 22 electrometers are processed in real-time at up to 10 Hz to provide spectral data and other metrics.[10]

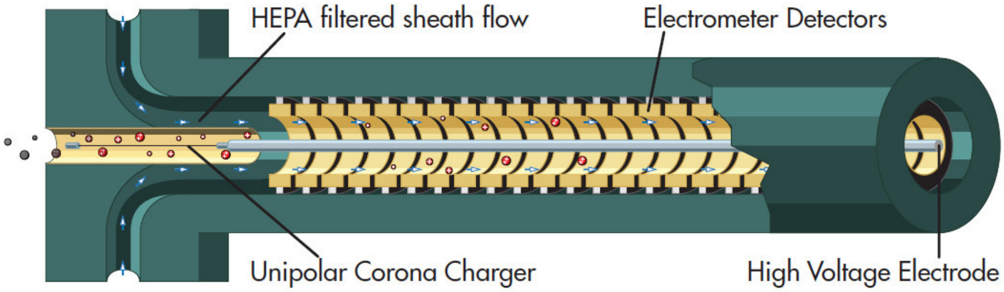

Figure 3 - Classification section - extracted from DMS500 manual [10]

3.3. Samples preparation

As CERN already previously conducted experiments on the same cables as a part of the test campaign "CERN Cable Fire Tests" (CERN-CFT), the cables will be labelled in the same manner for the sake of easy comparison. Blue cables (C01), black cables (C02) and brown cables (C04) where C stands for CERN cable. Blue and black cables were regular multi conductor cables with thermoset insulation, whereas the brown cable was a coaxial cable with tight metal shield and a thermoplastic dielectric insulator around the core conductor (see figure 4). Oils tested were the most common ones used as electric insulating oils in transformers and klystrons present in CERN. Those were synthetic ester transformer oil MIDEL 7131 and Shell Diala S4 ZX-I having their flash points at 260 °C and 191 °C respectively. (see figure 5)

Figure 4 - Cable types - C01, C02 and C04

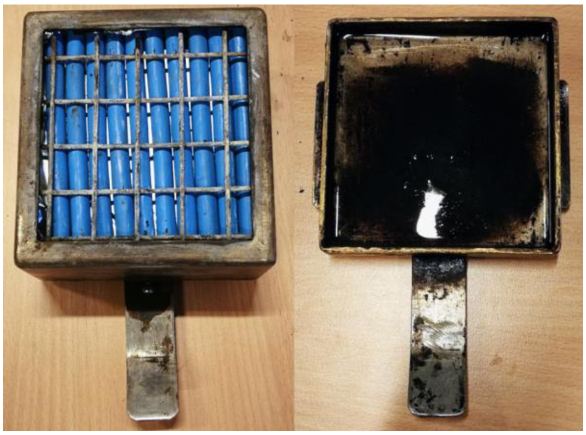

Figure 5 - Blue cables and oil in their specimen holders

As in the first repetition blue cables (C01) did not ignite under the 25kW/m^2 of imposed heat flux, due to the lack of time, it was decided to test all the cables under heat flux of 50kW/m^2.

On the other hand, oils were in the first trial tested under 30kW/m^2, but due to quite aggressive burning, causing even a lot of spills, especially for the Shell Diala oil, it was decided to conduct further tests on oils under the heating power of 20kW/m^2.

3.4. Results

Particles in the submicron range are divided in two groups – particles smaller than 100nm or 1st mode particles, and particles in the range of 100 nm and 1000nm or the 2nd mode particles. It was clearly noticeable that 2nd mode particles were dominant with both oil types (Shell Diala and Midel). When burning cables, as they have several modes of degradation due to several different materials used, it was observed that while outer sheath was burning, 1st mode particles were dominant, whereas in the second period of burning, when fire caught inner sheath, 2nd mode particles became dominant. (figures 6 and 7).

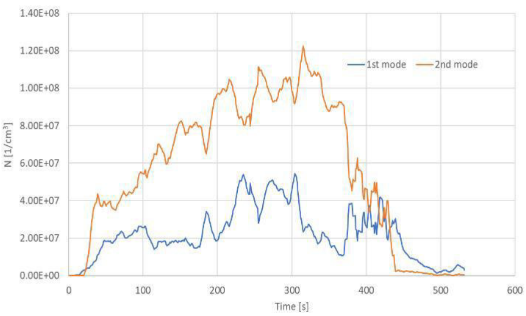

Figure 6 – Shell diala 1st and 2nd mode concentration

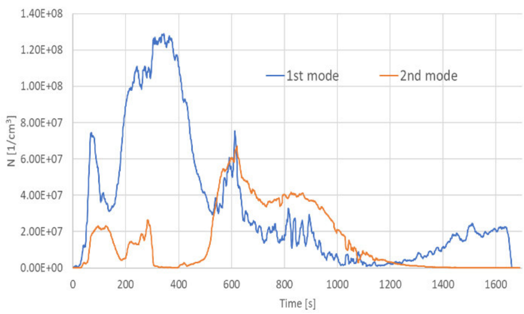

Figure 7 – Blue cables 1st and 2nd mode concentration

A very interesting phenomena is observed when comparing results for smoke production rate (SPR) measured with cone calorimeter with particle concentrations. SPR (m^2/s) is obtained as a product of the volumetric flow rate of smoke (m^3/s) and the extinction coefficient (1/m) of the smoke at the point of measurement. Extinction coefficient is given as natural logarithm of the ratio of incident light intensity to transmitted light intensity, per unit light path length. [11]

Thus, in simple words, greater attenuation of laser results in greater smoke production values. When comparing concentration values and smoke production rate for cables, it is observed that SPR almost perfectly accords with 2nd mode concentration particles, as it can be observed on example of black cables on the following figure:

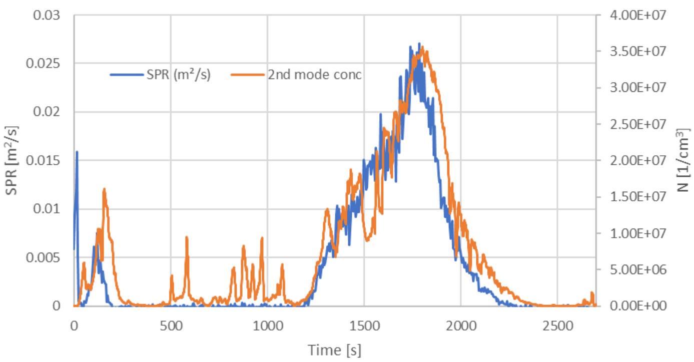

Figure 8 - Smoke production rate vs 2nd mode concentration - Black cables

On the other hand, when comparing SPR and 1st mode concentration particles, it can be observed that they do not agree at all (figure 9). Default Cone Calorimeter operates using a laser with red light having its wavelength of 630nm, which is apparently too high to be affected by the tiny smoke particles. This demonstrates the cone calorimeter's incapability of "capturing" all the smoke produced if the default version is used. This limitation should be taken into account when dealing with cone calorimeter in future. This can maybe be solved when using instead lasers with lesser wavelengths, e.g. ultraviolet light lasters.

Same behavior was observed in other cables tested. SPR values matched greatly with 2nd mode concentration, while 1st mode particles although sometimes having extremely high concentrations, were practically "invisible" on smoke production rate measurements. As oils had shown steadier burning, and dominance of 2nd mode particles, this behavior cannot be clearly demonstrated with graphs, thus it will not be shown here.

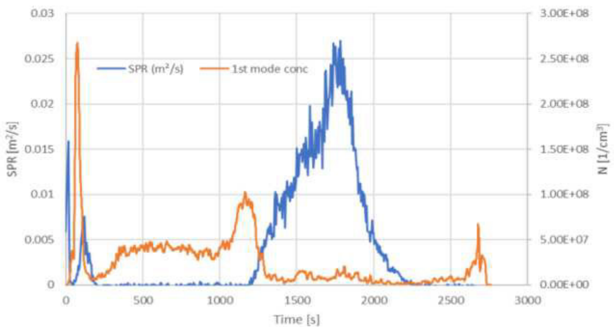

Figure 9 - Smoke production rate vs 1st mode concentration - Black cables

3.5. 3D plots

The following 3D plots show particle concentration of different sized particles variation over time for Blue Cables (C01) and Shell Diala oil. Bimodal distribution of particles is more than obvious. 1st mode burning in the first part of burning represents burning of the outer sheath, and the 2nd mode particles present in second part of burning represent burning of wires sheath. It is obvious that main (outer) cable sheath and inner wire sheath are made of different materials.

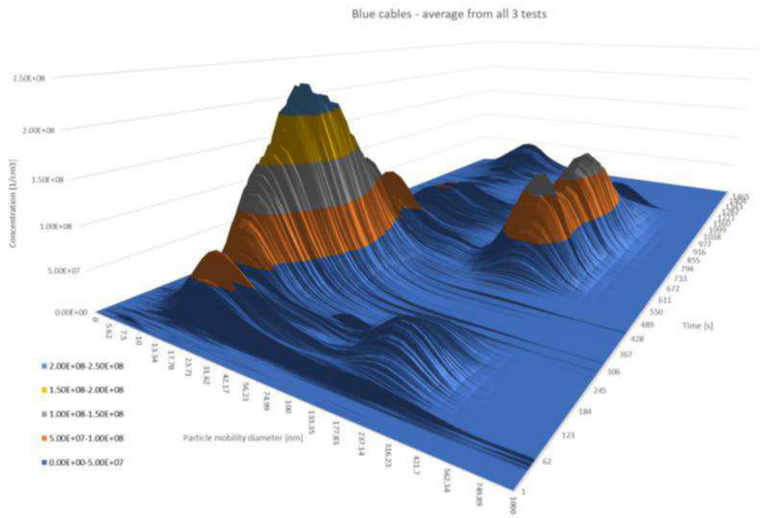

Figure 10 - Concentration vs Mobility Diameter vs Time - Blue Cables (C01) – average from all 3 tests

On the other hand, dominance of 2nd mode particles is clear in Shell Diala oil as it can be observed in figure 52.

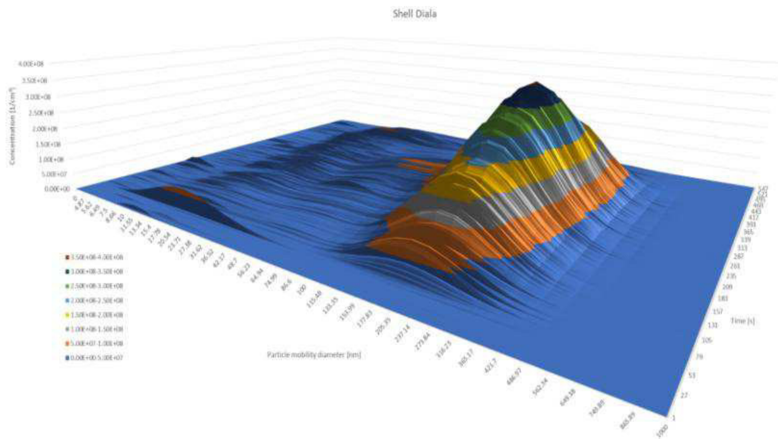

Figure 11 - Concentration vs Mobility Diameter vs Time - Shell Diala – average from all 3 tests

4. CONCLUSIONS AND FUTURE WORK

4.1. Conclusions

In the first part of this thesis, an Excel calculator giving design fire for electrical cabinets and racks present in CERN is developed. Findings from experiments conducted in the USA, Finland and France were used to obtain an envelope case covering the worst possible case. The user can specify any combination between the most basic one – a single cabinet, to the most severe one – 2 rows containing 10 cabinets each.

In the second part, an experimental campaign is conducted on three types of most common cables used in CERN, as well as on two most common insulating oils used in CERN. The goal of the experiments was to obtain detailed smoke characterization of the specimens, which would be extremely useful for validating and further developing FDS modelling related to aerosol deposition and particle distribution. CERN is in particular interested in these results, as smoke particles are expected to carry radiation further away from the seat of the fire, which is a great hazard both for the facility and for environment.

4.2. Future work

Excel calculator developed for electrical cabinets and racks can if needed be extended to more cabinets. On top of that, if other fuel types than cabinets and racks can be present at some positions, they could be included in the calculator.

To author's knowledge, the tests conducted with DMS500 coupled with cone calorimeter, were a first attempt of a kind in characterizing particle size distribution in cables and oils. Results obtained are more than promising. In order to further validate them more repetitions should be performed. It is advised to use a camera to record all experiments, as it would additionally help in explaining the phenomena observed.

5. REFERENCES

[1] Chavez, J. M., "Experimental Investigation of Internally Ignited Fires in Nuclear , Power Plant Control Cabinets : Part 1 : Cabinet Effects Tests," no. April, 1987.

[2] Mangs, J. and Keski-Rahkonen, O., *Full scale fire experiments on electronic cabinets I*. 1994.

[3] Mangs, J., Paananen, J., and Keski-Rahkonen, O., "Calorimetric fire experiments on electronic cabinets," *Fire Saf. J.*, vol. 38, no. 2, pp. 165–186, 2003.

[4] Plumecocq, W., Coutin, M., Melis, S., and Rigollet, L., "Characterization of closed-doors electrical cabinet fires in compartments," *Fire Saf. J.*, vol. 46, no. 5, pp. 243–253, 2011.

[5] Coutin, M., Plumecocq, W., Zavaleta, P., and Audouin, L., "Characterisation of open-door electrical cabinet fires in compartments," *Nucl. Eng. Des.*, vol. 286, pp. 104–115, 2015.

[6] Kassawara, R. P. and Hyslop, J. S., "EPRI / NRC-RES Fire PRA Methodology for Nuclear Power Facilities (EPRI-1011989 and NUREG/CR-6850) Volume 2 : Detailed Methodology," vol. 2, 2005.

[7] Mangs, J., "On the fire dynamics of vehicles and electrical equipment," *VTT Publ.*, no. 521, pp. 3–62, 2004.

[8] Overholt, K. J., Floyd, J. E., and Ezekoye, O. A., "Computational Modeling and Validation of Aerosol Deposition in Ventilation Ducts," *Fire Technol.*, vol. 52, no. 1, pp. 149–166, 2016.

[9] British Standards Institution, "BS ISO 5660-1:2015. Reaction-to-fire tests — Heat release , smoke production and mass loss rate. Part 1 : Heat release rate (cone calorimeter method) and smoke production rate (dynamic measurement)," p. 66pp, 2015.

[10] Cambustion Ltd., "DMS500 MkII The Rapid Response Engine Particulate Analyzer."

[11] IEC, "Reaction-to-fire tests — Heat release, smoke production and mass loss rate," *IEC 60721-3-3, Classif. Environ. Cond. Part 3-3 Classif. groups Environ. parameters their Sev. Station. use Weather. Locat.*, vol. 2002, no. part 2-Smoke production rate (dynamic measurement), 2002.

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MOBILE APPLICATION FOR LAND MINE RISK ALERT

Abstract: Bosnia and Herzegovina is deeply affected by land mines and explosive remnants of war (ERW) and it is one of the most mine contaminated countries in Southeastern Europe region. Land mines posed a great risk immediately after the war and most of the victims were injured or killed by land mine in that period of time. People are still endangered by land mines. BiH doesn't have proactive land mine map that could be used by anyone concerned with this problem. All minefields are not marked properly at this time since many markings were removed or destroyed during past more than 20 years. Mobile application for land mine risk alert developed by students is presented in this paper.

Key words: land mines, mine risk management, android application, smartphone, mine alert

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1. LAND MINE RISK MANAGEMENT

War conflict during the end of 20th Century in the territory of Bosnia and Herzegovina have left millions of unexploded and unidentified mines. Mine fields data as well as the number of land mines, and their impact on various spheres of life are neither complete nor reliable. Because of this even today, land mines are an extremely serious problem in country, and their non-removal is still one of the leading causes of suffering in Bosnia and Herzegovina.

When it comes to organized mine and UXO (Unexploded ordnance) actions, the authorized organization is BHMAC (Bosnia and Herzegovina Mine Action Centre). BHMAC is a unified mine action centre in Bosnia and Herzegovina. As far as structures are concerned, the Ministry of Civil Affairs is at the top of the organization itself, followed by the Demining Commission of Bosnia and Herzegovina and then BHMAC. BHMAC main responsibilities are location of suspect areas and its declaration as risk or no obvious risk areas.

Demining is carried out by accredited demining organizations and trained deminers who must be physically and mentally capable of doing this. The realization of the demining process in Bosnia and Herzegovina requires legislation that would allow control by the state authorities. Demining activities are important for BiH's security, human health and the environment.

A large number of organizations with the governments of many countries have been involved in actions against antipersonnel land mines and many countries have signed the Otawa convention[1].

1992 an International Campaign to Ban Landmines (ICBL) - a coalition of non-governmental organizations was formed. The main goals of this campaign were:

- a full ban on mines,
- give help to the victims,
- the extent of removing or mine clearance.

In today's modern times when information technology increasingly takes on all spheres of our lives, can be very easily imagined that they are as well part of the protection for ordinary civilians from mines and UXO.

1.1. The extent of land mine problem in BiH

The current size of land mine suspected area in BiH is 2.2% [2] in relation to the total area of Bosnia and Herzegovina. The BHMAC database is currently registering 20,220 minefield records. Mined areas in vulnerable communities are little or no different from safe areas (visually), and therefore signs that warn of the presence of mines are mandatory.

There are many ways of marking minefields or mine suspected areas. There are various tags like:

- flags, rods or branches,
- wires around the suspect area,
- written with handwriting,
- warnings that include the symbol of the deadhead with a MINE inscription etc.

A main issue nowadays is mine marks removal from minefields. Many marks are stolen or destroyed, which is a major problem for civilians. Removing mine marks is the same as setting up new mines.

[1] Convention On The Prohibition Of The Use, Stockpiling, Production And Transfer Of Anti-Personnel Mines And On Their Destruction (http://www.un.org/Depts/mine/UNDocs/ban_trty.htm)

Figure 1- Land mine warning sign

The locations of the land mines are also affected by weather disasters. Heavy rains, landslides and earthquakes can have a significant effect on land mines relocation as moving deeper into the ground or further on the surface.

In the post-war period, 1,756 people were killed or injured by land mine in BiH (out of which more than 600 died) [4].

During the humanitarian demining operations in BiH, there were 127 deminers casualties, of which 51 were killed (BH MAC).

Major problem is that in 22 years after the war BiH still does not have interactive minefields maps.

The new generations are increasingly moving away from the mine theme and therefore population is more and more endangered. Younger generations are not familiar to where minefields are located or mine suspected areas. The fact that mine fields marks are removed, were stolen and destroyed makes it increasingly difficult to inform people. Land mines are not only a less active topic in schools, but also the media are less concerned with the subject. The theme that is out of focus, becomes important just at the moment when an accident occurs, and when times for field trips and excursion comes ignorance about minefields can mean lives.

The new problem in BiH is also a migrant crisis and refugee wave with people that are not informed about minefields in our country. In June 2018, migrants entered Bosnia and Herzegovina illegally and accidentally found themselves in the minefield. Thanks to the locals who warned them but, more than all, thanks to their luck, they managed to escape without consequences.

Land mine action financing earlier and nowadays differs a lot. In the post-war period demining has started, but it decreased as resources were spent. The mines removal in BiH is not continued just as they were removed 20 years ago. Various donations were directed to demining in BiH, and they were about a million dollars. There was a huge number of donations in the post-war period, and many demining companies were on the ground. Funds were spent, and the number of demining organizations has diminished by the lack of money.

A big problem and aggravating circumstance is the fact that mine maps were lost, conflicting parties misplaced the data in maps as well as many other causes that reflect demining in BiH. People believe that BiH will be mine polluted for the next 20 years, if not even more.

2. APPLICATION OF MODERN TECHNOLOGIES FOR IMPROVING RISK MANAGEMENT OF LAND MINE AND UXO

Interactive maps of minefields are not established even 22 years after the war, and data can be uploaded by BHMAC and can be combined with available platforms such as Google Earth. The future is an interactive map of land mine suspected surfaces, which can be downloaded by everyone interested, but these still do not exist.

Motivation for this project and application development was the news story of two boys who got lost in a BiH minefield. They were found by satellite that had their cell phone located. It was the only way to get the GPS data of their mobile phones and so they were found and rescued.

Today's modern technologies are present in our lives and we need to use them in the best possible way. If lost children did not have a cell phone they would probably not been rescued. All these facts brought up an idea to develop this application, which will be of help to new generations.

2.1. Application „MINE ALERT BiH“

The purpose of the application „MINE ALERT BiH“ is to warn the person who owns it on a smartphone when encounter a danger of the mine suspected area. The application should help to prevent further accidents in BiH.

2.1.1. Applied technology

The Android Studio was used to create the application. It is a development environment that is used to create Android applications. Also, GPS is used, a satellite network that continuously transmits encrypted information, enabling precise positioning on the Earth, and Google maps that are one of the Google's digital network map technologies, which make up the basics of many services, from browsing satellite imagery, route planning (travel plan), etc.

2.1.2. Application design

As for application design, it is customized for all ages, simple, practical and understandable, so everyone can deal with application. The application has its own recognizable logo that is red. Red color is associated with danger while the symbol is white and indicates a mine danger. In the picture below, the look of the logo itself is presented.

Figure 2- Logo

Figure 3- Shape of Logo

The logo can have more shapes and sizes depending on its purpose. When enter the application, there is the "Loader" that only appears when you enter the application. After that, "Menu" appears, which has 2 buttons of different purpose. The menu is made to be easy for user.

As for the interior design, there are polygons marking the mine suspect surface and are also painted in red color to make the user more easily recognize the danger they are encountering. The following pictures show the " loader", "menu", and the "map" itself.

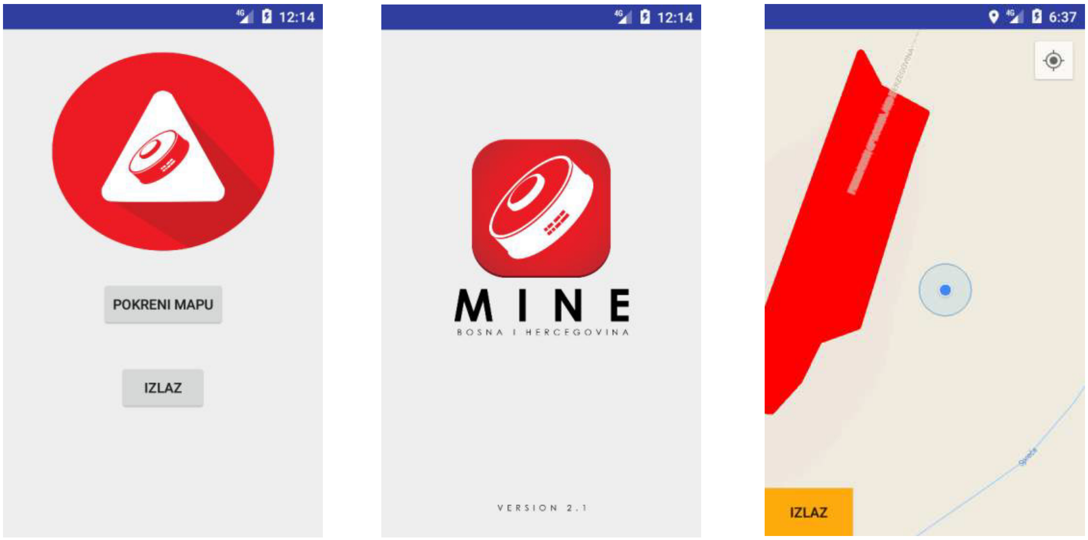

Figure 4 - Loader, Menu and Map

2.1.3. Functionality

The application's work is based on the GPS location system. Takes and compares coordinates from application user with the coordinates of the mine-suspected areas by GPS from smartphone and notifies the user if it is nearby or within the designated mine-suspected area.

Figure 5- View an app when a user is near a mine suspected area

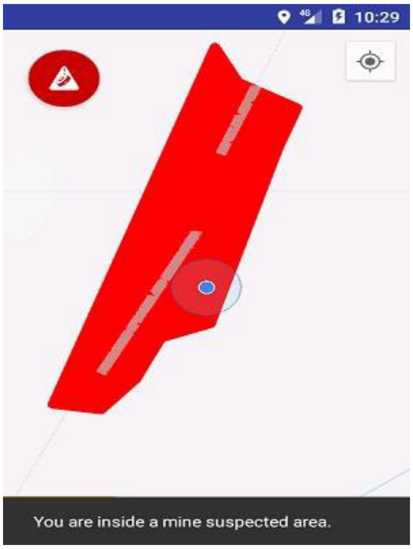

Figure 6 - View an app when a user is in a mine suspected area

2.1.4. Targeted population

The application is designed for everyone, all ages and generations, working on all smartphones running on android operating system version 4.1.1 or later and covering 99% of devices with the android operating system [1].

It's easy to use, and the user is able to check coordinate of his locations by touching the icon of location at any time (Figure 7).

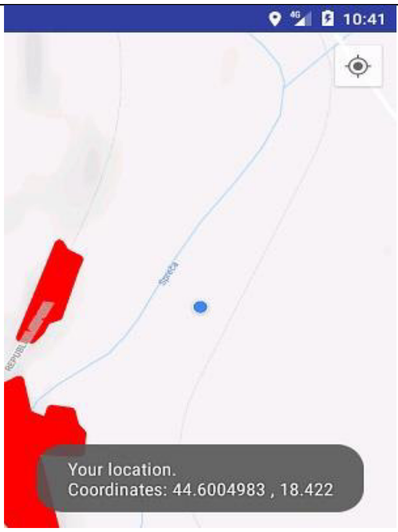

Figure 7- View user coordinates after touching the location icon

3. CONCLUSION

The BiH Mine Action Strategy for 2009–2019, adopted by the Council of Ministers in 2008, sets the target of the country becoming free of mines by 2019. Obviously, this goal is far from fulfilment.

Current mine situation in Bosnia and Herzegovina requires innovative solutions for people protection. Map of mine situation on BH MAC web site is the only source of information and for ordinary people such information is not sufficient. There is a need for interactive warning system in order to prevent casualties.

Application „MINE ALERT BiH" as a tool for land mine risk management is very useful and user friendly application that can prevent many mine accidents and save lives.

It is available to anyone with smart phone, doesn't require internet connection and because of its simplicity can be used even by the most vulnerable population - children or older people.

This application is not in official use and it is presented to public in BiH as well as to land mine action authorities in BH MAC and Civil protection.

„Although landmines are not considered weapons of mass destruction, there are more people killed by landmines than by chemical and nuclear weapons together ". (A. Berhe[2])

4. REFERENCES

[1] https://developer.android.com/about/dashboards/

[2] https://www.klix.ba/vijesti/bih/bih-bez-mina-za-50-godina-najcesce-stradaju-samouvjereni-jos-nema-interaktivnih-mapa/171208082

[3] http://www.bhmac.org/?lang=hr

[4] Lisica, Darvin 2006. *Risk management in mine action planning*. Sarajevo

[2] https://www1.essex.ac.uk

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NUMERICAL INVESTIGATION OF PRESSURE DEVELOPMENT IN ENCLOSURES DURING FIRE

Abstract: Previous studies have shown that the pressure development during fires in modern air tightened buildings can be critical. This high pressure can hinder the opening of doors and thereby block the evacuation route. Furthermore, an overpressure can give rise to increased smoke spread to adjacent fire compartments through the ventilation systems. The pressure development in an apartment building with a balanced ventilation system has been analysed utilizing the Fire Dynamic Simulator (FDS). The parameter study showed that both fire growth rate, heat release rate and the ventilation system as expected had an impact on the pressure build up in the enclosures. A faster fire growth rate leads to that the magnitude of the peak overpressure increased. However, a reduction in the leakage area of the building, together with a balanced ventilation system, revealed that the change in overpressure was small. The main reason is that the relief of overpressure happens through the ventilation system. The parameter study results also showed a risk of smoke spread with a running smoke ventilation system and 50 Pa overpressure. This is for a fire growth rate faster than the medium rate, according to NFPA 204M (0.012 kW/s^2) and a leakage area according to the Danish BR 2015.

Key words: FDS, pressure development, smoke spread, modern air tightened buildings

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1. INTRODUCTION

In the past the fire protection community has not considered the overpressure from enclosure fires as a potential safety risk for the occupants in the building. The phenomenon of fire-induced pressure increase in domestic buildings is limited, because the leakage areas in these building often are fairly large.

This assumption is not valid anymore because of the social and political awareness on energy consumptions of buildings. The latest building regulations in Denmark has been focusing on reducing the energy consumptions. This is achieved by both introducing multilayer windows (energy efficient windows), increased insulation demands and the reduction of the allowable leakage area in the building envelope [1]. The decrease in leakage area in the building envelope, has from the 2010 to 2015 building regulation decreased from 1.5 L/s per m^2 (of heated floor area at 50 Pa) to 1.0 L/s per m^2 [1]. Furthermore, it is expected that this will be further decreased to 0.5 L/s per m^2 in the 2020 building regulation [1].

The use of energy efficient windows which today can consist of up to three layers of glass has also impact on the fire dynamics in enclosures. For double and triple glass windows, data from full-scale experiments reported in the literature states that windows consisting of 6 mm double glazing doesn't break before temperatures of around 600 °C [2].

This paper investigates the consequence of these changes with relation to leakage area, fire growth rate and ventilation conditions by the use of CFD. This paper is based on a thesis from the Technical University of Denmark by Jess Grotum Nielsen [3].

The method has been to first validate the CFD code, before using the code on a typical modern apartment setup with a balanced ventilation system.

2. LITERATURE STUDY AND VALIDATION

The Fire Dynamic Simulator (FDS 6.5.3) [4] was chosen as the tool for carrying out the study after a literature study on the performance of FDS for the actual use. The US Nuclear Regulatory Commission did in 2007 publish the "Verification and Validation of Selected Fire Models for Nuclear Power Plant Application, Volume 7: Fire Dynamics Simulator" [5]. Several parameters were validated and the results marked by a colour code as seen in Table 1. A green code indicates that the model can be used with confidence to calculate the specific attribute, whereas a yellow classification indicates that the validation process indicates that the numerical results are outside the experimental uncertainty, and furthermore, there is no consistent pattern of the over- or under-predictions [6]. The results of the validation study for each parameter is given in Table 1.

Parameter	Validation – Comments	Validation– Color code
Hot gas layer temperature	Both in room of origin and adjacent room	OK
Hot gas layer height		OK
Ceiling jet temperature		OK
Plume temperature		Caution
Flame height		Caution
Oxygen and Carbon dioxide concentration		OK
Smoke Concentration		Caution
Compartment pressure		OK
Radiation and total heat flux and target temperature		Caution
Wall heat flux and surface temperature		Caution

Table 1 Overview of different FDS parameters validation obtained from US Nuclear Regulatory Commission (2007) [5]

The validation of the compartment pressure has been given a green code, which implies that the relative difference between the experimental and numerical results are within the experimental uncertainty. If the validation results are investigated in further details, the predicted pressures are within 50% of the measured pressures, but this is consistent with the reported uncertainties for the leakage area and the ventilation rate [6]. A relative difference of 50 % is considerable, compared to the size of the actual over-pressure ranging between 50-300 Pa in the experiments [7].

Based on the relatively high experimental uncertainty from the experiments used above it is necessary to review more validation works regarding FDS's capability of predicting the compartment pressure. In modern buildings, a HVAC system is an integrated part for ensuring a good indoor environment. Therefore, it is also important for FDS to be able to predict the impact from the HVAC system in case of a fire in the enclosure. The following validation works has shown good agreement between the experimental and FDS results:

- Validation of FDS for large-scale well-confined mechanically ventilated fire scenarios with emphasis on predicting ventilation system behaviour, (Wahlqvist & Van Hees 2013) [8]
- CFD modelling of pressure rise in a room fire, (Li 2015) [9]
- Fire Induced Flow in Building Ventilation Systems, (Janardhan 2016) [10]
- NIST/NRC Experiments – FDS Validation, (Hamins et al. 2005) [11] and (McGrattan et al. 2017) [12]

The validation works given above are presented in further details in the thesis of Nielsen to highlight the FDS setting used to obtain the results. Based on the findings in these validations works it is possible to conclude that FDS can be used to perform the desired parameter study.

3. SIMULATION SETUP

The basic layout of the model setup is inspired from the parameter study performed by (Hostikka & Janardhan in 2017) [13] . The geometry of the floor plan, surface and material properties, the fire size and fire growth are similar to model setup by Hostikka & Janardhan. But because of lack of information regarding the HVAC setup and the actual fire base and burning material, this has been adjusted according to the Danish building regulation regarding the HVAC setup values.

The floor of the modeling area is estimated on the basis of (Hostikka & Janardhan 2017) [13] and (Hostikka et al. 2017) [14]. The floor is illustrated in Figure 1 including the primary dimension, which is given in mm. Only apartment 2 is sketched in details with all rooms, since the fire is located in the kitchen. For the other apartments the subdivision into rooms can be ignored since they are just single pressure zones.

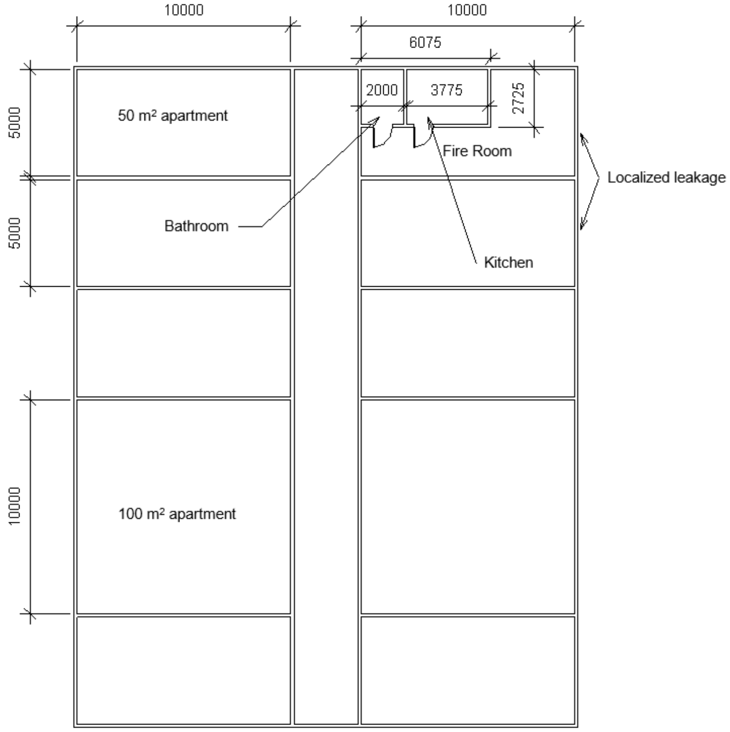

Figure 1 – Illustration of the apartment layout used for the parameter study. All measurement is given in mm.

Table 2 shows the fire leakage area in the two sizes of apartment. The allowed leakage area has been halved in the proposed changes of the 2015 regulations to the 2020 regulations.

BR2015	**Volume flow [m³/s]**	**Δρ [Pa]**	**A_{leak} [m²]**
50 m² apartment	0.05	50	0.0055
100 m² apartment	0.10	50	0.0110
BR2020	**Volume flow [m³/s]**	**Δρ [Pa]**	**A_{leak} [m²]**
50 m² apartment	0.025	50	0.0027
100 m² apartment	0.050	50	0.0055

Table 2- Overview of the leakage areas for both the 50 m² and 100 m² apartment, with respect for the volume flow demand given in the 2015 and 2020 building regulation.

A mesh sensitivity study was conducted. It proved that a mesh size of 125 mm in the fire room and a mesh size of 250 mm in the rest of building was sufficient to get a mesh independent solution. A total of 16 simulation were done subsequent to investigate the combination of fire growth rate, leakage area and ventilation system (on/off).

4. RESULTS

The results presented in Figure 2 reveal that a faster fire growth leads to a higher pressure in the fire room. The results are also consistent for both settings of the HVAC system. The reason why the peak overpressure increases with a faster fire growth is due to the fact that for a faster fire growth the heat release rate can reach a higher value within the same timeframe.

Also, the results in Figure 2 reveals that the pressure increase in the fire room is larger with a running HVAC system compared to a non-running system. A reason for this could be the difference in the amount of pressure relief the fire compartment can have through the HVAC ducts. For a non-running HVAC system the fire compartment can use both the inlet and outlet ducts a pressure relief paths, whereas with at running HVAC system only the outlet HVAC duct can function as a pressure relief path. For a running HVAC system the inlet duct will have a dynamic pressure resistance that the fire would have to overcome in order to use it as a pressure relief path.

At the same time a running ventilation system is beneficial for the visibility in the rooms as will prevent smoke from being leaked from the fire room to other rooms. This was confirmed by the simulation results. The smoke spread to other apartments with a running ventilation system is lower comparted to the situation with a stopped ventilation system.

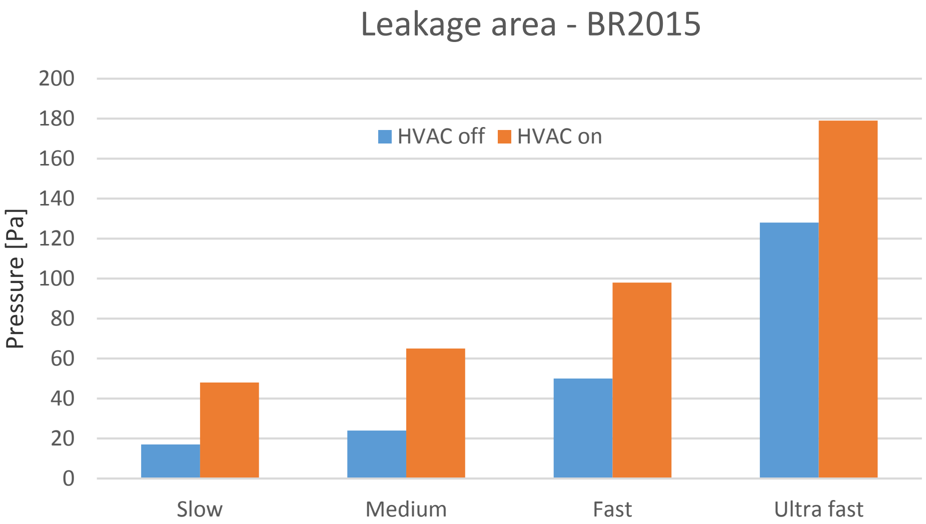

Figure 2 – Results for the pressure peak with the heat release rate growth as the parameters investigated for the leakage areas given in building regulation 2015

As the results indicate, the critical condition with respect to the 100 Pa peak overpressure, is a function of the fire growth rate and the ventilation system setting. For ultra fast fires the threshold of 100 Pa, is achieved within the first 50 seconds and for the fast fires, it happens shortly around ~175 seconds. This shows that a ultra fast fire development can hinder the opening of doors, even when the ventilation system is stopped.

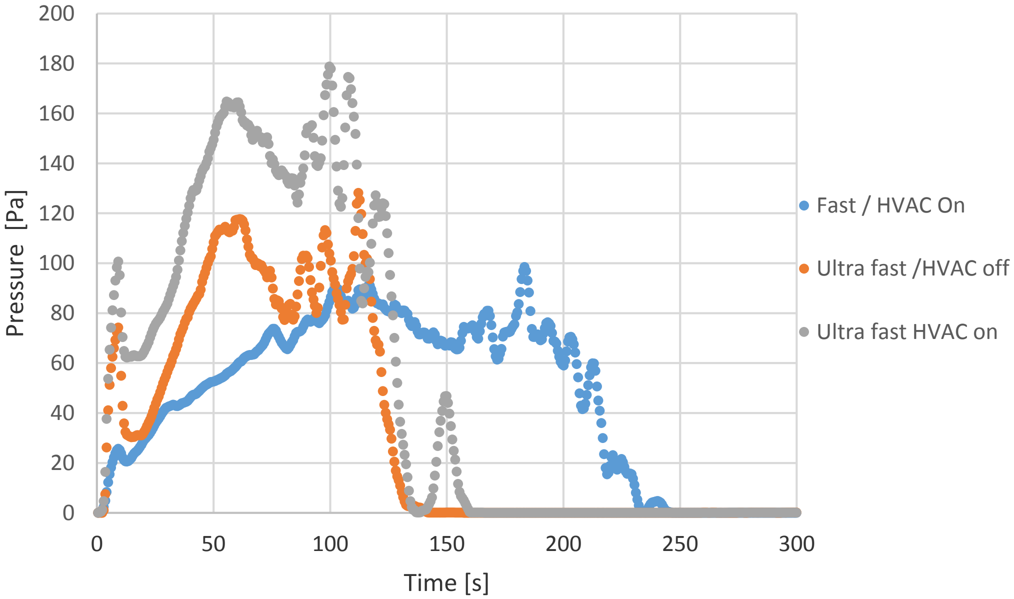

Figure 3- Illustration of the peak overpressure as a function of time for parameter study 10 (Fast / HVAC on), parameter study 13 (ultra fast / HVAC off) and parameter study 14 (ultra fast / HVAC on).

Further analysis revealed that most of the pressure relieve happens through the ventilation. With today's regulation the buildings are so tight that even if the leakage area is halved it has only limited effect on the pressure relieve.

5. CONCLUSIONS

The results of this study revealed that both the fire growth, heat release rate and the ventilation system as expected had an impact on the pressure build up in enclosures. The results showed that with faster fire growth the magnitude of the peak overpressure increased. The results for the change in the proposed leakage area, revealed that the change in overpressure was insignificant.

The interpretation of the parameter study results showed a risk of smoke spread in a smoke ventilated system with only 50 Pa overpressures for all fires faster than a medium fire growth, with a leakage area of BR2015 and a running ventilation system. The findings in the parameter study also revealed that many parameters have an influence on the results, including some parameters, which was not possible to investigate in this study. Therefore, more studies are needed in order to clarify these subject.

6. REFERENCES

[1] Trafik og byggestyrelsen. *Danish building regulation 2015*. 2016; Available from: http://bygningsreglementet.dk/.

[2] Babrauskas, V. *Glass breakage in fires*. 2011; Available from: http://doctorfire.com/GlassBreak.pdf.

[3] Nielsen, J.G., *Numerical investigation of pressure development in enclosures during fire (M.Sc. thesis)*, in *Department of Civil Engineering*. 2017, Technical University of Denmark: Kgs. Lyngby, Denmark.

[4] McGrattan, K., et al., *Fire Dynamics Simulator User's Guide, FDS Version 6.5.3, Revision: FDS6.5.3-569-ge3d0d6c, NIST Special Publication 1019*. January 2017, National Institute of Standards and Technology, : Gaithersburg, MD USA.

[5] U.S. Nuclear Regulatory Commission, *Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications, Volume 7: Fire Dynamics Simulator (FDS)*. 2007.

[6] U.S. Nuclear Regulatory Commission, *Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications, Vol 1, Main Report*. 2007.

[7] Prétrel, H., W. Le Saux, and L. Audouin, *Pressure variations induced by a pool fire in a well-confined and force-ventilated compartment.* Fire Safety Journal, 2012. **52**(Supplement C): p. 11-24.

[8] Wahlqvist, J. and P. van Hees, *Validation of FDS for large-scale well-confined mechanically ventilated fire scenarios with emphasis on predicting ventilation system behavior.* Fire Safety Journal, 2013. **62, Part B**: p. 102-114.

[9] Li, Y.Z., *CFD modelling of pressure rise in a room fire (SP Report 2015:08)*. 2015, SP Technical Research Institute of Sweden: Borås, Sweden.

[10] Janardhan, R.K., *Fire Induced Flow in Building Ventilation Systems (M.Sc. thesis)*, in *School of Engineering*. 2016, Aalto University: Espoo.

[11] Hamins, A., et al., *Report of Experimental Results for the International Fire Model Benchmarking and Validation Exercise #3 (NIST Special Publication 1013-1)*. 2005, NIST: Gaithersburg, MD 20899

[12] McGrattan, K., et al., *Fire Dynamics Simulator Technical Reference Guide Volume 3: Validation, NIST Special Publication 1018-3, Revision: FDS6.5.3-564-g0eba564,*. January, 2017, National Institute of Standards and Technology, : Gaithersburg, MD USA.

[13] Hostikka, S. and R.K. Janardhan. *Pressure management in compartment fires*. Aalto University publication series SCIENCE + TECHNOLOGY; 1/2017 2017; Available from: http://urn.fi/URN:ISBN:978-952-60-7239-5.

[14] Hostikka, S., et al., *Fire-induced pressure and smoke spreading in mechanically ventilated buildings with air-tight envelopes.* Fire Safety Journal, 2017. **91**(Supplement C): p. 380-388.

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THE IMPACT OF VARIABILITY AND UNCERTAINTY OF SELECTED INPUT PARAMETERS ON RESULTS OF ROOM FIRE SCENARIOS

Abstract: Computer modeling of fire in an enclosed space is associated with variability which is caused by large number of input parameters. The variability of these parameters affects outputs and is also a significant source of uncertainty. This paper deals with determination of the impact of variability in the process of defining fire as well as variability in the size of openings in the boundary structures on the outputs of CFD fire model. The degree to which uncertainty and variability affect outputs cannot be accurately estimated, therefore it is necessary to examine selected input parameters based on the outputs of predefined fire scenarios in an enclosed space. Individual simulations were performed by Fire Dynamics Simulator (FDS) in fully equipped compartment.

Key words: uncertainty, variability, fire in an enclosed space, FDS, input parameters

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1. INTRODUCTION

Computer modelling makes it possible to comprehend the investigated problem of dynamics of fire in an enclosed space and therefore is becoming a more popular tool in fire engineering. However, the quality of outputs is fundamentally influenced by a large number of circumstances where the correct definition of input parameters plays a crucial role.

The input parameters are associated with uncertainty and variability. According to [1] it is uncertainty that represents the diversity in understanding of objective reality and its source is often the lack of information, subjectivity, error rate or approximation. The variability of the input parameter is determined by the volatility of matter and events around us which causes the input parameter to acquire different values as a function of time [2].

In this paper the uncertainty is associated with various definitions of the fire source of the sofa whereas the variability is associated with various sizes of holes in the boundary structures.

2. THE CFD MODEL OF FIRE IN AN ENCLOSED SPACE

The CFD modelling divides the investigated space into a large number of small computational fields and is based on a complete, time and three-dimensional solution of fluid flow laws, allowing detailed physical and chemical calculations accompanying ignition and spreading of fire products into the investigated area [3]. The selected enclosure fire scenarios were simulated using the Fire Dynamics Simulator program (FDS) in version 6.6.0. FDS is a freeware and at the same time the most widely used CFD model of fire in the engineering practice.

2.1. The geometry and materials in FDS

In the FDS program it is necessary to generalize the investigated space by its conversion into a right-angled square network (calculation field) in which three types of different geometric elements can be created [4]:

- **OBST** serves for creating a three-dimensional solid body (wall, ceiling, furniture)
- **HOLE**, on the other hand, creates a hole in solid bodies (a window in bounding constructions)
- **VENT** is two-dimensional and assigns different qualities to the surface of the bodies. It can also serve as a boundary of the computational space (fire area, open space).

Physical properties are assigned to the described geometric elements. This process consists of creating a database of the specific material properties. These are then added to the so-called surfaces which are included in defining of the OBST and VENT elements. By doing so even more complicated construction elements or space equipment can be created.

2.2. Definition of fire in FDS

There are several alternative ways to define fire in the FDS program. For an enclosed space equipped with furniture it is necessary to determine the initiation source. The basic method prescribes the value of the heat release rate (HRR) on the designated area using the *"ramp"* function or as heat release rate per unit area (HRRPUA). The second method uses the effect of a hot particle (so-called ignitor) on a combustible substance at a specified time. The possibility of being able to choose alternative ways presents a certain amount of uncertainty that needs to by pointed out [4, 5].

3. DESCRIPTION OF FIRE SCENARIOS

In order to assess the uncertainty and variability of selected input parameters, a total of 4 fire scenarios have been created. Their geometry, material composition and fire definition are more specified in this chapter.

3.1. Description of geometry and material used

The calculation filed of all scenarios comprised of 72 000 cube-shaped cells with 0.1 m long edge. Figure 1 shows the plan view of the boundary structures as well as the furniture in the enclosed space.

The room height is 2.5 m. The doors are of fixed height of 1.9 m and are above the floor by 0.1 m because if they were in contact with the boundaries of the calculation field there would be errors in the calculations. The height of the other openings in the boundary constructions is the same as their width as in Figure 1. In scenarios S1 and S2 the total area of their apertures is 2 m^2 and in scenarios S3 and S4 the area increased by 69 % to 3.38 m^2.

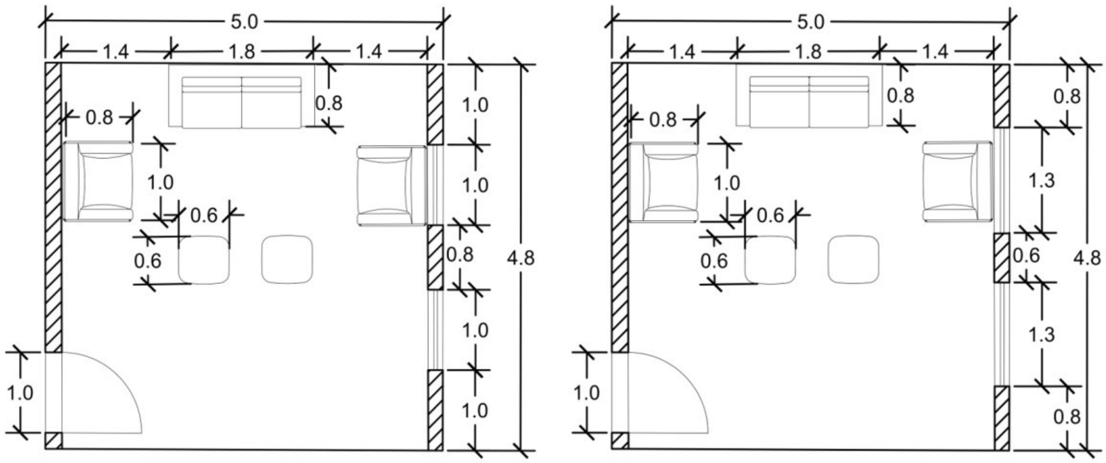

Figure 1 - Floor plan of scenarios S1 and S2 (left), S3 and S4 (right)

The furnishing of the space comprises of a seat, two arm chairs and chairs with upholstered surface and foam filling. There is a fabric carpet on the floor. The material properties of the equipment in the enclosed area were obtained in the material and surface database in *IGP no. 20170.*

3.2. Specifying the fire scenarios

In the first (S1) ant the third (S3) scenario an initial power source of 50 kW (HRRPUA = 5000 kW) and ground plan area of 0.01 m^2 was used. It is located in the left corner of the seat (surface source).

In the second (S2) and the fourth (S4) scenario the fire was initiated by two hot particles (1000 °C) which were placed diagonally at the corner of the seat creating the same area as the S1 and S3 fire. In all scenarios the duration of the initiation source was 360 s. Both fire initiation methods were chosen intentionally so that they would have an approximate same impact on the exposed flammable material and thus create the uncertainty in defining the initiating source.

4. IMPACT ON SELECTED CFD MODEL OUTPUTS

This chapter summarizes the results of all scenarios by means of the HRR graphs, the average height of the smoke layer and the anticipated flashover time.

4.1. Heat Release Rate

When burning, a certain amount of energy is released in the form of heat per unit of time. The HRR depends on material properties of the combustible substance as well as on air accessibility and space position [6]. The graphs of the HRR curves are shown in pairs in Figure 2.

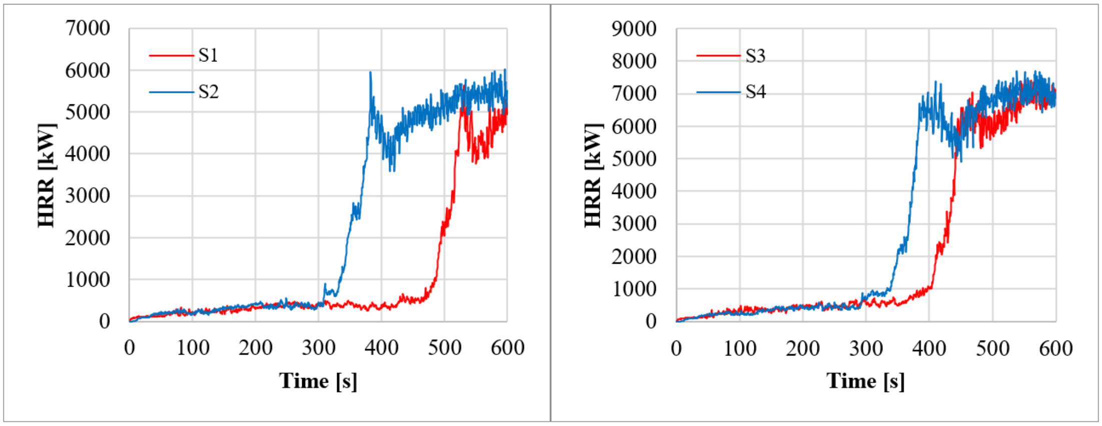

Figure 2 - Graphs of the HRR curves: S1 and S2 (left), S3 and S4 (right)

The uncertainty in defining the fire source is reflected by a significant shift of the HRR curve where the S1 scenario reaches 1000 kW by approximately 150 s later the S2 scenario. For scenarios S3 and S4 this difference is 57 s which is significantly lower. It is obvious that the outputs are to a large degree influenced by the uncertainty.

The increase of the aperture area (variability) in the boundary structure caused HRR increase in the S1 and S3 scenarios where the difference in average values of HRR reached 215 %. For the S2 and S4 scenarios the difference of average values presented only 27.5 %.

4.2. Impact on the smoke layer position

The position of the smoke layer has a major impact on a safe evacuation of people that are situated in the enclosed space. Its drop below the critical height (usually 1.5 m) highly complicates the movement and orientation of the people. The detection of the smoke layer position is typical for simple zone models but not for CFD models. The FDS program enables creating a device that determines the position of the smoke layer [4] based on evaluating temperatures and the smoke properties. Since this is a point device that does not evaluate the position of the smoke layer on the entire floor plan the average value of several devices was evaluated (Figure 3).

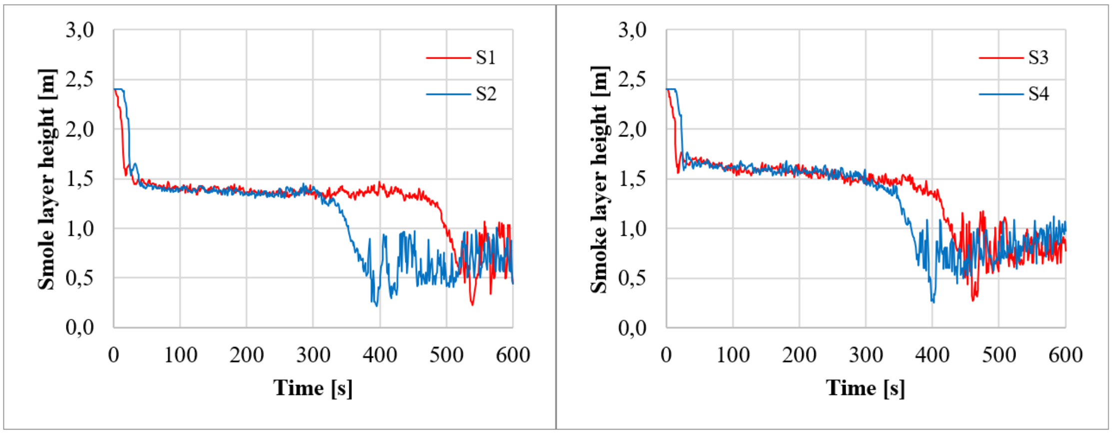

Figure 3 - Smoke layer heights curves: S1 and S2 (left), S3 and S4 (right)

The influence of uncertainty and variability of the input parameters on the position of the smoke layer is not as significant as in the case of HRR. Surprisingly, in the S3 scenario although having a larger aperture area for conducting away the combustion products, the smoke layer descends faster than in the S1 scenario. This phenomenon is probably caused by the swift increase in fire power output over this period of time (see Figure 2).

4.3. Influence on flashover

Ignition of most of the exposed combustible material in an enclosed space, also called "flashover" is the transition between the expansion phase and a fully developed fire. It happens when a fire of all combustible substances in an enclosed area is estimated. During this transition a swift change in the condition of the area occur and therefore it is important to highlight this significant process [7].

The main criterion for the flashover is the temperature at which the radiant heat from the hot gases in the enclosed space causes the ignition of all flammable substances. The flashover in an enclosed space occurs according to [8] in the following cases:

- The temperatures of hot gases in the area reach values in the range of 300 – 650 °C (in the engineering practice, however, the temperature range of 500 – 600 °C occurs),
- The heat flux at the floor level reaches as much as 20 kW.m^{-2}.

For the purposes of assessing the flashover in all scenarios, the average hot gas temperature (approximately 600 °C) was compared in the area with the output of the device detecting the heat flux of 20 kW.m^{-2} placed on the floor at the centre of the area. The final flashover time was visually compared with the outputs of the individual scenarios in the Smokeview program. Figure 4 presents the predicted occurrence of the flashover phenomenon in the different scenarios.

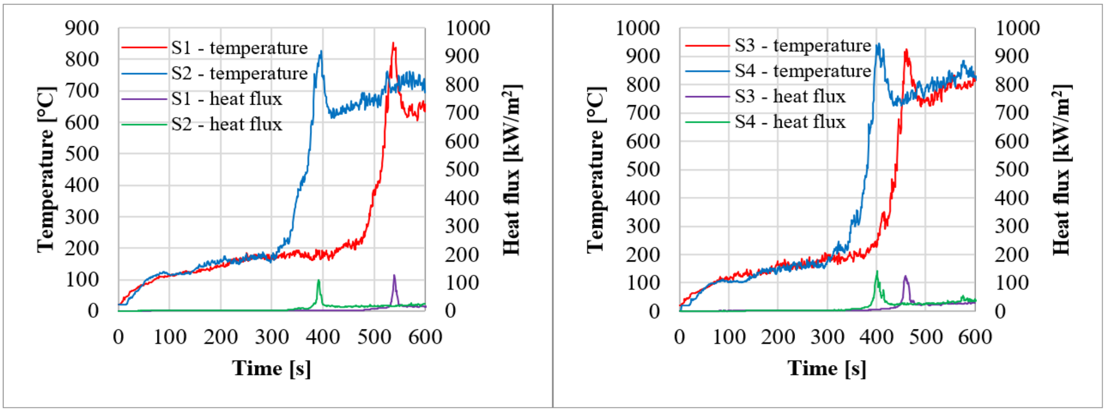

Figure 4 – Prediction of flashover: S1 and S2 (left), S3 and S4 (right)

Since the output values were generated by FDS in second intervals, the average value that was between the value exceeding the heat flux 20 kW.m^{-2} and the nearest lower value was selected. Table 1 lists the time values when the flashover conditions were met.

When assessing the individual scenarios it became evident that the uncertainty in the manner in which the fire was defined affects to a large extent the time of the flashover formation. It is indicated by the time difference of 147 s that occurs between the initiation of the planar source (S1) and the initiation of the hot particles (S2).

The variability mostly influenced the scenarios initiated by the planar source (S1 and S3). It is remarkable that that the changes in the aperture area in the bounding structures had almost no effect on the flashover formation for the S2 and S4 scenarios that were initiated by hot particles.

Table 1 – comparison of times when the flashover conditions were met

Scenario	Time to flashover [s]	Hot gas layer temperature [°C]	Heat flux [kW.m^{-2}]
S1	528	666	20.5
S2	381	608	20.5
S3	445	646	19.3
S4	384	646	20.2

5. CONCLUSION

The main purpose of this paper is to point out the significance of uncertainty and variability in defining the input parameters and to evaluate to what extent the outputs are influenced when we change the definition of fire (initiation source) and at the same time the size of apertures in the boundary structures.

It can be concluded that the uncertainty in defining fire has a large impact on the outputs. This does not only influence the HRR values but also the time of flashover formation. The variability did not manifest to the degree of uncertainty in the assessed scenarios.

For a complex assessment of variability, it is necessary to create a much larger number of scenarios in which a more profound analysis of influence of changed parameters can be carried out.

6. REFERENCES

[1] NOTARIANNI, Kathy A. a Gareth W. PARRY. Uncertainty. In: SFPE Handbook of Fire Protection Engineering [online]. New York, NY: Springer New York, 2016 [Acessed 2018-07-08], p. 2992–3047. ISBN 978-1-4939-2564-3. Available from: doi:10.1007/978-1-4939-2565-0_76

[2] BEGG, Steve H., Matthew B. WELSH a Reidar B. BRATVOLD. Uncertainty vs. Variability: What's the Difference and Why is it Important? In: [online]. B.m.: Society of Petroleum Engineers, 2014 [Acessed 2018-07-10]. Available from: doi:10.2118/169850-MS

[3] KARLSSON, Björn a James G. QUINTIERE. Enclosure fire dynamics. Boca Raton, FL: CRC Press, 2000. Environmental and energy engineering series. ISBN 978-0-8493-1300-4.

[4] MCGRATTAN, Kevin B a Glenn P FORNEY. Fire dynamics simulator (version 6) :: user's guide [online]. NIST SP 1019. Gaithersburg, MD: National Institute of Stan-dards and Technology. 2014 [Acessed 2018-07-12]. Available from: doi:10.6028/NIST.SP.1019

[5] WALD, František et al., ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE a STAVEBNÍ FAKULTA. Modelování dynamiky požáru v budovách. 2017. ISBN 978-80-01-05633-2.

[6] HURLEY, Morgan, ed. SFPE Handbook of Fire Protection Engineering. 5. ed. New York: Springer, 2016. ISBN 978-1-4939-2565-0.

[7] MÓZER, Vladimír. An Analysis of Factors Affecting Available Safe Escape Time. Advanced Materials Research [online]. 2014, 1001, 267–271. ISSN 1662-8985. [Acessed 2018-07-12]. Available from: doi:10.4028/www.scientific.net/AMR.1001.2..67

[8] DRYSDALE, D. An Introduction to Fire Dynamics. 3rd ed. Chichester, West Sussex: Wiley, 2011. ISBN 978-0-470-31903-1.

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INTRODUCTION TO METHODOLOGY OF EUROPEAN YOUTH PARLIAMENT

Abstract: Methodology of *European Youth Parliament* (EYP), one of the largest educational programmes in Europe, has been constantly developing for more than 30 years. Nowadays it represents a carefully balanced combination between different elements of individual and team work, aimed at encouraging independent thinking and initiative in young people as well as facilitating the learning of crucial social and professional skills. This paper gives a summary of the most important aspects of EYP's methodology and offers insight into the best practices that the organisation implements in its work.

Key words: European Youth Parliament, methodology, education, youth, team work, political debate

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1. INTRODUCTION

The European Youth Parliament (EYP) was founded in Fontainebleau, France in 1987 as a school project by teachers. The educational value of EYP events has played a crucial role in the development of work methodology and processes used during event. In the early stages, teachers strived to create engaging projects for small groups of their students, where they would be learning in a different setting, following different processes than in a classroom. Therefore, in its very core, EYP was created from a cooperation between students and teachers. Over the following years, this project started to cross the borders of France and involve more European countries. The international coordination of EYP was established by a teacher in the United Kingdom, starting in 1991. In 2004, the headquarters of the organization move to Berlin, Germany and former members start to be appointed to the Executive Director position [1]. In the current structure and functioning, teachers play a significant role in putting their students in touch with EYP, however events are entirely organised and run by young people.

The EYP network officially recognises a variety of events i.e. session with different lengths and sizes, the largest of which is an International Session – a well-funded 9-day event taking place three times per year, with over 300 participants. The smallest event is an EYP Day, which takes place usually in smaller cities with the aim to popularize the organization on the local level, gathering not more than 50 to 60 participants. This event is usually done with only in-kind sponsorship and last for one full day. The core EYP methodology applies to all sizes and durations of sessions and is used in various forms and adapted depending on the length of the event, number of participants grouped together and even resources available (e.g. materials and supplies, working environment, number of rooms).

Before the start of every session, participants of the event are divided into groups i.e. committees that work on a single topic. These committees are named after the committees existing in the European Parliament, for example the Committee on Environment, Public Health and Food Safety (ENVI) or the Committee on Development (DEVE) [2]. All members of a committee are, in session terminology, called delegates. Each committee has one or two chairperson(s) who are the delegates' peers and are responsible for preparing academic materials for the session, creating and leading activities, facilitating discussion and making sure the final output i.e. the committee resolution is factually accurate and represents the views of the committee [3]. All teams participating in the session have their respective team leaders, therefore a president is appointed at every session to lead the team of chairpersons just as the chairperson leads his/her committee. In addition, the organizing team, with the head organizer(s) as leaders, is responsible for the non-academic processes of the session e.g. logistics. It is important to note that, in the EYP methodology, leadership does not entail giving lectures or instructions of an academic nature, it is imperative that the leaders give their teams enough space to create and express their opinion whilst providing only support and training.

2. EYP METHODOLOGY FRAMEWORK

With the overview of session classification and human resource structures, it can be noted that these sessions differ in many aspects, however there are elements that are the same for all of them and thus these elements form the core of the EYP methodology. They can be split into two categories with first one being the qualitative features of EYP events and the second one the EYP methodology framework. The latter will be analysed first with distinct sections ordered chronologically.

2.1. Preparation

As participants of EYP events are young adults, the topics that are put up for debate are complex and thus demand a high level of preparation before the session. There are two significant aspects of the pre-session preparation:

- *Formulating and selecting topics.* The preparation of the academic proceedings of the session starts with formulating committee topics. Committee topics in EYP cover a wide range of issues, which usually include a European perspective on current policy discussions, societal developments and specialist areas such as science, health and agriculture. Formulating them is a delicate process since they need to satisfy several criteria. Firstly, they need to be broad enough to enable the committee to agree on 5 to 15 actions i.e. solutions to the topic. Secondly, these solutions need to be debatable i.e. there should be more than one way of alleviating the problem. After all the topics have been formulated, delegates will be asked to indicate their topic preferences and are then assigned one. In recent years, more and more area-specific projects are being organized in EYP, such as Power Shifts [4], in which all topics pertain to a broader field.

- *Preparation material.* The material given out before the session usually centres around an Academic Preparation Kit, which is a document containing introductions and overviews of all topics. These are written and prepared by chairpersons and their main purpose is to enable delegates to familiarise themselves with the topic and get a factual overview of the crucial information before the discussion. A topic overview often contains relevance and explanation of the problem, key conflicts, key actors, measures in place, questions to be answered by delegates and links to further research. Each delegate receives topic overviews for all committees, as he/she will debate all the proposed resolutions at the General Assembly. Time is allocated during Committee Work for General Assembly preparation and chairpersons will provide support to delegates wishing to participate.

It is important to note that the role of the delegate is to discuss solutions to the questions posed during the session. The delegates are tasked in their committees with coming up with a policy position in response to the neutral topic question. Delegates are free to propose responses that are as cautious or as radical as they wish, because of their research and stances on the topic.

2.2. Teambuilding

Teambuilding can be regarded as the introduction phase and is not part of the parliamentary simulation. The aim is to try and set the appropriate atmosphere and group dynamics in order for the committee to be able to tackle the problem at hand. When working in a new and very international environment with students who might not be fully familiar with this type of setting, teambuilding is crucial to facilitate a relaxed, trusting and open environment.

The process starts with activities aimed at introducing participants to each other and surpassing the barrier of a first encounter. This is followed by activities in which participants get to know each other more closely. A set of communication and problem-solving activities closes the teambuilding phase, giving an opportunity to every participant to assume his/her natural place in group functioning. The desired outcome of this period is a committee of participants that feel comfortable voicing their opinion and any concerns they might have about how the process is being handled by a group member.

2.3. Committee Work

Committee Work is a central element of the EYP methodology. During this stage, every committee is tasked with writing the resolution on its own topic. The work process itself is informally divided into several stages. Firstly, the participants aim to understand and define their topics in detail, usually through sharing their research findings and group discussion. Following the detailed formulation of the topic problem, an exchange of opinions is initiated with the aim of reaching a consensus about the actions which need to be taken to solve the specific problem. This brings the committee to the final Committee Work product.

A resolution is a document in the format of a list of clauses which summarise the problems identified by the committee and the solutions proposed. The format is in two parts with the first part comprising of the Introductory Clauses describing the current situation and background to the topic and the second part comprising of the Operative Clauses which contain the solutions. Students need to keep in mind that operative clauses should be concrete solutions or further developments of existing solutions, while remaining realistic and in line with existing policies.

2.4. General Assembly

The General Assembly (GA) is the section of the event which is based on the decision-making process within the EU's main legislative body - the European Parliament. During the GA, all the resolutions developed by the committees are presented and discussed with other delegates in a parliamentary setting. Until this point, committees are working on writing their own resolutions, and General Assembly is the first part of the programme when all the participants are debating all resolutions written altogether. This means that a certain procedure needs to be followed, which is ensured by the President and Board of the session who facilitate the debates.

The procedure represents a simulation of the EP procedure and includes:

- Reading of the Operative Clauses of the Resolution,
- Delivering a speech in defence of your Resolution,
- Three rounds of debate where participants have the opportunity to ask questions in each round and then a delegate from the proposing committee answers,
- Delivering a summation speech in which a delegate from the proposing committee summarises the main issues that were raised during the debate and encourages people to vote in favour of the Resolution and
- Voting.

This part of the process is an opportunity to engage with other topics during the plenary debates and critically assess the proposed solutions by constructively discussing and evaluating the resolutions. In International Sessions, resolutions that are voted through are being sent to the European Parliament. If any of these topics finds its place on EP's agenda, independently from EYP, the resolutions are being taken into consideration during public debate on their proposals as the voice of youth.

3. QUALITATIVE FEATURES OF EYP METHODOLOGY

3.1. Peer-to-peer learning

Peer-to-peer learning has been a cornerstone of EYP methodology since its formation. Research suggests that people are more likely to hear and personalize messages, and thus to change their attitudes and behaviours, if they believe the messenger is similar to them and faces the same concerns and pressures [5]. That, when translated into EYP context, means that young people are more likely to engage and care about the topic they need to tackle, if people facilitating their work are closer to their age. The positive consequences of this behaviour are applied across all teams at a session, from delegate engaging with each other to engaging with chairpersons and organisers. This element is integral to EYP's educational work, because the process of organising EYP experiences for other participants is in itself an educational experience and is empowering young people.

3.2. Simulation of the parliamentary procedure

Most of European Youth Parliament events follow a parliamentary format, but the organization does not seek to strictly stimulate the European Parliament or any other real legislative body or legislature, making EYP's parliamentary format very flexible. The priority is, or at least should always be put on the content, not the procedures themselves. Overall, a parliament is regarded as a forum for citizens to come together and share opinions, debate and seek consensus on important issues. The idea of using parliamentary procedure at EYP events is primarily motivated by the need to have a platform to practically implement values such as democracy, contribution and intercultural understanding. Another equally important aspect is the opportunity for the participants to get familiarised with the decision-making process in the European Union, something that is done is a unique, immersion-based way in the methodology.

3.3. Learning in a non-formal environment

The short-comings of formal education can be identified as the lack of an experience-based aspect and approach. In addition, some of the important issues on which EYP focuses, such as current European affairs and policies, are often not covered in an engaging way [6]. In this respect, the EYP doesn't underestimate formal education but seeks to complement it through its own non-formal, experience-based education model. Furthermore, formal education doesn't always cater to various transversal skills i.e. 21st century skills, identified as important in today's work life and society by the Erasmus+ programme [7]. This is again something the EYP seeks to complement, in particular by helping its participants to learn by doing.

3.4. Consensus-based decision-making

Debating and discussion in EYP is consensus-based. The methodology promotes discussion and seeks consensus, primarily within the committees' work. This does not preclude ideological conflicts and debates, but the aim is to develop ideas and solutions together. Many activities that take place during teambuilding are designed to tackle the group's ability to solve conflicts and reach consensus on polarising issues. That way, group dynamics are shaped into a productive format for future debates and resolution building.

3.5. Internationality

The aim is for the participants to both meet people from different places and encourage them to travel abroad. For example, in International Sessions committees are formed from fifteen people with the aim of having the same number of nationalities if possible. This provides participants with tremendous cultural exchange as well as with the comfort of being in an international environment. Due to the internationality of the organisation, cultural exchange, frequent travels and conferences all over Europe the official working language of all events is English.

3.6. No role-play

The majority of events are conducted in a parliamentary format, but participants always represent and debate their own views and stances. This kind of ownership that participants have is important for two reasons: firstly, it is vital for the motivation and engagement of participants and secondly it gives the participants a platform to express how they personally feel about a problem and engage in a discussion ultimately leading to a solution. In addition, any opinion expressed in the resolution is not an opinion of the European Youth Parliament as a body, nor will it be the opinion of a K-FORCE project, but rather the opinion of all the participants involved in the topic. As mentioned before, the focus is put of the learning and working process, not the end product.

3.7. Expert support

Since topics can often be highly demanding for participants, every committee is appointed a committee expert. An expert is defined as a person who either works in a topic-related field or is very knowledgeable on it. Even though chairpersons are very informed about the committee topic, they sometimes lack the insight obtained by working in the field in question. As was mentioned, chairpersons are not to interfere with the academic process any more than identifying factual information and therefore need not be experts on the topic. It is important to note that experts are usually not present during the whole working process, but rather only a limited amount of time not to damage the learning process. Therefore, it is crucial that experts are able to transfer the knowledge in an efficient way, being free to use all types of aid such as presentations, conversation, questions & answers and so on.

4. EYP AT S-FORCE

As mentioned earlier, the methodology of EYP is adjustable and flexible, according to needs of the event. The S-FORCE event presents an opportunity to demonstrate how the EYP methodology can be applied in different surroundings and with a different group of participants, using its framework and qualitative features, both of which were introduced earlier. The unique nature of this cooperation is seen in factors shaping the methodology different than usual. Firstly, the workshop will last for one day, drawing similarities with an EYP Day. A unique aspect of the event is the fact that participants will mostly be Master students or PhD students, as opposed to usual practice where participants are High School or Bachelor Students. Having in mind that participants possess a certain level of experience in the topics, the chairperson must give additional attention to the preparation stage and his/her methods of leadership and facilitation. This change of the participant group and the goal of practicing parliamentary procedures shift the focus more towards the GA and the debating and voting procedures. In addition, the event will be under the K-FORCE motto *Knowledge for a Resilient Society*, with the topics given to committees pertaining to the field of Disaster Risk Management and Fire Safety (DRM&FSE).

To conclude, during S-FORCE these will be a chance to witness what product young minds are capable to deliver in the field of DRM&FSE guided by EYP methodology. Three to four Resolutions will be made during Committee Work and presented and debated on in the General Assembly. This will be the demonstration of European values and parliamentary procedure put into practice as part of the K-FORCE project.

5. REFERENCES

[1] European Youth Parliament, “History,” 2018. [Online]. Available: https://eyp.org/about/history/.

[2] European Parliament, “List of Committees,” 2018. [Online]. Available: http://www.europarl.europa.eu/committees/en/parliamentary-committees.html.

[3] European Youth Parliament, “Our Session Concept,” 2018. [Online]. Available: https://eyp.org/our-session-concept/.

[4] European Youth Parliament, “Power Shifts: Reflecting Europe’s Energy.” 2015.

[5] Advocates for Youth, “Peer Education,” 2008. [Online]. Available: http://www.advocatesforyouth.org/peer-education-workingwithyouth.

[6] European Youth Parliament, “Education in the EYP: Explanatory document on the educational work of the European Youth Parliament,” 2015.

[7] ATS2020 Project, “Areas of Competences and Skills.” pp. 1–6, 2018.

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LANDSLIDE HAZARDS AND RISK IN NORTHEASTERN BOSNIA

Abstract: The area of Northeastern Bosnia represents the most vulnerable part of the territory of Bosnia and Herzegovina in terms of the development of the sliding process. The landslides have proved to be particularly problematic, due to the absence of clearly defined responsibilities of the various institutions that are primarily deal with them, as well as, lack of strategy, absence of information and data (Cadaster), forecasts maps (hazard and risk), and ultimately a low level of awareness of landslides and their consequences in the wider public, including various levels of government. In the future, systematic approach to the research and monitoring of landslides should be implemented in the entire territory of Tuzla Canton and on the whole Bosnia and Herzegovina territory. Only then, we can access the implementation of appropriate preventive measures by the priorities, in order to reduce the vulnerability of population and material goods and prevent the spread of the sliding process on secluded areas where geohazards potential is expressed. The long-term solution also implies specific measures in the sense of improvements or change of legal regulations.

Key words: landslide, Hazard and Risk, the Cadaster of landslide

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1. LANDSLIDES

Landslides are a part of the geomorphologic environment limited by the surface and the depth of the slip, where gravitational displacement of the initiated masses in the hypsometric lower parts of the slope occurs without loss of sliding mass contact with a stable substrate. Landslides and mass movements can cause human fatalities, destruction of material goods, or human activity disorder. Landslides represent the most significant manifestations of instability on the slopes, and their appearance patterns, regarding the sliding mechanism, are very different.

The causes of landslides, by their nature, may be:

- Natural causes (physical and mechanical disintegration of rocks causing reduction of shear resistance, influence of surface and groundwater in the slope, change of hydraulic gradient, slope geometry, significant discontinuity and degradation of rock mass, increase pore pressures in the soil during large precipitation, swelling of the soil and the process of freezing, natural seismic influences).
- Technogenic or anthropogenic causes (building of construction objects on conditionally stable and unstable slopes, inadequate execution of groundwork's, devastation of terrain by deforestation and cutting of vegetation, dynamic loading of roads, artificially induced seismic influences and so on) [2].

1.1. Classification of landslides

There are many suggestions for classifying this phenomenon. The reason for this number of classification systems is the fact that they are based on the different approaches and criteria which is used for classification. In general, the selection of the classification system should enable the best possible determination of the most important characteristics of the sliding process, occurring in the particular case. Based on these data findings, complete identification of the problem is provided and appropriate solution for this problem could be found. According to Nonveiller, there are several divisions, i.e. landslide classification. Classification, thus, provides only the primary framework, which form the basis for slides recognition and classification, according to their study.

Landslides, therefore, represent the most significant manifestation of instability on the slopes and their appearance forms, from the slide mechanism point of view, they are very different, furthermore, their diversity and specificity in each particular case, is reflected in the wide scale and activity of landslides. In this regard, special attention should be paid to the remediation of landslides. Keeping in mind that the total sliding factors and their mutual relations are specific for each slope, it is necessary to conduct geo-mechanical tests and, on this basis, draw up the project documentation with a technical solution. Rational design allows an optimal technical and economic remediation solution. [2]

1.2. Eurocode 7: Geotechnical categories

EN 1977 (Eurocode 7) introduces a classification of three geotechnical categories in order to rationalize the scope of investigative works and the complexity of stability and usability demonstration procedures for buildings of substantially different degrees of complexity and different levels and exposure to high risk. In geotechnical category 3, in addition to many complex interventions and high risk interventions, landslides are also classified. For this category, the norm does not provide specific instructions. Rather, it requires more rigorous criteria and procedures for research, design, observation and supervision under the guidance of geotechnical engineers with proven experience and standardization is left to the specific needs. [1]

Figure 1 – Head cracks and denivelation of the terrain on the road, as clear indicators of terrain instability. [7]

2. HAZARD AND RISK

The sliding process on slope represents a geological hazard. Like any hazard and sliding process, it has its quantitative measure, expressed through risk, affecting material goods and people. According to the ISO standard, the Hazard Definition is: "Hazards are insufficiently established risks or dangers that are not adequately assessed from the aspect of the likelihood of occurrence and the consequences they may cause." In other words, the hazard is the name of an unfavorable event.

The risk is a quantified, objectified, compared or determined hazard with a defined probability of occurrence and damaging consequences. Therefore, the risk represents the likelihood and quantum (numerically or descriptively) of the named hazard. Worldwide, experts have been involved in hazard and risk assessment for thirty years. When it comes to the international community, the sponsor of these activities is the UN. At the national level, this activity has been intensively implemented in the period 1991-2000, as a part of the International Decade for the Reduction of Natural Disasters (sponsors were UN). [2]

3. LANDSLIDES IN NORTHEASTERN BOSNIA

The Tuzla Canton is located in the northeastern part of Bosnia and Herzegovina and represents one of the ten cantons of Federation of Bosnia and Herzegovina. It consists of 13municipalities and occupies an area of 2.658km2, with 486.830 inhabitants.

3.1. Causes of landslides

Territory of Tuzla Canton is significantly endangered by landslides, which, year by year increasingly destroy material goods and directly and indirectly endanger human lives. Landslides are one of the major limiting factors of spatial development in this area.

One of the main causes of the occurrence of a large number of landslides in the Tuzla Canton area is, above all, its geological structure, geomorphologic terrain characterization, hydrological and hydrogeological characteristics of the terrain, climate characteristics, illegal construction and inadequate anthropogenic activity and other. In this area are represented Permian, Trias, Jurassic, Cretaceous, Paleogene, Neogene and Quaternary. [4]

It is common that one landslide is triggered by several causes. For the Tuzla Canton, which is characterized by hundreds of recorded landslides, there is a very heterogeneous geological composition of terrain with dominance of rocks susceptible to physical and chemical decomposition. The rock disintegration process is particularly expressed in sediments (marl, clay, poorly bound sandstones), which cause a relatively rapid decomposition of 1m to 5m thick crust. These decomposition crusts, during intense and long-lasting rainfall, as well as by sudden snow melting, are saturated with large amount of water which, along with the gravity, leads to their sliding down the slope. This sliding process in a significant number of cases is stimulated by human activity (cutting and slope loading, vegetation destruction, incorrect or insufficient drainage of surface and ground waters, etc.). This leads to a weakening of the physical-mechanical characteristics of slope material, the increase of the pore pressure, which then often leads to progressive fracture or sliding. We can conclude that over 90% of landslides in the area of Tuzla Canton are of the consequential type with sliding of decomposition crust, general thickness of 1m - 5 m. [3]

3.2. Number of landslides

The state of landslide in one area is generally monitored in three different ways, that is, the levels which also present different degrees of detail and reliability of data:

- Records of reported landslides
- Data of mapped landslides
- Cadaster of landslides (comprehensive database)

In the area of Tuzla Canton, the so-called “Landslide evidence” is recorded, which is mainly reported by the local population.

Records of landslides (the lowest level of landslides monitoring) in Tuzla Canton area and also in the municipalities, are conducted by different services (Civil Protection Service, Spatial planning Service, Communal Services Department). Each of these services has different data on the number of landslides and especially their surface. The reason for such a situation is unsystematic monitoring and study of landslides. In the period from 1995 till today, the number of reported landslides has been changing and increasing periodically. In 2010, 2372 landslides have been recorded in the Tuzla Canton area, while in 2014 there were 6742 landslides. [3]

Table 1- Number of recorded landslides by municipalities of Tuzla Canton in 2010 [3]

Municipality	Surface (ha)	Number of landslides
Banovići	18196,82	96
Čelić	13971,12	105
Doboj Istok	3995,62	113
Gračanica	21412,96	174
Gradačac	21470,78	198
Kalesija	19818,62	147
Kladanj	32762,55	233
Lukavac	35256,25	157
Sapna	12159,79	180
Srebrenik	24772,02	256
Teočak	3284,28	37
Tuzla	29685,75	646
Živinice	29092,03	30
Tuzla Canton	265878,59	2372

Table 2- Number of recorded landslides by municipalities of Tuzla Canton in 2014 [3]

	Municipality	Number of reported landslides
1.	Banovići	290
2.	Čelić	282
3.	Doboj Istok	192
4.	Gračanica	430
5.	Gradačac	288
6.	Kalesija	1.300
7.	Kladanj	204
8.	Lukavac	247
9.	Sapna	386
10.	Srebrenik	623
11.	Teočak	179
12.	Tuzla	2.174
13.	Živinice	147
	Total	6.742

3.3. Landslide consequences

Consequences and damages caused by landslides are constantly increasing. Total damages to the Tuzla Canton in 2010 was estimated to 17.5 million EUR (Tuzla town 5.2 million EUR) while after the disaster in May 2014, the damages were estimated to 444.4 million EUR in Tuzla Canton (Tuzla town 220 million EUR). Among the significant landslides of this area, some can be distinguished: Husino, Žigići and Čaklovići in Tuzla. The area of Tuzla Canton is particularly sensitive with varying volume and degree of activity to the occurrence of landslides in rainy periods, when at the same time up to 1000 landslides can be activated, with varying volume and degree of activity.

After the May 2014 disaster (Tuzla Canton area):

- 9 people lightly injured
- 7286 people evacuated
- 35 residential and 50 auxiliary facilities destroyed
- Flooding of the basements of 30 schools
- 6742 landslides activated
- 397 buildings were destroyed due to landslides, while 1801 residential and 494 auxiliary buildings were damaged
- Three schools have been damaged by landslide activity

Based on the field research and analysis of the existing documentation, an appropriate engineering and geological map of Tuzla Canton has been created, defining the total surface of the terrain under the landslides and zoning the terrain according to the degree of stability. In the area of Tuzla Canton, the 14.844, 43ha of terrain was affected by sliding process, which makes up to 5.58% of the total area of the canton. [3]

Figure 2 – Rock slide as a form of a sliding process. Very often such hazards are defined as landslides even though there is a significant difference in the mass transfer mechanism. Because of this, defining hazards in sliding processes is very important for adequate prevention. [6]

3.4. Geohazard potential

Landslides, as very harmful occurrences for humans, are the product of the corresponding geohazards that are present in some areas. This is the reason the frequency of landslides occurrence directly depends on the degree of geohazard potential of an area. In Bosnia and Herzegovina, a unique methodology for assessing sliding hazards has not yet been developed, as there are different approaches to empirical analysis for determination of the influential factors and their rating on sliding. By analyzing influential factors on the stability, with rating and the analysis of a number of other important parameters for the assessment of the sliding hazards, specific to the Tuzla Canton area, area classification (based on the degree of sliding hazards) was carried out. The outcome of the analysis gave five classes of sliding Hazard (from H = 0 to H = 4), with the fifth grade (H = 4) being impending landslides. [3]

Table 3- Hazard classes on sliding process with the score limits for the Tuzla Canton area [3]

HAZARD CLASSES	HAZARD CLASS PROPERTIES	NUMBER OF POINTS
Very low hazard (nonexistent hazard) **H=0**	No sliding of the terrain is expected under any changes in their properties	0-20
Low hazard (LH) **H=1**	Smaller local slides may occur under certain conditions that are low probability of occurrence (extreme falls, earthquakes ...)	20-50
Medium hazard (MH) **H=2**	Sliding will take place under certain conditions expected in the coming period, likely to occur (major technical interventions on labile slopes, intense rainfall, etc.)	50-70
High hazard (HH) **H=3**	Sliding is likely to occur in the near future under the conditions of frequent occurrence of adverse weather conditions (seasonal falls, sudden snow melting, technical interventions, etc.)	≥70
Established landslide	Great probability of reactivating existing landslides	-

Table 4- Established level of hazard to sliding in the municipalities of Tuzla Canton [3]

Municipality	Hazard classes(H)
Banovići	H=1
Čelić	H=2
Doboj Istok	H=3 i H=4
Gračanica	H=3 i H=4
Gradačac	H=3 i H=4
Kalesija	H=3 i H=4
Kladanj	H=2
Lukavac	H=2
Sapna	H=3 i H=4
Srebrenik	H=3 i H=4
Teočak	H=1
Tuzla	H=3 i H=4
Živinice	H=1
Tuzla Canton	

4. REDUCTION OF HAZARDS AND RISK OF LANDSLIDES

Landslide Cadaster represents the highest level of landslide tracking when approaching systematic (daily) research and monitoring of landslides. All vital data on landslides, which are obtained in landslide studies, are registered in the corresponding Cadastral sheets and uploaded into a database. This database is updated on a daily basis. In the area of north-eastern Bosnia, the landslide monitoring mostly takes place on the first, lowest level (Records of landslides), while the area of Tuzla was the only one that has completed the first phase of establishing a Landslide Cadaster. In the forthcoming period, the second phase of Landslide Cadaster should be carried out. The data of the current level of representation and the vulnerability of the terrain by sliding process is the justification for establishing the Landslide Cadaster, in other municipalities of Tuzla Canton. According to the current available data of mapped landslides in the Tuzla Canton area, 14.844 hectares of terrain were affected by the sliding process, which is 5.58% of the total area of the Canton [3]. In the forthcoming period, systematic research and monitoring of landslides should be undertaken in the entire territory of Tuzla Canton, and throughout the territory of Bosnia and Herzegovina, since only then priority preventative measures can be implemented in order to reduce the surface area threatened by the slide process and prevent the sliding of the separated area, where geo-hazardous potential is expressed. The Landslide Cadaster represents the basis for quality hazard and risk management and the prevention of their slow activity.

In addition to the establishment of a unique landslide database, it is also necessary to create maps of landslide susceptibility, which represent one of the most important segments in risk assessment and mitigation. [5]

In areas where there is a possibility of landslide occurrence, creation of landslide susceptibility maps is an important step in defining the geological characteristics of areas related to spatial (urban) planning. Landslide susceptibility maps show the spatial probability for sliding, with the extraction of similar sliding zones and their rankings in classes. [5]

All activities carried out on the study and research of landslides aim at obtaining a rational, economically and technically justified optimal remediation solution. In order to find the optimal solution for the landslide remediation, it is important to note that the planning (regarding the program and the project of geotechnical research), should be carried out in detailed. If there is no complete basic data, which can only be provided by proper planning, or by the design of a program and project, it is quite certain that the remediation measure at the site will not be technically and economically optimal.

In addition to the above, it is necessary to revise the spatial and urban planning documentation in all municipalities that were threatened by floods and landslides in 2014, which local government, in financial and professional terms, cannot carry out. This is also the conclusion in most local self-governments. Also, there is a need for professional staff, additional education and technical equipment and so on, as well as, better communication with institutions at Bosnia and Herzegovina country level. The institutional framework of landslides risk management is the basis for the consistent application of certain segments of the process. Therefore, it is necessary to define the framework through legal regulation, where appropriate with new legal solutions or amendments to legal legislation. In the segment of the implementation of structural measures, change of certain law amendments is necessary, but also it has to be clearly defined on who can implement them (licensing within professional associations needs to be defined, e.g. engineering chambers or some other form). Particular attention should be turned on the Law on Spatial Planning and Land Use amendment at the Federation BiH level.

Failure to respect any segment of the landslide risk management process, the laws of the Federation of Bosnia and Herzegovina and the cantons, should require financial sanctions, measures of waiving right to work in the profession and so on.

5. CONCLUSION

Landslides represent one of the most important geological exogenous processes, during which slopes are formed. The cause of these moves is the disturbed equilibrium conditions that dominate in earth or rock slope. Consequences are mainly, partial or complete demolition of residential facilities, traffic and communal infrastructure facilities as well as loss of human life. Based on the conducted researches and analysis carried out, the conclusion is that the area of Tuzla Canton (north-eastern Bosnia) is the most endangered part of the territory of Bosnia and Herzegovina from the point of sliding process development as well as the territory with significant geo-hazardous potential and determined high level of hazards on the landslides occurrence. In order to reduce the degree of risk from the consequences of landslides, it is necessary to establish a Cadaster of landslides (data bases), as the basic level of the process. Next step is to define the landslide susceptibility method, hazards and risk, risk treatment model and in the end, model of risk management. For real improvement of landslide risk management, it is also necessary to change the legal regulations.

6. REFERENCES

[1] Ivšić, T., Nossan-Szavits, A, 2006. Novi Eurokod 7: geotehničko projektiranje. *Ojačanje tla i stijena.* Savjetovanja HGD-a, Opatija, 455-469.
[2] Mandžić, K., Ibrahimović, A.(ed.), 2013. *Sanacija klizišta.* Faculty of Mining, Geology and Civil Engineering, Tuzla. Tuzla, d.o.o. Mikroštampa.
[3] Mulać, M. 2016. Landslide situation and Hazard degree for the development of sliding process in the territory of the city of Tuzla and Tuzla Canton. *Landslides in the Republic of Srpska as a consequence several-days rainfall in May 2014.* Scientific conference, Banja Luka, (28), 147-164.
[4] Vrabac, S. 2003. Osnovni uzroci pojave klizišta na području Tuzlanskog kantona. *Civilna zaštita-Glasilo Kantonalnog štaba Civilne zaštite Tuzla,* Tuzla (1), 7-9.
[5] IPACBC Interreg HR-BA-ME „Transnational advanced management of land use risk through landslide susceptibility maps design“- acronim „safEarth“, https://www.safearth.com/int
[6] (https://www.dnevnik.ba/vijesti/veliki-odron-na-putu-prema-foci)
[7] (https://www.blic.rs/vesti/republika-srpska)

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INSURANCE AS A MEANS FOR FINANCIAL RESILIENCE - THE CASE OF BUSINESS SECTOR IN ALBANIA

Abstract: Macroeconomic impact caused by natural disasters has led to considerable decrease in production. Albania is one of the countries which has faced large output declines because of natural disasters compared to developed countries or bigger economies. However, experience of other countries has demonstrated that the implementation of a financial strategy in case of disasters is indispensable. One of the ex-ante financial strategies is related to purchasing insurance, which can lower the cost and the consequences of the natural disasters like floods, earthquakes, fires, and landslides, etc. The purpose of this study in Albania was to assess the perception of small business managers on purchasing insurance and their familiarity with it. The interview questions of the study identified the factors that affect their behaviour and the reasons why they are refrained from buying insurance. Through this qualitative methodology it was intended to evaluate their level of attitude towards insurance in order to offer future recommendations to address this issue. The factors identified through this qualitative study consist of: insufficient understanding of the advantages of insurance and what this financial means represent; the lack of trust towards insurance companies and the low level of financial literacy and lack of commitment of the insurance companies and government institution to increase public awareness regarding disaster risks.

Key words: insurance, financing risk, natural disaster, demand for insurance, SME, perception, Albania

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1. INTRODUCTION

The considerable impact of disasters has not only led to damages related to human lives, buildings and infrastructure, but has also hindered economic activity, resulting in potential national and global effects. Albania is considered one of the most endangered countries in the European continent from natural disasters. Albania ranks 41st in the world in terms of vulnerability landslides, 43rd in terms of earthquakes and 58 in terms of drought risks [23]. The annual average population affected by flooding in Albania is about 50,000 and the annual average affected GDP is about $200 million. Within the various provinces, the 10 and 100-year impacts do not differ much, so relatively frequent floods have large impacts on these averages [25].

Due to numerous disasters that have been experienced, it has become urgent and indespensable for the government, companies, international and national organisations not only to develope their financial strategies but also to properly coordinate them. It has been deemed as crucial for the governement and relevant institutions to categorize as ex post and ex ante financing instruments. Ex ante risk financing instruments require proactive advance planning and include reserves or calamity funds, budget contingencies, contingent debt facility and risk transfer mechanisms [17].

As emphasized in the international financial literature strategies and recommendations risk transfer instruments, such as insurance, are very effective means in addressing disaster risks in developing countries. Even though insurance and reinsurance payments are considered as one of the main alternatives in the literature, their implementation in Albania has encountered several problems also considering the fact that there is a very low level of private insurance. In many cases in developing countries, kin relationships and social capital have been the only option for the individuals and small businesses that have experienced disasters to cover their financial losses and disaster shocks. This is a consequence of the lack of risk mitigation strategies [16]. In most cases, the above mentioned options are not sufficient to cover losses and hinder the sustainability of the businesses.

The first section of this paper presents on overview of the literature regarding the main factors identified because of which individual and business refrain from demanding insurance. The analysis of the effects of disaster on marginalized population, their causes and the perception on insurance in poor countries are a good source that may urge the development of financial strategies in other countries, including Albania, so as to properly address weather- related disasters and contribute in improving insurance choice behaviour.

Further on the research methodology and its result are presented. The goal of the study was to evaluate the perceptions of the small and medium enterprises in Albania on disasters and how they cope with them in terms of financial strategies. The selected sample refers to businesses located in areas that have a high probability of natural disasters and were affected in the last years by a natural disaster such as floods, fire and landslide. Using a qualitative case study research method intended to generate information on insurance choice behaviour so important for insurance organizations, government entities, non profit organization, and other researchers. In this way they cannot simply understand the problem but contribute in educating individual and small businesses about the importance of insurance.

The final part of the paper presents the conclusions and links of the results with other international studies. From this study it has resulted that in order to increase public awareness toward the necessity of adopting financial strategies such as risk transfer through insurance it is necessary to introduce specific courses about insurance in schools curricula. On the other hand it is the responsibility of the government to review insurance laws and regulations by making property insurance compulsory for business. Apart from that insurance companies should improve insurance marketing practices in order to contribute in building trust of the individuals and businesses.

2. LITERATURE REVIEW

As emphasized in the international financial literature, risk transfer instruments such as insurance are very effective means in addressing disaster risks in developing countries. The definitions included in the literature define insurance, as a social good, which serves as a significant tool to reduce the adverse consequences of disaster shocks on individuals and small business [15].

Despite the recommendations this means of financing disaster risk is the least acknowledged risk mitigation strategy in less developed countries. In many cases in developing countries, kin relationships and social capital have been the only option for the individuals and small businesses that have experienced disasters to cover their financial losses and disaster shocks. This is a consequence of the lack of risk mitigation strategies [16]. In most cases, the above mentioned options are not sufficient to cover losses and they hinder the sustainability of the businesses.

Lack of financial strategies to protection is a disadvantage for individuals in low income countries, despite their increasing necessity for financial support in case of disasters [1]. There is a very low level of private insurance in Albania. The reasons identified in the literature referring to this finding are related not only to the low income per capital of the population to afford premium payment but also to the lack of the weather insurance products offered in the market. Problems with property rights also make the insurance companies unwilling to sell insurance to the population [2]. According to Sharku & Shehu (2016) ([19], [20]), Albania is ranked the last of the Western Balkan Countries (WBC) referring to insurance density rate and insurance penetration rate. The insurance market in Albania has been always dominated by non-life insurance products, which share was about 92,7% of the total volume of gross written premiums. Compared with other Western Balkan countries, the insurance market in Albania is less developed. In 2015, Albanian citizen has spent on average Euro 35 on insurance products (in Bosnia & Herzegovina and in Serbia the density rate in 2015 has been respectively Euro 80 and Euro 93). The insurance penetration index was 0,99 % in Albania (In Bosnia & Herzegovina and in Serbia has been respectively 2,1% and 2%). Insurance companies insure the property of business and households, against fire and other natural perils, on a voluntary basis. Even though open market has been operating for more than 25 years the insurance sector is still underdeveloped.

Poverty, culture, demographics, and lack of public awareness are some of the main factors identified in international studies because of which individual and business refrain from demanding insurance. The analysis of the effects of disaster on marginalized population, their causes and the perception on insurance in poor countries are a good source that may urge the development of the financial strategies in other countries including Albania so as to properly address weather- related disasters and contribute in improving insurance choice behaviour.

From the literature review, it has been concluded that the main factors that affect the insurance choice behaviour are related to poverty ([18], [14]) and lack of education [12]. However another factor that hinders the purchase of insurance is the lack of social responsibility at all levels of the society [2].

While reviewing literature it has been observed that there is a gap in literature on the determinants of purchasing insurance in WBC in general and in Albania in particular. In countries like Albania, the concept of insurance comes within a difficult context. Because of the inherited culture from previous system, several informal and social connections particularly extended family systems; still remain as important resources to cope with natural disaster. As a consequence the individual's sense of vulnerability to financial shocks is lowered [13]. The low demand for insurance in low income countries is also explained by the fact that there are insufficient insurance products and limited information on such products ([6], [10]).

Schneider (2004) [18] and Stevens-Benefo (2015), [1] underlines the building of trust among clients as an importante factor in uptaking insurance products. Among other factors identified in international studies lack of awareness to the existence of the insurance products, and a poor understanding of the concept of insurance are the sources of considerable low uptake of insurance in low income countries. Finally risk aversion and individuals concept on basic risk determine small business managers' participation in insurance [1].

3. RESEARCH METHODOLOGY AND DATA ANALYSIS

Purposive sampling was the method for selection of study participants as it is a non-probability sampling technique used to recruit study participants from a specific predefined group [8]. With purposive selection (there were selected business from areas that were affected by floods and other natural disasters in the last 10 years), it was made possible to gain access to the segment of population with the most information on the subject of study and understand the problem and the research question. The purposive sample for this multi-case study involved participants chosen from local businesses, in different regions of Albania. Given the objectives of the study the method of interviews became necessary, as it aimed at discovering and reconstructing the complex connections of the various sides of a phenomenon. Participants were engaged in in-depth interviews, not to substantiate any hypothesis or to answer questions, but to understand the experiences, perspectives of each participant, and the meanings that carry these experiences. Through interviews conducted in 5 different cities (Shkodra, Tirana, Fier, Librazhd, Kruja) talks and observations were provided in the form of words and sentences. These cities were affected by natural disasters due to weather condition factors. Flick, (2009) [9] links the importance and success of semi-open face-to-face interviews with the fact that participants' views are more complete and clear as compared to a non-face-to-face questionnaire. All participants were informed that the answers to the questions were voluntary and withdrawal from the study could be done at any time without any risk to them. They were given the opportunity to ask questions about study objectives and interview procedures. All participant responses were coded to ensure proper confidentiality with respect to the study. Each of the 15 business names was removed from the data to be analysed and replaced with numbers to protect their identity and ensure confidentiality. The interviewed were mostly business owners but also managers. During the interviews, an audio device was used to record, which would provide accurate information as well as the ability to review the interviews at a later time if forgotten or lost information was required.

Intermediate half-open interviews were conducted as the participants intended to explain their perception about insurance and the determinants factors on purchasing insurance. Full structuring of the questions would make the process difficult, because the participants' thoughts and ideas are not known in advance, and the differences between the experiences and perceptions of each of them. Interviews were recorded and lasted from 30 to 40 minutes.

With the participants, who were small business owners and managers was conducted an interview divided into 2 parts: the first part was related to demographic data, such geographic area, number of the employees they had, type of activity and the number of years they were running that activity. In the second part of the interview each participant was asked six questions to investigate their perception and knowledge about insurance. For example they were asked whether they had information about insurance, the existence of cultural and social attitudes to risk adverse, their level of education in general and the one related to financial literacy and their reaction towards disasters and management of losses.

Data were collected based on 15 participants. Their responses received from the interview provided relevant insight to the research objectives. The interview questions complemented the central research purpose. Questions were open-ended and semi structured to help answer the central research question.

The interviews were conducted in 5 different cities. The businesses selected for this study were mainly SE. In fact 99.9 % of active registered businesses in Albania are considered SME according to

[11] 75% of the interviewed businesses were retail businesses and the rest were manufacturing firms. On average the interviewed business had 5-10 employees. As it resulted from the interviews, most of them had basic and elementary knowledge about insurance. The rest answered that they did not have any knowledge at all about property insurance. As displayed in the chart below 60% of the participants had general idea of what insurance was. 20% had no correct information and 20 % responded that they had no information at all.

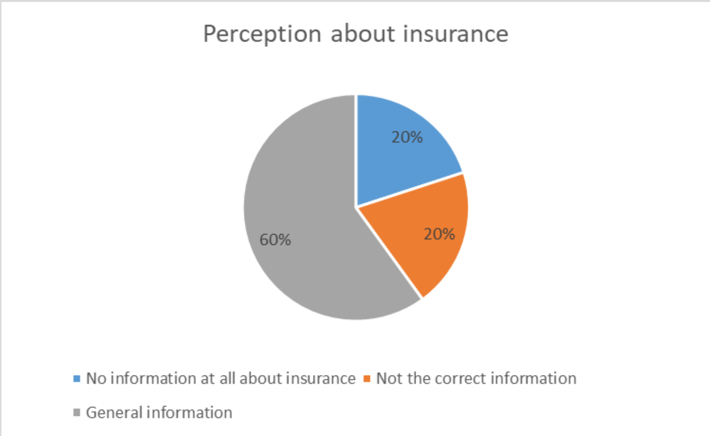

Figure 1: Perception about insurance

The thematic analysis was chosen as an appropriate method because it is commonly used to describe, analyze, and report topics and models in data [4]. Table 1 describes the steps in which this analysis was conducted. Using this theoretical approach as the interviews were conducted, responses to the questions of the former interviews provided information to design new questions that could be addressed to participants in the latter interviews. The purpose of this qualitative study was not to generalize the results but to study the phenomenon in depth. Moreover, it would be very useful to conduct other studies in this area in other Western Balkan countries, to gather data and knowledge and to compare it with the findings of this study.

Table 1. Data analysis phases and description of the process

Data analysis phases	Description of the process
Following the recommendations made by Braun,V. and Clarke,V. (2006).	Each author read and reread the transcripts, made notes about their initial interpretations, and generated codes, classified the codes into possible topics, reviewed themes and named each of the topics. This stage was accomplished by each author working separately.
Analysis session to discuss the codes and topics identified by each author	At the joint meeting the authors describe their individual interpretations. The findings were compared and discussed on differences in findings. Finally, the final themes were decided.
Final Review of Data and Validity of Findings	Each author read transcripts again to ensure that the final themes really reflected the collected data.
Writing a report	Each topic identified was included in a report including specific terms used by the study participants as examples to describe each topic.

4. FINDINGS OF THE STUDY

From the answers of the participants it resulted that most of them had a fair understanding of the need for insurance but very few understood the concept of insurance. One of the common answers referring to the idea of insurance was "If you pay an amount of money to an insurance company regularly every month it is expected to be compensated by that company in case of a disaster". The majority of participants stated the right definition on the insurance, however they did not understand the concept of risk-pooling and the larger the number of the insured clients the more effective the scheme is. The data indicated that even business owners with a higher level of education lacked in-depth knowledge about the concept.

When asked what financial strategies they used in case of disasters, they answered that the losses were mainly covered by their personal savings, family support and even debts. "*Thanks to my personal savings, support from my family and relatives I have managed to partially cover the damages*". Another answer given by the participants was that "*It is a responsibility of the government to cover my losses in case of disasters*". This concept is inherited from the previous socialist system were the government was expected to control and cover totally any kind of losses. Participants explained that they used their savings to cover damages as they did not trust insurance companies and as a result they refrained from buying insurance. In most cases they said that the little precautions they could take were just the reallocation of goods to the second floor of their premises.

Some participants ignored the idea of precautions for managing disasters and they explained it that they have no power to prevent a disaster "*...it is God's will which decides my destiny*".

When they were asked how their education affected the decision of buying insurance their response was: "*Even though I have had secondary school education, no such information was given to us in school*". As calculated from the interviews most of the participant, 86% of them had a secondary school education while only 14% had attended university. Although some of the participants had sufficient means to pay the premium they still did not choose to do that as they either did not trust the insurance companies or because there is no law enforcement to make them insure their property. Only one of the participants stated that he had bought any property insurance when it was a requirement to do so from the debt financial institution.

From the study findings it was noticed that 3 of the participants justified their refusal to buy insurance because the insurance agents had no sufficient education to explain the benefits of insurance products and instead of "*…persuading us to buy the product they make the impression on us that they are just thinking of making their own profit*" Meanwhile the other participants claimed that insurance companies had not undertaken any awareness-raising campaigns in their area regarding insurance. "*They have never ever knocked on our doors to make us aware of the necessity of buying insurance. There have been no TV spots or any programs on the benefits of insurance in case of disasters*"

Lack of trust has been one of the main factors that people have not uptaken insurance strategies. "*I do not expect to be compensated for the losses from the disasters even though I might have bought insurance*". Schneider (2004) [18] stated that the lack of trust in insurance companies affects negatively the demand for insurance.

5. DISCUSSIONS

Climate-related risks such as floods, droughts, earthquakes, and fires have continued to increase in poor countries undermining their resilience to absorb the loss and recover from effects such as decreasing economic development and sustainability and increasing diseases [24]. Natural disasters in Albania have had a big economic and financial impact. The total sum of registered losses in the last 20 years is 92 mln $, in an average of 0.026% of GDP [22]. Insurance products enable businesses to transfer risk and benefit from risk reduction. However, the insurance market is very limited in developing economies like Albania which has the lowest density and penetration rate on insurance market in WBC ([19], [20]).

During the semi structured interviews it was found that managers had little to no information about property insurance as a financial resilience means in case of disasters. This finding is consistent with findings of Cole et al. (2013) [7], who argued that insurance products are complex and as a result individuals with little financial education face difficulties in understanding the logic. Risk-pooling and risk diversification is the crucial element of insurance and lead to success. It is indispensable for the businesses to understand the concept of risk-pooling, risk spreading, and risk transfer mechanism so that they can take advantage if the financial strategy.

Financial literacy has proven to be the right path that leads to insurance demand. This conclusion was drawn during the study which participants reflected low level of financial education. This supports the findings of Chan, K. L., & Chan, (2011) [5] who suggested that expected participants with higher financial education level would understand insurance better and have a positive perception than people with a low level of financial literacy. As per Ioncica et al., (2012) [12] the more educated consumers are, the more they are convinced on the necessity of protection of life, health, and properties, and the more likely they are to purchase insurance as a tool of risk transfer.

The results of the study showed the best strategy to deal with losses in case of natural disasters, were savings and debts from financial institutions or relatives. This finding has been also mentioned by Bayer and Mechler (2009) [3] underlining that when the government assistance and international aid are missing, those who experience natural disasters try to cope with the losses by borrowing money from kin relatives, selling their assets etc.

Findings from the study indicated that Albanians doubt whether their payments to insurance companies are used to their benefit or not. The study results showed that if managers and SME owners are convinced that insurance companies will guarantee and make their payments claims in time, they would purchase property insurance. This result is consistent with the findings of Akotey et al (2011) [2] who confirmed in their study that trust is a very important variable that influences the insurance demand.

6. CONCLUSIONS AND RECOMMENDATIONS

The goal of the study was to evaluate the perceptions of the small enterprises in Albania on disasters and how they cope with them in terms of financial strategies. Relevant factors emerged from the analysis, which seemed to have significant value on the decision on purchasing insurance or not are:

Lack of educational awareness on the benefits of insurance affects one's ability to make an informed insurance purchase decision. The majority of the participants in the study indicated that there has to be more insurance education to increase awareness and insurance providers should provide reliable information and products. This finding suggests that governments and other relevant institutions should include insurance education as part of schools curricula. On the other hand this finding might encourage insurance companies and "*Financial Supervisory Authority*" to provide *Life Long Learning* programs about property insurance for SME and their managers.

Lack of trust was one of the main factors which had a negative effect on purchasing insurance. Government should protect the consumer by ensuring that insurance contract is compiled in clear, understandable content for the consumer. Government should mandate insurance from all companies despite the fact that they may or may not experience any natural disasters. The risk pool can be increased by the increase of the insured clients and type of risks and in this way the cost of insurance is lowered and the government expenditure and foreign aid after a catastrophic disaster are reduced.

Insurance providers can build trust by demonstrating professional expertise, responsiveness to policyholders, and ensuring quality claim handling processes to policyholders.

The results of the study may serve as a source of information about how people's perceptions about insurance affect its demand in Albania and provide recommendations that suggest ways to improve the perception of insurance. The recommendations include formulating strategies and policies to increase insurance awareness among businesses owners and managers, as well as adoption of principles and practices that may promote and improve the image of insurance in the public eye.

This study has been an initial attempt that led to the identification of some findings which were also confirmed by international literature. However it is considered that this study can be extended further to identify other factors if it is undertaken at a broader geographic scope and increased sample size. Researchers may examine the relationship between an individual's marital status, gender or age, religion, cultural group, level of incomes and their ability to purchase or not purchase insurance.

7. REFERENCES

[1] Adamba, C., & Owus, A. Y. (2011). Burden of buruli ulcer: How affected households in a Ghanaian district cope. African Study Monographs .

[2] Akotey et al, O. J. (2011). The demand for micro insurance in Ghana. The Journal of Risk Finance.

[3] Bayer , J. L., & Mechler, R. (2009). Insurance against Losses from Natural Disasters in Developing Countries, DESA Working Paper No. 85

[4] Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3 (2). pp. 77-101. ISSN 1478-0887 Available from: http://eprints.uwe.ac.uk/11735

[5] Chan, K. L.,, & Chan, A. (2011). Understanding industrial safety signs: implications for occupational safety management. Industrial Management & Data Systems, 111(9):1481-1510, September 2011

[6] Churchill, C. (2006). Protecting the Poor, A microinsurance compendium.

[7] Cole, S., Giné, X., Tobacman, J., Topalova, P., Townsend, R., & Vickery, J. (2013). Barriers to Household Risk Management. American Economic Journal: Applied Economics , 5.

[8] Pettus-Davis, C., Grady, M. D., Cuddeback, G. S., & Scheyett, A. (2011). A Practitioner's Guide to Sampling in the Age of Evidence-Based Practice: Translation of Research into Practice. Clinical Social Work Journal, 39(4), 379-389. DOI: 10.1007/s10615-011-0345-2

[9] Flick, O. (2009). An Introduction to Qualitative Research.

[10] Geisbert, L. (2012). Subjective Risk and Participation in Micro Life Insurance in Ghana, GIGA Working Papers

[11] INSTAT. (2016). Statistics on Small and Medium Enterprises, 2016.

[12] Ioncică, M., Petrescu, E.-C., Ioncică, D., & Constantinescu, M. (2012). The Role of Education on Consumer Behavior on the Insurance Market. Procedia - Social and Behavioral Sciences .

[13] Kulatunga, U. (2010). Impact of Culture towards Disaster Risk Reduction . International Journal of Strategic Property Management .

[14] Langat, W. K., Naibei, I., & Machogu Getare, C. (2017). Determinants of Insurance uptake in developing countries: Evidence from CIC insurance, Kericho Branch, Kenya. International Journal of Scientific and Research Publications .

[15] Lehtonen, T.-K., & Liukko, J. (2011). The Forms and Limits of Insurance Solidarity. Journal of Business Ethics , 103, 12.

[16] Meze-Hausken, E., Patt, A., & Fritz, S. (2009). Reducing climate risk for micro-insurance providers in Africa: A case study of Ethiopia.

[17] Pojani , E., Luci, E., Grabova, P., & ĆIRIĆ, D. (2017). Financing Means For Disaster Risk Management - The Case Of Albania Financing Means For Disaster Risk Management - The Case Of Albania, 1st INTERNATIONAL SYMPOSIUM K-FORCE 2017 Knowledge FOr Resilient soCiEty, Novi Sad, 2017

[18] Schneider, P. (2004). Why should the poor insure? Theories of decision-making in the context of health insurance. NCBI .

[19] Sharku, G. (2016). Comparative analysis of insurance industries in the countries of Western Balkan. Working paper.

[20] Sharku, G., & Shehu, S. (2016). Concentration of Albanian Insurance Market. Ekonomika a management. , 2016 (3).

[21] Stevens-Benefo, H. (2015). Perceptions of Home and Small Business Owners on Insurance in Accra, Ghana. Walden Dissertations and Doctoral Studies.

[22] Toto, E., Deda, M., Rosello , L., Rubado, D., & Gomes, I. (2013). Collection of historical data on disaster losses in Albania. UNSIDR, Cima International Centre On Environmental Monitoring.

[23] UNISDR. (2013). World Risk Report.

[24] Warner, K., Ranger, N., Surminski, S., Arnold, M., Bayer, J., Michel-Kerjan, E., i drugi. (2009). Adaptation to Climate Change: Linking Disaster Risk Reduction and Insurance. UNISDR.

[25] World Bank. (2017). Europe and Central Asia: Country Risk Profiles for Floods and Earthquakes. World Bank .

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INSURANCE AND DISASTER RISK MANAGEMENT: REDUCING VULNERABILITY AND RISK

Abstract: Financial instruments have been recognized as an important mechanism for the disaster risk management in the field of climat change adaptation. This paper analyzes the importance of insurance as a financial instrument for reducing the socio-economic vulnerability of societies to the impacts of natural disasters caused by climate variability. Inovative insurance solutions have been recognized as a chance for developing countries, in their struggle and efforts to reduce poverty and adapt to constant climate variability.

Key words: Risk, Climate variability, Reducing vulnerability, Risk transfer, Insurance

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1. INTRODUCTION

Potential changes in climate variability are well recognized as a major social concern. Natural disasters, impacting on societies and economies over the last two decades, are constantly increasing and, obviously, it is very likely that this trend will continue, as a result of two complementary reasons: first, it is expected that climate change could increase intensity and frequency of weather related events, and second, financial consequences of natural disasters are increasing due to socio-economic development that include increase of values and growth of population and settlement that are exposed to weather extremes. In the face of predicted growing weather extremes and profound shifts in natural systems, the need is greater than ever to support the most vulnerable people and countries in finding effective strategies to manage risks and unexpected shocks and to build resilience to climate impacts. [1] The need to enhance action to reduce the risk of climate change and manage residual impacts has been recognized in many international agreements and frameworks that guide policy agendas and set the stage for shaping "the trajectory of resilience and sustainable development for the coming decades". [1]

Financial instruments, such as insurance, have been recognized as an important mechanism for the decrease of socio-economic vulnerability of societies. Disaster risk financing and insurance solutions provide efficient means for countries to financially protect themselves from natural disasters as well as foster disaster risk management efforts.[2] This strategies allow countries to increase their financial response capacity in the aftermath of disasters and to reduce the economic and fiscal burden of natural disasters by transferring excess losses to the private capital and insurance markets.[2] Thus, insurance and financial markets have a significant role in prevention and mitigation of the effects of climate change, and also may have a key role in recovery process.

2. VULNERABILITY AND RISKS OF CLIMATE VARIABILITY

Climate on the Earth is constantly changing and it shows the natural variability through the time. Until the beginning of the industrial revolution, the climate was changing as a result of changes in natural conditions. Today, however, we use the term of climate change when we want to talk about changes in climate that have occurred since the beginning of the twentieth century. The changes that have been registered in previous years, and those that are anticipated, are consider that emerge as a result of human activities, not only as a result of natural changes in the atmosphere.

Potential changes in climate variability in sense of increase of the frequency or intensity of extreme events, are well recognized as a major social concern. The consequences of weather pattern change are often extreme and they reflect, through extreme weather events, in all spheres of life. They have impact on the environment, communities and economies, both at global and local level. People are all vulnerable to extreme weather conditions, directly or indirectly through bounds to each other.

For a long time, technical responses to natural hazards have been considered as a key role in disaster risk management, but recently attention has shifted to vulnerability and how disaster risk reduction can reduce vulnerability to extreme events.

Vulnerability to extreme events is measured trough expected damage, but also is the risk. Hazard frequency and magnitude indicate that we are talking about risk and not vulnerability. The most widely accepted theory is that risk is probability of harmful consequences or losses resulting from a given hazard over a specified time period.[3] But, from the standpoint of extreme weather conditions, disaster risk must be viewed as a function of hazard, vulnerability, exposure, and resilience.[4]

Vulnerability to weather events and disasters is result of multitude environmental, social, economic and political factors which leave marks on different levels and in combination whit each other affect vulnerability. Generally, vulnerability to extreme event can be defined as capacity level of natural or social system to cope with a specific hazard, as a result of the impacts of environmental change or extreme event, depending on their nature, structure and exposure to hazard, as well.[4]

Possible effects of weather extremes cannot be understood without knowing social, economic and cultural background of some community. Every disaster starts with a hazard, but hazard per self cannot make disaster. Context in which hazards appears leads to catastrophical consequences. Without people there is no disaster event. In that sense, when analysing the vulnerability of areas at risk, special attention should be focus on the analysis of socio-economical vulnerability.

2.1. Social aspects of vulnerability to weather-related risks

Technical responses related to natural hazards and climate impacts historically have been considered very important, still, over the past decades attention suddenly has shifted to a focus on vulnerability of society. Particular attention is given to reducing vulnerability to climate variability, hazards and extreme events through climate change adaptation and disaster risk reduction.

Social vulnerability is differentiated between and within groups through their institutional and economic position. Variability in social vulnerability comes with changes in living standard (it is likely that vulnerability will be less if there are adequate and sustainable life standard) and poverty appearances or reduction (poor population groups are more vulnerable and less able to recover from catastrophic event).

Institutional and political dimensions are also important in contextualizing socio-economic vulnerability, in sense of public amenities lack, or regulatory gaps and deficiencies on part of government, etc.

2.2. Economic aspects of vulnerability to weather-related risks

Except the strong influence of global warming and extreme weather conditions on realization of catastrophic events that threaten human lives and have a strong social influence, these events cause enormous financial losses. Accordingly, global economy are under influence of climate change, and therefore under the influence of weather related risks. Climate change affects the social wealth, availability of resources, energy cost and companies value. Through impact on the availability of raw materials, continuity of production, damage and destruction of production facilities, climate change has an effect on the capital market and stock prices.

According to Stern's report [5] on the impacts of climate change on the economy, predictions are that extreme weather conditions could cause the fall GDP for about 1%, and further increase of temperature by 2 to 3 Celsius degrees could reduce the total global economic output for 3%. If temperature increases for 5 Celsius degrees, this reduction could be around 10% and in the worst-case scenario, a total global consumption per capita could decline by 20%, which would have farreaching negative economic consequences.

The societies that are the most vulnerable to the effects of climate change i.e. weather-related risks are those located in coastal areas and rivers' deltas. But, at the same time, also areas whose economies depends on resources sensitive to climate change and areas exposed to extreme weather conditions, all stressed by process of accelerated urbanization.

3. VULNERABILITY REDUCTION: POSSIBLE ROOLE OF INSURANCE

If natural disaster is an intersection of two opposing strength, processes that generate socio-economic vulnerability (pressure) and appearance of natural hazards (physical exposure), then the idea of disaster mitigation is built on next assumption: pressure can be released on those exposed to risk only by decreasing or eliminating vulnerability.

Holistic management of disaster risk requires action to reduce impacts of extreme events before, during and after they occur, including technical preventive measures and aspects of socio-economic development designed to reduce human vulnerability to hazards. [6]

Managing weather-related risk and therefore also reducing vulnerability can be done using several techniques: risk retention, risk reduction, risk prevention, transferring risk, before disaster occurs and transferring risk, after disaster occurs. One of these techniques is particularly different from other risk management techniques. That is risk transfer, before disaster occurs and refers to risk management through insurance.

Which technique to use, differs from risk intensity. Also, they differ on timescale. Pre-event disaster risk reduction measures are adequate for low and middle layer risk. For high level risk, risk transfer is required (Figure 1).

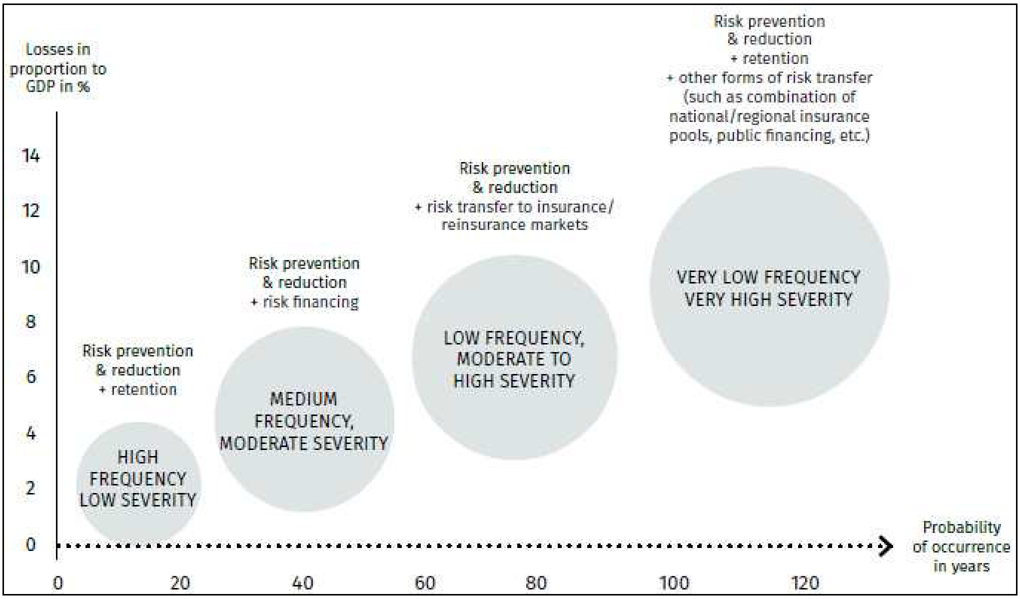

Figure 1. The risk-layering approach [1]

It is very important to notice that both, communities and households benefit when they predict and manage weather-related risks before they occur and cause losses.

3.1. Insurance as a vulnerability reduction financing tool

Risk transfer instruments refer to those adaptation measures aimed at limiting the financial impact of disasters on people by distributing the risk to other players in the market.[1] Risk transfer instruments are particularly effective in the case of low-frequency and high-severity events and are based on transferring part of the risk to a third party (e.g., an insurance and/or reinsurance company or the capital markets), and include both traditional insurance products and alternative risk transfer instruments (e.g., cat bonds).[1]

In its role as risk manager, risk carrier and investor, insurance have been recognized as an important mechanism for the decrease of socio-economic vulnerability of societies exposed to natural hazards. International milestones on disaster risk reduction [7], finance for development [8], new sustainable development goals [9] and a new climate change agreement [10] provide the context for strategic reflection on the policies and partnerships necessary to realize the full potential of insurance.

Insurance is preventive but also and corrective measure. The main principle of insurance is risk dispersion in space and time. Risk is transferring from individual to professional insurer. By insurance policy between the insurer and the insured, known as the policyholder, insurer undertakes that will compensate losses that may or may not occur. From that viewpoint, insurance is preventive measure for individuals. Still, if insured event occurs, insurance indemnity will cover the loss and facilitate recovery process.

The essence of insurance, as an economic category, is that the owners of assets, who are exposed to certain risks, are joining, directly or indirectly, for the purpose of joint damage risk carrying, that eventually, could strike one of them, due to realization of a risk. Insurance has three fundamental functions: assets protection; financial function and social function. [11] By knowing these functions and principles of insurance, it is very easy to link insurance with disaster risk reduction and to comprehend benefits from that connection.

Insurance provides security opposite to economic shocks that occurred as a result of droughts, floods, earthquake, tropical cyclones and other weather extremes. The benefits of insurance, as a financial instrument, offer the possibility for developing countries to reduce poverty and to adapt to climate change. It also creates new business opportunities. New mechanism for transfer of catastrophic risk to global financial markets is opening new perspectives for reinsurers.

In terms of reduction of weather-related risk with catastrophic consequences, insurance activities need to be realized as part of a climate risk management strategy that includes activities that prevent human and economic losses from climate variability and extremes (Figure 2). The *Bali Action Plan* [12] calls for “consideration of risk sharing and transfer mechanisms, such as insurance” to address loss and damage in countries particularly vulnerable to climate change, i.e. developing countries.

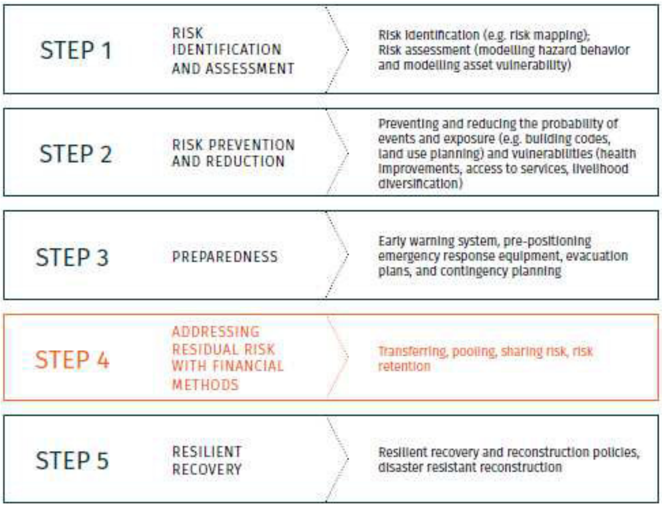

Figure 2. Insurance in the process of comprehensive climate risk management [1]

3.2. Insurance for developing countries vulnerability reduction

Possibilities for developing countries, if they incorporate insurance process of adaptation to climate change, are numerous, but still insufficient for all challenges that they are facing to. Slow climate impacts such as desertification or a sea-level rise are foreseeable and generally not suiteable for insurance companies. These foreseeable risks need to be addressed as prevention issue. Additional risks, such as floods and storms can and must be addressed to insurance.

In order to ensure that climate risks insurance became more accessible to the poor in developing countries, Index Insurance has been developed. Index Insurance is a good mechanism for reducing vulnerability to natural disasters in developing countries, where other, traditional insurance products are not always applicable, due to the underdevelopment of the insurance market, or because of the inaccessibility of financial mechanisms for managing risk from poverty. [1]

Index Insurance is most often used in agricultural insurance and has been developed as an alternative to traditional yield insurance of a number of risks. However, it is also applicable to insurance of property and investments from the consequences of natural disasters.

Unlike traditional insurance based on loss assessment and payouts after an extreme event occurs, Index Insurance pays out the agreed sum insured after an index has been triggered by exceeding a predefined threshold (e.g. a certain air temperature over a period of time or a certain amount of precipitation).

Index Insurance not requiring a claims assessment process. Insurance contracts are transparent and operating costs are considerably lower than for traditional insurance. The possibility of adverse risk selection and the emergence of moral hazard is completely excluded. Accordingly, considerable funds have been saved. This creates the conditions for reducing insurance premiums and therefore increases the availability of insurance in those environments where the insurance market is not sufficiently developed or not at all.

4. CONSLUSION

Insurance solutions have been recognized as one of the basic instruments for adapting to climate change and reducing the impact of natural disasters on exposed societies. Well-designed insurance instruments can provide powerful incentives for reducing risks and also societies vulnerability to weather variability. By reducing the effects of climate variability and extremes on national economies and providing security to escape poverty, insurance could have critical role in climate change consequences mitigation. All insurance and disaster risk management related activities can be take up as an important component that contributes to the sustainable development goals, as well as the quality of life on individual and population level. Accordingly, insurance must be seen as part of climate risks management and climate change adaptation strategy, which means, above all, actions that prevent human and economic losses due to weather extremes.

5. REFERENCES

[1] Schäfer, L., Waters, E., Kreft, S., Zissener M. (2016). *Making climate risk insurance work for the most vulnerable: Seven guiding principles.* United Nations University, Institute for Environment and Human Security

[2] *Disaster Risk Financing & Insurance in the Disaster Risk Management Framework* (2012). Avaliable at: http://siteresources.worldbank.org/FINANCIALSECTOR/Resources/Insurance_DRFI&DRM_Concept.pdf [accessed August 2018]

[3] Schneiderbauer, S. and Ehrlich, D. (2004). *Risk, Hazard and People's Vulnerability to Natural Hazards. A Review of Definitions, Concepts and Data.* European Commission Joint Research Centre (Ed)

[4] Thywissen, K. (2006). *Components of Risk: A Comparative Glossary*. United Nations University – Institute of Environment and Human Security, Bonn, Germany

[5] Stern, N. (2006). *The Economics of Climate Change.* Office of Climate Change, HM Treasury, London, UK

[6] Few, R. et al. (2006). *Linking climate change adaptation and disaster management for sustainable poverty reduction.* Synthesis Report for Vulnerability and Adaptation Resource Group

[7] *Sendai Framework for Disaster Risk Reduction 2015 – 2030.* (2015). Third United Nations World Conference on Disaster Risk Reduction, Sendai

[8] *The Addis Ababa Action Agenda on Financing for Development* (2015). Available at: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/69/313FFD [accessed August 2018]

[9] *The UN Sustainable Development Goals* (2015). Available at: https://www.un.org/sustainabledevelopment/sustainable-development-goals_ [accessed August 2018]

[10] *The Paris Agreement* (2015). Available at: http://unfccc.int/files/home/application/pdf/paris_agreement.pdf [accessed August 2018]

[11] Avdalović, S., Avdalović, V., Ćosić, Đ. (2010). *Osnove osiguranja sa upravljanjem rizikom*. Novi Sad: Faculty of Technical Science

[12] UNFCCC (2007). *Report of the Conference of the Parties on its thirteenth session.* Available at: https://unfccc.int/resource/docs/2007/cop13/eng/06a01.pdf [accessed August 2018]

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DISASTER RISK MANAGEMENT AT LOCAL GOVERNMENTAL LEVEL, EVIDENCES FROM ALBANIA

Abstract: The necessity for natural hazard risk management has significantly increased over the last years, as an important issue for achieving sustainable development. Several studies reveal that disaster management requires effective community-based strategies which include programs and measures to prevent, prepare, mitigate and recover from the impacts of disasters. In recent years, research in disaster risk management is focused in the local governmental level. However, local government units in Albania lack sufficient knowledge about disaster risks and vulnerabilities of their communities. The aim of this paper it to give an insight of how local government units in Albania operate regarding disaster risk management and to come out with recommendations on how to affectively use the right local mechanisms for disaster risk reduction, including financial and institutional incentives for a multi-level cooperation.

Key words: disaster risk reduction, local government, institutional arrangement.

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1. INTRODUCTION

Disaster risk management is an important issue for achieving sustainable development of cities, taking into account the fast growing of urban areas and the fast population expansion. It is defined as the systematic development and application of policies, strategies and practices to reduce disaster risk. Making cities resilient is a complex task, which requires collaborative efforts of various stakeholders, including: decision makers, community groups, private sector, civil society and academia. The ability of governments and civil organizations to prevent risk and deal with disasters and chronic vulnerability depends on wider social and political conditions that include planning capacity, the normative institutional environment, chains of responsibility and penalties for noncompliance with planning regulations (Ruiz-Rivera and Melgarejo-Rodríguez, 2017). Several studies reveal that disaster management requires effective community-based strategies which include programs and measures to prevent, prepare, mitigate and recover from the impacts of disasters. Following this argument, in recent years, research in disaster risk management is focused in the local governmental level.

According to the UNDP studies, the active commitment and leadership of a local government is important for the implementation of any local disaster risk reduction measures to deal with different stakeholders and multiple layers of government. As the most immediate public service provider and interface with citizens, local governments are naturally situated in the best position to raise citizens' awareness of disaster risks and to listen to their concerns. Even the most sophisticated national disaster risk reduction measures (such as early warning systems) may fail, if communities are not properly informed and engaged (UNDP, 2010). As the governmental body responsible for the long-term development and viability of its area, a local government is required to consider and institutionalize disaster risk reduction in its day-to-day operations, including development planning, land use control and the provision of public facilities and services.

Albania is exposed mainly to natural hazards including those of hydro-meteorological and geological origins, such as earthquakes, floods, droughts, forest fires and landslides. The Directorate General for Civil Emergencies (DGCE) is responsible for undertaking national disaster risk assessments and coordinates with the line ministries and institutions that have responsibility for the respective sectorial risk analysis, development strategies and integrated plans. At the local level, the prefectures and municipalities are responsible for their own risk assessment and planning. At present, Albania is working towards the inclusion of disaster risk reduction (DRR) in the legal and institutional framework and transitioning from a reactive to a more proactive disaster risk reduction orientated approach (FAO, 2018). According to DGCE increasing and changing risk in Albania is due to the current rapid economic development in certain parts of the country and growing inequalities in others. It is reflected in the impact of recurrent floods and forest fires. Un-realized risk in Albania, such as the risk to earthquakes - that will occur in the future - need to be factored in the national economic projections as well as emergency and rescue service plans (National Strategy for DRR, 2014). However, as suggested from previous studies, local government units in Albania lack sufficient knowledge about disaster risks and vulnerabilities of their communities as well as appropriate disaster risk reduction measures and tools.

The aim of this paper it to give an insight of how local government units in Albania can affectively use the right mechanisms for disaster risk reduction, including financial and institutional incentives for a multi-level cooperation. The first sections of the study present the theoretical framework and literature review for the disaster risk management at local level and the background of institutional arrangements in Albanian administrative structures regarding DDR planning and response. Through assessing the current situation in local disaster risk incentives in Albania, and comparing with best practices provided by international institutions and organizations, we come out with recommendations and conclusions on how local government units can improve their measures toward disaster risk reduction.

2. LITERATURE REVIEW

The necessity for natural hazard risk management has significantly increased over the last few decades (World Bank, 2014). Researchers, policy-makers and practitioners increasingly seek to use risk modelling to access the consequences for hazard scenarios that people are exposed to but have little historical information about (Crawford et al. 2018). According to Pondard and Daly (2011), risk modelling can give a more comprehensive insight into natural hazards and their socioeconomic consequences. They point out three key benefits: a) clearer overview of geographical concentrations of natural hazard risks, across different frequencies and magnitudes; b) calculation of potential physical damage, business influences and casualties; and c) identification of key risk drivers. At the same time, higher attention is directed towards studies aiming to address the policies and governmental strategies for the disaster risk management at the local level, as the responsible tier of government for addressing communities' needs and being closer to citizens (Anguelovski and Carmin, 2011).

With local governments increasingly taking an important role in the sustainable development, the need for globally comparable knowledge of disasters risks has gained higher importance (Amaratunga et al. 2017). Disaster risk reduction has become a global strategy for making cities more resilient. Risk reduction at the local scale is the result of environmental factors, social characteristics, and institutional arrangements and regimes, and it depends on contexts and interactions at different scales (Young, 2002a). Disaster risk reduction and resilience building require a team effort that incorporate efforts of: local government, academia, citizens, community groups, private sector /business communities, professional groups, civil society, nongovernmental organizations, national government authorities and parliamentarians, and international organizations (UNISDR, 2012b). However, it is the responsibility of local government units to lead the implementation of disaster risk reduction and resilience building programs and turn such efforts into realistic outcomes.

Disaster governance is particularly challenging in small cities, communities with vulnerable urban population where disaster management institutions, knowledge, and capacity are often lacking (Rumbach, 2016). For this reason, more efforts must be put in disaster risk management practices to improve disaster governance in small cities, by closing the distance between citizens and their government and by improving local governance capacity. The decentralization literature argues that decentralization policies may lead to better outcomes, strengthening legal, administrative, and financial capacities of municipalities for disaster risk management (Ribot, 2002; Twigg, 2004). Study work of Valdivieso and Andersson (2017) concludes that knowledge about the barriers and opportunities for disaster risk management will be enriched if we try to better understand through institutional analysis and a multisystem perspective how local governments make their decisions and how institutional arrangements generate incentives for decision makers.

In the international context, the term disaster risk reduction refers to a complex series of public actions covering both prospective, preventive and reactive actions in sectors such as health, land use, ecosystem conservation and social development (Ruiz-Rivera and Melgarejo-Rodríguez, 2017). A decentralized risk management system, where local actors carry out a relevant role, may constitute a very effective way of reducing disasters in the region (Bollin et al. 2003). According to the study of Bollin et al. (2013) it is suggested that local governments should encourage the population's awareness of natural disasters, with the purpose of developing a culture of prevention and encouraging their participation in risk management. In this context, in order to achieve the goal of participation in disaster risk management, several local actors may be involved of both the public and private sectors. Other studies (Amaratunga et al. 2017) also conclude that it is important to focus on reducing the risks associated with urban areas and to make necessary structures, systems and capacities at local level to withstand the disaster risks.

In the context of disaster risk management in Albania, the studies are only recent and there is a lacking of elaborate data and information in the literature. However some of the studies are focused in financial issues such as insurance of natural hazards and further financial aspects in the macro level (Lito, 2013; Pojani et al., 2017). According to previous work there is evident an ongoing gap between legal provision obligations and the mechanisms for implementation of disaster risk reduction measures. In addition, studies in the local level for Albania are almost nonexistent, which increases the importance for further analytical work in the direction of how local government units can improve the disaster risk management by taking preventing measures and building capacities for resilience.

3. CONTEXT AND BACKGROUND OF THE STUDY

3.1. Natural hazard exposure in Albania

The four main hazards affecting Albania are: floods, earthquakes, forest fires and snowstorms. Other hazards include landslides, drought, epidemics, avalanche, tsunami, technological hazards, dam burst and storms. Albania ranks 41st in the world in terms of vulnerability to landslides, 43rd in terms of earthquakes and 58th in terms of drought risks (UNISDR, 2009). Increasing and changing risk in Albania is due to the current rapid economic development in certain parts of the country and growing inequalities in others. The two main hazards are explained further in the next paragraphs (information taken from the National Strategy on DRR, 2014).

Albania is characterized by a high rate of seismicity. Albania, together with Greece, Montenegro, Macedonia, southern Bulgaria and western Turkey (all located in the same region), experience almost annual occurrences of at least one earthquake of magnitude ≥ 6.5. Albania is characterized by intense micro ($1.0<M\leq3.0$), small ($3.0<M\leq5.0$) and medium-sized ($5.0<M\leq7.0$) earthquake activity, and rarely by large ($M>7.0$) earthquake events. Tirana accounts for more than one quarter of the urban seismic risk, perhaps considerably more if the official population is an underestimated figure. The seven largest cities at risk in Albania account for more than 75 percent of the urban risk (UNDP, 2011). The annual average population affected by earthquakes in Albania is about 200,000 and the annual average affected GDP about $700 million. The annual averages of fatalities and capital losses caused by earthquakes are about 50 and about $100 million, respectively. The fatalities and capital losses caused by more intense, less frequent events can be substantially larger than the annual averages (World Bank, 2015).

The Albanian river system poses the highest risk of flooding to the country, generally of pluvial origin. The hydrographic basin encompasses an area of 43,305 km2, of which 14,557 km2 belong to the watersheds of the Drini and Vjosa rivers, which encompass parts of Greece, Macedonia and Kosovo. The eight main rivers in Albania are grouped into six watersheds that transverse the country from east to west. Their mean annual discharge is 1,308 m3/sec, which corresponds to the discharge of 30 m3/sec/km2. Floods are more frequent during the November–March period, when the country receives about 80–85 percent of its annual precipitation. Due to topographic patterns, these floods occur rapidly after water has run through the main river hydrographic network for around 8–10 hours. The annual average population affected by flooding in Albania is about 50,000 and the annual average affected GDP about $200 million. Within the various provinces, the 10- and 100-year impacts do not differ much, so relatively frequent floods have large impacts on these averages (World Bank, 2015).

3.2. Local government structure and decentralization of power

Local government in Albania is organized in two tiers: the first tier includes 61 municipalities as the basic unit of local government; the second tier includes 12 regions (qark). The establishment and functioning of the local government in Albania is determined by the Constitution of Albania, the European Charter for Local Self-Government and the Law "On the Organization and Functioning of Local Government". These documents provide a clear definition of governance levels in Albania and how they function. Local government units are organized into constituent administrative units (former communes) as their administrative subdivisions. Tirana has 24 administrative units (11 municipal units and 13 former communes). From the urban planning viewpoint, municipalities will continue to be organized in towns and villages. Prior to the implementation of the law on the New Administrative and Territorial Reform (Law No. 115, 2014), Albania was divided into 308 communes and 65 municipalities in the first level and 12 regions (qark) in the second level.

Demographic changes and the democratic processes that took part in Albania beginning in 1990, have presented non symmetrical developments within different local government units, conditioned also by the concentration of economic enterprises and activity in more central cities or regions. There have been major incentives for a successful decentralization process, not only in the financial aspect but also in the decentralization of power. The decentralization reform has progressed during 1999 and 2000, based on the Constitution (1998), the European Charter for Local Self-Government (ratified in November 1999) and the National Decentralization Strategy, adopted in 1999. The most important specific step was the approval and implementation of the Law No. 8652 of 31 July, 2000, “On the Organization and Functioning of Local Government”, which sanctions the rights and authorities of the local governments units in conformity with the Constitution and the

European Charter for Local Self-Government, and which was followed by other laws regulating the activity of the local government and consolidating the autonomy (Ministry of Finances, 2015). Since 2005, municipalities are responsible for the water and sewage service, as part of granting the right to administrate and develop public assets of local government. Even though progress was achieved in these years, fiscal autonomy of local government still remains a challenge. Local authorities do not have appropriate financial resources and they are depended on transfers from the central government budget (Kapidani, 2018).

4. DISASTER RISK MANAGEMENT AT LOCAL LEVEL IN ALBANIA

4.1. Institutional arrangement for disaster risk planning and response

Municipalities, as the basic unit of local government, have responsibility for preparedness, planning and undertaking civil emergency response for situations developing in their territories. The Mayor and Head of Administrative Unit (former commune) are responsible for civil emergency planning and crisis management within their respective municipality and administrative unit. Prefects in the Qarks (regions) are responsible for planning and coping with civil emergencies at regional level. Under the chairmanship of the prefect, the Commission of Planning and Responding to Civil Emergencies is established whose task is coordination of activities of the regional authorities and voluntary organizations for planning and coping emergency. The 12 Qarks of Albania have one full-time civil emergency officer.

Under the chairmanship of the mayor or the head of commune, the Commission of Planning and Responding with Civil Emergencies is established, and its main task is to coordinate all activities of the local government unit and voluntary organizations, responsible for planning and responding to emergencies. Municipalities have their own civil emergency officers who are currently under the legal department. These officers have no decision power in terms of disaster management. The exception is the municipality of Tirana, which has its own department for civil emergencies (constituted of 11 sub-municipalities or units) – providing the municipality with the authority for decision-making. Many municipality authorities have mentioned the need to have this same prerogative extended to them (National Strategy for DDR, 2014).

According to the National Civil Emergency Plan (2004), every municipality and administrative unit, including the municipal units of Tirana, establishes and maintains a system of: a) early warning and notification of key structures; b) alarm and evacuation of population; c) squads and other active structures prepared to prevent, mitigate and respond to civil emergency situations; d) undertake and administering rehabilitation activities for the affected area. While there are governance systems, structures and legal provisions in place at the national and local level, Albania's approach to disaster risk is largely focused on preparedness and response.

4.2. Risk assessment at municipal level

As it was explained in the first part of the paper, two main natural hazards for the Albanian economy are floods and earthquake, based on the frequency of occurrence and the financial damages. According to the study conducted by the World Bank study (2015), the main region affected by floods is Shkodër district, with an annual average of 14% of GDP. The region with the higher level of earthquake damages is Fier, with an average of 9% of affected GDP. However, the potential for greatest annual average capital losses in the future and highest annual average numbers of fatalities, as determined using an earthquake risk model by World Bank, occurs in Tiranë, given the economic importance of the province. Results are presented in table 1. As it results from the assessment of municipal framework, in the local administration there is evident a high focus on disaster response and recovery situations and there is an almost indifferent attitude towards disaster preparedness and prevention. This issue should be addressed in order to have more effective results on disaster risk management.

Table 1. The most affected regions by main natural hazards, World Bank 2015.

Floods		**Earthquakes**	
Annual average of affected GDP (%)		Annual average of affected GDP (%)	
Shkodër	14	Fier	9
Mirditë	10	Lushnje	8
Përmet	10	Tiranë	7
Tepelenë	8	Durrës	7
Lushnje	5	Kuçovë	7
Fier	3	Delvinë	7
Dibër	3	Kavajë	6
Kurbin	2	Gjirokastër	6
Tropojë	2	Vlorë	6
Mallakastër	2	Kurbin	6

Regarding flood risk assessment, the legal framework is not clear, with many overlaps and gaps especially when it comes to the shared responsibility between the Ministry of Agriculture and the Ministry of Environment. At the local level, drainage boards do not have the technical capacity to carry out flood risk assessments, which as a result are more focused on the implementation and management of flood protection infrastructures. Municipalities do not perform disaster risk assessments and it has been noted that there is no real spatial planning process available at a local level (WMO, 2012). In general, the disaster response and planning capacity at municipality levels is very weak and therefore support from the central government level is required to enhance disaster response as well as DRR related capacities (FAO, 2018).

4.3. Considerations on disaster risk measures at local level

National and local authorities in Albania are becoming more aware of the need to develop long-term risk reduction approaches. However, the main challenge is increasing the level of understanding of DRR concepts in order to shift perception of DRR from disaster response towards risk reduction (UNDP, 2011). This needs to be addressed within long-term development national plans but also in the local strategies developed at municipal and regional level. If disaster risk reduction needs are always approached in a centralized manner then the neglect of communities' own capacities could lead to a decrease in such capacities in the long run.

Regarding financial resources, the current law mentions that the State budget is the primary financial resource for civil emergency planning and crisis management. The draft law also mentions the need for local governments to receive financial support from the central government for civil protection work, but also the obligation to use some of their incomes and to fundraise through donations. Increased financial autonomy of local government units should also address the need for more financial resources in programs that support disaster risk reduction not only in the response phase but also at the preliminary phase of risk assessment and prevention. DDR programs should be included in municipal budgets annually.

There is a need for a database that compiles all data on regional disaster risks, impacts and losses, and that should be regularly updated by local authorities. This could enhance the level of studies in the field of disaster risk reduction but also enable local authorities with more empirical data for disaster risk assessment.

Another important issue to address that is relevant to Albanian urbanization in the last decade is the informal construction sector and unregulated buildings that took place mostly after the 90'. Risk sensitive building regulations, construction codes and land use planning are essential in reducing risk and vulnerability (UNISDR, 2012). For this reason municipalities must engage in monitoring and conducting disaster risk measures in order to achieve prevention and resilience in sensitive areas to floods or seismic activity.

Appropriate policies and an institutional framework accompanied by decentralized power and resource allocations are essential for sound disaster risk reduction actions. For DRR actions to be effective, cities must have a clear understanding of the risk that they are facing; risk assessments are therefore essential in understanding the risks and for making informed decisions. Public awareness programmes play an important role in better preparing the communities, and there are many examples of DDR practices. Multi-stakeholders cooperation should be encouraged, in order to coordinate overlapping resources and responsibilities. Lastly, protecting ecosystems and natural buffers are essential in mitigating disasters arising from natural hazards.

5. CONCLUSIONS OF THE STUDY

Both national and local authorities in Albania are becoming more aware of the need to develop long-term risk reduction approaches. However the incentives for disaster risk assessment in the local government units are at a non-considerable level. As it results from the analysis of municipal framework in Albania, in the local administration there is evident a high focus on disaster response and recovery situations and there is an almost indifferent attitude towards disaster preparedness and prevention. Increased financial autonomy of local government units should also address the need for more financial resources in programs that support disaster risk reduction not only in the response phase but also at the preliminary phase of risk assessment and prevention. Municipalities must engage in monitoring and conducting disaster risk measures in order to achieve prevention and resilience in sensitive areas to floods or seismic activity, especially in those territories consisting of unregulated buildings and informal constructions. Multi-stakeholders cooperation should be encouraged, in order to coordinate overlapping resources and responsibilities between local government units and other partners. Appropriate policies and an institutional framework accompanied by decentralized power and resource allocations are essential for sound disaster risk reduction actions.

6. REFERENCES

[1] Albania's National Civil Emergency Plan (NCEP). 2004. Available at: http://www.mbrojtjacivile.al/wp-content/ uploads/2013/09/National-Civil-Emergency-Plan-of-Albania-2004.pdf

[2] Amaratunga, D., Malalgoda, Ch., Haigh, R., Panda, A., Rahayu, H. 2017. Sound Practices of Disaster Risk Reduction at Local Level. 7th International Conference on Building Resilience; Using scientific knowledge to inform policy and practice in disaster risk reduction, ICBR2017, 27 – 29 November 2017, Bangkok, Thailand.

[3] Anguelovski, I. and Carmin, J. 2011. Something borrowed, everything new. *Current Opinion in Environmental Sustainability*, 3, 169–175.

[4] Bollin, Ch., Cárdenas, C., Hahn, H., Vatsa, K. S. 2003. Disaster Risk Management by Communities and Local Governments. Inter-American Development Bank for the Regional Policy Dialogue Study Material.

[5] Crawford, M. H., Crowley, K., Potter, S. H., Saunders, W.S.A, Johnston, D. M. 2018. Risk modelling as a tool to support natural hazard risk management in New Zealand local government. *International Journal of Disaster Risk Reduction*, 28, 610–619.

[6] FAO, Food and Agriculture Organization of the United Nations. 2018. Enhancement of Disaster Risk Reduction and Management (DRRM) capacities and mainstreaming Climate Change Adaptation (CCA) practices into the Agricultural Sector in the Western Balkans (TCP/RER/3504).

[7] Kapidani, M. (2018). A comparative analysis of local government financial autonomy in Albania. *Journal of Business, Economics and Finance (JBEF)*, V.7(1), p.1-9.

[8] Law no. 8652, dated 31 July 2000 "On organization and functioning of local governance", as amended, and Law no. 8653, dated 31 July 2000. On administrative-territorial division of local government units.

[9] Ligji Nr.115/2014, Për ndarjen administrativo-territoriale të njësive të qeverisjes vendore në Republikën e Shqipërisë.

[10] Lito, G. 2013. Menaxhimi i Riskut të Katastrofave, Rasti i Shqipërisë. Doktoraturë e mbrojtur pranë Fakultetit të Ekonomisë në Universitetin e Tiranës. Tetor 2013.

[11] Ministria e Financave, Republika e Shqipërisë. (2015). Strategjia Ndërsektoriale për Decentralizimin dhe Qeverisjen Vendore 2015 – 2020.

[12] Pojani, E., Luçi, E., Grabova, P., Ciric, D. 2017. Financing Means for Disaster Risk Management-The Case of Albania. 1st International Symposium Knowledge For Resilient Society K-FORCE 2017 Novi Sad, September 14-15, 2017.

[13] Pondard, N. and Daly, M. 2011. Natural hazards risk modelling: an approach providing risk management solutions for local government. *GNS Misc*. Ser. 38 (2011) 12.

[14] Republic of Albania. 2014. National Strategy for Disaster Risk Reduction and Civil Protection 2014-2018. Draft for consultation – version 19 June. Tirana.

[15] Ribot, J. 2002. Democratic decentralization of natural resources. Washington, DC: World Resources Institute.

[16] Ruiz-Rivera, N and Melgarejo-Rodríguez, C. R. 2017. Political inequality and local government capacity for Disaster Risk Reduction: Evidence from Mexico. *International Journal of Disaster Risk Reduction*, 24 (2017) 38–45.

[17] Rumbach, A. 2016. Disaster governance in small urban places: issues, trends, and concerns. In M. A. Miller, & M. Douglass (Eds.), Disaster governance in urbanizing Asia. Singapore: Springer-Verlag.

[18] The World Bank, 2014. Understanding risk: review of open source and open access software packages available to quantify risk from natural hazards, Glob. Facil. Disaster Reduct. Recovery (2014) 67.

[19] Twigg, J. 2004. Disaster risk reduction. London, England: Overseas Development Institute.

[20] UNDP. 2010. Local Governments and Disaster Risk Reduction, Good Practices and Lessons Learned. A contribution to the "Making Cities Resilient" Campaign. United Nations secretariat of the International Strategy for Disaster Reduction.

[21] UNDP. 2011. Disaster Risk Reduction Capacity Assessment Report for Albania. April 2011.

[22] UNISDR (United Nations International Strategy for Disaster Reduction). 2012b. How to make cities more resilient: A handbook for local government leaders.

[23] UNISDR. 2009. Global assessment report on disaster risk reduction.

[24] Valdivieso, P. and Andersson, K. P. 2017. Local Politics of Environmental Disaster Risk Management: Institutional Analysis and Lessons From Chile. *Journal of Environment & Development*, 2017, Vol. 26(1) 51–81.

[25] WMO. 2012. Strengthening Multi-Hazard Early Warning Systems and Risk Assessment in the Western Balkans and Turkey: Assessment of Capacities, Gaps and Needs. Geneva. 310 pp.

[26] Young, O. R. 2002a. The Institutional Dimensions of Environmental Change: Fit, Interplay, Scale. The MIT Press: Cambridge.

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SIESMIC PERFORMANCE EVALUATION OF AN EXISTING REINFORCED BUILDING IN ALBANIA

Abstract: Among the natural hazards, earthquakes have the potential for causing the greatest harms. Due to the fact that earthquake powers are irregular in nature and inconsistent, the engineering tools need to be sharpened for analysing structures under the action of these forces. Seismic loads are to be modelled so as to evaluate the real behaviour of structure with a clear understanding that damage is expected but it should be regulated. The seismic performance conducted in this study is realized according to ATC-40 and FEMA 356, while ETABS CSI 2013 is employed for modeling. After the pushover analysis was conducted is realized that the performance of the building wasn't in the required levels. Application of inelastic pushover analysis is very adequate, as it exposes design weaknesses. Material quality, supervision quality and lack of shear walls maybe some reasons for performance deficiencies. It also encourages the design engineer to recognize important seismic response quantities and to use sound judgment concerning the force and deformation demands and capacities that control the seismic response close to failure. The conclusions are accompanied by tabulated and discussed results.

Key words: capacity, demand, earthquake, ETABS, pushover analysis, RC building

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1. INTRODUCTION

1.1. Background

Seismic activity of Albania is identified as continuous and sporadic. The main cause of Albanian seismicity is the collision of Adria with the Albanian orogen [1].

Earthquake forces are random in nature and unpredictable, so the static and dynamic analysis of the structures have become the primary concern of civil engineers [2]. There is a lack of applications of seismic design of buildings in Albania, especially those built during the communism period or at early '90 as well [2]. This buildings represent a considerable amount of building stock in Albania so testing how these buildings could perform if they were supposed to experience an earthquake it is of high importance. Thus, the ambition in this study is to evaluate the performance level of the building which could represent most of building in Albania.

This study is focused on the non-linear analysis (pushover) of a reinforced concrete building, built in Komuna Dajt in 1990. This building was designed under "Albanian Designing Conditions" KTP-2-89. The scope of this analysis is to verify the performance of the selected building under the effects of the progressive lateral loads representing the inertial forces which would be experienced by the structure when subjected to ground shaking. The seismic performance conducted in this study is realized according to ATC-40 and FEMA 356, while ETABS 2013 CSI is employed for modeling.

1.2. Nonlinear Static Analysis: Pushover Analysis

Inelastic analysis procedures show how the structures truly act by distinguishing modes of failure and the danger for progressive collapse [3]. Pushover analysis is a static nonlinear procedure in which the magnitude of the structural loading along the lateral direction of the structure is incrementally increased in accordance with a certain pre-defined pattern [4]. With the increase in magnitude of lateral loading, the progressive non-linear behavior of various structural elements is captured, and weak links and failure modes of the structure are identified.

The seismic performance of a building can be evaluated in terms of pushover curve, performance point, displacement ductility, plastic hinge formation etc. The base shear vs. roof displacement curve is obtained from the pushover analysis from which the maximum base shear capacity of structure can be obtained. This capacity curve is transformed into capacity spectrum and demand. The intersection of demand and capacity spectrum gives the performance point of the structure analyzed [3].

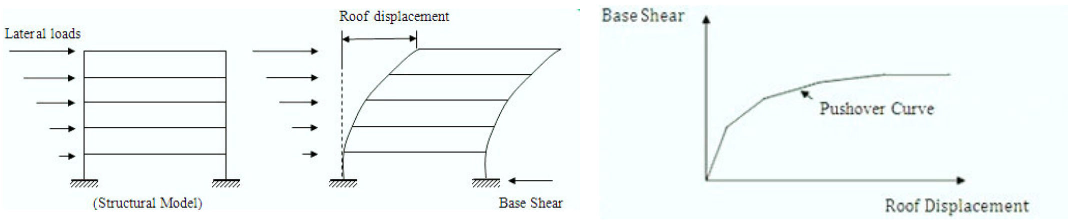

Figure 1- Static Approximations in the Pushover Analysis (left), Base shear vs roof displacement [3]

At the performance point, the resulting responses of the building should then be checked using certain acceptability criteria. ATC-40 defines the procedures to find the performance point [5].

The overall capacity of structure depends on the strength and deformation capacities of the individual components of the structure. A Pushover Analysis procedure uses a series of sequential elastic analysis, superimposed to approximate a force-displacement capacity diagram of the overall structure [3]. The mathematical model of the structure is modified to account for reduced resistance of yielding components. A lateral force distribution is again applied until a predetermined limit is reached. Pushover capacity curves approximate how the structure behaves after exceeding the elastic limits. Typical seismic demand versus capacity are shown in figure 2a and 2b.

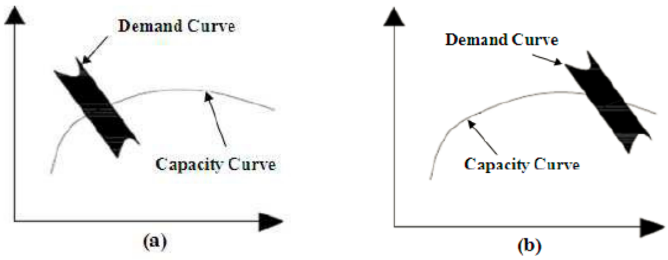

Figure 2 - Typical seismic demand vs. capacity - (a) Safe Design (b) Unsafe Design [4]

Performance of building is classified into 5 levels [4]:

- Operational (OP)
- Immediate Occupancy (IO): very limited structural damage has occurred after the earthquake;
- Damage Control (DC): less damage than that defined for the Life Safety level;
- Life Safety (LS): significant damage to the structure has occurred, but this has not resulted in large falling debris hazards;
- Collapse Prevention (CP): the building is on the verge of experiencing partial or total collapse.

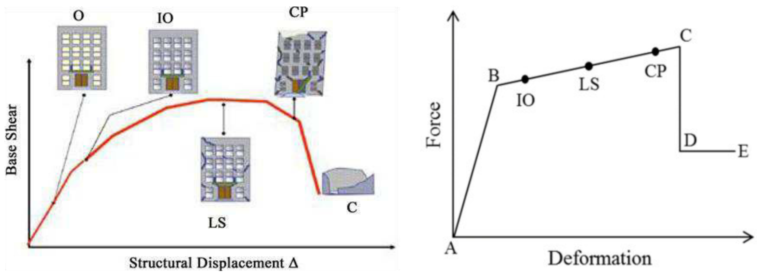

Figure 3 - Different building performance levels [4]

2. METHODOLOGY

2.1. Overview of the Building

The selected building for this study is a residential building built in Komuna Dajt in 1990. It is designed as moment resisting frame with reinforced columns and beams. The building has a regular planimetry. It has a total height of 18 meter and composed of 6 stores. The dimensions of the floor are 11x18 m. Slab thickness is 20 cm and concrete is of grade C20/25. The slab is converted into rigid diaphragm. The beams have a concrete grade of C16/20 and dimensions of 70 cm width and 25 cm depth; 25 cm depth and 10 cm width; 40 cm depth and 25 cm width.The columns have dimensions 50x30 cm and grade C20/25. Steel grade used for rebars is S355 and f_{yk}=355 MPa.

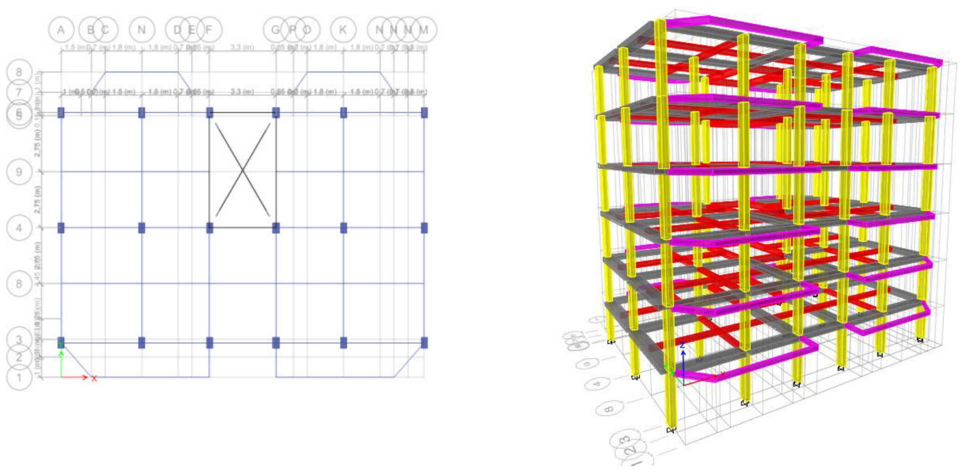

Figure 4 - The selected building: top view (left), a 3D view (right)

2.2. Analytical Modeling of the Building

In order to assess the seismic response of the structure is assumed that the behavior is non-linear elastic [3]. Non-linear static analysis performed in this study is realized by applying inverted triangular load pattern in two orthogonal directions, X and Y respectively. Lateral loads considered equivalent to the earthquake forces are combined with gravity loads [4].

In this study for modeling and analysis of the structure is used ETABS CSI 2013 and the building is modeled as 3D moment resisting frame system consisting of beams and columns. The joints in this case are restrained from all degrees of freedom.

In this analysis two load cases are defined which are dead load case and live load case. Load of slab is transferred to beams and the self -multiplier is assigned as equal to zero. Also, the weight of slab is distributed (2-way slab type) on the supporting beams. The weight of masonry walls is applied as uniform load on the supporting beams. Since the slabs are not modelled by plate elements, the structural effect due to their in-plane stiffness is taken into account by assigning 'Diaphragm' action in ETABS [4]. The loading pattern is selected like that it should produce a deflected shape in the structure similar to that that would undergo in earthquake response. FEMA 356 requires use of Inverse triangular or first mode [5].

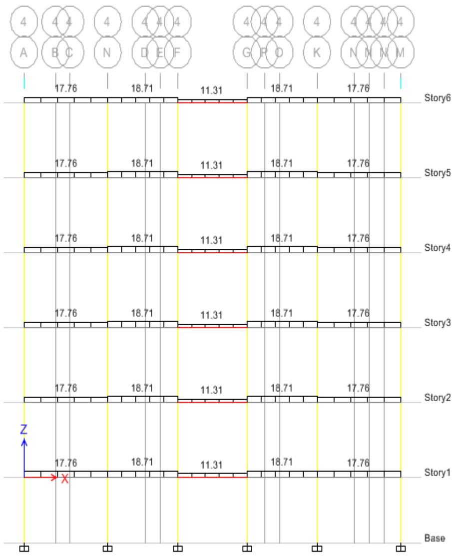

Figure 6 - Total dead load assignment on beams

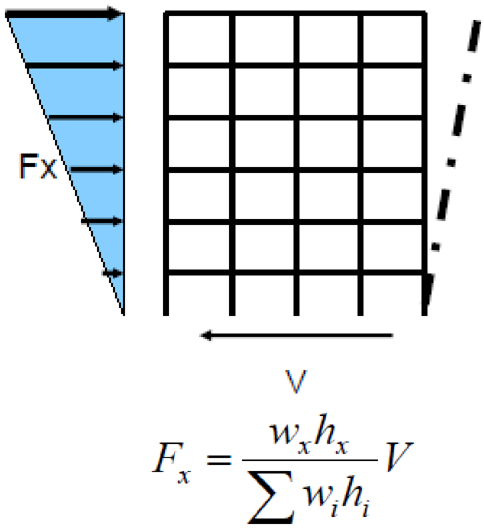

Figure 5 - Pushover load pattern [5]

Where w_x is the total load (equal to the sum of dead load and 30% of the live load), h_i and h_x are the height from the foundation level to floor i and x, w_i is the portion of the total gravity load W located at level i. V stands for the design base shear and is equal to the product of seismic shear coefficient C (obtained from the designed spectrum as C = 0, 242) and the seismic weight.

2.3. Procedure of Pushover Analysis using ETABS

The procedure of Pushover Analysis using ETABS software follows these main steps:

1. Create the model;
2. Define the arbitrary static load cases for use in the pushover analysis;
3. Define the pushover load cases (gravity and lateral load pattern);
4. Define hinge properties. The sequence of plastic hinge formation and state of hinge at various levels of building performance can be obtained from ETABS output. This gives the information about the weakest member and so the one which is to be strengthened in case of a building need to be retrofitted. Accordingly the detailing of the member can be done in order to achieve the desired pattern of failure of members in case of severe earthquakes;
5. Assign hinge properties to frame objects and wall objects. It is important that frame objects and wall objects be designed, e.g., reinforcement should be defined for the concrete frames and walls, prior to running the pushover analysis. . Pushover hinges are assigned to all the member ends. In case of Columns PMM hinges (i.e. Axial Force and Biaxial Moment Hinge) are provided while in case of beams M3 hinges (i.e. Bending Moment hinge) are provided;
6. Run the pushover analysis by selecting a static nonlinear load case on the Set Load Cases to Run form. The load case will be available only if there is at least one frame or wall object with a hinge property assigned to it, and there is at least one pushover load case defined;
7. Review on the pushover analysis results.

3. RESULTS AND DISCUSSION

3.1. Pushover Analysis Curve

Assigning all properties of the model, the displacement- controlled pushover analysis curve is carried out. The model is pushed in monotically increasing order until target displacement is reached. The target displacement at roof level and number of steps in which this displacement occurs is taken as 5% of the total building height, minimum number of saved stages as 10 and maximum number of saved stages as 100, respectively. The resulting pushover curve for the considered building for both directions X and Y are shown in figure 7.

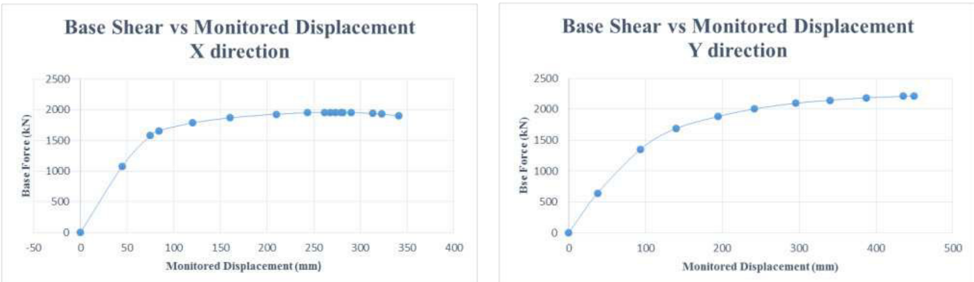

Figure 7 - Pushover curve in X direction (left) and Y direction (right)

In the both cases, the curve is initially linear but start to deviate from linearity at the moment that beams and columns undergo inelastic actions. In the case that the building is pushed again into elastic range, the curve become again linear but with a smaller slope.

For X direction, the peak belongs to displacement of 340,47 mm which is reached for the base shear of the structure equal to 1904,80 kN. For Y direction, the peak belongs to displacement of 450.00 mm which is reached for the base shear of the structure equal to 2215,65 kN.

For a better interpretation the base shear- roof displacement curve is normalized, in order to obtain the percentage of roof drift according to base shear (seismic weight) and to define the yielding point of the building as well. So, the base shear is dividing with seismic weight of the building and the displacement by the total height of the building (Figure 8).

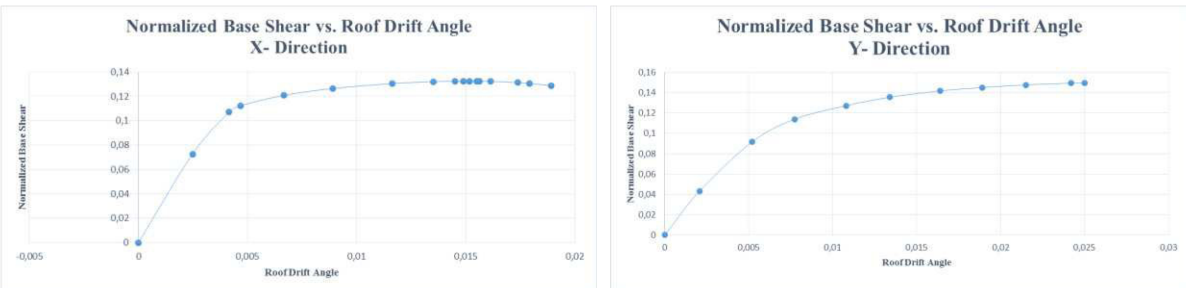

Figure 8 - Normalized Base Shear vs. Roof Drift Angle, for both X & Y direction

From the figure 8, it is noticed that only 13% and 15% in X and Y direction respectively, of the earthquake demand is afforded for the existing capacity of the building. The performance of the building is not at the desired level. It has a low resistance in both directions.

3.2. Plastic hinges mechanisms

Plastic hinges formation for the building mechanism have been obtained at different displacement levels. On the X direction the building developed it in 16 steps and on Y direction in 18 steps. The hinging patterns for different displacement levels are shown as below:

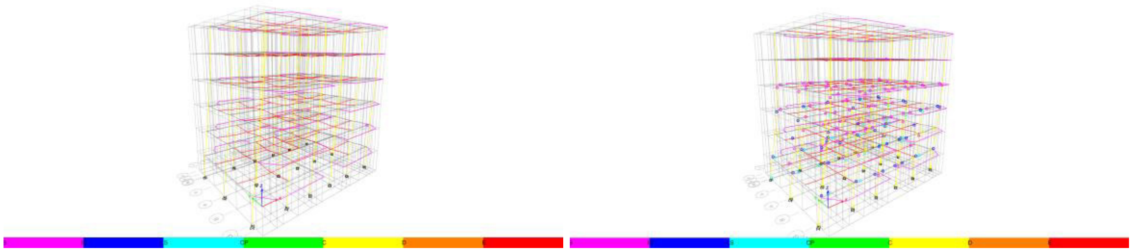

Figure 9 - Plastic hinges mechanism on X direction at step 1 (left) and at step 16 (right)

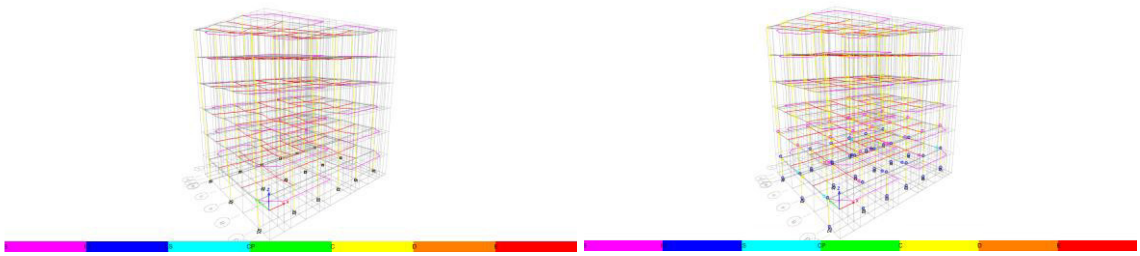

Figure 10 - Plastic hinges mechanism on Y direction at step 1 (left) and at step 18 (right)

The generated patterns for plastic hinges mechanism for both directions show that plastic hinges formation starts with beam ends and base columns of lower stories, then it propagates to upper stories and continue with yielding of interior intermediate column in the upper stories.

3.3. Demand and Capacity curve

ETABS defines also the capacity curve and demand displacement by allowing the performance check of the building. After the capacity curve (base shear vs roof displacement) was generated, the ETABS has the option to convert it in Acceleration – Displacement Response spectra (ADRS or AD) in order for the comparison for the capacity and demand to be more easily visualized.

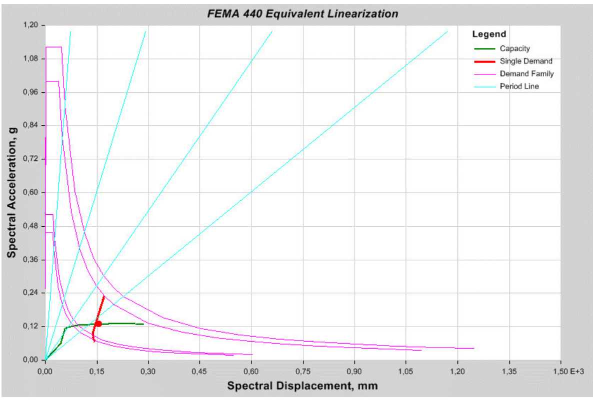

Figure 12 - Generated capacity spectrum in ADRS format, X direction

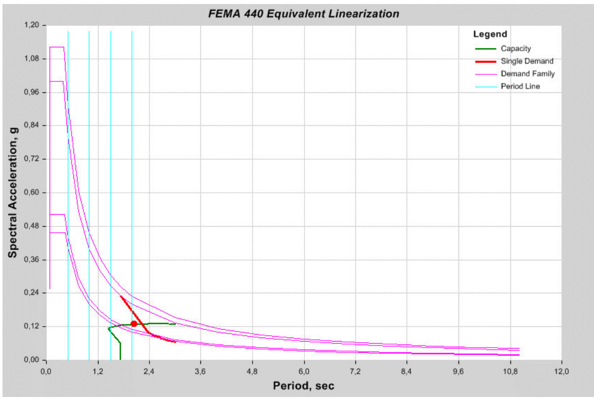

Figure 11 - FEMA 440 equivalent linearization, X direction

The base shear and roof displacement are converted to spectral displacement Sd and spectral acceleration Sa and the lines radiating from the origin are constants which in this case were computed using the equation:

$$T = 2\pi \sqrt{\frac{S_d}{S_a}} \tag{1}$$

The period T of the performance point is calculated to be 2. 048 sec. The calculated period T = 2. 048 sec, is close to the values of the steps 5 and 6 (figure 13&14). Checking the hinge formations at step 5th the plastic hinges mechanism belong to the B-IO range of immediate occupancy. In the 6th step it is noticed that the number of plastic hinges is increased and a some of them are in the range of LS-CP collapse prevention (little stiffness and strength for corresponding column and beam) and 3 hinges reaches the point C. This is an evidence that retrofit provisions must be taken.

FEMA 440 Equivalent Linearization			
Step no.	Spectral Displacement mm	Spectral Acceleration, g	T (sec)
0	0	0	-
1	44,6	0,060038	1,728
2	57,7	0,112727	1,434
3	65,6	0,11759	1,498
4	93,9	0,125856	1,732
5	127,6	0,128549	1,998
6	183,4	0,131461	2,368
7	201,6	0,131009	2,487
8	217,7	0,131203	2,583
9	224,1	0,131088	2,622
10	228,6	0,131058	2,648
11	234,1	0,131029	2,680
12	236,3	0,131041	2,692
13	243,9	0,130858	2,737
14	263,3	0,129845	2,855
15	275,6	0,128856	2,932
16	287,9	0,127439	3,014

Figure 14 - Capacity curve coordinates, X direction

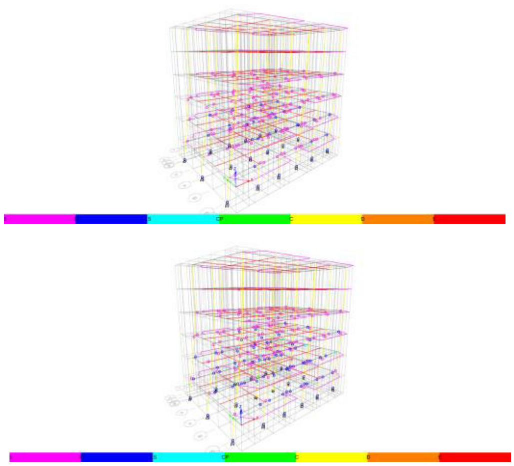

Figure 13 – Plastic hinges mechanism on X direction at step 5 (on top) and at step 6 (bottom)

Following some procedure as in the X direction, the steps for the performance point in Y direction are obtained in the same manner. The period T of the performance point is calculated to be 2. 051 sec.

Also, the capacity curve coordinates in figure 15 are obtained using equation (1).

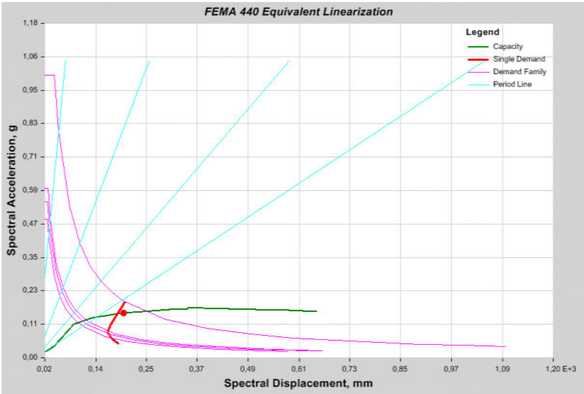

Figure 15 - Generated capacity spectrum in ADRS format, Y direction

FEMA 440 Equivalent Linearization, Y direction			
Step no.	Spectral Displacement mm	Spectral Acceleration, g	T (sec)
0	0	0	
1	37,5	0,035856	2,051
2	84,9	0,114977	1,723
3	127,7	0,136953	1,936
4	197,9	0,155357	2,263
5	244,6	0,161279	2,469
6	307,8	0,167392	2,719
7	349,5	0,170727	2,869
8	350,7	0,171797	2,865
9	353,5	0,171938	2,875
10	359,1	0,17199	2,897
11	373,2	0,172158	2,952
12	376,9	0,172442	2,964
13	382,4	0,172522	2,985
14	388,7	0,172579	3,009
15	446,7	0,171142	3,239
16	510,1	0,168742	3,486
17	587	0,163905	3,794
18	652	0,159446	4,055

Figure 15 - Capacity curve coordinates, Y direction

The calculated period T = 2. 082 sec, is close to the values of the step 4. Checking the hinge formations at step 4th (figure 17), the plastic hinges mechanism belong to the LS-CP range of collapse prevention. In the upper steps, it is also noticed that the number of hinges tends to reach the C range. This indicates that it is of great importance to do some intervention on this direction.

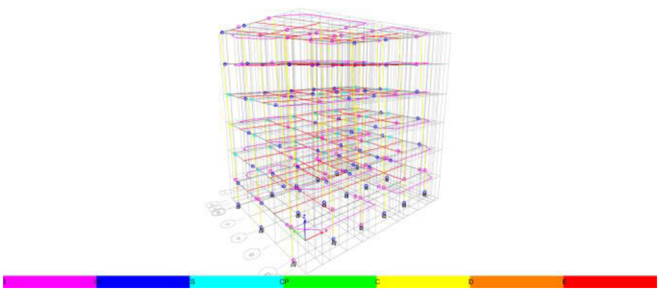

Figure 16 - Plastic hinges mechanism on Y direction (step 4)

4. CONCLUSIONS

The seismic performance conducted in this study is realized according to ATC-40 and FEMA 273, while ETABS 2013 was employed for modeling and analysis of the structure after lateral loads were assigned. The performed Pushover Analysis was used to determine seismic capacity of the building, which was first modelled in ETABS.

From this study the following conclusions are obtained:

- The pushover analysis is a useful, but not infallible, tool for accessing inelastic strength and deformation demands and for exposing design weaknesses.
- It encourages the design engineer to recognize important seismic response quantities and to use sound judgment concerning the force and deformation demands and capacities that control the seismic response close to failure.

However, it must be emphasized that the pushover analysis is approximate in nature and is based on static loading. As such it cannot represent dynamic phenomena with a large degree of accuracy. It may not detect some important deformation modes that may occur in a structure subjected to severe earthquakes, and it may exaggerate others. Inelastic dynamic response may differ significantly from predictions based on invariant or adaptive static load patterns, particularly if higher mode effects become important. Thus performance of pushover analysis primarily depends upon choice of material models included in the study.

5. REFERENCES

[1] N. Pojani, Inxhineria Sizmike, Tirane: Universiteti Politeknik i Tiranes, 2004.

[2] I. F. Huseyin Bilgin, „Predicting the seismic performance of typical R/C healthcare facilities: emphasis on hospitals," International Journal of Advanced Structural Engineering, t. 9, br. 3, pp. 277-292, 2017.

[3] A. K. Chopra, 1. A Modal Pushover Analysis Procedure to Estimate Siesmic Demands for Buildings: Theory and Preliminary Evaluation, Berkeley: University of California, 2001.

[4] R. F. F. R. R. Bento, „Nonlinear Static Procedures in Performance Based Siesmic Design," 2004.

[5] F. E. Agency, FEMA 356 Prestandard and Commentary for Seismic Rehabilitation of Buildings, Washington: Federal Emergency Agency, 2000.

[6] A. T. Council, ATC-40 Seismic evaluation and retrofit of concrete Buildings, California: Applied Technology Council , 1996.

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THE ROLE OF THE RED CROSS OF SERBIA IN DISASTERS

Abstract: One of the main public duties performed by the Red Cross of Serbia is to initiate, organise and perform or participate in regular or emergency solidarity activities in the Republic of Serbia. This includes providing assistance to persons at risk and victims of natural, environmental and other accidents as well as armed conflicts. The goal behind such activities is to provide assistance and guarantee the respect of humanitarian rights as well as the improvement of the humanitarian principles of the society. The paper describes a part of activities of the local Red Cross organization in Subotica. The activities included collecting, organizing and transport of humanitarian aid during the 2014 floods. In spring 2014, more than 30.000 people in Serbia were at risk or displaced.

Key words: Red Cross, emergency, landslides

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1. GENERAL INSTRUCTIONS (STYLE HEADING 2)

The long-term, responsible and planned construction of all capacities and resources of the Red Cross of Serbia constitutes serious grounds to organize and perform complex operations and humanitarian activities. Educated and trained volunteers and employed professionals in the Red Cross have a central role in the available capacities of the organization.

Emergency headquarters, along with the local self-governments and representatives of competent legal persons in this area provide significant support and encouragement in performing activities in emergency situations.

2. RED CROSS OF SERBIA

The Red Cross of Serbia is a humanitarian, independent and non-profit citizens' association which helps state authorities as well as local self-government authorities in the area of humanitarian aid. They perform the said activities in accordance with the ratified international agreement and as per the Law and other regulations [1].

The activities in this organisation include the following tasks:

- participation in the protection and saving of the population and other goods in case of emergencies and armed conflicts;
- organising the collection of aid and allocating the collected aid form international and other organisations and donors for the population affected by armed conflicts or natural or other disasters;
- organising the collection of assistance and its dispatch abroad as part of the programme implemented by the authorities of the Republic of Serbia for population in the area endangered by war or natural and other emergencies;
- participation in taking-in and accommodating the evacuated population, refugees and displaced persons;
- organizing of solidarity activities to collect material, financial and other goods for the population in need of such assistance;
- performing the tasks of the Tracing Service for the purpose of collecting and recording data on refugees, evacuated, displaced and missing persons;
- training citizens – representatives of civil protection on the territory of the Republic of Serbia to provide first aid in case of natural, environmental or other emergencies as well as armed conflicts;
- organising, training and preparing the team for first aid, hygienic and epidemiological protection, care for the injured and sick, social work, psychological assistance to the population and technical assistance in case of war or other emergencies;
- participation in the health-related education of the population, training the population in terms of providing first aid in case of armed conflicts, natural and other emergencies in both peacetime and wartime;
- popularising the voluntary blood donation and participating in the organisation of voluntary blood donation activities in cooperation with the blood transfusion services and health institutions;
- cooperation with local self-government authorities and provincial and republic authorities [1].

2.1. Structure of the Red Cross of Serbia

The Red Cross of Serbia includes provincial, city and municipal Red Cross organisations established on the territory of the Republic of Serbia. Red Cross of Serbia and Red Cross organisations established in provincial administrative units or local self-government units have the status of legal persons.

2.2. Public competences and duties

Public competences and duties conferred by the Law on the Red Cross of Serbia (The Official Gazette of the RS no. 107/2005) to the national association on the territory of the Republic of Serbia and performed by the Red Cross of Serbia are the following:

- initiating, organising and performing or participating in regular or emergency solidarity activities in the Republic of Serbia for the purpose of providing assistance to people at risk and victims of natural, environmental and other emergencies and armed conflicts as well as providing, in accordance with the law, training, material, financial and other requirements for such activities;
- enabling citizens to voluntarily organise to perform civil protection activities on the territory of the Republic of Serbia, to provide first aid in case of natural, environmental and other emergencies, as well as armed conflicts;
- organising, training and preparing teams for first aid, hygienic and epidemiological protection, care for the injured and sick, social work, psychological assistance to the population and technical assistance to perform tasks in case of natural, environmental and other emergencies as well as armed conflicts;
- popularising voluntary blood donation and participating in the organisation of voluntary blood donation activities in cooperation with the blood transfusion services and health institutions.

The Red Cross of Serbia keeps appropriate records and issues certificates for previously listed public competences and duties [1].

2.3. Objectives and tasks of the Red Cross of Serbia

Red Cross of Serbia aims at relieving human suffering, with the objective of providing assistance to persons of risk in case of war conflicts, natural, environmental or other emergencies. Their priority is to save lives and health of people at risk as well as to ensure the respect of humanitarian rights. In addition, Red Cross is also engaged when the need arises in terms of social protection and care with the aim of acting preventatively and educating citizens in the field of health and social protection and improving the humanitarian principles of the society.

In performing tasks that pertain to the achievement of objectives and performance of duties, the Red Cross of Serbia, in accordance with the:

- ratified international agreements and generally accepted rules in the field of international humanitarian law, especially in accordance with the Geneva Convention on the Protection of War Victims of 12th August 1949 (Geneva Convention) and the Amendment Protocols to the Geneva Convention as of 8th June 1977 (Amending Protocols);
- basic principles, the Statute and other acts and rule adopted by the International Red Cross and Red Crescent Movement;
- objectives and tasks of the National Association [1].

3. ENGAGEMENT OF THE RED CROSS OF SERBIA IN THE EMERGENCY SITUATIONS IN SERBIA IN 2014

The major catastrophe which struck the Republic of Serbia in May 2014, caused by the Cyclone Tamara, resulted in never-before seen floods and landslides. As a consequence of the emergency situation, which affected all the spheres of the society and did a lot of damage to vital facilities, a need arose to perform a detailed analysis and establish a single legal system which would regulate the issue of decreasing risk i.e. preventing, responding, renewal or providing assistance with the purpose of mitigating the consequences of natural and other disasters and managing in emergency situations.

The floods happened in May 2014, in the Republic of Serbia the likes of which have not been recorded in the last 120 years. They endangered lives, health and property of more than 1.6 million people (22% of the entire population) in 119 municipalities in central and west Serbia, and the total flood damage amounted to EUR 1.7 billion i.e. more than 4% of the GDP. The floods primarily affected the energy system of the country, the agricultural production, the infrastructure (roads and bridges) and the property of natural persons. The complete and comprehensive review of the flood consequences was impossible to perform until the first flood wave ended. However, it was evident that the damage was extensive and that it will be instrumental to, in order to mitigate the damages, provide significant funds, engagement of a large number of people, military and law enforcement personnel as well as other professional organisations. Fig. 1 shows the national team of the Red Cross of Serbia which was engaged in 2014 in order to assess the consequences of the emergency and coordination of operating activities.

Figure 1 – Red Cross of Serbia National Team engaged in the field assessment of the emergency and the coordination of operating activities

In the last ten years, the Republic of Serbia faced with four extreme weather conditions two of which were caused by floods and the other two were caused by earthquakes. The aforesaid events served as a warning and notice that more serious measures need to be taken; such as planning and realising the investments based on knowing the risks. In that manner, the highest possible degree of protection of people and property will be ensured in terms of protection from potential, new, more severe floods i.e. the risk of greater consequences would be mitigated [1,2].

Decreasing the risk of severe weather and other emergencies includes a system of measures and activities determined by law, other general acts, plans, programmes and other documents which aim at:

- precise identification, regular assessment and risk monitoring for severe weather and other emergencies for the purpose of their control;

- decreasing the impacts of the factors which cause or increase the risk of severe weather and other emergencies through responsible and appropriate management of the environment, soil, water and other natural resources, planned use of soil and by using appropriate technical and other measures;
- mitigating the harmful consequences on the grounds of the most comprehensive understanding of the risks, planning their prevention and increasing the readiness to react and provide the best response;
- investing in prevention and decreasing the risk of severe weather and other emergencies through encouraging the public and private investments and using the structure and non-structure measures;
- establishment of cultural security and resilience of the individual and community to severe weather and other emergencies;
- intensive cooperation of all competent institutions on all government levels, as well as a partnership with private and public companies, other legal persons, entrepreneurs, civil society organisations and other interested citizens which may provide contribution to decreasing the risk of severe weather and other emergencies;
- establishment of precise procedures for the exchange of information and experiences significant in terms of decreasing risk and for the efficient provision and acceptance of mutual operational and humanitarian assistance for the purpose of mitigating the consequences of severe weather and other emergencies and the initial renewal of the affected areas.

4. ACTIVITIES OF THE RED CROSS OF SERBIA ORGANISATION IN SUBOTIVA DURING THE MAY 2014 FLOODS

4.1. Organising the collection and disbursement of assistance

The legal grounds for the realisation of the totality of the activities of the Subotica Red Cross – City Organisation during the emergency state are the following: Law on Emergency Situations, Law on the Red Cross of Serbia, Articles of Association of the Red Cross of Serbia – City Organisation Subotica, Decision on the Organisation of the Protection of Citizens and Material Goods on the Territory of the City of Subotica in Emergencies and the Contract on Performing Public Competences and Duties on the territory of the City of Subotica.[3]

During the emergency situation declared in May 2014, the Subotica Red Cross employed professionals and volunteers participated in the operating activities of accommodating the people at risk and providing humanitarian aid (Fig. 2).

Figure 2 – Activities of the Red Cross of Serbia during the floods in Obrenovac in 2014

In this period, the City Emergency Headquarters adopted operating decisions and conclusions instrumental in realising the provision of the humanitarian activities of the Red Cross – City Organisation Subotica. All the proscribed obligations pertaining to the accommodation and food for the persons affected as well as the organisation of the transport of humanitarian aid, primarily from the Provincial Emergency Headquarters were fulfilled in an organised manner and responsibly.

The report submitted to the City Emergency Headquarters by the Red Cross – City Organisation Subotica included all the operating activities in the period of 17th May to 11th June 2014 [3,4].

According to the Conclusion of the District, as well as the City Emergency Headquarters, Red Cross – City Organisation Subotica was the organisation responsible for the activities pertaining to the collection of humanitarian aid. The aid was collected in various locations with appropriate storage records on the reception and provided transport and subsequently received by the Red Cross – City Organisation Subotica where the latter was stored and prepared for transport to the affected areas.

Thanks to the support of the District Emergency Headquarters and with the aim of achieving a higher degree of organisation in terms of receiving the donations from abroad, a joint session of the Customs Office in Subotica with the appropriate services of the Republic Inspectorate, the Police Administration Unit in Subotica and freight companies was held. The goal was to establish the coordination of activities related to the acceptance of vehicles with humanitarian aid from abroad with the purpose of shortening the time required to forward that aid to the planned destination.

In the reporting period, a total of 22 humanitarian transports with a total of 152.6 tons of humanitarian aid was organised; while the estimated value of the services donated by the transport companies was around RSD 700,000.

The process of accepting, sorting, packing and storing engaged on average 100 volunteers and 12 employed associates of the Red Cross – City Organisation Subotica per day. The reporting period accounted for more than 16,000 hours of volunteer work of the Red Cross – City Organisation Subotica, primarily youth. During the emergency situation, the Red Cross – City Organisation Subotica, in coordination with Red Cross of Serbia and the Red Cross of Vojvodina, sent three equipped teams to the affected area, namely to:

- Stara Pazova (Reception Centre for Evacuated persons from Šid);
- Obrenovac (Team for the field assessment and coordination in mitigating the consequences of the emergency in terms of required humanitarian aid);
- Obrenovac (Specialised team for the distribution of humanitarian aid for the distribution of humanitarian aid to citizens at a distribution point) (Fig. 3)

According to the mandate of the organisation and pertaining to the Tracing Service and the defined obligations for the organisation in terms of persons from the flooded areas who took up temporary residence with their relatives, an adequate, rule-based record keeping procedure was done followed by the provision of the required humanitarian aid in food, hygiene and clothes. Red Cross – City Organisation Subotica reported daily to all organisation levels on the number of recorded persons who were registered on the territory of the City of Subotica, namely 20.

In addition, the City Centre for Social Work was also informed on the number of registered persons for the purpose of performing activities by the professionals according to the Instruction of the competent Ministry [3,4].

Figure 3 – Part of the team for the distribution of humanitarian aid in Obrenovac in 2014

4.2. Statistic indicators

Activities of collecting humanitarian aid during the May 2014 floods were realised in almost all primary and secondary schools on the territory of the City of Subotica, at faculties, local communities, professional associations, NGOs and religious communities. This period was characterised by an exceptionally high degree of citizen solidarity. The organisation of the state authorities contributed to this, in coordination with the District and City Emergency Headquarters.

The statistic indicators which describe the activities of the Red Cross – City Organisation Subotica in that period indicate to a high number of volunteers which further on confirmed the high awareness of citizens in terms of humanitarian work. Along with the employees, the volunteers participated in the activities of collecting, sorting and packing humanitarian aid (Fig. 4).

A large number of citizens and legal persons collected and delivered humanitarian aid during the emergency situation. The overview of the number of the persons engaged in providing humanitarian aid done by the Red Cross – City Organisation Subotica is the following:

- Number of Red Cross – City Organisation Subotica employees: 12
- Average number of engaged volunteers daily: 100
- Number of volunteering hours in the reporting period: 16,000
- Number of natural persons who provided humanitarian aid: 1,450
- Number of legal persons who provided humanitarian aid: 67
- Number of vehicles carrying humanitarian aid that passed the customs: 8
- Amount of collected humanitarian aid in tons: 250
- Number of organised transports to flooded areas in the reporting period: 22

The aforementioned statistics indicate to a high level of demonstrated humanitarian values in the City of Subotica and the region [4].

Figure 4 – Disbursement of humanitarian aid to persons affected by the 2014 floods

5. CONCLUSION

Without any doubt, the strength of the basic principles of the Red Cross organisation in terms of the relationship towards the partners and mobilising volunteers was confirmed as well as the fact that the organisation actually has a great number of activists available at any time, who are able to perform complex and extensive humanitarian operations for the purpose of providing wellbeing and assistance to persons affected. The volunteers spent a total of 16,000 working hours volunteering and average of 100 volunteers were engaged daily. In addition to volunteers, a great number of volunteers and citizens also participated in collecting aid (a total of 250 tons was collected) and transporting aid (a total of 22 vehicles were dispatched), which demonstrates a high awareness of the society in terms of humanitarian work and good organisation of the Red Cross – City Organisation Subotica.

The public information facility also fulfilled their social role with their constant, objective and timely updating of the public regarding the flow and the realisation of humanitarian activities which greatly helped with the coordination of the required aid.

The role and the tasks of the Red Cross of Serbia, including the local organisations, did not end with the cancelation of the emergency situation, and the activities aimed at helping the persons affected are continued in accordance with the mandate, the objective needs and the available aid capacities.

6. REFERENCES

[1] Zakon o Crvenom krstu Srbije. Službeni glasnik Republike Srbije broj 107/2005.

[2] Zakon o vanrednim situacijama. Službeni glasnik Republike Srbije broj 111/2009.

[3] Odluka o organizovanju zaštite građana i materijalnih dobara na teritoriji Grada Subotica za slučaj nesreće. Službeni list Grada Subotica broj 12 od 25. juna 2009. godine.

[4] Izveštaj o radu tokom vanredne situacije u maju 2014. godine. Crveni krst Subotica-gradska organizacija 11. jun 2014. godine.

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LIQUEFACTION OF SOILS CAUSED BY SEISMIC FORCES

Abstract: Big natural disasters lead to great material damages, but also loss of human lives. Sharing of knowledge, awareness and research is the basis for managing hazard risks. Main topic of this paper are hazards caused by liquefaction during earthquakes, although the main goal is to describe the specific process that occurs in the phenomenon of liquefaction, effects that cause this particular phenomenon, and the types of soil that are endangered. The accent is given to non-cohesive types of soil. To properly approach the problem, we will first describe the types of geohazard that may arise, and a simplified way to estimate the liquefaction potential of the soil. On a simple example, it is shown how we can calculate the safety factor for the occurrence of this hazard and eventually provide some protection measures for the appearance of liquefaction.

Key words: liquefaction, earthquake, geohazard, liquefaction potential

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1. EARTHQUAKES AND LIQUEFACTION

Earthquake naturally (as result of earth internal energy) or artificially (human activity) causes oscillation of soil particles. Earthquakes occur in the Earth's lithosphere or directly below, in the next layer called asthenosphere which makes up most of the Earth's mass. Part of the kinetic energy that dissipated through the lithosphere is called seismic energy and is measured in seismic observatories. In most earthquakes, seismic energy is proportional to total kinetic energy. Release of energy can be constant- in terms of slow seismic motion which can last for years, or instant, when earth last less than a minute. Earthquake's initial rupture point (place of release of energy) is called focus or hypocenter. The hypocenter of the earthquake is a place in the interior of the Earth's crust from which seismic waves begin to spread. Differently from hypocenter, epicenter is a orthogonal projection of hypocenter on surface, where the earthquake movement is most strongly felt. The earthquake is spreading in waves, and the lines where we connect the places of the same strength of earthquake on the map are called isoseismal. According to the mode and speed of propagation, earthquakes can be with longitudinal or transverse waves. Longitudinal are the fastest and extend in the direction of spreading, while the transversal causes particle spacing and spreads only through solid material. Other waves cause circular and horizontal spinning and have the weakest effect. The magnitude of the earthquake depends on several factors, such as the amount of energy released, the depth of the hypocenter, the distance of the epicenter and the material of the Earth's crust. It is expressed in different scales, of which the most commonly used are MCS and MSK - 64 scales of twelve degrees. The magnitude of the earthquake is a measurment for liberated energy in the hypocenter. It is expressed by the Rihter's magnitude scale that does not have the upper limit, but since no earthquake of 10 is yet recorded, it is usually represented up to 9 units [1]. Main topic of this paper are the geo-hazards, caused by earthquakes. In the data of over 40 countries, it has been concluded that earthquakes with a magnification of over 5 can lead to large geo-hazards. The release of energy and the wave spreading through the Earth's lithosphere cause cyclic loading, which leads to increased soil pressures. This can cause major changes in saturated soil. Pressure provokes water from the pores, which leads to high pore pressure, and reduces the effective stress. Finally, there is a complete loss of load capacity. A number of embankments, slopes and foundations collapses can be attributed to the influence of soil liquefaction caused by the earthquake. Historically speaking, large-scale hazards such as avalanche of 7 million cubic miles of alluvial sand, launched on the Zealand coast (1937), as well as one on the coast of the Mississippi River, which covered 4 million cubic meters of fine sand . Damaged dams are objects that are particularly vulnerable and of great importance. The catastrophes caused by liquefaction also affected the Calaveras dams and the San Fernando dam in California (1918), and the Fort Pack dam in Montana (1938). This phenomenon raised attention and was recognized for the first time by Casagrande (1936). However, it did not receive the proper attention in 1964, when earthquakes hit Ankara, Alaska and Japan. The earthquake in Alaska, with magnitude 9.2 on the Richter's scale, destroyed and damaged more than 200 bridges and caused huge landslides. During a 7.5-magnitude earthquake on June 14, 1964 in Japan, it was estimated that extensive sand deposit resulted in damage on 60,000 buildings and houses (Sung, 2015). To date, after 30 years of intensive research on this topic, great progress has been made in the process of understanding the concept of liquefaction, under the influence of seismic forces [2]. It is necessary to recognize which soil is endangered and take measures that can prevente these major hazards. Only several of the findings have been made in this paper.

1.1. The term and main basics of liquefaction

Soil liquefaction is a term that describes the phenomenon in which saturated or partially saturated soil loses strength and stiffness in response to a load, usually an earthquake, or some other change in the effective stress, which makes it behave like a liquid. When the water pressure in the saturated soil is large enough to carry all the weight, this leads to separation of the particles and leads to a flow state.

Water that is trapped inside the soil and cannot move freely creates a pressure, and these separated particles move freely by creating liquid sludge. In the event of an earthquake, seismic forces cause additional pore pressure. The process of separating particles and creating a crack is shown in Figure 2 [3].

Figure 1 – Geohazard caused by liquefaction [9]

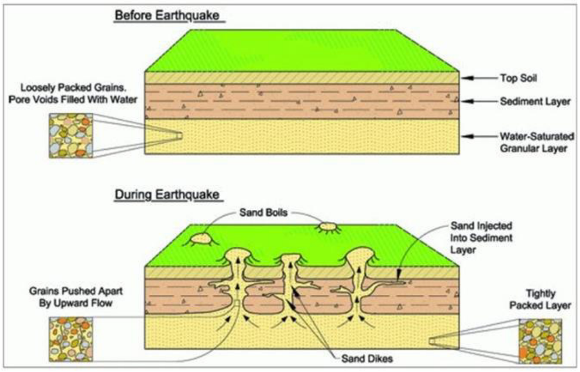

Figure 2 – Liquefaction process [10]

In other words, the liquefaction of the soil occurs when the effective stress of the soil is equal to zero, due to the excessive pore pressure that is created when the load is transferred from the soil to the water. The effective stress can be expressed as:

$$\tau = \sigma' tan\varphi \tag{1}$$

$$\sigma' = \sigma - u \tag{2}$$

where:

τ - shear strength

σ' - effective normal stress

σ - total normal stress

u - pore pressure

φ - angle of internal friction

When saturated soil is exposed to cyclic load (caused by earthquake activity) for time that is not enough for ground to consolidate, then the pore pressure progressively grow. By equalizing the pore pressure of soil with total pressure, effective stress is equal to zero, and thus phenomena leads to boundless deformation.

The type of soil most susceptible to liquefaction is one in which the resistance to deformation is mobilized by friction between particles. If other factors such as grain shape, uniformity coefficient and relative density are equal, the frictional resistance of cohesionless soil decreases as the grain size of soils becomes smaller. Tsuchida (1970) summarized the results of sieve analyses performed on a number of alluvial and diluvial soils that were known to have liquefied or not to have liquefied during earthquakes. He proposed ranges of grain size curves separating liquefiable and nonliquefiable soils as shown in Figure 3. The area within the two inner curves in the figure represents sands and silty sands, the soils with the lowest resistance to liquefaction. A soil with a gradation curve falling in the zones between the outer and inner curves is less likely to liquefy. Soils with a higher percentage of gravels tend to mobilize higher strength during shearing, and to dissipate excess pore pressures more rapidly than sands. However, there are case histories indicating that liquefaction has occurred in loose gravelly soils during severe ground shaking or when the gravel layer is confined by an impervious layer [4]. Fine clay particles often tend to increase the sand resistance to flow. The clay particles in the water can act in a complex system of forces, including universal attractive forces and mutual attraction of individual ions, attract particles side by side, while on the other hand electrical charges of the grain and electric charges of the absorbed cations cause interaction rejection of the particles. So, with regard to the clay genesis, some structures can be relatively stable, while others have a tendency to soften. However, nonplastic fines such as rock flour, silt and tailing slimes may not have as much of this restraining effect. Because of the aforementioned facts, Ishihara (1985) noted that silts and clays of low plasticity exhibit similar properties as sands, and although they are located beyond the boundaries of the curves in Figure 3, they can lead to hazard and liquefaction. Increasing plasticity will lead to a reduction of pore pressure. This reduction, however, is not significant enough to resist liquefaction for soils with plasticity indices of 5 or less. Even though major slide movements during earthquakes have occurred in clay deposits, they are commonly considered to be nonliquefiable during earthquakes in the sense that an extensive zone of clay soil is converted into a heavy fluid condition. Frequently, landslides in clay deposits containing sand or silt lenses are initially triggered by the liquefaction of these lenses before any significant strength loss occurs in the clay. This has been supported by laboratory test results which indicate that the strain required to liquefy sands is considerably smaller than the strain required to overcome the peak strength of cohesive soils [4].

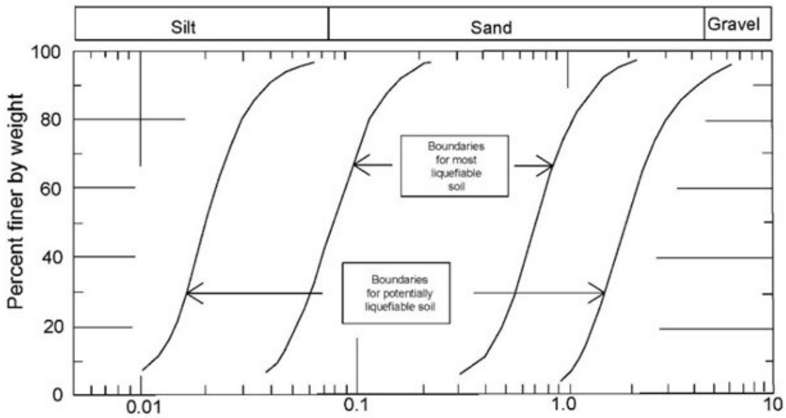

Figure 3 – Limits in the gradation curves separating liquefiable and no liquefiable soils [7]

1.2. Soil characteristics and facts showing the liquefaction potential of the soil

Laboratory test results and field case histories indicate that, for a given soil, initial void ratio or relative density is one of the most important factors controlling liquefaction. Liquefaction occurs principally in saturated clean sands and silty sands having a relative density less than 50%. For dense sands, however, their tendency to dilate during cyclic shearing will generate negative pore water pressures and increase their resistance to shear stress. The lower limit of relative density beyond which liquefaction will not occur is about 75%. It is well known that an increase in the effective vertical stress increases the bearing capacity and shear strength of soil, and thereby increases the shear stress required to cause liquefaction. From field observations it has been concluded by a number of investigators that saturated sands located deeper than 50 to 60 feet (15 to 18 m) are not likely to liquefy. Soil with a higher overconsolidation has a higher flow resistance. If soil has coefficient of uniformity less than 5, it is more sensitive than well graduated materials. In addition to soil properties, it has been proven that the previous seismic soil history can significantly affect the preference of soil liquefaction. During earthquake cyclic load, there is a slight increase of pore pressure, which can slow down the rapid increase of the pore pressure during the next seismic impact. Resistance can increase if soil grains pack more uniformly during earthquake. Large earthquake cyclic load can lead to weakening od some zones in the soil, and collapse can occur during following seismic impact [5].

Liquefaction will not occur in dry soils. Very little is known on the liquefaction potential of partially saturated sands. It is sure that sand samples with low degree of saturation can become liquefied only under severe and long duration of earthquake shaking. Another important thing is the thickness of the sand layer In order to induce extensive damage at level ground surface from liquefaction, the liquefied soil layer must be thick enough so that the resulting uplift pressure and amount of water expelled from the liquefied layer can result in ground rupture such as sand boiling and fissuring. Also, the sand layer can remain intact if it is between non-impermeable layers of soil [5].

2. EVALUATION OF LIQUEFACTION POTENTIAL OF HORIZONTAL GROUND USING SPT RESISTANCE

Investigations based upon in-depth theoretical study and extensive review of field performance of sands and silty sands during actual earthquakes in the western United States, Alaska, South America, Japan and China, show that a high correlation exists between soil liquefaction resistance under earthquake shaking and soil SPT resistance in level ground conditions. Based on this correlation, a design procedure for evaluating the liquefaction potential of level ground has been developed as follow [5]:

- determine the layers that make up the geological structure, and examine all the above-mentioned factors that indicate whether the soil is endangered
- compute the average induced cyclic shear stress ratio due to earthquake shaking for each potentially liquefiable layer using the following relationship [6] :

$$\frac{\tau_{av}}{\sigma_0{}'} = 0{,}65 * \left(\frac{a_{max}}{g}\right) * \left(\frac{\sigma_0}{\sigma_0{}'}\right) * Y_d \tag{3}$$

where :

$\frac{\tau_{av}}{\sigma_0{}'}$ - earthquake-induced cyclic shear stress ratio

τ_{av} - average peak shear stress

a_{max} - maximum horizontal ground acceleration

σ_0- total overburden pressure at depth under consideration

$\sigma_0{}'$- effective overburden pressure at depth under consideration

g - acceleration due to gravity

Yd - is a stress reduction factor that goes linearly from 1 to 0.9 to a depth of 10.67 m.

- Diagrams are formed so that for projected earthquake magnitude with given values of fines content and (N1)60, read off the shear stress ratio required to cause liquefaction [5].
- If the fines content of soil is greater than 30%, a correction may be made to the shear stress ratio required to cause liquefaction depending on the plasticity index of soil. If the plasticity index of the soil is greater than 5%, multiply the shear stress ratio required to cause liquefaction by correlation coefficient ß. For soil with plasticity index not greater than 5%, ß equals one and no correction to the resisting shear stress ratio is needed [5].
- Calculate the safety factor against liquefaction, which is defined as the ratio between the shear stress ratio required to cause liquefaction [5].

Example:

Calculate the liquefaction potential of the first and second soil layers, if the earthquake magnitude magnitude 6.0. Layers are of the following characteristics:

Table 1- Example of soil characteristics

Layer No.	Soil Type	Unit Weight [kN/m^3]	Depth [m]	SPT [N]	Fines Content [%]
1	Gravelly Sand	20	0-6,5	10	<5
2	Sandy Silt, Clayey	18	6,5-20	15	35
3	Sand	18	20-30		15

Maximum Horizontal Acceleration = 0.15g, and the groundwater level at 2 m below the surface.

Since this layer of soil is above the ground water table, liquefaction is not expected to occur. For the second layer it is necessary to calculate the total and effective stresses in the center of the layer.

$$\sigma = \gamma_1 * H_1 + \gamma_2 * \frac{H_2}{2} = 20 * 6.5 + 18 * 3.25 = 188.5\ kPa$$

$$\sigma' = \gamma_1 * H_1 + (\gamma_2 - \gamma_w) * \frac{H_2}{2} = 20 * 6.5 + 8.193 * 3.25 = 156.62\ kPa$$

Factor Yd = 0.96

$$\frac{\tau_{av}}{\sigma_0{}'} = 0,65 * \left(\frac{a_{max}}{g}\right) * \left(\frac{\sigma_0}{\sigma_0{}'}\right) * Y_d = 0.65 * 0.15 * \left(\frac{188.5}{156.62}\right) * 0.96 = 0.1126$$

For an earthquake magnitude of 6.0, and fines content of 35%, from Figure 4:

$$\left(\frac{\tau_{av}}{\sigma_0{}'}\right) = 0,32 \quad (4)$$

Factor of Safety against liquefaction:

(0,32 / 0.1126) = 2,84>1.1

Therefore, layer No. 2 is no liquefiable.

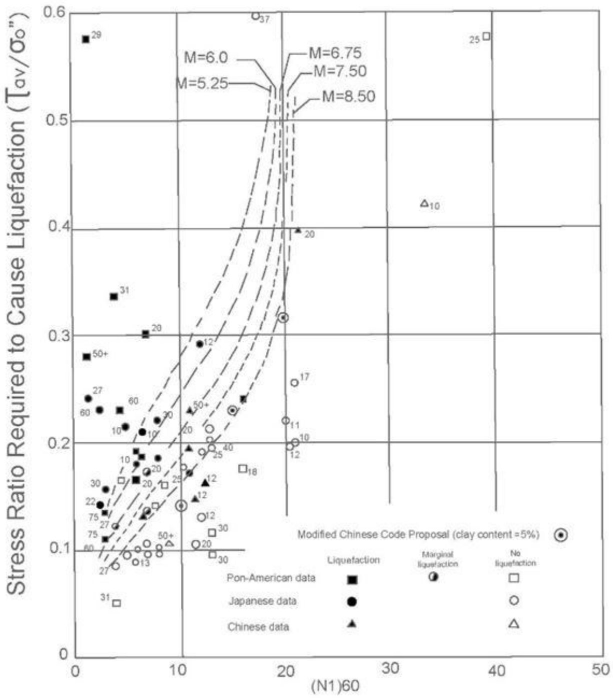

Figure 4 – Relationship between stress ratios required to cause liquefaction and (N1)60 values for cohesionless soils having fines content of 35% in M=5.25-8.5 earthquakes [5]

3. METHODS FOR IMPROVING LIQUEFACTION - PROVE SOILS

Liquefaction can be slowed down or prevented with:

- dewatering –increases the effective stress and shear strength and reduces the extent of saturated soil, all of which increase resistance to liquefaction
- increasing soil density
- making provisions to reduce the time required for relieving the excess pore water pressures generated by earthquake loading. these, except dewatering, may be best achieved by ground improvement techniques.

3.1. Ground improvement techniques

If the layer is less than 3.5 m it is recommended to replace the soil, and if the problem area is deeper than 3.5 m, other solutions are:

- in-situ deep compaction
- compression
- pore pressure relief

- injection and grouting
- admixture stabilization
- soil reinforcement.

Which method will we use depends on the type of soil and the effects we want to achieve. Other factors are certainly the saturation and depth of the layer [3].

4. CONCLUSION

Big natural disasters lead to great material damages, but also loss of human lives. Sharing of knowledge, awareness and research is the basis for managing hazard risks. Main goal in this papir, was to describe the specific process that occurs in the phenomenon of liquefaction, effects that cause this particular phenomenon, and the types of soil that are endangered. Soil liquefaction is a term that describes the phenomenon in which saturated or partially saturated soil loses strength and stiffness in response to a load. Water that is trapped inside the soil and cannot move freely creates a pressure, and these separated particles move freely by creating liquid sludge. In the event of an earthquake, seismic forces cause additional pore pressure. The type of soil most susceptible to liquefaction is one in which the resistance to deformation is mobilized by friction between particles. Liquefaction occurs principally in saturated clean sands and silty sands having a relative density less than 50%. Liquefaction can be slowed down or prevented with dewatering, increasing soil density, making provisions to reduce the time required for relieving the excess pore water pressures generated by earthquake loading and with ground improvement techniques.

5. REFERENCES

[1] Wikipedia, "Earthquake," /, 2018.

[2] Wikipedia, "Soil liquefaction," /, 2018.

[3] W. D. National Research Council, Liguefaction of Solis During Earthquakes, Washington, 1985.

[4] H. S. R. B. H. L. a. J. H. Seed, Examination of Post-Earthquake Slide od February 9,1971, Washington 1989, 1989.

[5] J. T. Sung, Liquefaction potential of cohesionless soils, Chicago: State of New York, Department of Transportation, 2015.

[6] S. H. a. I. I.M., Settlement of Dry Sands during Earhtquakes, 1972.

[7] D. o. t. G. e. B. State of New York, Liquefaction potential of cohesionless soils, Chicago, 2015.

[8] A. Ibrahimović, Sanacija klizišta, Tuzla, 2013.

[9] Wikipedia, "1964 Niigata earthquake," /, 2017.

[10] T. A. W. o. Geosynthetics, "Basics of Soil Liquefaction – 3 (Reasons for damages to structures)," /, 2015.

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DISASTER RISK EVALUATION (CASE OF FLOOD IN ALBANIA)

Abstract: The aim of this paper is to give a clear understanding regarding the risk associated with floods in Albania. Albania has a geographical position that determines its Mediterranean climate with humid winters and dry summers. The majority part of rainfall occurs during the second half of the year. Over the last few years, Albania has faced flood situations in a series of Albanian districts, not only with economic but also with social impact as well. The focus of this paper is to evaluate the risk coming from the floods, in terms of frequency, probability and financial damage. The methodology for evaluation will be based on primary and secondary data. The primary data are collected by interviews with families and businesses in Shkodra, Fier and Vlora, that are three most vulnerable cities regarding flooding in Albania. The secondary data refers to different national reports conducted by Ministry of Environment, UNDP, PDNA etc.

Key words: flood, risk assessment, frequency, financial damage

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1. INTRODUCTION

Hydrological system of Albania has a surface of 43305 km^2. This system includes 8 big rivers (Drin, Mat, Ishëm, Erzen, Shkumbin, Seman, Vjosa and Bistrica) and their branches' network, 3 big natural lakes (Shkodra, Ohrid and Prespa) and a huge number of small lakes and reservoirs. The eight big rivers are grouped in six areas and cover the country from east to west with an average annual flow of 1'308 $m^3 s^{-1}$. The river system is the biggest hazard of flooding in Albania. The floods, usually have happened during November – March, when 80-85% of annual raining occurs. The floods usually happen suddenly in 8 to 10 hours and during the floods the specific flow of rivers ranges between 0.5 $m^3 s^{-1} km^2$ to 2-5 $m^3 s^{-1} km^2$. For small rivers the range gets even bigger, 2-10 $m^3 s^{-1} km^2$. According to historical data[1], Albania has a long history of flooding in the west lowland. Turkish chronics of 19th century tell that during 1854-1871, 11 big floods have occurred, causing considerable damage of property. Other data[2] tell that big floods have occurred in all areas of Drini and Buna (1905, 193, 1952, 1960), Ishëm, Erzen and Shkumbin (1946), Seman and Vjosa (1937). The flood occurred during November 1962-January 1963 is registered as the biggest one in Albania. Drini and Buna flooded the field of Shkodra, Velipoja and Zadrima. The field of Lezha was also flooded by Mat and Drini. In total 70000 hectares of agricultural land were flooded, causing huge economic damages. In 1992 regions of Lac, Kruja, Lezha, Shkodra, Tropoja and Mirdita were flooded. In total there were 17000 hectares of planted land flooded and the evaluated damage was 12 milion USD. Another flood occurred on September 2002 caused by rivers Erzen, Osum and other small rivers as Gjanica, Gjadri, etc. Cities of Lezha, Berat and the surrounding areas were affected and the water covered 30000 hectares of agricultural land. According to the World Bank data, the total damage was 23 million USD and city of Lezha had the biggest damage. In 2010 another big flood occurred in north of Albania. It is considered as the biggest one of the last 50 years[3]. There were 14100 hectare flooded, 4600 houses were surrounded by water, 2580 of which were inundated. 59604 habitants (5% of total population) were affected, of which 14200 were displaced (7% of total population). 3712 domestic animal and poultry were drowned (1.6%) and many other were transported in safe areas[4]. Another big flood occurred in February 2015 affecting 9 regions and 53 municipalities. Over 10000 hectares of planted area was flooded and the overall damage and needs for recuperation was 110 million USD[5].

Refering to the above overview of the flood situation in Albania, in this paper, we aim to measure the risk associated to inviduals in terms of financial damages. It doesn't take into consideration the costs of public recovering like damaged roads, health care centers, channels, dams etc. It also doesn't count the cost of financial aid for the affected people during the floods and in the following days. If all that would have been taken into consideration the evaluated damage would have been way higher and it would require a lot more work to conclude. This is the main reason why we are limited in inviduals' damage. The other reason of this limitation is the lack of data regarding to the overall damages. The prediction model is based on past data regarding to frequencies of floods and damages. The most risked area is that of Shkodra, which has also more information related to historical events.

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[1] UNDP: "Third National Communication of the Republic of Albania on Climate Change", Ministry of Environment, 2016

[2] UNDP: "Risk Assessment of Catastrophes in Albania", October 2003

[3] World Bank Group: "Europe and Central Asia (Eca) Risk Profiles" 2015

[4] World Health Organization: "Flood in Shkodra, Initial Rapid Assessment", December 2010.

[5] Institute of Geo Sciences, Energy, Water and Environment: "Disaster Management in Albania with the web-based platform DEWETRA" November 2016, Cyprus

2. CHARACTERISTICS OF FLOODED AREAS

2.1. The Southwestern region of Albania

One of the biggest floods in Albania occurred in 2015. Continuous rainfall that began on January 31, 2015 and lasted a week, led to unprecedented river levels. In addition to the above average high rainfall intensity, the fast melting of snow, accumulated in the days before in neighboring Greece, exacerbated the severity of the floods. The flood affected mainly areas along the streams of the Vjosa, Drini, Osumi and Gjanica rivers, with the most serious situation in Vlora and Fieri regions. In a final account, a total of 9 regions and 53 local government jurisdictions (as per the administrative division prior to the June 2015 local elections) were affected by the flood at various extents causing a totall damage of 110 million USD[6]. The number of people affected in all the flooded areas was: 15800 in Vlora, 20000 in Fier and 6100 in Berat, Elbasan and Gjirokaster. 850 families have been evacuated. Around 2000 houses were surrounded by water, most of them flooded and seriously damaged: 750 houses in Vlora,720 houses in Fier, 180 houses in Berat, 260 houses in Elbasan and in Gjirokaster 90 houses. Around 3500 heads of livestock were killed: around 6000 animals have been evacuated. An area of 17000 acres of farm land was flooded: in the areas of Vlora 8000 acres, Fier 7000 acres, Berat 1000 acres, Elbasan 600 acres and Gjirokastra 400 acres. In Novosela (a village near Vlora city), from the interviewed families that were affected by floods in the Administrative Unit of Novosela, the following data were gathered: The water flooded the yards and basements of 100% of the households, 87% of the ground floors were flooded, while only 6% report the level of water being up to the rooftop of reaching the second floor. Overall, the main source of households' income in the affected areas was reported agriculture and livestock activities (Vlora 68%, Berat 81%, Gjirokastra78%). Respondents were asked how their households' current financial situation was compared to that before floods. The vast majority of households (97% of respondents in Vlora, 92% in Gjirokastra, and 56% in Berat) reported worse income. As most of the affected population was rural, the primary causes cited for the loss of household income were the loss of crops and animals. Deterioration of the economic conditions due to floods is confirmed even by the drop of revenues in absolute amount. Once again, revenues from livestock - considered as the highest revenue prior to the floods - have more than halved. Also revenues from agriculture have significantly decreased, by approx. 80%[7].

2.2. The Basin of Drini-Buna (the northern region of Albania)

All watershed area of Drin-Buna basin is approximately 20.380 km2 and it includes 3 rivers, White Drin, Black Drin and Buna, and the lakes of Shkodra, Ohrid and Prespa. Black Drin flows from Ohrid lake and goes north passing the border between Macedonia and Albania. White Drin flows from Kosova and both rivers flow into Fierza reservoir then pass the cascads of dams of Fierza, Koman and Vau Deja reservoirs, all in function of KESH (Albanian Electroenergetic Corporation). The dams are

[6] Institute of GeoSciences, Energy, Water and Environment: "Disaster Management in Albania with the web-based platform DEWETRA" November 2016, Cyprus

[7] UNDP: "Assessment of the Social Impact of Flooding in Albania", April 2016

built respectively till 1978, 1985 and 1975. The high risk of floodings in this area comes from the deviation of Drin river in the 19th century. Till year 1848 the river used to flow straight to Adriatic sea near Lezha, crossing through Bushat and Gramsh. Due to the floodings in 1848, 1858 and 1896, its flow auto diverted. This natural change of the flow was latter supported by building channels and by partial closing of the former flow of Drin. Nowdays Drin flows into the sea mainly through Buna river. The old riverbad is part of the drainage system but with no big potencial. Nowdays, the hydraulic capacity of the actual riverbad can face only small floodings. In the first 9.5 km after connecting with Drin, Buna river has a transporting capacity of 1500 m3/s. The others, 32 km till it reach his delta, are protected with dams and have a capacity of 2200 m3/s. The average flow of Drin-Buna is 680 m^3/s, of which 360 m^3/s come from Drini itself and 320 m3/s from Buna – lake of Shkodra[8].

3. METHODOLOGY

The methodology to conduct this study is based on both, primary and secondary data. The secondary data are provided from United Nations Development Program, World Health Organization, Ministry of Environment, etc. The idea of this paper is to create a model based on historical information in order to make a risk evaluation. Given that past data are not completed and do not provide full evidences, assumptions are to be made. And because of that we will evaluate the damages for 3 of the most risked areas in Albania, but the risk evaluation will be possible only for Shkodra region. Given that the data were not completed, it was seen as reasonable to gather primary information in the area. In order to do this, 32 interviews were conducted with different households from 2 communes that face problems from flooding in the region of Shkodra, 20 interviews in Fier and 22 in Novosela. Each interview lasted 30 minutes to 1 hour and was divided in 4 sections: demographic information, information regarding to house infrastructure, questions on perception of the risk and the last one on consequences of the 2010 flood. In this paper we are interested more on the 4th section, damages of the flood. In the city of Shkodra and Novosela village, as most of the area is rural, people mostly have agricultural incomes. In the city of Fier people have less agricultural incomes because of the urban area.

4. ANALYSIS

Our aim is to calculate the expected annual risk and damage coming from floods in Albania and particularly in Shkodra. Given that we do not have accurate and reliable data related to frequency of floods and damages in Novosela and Fier, we cannot build a model to assess the risk. So for these two areas we are limited only in calculating a total damage in the cases of a big flood. The damage is limited and does not include all areas flooded and does not count the public damages and needs for recuperation which may be bigger than individuals damages. To do this we need to know 2 characteristics of the floods, their frequency and their damage. According to these 2 characteristics, floods are divided into 4 groups: extreme floods, big floods, medium floods and small ones. It is worth mentioning that this region faces floods every year but not all of them have considerable damages. All the groups we take into consideration are actually big floods with considerable damages but in order to create a model we need to make a relative separation compared to each other. Usually medium floods are considered those whose frequency is lower than 10 years and with small consequences which we are not considering. We are grouping normal floods with a frequency of 10-20 years. According to

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[8] Information on this paragraph is provided from: Ministry of Environment, Prefecture of Shkodra: "Plan of Risk Management of Floods, Shkodra Region", 2015

(TerraSAR and Radarsat from the German national aeronautics center and space exploration (DLR, 2010)) the January 2010s flood is grouped at floods with same frequency[9]. To calculate the real frequency of similar floods in this region we have searched for floods since 1850. From 1850 to 2018, which is a period of 168 years, there have been 13 "normal" floods (1854, 1858, 1905, 1937, 1952, 1960, 1970, 1979, 1992, 2003, 2010, 2013and 2018). So the frequency of these kinds of floods is 13 years. It makes sense with (TerraSAR and Radarsat) frequency of these floods which is 10-20 years. The December 2010 flood is considered as the biggest one of the last 50 years and given that we do not have other reliable information we are supposing and grouping it as big flood with a frequency of 50 years. The biggest flood ever registered is that of 1962-1963 and it is the only one of these dimensions ever registered[10]. Our data go back till 19th century and from 1800-2018 is a period of approximately 200 years and most of authors admit that extreme floods have a frequency of 200-500 years. So our assumption stands with the theory and we are classifying extreme floods with a frequency of 200 years and with the example of 1962-1963. Given that Shkodra faces floods almost every 1-2 years we assume that small floods have a frequency of 3 years and the rest of floods is medium, big and extreme.

If we want to make a risk assessment we need a model and the model requires the probabilities of each group of floods. So in 200 years we expect 87 floods (67 small ones, 15 normal floods, 4 big ones and 1 extreme flood). If a flood occurs, the probability of it to be a small flood is 77% (67/87), normal one is 17% (15/87), to be a big one is 4.6% (4/87) and an extreme one is 1.4% (1/87). But if we want to calculate the annual damage we need to know the probability of each one of the floods to happen in one year. If the frequency of a small flood is 3 years, the probability of it to happen in one years is 33%.For normal floods is 13 years, the probability of it to happen in one year is 7.7% (1/13). We do the same with the 2 other groups and their probabilities are 2% for the big floods and 0.5% for the extreme ones. The general probability of a flood to happen in one year is 10% (20 floods in 200 years).

So, to summarize, there are 87 floods in 200 years grouped in 4 categories:

1. Small ones with a frequency of 3 years
2. Normal ones with a frequency of 13 years
3. Big ones with a frequency of 50 years
4. Extreme ones with a frequency of 200 years

If there are 87 floods in 200 years, the probability of a flood to occur each year is 43.5% and if it does occur the probability to be a small one is 77%, normal one is 17%, big one 4.6% and an extreme 1.4%. Now that we have the probabilities and frequencies we need the expected damages for each one of them.

The best information on damages from floods is for the flood of December 2010. According to World Health Organisation, 14100 hectare were flooded, 4600 houses were surrounded by water 2580 of which were inundated. 59.604 habitant (5% of total population) were affected, of which 14200 were displaced (7% of total population). 3712 domestic animal and poultry were drowned (1.6%) and many other were transported in safe areas. The same information is confirmed by UNDP and local authorities. We couldn't find official information regarding the evaluation of damages so we will use primary data gathered from interviews.

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[9] Ministry of Environment, Prefecture of Shkodra: "Plan of Risk Management of Floods, Shkodra Region", 2015

[10] Amparo Samper Hiraldo, "Flood Early System in Albania", Institute of Geosciences, Energy, Water and Environment.

During the interviews, the people were asked how risked they feel from floods each year, what damages were calculated from the government for the 2010 flood, what damages they think they had and if they had damages in crops or in buildings and other assets. All of them felt very risked from floods, most of them admitted they had had more damages than the government actually calculated they had. The biggest percentage of damages were related to houses or other assets like tools, machines etc. To measure the damage we used the value they admitted that the government engineers calculated. The average damage to a household was 6000 Euro. According to World Health Organization, 2580 houses were inundated and according to UNDP the number was 2650 houses. We decided to use the average of both (2615). Knowing the number of households affected and the average damage for household we can calculate the total damage.

2.615 x 6.000 = **15.48 million Euro**

According to the respondents answers during the interview, we calculated that approximately 10 million (64%) of these were buildings and other assets damages and the other part were damages on crops and animals (36%) 5.4 million. This makes sense with the evaluations of Directory of Agriculture which concluded in a damage of in crops around 4 million Euro. According to them, 10280 hectares were flooded; of which 4887 was cultivated area (48%).

For extreme and medium floods there are no reliable data to calculate the damage, so we made 2 assumptions. To calculate the damage of small and medium floods, we will use the duration of floods in days, assuming that the damage rises with the duration of the flood. At the 2010s flood (big flood) the water stayed 35 days. In a small flood the water usually stays 2 to 4 days and in medium flood like January 2010s the water stays 10 days. So for the big floods the water stays (35/3) 11.7 times more than in the medium ones.

So expected damage for small floods is **15.48 x 3/35 = 1326857 Euro**

For normal ones the damage is **15.48 x 10/35 = 4422857 Euro**

To evaluate the damage of the extreme floods like 1962-1963 we used the area flooded as a coefficient of the damages. In 2010s flood 14100 hectares of agricultural land were flooded. In 1962-1963 there were 70000 hectares flooded in total. Assuming that the number of buildings doesn't change in portion with the area flooded (almost all populated area was affected, and the houses that were not flooded were 2 floors buildings or in safe areas), the size of the area flooded will affect only the damages of agricultural output, not buildings. So the calculated damage would be as follows:

{(15.48 – 10) x (70.000/14.100)}+ 10= 27.2 + 10 = **37.2 million Euro**

In Shkodra region the expected damage in cases of a flood can be calculated by multiplying the probabilities of floods with their expected damage. So the damage in millions of Euro is:

(1.327 x 77%) + (4.423 x 17%) + (15.48 x 4.6%) + (37.2 x 1.4%) = **3 million Euro**

In Fier because of the little information we are focused only in urban area, Fier city, affected by river Gjanica, evaluating damages only for big floods. 20 respondents were interviewed, which were households and businesses. The government did not do damage estimation in this area so we are focused just on their perception on the damages. The damages take value from 1000 Euro to 16000 Euro with an average of 5000 Euro. The damages were on business assets or buildings, no agricultural damages because of the urbanization. The floods in this area happen mostly because of malfunctions in canals. Since the 2015s flood they have been repaired and no floods have occurred since then. We are using 2015s flood as a reference to calculate damages. If the affected people in this region were 20000 and the houses and businesses surrounded by water were 720 we can calculate the overall damage as long as we know the average damage for household. 720 x 5000 = **3.6 million Euro**

In Novosela 22 respondents were interviewed. They had agricultural and building damages. Damages on agriculture were on crops and animals. Almost all had crops damages and half of them had damages in animals and poultry. So the average damage was higher, around 8250 Euro for household. 15800 people were affected by the flood and 750 households were surrounded by water. The total damage from a big flood is

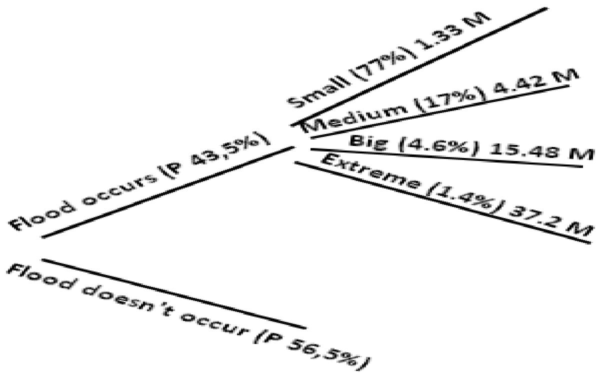
750 x 8250 = **6.19 million Euro**

So in case of a big flood that covers all the risked areas in the country, the expected damage is

15.48 (Shkodra) + 3.6 (Fier) + 6.19 (Novosela) = 25.27 milion Euro

The evaluated damage is in the same levels as calculated from World Bank [11] or UNDP [12] (23 million USD in 2002s flood). But, due to some predictions based on historical data, if a huge flooding, with a returning period of 100 years happens, and in worst case in all areas, 85500 (±10%) buildings will be affected, causing 560000 (±10%) people to be displaced temporary. According to these predictions, the damages may be even higher than we calculated above.

4.1. Prediction MODEL for Shkodra



If there are 87 floods in 200 years, the probability of a flood to occur each year is 43.5% and if it does occur the probability to be a small one is 77%, normal one is 17%, big one 4.6% and an extreme 1.4%. Now that we have the probabilities and frequencies we need the expected damages for each one of them. So the expected damage in one year can be evaluated as follows:

0.435 x {(0.77 x 1.33) + (0.17 x 4.42) + (0.046 x 15.48) + (0.014 x 37.2)} = 1305000 Euro

5. CONCLUSIONS

Albania has a big hydrological system and faces floods each year with the more risked areas in northwest, center and southwest. The most risked cities are Shkodra, Fieri, Vlora and Lezha.

Big floods lead to huge material damages around 20-30 million Euro. The biggest floods occurred in 1962-63 (70000 hectares flooded), 1992 (12 million Euro damages), 2002 (23 million Euro), 2010

[11] World Bank Group: "Europe and Central Asia (Eca) Risk Profiles" 2015
[12] UNDP: "Risk Assessment of Catastrophes in Albania", October 2003

(15.5 million Euro) and 2015 which is calculated to have caused 110 million Euro damages and needs for intervention and recuperation.

In Fier city the average damage for big floods is calculated to be 3.6 million Euro and in Novosela village (next to Vlora city) is 6.19 million Euro. In Novosela, floods occur almost each year but in Fier since the intervention in canals in 2015, the floods have stopped.

Shkodra is the most risked region in Albania. Floods occur almost once in 2 years and they have been grouped them into extreme, big, medium and small ones. The biggest flood ever happened in Albania (1963) was in this region and the evaluated damage is approximately 37.2 million Euro. The frequency of such extreme floods is 200 years. The evaluated damage from big floods is 15.48 million Euro and the frequency is 50 years. The expected damage from medium and small floods is calculated to be 4.42 million Euro and 1.33 million Euro which occur respectively every 13 and 3 years. The probability of a flood to occur each year in this area is 43.5% and if the flood occurs, the average damage expected is 3 million Euro. The calculated damage every year, regardless of the flood event, is 1.3 million Euro.

If a big flood hits all the three areas, it is calculated that the damage to inviduals would be 25.3 million Euro, but it does not take into consideration all areas and cities (Lezha, Gjirokastra ect.)

6. PAPER LIMITATIONS AND FUTURE SUGGESTIONS

The damage evaluated in this paper includes only the material damage of households and it does not take into consideration the public damages (schools, roads, canals ect).The paper also does not include in the analysis urgent needs for dealing with the flood and the long term needs for restauration and intervention after the flood. In some cases those other damages and needs may be higher than the damage to households. This can be done in future studies with more official data gathered.

Because of the limitations and the absence of information, this paper is build based on some suggestions. Further studies may use different methodology. It also does not include all the areas in Albania but is focused in 3 more problematic areas (Shkodra, Vlora and Fier). Other studies may focus in other areas or in all areas that face problems with floodings.

7. REFERENCES

[1] World Health Organization: “Flood in Shkodra, Initial Rapid Assessment”, December 2010

[2] UNDP: “Risk Assessment of Catastrophes in Albania”, October 2003

[3] World Bank Group: “Europe and Central Asia (Eca) Risk Profiles” 2015

[4] UNDP: “Assessment of the Social Impact of Flooding in Albania”, April 2016

[5] Ministry of Environment, Prefecture of Shkodra: “Plan of Risk Management of Floods, Shkodra Region”, 2015

[6] Institute of GeoSciences, Energy, Water and Environment: “Disaster Management in Albania with the web-based platform DEWETRA” November 2016, Cyprus

[7] UNDP, gef: “Third National Communication of the Republic of Albania on Climate Change”, Ministry of Environment, 2016

[8] Amparo Samper Hiraldo, “Flood Early System in Albania”, Institute of Geosciences, Energy, Water and Environment

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ALBANIAN'S WILLINGNESS TO INSURE THE FLOOD RISK

Abstract: Flood risk poses major problems for the community and insurance companies. Each year, flood losses have a direct or indirect impact on insurance, taxes and payments. In recent years, floods are present not only in Albania and the region but also beyond. Floods in Albania gave us the indicia to study this phenomenon for as long as it does not only produce measurable losses in monetary value, but also causes damage to the psychological side of individuals, which is difficult to measure. It should be mandatory or not the provision of this risk and which are the factors that create a culmination in the demand to be provided by the affected, is the focus of this paper. The main data were taken from a survey and interviews made in some areas affected by floods.

Key words: flood risk, insurance company, compulsory insurance, damages, premium, catastrophic losses

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1. INTRODUCTION

Floods are one of the most widespread and most commonly occurring natural hazards in the world, affecting on average 70 million people a year. Flooding has visible impacts on all cultures, religions and geographies, affecting life, ruining communities and businesses, damaging property, assets, and causing stress and bad health. In addition, Albania is affected by several natural disasters and, according to specialists, this is due to the changing climate conditions. According to GFDRR (Global Facility for Disaster Reduction and Recovered), river flood hazard in Albania is classified as high based on modelled flood information currently available to this tool. This means that potentially damaging and life-threatening river floods are expected to occur at least once in the next 10 years. The deadliest flood in Albania since 1900 occurred in 1992. It killed 11 Albanians and caused close to $12 million in damage. Flooding in 2002 caused one fatality but about twice the damage ($23 million) of the 1992 flood. Damaging flooding also took place on the Drina River in 2010. The annual average population affected by flooding in Albania is about 50,000 and the annual average affected GDP about $200 million (World Bank, 2015). Such flooding affected the entire economy of the country and the psychological side of family members and entrepreneurs who had invested their savings in their businesses. Most of the floods have been caused from the outflow of rivers. The damages caused by these floods have been indemnified mainly from the state budget. Another alternative source is insuring the property from floods in insurance companies. This technique is not still used in Albania, due to several factors that affect the demand for insurance in Albania such as low income per capita and low confidence in insurance companies. Therefore, the way society responds to these dangers is not just an engineering issue, but it is a complex decision of political, economic, social and environmental dimensions. And a very current issue is the debate on flood prevention. Insurance is traditionally defined as the business of transforming the risk event (insurable) through a two-party contract. The insurance provides a cost-transfer mechanism instead of risk transfer. The interest in providing flooding arises first and foremost from pursuit to find an efficient way to compensate those who suffer losses and to manage the financial risk of these unsafe losses. Insurance should be an important method to meet the financial consequences of flood risk.

2. LITERATURE REVIEW

Insurance companies would ideally want to avoid catastrophic losses. But unfortunately, it is not possible: catastrophic losses are unpredictable, the distribution of losses can hardly be estimated and the process of making premiums is very difficult. But in fact, insurance companies provide coverage for catastrophic losses, natural catastrophes and man-made disasters. Financiers have compiled agreements that provide protection to insurance companies facing catastrophic losses. This means that insurance companies have found a way to use financial market resources to cope with the catastrophic losses problem.

2.1. Insurance and Flood Hazard

Traditional principles of insurance risk management are mainly based on the probability of statistically measurable historical and predictable distribution of future events, which allows insurance companies to finance losses of random occurrences through contributions of their policy holders. Flood insurance should ideally encourage reduction of uncertainty caused when individual policy owners become aware of their inability to predict unique and individual future potential dangers and outcomes**.** Home owners may reduce their exposure to the uncertainty of events, by spreading the economic burden of loss among members of an insured group. Flood insurance, as all other insurances, therefore does not *prevent* loss, but *relieves* individuals, or community, organisation or municipality of the financial burden *in the event of a loss occurring*.

Table 1 indicates the tangible and intangible resources that can be damaged by floods. The social, economic, environmental and physical infrastructure impacts are generally aligned with the probability of the risk. Without adequate trend analysis and risk management, insurance companies are unable to remain viable in the face of large-scale payouts such as occur after major flood events.

Table 1: Selected forms of flood damages, source: Adapted from Penning-Rowsell et al., 2003.

MEASUREMENT			
		TANGIBLE DAMAGES	INTANGIBLE DAMAGES
Form of damage	Direct	Physical damage to assets e.g.: Buildings Contents Infrastructure	Loss of life Negative health effects Loss of ecological assets and services
	Indirect	Loss of industrial production and associated income and tax base Traffic disruption Disruption of supply of goods, services and food Emergency response and disaster management costs	Inconvenience (and sometimes impossibility) of post-flood recovery Increased social disruption and vulnerability of survivors Psychological impact on affected communities

According to Huber (2004) it is difficult, if not impossible, to privately protect against natural hazards. The difficulties are related to the fact that the threat is considered by the potential insurance population to be too distant to invest in insurance. Only those property owners, who are aware of being often exposed to floods and with serious consequences, may consider purchasing insurance. An insurance population based on these assumptions makes natural hazards a bad risk for insurance. In the face of normal insurance coverage, natural hazards create multiple demands over a given period and all allegations are centred around the occurrence of a single event. If, potentially, all insured persons have sought compensation at the same time, the funds will be discharged. If another event occurs before the fund has re-accumulated the necessary assets, the solvency of insurance companies will be under pressure.

SwissRe (1998) stated that the reinsurer claims floods can only be provided privately if two conditions are met: the state and the insurance industry promote risk awareness among the population with potential risk and "promote solidarity among those seriously at risk and those who are not in danger". Even in wealthy countries, private insurers have been reluctant to offer regional or national policies covering droughts, floods and other risks, partly due to the inherent or co-related nature of the risks. Also, well-diversified insurers may face a risk of insolvency if faced with repeated high loss events. A study has seen how the flood insurance scheme and the factors it depends on is designed and implemented. It is influenced by several factors on the supply, demand, and political or regulatory environment where the ability and willingness to pay for insurance are clearly the main factors, driven by financial risk awareness, education, and cultural aspects. According to them, individuals are more likely to buy the insurance policy shortly after a catastrophic event and whether they already live in a high-risk area. Several recent studies have explored the link between measures to reduce flood risk and premium pricing through methods such as interviews with the insured, model hypothetic, and willingness to pay the obligations. For Holland, Botzen, Aerts, & Van Den Bergh (2009) suggest many homeowners will be willing to invest in risk reduction if this would lead to a reduction in the insurance premium. About two thirds of people are willing to invest in flood barriers and about a fifth are willing to replace floor types that are vulnerable to flooding with water-resistant floor types. Moreover, about a quarter are ready to move central heating installations to safe flooring against floods. In Germany

Thieken, Petrow, Kreibich, & Herz (2006) discovered that secured families are more likely to take measures to reduce the risk than when they are not insured, suggesting that flood insurance puts an incentive on policyholders to act.

2.2. Insurance market in Albania

The insurance market in Albania has been always dominated by non-life insurance products, which share was about 92,7% of the total volume of gross written premiums. The structure of the insurance market in Albania has been changed from the state monopoly (until 1999) to oligopoly (up to 2002) and then to monopolistic competition (during the last decade) (Sharku G., 2016).

Compared with other Western Balkan countries, the insurance market in Albania is less developed. In 2015, Albanian citizen has spent on average Euro 35 on insurance products (in Bosnia & Herzegovina and in Serbia the density rate in 2015 has been respectively Euro 80 and Euro 93). The insurance penetration index was 0,99 % in Albania (In Bosnia & Herzegovina and in Serbia has been respectively 2,1% and 2%). Insurance companies insure the property of business and households, against the fire and other natural perils, on a voluntary basis. In terms of gross written premiums, the share of property insurance was 14% in 2015, recording the minimum value of the last decade. The share of the motor third party liability has been 64% in 2015. Motor third party liability is provided on a compulsory basis. Voluntary insurance activity is still underdeveloped. Actually, the life insurance and the major part of property insurance are purchased due to the application for credit in commercial banks, which require the assurance of property and borrower life. Therefore, these products are indirectly provided on a compulsory basis, which means that the real share of voluntary insurance is even lower. It shows a low level of insurance culture in Albania. There is some other compulsory coverage for business and professionals, particularly in liability insurance, but their share is very small (about 2%). In many cases of these categories, the law is not applied. Albanians spent very little on life insurance products – about only 8 percent. (Sharku G., Koci D. 2017).

Apart the low level of incomes, the difference between western countries and eastern European countries is explained by the voluntary element of life insurance activities. Non-life insurance products are generally compulsory one and the most part of the premium volume is generated from the motor third party liability i.e. in Albania, because of the increase in vehicle ownerships. Life insurance products are voluntary products. The individuals are not constrained from the state to purchase these kinds of products. The purchase of these products depends on the individual attitude and decision. Therefore, the most important determinant of such consumer's behaviour is the low level of insurance culture and the lack of insurance know-how.

3. DATABASE AND METHODOLOGY

The study is composed as a jumble of a descriptive and exploratory study, trying to make a detailed presentation of the areas studied. Two studies were carried out at different times to complete this research. The focus of both studies is to investigate the factors which affect Albanian's behaviour toward insurance. The first study consists of a survey in the areas affected by the floods which took place during the months of December 2017 and January 2018. This survey was conducted to collect data through a questionnaire in the city of Lezha, Fushë-Kruja, Fier, Durrës and Vlora. Since the event was current, the study was intended to see (i) how well informed are individuals about the flood protection; (ii) are the affected households willing to pay for assuring this natural disaster or not; and (iii) do they considerate insurance as a solution if it would be obligatory.

The second study was carried out in the framework of study cases for the city of Shkodra, Tirana, Fier and Vlora. These case studies were carried out during the post-flood period, specifically in May 2018, as the flood situation had been relatively calmed. The aim of this study was to look closer the damages and the consequences of flooding and to identify the causes of non-insurance by individuals (families). Half-structured interviews with residents were conducted to receive data, close observations were observed and their perceptions on the insurance culture were ascertained.

The population surveyed is finite because it is about Albania and the areas affected by floods. In this study, the sample unit is the family where the sample selected for the survey was 200 respondents through the questionnaire (scattered and collected), whereas in the case of the study 104 semi-structured interviews were conducted to provide information how people face the flood event, how local/central units respond to the needs of residents and the role of insurance.

In the first questionnaire apart from the demographic data and details over the flood, the main target was to get information about the disposition of individuals to insure their life and properties as they were experiencing the overflow and its damages.

While the second questionnaire (semi-structured interviews) was carried out in a broader context including data on apartment infrastructure, types of natural hazards that they experience, causes of flooding, strategies for protecting against natural disasters and the consequences of flooding. Considering that this occurred at a time when the flood event had passed, the focus was to find out why individuals do not take into consider the flood insurance as an important financial protection mechanism.

4. ANALYSIS

4.1. First questionnaire

The research strategy for data collection is the survey. While the tool used is a questionnaire, based on other previously tested questionnaires, but tailored specifically to the research question. About 200 questionnaires have been completed in the areas affected by recent floods.

4.1.1. Families affected by flood

Most of the respondents (47.5%) belong to families with 4 up to 5 members and their monthly income varies from 24,000 to 44,000 All / month, while 26% of them declare that they get 44,000 to 64,000 All/month. This indicates that these residents generally have low incomes.

4.1.2. Information about the flood

Based on the results obtained from the distributed questionnaire, citizens state that they have been informed about the expected situation. About 55.5% of them stated that they were informed, and the rest did not have such information. The results show that 10.5% of the respondents were informed two up to three days before, 5.5% were informed one day before the flood and the rest indicated other time periods of being informed.

Almost everyone has been notified through the media and local institutions. While the evacuation call was received by only 25.5% of the respondents.

4.1.3. Damages

Family members reported that the most damaged property from the floods was the house (about 51% of the respondents), followed by the land and agriculture products (31 %) and economic activity (16 %). The rest reported damages to other properties, i.e to vehicles.

4.1.4. Insurance awareness

Respondents were asked about property insurance and it turns out that 71 percent of them has not insured any property. Only a small part of them has insured the auto and a negligible part of them has insured the apartment from fire and flood risk. Asked how much they are willing to pay for the flood insurance premium, it turns out that 80 percent of them are willing to pay 1-30000 All/year. Asked whether they agree that flood insurance to become mandatory, only 28 percent of them gave positive answer, arguing that this action would financially relieve them from damages.

4.2. Case studies, second questionnaire

There are 104 semi-structured interviews conducted, out of which 31 interviews have been performed in Shkodra area, 30 interviews in Tirana, 23 in Vlora and 20 in Fier area.

Regarding the surveyed population, randomly 50% is consisting of female and 50% males. About 32 percent of respondents provide their living through the development of agricultural and livestock activities, about 13 percent through trading activities, 34 percent through employment, 2 percent from handicrafts activities, while the rest perform different jobs or are retired. Their incomes are mainly low: 51 percent of them has a monthly income up to 30000 All, 27 percent has a monthly income that ranges from 30000 to 50000 All, 20 percent has a monthly income that ranges from 50000 to 70000 All, while only the rest has a monthly income more than 70000 All.

While regarding to savings, about 62 percent of the interviewed people have no savings. The rest which had the opportunity to save some money, has invested them in buying a land, opening a business or depositing at a bank. Some of them considered child education as an investment. While a few have invested their money in agricultural activities or have kept the money at home.

4.2.1. Infrastructure of the apartment

Knowing that the type of house construction and the height of the building affect the insurance availability and price, it turns out that 60 percent of the interviewed persons own 1-floor houses and floor 0 is raised from the ground at a low altitude for the most part of them. More precisely, about 66 percent have floor 0 raised from the ground by 0-50 cm.

4.2.2. Flood Problems

Asked regarding the most serious problems they face, about 95 percent of the respondents answered that the flood is the most serious problem, followed by unemployment (78 percent), price increase (57 percent) and drought (26 percent). While other problems such as damage from storms, snowstorms, wind storms or home fire do not constitute a serious problem for them. The reason why flooding is a serious problem is due to the frequency of occurrence. In these areas 64.4% of the respondents face the phenomenon of flood almost every year, while 29.8% of them face floods even twice a year.

4.2.3. The consequences of the flood

Residents were asked whether they received flood damage evaluation. About 58 percent said they did not receive this service from competent governmental institutions. While in the case of the damage being assessed, it has been a superficial assessment, or they have just been ascertained and the assessment has remained in the context of a material assessment, simply written down on paper.

4.2.4. Insurance and reasons for non-insuring

About 92 percent of respondents are not insured. Three percent have insured property and lives, homes, and flood insurance, while 5 percent did not answer this question. They were asked about the reasons for this lack of insurance and their answers were several and complex. About 11.5 percent said it was not available in their area; about 38.4 percent declared that they do not have any information about flood insurance; 12.5 percent thinks insurance is very expensive; 12.5 percent does not believe that insurance companies will not indemnify them in case of damages; and 0.96 percent does not consider the flood insurance necessary.

It is also worth noting that a good part of the respondents has provided several responses at the same time, where 9.6 percent has no information and think that the insurance policies are very expensive. 4.8 percent stated that insurance is not available in their area and, they do not believe that insurance companies will compensate their damages. 3.8 percent of them thinks that insurance policies are very expensive and does not trust insurance companies, while 2.8 percent does not consider the flood insurance as necessity and they do not trust insurance companies as well. The rest of respondents gave more than two reasons for their failure to provide insurance against flood risk.

5. CONCLUSIONS

As result from the first study, it is worth mentioning the fact that the readiness for insurance was low. This contradicts the theory that individuals are more likely to buy the insurance policy shortly after a catastrophic event. This is because they underestimate the expected losses from flooding. While the respondents are experiencing the flood event, they consider the insurance price very excessive. Such attitude toward insurance may come since they were not yet aware of the suffered losses.

Referring to the literature for the second study we conclude that the causes of non-insurance are complex because they link the characteristics of the population to their activities. So, even though there is no direct relationship between income and insurance, we can conclude that low incomes influence on non-insurance behaviour. This is related to the opinion of interviewees about insurance policies as a costly protection alternative. Home insurance premiums are based on the type of construction, the size of the buildings and the location of the building. Considering these factors, it is logical that the premiums will be high, as long as the houses are built without criteria in hazardous areas and they are not built up to the right height from the ground or with other water-resistant materials.

Non-insurance for the vast majority of respondents is also related to their low level of insurance culture and the lack of insurance know-how, as only a small part of them were insured. This conclusion does not consider compulsory insurance of individuals against vehicles or in cases where they apply for collateral loans in financial institutions. The fact that Albanians have confidence issues with insurance companies shows the fears that these individuals have for not being compensated for their damages. This may be due to the minimum amounts of indemnifications they have received from local/government institutions in the past.

6. RECOMMENDATIONS

This section lists some recommendations for further researches in flood insurance. To adequately address the dynamic challenges of flood risk insurance, interventions at different levels are indispensable. The following section will provide recommendations for the relevant categories: local government, local communities and insurance companies.

6.1. Recommendations for local and national government

- Flood maps should be made available to the public. This way the public can see the probability of flooding in the flooded areas.
- Building regulations or standards have to be followed and improved, to make the building structures resistant to flooding, reducing damage and loss of property.

However the mitigation and adaptation of flood risk should be integrated with other strategies. As may be the initiatives created for more awareness of flood risk vulnerability and reduction of flood risk through marketing, communication and training. Although the need for simple flood management is required both in policy and legislation, this remains an unfinished and even neglected function.

6.2. Recommendations for Communities

- Local communities should be actively involved during the planning process in identifying local resources in reducing flood risk and early warning.
- Communities and individuals should take into account the benefits of using flood correction techniques. Those who live in vulnerable places such as the slopes of the hills, in the valleys or rivers and its branches, or flood plains, should build their flats according to municipal by-laws.

6.3. Recommendations for insurance companies

Insurance companies in Albania together with the government must provide a genuine insurance policy for individuals. A possible solution to this situation may be that property insurance be mandatory, as the households would not voluntary purchase the insurance policies, and the catastrophe risk (including flooding risk) may be shared between insurance companies and the government as well. The government has the duty to provide the proper infrastructure (physical and legal one), while the insurance companies should satisfy the insurance contract conditions. These measures would increase the confidence that households have in insurance companies. On the other hand, the insurance companies, having a guarantor like state as a reinsurer, would be more motivated to provide insurance against catastrophe risk, especially the flooding risk.

7. REFERENCES

[1] Botzen, W., Aerts, J., & Van Den Bergh, J. (2009). Willingness of homeowners to mitigate climate risk through insurance. *Ecol Econ* , 68 (8-9),2265-2277.

[2] Huber, M. (2004). Insurability and regulatory reform: is the English flood insurance regime able to adapt to cimate change. *The Geneva papers on risk and insurance.* , 29: 169-82.

[3] Penning-Rowsell, E.C., Johnson, C., Tunstall, S.M., Tapsell, S., Morris, J., Chatterton, J. & Green, C. 2005. The benefits of flood and coastal risk management: a manual of assessment techniques.

[4] Pojani, E., & Tola, M. (2010). he effect of Climate Change on the water sector with a case study of Albania: An economic perspective.

[5] Rejda, E. George 2003. *Principles of risk management and insurance*. Pearson Education.

[6] Sharku, G., & Janku, D. (2017). Insurance Availability For Disasters Risk.

[7] Sharku G., Shehu S. 2016. "Concentration of insurance market in Albania" *Ekonomika a management*. Prague. Vol 2016, Issue 3.

[8] SwissRe. (1998). Floods - an insurbale risk. Zurich: Swiss Reinsurance Company.

[9] Thieken, A., Petrow, T., Kreibich, H., & Herz, B. (2006). Insurability and Mitigation of Flood Losses in Private Households in Germany. *Risk Analysis* , 26 (2) 383-395.

[10] UNDP. (2016). Assessment of The Social Impact of Flooding in Albania.

[11] UNISDR. (2011). Global Assessment Report on Disaster Risk Reduction: Revealing Risk,.

[12] World Bank (2015) http://pubdocs.worldbank.org/en/799491483041822945/albania.pdf.

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DISASTER RISK PERCEPTION AND RISK COMMUNICATION - A CASE STUDY RESEARCH FOCUSED ON ALBANIAN FLOOD PRONE AREAS

Abstract: The risk of natural disasters has been growing, turning Albania into the most vulnerable country in the European continent and putting it in front of many economic and social challenges. In particular floods affect the country every year and have serious impacts on the livelihood and economy of local communities. While disasters in most cases cannot be prevented, the process of risk management and risk communication can reduce the overall consequences of a disaster event. In this regard, the identification of the way disaster risk is perceived by the population living in affected areas can help to guide the disaster risk management process. This study is precisely addressing the issue of disaster risk attitude by trying to identify the relevant factors that affect it. This case study research is focused in 4 flood prone areas of Albania. The main data collection technique used is the semi-structured interview. In addition, notes from observation conducted on the field, and secondary data obtained by public reports have helped to triangulate the findings of the study. The study concluded that age, civil status, monthly income level of the family, education and the area of living, affect the perception that residents have about natural risk.

Key words: information, perception, natural hazards, Albania, floods

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1. INTRODUCTION

Natural disasters are very difficult to prevent, but that does not mean that no measures are to be taken in this respect. Effective risk communication is one of the means that can help mitigate the effects of a disaster event. Risk communication is a social process by which people are informed of the dangers, their behavior is influenced by information and they are given the opportunity to participate in decision-making about risk issues in an informed manner [13]. Such activities are part of almost all emergency management strategies. For effective risk communication, a sense and a sound understanding of the perceptions and attitudes that individuals have to the risk (including the risk of natural disasters) is imperative.

Albania is ranked on a global scale as one of the countries with the greatest economic consequences caused by natural disasters. Its annual average losses are about 2.5% of its GDP [22]. Developing and implementing an efficient disaster risk management strategy is necessary in the light of preventing and mitigating disaster effects. In this regard, an important step is the analysis and identification of the factors affecting disaster risk perception of Albanian population. Such results can help the decision making process and the identification of efficient policies that would address the need of the population and their expected reaction to disaster events. This was the starting point of conducting the research presented in this paper. Context, information, personality and risk factors that affect the perception and attitude of Albanian individuals to the risk of natural disasters will be identified for this purpose.

The first section of this paper will offer an overview of literature in the field of disaster risk perception and risk communication. After that, Albanian social and economic background will be presented. It will be succeeded by the presentation of the research methodology and its main results. The final part of the paper will link the results of the study with recommendations on implementation of an effective risk communication strategy.

2. A LITERATURE REVIEW ON DISASTER RISK PERCEPTION AND RISK COMMUNICATION

Disaster risk is expressed as the likelihood of loss of life, injury or destruction and damage from a disaster in a given period of time [20]. Any population exposed to natural dangers - such as earthquakes, hurricanes, fires or floods; or technological ones, such as explosions, chemical spills, train crashes and so on - wish and should be optimally informed about the risk characteristics, preventive measures and appropriate behaviors during emergencies. Authorities should devise appropriate planning, prepare coping strategies, and effectively communicate information to residents, people in the workplace, and communities as a whole. Better response to natural disasters requires active involvement of residents, which should have been informed and taught about the dangers they are facing [12]. In other cases, public discussion, stakeholder participation and perhaps joint resolution of conflicts are needed [16]. All these situations include social processes that are commonly included in the term "risk communication"[17]. Risk communication is perceived as a necessary link between perception of risk and its management. Communication programs should be based on a sound understanding of individuals' sociopsychology [13].

In general terms, perception of risk can be considered as an interpretation or understanding that the individual gives to particular threats that could potentially cause loss of life or property [19]. Risk perception includes the process of collecting, selecting and interpreting signals about uncertain impacts of events, activities or technologies [13]. These signals can be referred directly to observations (for example, evidence of a car accident) or information from others (for example, reading about nuclear power in the newspaper). Floods have the largest number of studies conducted in relation to the attitude, perception, information and preparation of individuals to the risk of natural disasters ([9],[14],[15],[18]). Few studies have addressed the risk perception in case of earthquakes and other types of natural disasters (see for example [1],[10]).

Risk perceptions may vary depending on the type of risk, the risk context, the individual's personality, and the social context [16]. Moreover, the perception of risk is affected by the so called situation and cognitive factors [9]. These perceptions guide people’s judgments about the acceptability of risks and have a crucial influence on behavior before, during and after a natural or human disaster either [16]. Summarizing the above, Messner and Meyer (2005) conclude that knowledge, experience, values, attitudes and feelings influence the thinking and judgment of people about the seriousness and acceptability of risks.

The factors contributing to the attitude and perception of the risks of natural disasters have been grouped by some authors into 4 categories: risk factors, information factors, personal factors, and context factors [21]. Risk factors are related to individuals experience, and are influenced by the way the likelihood and frequency of an event is perceived, based on individual’s own encounters with past events. Findings about the impact of risk factors are somewhat contradictory. Some survey data show that in some cases people doubt that danger will be repeated. Instead they argue that "lightning never hits twice in the same place" and do not seriously take into consideration past experience. This was the case in Heitz, Spaeter, Auzet, & Glatron (2009) study, in which they found out that the perceived likelihood that a disaster event will happen again has not a relevant statistical relationship with past experience with disaster events. According to the authors this happens because of people psychology, which refuses to believe that bad episodes will be repeated. This was also the case of Kates (1971) findings of his case study research of risk perception in the East Coast in the US. He revealed how people are not willing to draw logical conclusions from their personal experience and they underestimate the risk of repetition of natural disasters. In other cases, studies have found that experience alters perception. A study conducted by Baan & Klijn, (2004) in the Netherlands for example show that after 1993 flooding events the perception of population toward disaster events changed totally once their catastrophic consequences were experienced.

Informational factors include the issue of risk communication and its impact. Information flow from experts, public authorities and media contribute to the perception people have on the efficiency of disaster risk management strategies and consequently to the perception of the level of safety from an eventual disaster event. In this regard, Harries (2008) argues that the more individuals have trust in society and the state as an institution, the less they take action against floods. On the other hand, Siegrist and Cvetkovich (2000) studying risk attitute in various, mostly natural, disaster events, were able to prove the hypothesis that the more individuals had knowledge and information about the potential and the risks of a natural disaster, the less they believed in the information provided by state authorities. The factor influencing risk perception in this case was the self-confidence of individuals.

Personal factors have been largely addressed by literature. They include factors such as: age, gender, educational level, profession, stakeholder membership, personal knowledge, personal disaster experience, trust in authorities, trust in experts, confidence in different risk reduction measures, involvement in post-disaster recovery action, world views, degree of control, religiousness, etc. Interesting findings have been produced by international literature in relation to these factors. It is common understanding for example that women, perceive a higher level of risk. Miceli, Sotgiu, & Settanni (2008) have confirmed this in their research, while studying the impact of age and gender on disaster risk perception. They state that women are less tolerant of the risk of natural disasters than men, while older ages are more tolerant. Armas (2007) shows that grown-ups and individuals with higher levels of education are less tolerant of natural risk, while finding that income was not statistically significant in his study. Income, on the other hand, has been found to affect disaster risk tolerance in Baan & Klijn (2004) study. They find that the increase in family income reduces the tolerance of individuals to natural risk. Religion and belief is also addressed in the literature. Some people for example attribute responsibility for disaster events to a higher power or authority, such as God, destiny or national government [6]. In other cases, disaster risk was found to become part of the identity of an individual or community. In such cases they would accept to coexist with danger, even by developing an emotional connection with it, thus neglecting the serious consequences of this disaster [1]. This was the case of people in living in Yungay, Peru, who do not want to move from their homeland despite the high earthquake risk [2]

Finally, context factors, such as economic factors, vulnerability indices, home ownership, family status, country and area of living, closeness to the waterfront, size of community, age of the youngest child, also affect the way risk is perceived by the population [9].

3. THE SOCIO-ECONOMIC AND CULTURAL CONTEXT OF INFORMATION, COMMUNICATION, PREPARATION AND ATTITUDE TOWARDS NATURAL HAZARDS IN ALBANIA

Albania is a post communist country. This heritage has contributed to the socio-economic background of the country today. In fact, most of social, economic and political movements in Albania have to cope with the communist heritage of the country which has left behind a culture of lack of initiative, disregard of public properties, and unwillingness for cooperation. This is clearly evidenced in the occurrence of uncontrolled and chaotic urbanization of last two decades. On the other hand, after the fall of communism, the transition period the country faced was characterized by almost three decades of constantly changing public policies, short term strategies, and unclear vision of the different governments that have ruled the country ever since. These features have had a strong impact on drafting and implementing disaster risk management strategies. Another challenge in this regard is the lack of a solid culture of volunteering. Currently, among civil society organizations, the Albanian Red Cross (ARC) is the only voluntary organization in the country with real capacities and structures that have a significant impact on civil emergencies. Due to a "conceptual outline", what is considered as "risk assessment" in Albania is generally a "risk tabulation" that does not include "a clear analysis with different scenarios of disasters and exposure levels of population and assets her approach to each scenario" [7].

Early warning is conceived as a warning to an eminent accident or disaster. Consequently, there is no clear system for long-term disaster monitoring to identify emerging trends and provide early information to national authorities, to be reflected in the various development plans of the country. A database to combine all partial data about regional disaster risks, their impact and losses, which is regularly updated by the relevant authorities is also missing and needed.

Finally, the lack of culture of public/private insurance schemes for natural disasters protection further aggravates the adverse effect of disasters as well as the possibility of reclamation time. There is an expectation among the Albanian population that in case of damage from a natural disaster the Government is the one that should compensate for all damages [7]. In fact, the Albanian legislation clearly stipulates that the possible compensation is no more than 40% of the losses. This further demonstrates the general lack of information, or misinformation of the population. This is caused not only because of the lack of information campaigns, but also because of the apathy of the population, which chooses in most of the cases to discuss these issues only with friends and relatives, rather than requesting appropriate information from public authorities.

No studies up to date have addressed the issue of disaster risk perception in Albania. Under the circumstances presented above, a clear understanding of the safety culture, and the factors that affect it, is necessary in order to properly develop strategies and plans for disaster risk management. Therefore the remaining part of the paper will try to understand the level of awareness of disaster risk, and the factors that affect risk perception. In addition, the link between disaster risk perception and risk communication have been addressed and recommendation in this regard are drafted in the last part of the paper.

4. METHODOLOGY OF THE STUDY

This study is an interplay between explanatory and exploratory research. On one hand, it intends to establish causal relationships between demographic, social, and economic variables, and the risk attitude toward natural disasters by carrying out a quantitative analysis through multiple regression. On the other hand, the study aims to shed light on the process of information, communication and risk-taking, thus performing a qualitative analysis of the generated data. Thus, this case study have used both qualitative and quantitative data analysis. Four flood prone areas of Albania have been chosen for this purpose: Dajç area in Northern Albania, Fier and Novosela area in South Albania, and Lana's river zone in Tirana (Central Albania). Both observation and semi-structured interviews were used in the process of collecting primary data, and public reports review was used to triangulate the findings.

With the aim of being closer to the affected population world and better understanding of the behavior and responses they have given, face-to-face interviews were conducted. A total of 104 interviews were completed. The interview had 68 questions divided into 4 sections (Table 1).

Table 1. The content of semi-structured interview

Section	Description	Nr of questions
1	Demographic data for households	11
2	Infrastructure of the apartment	8
3	Disaster Risk Perception / Attitude and Risk Communication	23
4	Flood consequences of 2017-2018	26

The data were gathered from 26 open-ended questions, which aimed at gathering qualitative data, and 42 closed-ended questions, which aimed at gathering both qualitative and quantitative data. Quantitative data were used to carry out quantitative analysis with the aim of finding causal relationships between different variables and disaster risk attitude in the studied areas.

Case study areas have been chosen based on their relevance in relation to flooding events. Dajçi village is a scenic area situated in the banks of Buna river. The village never experienced a flooding event during communist area, and it is reported (both by public reports and by the population living in the area) that flooding today is caused by the management of the flow of Drini river which supplies water to Buna river. About 2000 people live in Dajçi, working mainly in agricultural sector.

Lana river's zone is located in Tirana city, with about 1000 people living there. They earn money by caring out survival activities. This area is constantly affected by the floods, which seems to be caused mainly by human activities. Most of the inhabitants of this area are uneducated and have very low incomes, which forces them to embrace the risk of flooding in their area.

Gjanica's river zone is located in Fier city, with about 1500 people living there. The population here is mostly composed of middle income families working in different professions. They experience flooding from Gjanica river constantly. The river bed is filled with inert, urban and hydrocarbon residues.

Novosela area is located in Vlora city, with about 8200 people living there. The population mainly deals with the cultivation of vineyards, olive groves, vegetables, corn, typical for an area that is part of

Mediterranean zone. Flooding events in this area have risen especially after the construction of the Fier-Vlore highway, which has blocked the normal flow of the Vjosa River.

Purposive sampling was used to identify the participants in the study. Population living in the most affected neighborhoods of each case study area have been selected for interview. The response rate is 100%, because all individuals who are asked for participation in the interview have given their approval and have become part of the study. A sampling division by zone, gender and age is presented in Table 2.

Table 2. Sampling division by area, gender and age.

Area	Gender			Average age		
	F	**M**	**Total**	**F**	**M**	**Total**
Tirana city (Lana's river zone)	26	4	30	48	41	44
Shkodra city (Dajç area)	13	19	32	47	53	50
Vlora city (Novosela area)	6	16	22	49	46	48
Fier city (Gjanica's river zone)	7	13	20	44	50	47
Total	52	52	104			

5. DATA ANALYSIS OF CASE STUDY

5.1. Individual's disaster risk attitude and factors affecting it.

5.1.1. Study variables

Disaster risk tolerance is the dependent variable of this study, which will be represented by 2 blocks of questions presented in the tables 3, 4 and 5. The measurement scale is Likert type 1-4 for block I and 1-5 for block II. Respondents should choose one of the following answers for each of the block question I: 1. Disagree 2. Neither agree/disagree 3. Agree 4. Strongly agree; while for Block II can choose between: 1. Strongly disagree 2. Disagree 3. Neither agree/disagree 4. Agree 5. Strongly agree. Answers are coded in such a way that 1- indicates risk avoidance; 2, 3, 4 increased risk tolerance and 5- perceptive / tolerant attitude toward natural risk.

Table 3. Disaster risk tolerance (N=104)

Block I	**(Mean) щ**	**(Standard Deviation) σ**
It is said that disasters can not be precisely predicted and therefore the government must continuously provide financial assistance for the damage caused to residents.	1.1	0.3
Another point is that people know the risks of living in such an area, so the damages they have to cover themselves.	3.55	1.18
Another view is that the state should stop people from building in risky areas through the relevant legislation.	2.73	1.96
The government should strengthen the rules in building codes.	2.65	2.01
The government should make the provision of compulsory property.	3.21	1.92
The government should set a specific tax that will serve to cover monetary losses from natural disasters	3.25	1.86
One of the reasons for flooding is related to the lack of maintenance of drainage channels. Individuals are responsible for their maintenance.	3.22	1.85

Block I: щ = 2.82 and σ = 1.23

Table 4. Disaster risk tolerance (N=104)

Block II	(Mean) щ	(Standard Deviation) σ
I think everything that happens is accompanied by danger and nothing can be done about it.	4.01	1.17
I think life is in God's hand.	4.08	1.19
I am concerned about the few measures taken by the administrative organizations to mitigate flood damage.	1.74	1.22
I think flood damage can be minimized if everyone takes precautionary measures.	2.49	1.39
I do not think that if I do something to reduce flood damage, there is a big difference.	2.95	1.57
If the responsible units hold seminars or do disaster prevention training, I want to attend.	3.12	1.81

Block II: щ = 3.06 and σ = 0.54

For both blocks of questions щ = 2.94 and σ = 0.78; so according to descriptive statistics it is noticed that individuals tend to resort to the risk tolerance of natural disasters, as the average of their responses (2.94) is closer to number 5, which indicates the tolerance to the risk considered.

Independent study variables include several factors that are classified according to the study of Heitz, Spaeter, Auzet, & Glatron (2009). They are:

- Risk Factors: The number of previous experiences with natural hazardous events, which are self-coded as numbers.
- Information Factors: source and level of information obtained from the local unit, which is encoded with zero when no warning is made for the individual and with 1 when realized.
- Personal factors: a) age, which is self-styled; b) gender, which is coded for 0 for males and for 1 for females; c) education level, which is coded from 1-4 for each category: no education, 8/9 years primary school, high school/gymnasium, university; d) occupation, which is encoded with zero for individuals without occupation and with 1 for those with occupation; e) civil status, which is coded from 1-4 for each category: single, married, divorced, widowed; f) number of members in the family; g) monthly earnings, which are coded from 1-5 for each category: up to 30000 ALL (Albanian Lek), 30001-50000 ALL, 50001-70000 ALL, 70001-90000 ALL, more than 90000 ALL; the belief in major forces, which is coded with 1 for cases where individuals see the will of the God as the main cause of flooding and 0 when they do not see it as such; emotional bond with property, which is encoded by 1 for individuals who say they will never leave their area and 0 for individuals willing to move.
- Context factors: the living area, which is encoded by 1-3, respectively, for the areas located in Northern Albania, Central Albania and South Albania.

A multiple regression model has been established to understand in detail the relationship between tolerance to the risk of natural disasters and the independent variables presented above.

Table 5. Independent multiple regression variables

Nr	Variable	β (beta)	Σ	t_o	Probability
1	Net monthly household income	-0.081	0.055	-1.473	0.1439*
2	Civil Status	-0.078	0.041	-1.88	0.06**
3	Education	-0.13	0.032	-4.09	0.0001****
4	Age	-0.002	0.0017	-1.55	0.12*
5	Living area	0.055	0.027	2.018	0.043***

R^2=0.30 F_V=8.67**** *p<0.15 **p<0.1 ***p<0.05 ****p<0.01

As can be seen from Table 5, the final multiple regression consists of 5 independent variables among which:

- Education has been statistically significant at the error level or p <1%
- The living area has been statistically significant with p <5%
- Civil status has been statistically significant with p <10%
- Two variables in the model; the net monthly household income and age are statistically significant with a higher level of error, with p <15%; but is set to be kept in the model for two reasons: 1 - because the error level for these two variables does not exceed 15% (a level acceptable in some studies) 2 - because the global model results statistically significant with p <1% .

5.2. Preparedness, planning and disaster risk communication in case study areas

Some important findings were produced in relation to the level of risk communication and preparedness of the population in case of disaster. This findings were mostly produced from the analysis of qualitative data.

In Dajçi area flood risk information and communication is carried out mainly by the local unit (village chief) shortly before the occurrence of the event, preventing appropriate measures to be taken from residents. There is no seminar meeting in this village to inform or teach residents how to face floods. About 62.5% of respondents declared that their family does not have an emergency plan. Also, 68.75% of the interviewed residents do not take away food reserves in case of flooding. 53% of them have erected houses to such heights to protect them from flooding fluctuations. The rest did not do it.

In Tirana area, the respondents reported that for them the main causes of flooding were the lack of sanitation, the unreacted river bed and the will of God. Asked about the information they had about the area and the risk involved there, they mostly answered that they were placed there even though they knew it was dangerous. This shows how they embrace the risk for reasons that definitely relate to income, but also to their level of education. No training has been done in this area to deal with disaster situations. The process of information and risk communication by the institutions was very poor. The residents did not even have their own family plans in case of floods, but in the event of such catastrophes, their only plan was to leave as soon as possible.

Respondents from Fieri report that in the case of flooding events of 2015 risk communication was performed only two days before the occurrence of the disaster event. This time is perceived not enough by the inhabitants to take the appropriate measures. The vast majority of households, about 80%, have developed an emergency plan in case of flooding. 75% of the respondents do not hold dedicated savings to cover the floods, even though this natural disaster is no longer an unexpected phenomenon.

The last area from the South, Novosela, reports other problems in relation to risk communication. Residents of this area have spoken of the last two floods, which damaged the economy as well as their health and psychology. Two floods occurred one after the other; one in December 2017, while the other on 3 January 2018. For the first case residents were warned of the meteorological forecasts and the civil emergencies of the Vlora municipality. The warning came 2-3 days before the event. According to them this was a time totally inadequate to take action, even though they did what they could. Regarding the flood of January 3, 2018, residents stated that no public institution reported them, and they were totally unprepared, thus suffering significant damage to dwellings, cattle and agriculture. Most of the interviewed residents consider that the construction of the Fier-Vlore highway, which has blocked the normal flow of the River Vjosa, has been the main cause of the flooding of the last years. There are also residents who perceive the flood as natural disasters. No civil emergency meeting / training is organized to prepare residents for emergencies. 63.6% of them develop basic emergency family plans. 40.9% of residents hold some food shortages, as a measure to cope with the difficult situation. Also, a large part of them, about 81.8%, have not raised the dwelling to the right height to protect against floods. 60% of them do not hold dedicated savings to use in case of flooding, although they already know that this phenomenon has some time to embrace. So they do not tend to avoid natural risk. Asked about their attitude to disaster risk before settling in this area, most of them, about 95%, said they did not think of the possible occurrence of a natural hazard then. Today, some of the residents, especially young people, say they would like to leave but have no where to go.

6. DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

This study was focused on two main points: disaster risk perception and risk communication. Disaster risk communication is not properly implemented for residents of study areas, resulting in major consequences and problems in their lives. The understanding of disaster attitude and of the factors affecting it is a major step to the right development of public strategies.

The qualitative and quantitative analysis done in this study produces some very important findings in relation to risk attitude of Albanian population living in the study areas. Families with higher monthly incomes are the ones that are more likely to avoid the risk of natural disasters, so they are more willing to take action to combat the phenomenon and natural risk. Measures such as improving housing conditions to protect against floods, willingness to pay specific flood tax, readiness to leave the risk area, willingness to attend pre-disaster training, saving for emergency situations, etc., are some of the examples of disaster risk response of the population. This relation is best connected to literature (Baan & Klijn, 2004). Unmarried respondends are more tolerant of risk, and this is normal because it relates to the fewest responsibilities they have, compared to married ones. As the level of education increases, the tolerance of individuals to the risk of natural disasters decreases. This is logical because as much knowledge becomes available, the more the tendency to avoid disasters increases. This conclusion is also related to the literature studied (Armas, 2007). Age also has the same relation as education with tolerance to natural hazards. The model also shows that individuals in the central and southern parts of Albania are more tolerant of the risk of catastrophes. This is mainly related to the economic inability of Tirana river banks to take measures against floods and the lack of desire of residents in southern areas to leave the property for decades and their generations.

Other independent variables that were included in the study, but were not relevant in the model. This do not imply that they do not play a role in the residents' attitude towards natural hazards. Emotional bonds with property, trust in major forces, the number of previous experiences with floods have definitely influenced the perception they have on natural risk.

Finally, from the qulitative data gathered, it is evident that the level of disaster risk communication in all study areas is very problemaric. Moreover, the inhabitants of the community considered flooding in most of the cases as human activity, urging for measures to be taken in this regard. This is a string indication for the public authorities in relation to the development and implementation of public disaster risk management policies and strategies. The gap in communication, warning, and in all processes related to the preparation of the population for the natural hazards that are threatened, comes from a whole range of causes directly or indirectly linked to one another. This is definitely related to the stage of development of Albania, the way of functioning and the integration of institutions. It is important to build the necessary capacities from the relevant institutions to make the risk communication process more efficient, to create the right mechanisms for communication to move in the fairest and shorter way to get closer to the endangered population, and to help them as much as possible in their struggle against what the power of nature or the power of man brings.

Further studies can be delveloped follosing the reccomendation in relation to disaster risk management strategies development and their relation to risk attitute and risk communication.

7. REFERENCES

[1] Alam, E. (2016). Earthquake and Tsunami Knowledge, Risk Perception and Preparedness in the SE Bangladesh. *University of Chittagong*.

[2] Armas, I. (2007). *Social vulnerability and seismic risk perception. Case study: the historic center of the Bucharest Municipality/Romania.Natural.*

[3] Baan, P., & Klijn, F. (2004). Flood risk perception and implications for flood risk management in the Netherlands. *International Journal of River Basin Management 2*, pp. 113-122.

[4] Baan, P., & Klijn, F. (2004). Flood risk perception and implications for flood risk management in the Netherlands. International Journal of River. *International Journal of River Basin Management* , 113-122.

[5] Cutter, S. L. (1993). Environmental Risks and Hazards byr. *Progress in Human Geography*, 529-539.

[6] DRT. (January 2017). *Assessment of Kenya's preparedness to disasters caused by natural hazards.* Uganda: DEVELOPMENT RESEARCH AND TRAINING.

[7] Duro, F. (2015). *Menaxhimi i Emergjencave Civile në Shqipëri.* INSTITUTI PËR DEMOKRACI DHE NDËRMJETËSIM, Qendra për Çështje Evropiane dhe të Sigurisë.

[8] Harries, J. (2008). *The Far- Infrared Earth.* American Geophysical Union, Reviews of Geophysics, 46, RG4004 .

[9] Heitz, C., Spaeter, S., Auzet, A., & Glatron, S. (2009). *Local Stakeholders' Perception of Muddy Flood Risk and Implications for Management Approaches.* A case study in Alsace (France).

[10] Liv, H., McClure, J., & Crozier, M. (2015). Effects of risk framing on earthquake risk perception: Life-time frequencies enhance recognition of the risk. *International Journal of Disaster Risk Reduction*, Volune 13, 145-150.

[11] Messner, F., & Meyer, V. (April 2005). *Flood damage, vulnerability and risk perception. – challenges for flood damage research.* Dresden, Germany: UFZ –Centre for Environmental Research Leipzig-Halle, Member of the Dresden Fllod Research Center.

[12] Miceli, R., Sotgiu, I., & Settanni, M. (2008). Disaster Preparedness and Perception of Flood Risk: A Study in an Alpine Valley in Italy. *Journal of Environmental Psychology* , 164-173.

[13] Morgan, M., Fischhoff, B., Bostrom, A., & Atman, C. (2001). Risk Communication: A Mental Models Approach. *Cambridge University Press*.

[14] Plapp, T., & Werner, U. (2006). Understanding Risk Perception from Natural Hazards. Examples from Germany.

[15] Plattner, T., Plapp, T., & Hebel, B. (2006). Integrating public risk perception into formal natural hazard risk assessment. *Nat. Hazards Earth Syst. Sci*, 471-483.

[16] Renn, O. (2008). Risk governance. Coping with uncertainty in a complex world. Earthscan, London.

[17] Rohrmann, R. (2000). A socio-psychological model for analyzing risk communication processes. *The Australasian Journal of Disaster and Trauma Studies*, ISSN: 1174-4707.

[18] Terpstra, T. (2009). Flood preparedness: thoughts, feelings and intentions of the Dutch public. *Thesis University of Twente* .

[19] UNISDR. (May 2009). *UNISDR Terminology on Disaster Risk Reduction* . Geneva.

[20] UNISDR. (2015). *Global Assessment Report* . United Nations Office for Disaster Risk Reduction.

[21] Wachinger, G., & Renn, O. (2010). *Risk perception of natural hazards.* CapHaz-Net WP3 Report, DIALOGIK Non-Profit Institute for Communication and Cooperative Research, Stuttgart.

[22] World Bank, W. (2009). *"Albania's climate vulnerability",*. World Bank.

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FIRE SAFETY ASSESSMENT OF RESIDENTIAL BUILDING: PRESCRIPTIVE APPROACH AND EVACUATION MODELLING

Abstract: Buildings are currently designed and constructed in accordance with prescriptive and performance-based design to ensure a certain level of safety during fire emergencies. Over past few decades, sophisticated computational software, that go beyond basic hand calculations, have been developed; e.g. simulating individual agent movement and even modeling human behavior. In this paper, the results of fire safety assessment of residential building in Novi Sad, including estimation of occupant's evacuation time, are presented. The idea is to improve the accuracy of the results produced by prescriptive methodology, by using performance-based calculations and analyses. In this study, software for simulating the evacuation - Pathfinder was used and several scenarios were created in order to determine evacuation time and flow characteristics of buildings occupants.

Key words: prescriptive design, modeling, simulation, fire, calculation

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1. INTRODUCTION

Buildings are currently designed and constructed in accordance with prescriptive and performance-based methodologies to ensure required level of safety. Prescriptive approaches rely on the application of a predetermined set of rules that usually refer to estimation of evacuation time by using simple engineering equations. For example, the movement of the buildings occupants is determined by the number of people in the available floor space, with the population effectively behaving like a fluid travelling along a pipe. These methodologies suggest adopting several parameters, such as: evacuation speed (depending on terrain level), pre-evacuation time (depending on age and basic abilities) and limiting evacuation times are set in order to achieve needed degree of safety. In this way, these methodologies make simplified assumptions regarding performance and do not explicitly represent many of the expected evacuee behaviors, or the factors influencing them.

With the development of evacuation software, engineering applications are growing in number and are showing a powerful applicability. These tools often more accurately represent the nature of the space, agent attributes and indicate critical point during evacuation. These models have the potential for representing factors that influence agent behavior and the agent decision-making process. Although they mostly represent the evacuee and evacuee decision-making in a simplified form, they can be powerful tool to quantify evacuee performance. Evacuees are represented as purely physical entities, not taking into account decision-making, route choice, social identity etc.

The process of decision-making begins when people witness cues from the event. Individuals may encounter only one type of cue (for example, seeing smoke) or may be presented with a variety of different cues, including environmental cues, the behavior of others, and warning messages. The introduction of these cues initiates a series of pre-decisional processes that must occur in order for the individual to perform protective actions: receiving the cue(s), paying attention to the cue(s), and then comprehending the cue(s). Once these pre-decisional processes are complete, individuals engage in a series of stages, including risk identification, risk assessment, protective action search, and finally, protective action implementation. (Kuligowski, Gwynne, Kinsley and Hulse 2016.)

The following table, by Proulx (2001), represents the factors influencing human behavior in fire (Bayat 20).

Table 1 - Factors influencing human behavior in fire

Occupant Characteristics	Building Characteristics	Fire Characteristics
Profile: • Gender • Age • Ability • Limitation	**Occupancy:** • Residential • Office • Factory • Hospital • Hotel • Cinema • College and University • Shopping Centre	**Visual cues:** • Flame • Smoke • Deflection of wall, ceiling, floor

Knowledge and experience: • Familiarity with the building • Past fire experience • Fire safety training • Other emergency training	**Architecture:** • Number of floors • Floor area • Location of exits • Location of stairwells • Complexity of space/Way finding • Building shape • Visual access	**Olfactory cues:** • Smell of burning • Acrid smell
Condition at the time of event: • Alone vs. others • Active vs. passive • Alert • Under drug, alcohol, medication	**Activities in the building:** • Working • Sleeping • Eating • Shopping • Watching a show, a play, a film, etc.	**Audible cues:** • Cracking • Broken glass • Object falling
Personality: • Influenced by others • Leadership • Negative toward authority • Anxious	**Fire Safety Features:** • Fire alarm signal • Voice communication system • Fire safety plan • Trained staff • Refuge area	**Other cues:** • Heat
Role: • Visitor • Employee • Owner		

According to Quarantelli's (1980) notion, as far as human behavior and evacuation process in fires and emergencies is concerned, there are five patterns of behavior shown by people. They include: warning, withdrawal movement, shelter, and return**.** (Bayat)

In this paper, fire safety assessment of residential building, including its evacuation parameters, located in Novi Sad, was carried out.

2. THE BUILDING DESCRIPTION

The residential building (Fig. 1) is located in the Street Narodni front, number 26. It was built in 1972.

The dimensions of the building are 21.91m x 13.45m and height of the last floor (where occupants live), in relation to the surrounding ground, exceeding 30m (42m) which classifies the building as high-rise building, according to Technical rule on High-rise buildings. It consists of a basement, ground floor and 13 floors. The roof is flat, without fence. All partition walls are made of prefabricated plaster boards, and these elements are doubled between the apartments and the corridor.

The building is the mixed residential-business type, with additonal and technical premises in the basement. The building was designed as an residential building, but in the past period, the part of ground floor space was addapted in business premises.

There is only one building entrance, from the parking side. The entrance plateau is raised 120 cm from the ground level and it could be reached by the stairs or the ramp. Vehicles can enter the parking area from the both Šekspirova and Narodni front streets.

Figure 1 – Case study building elevation

Figure 2 – The primary (1), secondary (2) and tertiary (3) route of the Fire brigade Novi Sad to the building

The distance of Fire brigade Novi Sad is about 3 km (9 minutes ride) – Fig. 2. The access roads from the Fire brigade to the building are made of concrete and asphalted, of adequate width and load-bearing capacity for traffic of fire vehicles without barriers. The only obstacles in eventual intervention, could be the traffic jam.

3. CALCULATION OF THE EVACUATION TIME

Calculation model is usually applied in order to determine the time required for evacuation. In addition to this method, within assessment of buildings' fire risk, evacuation models are becoming the main tool. In this study, the time, obtained by hand calculation model was determined and compared with time obtained from Pathfinder (evacuation simulation software). Real time of evacuation is somewhere between these two values.

According to SRPS TP21, there are four phases in evacuation from a building in fire. Phases of evacuation are:

- I phase – from SP (starting point) to FE (first exit; SP=FIE (final exit) for rooms with direct exit to safety)
- II phase - from FE (first exit) to EE (evacuation exit, EE=FIE for rooms on the ground floor),
- III phase - from EE to FIE,

- IV phase - from FIE to SPO (safe point, at least 25m away from the building in fire, where harmful effects of fire are not expected).

The movement of people in the first phase of evacuation should be completed in 30s according to the technical recommendation; the people movement in the second phase should be completed in less than 60s and in the third phase should be completed in less than 3 minutes.

Design speed of the people movement (v_o) on the flat floor is 1.5 m/s. Speed of evacuation is being reduced due to grouping of people in the narrowing of the corridor (doors etc.), turnings of the corridor, on the stairs, and similar occasions..

Slower design movement speed (v_e) is product of speed and deceleration factor.

$v_e = u \cdot v_o$

u = 0.8 (when moving down the stairs);

u = 0.6 to 0.05·d (when moving upstairs, where d represents the number of levels 3 m in height).

Retention time of 3s for every 10 persons should be taken in the calculation while crossing a narrowing of the corridor or door openings of less than 1.00 m width, for 10 to 40 people, or door openings of less than 1.60 m width, for 40 to 200 people.

For each turn at an angle wider than 30° and less than 60°, and confronting the stairs or ramp, retention time is 2s for every 10 persons. For any change in direction at an angle wider than 60°, additional 5 seconds is added for every 10 people evacuating.

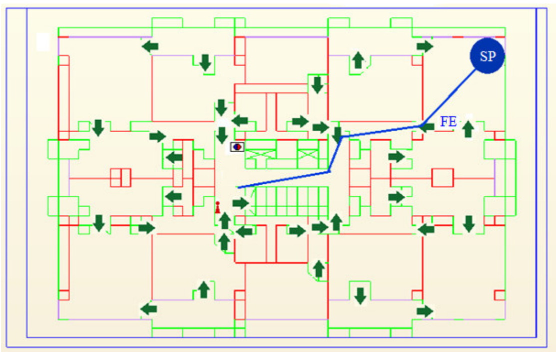

Figure 3. Evacuation route from the building with marked SP and FE, the route line and arrows in the direction of movement from the higher floors (from 13th to 1st floor)

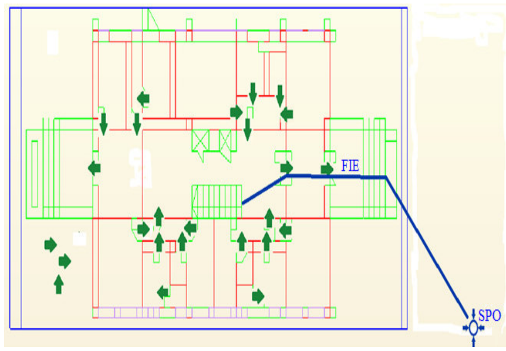

Figure 4. Evacuation route from the ground floor of the building with marked FIE and SPO, the route line and the arrows in the direction of movement

Evacuation scenario assumption is the building evacuation from the 13th floor starts simultaneously from all apartments. The most distant starting point of evacuation is in the living room of the furthest apartment on the 13th floor (Fig. 3). The occupants of the building are evacuated from the starting point (SP) to the first exit (FE), then along the corridors from the first exit (FE) to the evacuation exit (EE), down the stairs to the ground floor (Fig. 4) through the hallway to the exit doors - the final exit (FIE). From the final exit (FIE) to the safe place (SPO), 10m away from the building.

In the first Scenario, calculation model included all occupants in the building. There are 4 occupants in every apartment, so the total number of tenants in the building is 224. The assumption is that the worst case scenario is the one where people are jammed at every floor at the staircase. Time required for evacuation in phases is calculated:

t_I = 4,7s < 30s (SP-FE)

t_{II} = 37 min 19s > 60s (FE-FIE)

t_{IV} = 1 min 18s (FIE-SPO)

The third stage does not exist as there is no evacuation route isolated from fire and smoke. Evacuation phases are illustrated in Figures 3-4.

Taking preparation time for the evacuation (10 minutes) into account, as recommended by SRPS TP 21 for residential buildings, total evacuation time from the building is:

$t_e = t_{pe} + t_I + t_{II} + t_{IV}$ = 48 min 42s

4. EVACUATION MODELING SOFTWARES

There are many simulation software for evacuation modeling in use today and some of them are described below.

4.1. SIMULEX

Simulex, a commercially available software tool, has been developed in the UK by Integrated Environmental Systems (IES) since the 1990s (Thompson & Marchant 1995a, 1995b). The Simulex used in this research is standalone Version 13.0, and there is another later version called VE-Pro Version 6.0 which was not available for this research. Simulex has been appraised as being well validated (Chow et al. 2011; Pan 2006) and has been applied in single and multi-storey buildings to simulate evacuation for a large number of people, for example airport arrival hall (Chow & Ng 2008), high rise buildings (Tsai 2007a), hotel buildings (Kuligowski & Milke 2004) and lecture theatres (Ko 2003). Different characteristics of occupants, such as travelling speed, body size and pre-movement time can be entered into the model for evacuation calculation. Simulex has three types of distribution functions inbuilt to generate premovement time and travelling speed: random, uniform and triangular to generate distribution on these parameters, if necessary (Tan 2011).

4.2. FDS+Evac

FDS+Evac, being developed by the VTT Technical Research Centre of Finland in recent years, uses the same platform as the Fire Dynamic Simulator (FDS) (Korhonen & Hostikka 2009) which is a fire calculation software tool. FDS+Evac is an agent-based model and has the ability to account for the interactions between the occupants and the hazards generated in a fire event. Thus, the evacuation model 25 can be coupled to run with fire hazards generated by FDS. Furthermore, social and individual behaviour can be incorporated in the model as well as the decision makings that factor in familiarity with exits (Korhonen & Heliovaara 2011). (Tan 2011.)

4.3. EvacuatioNZ

EvacuatioNZ, currently under development in the University of Canterbury, uses a coarse network approach to separate the floor plan into nodes where occupants can move from one node to other (Teo 2001). Nodes that represent the spaces in the building are connected by a path. The characteristics of the node will include the space size (length and width, or simply by area), whilst the connections will contain characteristics of egress components such as doors or staircases and the distance between two nodes. One or more “SAFE” nodes will signify the final egress where occupants are considered as safe.

5. EVACUATION SIMULATION IN PATHFINDER

Pathfinder is a software for simulating the evacuation of Thunderhead Engineering, which uses the integrated user interface 3D visualization of results. Pathfinder enable the efficient evacuation model creation, in accordance with different scenarios based on engineering assumptions about possible evacuation scenarios. Input data for creating a simulation model are the relevant building data (building type, the floor plans, the position and dimensions of the staircases and other communications, the number of residents, etc.). Visually, Pathfinder highlights human models, motion paths, floor distributions, and other aspects of 3D views. It allows seing the movement of all actors in a real time.

In this study, the simulation scenarios are based on building layout and occupants' density in the case of real fire incident (Fig. 5). Walking speeds are defined by technical recommendations SRPS TP 21. The characteristics of the occupants (shoulder width, etc.) were randomized, in order to take into account different egress behaviour of different evacuees. Results are given in Table 2.

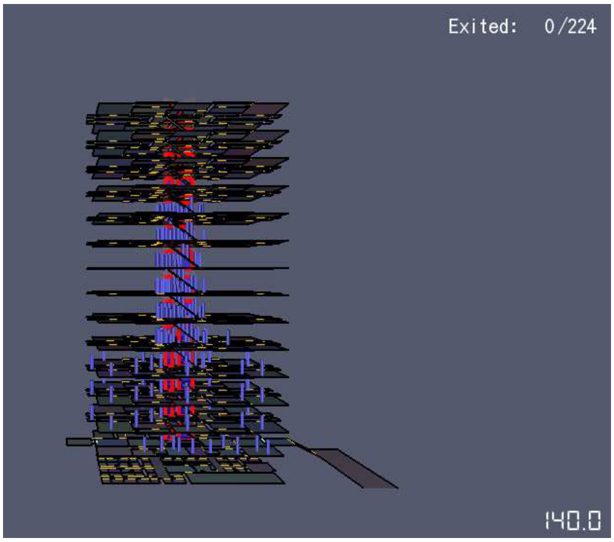

Figure 5. The building's evacuation simulation model created in Pathfinder

Table 2. The results obtained in Pathfinder

First occupant	*Last occupant*	*FE*	*FIE*	*SPO*	*Min*	*Max*	*Min deviation*	*Max deviation*	*Number of evacuees*
216s	*480s*	*4,2s*	*468s*	*480s*	*16m*	*157m*	*0s*	*196s*	*224*

The software provides the result in time – how long it takes for the first and last evacuae to reach a certain point of the building. This type of evacuation simulation and modeling has its advantages in comparation to hand calculation model. It is much easier to control the parameters and manage the evacuation. It can also point out critical points in the evacuation path, where occupant piles up, or where is a deadlock and similar.

6. THE ASSESSMENT OF FIRE SAFETY OF THE BUILDING

Fire Safety assesment criteria has been created for high-rise buildings whose parameters have been established in accordance with the Rule on fire protection of high-rise buildings. By checking the existence or absence of parameters from this list, it was determined that the building does not fully comply with the principles of fire safety.

It has been noted that there is a ***plateau for the fire vehicles approach and interventions***. It is possible to use auto-mechanic ladders in all positions. It is possible to move the vehicle in advance because there is a wider part of the plateau that can be rotated. The obstacles on the access road are cars. Access to the facility is provided from the front and one lateral side of the building. On these sides there are openings such as windows, doors and similar openings through which extinction and rescue can be carried out.

The ***building's structure*** is built of reinforced concrete (a massive system) which means that the structure has a satisfactory fire resistance. The walls of the evacuation corridor are built of brick, and are adequately protected from the effects of fire (a brick wall can withstand fire for up to 5 hours). The corridor evacuation door is steel with glass openings. This combination of materials is not reliable in the event of fire due to high sensitivity of steel to high temperatures.

The ***distance from the next-by closest building*** is more than 8 meters. There is no building that is leaning on the building, which reduces the probability of transferring a fire from one building to another. The facade of the building is constructed so that the fire cannot be transferred from one floor to the other, because there is a vertical fire interruption between the facade openings, width of more than 1m. There is no thermal insulation on the building's facade.

Windows are made of wood, protected by fire by fire-rated coatings. Access opening for control of installations are also made of wood with a coating meets the class of fire resistance F30.

There is only one internal ***staircase*** in the building, in the central position of floor plan. The width of the staircase is 1.20 m, which is the minimum width of the stairs according to the SRPS TP 21. There is no separated smoke-free space in front of the stariecase. The longest evacuation route from the FE to the staircase, through the corridor, is not more than 30m as stated in the SRPS TP 21, but there is no firesafe staircase.

There is no any kind of ***evacuation sign to the exit way*** through the attic door, further more the doors are locked.

There are no systems for ***smoke ventilation*** in the building, and ther is no ***window openings at the staircase.*** The ventilation is possible only through the terrace doors on the attic. This is the major problem when evacuating.

There is no ***emergency lighting*** in the building, and also evacuation signs are missing. The fire extinguishers are located on floor, while the ***internal hydrants*** are located on every odd floor, but with no hoses.

There is no ***external hydrant system***, but the distance from the building – intevention position, is 28m, more than the maximum recommended 20m.

There are no ***fire alarms***, and the ***elevator*** is of old type, so with no authomatic devices to take the cabin to the ground in case of fire and turn off the elevator after people leave. The elevator door is not closed automatically but manually. There is no fire elevator.

There was no occupants' ***evacuation exercise*** organized for the past 5 years.

7. CONCLUSION

The results, obtained by calculation of evacuation time indicate that the time it takes for all people to safely evacuate from the building does not meet the time recommended by the "Technical recommendation for fire protection of residential, business and public buildings - SRPS TP 21". In order to get a more realistic image during evacuation and to see more easily critical points where congestion or congestion can occur, simulation software Pathfinder was used. It was determined that there are no critical points or piling up of occupants along the evacuation corridor. The main problem is central staircase as it represents the only evacuation path in the building and it is neither fire-rated nor isolated. There are no evacuation paths in the building and the structure is not divided into fire compartments.

It was determined that building lacks some basic fire safety requirements. It is necessary to put the evacuation markings in the right way, which should be placed on the walls at a height of 0.5m and on the floor due to reduced smoke visibility and should be placed in such a way that they give a clear picture in a timely manner. Electrical installations are not installed in an easily accessible location, and can be delayed by their shutdown and endanger safe evacuation. The building needs to be equipped with sufficient number of fire extinguishers, as well as internal hydrants complete equipment.

In order to improve building's fire safety, some of following measures could also be undertaken:

- Raising occupants' awareness through education and informing;
- Repair, periodical checking and regular maintaining of installed facilities, such as house fire hydrants;
- Planning and construction of fire escapes to be accessible from each apartment (external fire-rated staircase);
- Installation of automatic fire alarm system.

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8. REFERENCES

[1] Bayat N.: Panic and human behavior in fire, p. 7-8, 20

[2] Kuligowski D. E., Gwynne V. M. S., Kinsey M. J., Hulse L.: Guidance for the Model User on Representing Human Behavior in Egress Models, p. 656, 2016.

[3] SRPS TP 21: Technical recommendations for urban and civil engineering measures of fire safety for residential, commercial and public buildings, 2003.

[4] Šupić S., Vukoslavčević S., Laban M., Šešlija M., Milović T.: Fire safety assessment of residentual building using calculation and evacuation simulation model, p.4, 20

[5] Tan Y. K.: Evacuation timing computations using different evacuation models, p. 23., 24., 27., 2011.

[6] Rule on fire protection of high-rise buildings (Official Gazette RS, No. 80/2015)

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PROPOSAL OF EVACUATION MEASURES FOR PERSONS WITH DISABILITIES DURING CATASTROPHIC EVENTS

Summary: Persons with disabilities are the most vulnerable part of population in emergencies primarily due to a lack of a systemic plan which would take into account the characteristics of persons with disabilities in terms of their protection and rescue. The protection and rescue system, as a multidisciplinary area, obliges us to treat persons with disabilities responsibly, professionally, thoroughly and in accordance with international standards. The paper provides an overview of adequate alerts, distribution of information, education and other forms of assistance for persons with disabilities during evacuation in case of catastrophic events.

Key words: Persons with disabilities, Evacuation, Catastrophic events.

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1. INTRODUCTION

Persons with disabilities have equal rights as other citizens when they are in a situation which prevents them to function properly due to spatial, economic and social barriers that these persons cannot overcome in the same manner as other citizens.

These barriers are often increased by general views which bring persons with disabilities to the social margins. The community is obliged to remove, minimize or compensate for the barriers, to enable every individual to fully use their rights as citizens, while respecting the rights and duties of every member of the community.

Persons with disabilities constitute 10-20% of the global population, or about 650 million people. This number is constantly changing as any person can become disabled at any moment, regardless of their current health status. The causes of the disability (hereditary, congenital and acquired) can be different - all kinds of accidents, wars, malnutrition, illness and old age [1].

Disabilities are categorized as:

- physical (wheelchair users, persons with mobility problems and other physical injuries);
- sensory (persons with hearing or vision impairments);
- learning disability (persons with intellectual disability, persons with autism).

Combined disabilities also occur frequently. In terms of causes of disabilities for persons with physical disabilities, the following are distinguished: persons with paraplegia or quadriplegia, persons suffering from muscular dystrophy, infantile paralysis, multiple sclerosis, cerebral palsy, arthritis, etc. Each of these disorders have their own characteristics, which determine if the person with that type of disability can function independently or they require assistance of another person.

2. TYPES OF DISABILITIES AND EXPECTED METHOD OF ACTION DURING CATASTROPHES

Arthritis

Arthritis is a painful inflammatory disease that most commonly affects joints in any part of the body. An inflamed joint with arthritis becomes painful, swollen, red, hotter and can even cause strong pain which hinders movement. Approximately 15% of the population of all ages are affected by some form of arthritis, of which two thirds are females [2].

In case of catastrophes, people with arthritis are treated differently depending on the form of arthritis. Persons with mild forms of arthritis can respond independently up to a certain degree during an emergency, evacuate and notify the emergency services on the state of the emergency. Persons with severe forms of arthritis cannot move independently and will require assistance during evacuation and can be evacuated by using the evacuation chair, which requires human assistance.

Autism

Autism is a complex brain development disorder, which is characterized by low or no social interaction and communication, restricted and repetitive behavior patterns, and it usually appears during the first three years of life [3].

During catastrophic events, persons with autism should be informed about the situation in a calm and composed manner, as behaving otherwise will additionally frighten the person and make evacuation more difficult. Persons with autism require human assistance, to inform and evacuate them, and take them to a safe place after evacuation, to provide medical assistance if needed; however, it is possible that such persons will evacuate independently. It is important to avoid resistance and violent reactions that could happen in case of an inappropriate approach. As this group has no problems with mobility, not consenting to the evacuation or providing physical resistance could be the problem.

It is very important in these situations that the person with autism trusts the firefighting and rescue team, which can only be achieved through programs of education and occasional visits to fire stations. Education is conducted in a series of lessons where the firefighting and rescue teams are introduced to persons with autism, they learn about them and their needs and perform evacuation drills. This is of crucial value both to fire fighters and persons with autism. In this way, the persons with autism will also remember the uniforms of firefighting and rescue teams and will react faster during catastrophic events.

Cerebral palsy

Cerebral palsy is a permanent loss of muscle strength (paralysis) due to brain damage. Apart from the motor disorder which can vary greatly ranging from discrete to complete disability, there are certain forms of the disorder including intellectual disorders and epilepsy. All combinations are possible. The frequency of cerebral palsy is 2 in 1,000 newborns [4].

Cerebral palsy can also affect speech, sight and hearing; hence these persons require human assistance, especially during catastrophic events. They should be informed of the state of the emergency, evacuated, taken to a safe place and provided with medical assistance, if needed. The evacuation chair is a great advantage during evacuation of persons with cerebral palsy. The rescue team must be trained and equipped to provide first aid to these persons.

Dyslexia and dysgraphia

Dyslexia is a learning disorder pertaining to reading despite normal intelligence, good sight and hearing, systematic training, adequate motivation and constant favorable educational, psychological and social conditions. Dyslexia is a significant disagreement between the actual and the expected level of reading when compared to their mental age [5].

Dysgraphia is a disability in mastering the skill of writing. It is manifested by distorted and illegible handwriting, letters of different sizes and uneven, disconnected, while the lines are slanted or curved. The letters are facing the wrong way, they are missing or are replaced by other letters, and the sentence is grammatically incorrect [5].

Dyslexia and dysgraphia do not cause mental disorders, they do not affect speech, sight and hearing. Persons with these disorders can act independently in case of an emergency. These persons do not require special treatment by rescuers.

Down syndrome

Down syndrome, most frequently present in the form known as “Trisomy 21” is a specific condition, which means that the person was born with additional chromosomes. Normally, children are born with 46 chromosomes, while the babies with Down syndrome have a duplicate of one of the 46 chromosomes i.e. chromosome 21 is duplicated [6].

Persons with Down syndrome are unable to understand directions, the gravity of the situation and the purpose of evacuation. These persons will follow others, and this is the reason why human assistance is required during catastrophic events. The members of the firefighting and rescue teams should be careful not to violate their human dignity and keep in mind that these persons react slower, which makes the evacuation more difficult.

Paraplegia

Paraplegia is the condition caused by damage to the spinal cord. The damage can occur from injuries or illnesses of the spinal column and the spinal cord. Depending on the injury, such conditions are divided into those with the total disconnection between the brain and the spinal cord (paraplegia and quadriplegia), and those with partial interruptions (paraparesis and quadriparesis) [7].

Persons with the mentioned conditions understand the messages from their environment but are unable to react without the assistance of others because of their immobility. During the process of evacuation, the transport of such persons needs to be planned as they cannot be evacuated by standard transportation means.

3. EVACUATION OF PERSONS WITH DISABILITIES IN CASE OF CATASTROPHIC EVENTS

Preparedness and the readiness of the firefighting and rescue teams must be in accordance with the needs of the persons with disabilities, while operative procedures and operational plans for actions during catastrophic events must foresee all situations for protection and rescue of persons with certain needs (impaired vision, blindness, deafness, persons with low intellectual abilities, persons with mobility impairments or wheelchair users).

3.1 Problem of evacuation of persons with disabilities

The issue of evacuation of population must take into account the characteristics of the planned evacuation zone with the assumption that among the population for evacuation there are also persons with disabilities who require additional care and a special approach. This is why it is necessary to define persons with disabilities and their particular needs during the process of evacuation, to collect accurate information on their numbers and their spatial distribution, especially in urban areas, and then to determine all of the obstacles that prevent successful evacuation.

In the context of spatial distribution of population, it is more difficult to perform evacuation of persons with disabilities in urban areas, because of the concentration or the number of people, and alienation of the population which is more widespread in urban areas. In smaller communities it is simpler to obtain information on who has still not been evacuated, who has disappeared and so on [8].

The registers and databases of persons with disabilities are not updated often or are not available to the authorities, particularly during evacuation and rescue activities. The architectural solutions for buildings in most cases are not designed for efficient and safe evacuation of persons with disabilities. Multi-storey buildings and shelters pose a particular problem, while another big problem is to perform evacuation of institutions for persons with disabilities, especially during the night. A small number of rescue employees is evident and they cannot organize and conduct the evacuation of the involved persons in an efficient and safe manner.

3.2 Evacuation of persons with disabilities in case of catastrophic events

In the case of natural disasters and other disasters and catastrophic events, the treating of persons with disabilities varies depending on the type of disability and their particular needs.

3.2.1 Recommendations for persons with disabilities during fire

Persons with complete or partial blindness

- Persons with vision impairments should be informed about their immediate environment and about the evacuation route and previously about the sound of the fire alarm;
- The blind or visually impaired person should be offered to put their hand on your shoulder and they should be guided towards the exit of the building, and should be provided with instructions on how to move (left, right, up, down);
- Some blind persons have guide dogs, but dogs can become disoriented during evacuation, and these persons will require additional assistance;
- Speech, clapping and whistles should be used as signs to turn the attention of blind persons to the rescuers and so they could orientate themselves on the location of the rescuer [9].

Deaf and hearing-impaired persons

- Persons with hearing impairments should be notified that there is a fire and what is the evacuation route using writing and sign language;
- Turn the light on and off in the room to get their attention – then explain what is going on and where they need to go by using gesticulation or writing on a board;
- Show the safest route and evacuation direction (evacuation map) by using visual instructions [9].

Physically disabled persons – wheelchair users

- Immediately notify the emergency services about all of the people who are still in the building and their locations;
- Possibilities of fire and the evacuation route should be discussed with persons with physical disabilities or mobility impairments. It should be verified whether the person can move on their own, with the assistance of another person or by using the handrails in the building, if they exist. It is important to find out about wheelchair users whether their wheelchairs are mechanical or electronic and how many people it takes to safely carry them out of the building. Evacuation chairs would be useful in buildings and everyone should know where they are, so they could be used during evacuation;
- Electronic wheelchairs have heavy batteries that make the evacuation of wheelchair users more difficult, and this is why it is best to ask the user if they would use the evacuation chair. If the wheelchair has respiratory equipment which is necessary for the user, the battery should be removed, and the person should be evacuated in the wheelchair;

- The favorable options for evacuation of persons with restricted mobility are horizontal evacuation on the outside of the building or horizontal evacuation in another safe location. If that is not possible, the manner of carrying out the person in their wheelchair should be planned ahead [9].

3.2.2 Recommendations for persons with disabilities during floods

- Persons with disabilities should be prepared ahead for the floods with the instructions of their instructor;
- If assistance is not available, the person with disability should remain close to the stairway. The rescuers will first check all exit routes and stairways. The persons at risk should continue to seek assistance until they are saved;
- The persons who cannot speak loudly or a person who has a speech impairment should carry a whistle to draw attention;
- Persons with disabilities should know the alarm signals;
- They should not return to the building until the competent service allows it;
- They should write down the instructions on how to act on the refrigerator in case of a flood;
- They should have an alternative means for communication, such as a dry-erase board;
- Additional batteries should be kept in the wheelchair, catheters and other objects they could need, and also a list of numbers that are used during floods;
- Do not use the elevator in case of floods, if the competent services do not allow it;
- Call 193 or 1985 in case of floods;
- Work together with the competent service during evacuation [10].

4. INTRODUCTION OF A FIRE NOTIFICATION SYSTEM VIA SMS

Training of firefighting teams to receive SMS notifications and to establish this form of communication would be the first step. The next step would be to train firefighting-rescue teams to maintain conversation with persons who have problems with establishing communication. Knowing sign language and mastering sign language would enable the firefighting-rescue teams and other competent officers from various institutions to become a true service for citizens in all situations, even fires [11].

Advantages of SMS messages in comparison to telephone conversations

Persons with speech impairments, deaf and hearing-impaired persons, cannot establish appropriate communication over the telephone with firefighting-rescue team and cannot provide them with the required information. The words these persons would say to the firefighting-rescue team would not seem serious but would rather seem like disruptive behavior of irresponsible citizens. SMS messages can provide the precise location of the fire and all other necessary information to the firefighter-rescue team. The firefighter on duty can reply to the message, notify the person that the message was received and give instructions or guidelines on how to behave and which measures and actions they should undertake until the arrival of the rescue team.

Disadvantages of SMS messages

Writing and sending SMS messages with all the required information on a fire take a certain amount of time. This can be considered an important disadvantage, since that it enables unhindered expansion of the fire. There is also the possibility that the message "is not received" or that it is sent to another number. Thus, the person who sent the information about the fire is unsure if the message reached the firefighting-rescue team. If the message did in fact reach another address, it would eliminate or significantly prolong the intervention of the firefighters which would contribute to increasing of the consequences of the fire.

The procedure for introduction of the fire notification system via SMS messages [11]

- Define the requirements for software developers regarding the system features;
- Determine abbreviations or codes to be used to decrease the time needed to write the message, that would at the same time ensure clear and precise information about the fire;
- Ensure permanent records and storage of all information from incoming and outgoing messages;
- Eliminate the possibilities of messages going to unwanted addresses or at least reduce it to a minimum;
- Foresee the possibility to quickly determine the location where the message has come from;
- Ensure the transition from number 193 to the number 112 as a unified number for emergencies when this number is introduced;
- The firefighting-rescue team should be trained to use the system of SMS messages;
- Train the firefighting-rescue team to communicate with the deaf; to learn and use the sign language;
- Train persons with speech impairments, deaf and hearing-impaired persons and other citizens to use the system of SMS fire notifications;
- Work on prevention and stop the misuse of this technical solution by the telecommunication service provider; and
- Ensure permanent maintenance, updates and system improvements.

5. CONCLUSION

The firefighting-rescue team should be trained to provide service to persons with disabilities, while keeping in mind the characteristics and particular needs of their condition (according to the type of their disadvantage), to master sign language and skills for providing psychological help to persons with disabilities.

The residents of buildings and assisting staff in hospitals should be prepared to act during catastrophic events. It is necessary to train staff, students in their dormitories, employees, and friends, so they would know what persons with disabilities need and how to help them. Also, it is important to organize evacuation lessons for tenants and persons with disabilities and develop plans which will affect improvement of these conditions during evacuation. Everyone should have the responsibility to act at times of catastrophes, as well as to undertake the necessary measures to help persons with disabilities.

6. REFERENCES

[1] Lazarević A. (2017), Persons with disabilities during catastrophic events, pages 7-17, Croatia, The Croatian firefighting community. http://www.vzpgz.hr/upload/zbornik_XIII_strucni_skup_2017_lowres.pdf (09.07.2018)

[2] http://www.bolesti-zglobova.com/sr/blog/artritis (10.07.2018.)

[3] https://sr.wikipedia.org/sr-el/Autizam (10.07.2018.)

[4] http://www.simptomi.rs/index.php/odojce/1167-cerebralna-paraliza (10.07.2018)

[5] http://disleksija-sluh.com/sta-je-disleksija-a-sta-disgrafija/ (10.07.2018)

[6] https://kalorijskatablica.com/daunov-sindrom-kod-beba-i-dece-simptomi-uzroci-i-lecenje/ (10.07.2018)

[7] http://www.hendidrustvo.info/forum/index.php?topic=44.0 (10.06.2018)

[8] Ilijaš O., Magdalenić I., Milić K. (2017), The Issue of Evacuation of Endangered Groups, pages 31-45, Croatia, The Croatian firefighting community, http://www.vzpgz.hr/upload/zbornik_XIII_strucni_skup_2017_lowres.pdf (09.07.2018)

[9] https://www.nfpa.org/Public-Education/By-topic/People-at-risk/People-with-disabilities (10.07.2018)

[10] http://flash.org/peril_inside.php?id=42 (10.06.2018)

[11] Krnjaić Lj., Ivana P., Jelena P. (2011), Introduction of the SMS fire notification system, the Proceedings "Risk and safety engineering", the Higher Education Technical School of Professional Studies, Novi Sad, Serbia.

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EVACUATION ROUTES IN CASE OF FIRE

Abstract: Considering the consequences of building fires, planning of evacuation routes is regarded as one of the most important issues in design and management of facilities. Evacuation routes should enable fast and efficient evacuation of people from a building in case of fire or other emergencies. Evacuation routes include emergency exists, doors, stairs and elevators. Each of these must be separated fire compartments with surfaces made of non-combustible materials. Evacuation routes should be constructed on adequate and safe way in order to suppress and prevent fire. In planning and constructing evacuation routes recommendations for construction regarding width of exits, number of exits and elevators, type of stairs as well as choice of construction materials must be followed. Also, attention should be addressed to risk assessment, appropriate distance between industrial and residential zones as well as building itself.

Key words: evacuation routes, safety, elevators, stairs, doors, exits

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1. INTRODUCTION

As a result of fire, every year about 2-5% of housing it is damaged or destroyed worldwide, and the damage is often accompanied by human victims. About 75% of the total number of fire victims were killed in residential buildings. Number of casualties is not directly linked to the flame or smoke, but also to unstable and unsafe structures, which are not adequately designed to withstand high temperatures [8]. Sector for Emergency Situations of Serbia assessed that the total number of fires and explosions from 2010 to 2012 was 79,886, while the injuries and deaths were estimated to 1,280. Also, the economic consequences of fire are not negligible. According to statistical data of The Geneva Association it is estimated that the economic losses are around 1% of gross national revenue per year globally [6].

According to Gemović, it has been shown that the human factor plays an important role in causing fire, meaning that in many cases the cause of fire is human carelessness, ignorance or inadequate behavior at a given moment. In particular, statistical analysis conducted by Gemovic showed that 30% of fires are caused by carelessness and inattention, in 12% cause is inadequate electricity, 10% as a consequence of an open flame and incandescent body, as well as 8% due to the shortcomings of construction structure [3].

One of the most important tasks which should be solved in the course of fire are the escape routes. Facilities should have safety routes for evacuation of people as well as evacuation routes which could be used by firefighters [8]. Expansion of cities led to the fact that almost a third of European population lives in urban environment. Faster and denser building represents a major problem in terms of fire protection. Planning and implementation of preventive measures, as well as risk assessment of fire should enable more efficient prevention in terms of human lives and properties [1,5]. The basic principle of safety in facilities is related to the protection of people who are inside the facilities in normal circumstances as well as in the case of fire. It is very important to ensure safe evacuation from a facility before the situation becomes dangerous. Generally, when projecting a facility, object localization, size, capacity, building entrances and characteristics of constructing material should be taken into consideration [7]. National legislation on fire safety as well as EU regulations stipulate certain rules during construction. Industrial and residential zones should be constructed at appropriate distance, as well as objects within these areas. This means that the distance between objects is minimum ½ height of the building. Access roads should be planned in order to provide sufficient road width to ensure passage of fire engines.

2. EVACUATION ROUTES

Evacuation routes should enable fast and efficient evacuation from a building in case of fire or other emergencies. In facilities, passages, doors, corridors, exits, stairways and others are considered by evacuation routes. For safe and effective evacuation of people it is particularly important to determine a correct path of evacuation route, optimal width of evacuation routes elements, necessary number and proper arrangement of exist. Facilities and evacuation routes must follow certain construction recommendations in order to meet the basic requirements:

- It is necessary to provide a sufficient number of exits from a room, taking into consideration their positioning in the object, as well as a sufficient number of evacuation routes, in order to avoid grouping of people on one part of the road;
- Evacuation routes should be designed so that they do not contain any constrictions that all roads have a special fire compartment and that constructions which are next to the evacuation routes are fire-resistant [3];
- Building-structures must be resistant to fire for at least 2 hours. The walls of a building should be also fire resistant and each department in the building must have a special exit in case of fire which should not be longer than 30m;

- Cladding on buildings should be designed to prevent the spread of fire to adjacent buildings;
- Light signalization should be in function for at least 60 minutes and it must have its own power supply;
- Fire-alarm system as an active fire protection system needs to detect fire or the effects of fire such as smoke or heat.

Apart from the measures mentioned above, there are other technical standards related to the heating, ventilation, water and power supply [4].

In addition to well-designed and marked evacuation routes, an important role in the fast and efficient evacuation certainly has the perception of people about danger at the given moment. The decisions on how to react in a given time depend on individual short memory. Since perception is based on information, stressful situations such as fire limits the available number of information to people such as which exist should be used, or how to behave in general [1]. Also, the factors which influence the behavior during the fire can be divided into those before the event, after the event, and those which depend on the number and types of signs and information during a fire. Since these factors are very different and human perception differs from person to person, it is very difficult to predict development and course of evacuation in case of fire. However, as technology advances more sophisticated evacuation softwares are available. Computer modelling of evacuation process enables analysis of more scenarios which provides better information that could improve security measures in case of fire [6].

3. EXITS

Since the way from a room to the final exits of facilities leads through the passage and hallways, all of these pathways are dimensioned according to the same criteria for all the outputs. The unit of passage represents a necessary width space enough for the passage of one man. The movement of people can be carried out in a column of two, three or more, depending on the passage width. The width passage is expressed in units of passages so that one passage unit is 0,6m. However, when it comes to narrow corridors lined with high walls, then the passage unit is 0,8m. To calculate the required number of units it is taken into account that one unit can be used for the passage of 100 people. Therefore, if the capacity of a facility is 400 people, it is necessary to provide 4 units of passage. Depending on how many people can fit into certain rooms, number of exist differs but attention is addressed to the most possible uniformity in terms of sending people to specific outputs. For example, in France, a room that can accommodate 20-50 people has two exits leading directly to the outside, hallway or another room that has its own exit. One exit must have a minimum width of 0.8 m and the second auxiliary exit must have a width of 0.6m. If it cannot be provided that the normal exits are placed into sufficient distant places, it is necessary to set the auxiliary outputs in order to meet the required number of unit passages. It is important to take into account the number and width of exits. Auxiliary outputs are placed in a way that they are easily accessible and useable. Doors of auxiliary output may be smaller in width than the normal output, but not less than 0.6m. The auxiliary outputs should not be used in normal circumstances, but only in case of fire, either for evacuation or as the access to firefighters [2].

4. DOORS

During evacuation, the doors represent the most critical obstacle. The manner of construction, positioning and opening direction is very important. Rooms with a capacity of 50 people must have a door with the opening direction towards the exit, which should be easy to open. Doors with horizontal and vertical displacement, as well as revolving doors are also not a good option due to easiness of opening. During the fire, cold air from the outside is coming into the room, so a windshield is often placed at the entrance. Windshields should not be an obstacle during the evacuation. The door leaf of windshield should be placed with the opening towards the exits. Public buildings should have doors with a width of 1.2 m or three passages units. Meaning, their width should not exceed 0.8m when it comes to a single door and 1.40 m for folding door, while the winged door width should be 1.80 m. Increased width of the door is not recommended due to their bulkiness. However, if it is necessary to close the passage of greater width, an appropriate number of doors with proper dimensions should be placed. For example, for 4 passages units of 4x0,6 m = 2.4 m, it is not preferably to set door with four wings. In these cases two separate doors with the width of two passage units are set, i.e. 2x0, 7m = 1.40 m [2].

5. STAIRWAYS

Stairs in buildings represent an important escape route. If they are not projected properly, stairways represent a place of fire spread. In a case of fire, of particular importance is the protection of stairway from smoke and fire spreading in vertical direction. In such circumstances staircase represents a chimney for fire spreading from floor to floor. For these reasons, the staircase should be isolated from other rooms. It also should be completely closes with walls of brick, concrete or other durable material. Each floor must have access to the stairs across the safe area or buffer zone. If the stairways are placed in the middle of facility, then the exit must go through an isolated stairway. Walls and doors of stairs and buffer zones must be made of refractory materials with resistance to fire of 2 hours. Physical separation of stairways from other rooms can be made in several different ways. One way is placement of the court or the buffer rooms which are mechanically ventilated and which are separated from the hallway by doors that do not leak smoke. Also, the separation of stairways from the hallway could be achieved by projecting a hall in which overpressure could be provided. Another way of separating the stairways is projecting the stairs for evacuation outside of the building in a way that stairs have connection to each floor. Doors on the stairways should be equipped with automatic closing system, and the same applies to the fire stairways as an alternative way of evacuation. Special attention should be addressed to the treads, landings and intermediate landings. They should be covered with a non-slippery material and that ensures normal use.

When projecting tall buildings, it is very often planned to build external stairs. In these circumstances, the height of the fence should not be less than 120 cm. These stairs are located on the outside of the building and are not used in normal circumstances, but only in case of fire. Access to the external staircase for evacuation can be provided from a hallway of the object or through the windows. The minimum width of the external fire stairs is 80 cm, and the material of which is made should be fireproof (concrete, steel, etc.). Also, spiral staircase is not recommended [3].

Number of stairways and their dimensions are determined by a number of people present in the building. Facilities which could accommodate 50 to 100 people should have one staircase with two passage units. Public buildings which can accommodate 100 to 200 people should have two staircases with the total width of 3 passage units. In public buildings the minimal width of staircase depends on passage units. If there are stairs with two passage units, length of staircase arm which is lined up with the walls is 1.40m. If the staircase arm is lined up with walls on the one side, and with the fence on the other side, then the width of staircase is 1.30m. In case where staircase arm is fenced on both sides, then the width of staircase is 1.20m. The width of the staircase arm with more than two passage units is calculated on the way that for each passage units the width is considered to be 0,6m. For instance, stairway arm of 3 passage units has a width of 3x0. 6 m = 1.80 m [2].

6. ELEVATORS

In high buildings each fire compartment must be connected with at least one elevator for transport of persons, and the walls of elevator must be resistant to fire for at least 1.5 hours. In buildings higher than 40m, elevator window must be separated from the stairway. Also, access to the elevators should be enabled from the hall. The facilities that are up to 40m in height it is allowed that vented space is common for elevators and stairs. Elevator's cabin and windows must be constructed of non-combustible material and must close automatically. In case of fire elevators must be equipped with devices which will enable bringing elevator to the ground floor and after leaving persons from the elevator, it will be out of function automatically. In buildings which are higher than 75m, one of the elevators is determined as a lift for evacuation during a fire, and it is called a safe lift. Temperatures which are generated in case of fire should not affect the operation of the safety of elevators for a period of 1 hour, and these elevators must be visible labeled [3].

7. CONCLUSION

Having in mind the consequences of fire on human lives and properties, a crucial role in fire protection has adequate and safe design of buildings. Based on number and causalities of fires, it is necessary to make a comprehensive analysis of fire risk, anticipate risk events and situations and based on those information make an adequate assessment of building. Also, finding effective methods to reduce the probability of the adverse situation is very important. Compliance with certain rules, legislation and laws should enable safe construction and maximum protection. Proper design of evacuation routes should enable safe and efficient evacuation of people. When projecting the exits in case of fire it is necessary to pay attention to number of passage units, as well as the number and width of exits. In addition, doors must be constructed of non-combustible materials and should be easily and quickly opened. Also, stairways and elevators are indispensable for evacuation in case of fire. In buildings, each floor should have a separate access to the stairs and doors and walls must be resistant to fire for at least 2 hours. Buildings must have at least one elevator in case of evacuation and its usage and funtion must be clearly defined. Cooperation between different profiles of experts who are engaged in the security engineering is necessary to decrease the fire risk to the lowest possible level.

8. REFERENCES

[1] Choi, M., Park, M., Lee, H., Hwang, S., Anderson, K., & Lee, S. (2016). Understanding the Role of Dynamic Risk Perception during Fire Evacuations Using Agent-Based Modeling. *Construction Research Congress 2016*: 1668-1679.

[2] Gašić, M. M. (2005). *Zaštita od požara i eksplozija*. Banja Luka: Univerzitet u Banjoj Luci, Mašinski fakultet.

[3] Gemović, B. (2010). Značaj preventivnih mera i implementacije standarda BS OHSAS 18001:2007 u zaštiti od požara. *Međunarodna Konferencija "Bezbednosni Inženjering" I "ZOP2010"*: 46-54.

[4] Laban, M., & Milanko, V. (2008). Fire safety assessment of high - rise residential towers. *1. Međunarodna Naučna Konferencija Bezbednosni Inženjering i 11. Međunarodna Konferencija Zaštite od požara i eksplozije*: 3-15.

[5] Laban, M., & Milanko, V. (2010). Procena požarne bezbednosti gradskih stambenih blokova u odnosu na prilazne puteve. *Međunarodna Konferencija "Bezbednosni Inženjering" I "ZOP2010"*: 173-179.

[6] Laban, M. Đ, Popov, S. B., Vukoslavčević, S. R., & Šupić, S. M. (2015). Performanse puteva evakuacije i bezbednost zgrada od požara. *TEHNIKA – NAŠE GRAĐEVINARSTVO* 69: 599-605.

[7] Sagun, A., Anumba, C. J., & Bouchlaghem, D. (2014). Safety Issues in Building Design to Cope with Extreme Events: Case Study of an Evacuation Process. *Journal of Architectural Engineering* 20(3): 05014004-1-05014004-10.

[8] Vidaković, M., Vidaković, B. (2008). *Požar i Arhitektonski Inženjering*. Beograd: Fahreinheit.

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FLOWARD TOWARDS A SAFER AND MORE SUSTAINABLE ALBANIA

Abstract: Recently, Tirana has been suffering flood events during the winter. One of the most devastating occurred on December 2017. One of the spots where the damages have been more critical is an out of town mall area. Located in strategical spot, next to two of the most important highways in Albania, one connecting the port of Durres to the hinterland the other connecting the North and the South of Albania, the flood damaged the transportation services and private users land and property. Built in 2011 the mall gave the area an economic growth, making more private companies establish in the area. The land use has changed from agricultural to commercial and industrial, increasing this way the economic value of the land and consequently potential loss. Based on the abovementioned reasons, the municipality of Tirana is carrying out a feasibility study to reduce the risk of flooding on the area. The challenge in this project is to find the optimal balance between the different fields intervening. The resulting concept should be solid from a technical point of view, but it also should suit in the environment. For this reason, it was necessary to take a step back to have a global perspective of the project. Several ideas have been proposed to build a more prosperous Albania, additionally benefitted from the advantages of becoming a new EU partner.

Key words: flood, damage, highway, risk, loss

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1. PREFACE

From the 26th to the 30th April 2018 a group of students analyzed the management of flooding events in the municipality of Tirana, Albania. The scope of the workshops organized was gaining a better insight in the interaction between public and private parties in the interventions as a response to floods.

The partnership between students, institutions and professionals was fundamental to obtain the maximum profit of the work done. The collaboration local expert engineers made it easier to set a context for the project, by sharing data, experience and means.

2. INTERDISCIPLINARY APPROACH

The main goal of the project is achieving an integral design that can solve the flood risk hazards. To reach so, it is necessary to carry out independent studies in the different fields of knowledge intervening in the project and, subsequently, find the solution that suits all the disciplines.

In the interventions suggested, concepts of transport, infrastructure, transport & logistics, landscape architecture and hydraulic engineering have been brought together, in order to arrive to proposals based on sustainability, strategic planning and technical feasibility, thus combining our different study backgrounds.

The challenge in this project is to find the optimal balance between the different fields intervening. The resulting concept should be solid from a technical point of view, but it also should suit in the environment. For this reason, it was necessary to take a step back to have a global perspective of the project.

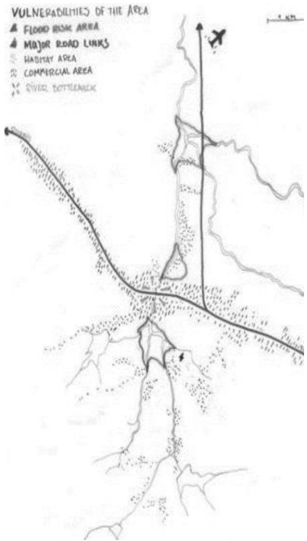

Figure 1 - Vulnerabilities of the area of interest considered in this study

3. CONTEXT

Throughout the last couple of years, Tirana and its surroundings areas have been coping with flooding events in different spots of the municipality. The most remarkable ones occurred during the

2nd and 3rd of December 2017. One of the most affected point was the City Park, that settles in the Western outskirts of the city [1] [2].

The City Park has a strategic positioning in the map, since it is placed right at the crossroad between one of the main roads connecting the North and the South of Albania, and the main connection from Tirana to the port of Durres. For this reason, private investors were attracted to set a new business in this spot, and in 2012 a shopping mall and an aquapark were constructed.

The launching of new commercial facilities in the area clearly benefits the local citizens. However, due to the change in land use from agricultural to commercial use – which is considered more valuable in standardized monetar terms - the consequences of flooding are increased. In order to protect the mentioned commerce and create confidence in new companies to settle there, a master plan has been developed to offer different alternatives to tackle flooding [3].

Figure 2 - The City Park shopping mall and its adjacent parking lot being completely flooded, December 2017. [2]

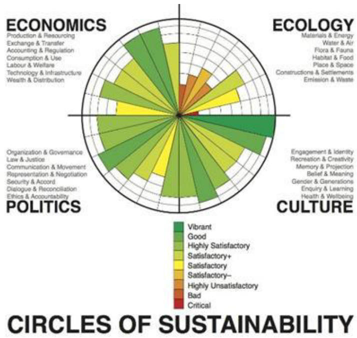

Figure 3 – Sustainability

4. VISION

Sustainability responds to generation of solutions that create long term potential in the area. We looked for a combination of interventions that are technically solid, friendly with the environment and cost limited.

For the City Park area, there is a need for an integrated, multidisciplinary approach by a combination of implementing both rock-solid and soft interventions along the rivers. Considering the rising economy, the diminishing unemployment rates and the prospect entering the European Union, Albania is already moving towards a brighter future.

On the other hand, there exists a need to enforce the social and property regulations, and the creation of flood hazards awareness. For this reason, the design proposed also looks for the respect among the citizens. Certainly, Albania has a great compromise with renewable energies. The vast majority of the energy consumed in the country is produced in their hydropower plants [1].

This project is, hence, a great opportunity for those companies who bet for a sustainable future.The vision of the project is based on the creation of a safe and sustainable water system for the Limuthi river. We aim to create a model of design applicable in the rest of Albania.

5. TENSION FIELD BETWEEN STAKEHOLDERS

Solving the externalities emerging from the floods cannot be done without taking into consideration the interests of the multiple stakeholders involved.On the one hand, the Government must fulfill the needs of the inhabitants and facilitate the easy settlement of companies in the area. The main goal is to set the stage and create more awareness among the citizens of Albania, accompanied by the increase of the dynamism of the Albanian economy.

Other stakeholders are the Aquapark, the shopping mall and the construction and shipping companies, which also might be interested in the protection of their businesses, which were directly affected during the last year flood event.

On the social dimension, both the municipality and the residents show at global scale that their willingness is serious when it comes to change. The municipality wants to create an Albania that is known for its safe and sustainable character by 2030 [4][5]. The project aims, eventually, to enhance the cohesion between the citizens of the municipality of Tirana.

6. PUBLIC-PRIVATE PARTNERSHIPS

The Albanian government is determined to open itself to the international market. Particularly in the capital, Tirana, the presence of international investors is growing notoriously. Due to the migration of Albanians from the rural areas to the city, the service sector is overwhelmed. As a result, facilities are given to investors.

This dynamism in the economy impulse the rest of the sectors. One of the most important ones, which is basic to the development of the society, is the infrastructural sector [6]. The Municipality and the Government are aware of the large investments this business carries. For this reason, they have impulse initiatives to assume an important part of the risks of the project, in order to attract private investment.

Besides, the state promotes policies of reduced taxes and the land use prices are still low. In addition, investors will have access to the funds given by the EU to the state members, while enjoying of a safe and regulated market.

The imminent entrance of Albania in the European Union and its still undiscovered market make it very convenient to stablish business in the country.

7. INTERVENTIONS

According to the vision of the project developers, several solutions are proposed:

- Technical: construction of culverts to control the discharge of the river, use of gabion walls to protect the slopes and the river bed and flood plains to increase the capacity of the river.
- Social and Environmental: increase of the number of waste disposal points and reward system, by which the citizens obtain discounts in certain articles in case of proper disposal.
- Economical: modal split to incentivate public transport and cycling, reduction of emissions and mitigation of the effects of the interruption of arterial highways. Impulse of railway transport from the port of Durres.

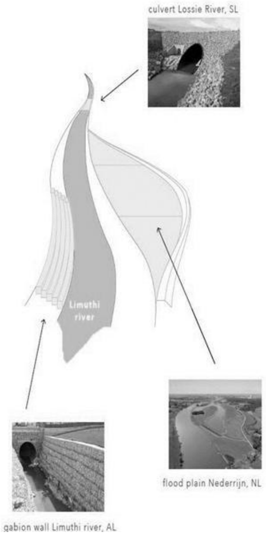

Figure 4 - Possible considerations for the proposed solutions

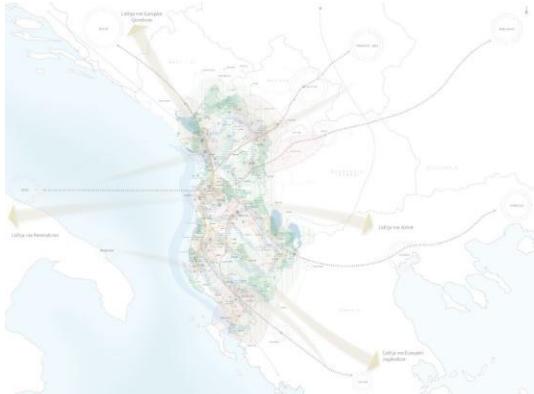

Figure 5 - General National Plan (PPK) "Albania 2030" is the highest instrument of territorial planning in Albania and designs for the first time in our country.

8. FUTURE

Entities such as the Municipality of Tirana and the European Bank for Reconstruction and Development (EBRD) are working together to upgrade the municipal infrastructure in Albania. Their plan is to make the capital more environmentally conscious and promote sustainable growth and development [7].

The municipality of Tirana and the EBRD are working through a memorandum of understanding for the development of urban transport, roads, water and wastewater services, solid waste management, street lights and improving energy efficiency. Albania shows the great benefits of international aid: poverty reduction, roads being built, developing cities and providing for the people of the state.

However, improvement growth models need to represent sustainability, investment-strong and export-led ideals. Focusing on macroeconomic and government fiscal sustainability enhances reform and development for Albania. This, in turn, will benefit all sectors within infrastructure in Albania.

Foreign aid in the form of investments will allow Albania to continue to decrease its poverty rate and boost the economy enough to further state development.

9. BENEFITS FOR THE SOCIETY

For the City Park area, we want to achieve the following benefits that accompany the sustainable developments in the area:

- Raising awareness: Showing and encouraging people to think and act in a sustainable way, this project can be used as an example for future sustainable projects in Albania.
- Creating a safe environment: The system should be safe and less vulnerable for floods by the implementation of hydraulic interventions along the river banks in the commercial area around City Park, but also further up- and downstream the Limuthi river.

- Increasing the attractiveness of sustainable transportation: The aim is to develop new and improve existing more sustainable modes of transportation with regard to public transport as well as the transportation of cargo.
- Creating social cohesion between the commerce and citizens: we would like to move people and companies to act sustainably by creating incentives which will focus on waste management and that involves interactions between the different stakeholders.
- Providing the tools for innovative economic growth and increased land value: The goal is to make the area both more attractive for visitors, but also to make the industries and other businesses in the area more accessible, through the implementation of new and improved infrastructure.

10. CONCLUSIONS

The economic growth of a country has a narrow relationship with the development of the infrastructures. An advanced and safe network of supplies and transportation guarantees the interconnection of economical nodes.

Several ideas have been proposed to build a more prosperous Albania, additionally benefitted from the advantages of becoming a new EU partner. This climate of goodness is feedbacked by investment, which is facilitated by the Governmental entities.

These aspects make this moment unique for private companies to look into Albania, to find their spot in this still unexplored Balkan country.

11. REFERENCES

[1] E. U. d. M. Instituti i Gjeoshkencave, „Qendra Kombëtare për Parashikimin dhe Monitorimin e Rreziqeve Natyrore,“ June 2018. [Na mreži]. Available: http://www.geo.edu.al/newweb/?fq=cimady&gj=gj1.

[2] E. Civile, „SITUATA DHE MASAT PER PERMBYTJET,“ December 2017. [Na mreži]. Available: http://www.mbrojtjacivile.al/index.php/category/item/422-trajnimi-ipa-floods-2016.

[3] A. K. e. P. t. Teritorrit, „BRIGAID Albania,“ [Na mreži]. Available: http://planifikimi.gov.al/index.php?id=57&L=0feed%2Ffeed%2Ffeed%2Ffeed%2Ffeed%2Fcomments%2Ffeed%2Fcomments%2Ffeed%2Ffeed%2Ffeed%2Fcomments%2Ffeed%2Fcomments%2Ffeed%2Fcomments%2Ffeed%2Fcomments%2Ffeed%2F. [Poslednji pristup June 2018].

[4] S. B. Architetti, „Tirana 2030,“ 2017. [Na mreži]. Available: https://www.stefanoboeriarchitetti.net/en/news/tirana-general-local-plan/.

[5] B. e. Tiranes, „TR030 PLANI PËRGJITHSHEM VENDOR,“ [Na mreži]. Available: http://www.tirana.al/programi-transparences/tr030_plani-pergjithshem-vendor/. [Poslednji pristup June 2018].

[6] B. D. Roche, „Progress in Developing Infrastructure in Albania,“ The Borgen Project, Seattle, WA, 2018.

[7] V. Melohina, „Albania and EBRD to work together towards sustainable municipal infrastructure,“ European Bank for Reconstruction and Development (EBRD), Tirana, 2015.

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CHOICE OPTIMIZATION FOR THE EMERGENCY ROUTE FROM THE FIRE BRIGADE TO HIGH-RISE RESIDENTIAL BUILDINGS IN NOVI SAD

Abstract: The paper presents an overview of the analysis results of different routes from the Novi Sad fire brigade to high-rise buildings in Novi Sad. Analysis was conducted comparing time calculated with the Quantum GIS program and the real time of fire brigade arrival to the intervention place – building in fire. Fire safety of high-rise buildings, preventive measures for removal and reduction of fire, salvage and fire fighting, regulation of routes and access roads to high risk facilities are the basics of fire procedure planning. The state of fire protection equipment and access roads to three high-residential buildings in Novi Sad was analyzed, in order to indicate possibilities to reduce the fire risks, for safety of people lives.

Key words: Software modelling, route, optimization, fire safety, high-rise buildings, comparative analysis

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1. INTRODUCTION

Progress of the building industry can be perceived trough constant innovation in design and developing new structures and constructing materials. However, success in this field is not always followed by equal accomplishment regarding fire protection and fire safety.

Designing high-rise buildings brought specific problems regarding fire safety, from preventive to repressive measures, where the safety of occupants decreases with increase of number of storeys in building.

The City of Novi Sad, as urban area, has certain specificities regarding fire risk. Nowadays, the urban area building style is reflected in dense built buildings, with narrow passages and hardly accessible approaches to buildings, which results in many difficulties for fire brigade to take an action.

Considering that it is impossible to know in advance when and where the fire will occur, it is difficult to define the amount of resources in time, people and equipment needed to respond and neutralize the hazard. Additionally, time for surveying the conditions at the fire scene, planning an action and preparing equipment, has to be taken into consideration.

Rationally distributed Fire stations network in the city area, equipment possession and optimal route choice, are the basics of the fire – fighter's procedure plan. All of the above indicate the importance of the recognition of alternative emergency routes to take the fire brigade to the place of intervention, in case of clogging the main ones, by analysing all relevant parameters.

2. RESIDENTIAL BUILDINGS IN NOVI SAD AS FIRE HAZARD

Novi Sad (Figure 1) is the capital city of Autonomous Province of Vojvodina, and the second largest city in Republic of Serbia. It is located at the left bank of the River Danube, at confluence of Danube and one of the main melioration channels, Danube-Tisa-Danube. With 15 suburbs, territory of the city covers the area of 702,7 km². According to the 2011 census, administrative area of the City of Novi Sad has population of 341.625 inhabitants, while 231.798 of them live in the urban area.

Figure 1 – The City of Novi Sad – location on the map

Novi Sad is a typical Central European city. There are only a few structures left that are constructed before 19th century, due to devastating consequences of the revolution in 1849. Therefore, today, the city centre is influenced by the architecture of 19th century. Previously, around the central area where mainly family houses, but nowadays they are replaced by high-raise residential buildings.

Potential fire hazard in Novi Sad could occur in industrial complexes, public buildings, residential, business and combined buildings, transportation, opened space, etc.

Large number of fires occurred in residential buildings (around 60 percent of all fires in Novi Sad, according to Novi Sad fire brigade statistics in the last three years).

Residential buildings, especially high-rise buildings (Figure 2), could be very dangerous structures in case of evacuation during the fire. Significant number of these buildings in Novi Sad was designed with one central staircase, without fire stairs, because there were no technical regulations until 1983. Due to existence of only one exit-trough the stairwell-evacuation in these facilities could be complicated and dangerous, especially if the stairwell is smoke-filled[3].

Figure 2 – View of some of the high-rise buildings in Novi Sad

Fire brigade in Novi Sad has near 100 members, including executive and technical department . 88 of them are fire-fighters, which means there are 22 of them in one shift [5]. With that capacity, fire brigade participates in 1200 interventions per year on average. Although flame spread rate depends on various factors, in most cases full fire development time is less than 10 minutes [5]. Based on the fact that, on numerous occasions, this could take only a few minutes, time needed for fire brigade to come to the scene is extremely important for people lives and can be crucial in many situations. In the European Union, as well as in other modern countries in the world, maximum response time is defined by legal acts. In urban areas, this time is ranging from 6 to 10 minutes, depending on country. For example, average response time in England is 8 minutes and 30 seconds, according to IRS Statistical Bulletin [7].

The basic measure to obtain the adequate response time is to plan optimal number of fire stations in the city area. There is only one fire station in Novi Sad, which means it is almost impossible to satisfy the time limit criteria. Taking into consideration insufficient number of fire-fighters and density of urban area, the route choice optimization in Novi Sad is of the highest importance.

3. APPLICATION OF SOFTWARE MODELLING USING QUANTUM GIS

Gary Sherman began development of Quantum GIS (Geographic Information System) in early 2002. Development was continued in 2004, and Quantum GIS became an incubator project of the OSGeo Foundation (Open Source Geospatial Foundation) which integrates with other open-source GIS packages. Version 1.0 was released in January 2009. [2]

Quantum GIS offers combining of geospatial components and statistic data, it is free software for visualizing, managing, editing, analysing data, and composing printable maps.

Bringing the data into the spatial context, QGIS creates the visual display and database which can be searched by chosen selection of available data. [2]

4. ANALYSIS OF ROUTE CHOICE OPTIMIZATION

Analysis starts with uploading the map of the analysed building location. The map of Novi Sad was uploaded at QGIS (Figure 3) to start the research represented in this paper.

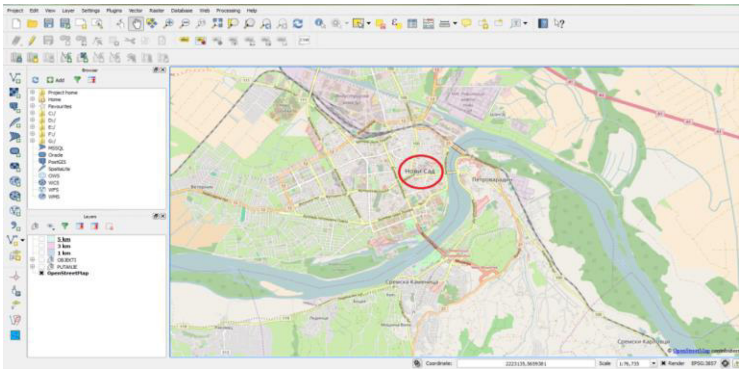
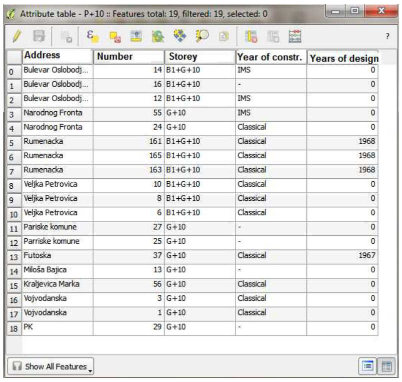


Figure 3 – Map of the Novi Sad in the program QGIS

4.1. Creating group of layers - buildings

For the geopositioning of high residential buildings on the map of Novi Sad, 19 layers were created. Within 18 layers, the positions of the high residential buildings were accompanied with following attributes: number of storeys, constructing system type and the year of designing. One layer is referring to the location of Novi Sad fire brigade.

Layers and their labels are defined according to number of storeys. Layers with label G+10 and it's attributes (Figure 4) refer to buildings with one ground floor and 10 floors, as well as buildings with one basement, ground floor and 10 floors (B1+G+10). This layer contains buildings on following addresses: Bulevar Oslobođenja Street, no. 12,14,16; Narodnog Fronta Street, no. 24,55; Rumenačka Street, no. 161,163,165; Veljka Petrovića Street, no. 6,8,10; Miloša Bajića Street, no. 13; Vojvođanska Street, no. 1 and 3; Pariske komune Street, no. 25,27,29; Futoška Street, no. 37. Other buildings are sorted in layers by the same concept.



Attribute table - P+10 :: Features total: 19, filtered: 19, selected: 0

	Address	Number	Storey	Year of constr.	Years of design
0	Bulevar Oslobodj...	14	B1+G+10	IMS	0
1	Bulevar Oslobodj...	16	B1+G+10	-	0
2	Bulevar Oslobodj...	12	B1+G+10	IMS	0
3	Narodnog Fronta	55	G+10	IMS	0
4	Narodnog Fronta	24	G+10	Classical	0
5	Rumenacka	161	B1+G+10	Classical	1968
6	Rumenacka	165	B1+G+10	Classical	1968
7	Rumenacka	163	B1+G+10	Classical	1968
8	Veljka Petrovica	10	B1+G+10	Classical	0
9	Veljka Petrovica	8	B1+G+10	Classical	0
10	Veljka Petrovica	6	B1+G+10	Classical	0
11	Pariske komune	27	G+10	-	0
12	Parriske komune	25	G+10	-	0
13	Futoska	37	G+10	Classical	1967
14	Miloša Bajica	13	G+10	-	0
15	Kraljevica Marka	56	G+10	Classical	0
16	Vojvodanska	3	G+10	Classical	0
17	Vojvodanska	1	G+10	Classical	0
18	PK	29	G+10	-	0

Show All Features

Figure 4 – Review of layers with label G+10

4.2. Creating groups of layers - routes

After the high-rise residential buildings were positioned on the map, routes for fire brigade were defined. One layer represents one route and distance from fire brigade to specific building. In total, 34 layers were made, which indicates that 34 groups of buildings, among 72 of them, were identified (Table 1). In order to determinate the time of arrival from fire station to intervention scene, different routes were created in software, and their distances calculated, based on 1 kilometre-1minute criteria.

Table 1- Attribute review

No.	Address	Distance [km]	Time of arrival[min]
1.	1b Vardarska	5	5
2.	9 Šekspirova	4	4
3.	17 and 19 Radnička	2	2
4.	161,163,165 Rumenačka	4	4
5.	12,14,16 Bulevar Oslobođenja	2	2
6.	94 and 115 Bulevar Oslobođenja	2	2
7.	9 and 28 Bulevar Oslobođenja	6	6
8.	1 Bulevar Oslobođenja	2	2
9.	4 and 6 Fruškogorska	4	4
10.	21 Fruškogorska	4	4
11.	51 and 55 Narodnog Fronta	5	5
12.	22 and 24 Narodnog Fronta	5	5
13.	26 Narodnog Fronta	5	5
14.	32 Bate Brkića	7	7
15.	37 Futoška	3	3
16.	1, 3 Vojvođanska	3	3
17.	13 Miloša Bajića	3	3
18.	56,58,60 Kraljevića Marka	2	4
19.	6 and 10 Veljka Petrovića	4	4
20.	8 Veljka Petrovića	4	4
21.	25,27,29 Pariske komune	3	3
22.	11,13,15,17 Brače Dronjak	6	6
23.	5 Bulevar cara Lazara	3	3

24.	116,118,120 Veselina Masleše	5	5
25.	8 Pariske komune	3	3
26.	37 and 41 Balzakova	5	5
27.	81,83,85 Bulevar Cara Lazara	6	6
28.	7 Bulevar Cara Lazara	3	3
29.	2,4,6 Bulevar despota Stefana	5	5
30.	39,41,43,45 Beogradski kej	4	4
31.	25 and 27 Bulevar Jovana Dučića 22 Partizanskih baza	6	6
32.	153 and 155 Bulevar Oslobođenja 18 Dragiše Brašovana	4	4
33.	69 and 71 Bulevar cara Lazara 1 Balzakova	6	6
34.	16 and 18 Bulevar despota Stefana 64 Balzakova	5	5

Figure 5 represents distance radius of 1km, 3km and 5km, from the fire station to the listed buildings. 1km radius is represented in blue colour, 3 km radius in purple, and 5 km radius is represented in green colour.

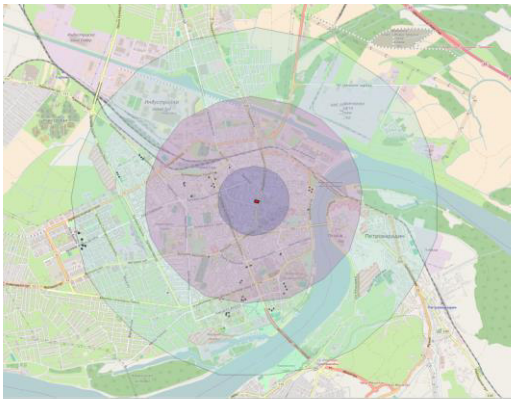


Figure 5 – Radius of 1km, 3km and 5km

According to criteria 1km – 1 min, fire brigade can arrive for 1 minute to the building involved in fire, which is 1km distant, and 3 and 5 minutes to the buildings 3 and 5 km distant, respectively. Results obtained in QGIS do not have verification in practice, where the time of arrival is longer.

4.3. Comparative analysis of time calculated by QGIS and real time of arrival of fire brigade

From the group of buildings geopositioned on the map and listed in the Table 1, three were chosen for comparative analysis: Building 1 on 7 Bulevar Cara Lazara Street; building 2 on 8 Veljka Petrovića Street and building 3 on 26 Narodnog fronta Street.

4.3.1. Building 1

High-rise residential building on 7 Bulevar Cara Lazara Street is built as G+16+AF. Number of residents in building is 250. Building is surrounded with parking lot and trees and it does not have adequate access road for fire trucks. Position of the building on the map is presented at Figure 6.

Figure 6 - Position of the building 3

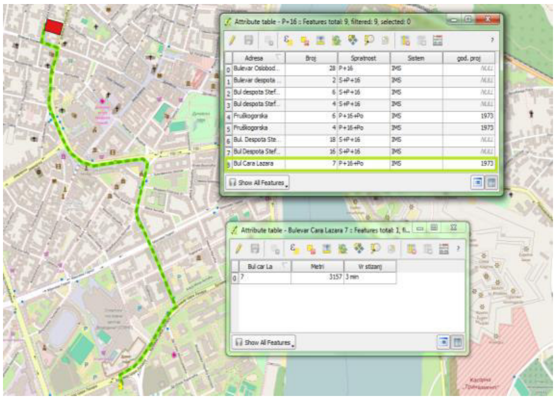


Figure 7 – Review of results in the program QGIS

Fire stairs in building are properly designed and functioning. Potential problem is high incline of the staircase, as well as their small width. Furthermore, there are no fire door that would separate main stairwell and hallway. Manual fire alarm system, regularly checked and maintained, provides in time fire alarm. There are no portable fire extinguishers.

The distance between building and nearest Novi Sad fire brigade is 3 km. Average time of arrival of fire brigade is 6 minutes and 30 seconds. This time was measured during the fire brigade exercise, when the fire truck used the route along following streets: Vuka Karadžića, Vojvode Bojovića, Jovana Subotića, Uspenska, Jevrejska, Bulevar Oslobođenja, Bulevar Cara Lazara. Fire truck approached to the building from Fruškogorska Street (Figure 7).

Access roads were not passable for the fire trucks, due to parked cars and jardinières placed by the road.

Hydraulic platform could be positioned only by one side of the building, at Bulevar Cara Lazara Street. In case hydraulic platform could not be placed at all, fire extinguishing would be done by using fire hose. During the exercise, 9 fire hosepipes were used, each 15m long. Time required for pulling out the hose to 10th floor is between 6 and 7 minutes.

According to the results from QGIS (Figure 7), based on 1km-1min criteria, distance from building to the nearest fire brigade is also 3 km, while the time of arrival does not match with the time measured at the fire brigade exercise. Time calculated with QGIS is 3 minutes, which is two times shorter.

Additionally, in order to reach more reliable analysis, time required to enter the apartment in fire has to be taken into consideration. This could prolong the start of extinguishing action, due to eventual security doors in case that apartment is empty. Consequently, additional 12 minutes (estimated by fire brigade) required for starting the fire extinguishing has to be added to time of arrival. Therefore, total time for starting the fire extinguishing, from the moment alert is received, is around 18 minutes, measured in real conditions, or 15 minutes calculated by QGIS program.

Having this in mind and being aware of the fact that time required from the moment fire occurred to full fire development is less than 10 minutes, this high-rise building is categorized as high-risk building.

4.3.2. Building 2

High-rise residential building on 8 Veljka Petrovića Street has 10 floors beside the ground floor, and the number of residents is 160. Building is surrounded with parking lot, garages and greenery. There is no adequate access road for fire trucks. Position of the building on the map is presented at Figure 8.

Figure 8 - Position of the building 2

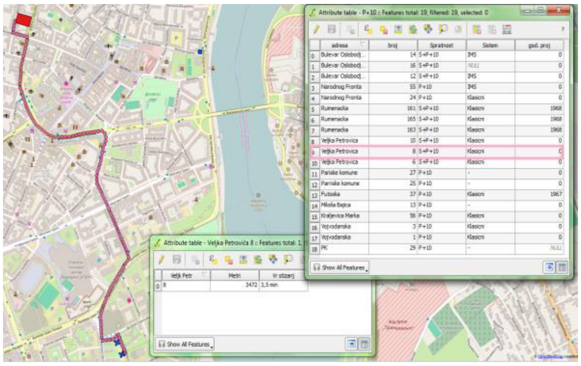


Figure 9 - Review of results in the program QGIS

Building contains one entrance and one staircase, as well as two elevators. Fire hydrants are placed on every uneven floor, but there is no fire equipment needed for their use. Building has portable fire extinguishers on every even floor.

The distance between building and closest fire brigade is 4 km. Average time of arrival of fire brigade is around 7 minutes. Fire truck used the route along following streets: Vuka Karadžića, Vojvode Bojovića, Jovana Subotića, Uspenska, Bulevar Mihajla Pupina, Žarka Zrenjanina, Stražilovska, Bulevar Cara Lazara, Fruškogorska, Jirečekova, Veljka Petrovića (Figure 9).

As in previous case, access roads were not passable, due to parked cars. Hydraulic platform could be installed only on the side of entrance, but, due to difficulty of placing hydraulic equipment, fire extinguishing would be done by using fire hose. During the exercise, 9 fire hosepipes were used, each 15m long. Time required for pulling out the hose to 10th floor is between 6 and 7 minutes.

According to the results from QGIS (Figure 9), distance from building to the nearest fire brigade is 3,5 km, and time of arrival of fire brigade is 3,5 minutes. This conflict with the results from fire brigade exercise-measured time is 7 minutes and distance is 4 km.

Additional 12 minutes required to start the extinguishing has to be added to time of arrival. Total time for starting the extinguishing, from the moment alert is received, is 19 minutes, measured during the exercise, or 15,5 minutes calculated by QGIS program.

As it was case with building on Bulevar Oslobođenja Street, required time from moment fire occurred to full fire development is less than 10 minutes. That being so, this high-rise building as well is categorized as high-risk building.

4.3.3. Building 3

High-rise residential building on 26 Narodnog Fronta Street is built as B1+G+13. There are 3 apartments on the ground floor and 4 of them on each floor. Access roads are not adapted, but it is possible to approach the building from two sides. Position of the building on the map is presented at Figure 10.

Figure 10 - Position of the building 3

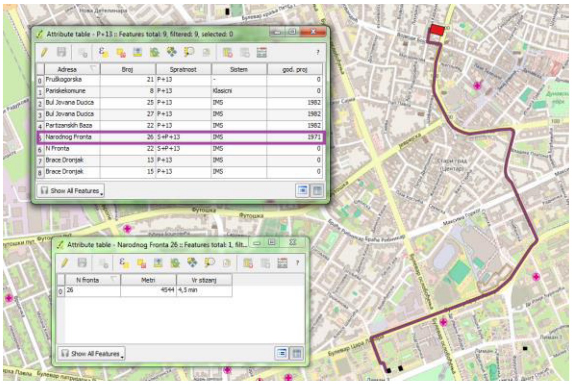


Figure 11 - Review of results in the program QGIS

The distance between building and nearest Novi Sad fire brigade is 3 km. Average time of arrival of fire trucks is around 6 minutes. The route that fire truck used is along following streets: Vojvode Bojovića, Šekspirova, Uspenska, Jevrejska, Bulevar Oslobođenja, Narodnog Fronta (Figure 11).

Manual fire alarm system in this building is damaged, and there are no fire extinguishers.

Because of difficult placing of hydraulic equipment, fire extinguishing could be done with fire hose. During the exercise, 9 fire hosepipes were used, each 15m long. Time required for pulling out the hose to 10th floor is between 6 and 7 minutes.

Distance from building to nearest fire brigade, calculated with QGIS is 4,5 km (Figure 11). Measured distance is 3 km. Time of arrival of fire brigade 6 minutes and 4,5 minutes, measured in real conditions and calculated by GIS, respectively. Once again, measured time is longer than calculated, although it has to be taken into consideration that the QGIS is calculating time by 1 km-1 minute criteria.

In this particular case, one apartment was in the middle of renovation. Unexpected obstacles, such as constructing material, bricks and sacks of cement were slowing down the fire-fighters, so the additional time required to start the fire extinguishing could be even longer than estimated 12 minutes. From the moment alert is received, total time needed to start the fire extinguishing is 18 minutes, measured during the exercise. Calculated by QGIS program this time is 16,5 minutes.

Time from moment fire occurred to full fire development is less than 10 minutes. This indicates that this high-rise residential building is categorized as high-risk building.

5. CONCLUSION

Analysing 72 high-rise buildings with 10 to 18 storeys, this paper represents two different methods of determination the time required for fire brigade to arrive to the building in fire. The first one is QGIS software calculation, conducted according to 1 km-1 minute criteria. The second one is based on measuring the time of arrival during fire brigade exercise.

In both cases, additional time needed to overcome the difficulties due to inaccessibility of buildings and to prepare the equipment for intervention has been taken into consideration. Comparing the results obtained from QGIS program and time measurements during the fire brigade exercise, it is concluded that fire brigade arrival time in real environment is longer than QGIS predicts.

Average difference between these results is 2,67 minutes. Depending on various factors, this time can be of significant importance when it comes to the fire brigade efficiency in case of fire extinguishing action. This implicates that the one of the most important issues is the choice of optimal route that will provide safe and fast way for fire trucks.

All of three analysed high-rise buildings were categorized as high-risk buildings. Access roads to the buildings either do not exist, or they are not maintained or approachable. Parts of fire protection equipment in these buildings are inadequate, old, or there is no equipment at all. Hosepipes and spouts in fire hydrants are missing in building 2 and there are no fire extinguishers in building 1 and 3. Manual fire alarm system provides in time fire alarm only in building 1.

In the light of these facts, route choice optimization has even more significance for fire safety. Aggravated circumstances listed above increase time for fire brigade to come to the local and react before vast consequences occur. Besides finding the optimal route, alternative routes are extremely important for planning and realizing fire intervention.

Although it is difficult to predict and include all variables, recurrent fire brigade practices provide insight into actual conditions. This information has important contribution to analysing different routes and optimal number of fire brigades and fire-fighters. Along with investing into equipment, these are the basics of the efficient fire procedure planning, in order to provide safety for society.

6. REFERENCES

[1] High-rise firefighting, http://www.hvz.hr/gasenje-pozara-visokih-objekata/

[2] http://bib.itb.hr/datoteka/614467.NK_Diplomski_rad.pdf - Bachelor project

[3] Jocić D. 2014. Application of information system in the first phase of tactical activity during fire-fighting interventions, Diploma project, FTN, Novi Sad.

[4] Laban M, Milanko V. 2010. Assessment of fire safety of city dwelling blocks in relation to access roads, 12th International conferention on fire and explosion protection Novi Sad, books of proceedings, page 84.-91.

[5] Novi Sad fire brigade

[6] Pravilnik o tehničkim normativima za zaštitu visokih objekata od požara, "Službeni glasnik RS", br. 80/2015 od 21.9.2015.

[7] Response times to fire attended by fire and rescue services: England, April 2016 to March 2017 - Statistical Bulletin 03/18.

[8] Uredba razvrstavanja objekata, delatnosti i zemljišta u kategorije ugroženosti od požara, "Službeni glasnik RS", br. 80/10.

[9] Zaštita od požara u građevinarstvu – Stepen otpornosti zgrade prema požaru, SRPS U.J1.240:1995.

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PARAMETRIC ANALYSIS ON FIRE RESISTANCE OF TIMBER COLUMNS ACCORDING TO EUROCODES

Abstract: Resistance to action of fire is an important factor for the safety and serviceability of timber structures as well as for their further application. Design of the mechanical resistance, due to the specified fire exposure is defined by the reduced cross-section method and the reduced properties method. In this paper, analysis of structural elements - solid timber columns subjected to compression and exposed to fire on four sides was carried out and both methods were used for the fire resistance design, according to EN 1995-1-2: Eurocode 5. The following parameters, were taken into account: dimensions 16/16cm, column height 2.5 m, solid wood strength classes (softwood strength class C14), modification factor Kmod=0.6 and design load ratio of the column (70%, 80%, 90% and 100%). Comparative analysis of both design procedures shows that reduced cross-section method gives less fire resistance of the column and is on the side of safety.

Key words: fire resistance, solid timber, columns, reduced cross-section method, reduced properties method

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1. INTRODUCTION

Fire resistance is an important factor for safety and an important criterion for selecting the material for construction. The flammability of the wood is one of the main reasons why many regulations and standards limit the use of wood as building material. However, today, with the appropriate fire resistance design of the structural timber elements, its use as a building material again increases.[1]

The purpose of this research paper is to analyse specific structural elements such as timber columns exposed to fire and to determinate their bearing capacity according to Eurocode 5. Columns will be analysed under the action of axial pressure forces. The analysis will include the impact of the following parameters:

- The type, quality and classes of the wood,
- The modification coefficient (Kmod) which depends on the degree of the wood humidity and the duration of the loading,
- Geometric characteristics of the elements: shape and dimensions of the cross-sections, height of the column expressed through the slenderness ratio of the column,
- The percentage of utilisation of the cross – section (stress level)
- The combustion speed of the wood β□, which depends on the type of the wood and is given in the EN 1995: part 1-2: Section 3.1. [2]

Analysis of centrically loaded columns in compression, exposed to the Standard fire action, will be performed. These structural elements are the most often elements in the classic roof constructions made of solid timber. In this case the columns are exposed to fire from all four sides. All items will be analysed for a case of direct fire action on the element surface without the use of insulation materials. In the fire performance analysis, the following classes of fire resistance will be defined R10, R15, R20 and R25 and R30. The calculation involves the determination and the load bearing capacity of a given section in conditions of normal temperature and under conditions of exposure to standard fire ISO 834. The calculation of the load bearing capacity will be carried out according to the reduced cross-section method and the reduced properties method given in the European standard EN 1995, Part 1-2. [3]

The aim of the research is to obtain data and define conclusionsa based on the comparative analysis between the results for the fire resistance of the elements obtained by the both methods of calculation, according to Eurocode 5.

2. METHODS OF CALCULATION OF THE FIRE RESISTANCE ACCORDING TO EUROCODE 5

According to the fire resistance standards for timber elements, given in Eurocode 5, two calculation methods were used for calculating the load bearing capacity of fire exposed timber columns:

- A method of reduced cross-section
- A method of reduced properties

In the reduced cross-section method an effective cross-section should be calculated by reducing the initial cross-section with the effective charring layer which has zero resistance. Reduced properties method takes into account the reduced mechanical properties of timber in the effective cross-section due to temperature. [4]

2.1. Reduced cross-section method

The effective cross-section should be determined by reducing the initial cross-section with the effective depth of coal that is determined by the expression: [3]

$$d_{ef} = d_{char.n} + K_0 \cdot d_0 \tag{1}$$

Where:

$d_0 = 7mm$

K_0 - coefficient

It is assumed that the material near the charring line in a layer of thickness $K_0 \cdot d_0$ has zero strength, while the remaining part of the cross-section is assumed to be unchanged. Figure 1

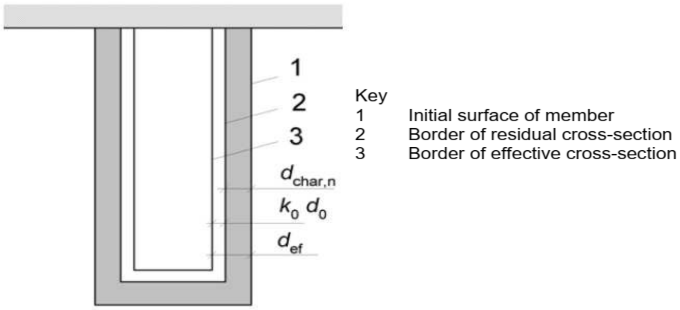

Figure 1 – Defining the residual cross-section and the effective cross-section [2]

The determination of the values of the coefficient K_0 is given in Table 1.

Table 1- Determination of K_0 for unprotected surfaces with time (t) in minutes [2]

	K_0
t < 20 min	t / 20
t > 20 min	1.0

2.2. Reduced properties method

This method is applicable to rectangular cross-sections of softwood exposed to fire on three or four sides and round cross-sections exposed along their whole perimeter [3]. The residual cross-section is determined according to the above mentioned procedure.

For t ≥ 20min, the modification factor for fire, $K_{mod,fi}$, is determined according to the following expression: [3]

– for compressive strength:

$$k_{\mathrm{mod,fi}} = 1{,}0 - \frac{1}{125}\frac{p}{A_r} \tag{2}$$

where:

p is the perimeter of the fire exposed residual cross-section, in metres;
A_r is the area of the residual cross-section, in m^2.

For t=0 $K_{mod,fi}$ should be taken equal to 1.0. For 0≤ t ≤ 20 minutes, the modification factor can be determined by linear interpolation, Figure 2.

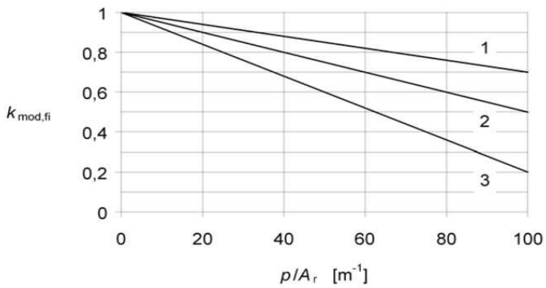

Figure 2 – Illustration of expressions for $K_{mod,fi}$ *[3]*

3. CALCULATION PROCEDURE FOR COLUMNS EXPOSED TO COMPRESSIVE AXIAL FORCE

The fire resistance of timber columns exposed to compression axial force, in accordance with Eurocode 5, is analysed in this paper. For this purpose, columns with cross-section dimensions 16/16 cm and length 2.5 m, made from softwood, strength class C14, were examined. Besides the influence of the geometric characteristics of the cross section and the strength characteristics of the material, the modification factor (K_{mod}) was taken to be 0.6. The influence of the geometrical characteristics of the cross-section, physical and mechanical properties of the material and the duration of the load has been investigated for four cases of initial utilisation of the cross-section at ambient temperature (100%, 90%, 80% and 70%).

The calcultaion was carried out with two differentt methods for determining the fire resistance of wooden elements: the method of reduced cross-section and method of reduced properties. The procedure for determining the fire resistance of one typical cross section is presented and the calculation results are given in tables for each section and for all variable parameters. The calculation includes the determination of the bearing capacity of the given section for normal temperature and under exposure to Standard fire ISO 834 for different time periods, i.e. 10, 15, 20, 25 and 30 minutes.

3.1. Load bearing capacity of a column at ambient temperature

Slenderness of the column:

$$\lambda = \frac{L}{i} = \frac{2500}{46.19} = 54.12$$

Relative slenderness of the column:

$$\lambda_{rel} = \frac{\lambda}{\pi} * \sqrt{\frac{f_{c,o,k}}{E_{0,05}}} = \frac{54.12}{3.14} * \sqrt{\frac{16}{4700}} = 1.006$$

$$K_z = 0.5 * (1 + \beta_c * (\lambda_{rel} - 0.3) + \lambda_{rel}^2) = 0.5 * (1 + 0.2 * (1.006 - 0.3) + 1.006^2) = 1.077$$

Buckling coefficient:

$$K_{cz} = \frac{1}{K_z + \sqrt{K_z^2 - \lambda_{rel}^2}} = \frac{1}{1.077 + \sqrt{1.077^2 - 1.006^2}} = 0.684$$

Compressive strength of timber parallel to the grain:

$$f_{c,o,d} = K_{mod} * \frac{f_{c,o,k}}{\gamma_M} = 0.6 * \frac{16}{1.3} = 7.385\ N/mm^2$$

Calculated compressive stress :

$\sigma_{c,o,d} = K_{cz} * f_{c,o,d} = 0.684 * 7.385 = 5.053\ N/mm^2$

The axial force that causes 100% utilisation of the bearing capacity of the colum:

$\boldsymbol{N_{max} = A * \sigma_{c,o,d} = 25600 * 5.053 = 129345.19\ N}$

3.2. Load bearing capacity of the column according to the reduced cross section method

The load bearing capacity of the column was determined for different moments of fire expose to ISO 834 standard fire. The results for the moment t=10 min. and 100% utilisation of stresses, according to the reduced cross section method are presented.

The charring layer thickness at moment t = 10 min:

$$K_0 = \frac{t}{20} = \frac{10}{20} = 0.5$$

$d_{ef} = 0.8 * 10 + 0.5 * 7 = 11.5\ mm$

Dimensions of the residual cross section:

$b_{fi} = h_{fi} = b - 2 * d_{ef} = 160 - 2 * 11.5 = 137\ mm$

Radius of inertia of residual cross section:

$$i_{fi} = \sqrt{\frac{I_{fi}}{A_{fi}}} = \sqrt{\frac{29356280.08}{18769}} = 39.55\ mm$$

Slenderness of the column:

$$\lambda_{fi} = \frac{L}{i_{fi}} = \frac{2500}{39.55} = 63.21$$

Relative slenderness of the column:

$$\lambda_{rel,fi} = \frac{\lambda_{fi}}{\pi} * \sqrt{\frac{f_{c,o,k}}{E_{0,05}}} = \frac{63.21}{3.14} * \sqrt{\frac{16}{4700}} = 1.175$$

$K_{z,fi} = 0.5 * \left(1 + \beta_c * \left(\lambda_{rel,fi} - 0.3\right) + \lambda_{rel,fi}^2\right) = 0.5 * (1 + 0.2 * (1.175 - 0.3) + 1.175^2)$

$K_{z,fi} = 1.278$

Buckling coefficient:

$$K_{cz,fi} = \frac{1}{K_{z,fi} + \sqrt{K_{z,fi}^2 - \lambda_{rel,fi}^2}} = \frac{1}{1.278 + \sqrt{1.278^2 - 1.175^2}} = 0.56$$

Compressive strength of timber parallel to the grain:

$f_{c,o,d,fi} = K_{fi} * f_{c,o,k} = 1.25 * 16 = 20\ N/mm^2$

Ultimate compressive stress of timber at moment t=10 min :

$\sigma_{c,o,d,fi} = K_{cz,fi} * f_{c,o,d,fi} = 0.56 * 20 = 11.2\ N/mm^2$

Intensity of the axial force in case of fire:

$\boldsymbol{N_{fi,max} = \eta * N_{max} = 0.6 * 129345.19 = 77607.11\ N}$

where:

η– reduction factor for permanent and live loads in case of fire.

Compression stress in case of fire:

$$\sigma_{c.o.fi} = \frac{N_{fi,max}}{A_{fi}} = \frac{77607.11}{18769} = \mathbf{4.135\ N/mm^2}$$

The following criteria has to be fulfiled:

$$\sigma_{c.o.fi} < \sigma_{c.o.d.fi}$$

$$4.135\ N/mm^2 < 11.2\ N/mm^2$$

The ratio between the stresses caused by the axial force and the load bearing capacity (ultimate stresses) of the column at moment t=10 min. is:

$$\frac{\sigma_{c.o.fi}}{\sigma_{c.o.d.fi}} = \frac{4.135}{11.2} = 0.37$$

The fire resistance coresponds to the moment when the ratio between the cross section stresses and ultimate stresses of the cross section are equal to 1.

$$\frac{\sigma_{c.o.fi}}{\sigma_{c.o.d.fi}} = 1$$

3.3. Load bearing capacity of the column according to the reduced properties method

The charring layer thickness after t = 10 min. of fire exposure:

$$d_{res} = \beta_n * t = 0.8 * 10 = 8\ mm$$

Determination of the reduced cross section:

$$b_{fi} = h_{fi} = b - 2 * d_{res} = 160 - 2 * 8 = 144\ mm$$

Perimeter of the residual cross section:

$$P_{fi} = 2 * b_{fi} + 2 * h_{fi} = 2 * 144 + 2 * 144 = 576\ mm = 0.576\ m$$

Radius of inertia of residual cross section:

$$i_{fi} = \sqrt{\frac{I_{fi}}{A_{fi}}} = \sqrt{\frac{35831808}{20736}} = 41.57\ mm$$

Slenderness of the column:

$$\lambda_{fi} = \frac{L}{i_{fi}} = \frac{2500}{41.57} = 60.14$$

Relative slenderness of the column:

$$\lambda_{rel,fi} = \frac{\lambda_{fi}}{\pi} * \sqrt{\frac{f_{c,o,k}}{E_{0,05}}} = \frac{60.14}{3.14} * \sqrt{\frac{16}{4700}} = 1.117$$

$$K_{z,fi} = 0.5 * \left(1 + \beta_c * \left(\lambda_{rel,fi} - 0.3\right) + \lambda_{rel,fi}^2\right) = 0.5 * (1 + 0.2 * (1.117 - 0.3) + 1.117^2)$$

$$K_{z,fi} = 1.206$$

Buckling coefficient:

$$K_{cz,fi} = \frac{1}{K_{z,fi} + \sqrt{K_{z,fi}^2 - \lambda_{rel,fi}^2}} = \frac{1}{1.206 + \sqrt{1.206^2 - 1.117^2}} = 0.602$$

Determination of fire modification factor:

$$K_{mod,fi} = 1 - \frac{1}{125} * \frac{P_{fi}}{A_{fi}} = 1 - \frac{1}{125} * \frac{0.576}{2.0736 * 10^{-2}} = 0.778$$

Compressive strength of timber parallel to grain:

$$f_{c,o,d,fi} = K_{fi} * f_{c,o,k} * K_{mod,fi} = 1.25 * 16 * 0.778 = 15.56\ N/mm^2$$

Ultimate compressive stress of timber at moment t=10 min :

$$\sigma_{c.o.d,fi} = K_{cz,fi} * f_{c,o,d,fi} = 0.602 * 15.56 = 9.37\ N/mm^2$$

Intensity of the axial force in case of fire:

$$\boldsymbol{N_{fi,max} = \eta * N_{max} = 0.6 * 129345.19 = 77607.11\ N}$$

Compression stress in case of fire:

$$\sigma_{c.o.fi} = \frac{N_{fi,max}}{A_{fi}} = \frac{77607.11}{20736} = \boldsymbol{3.74\ N/mm^2}$$

$$3.74\ N/mm^2 < 9.37\ N/mm^2$$

The ratio between the stresses caused by the axial force and the load bearing capacity (ultimate stresses) of the column at moment t=10 min. is:

$$\frac{\sigma_{c.o.fi}}{\sigma_{c.o.d,fi}} = \frac{3.74}{9.37} = 0.399$$

4. RESULTS ANALYSIS

For different level of utilisation of the cross section at ambient temperature, as a result of action of axial force, the fire resistance of the column with cross section 16x16 cm is between 25 and 30 min., according to both methods.

In case of 100% utilisation, the fire resistance of this column is 26 minutes and 9 seconds. By decreasing the utilisation, the time of fire resistance increases. The ratio between the stresses in the cross section and the ultimate stresses as function of the percentage of load intensity and the duration of the fire exposure according to the method of reduced cross-section are given in Table 2.

Table 2- Fire resistance of a column according to the method of reduced cross section

Ratio between the cross section stresses and ultimate stresses $\sigma_{c,0,fi}/\sigma_{c,0,d,fi} = 1.0$					
Load ratio	Time of fire exposure - t [min]				
	t=10	t=15	t=20	t=25	t=30
100%	0.37	0.5	0.71	0.93	1.24
90%	0.33	0.45	0.64	0.83	1.12
80%	0.29	0.4	0.56	0.74	0.99
70%	0.25	0.35	0.49	0.65	0.87

From Table 2 it can be concluded that with 100% and 90% initial utilisation of the cross section, the fire resistance of the column is in range from 25 to 30 minutes. For 80% utilisation the fire resistance is

30 minutes. With 70% utilisation, the fire resistance range is between 30 and 35 minutes. Aaccording to the method of the reduced cross section, the exact time of fire resistance was obtained by constructing a curve, represented by a graph " time – stress ratio", Figure 3.

The ratio between the cross-section stresses and the ultimate stresses as function of the load ratio and the time of the fire exposure, according to the method of reduced properties, is given in Table 3.

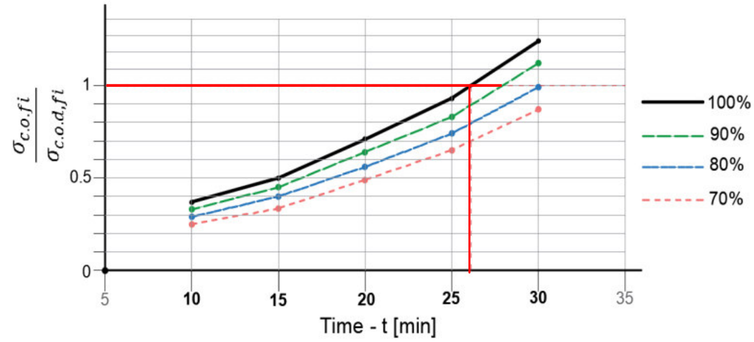

Figure 3 - Fire resistance of centrically loaded timber column with dimensions 16x16 cm, as function of the load ratio, according to the reduced cross section method

Table 3 - Fire resistance of a column by the method of reduced properties

Ratio between the cross section stresses and ultimate stresses $\sigma_{c,0,fi}/\sigma_{c,0,d,fi}=1.0$					
Load ratio	Time of fire exposure - t [min]				
	t=10	t=15	t=20	t=25	t=30
100%	0.39	0.49	0.62	0.82	1.06
90%	0.35	0.44	0.55	0.72	0.89
80%	0.31	0.38	0.49	0.64	0.84
70%	0.27	0.34	0.43	0.56	0.74

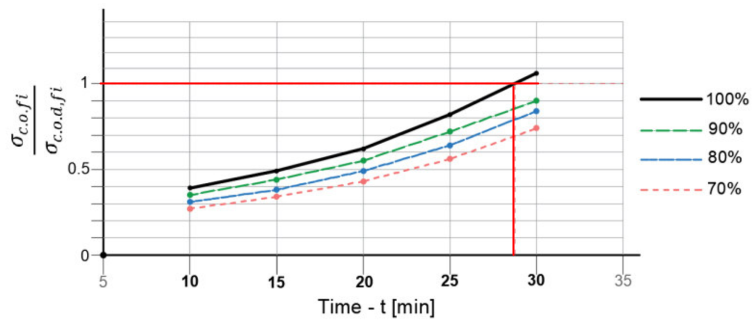

Figure - 4 Fire resistance of centrically loaded timber column with dimensions 16x16 cm, as function of the load ratio, according to the reduced properties method

From Table 3 it can be concluded that with 100% load ratio at ambient temperature, the fire resistance range is between 25 and 30 minutes. For 90%, 80% and 70% utilisation, the fire resistance is over 30 minutes. According to the method of reduced properties the exact time of fire resistance was obtained by constructing a curve, represented by a graph "time - stress ratio", Figure 4.

5. CONCLUSIONS

From the performed fire resistance analyses of the solid timber columns, the following conclusions could be made:

Fire resistance of centrically loaded columns depends on the percentage of utilization of bearing capacity of the cross section at ambient temperature. Reduction of the percentage of utilization increases the fire resistance.

By comparison of the results calculated according to the both methods, it can be concluded that the fire resistance determined by the reduced properties method is greater by 4.7% for 100% utilization of the bearing capacity of the cross-section. The results show that according to the reduced properties method, regardless the variation of the percentage of utilization of the bearing capacity and the variation of all other parameters, the fire resistance is always greater.

According to the obtained results from the performed calculations, the reduced cross-section method could be recommended for determining the fire resistance of columns made of solid timber, as the results are on the side of safety.

The recommendation for further research on fire resistance of timber elements made of solid wood is given in order to obtain more accurate data which of these two methods is more relevant for use in Balkan region.

6. REFERENCES

[1] D5.1 – Report on the needs to achieve improved fire protection as regards the implementation and development of the EN Eurocodes.

[2] EN 1995-1-2, Eurocode 5: Design of timber structures – Part 1-2: General – Structural fire design, November 2004

[3] EN 1995-1-1, Eurocode 5: Design of timber structures – Part 1-1: General – Common rules for buildings, November 2004.

[4] Thelandersson Sven, J. Larsen Hans (2003), Timber Engineering,John Wiley & Sons Ltd.

[5] Porteous Jack, Kermani Abdy, (2007), Structural timber design to Eurocode 5, Blackwell Science Ltd, a Blackwell Publishing company.

[6] Falk Andreas, Dietch Philipp, Schmimd Joachim, (2016), Cross Laminated Timber – A competitive wood product for visionary nad fire safe buildings, COST Proceedings of the joint Conference of Cost Actions, FP1402 & FP1404, KTH.

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AN OVERVIEW OF METHODS FOR ASSESSMENT OF DAMAGED REINFORCED CONCRETE (RC) STRUCTURES

Abstract: This paper presents a review of the methodology for assessing the condition of structures exposed to the environment. The introductory part of the paper gives a methodology for assessing the damage, with the comparison of existing scales of damage to objects. An overview of the assessment of structural construction status is given and more detailed methods of assessment of reinforced concrete structures are presented. At the end of the work, remarks and recommendations for assessing the status of construction structures from the aspect of effective risk assessment are given.

Key words: Structure, Damage, Assessment, Risk

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1. INTRODUCTION

Damage assessment (DA) provides disaster managers with comprehensive, standardized information on the impact of a hazard, which can be used to set priorities and make management for decisions relating to response to a disaster and to the initial steps leading to recovery. Theoretical considerations are given in [3]. DA can be defined as the information-gathering and decision-making process and should be undertaken in any situation in which the life or well being of persons is being threatened by a disaster event. DA enables immediate needs to be identified and analyzed, and thereby saves lives, minimizes injuries, damages and losses. Objectives of DA depend on the type and intensity of the disaster, which can be divided into minor or moderate disasters and major disasters. In case of minor or moderate disasters DA includes estimation of total losses and inputs for develop repair/rehabilitation procedures. In case of major disasters DA assess extent of damage to buildings and other structures (and its geographical distribution). Depending on the time limits, DA can be divided into short-term, medium-term and long-term. Short-Term DA must be realized within a few days and include quickly identification the safe and unsafe buildings, quickly estimation of total damage losses and quickly identification of status of lifeline buildings and other structures. Medium-Term DA must be realized within a few weeks and include assessment of safety status of doubtful category structures and reassessment and quantification of damage losses. Long-Term DA must be realized within a few months to years and include collection of inputs for development of rehabilitation/retrofitting procedures and identication of deficiencies in prevalent technical knowledge and its implementation mechanisms. DA should analyze the effects of the disaster its magnitude and effects on society, the infrastructure and the environment with the purpose of specifying the level and type of assistance required. DA should provide usable information on:

- Area affected;
- Number of people affected;
- Mortality & morbidity;
- Types of injuries & illnesses;
- Characteristics of affected population;
- Medical, water, sanitation, nutrition;
- Damage to homes & commercial buildings;
- Damage to agriculture & food supply system;
- Level of local response & capacities;
- Level of response by NGOs & other agencies.

Primary focus of DA is on condition of physical assets: buildings (Residential, Office, Commercial, Lifeline etc.), roads and bridges, water supply and sanitation structures, dams and other irrigation structures, industrial facilities (including power plants), ports and other coastal structures, electrical and communications system structures. Principles of structural assessment is given in [4].

In the paper is presented a review of the methods for assessing the condition of physical assets.

2. EVALUATION OF DAMAGE

The primary objective of DA is to assess the condition of the structure, but also objectives can be determination of the structural adequacy for actual or proposed loads, or the extent of damage and appropriate repairs.The scope of work should be clearly defined to ensure that the assessment objectives are met. Main steps of DA will be:

- to record the damage and the causes for distress,
- to assess the extent of distress and to estimate the residual strengths of structural components and the system,
- to plan the rehabilitation and retrofitting/strengthening of the building.

Table 1 – Damage scales for buildings

<table>
<tr><th>Damage Level (%)</th><th>HAZUS-99</th><th>FEMA-273</th><th>EMS-98</th><th>ATC-13</th><th>ATC-20</th></tr>
<tr><td>0</td><td colspan="5">No-Damage Limit State (Grade 0)</td></tr>
<tr><td>10</td><td rowspan="4">Slight Damage</td><td rowspan="3">Immediate Occupancy</td><td>Grade 1</td><td>Slight</td><td rowspan="4">Green Tag</td></tr>
<tr><td>20</td><td rowspan="3">Grade 2</td><td rowspan="3">Light</td></tr>
<tr><td>30</td></tr>
<tr><td>40</td><td rowspan="2">Damage Control</td></tr>
<tr><td>50</td><td rowspan="3">Moderate Damage</td><td rowspan="3">Grade 3</td><td rowspan="2">Moderate</td><td rowspan="4">Yellow Tag</td></tr>
<tr><td>60</td><td rowspan="2">Life Safety</td></tr>
<tr><td>70</td><td rowspan="3">Heavy</td></tr>
<tr><td>80</td><td rowspan="3">Extensive Damage</td><td>Limited Safety</td><td rowspan="3">Grade 4</td></tr>
<tr><td>90</td><td>Near Collapse</td><td>Red Tag</td></tr>
<tr><td>100</td><td>Partial Collapse</td><td>Major</td><td></td></tr>
<tr><td></td><td colspan="5">Collapse Limit State (Grade 5)</td></tr>
</table>

Overview of the methods for DA were given in [9].

After collection of informations about the damage and the causes for distress, evaluation of damage is next step, which implies placing the damaged building into damage scales. In table 1 some damage scales for buildings are presented. As can be seen from the table, different scales of damage are applied. HAZUS [1] was the study for policy makers, practitioners, and researchers in the public and private sectors who have roles in assessing risk, in developing strategies for managing risk, and in formulating plans for responding to and recovering from natural disasters, supported by FEMA. Two interrelated parameters are used to categorize the seismic risk:

- Annualized Earthquake Loss (AEL) (the probability of ground motion occurring in the study area, and the consequences of the ground);
- Annualized Earthquake Loss Ratio (represents the AEL as a fraction of the replacement value of the local building inventory).

In FEMA publication 273 [8] levels and ranges of seismic performance are defined. The levels are discrete points on a continuous scale describing the building's expected performance, or alternatively, how much damage, economic loss and disruption may occur.

In EMS-98 [5] damage grades were implemented. Damage grades for RC structures are:

- Grade 1: Negligible to slight damage (no structural damage, slight non-structural damage) Fine cracks in plaster over frame members or in walls at the base. Fine cracks in partitions and infills.
- Grade 2: Moderate damage (slight structural damage, moderate non-structural damage) Cracks in columns and beams of frames and in structural walls. Cracks in partition and infill walls; fall of brittle cladding and plaster. Falling mortar from the joints of wall panels.
- Grade 3: Substantial to heavy damage (moderate structural damage, heavy non-structural damage) Cracks in columns and beam column joints of frames at the base and at joints of coupled walls. Spalling of conrete cover, buckling of reinforced rods. Large cracks in partition and infill walls, failure of individual infill panels.
- Grade 4: Very heavy damage (heavy structural damage, very heavy non-structural damage) Large cracks in structural elements with compression failure of concrete and fracture of rebars; bond failure of beam reinforced bars; tilting of columns. Collapse of a few columns or of a single upper floor.
- Grade 5: Destruction (very heavy structural damage) Collapse of ground floor or parts of buildings.

The ATC-13 damage states were developed as a function of the percentage of replacement cost (damage factor). The damage states and corresponding damage factor ranges were based on inputs from earthquake engineering experts who provided estimates for different classes of facilities.

In ATC-20 the posting system was proposed. The system has evolved over the years that offers a standard method for posting buildings according to the extent of damage they received during an earthquake. The posting system uses three levels of color-coded placards: Inspected – Green, Limited Entry (Restricted Use) – Yellow and Unsafe – Red.The first level is called Inspected rather than safe because the inspection that can be made may be minimal. Inspected means that the building appears to be safe for lawful occupancy and use. Limited Entry (Restricted Use) means that some type of restricted use is appropriate for the building, and that this restricted use is controlled by the building owner or manager. Unsafe means the building is quite damaged. Entry to an unsafe building is not allowed. Any exception for entry is controlled by the building jurisdiction, not the owner or manager.

Some of the methods are used for rapid safety assessment and some for detailed safety assessment. Multiple methods are required to satisfy overlapping objectives. Rapid structural safety assesment for reinforced concrete structure is given in [6].

3. STRUCTURAL CONDITION ASSESSMENT

Structural condition assessments can be divided into two categories:

1. Preliminary assessments
2. Detailed assessments

The assessment methodology will vary depending on the building configuration and physical constraints. The assessment techniques may range from a visual review through non-invasive techniques, to destructive sampling and testing. The preliminary assessment results is based on a visual review and because of that it requires a systematic approach to ensure that all critical areas are addressed and appropriate recommendations are provided. A preliminary assessment report may recommend that a detailed assessment be undertaken. The engineer must clearly state the reasons and timeframe, and indicate the consequences of failing to do so. A detailed assessment may require invasive investigation and extensive engineering work, which could require significant investment by the owner. Consequently, the scope of the detailed assessment should be balanced against the probable risks to the public.

The structure examination is a primary component of a structural condition assessment. It is important that the examination is carried out in a systematic and scientific manner. The purpose is to identify significant structural concerns, including: defects, damage, distress and deterioration. Table 2 gives the list of test methods that could be deployed for detailed RC structure examination.

Table 2 – List of test methods for RC structure

Property under investigation	Corrosion of embedded Steel	Concrete quality, durability and deterioration	Concrete strength	Integrity and Performance
Test	- Half Cell potential - Resistivity - AC Impendance - Cover depth - Carbonation depth - Chloride concentration	- Surface hardness - Ultrasonic velocity - Radiography - Radiometry - Neutron absorption - Relative humidity - Permeability - Absorption - Petrographic - Sulphate content - Expansion - Air Content - Cement content - Abrasion resistance	- Cores - Pull-out - Pull-off - Break-off - Internal fracture - Penetration resistance - Maturity - Temperature - Curing	- Tapping - Pulse-echo - Dynamic response - Acoustic emission - Thermography - Radar - Reinforcement location - Strain measurement - Load test

A number of non-destructive evaluation (NDE) tests for RC members are available to determine in-situ strength and quality of concrete. The term 'non-destructive' is used to indicate that it does not impair the intended performance of the structural member being investigated. The NDE have been classified into two categories, 'in-situ field test' and 'laboratory test'. Depending on the purpose, the tests have been divide into five categories:

1. In-situ Concrete Strength
2. Chemical Attack
3. Corrosion Activity
4. Fire Damage
5. Structural Integrity/Soundness

NDE tests commonly used under each of these categories have been listed out in table 3.

Table 3 – Commonly used NDE tests for RC structure

Test Method	**Details**
1. In-situ Concrete Strength	
Rebound Hammer Test	A qualitative field test method to mesure surface hardness of concrete
Ultrasonic Pulse Velocity	A qualitative field test by measurement of UPV
Windsor Probe	A qualitative field test for assessment of near surface strength of concrete
Pull out test - Core sampling - Lab testing of cores	Field and lab test method for assessing quality of concrete (strength, density, texture, permeability)
Load test	A field test for assessing the load carrying capacity within the limits of elastic deformation
2. Chemical Attack	
Carbonation Test	A field and lab test for assessment of pH of concrete and depth of carbonation
Chloride Test	A field and lab test for assessment of chloride contents
Sulphate Test	A field and lab test for assessment of sulphate contents
3. Corrosion Potential Assessment	
Cover-Meter/Profo-Meter	A field method for measuring thickness of cover concrete, reifnorcement diameter and reinforcement spacing
Half Cell Method	A field method for measuring corrosion potential for assessing probability of corrosion
Resistivity Meter	A field method for assessing electrical resistivity of concrete to determine its corrosion resistance
Permeability - Water - Air	A field and lab method for assessment of in-situ permeability of concrete due to water and air
4. Fire Damage Assessment	
Thermo-Gravimetric Analysis	A lab test for assessment of temperature range to which concrete was subjected to
Differential Thermal Analysis	A lab test for assessment of qualitative and quantitative composition of sample of concrete
X-ray Diffraction	To determine the extent of deterioration in concrete subjected to fire
5. Structural Integrity/Soundness Assessment	
Ultra-sonic Pulse Velocity	A field method for determination of discontinuites, cracks and depth of cracks
Radiography	For details of inside of a concrete member
Impact Echo Test	A field and lab test method to detect hidden damage and its extent

As can be seen from the table above it is necessary to perform a series of tests in order to adequately done assessment of structures. These studies need to be done carefully, because detailed research facility in the field provides key input to the development of a strategy of maintaining facilities and reduced risk for catastrophic events.
Assesment of Fire Damage with NDT and DT techniques is given in [10].

4. CONCLUSIONS

Condition assessment and evaluation of safety of existing structures in disaster prone areas is the most important step in DA procedure. Non Destructive Testing (NDT) plays an important role in condition assessment of existing buildings. From the lists (see tables 2 and 3) can be seen that a whole series of tests are needed to determine the state of the construction, which mean that a great deal of expertise is required for interpretation of field observations and test results to make a proper assessment of the condition as well as for analyzing and evaluating safety.

5. REFERENCES

[1] FEMA 366, HAZUS Estimated Annualized Earthquake Losses for the United States, February 2001.

[2] FEMA 273, *NEHRP Guidelines for the Seismic Rehabilitation of Buildings*, October 1997.

[3] Ed. Grunthal G.: *European Macroseismic Scale 1998 - EMS 98*, Centre Europèen de Géodynamique et de Séismologie, Luxembourg, 1998.

[4] Bai J. W., Hueste M., Gardoni P.: *Probabilistic Assessment of Structural Damage due to Earthquakes for Buildings in Mid-America*, ASCE Journal of Structural Engineering, Vol.135, Issue 10, October 2009.

[5] ATC-20, *Procedures for Postearthquake Safety Evaluation of Buildings*, Applied Technology Council, California, USA, 1989.

[6] Rossetto T. et al.: *Comparison of damage assessment methodologies for different natural hazards*, Conference paper, COST Action C26 International Conference on Urban Habitat Construction Under Catastrophic Events, Naples, Italy, September, 2010.

[7] David G. Elms: *Achieving structural safety: theoretical considerations,* Structural Safety 21 (1999) 311-333.

[8] EPAC, *Rapid structural safety assessment and monitoring for reinforced concrete structure,* June 2003.

[9] Totsawat Daungwilailuk, Thi Nguyen Cao, Withit Pansuk, Phoonsak Pheinsusom, *Evaluating Damaged Concerete Depth in Reinforced Concrete Structures under Different Fie Exposure Times by Menas of NDT and DT Techniques,* Engineerig Journal, Volume 21 Issue 7, 2017.

[10] Dir.u.Prof.Dr.W.Rucker, Dipl.-Ing. F.Hille, Dipl.-Ing. R. Rohrmann, *Guideline for the Assessment of Existing Structures,* SAMCO Final Report 2006.

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FLAMMABILITY OF SELECTED SMALL-SIZE WOOD SAMPLES

Abstract: This paper describes the flammability of selected tropical wood, specifically Ipe wood. Data required for analysis are outputs of laboratory tested small wood samples. Experimental equipment was non-standardized laboratory equipment using a flame source of higher intensity (flame burner - propane-butane) affecting the test sample in an open environment The above-mentioned laboratory outputs are presented by numerous clear graphs. Statistical analysis of dependence of important parameters and use of an appropriate analytical method reveals important parameters in assessing the flammability of the test small-size sample.

Key words: tropical wood, small-size samples, laboratory testing, flammability, analyze of mutual relations

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1. INTRODUCTION

The use of tropical woods as tiling of building constructions is rapidly on its rise as far as interior and exterior spaces are concerned. The demand for foreign materials is mainly related to their colour design which is significantly different from the domestic one.

In addition to their appearance, the woody plants growing in the tropical climatic zone have a different structure through which they obtain better physical and mechanical properties [1]. It is necessary to mention the high contents of lignin in them which reduces their total flammability [2].

This report explores the flammability of the selected tropical wood. The conclusions are based on data measured by laboratory tests of small test samples.

2. LABORATORY TESTING

The samples used in the laboratory test were made from tropical Ipe wood. This woody plant originating from South America is characterized by its exceptional stability and hardness. When the wood is swelling and shrivelling only very small volume changes occur. This wood is predominantly fine-grained with a soft gloss [3].

From the above mentioned type of wood 10 samples of tangential section of 100x50x20 mm were made with no wood knots or damage on them. These samples were tested on a device consisting of a weighing machine, a sample holder, a Bunsen burner holder, a burner connected to propane-butane bomb and a computing technique (Figure1).

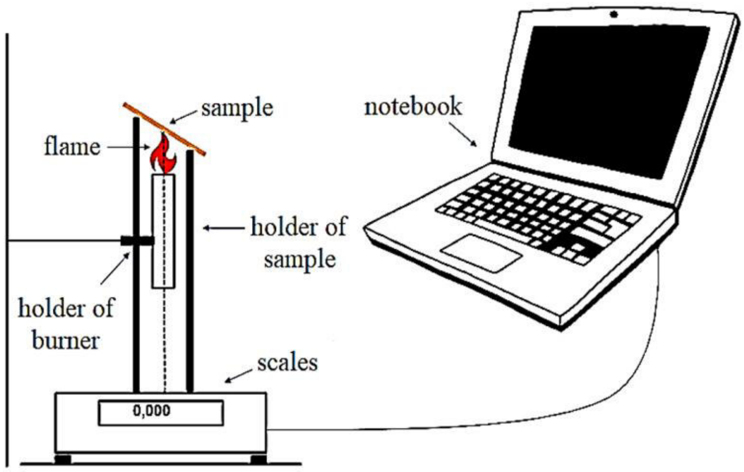

Figure 1 – Scheme of the laboratory equipment

Each sample was tested with the same method for the time of 10 minutes. During this time, every 15 seconds the weight loss was recorded which was caused by continuous stress caused by the burning flame sample from the burner.

2.1. Processing results

The weights recorded during the test were adjusted to a relative burn rate v_r coming from the relative weight loss δ_{mr} using relevant mathematical relations. The resulting mean values are presented in the graph in Figure 2.

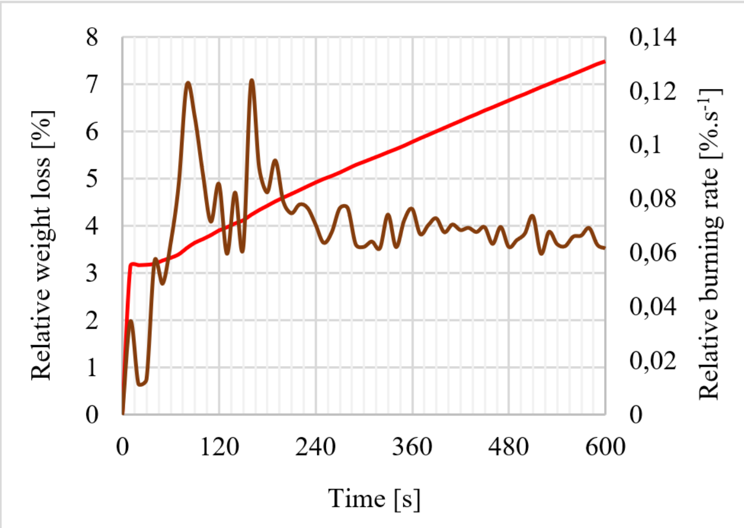

Figure 2 – Average values v_r and δ_{mr}

In the graph it can be seen that on average the relative weight loss reached the value of about 5.34% which does not represent a significant amount of material burned.

The samples were burning with the average loss of mass of 0.07 $\%.s^{-1}$. A significant increase in burning rate was observed by each sample at the beginning of the 60^{th} second which then either dropped and reappeared again around the 150^{th} second or continued burning oscillating around the above mentioned average speed.

2.2. Measurement of mutual relations

In ordinal variables an analysis of the dependence on the principle of their comparison among the units in the file was performed. Out of number of methods we selected the Spearman correlation, i.e. a correlation coefficient that is based on a sequence of variables and can also be applied to data that are not distributed normally and is not sensitive to extreme values either. In case of indirect dependency, the coefficient is between -1 and 0 and in case of direct dependency between 0 and 1.

The first step in detecting dependence was the determination of hypotheses. In our case, for the zero H0 and the alternative H1 hypothesis the following was true:

- H0 - The fluctuation in weight loss of the Ipe wood sample depends only on its relative rate of burning.
- H1 - The fluctuation in weight loss of the Ipe wood sample does not depend only on its relative rate of burning.

The determination of normality of the file followed. For its verification the Kolmogorov-Smirnov test was used. The test results are interpreted in Figure 3 [4].

One-Sample Kolmogorov-Smirnov Test

		v_r	δ_{mr}
N		41	41
Normal Parameters	Mean	,05	,99
	Std. Deviation	,01	,58
Most Extreme Differences	Absolute	,26	,07
	Positive	,26	,07
	Negative	-,25	-,07
Kolmogorov-Smirnov Z		1,69	,46
Asymp. Sig. (2-tailed)		,004	,982

Figure 3 - Verifying the normality of the distribution of values

In this table the significance level found in the last line is important. If the value is less than 0.05, the results are not normally distributed. For the relative rate of burning this statement is true, whereas for relative weight loss, it is not. Based on the test results we found that the data are not distributed normally, although the rule only applies to one of the parameters. That is why we used Kenall's tau (Figure 4) [4].

Symmetric measures.

Category	Statistic	Value	Asymp. Std. Error	Approx. T	Approx. Sig.
Ordinal by Ordinal	Kendall's tau-b	,36	,15	2,42	
	Kendall's tau-c	,35	,14	2,42	
	Spearman Correlation	,39	,18	2,63	
Interval by Interval	Pearson's R	,24	,23	1,56	
N of Valid Cases		41			

Directional measures.

Category	Statistic	Type	Value	Asymp. Std. Error	Approx. T	Approx. Sig.
Nominal by Interval	Eta	v_r	1,00			.
		δ_{mr}	,68			.

Figure 4 - The resulting values of Kenall´s tau

The result is presented by two tables. In the first one, Kenall's test gives us the outputs of different statistical methods whose values differ more or less from one another which is due to the fact that each method uses a different relation of calculation. Therefore, the lowest value selection rule is used for the resulting evaluation. Since the values are not high, i.e. they are closer to 0 than to 1 the correlation of the parameters exists, but is not very strong [4].

However, if we consider the dependence of weight loss on the rate of burning in general, then the value of the coefficient Eta = 0.68. The second table shows a relatively strong correlation. After its raising to the power of two and conversion to % we can say that 46.24% of variability from δ_{mr} depends on v_r.

In the H1 hypothesis we argued that the fluctuation in the weight loss of the Ipe wood sample does not depend only on its relative rate of burning which we confirmed. Therefore, the H1 hypothesis is accepted and the H0 hypothesis is rejected.

3. CONCLUSION

Laboratory test results indicate the low flammability of the tropical Ipe wood when exposed to an open flame for the time of ten minutes. This claim is based on the recalculated weight loss δ_m and its subsequent relative rate of burning v_r.

Since the measured and recalculated values were so-called ordinal variables the dependence analysis was performed which resulted in confirmation of the H1 hypothesis. It claims that the fluctuation in the weight loss of the Ipe wood sample does not depend exclusively on its relative rate of burning (since only 46.24% of variability depends on it).

Acknowledgments

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4. REFERENCES

[1] OLORUNNISOLA, Abel O. Design of Structural Elements with Tropical Hardwoods [online]. Cham: Springer International Publishing, 2018 [cit. 2018-02-07]. ISBN 978-3-319-65342-6. Available on: doi:10.1007/978-3-319-65343-3.

[2] DE FREITAS ROCHA, Monique Amaro a Alexandre LANDESMANN. Combustion properties of Brazilian natural wood species: PROPERTIES OF BRAZILIAN NATURAL WOOD SPECIES. Fire and Materials [online]. 2016, p. 219–228. ISSN 03080501. Available on: doi:10.1002/fam.2281.

[3] OLORUNNISOLA, Abel O. Anatomy and Physical Properties of Tropical Woods. In: Design of Structural Elements with Tropical Hardwoods [online]. Cham: Springer International Publishing, 2018 [cit. 2018-02-05], p. 7–29. ISBN 978-3-319-65342-6. Available on: doi:10.1007/978-3-319-65343-3_2.

[4] Meranie vzájomných vzťahov u ordinálnych premenných. Štatistika v PSPP [online]. 7. February 2017 [cit. 2018-02-15]. Available on: http://statistikapspp.sk/meranie-vzajomnych-vztahov-ordinalnych-premennych/.

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MAPPING OF FIRES IN MULTI-STOREY BUILDINGS IN NOVI SAD AND THEIR CLUSTER ANALYSIS

Abstract: The Paper presents the research results on fires in residential buildings based on statistical data. The measures of safety efficiency for residents and other occupants and possibilities of efficient intervention of fire rescue teams were made in accordance with this information.

Key words: fire, residential building, mapping, cluster analysis

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1. INTRODUCTION

Fires are a constant hazard in all environments. Apart from causing material damage, each fire endangers the health and sometimes the lives of people, which is the reason why fire protection is a common problem or an activity of special social importance for all communities. Today, most fires occur in residential buildings, which is understandable considering the number of these buildings, and the fact that people spend most of their time in their apartments, where they use various sources of heat. Those heat sources are often the cause of fires, accompanied by human negligence. The danger of fires in residential buildings increases in cases when the buildings are not used only for residential purposes, but for various business activities, such as: trade, hospitality and craft activities and others. A lack of construction land led to the construction of multi storey buildings, but also to the problem pertaining to the implementation of fire protection measures. According to the available statistical data, one third of all fires occurs in residential buildings. In terms of fire protection - a "high-rise building" (which must meet certain additional criteria) is any building where the floors of the highest storey are at least 30 m above ground level (compared to the previous height of 22 m). The Rule Book on the Amendments of the Rule Book on Technical Standards for the Protection of High-rise Buildings from Fire ("Official Journal of SFRY", no. 7/84) [1] was published in the "Official Gazette of RS", no. 86/2011, according to which the building height referred to by the regulations in the Rule Book was changed (increased). Extinguishing fires in high-rise buildings poses a great problem, due to malfunctions of the hydrant line and the inaccessibility of the surrounding terrain. Overcoming vertical distances is another difficulty. According to the information from the Ministry of Interior, the frequency of occurrence and the material damage caused by fires in high-rise buildings reached a concerningly high level, with a tendency of growth trend in the recent years. Implementation of preventive construction measures, which are manifested by the choice of construction location and construction materials, have significantly increased fire safety. Any oversights made in this phase will be hard to correct later on. Statistical data is used to realistically perceive fire hazards. Statistical information about fires, their consequences and causes can be collected from several sources, from the fire fighting services, insurance companies, medical statistics, police reports.

The goal of this paper is to analyze the most frequent locations and sources of fires based on the statistical data for 2015. The analysis was performed on multi-storey buildings in Novi Sad. Determination of the location of fire outbreaks was performed to provide recommendations for prevention of the spreading of fires.

2. MULTI-STOREY RESIDENTIAL BUILDINGS IN NOVI SAD

Construction of multi-storey buildings in Novi Sad began in the early 1960s. The aesthetics of residential skyscrapers of the 1960s was similar to that of the capital (Belgrade) school of architecture, with terraces and deep set balconies (loggias) in standard construction practice and construction materials used in those times. According to designs of the urban spatial plans, high-rises were built at good quality and beautiful city locations, on corners of busy streets or even on new squares. High-rises built in the beginning of this century offer outstanding building sections with partition walls made of panels that can withstand a fire for at least two hours on each floor, external mortar and decoration, steel components encased in concrete, external walls connected to every floor, floors constructed from reinforced concrete, external windows which can be opened regularly, and without central air management or without the air (purification) circulation system. Buildings erected in the period after 1960 were constructed without partitions (separate sections), with construction steel protection usually being protected by the spraying of fire-resistant materials, the external wall is the partition wall constructed of glass or metal (this partition wall is external, separated by 15 or 30 cm, which is the requirement for fire-resistant materials) (Fig. 1).

Tower blocks at Cara Lazara Boulevard

Tower blocks at the maternity ward in Branimira Ćosića street

Towers in Veljka Petrovića Street

Tower blocks at Jovana Dučića Boulevard

Tower blocks on Balzakova Street

Tower blocks on Šekspirova Street

Figure 1 - Multi-storey residential buildings in Novi Sad

High demand for space (schools, hospitals, etc.), which was traditionally designed longitudinally, was not an adequate solution for business premises. It was replaced by buildings designed for their height which were at the same time more convenient for the internal management of the working space. The required fire protection measures were not taken into during the construction of these buildings. Apart from the installation of hydrants, panic lighting and possibly fire extinguishers, no other measures were implamented. A small number of buildings has an adequate fire staircase which is not maintained and does not serve the required function. Unfortunately, this is also the practice today. According to the Law on Fire Protection ("Official of the Gazette RS", no. 111/2009 and 20/2015) [2], prevention in terms of fire protection is stipulated and ensured by planning and implementation of prevention measures and actions designed to efficiently prevent outbreaks of fires, and to, in case of fires breaking out, minimize the risk on human life and health, as well damage to material goods, and to contain the fire on the place of its outbreak [3].

3. STATISTICAL INFORMATION ON FIRES IN MULTI-STOREY BUILDINGS FOR 2015

3.1. Multi-storey residential buildings in Novi Sad

According to the 2012 Census, there are 341,625 residents in the administrative territory of Novi Sad, while the town itself has a population of 231,798 residents. A continuous influx of people in the beginning of the 1960s, accompanied by high demand for residential space, led to the emergence of buildings which could be defined as skyscrapers. Today, the same trend is continuing. This is the reason why neighborhoods designed for individual housing in family houses are replaced by multi-storey residential buildings. Previous research has found that 61 multi-storey buildings were erected. However, according to new research, this number changed and amounts to 173 buildings with the number of floors ranging from seven to fourteen floors, the buildings from the previous research were not included [4].

3.2. Fires in multi-storey buildings in Novi Sad in 2015

Most fires in multi-storey residential buildings (94.5%) in Novi Sad occurred in buildings intended for residences rather than residential-commercial (0.5%) and commercial buildings (4%). The reason for this is that in residential-commercial and commercial buildings, fire prevention measures are implemented and they are subject to regular inspections, making the risk of fires in those buildings significantly lower. Based on the registry of the Novi Sad Firefighting Service, an overview was compiled of the number of fires in the south Bačka region for 2015. The number of interventions of firefighting teams is shown in Fig. 2 according to individual months. As seen on Fig. 2, the number of fires varies depending on the month. In comparison with the total number of fires in residential buildings, the largest number of fires in Novi Sad occurred in December (36.6%), while the least number of fires occurred in April (8.1%) [4].

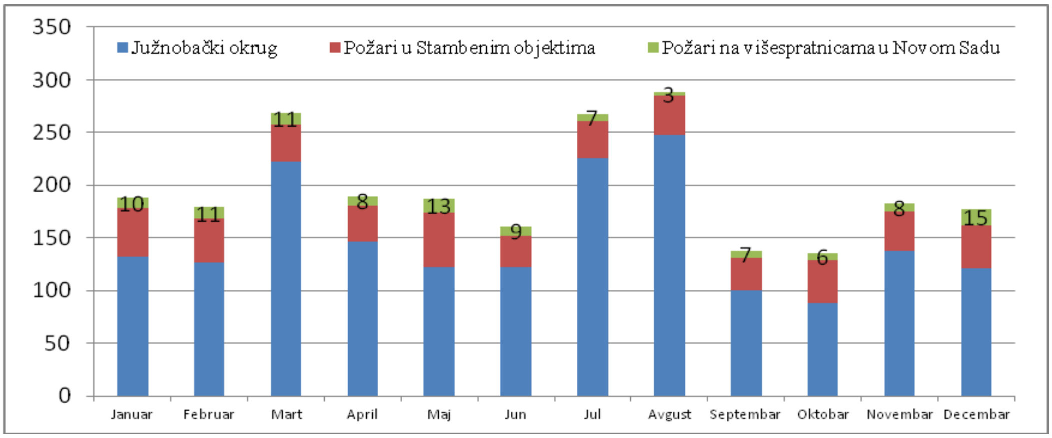


Figure 2 - The number of interventions of firefighting teams in 2015

/South Bačka region – Fires in residential buildings – Fires in multi-storey buildings/

Locations of fires in Novi Sad in 2015 are shown in Fig. 3.

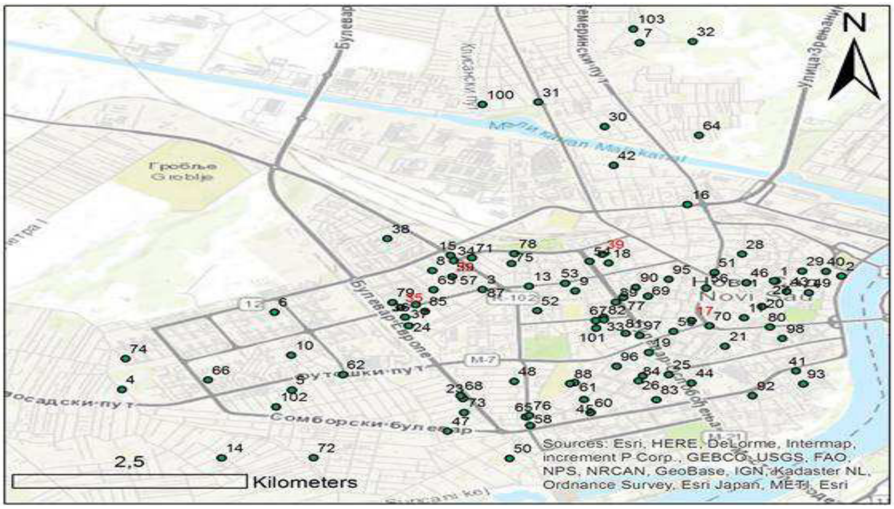
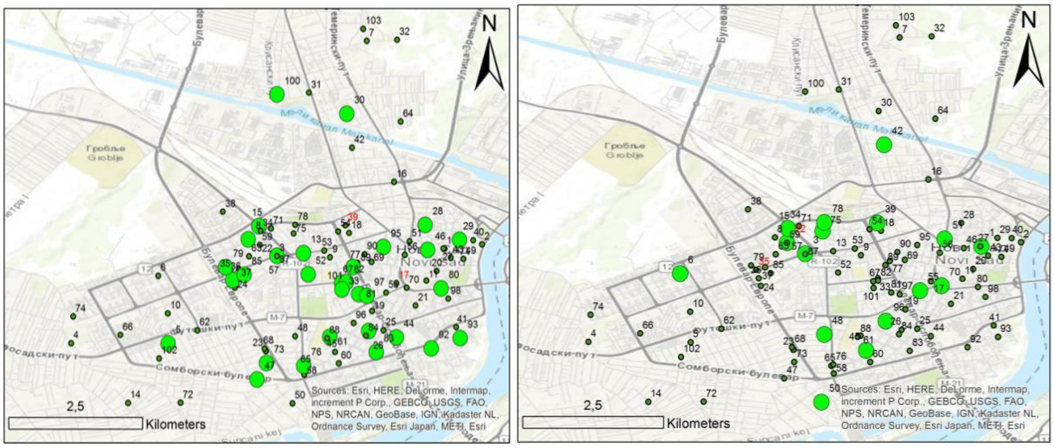


Figure 3 - Number of fires in Novi Sad in 2015

Some of the more important causes of fires include electrical installations, kitchen fires, malfunctioning fuses, fires on electrical appliances, fires in the room, etc. The locations for fires change depending on the month, but it is interesting to note that in March, there was a noticeable grouping of fires in the city centre, while in November and December, fires occured in the vicinity of the Bulevar Oslobođenja.

The most common outbrakes of fires in residential buildings in the territory of Novi Sad occurred due to faulty electrical installations, fuses and electrical appliances, as well as kitchen fires (Fig. 4).



a. Electrical installations b. Kitchens

Figure 4 - Cause of fires in buildings

Fig. 5 shows locations of fires in 2015 according to the number of floors. As can be seen from the Fig. 5, the most frequent location for outbreaks of fires is the ground floor, as high as 43.4%.

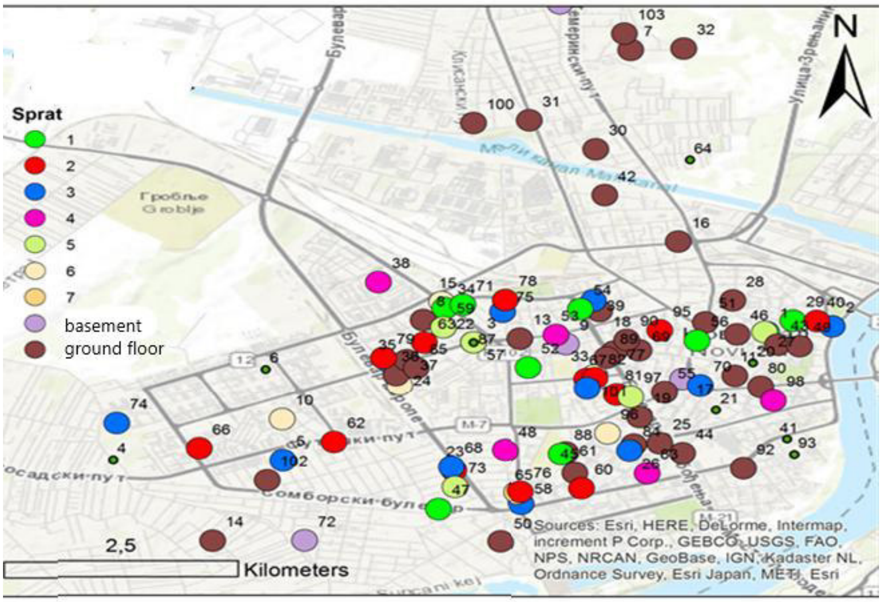


Figure 5 - Locations of fires according to the number of floors in buildings in 2015

4. CLUSTER ANALYSIS

Cluster analysis is a method of multivariant analysis used for grouping of variables into groups (clusters) [5] [6]. Cluster analysis can be treated as method for data reduction. Causes of fires are grouped into 6 groups of variables (ventilation, chimney, rooms, kitchen, business venue and electrical installations and appliances. A data matrix which includes the occurrence of variables on 132 locations according to months in 2015 was done. Cluster analysis was performed according to the Ward method, by using the SPSS 20 program on the observed sample of 72 elements by hierarchical cluster analysis. The method is based on the Euclidean squared distance as a measure of closeness. There are two branches on the dendrogram (Fig. 6.). One connects ventilation, chimney and fires in rooms, while the other connects fires in kitchens, bussines venue and electrical installations and appliances, which may point to their mutual cause.

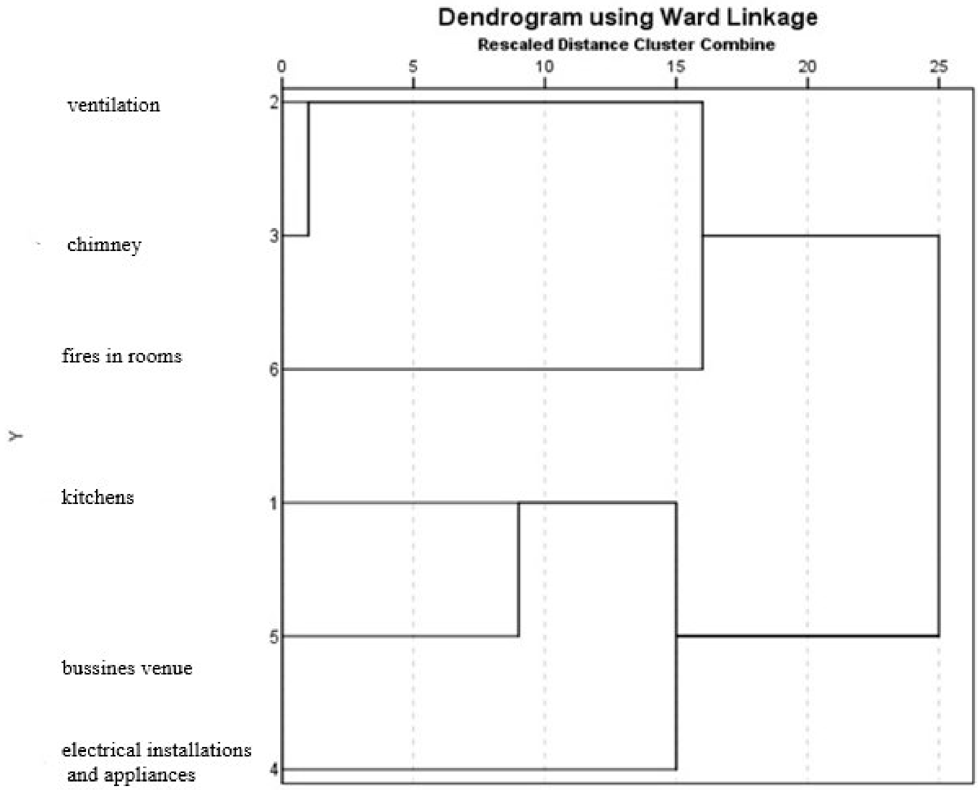


Figure 6 - Hierarchical dendrogram of the number of fires in 2015 according to the location of the fire

5. CONCLUSION

Multi-storey residential buildings do not belong to any category of fire risk, which leaves the entire responsibility for fire safety on the residents of the building or the president of the tenants' association. Neglecting fire protection prevention measures leads to a greater problem during fire extinguishing in high-rise residential buildings. Certain buildings in Novi Sad are higher than 30 meters and belong to the category of high-rise buildings. Buildings do not have adequate fire protection and their construction is not in line with the technical recommendations. Access roads and plateaus for fire trucks were not designed or constructed, and even if they were, they are occupied by parked vehicles. The emergency fire staircase does not exist on most of the residential buildings, and even if does exist, it is no longer reliable due to poor maintenance and does not fulfill its safety function. Based on the collected data for 2015 it can be seen that most of the fires in multi-storey residential buildings in Novi Sad occurred in buildings intended for residences in comparison to residential-commercial and commercial buildings. The reason for this is that in residential-commercial and commercial buildings, fire prevention measures are implemented and they are subject to regular inspections. According to the location of fires in multi-storey buildings, most of the fires occurred at the ground floor, followed by the roof or the attic, as well as between the first and fourth floors. Most of the fires started in the kitchen and bathroom, because most of the appliances are there. The second most frequent location for fires in apartments is the hallway, as most of the fuses are located there and they are often the cause of the fire.

To increase safety of fire outbreaks in multi-storey buildings, the existing legal regulations need to be alligned with the European Union regulations and all standards, measures and norms need to be implemented. Also, it is necessary to perform education of the population by educating children in schools, by engaging the president of the tenants' association and by active participation of all tenants during the performance of fire drills of the firefighting brigade in Novi Sad.

6. REFERENCES

[1] The Rule Book on the Amendments of the Rule Book on Technical Standards for the Protection of High-rise Buildings from Fire ("Official Journal of SFRY", no. 7/84)

[2] Law on Fire Protection ("Official of the Gazette RS", no. 111/2009 and 20/2015)

[3] Mirjana Laban, Verica Milanko: Fire safety assessment of high-rise residential towers, Proceedings, 1st Internacional Conference of Fire and Explosion Protection, 2008.

[4] Robert Varadi: Istraživanje požara na stambenim objektima na osnovu statističkih podataka, Završni rad, Visoka tehnička škola strukovnih studija u Novom Sadu, 2016.

[5] Kovačić Z.: Multivarijaciona analiza, Ekonomski fakultet Univerziteta u Beogradu, 1994.

[6] Pecina M.: Metode multivarijatne analiza-osnove, Sveučilište u Zagrebu, Agronomski fakutet, Zagreb, 2006.

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APPLICATION OF LWAC BASED ON EPS

Abstract: The low density of lightweight aggregate concrete resulting in high thermal insulation of buildings. Construction systems and thermal insulation of applied materials must meet the conditions such as durability and resistance to fire. The fire resistance of the objects depends on the overall constructive solution of the applied thermal insulation system. This paper gives analyses of the application of different thermal insulation systems based on expanded polystyrene (EPS), in first row analyzing their behavior under the fire load. Paper presents comparison with standard building systems and thermal insulation of objects, taking into consideration thermo-physical and mechanical properties of materials.

Key words: lightweight aggregate concrete, thermal insulation systems, expanded polystyrene, fire load, thermo-physical properties, mechanical properties

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1. INTRODUCTION

It is well-known that there is a contradiction between structural elements of bearing capacity on one side, and thermal insulation ability of material on the other side. Bearing capacity demands higher density of the material, and higher density implies lesser thermal insulation ability. To achieve a balance and an optimal ratio between mechanical and thermo-insulation characteristics of the building materials is still a challenge in today's building industry.

The change in concrete design due to high temperature depends on the type of applied aggregate used. Lightweight aggregate concrete has good insulating properties, and transmits heat at a slower rate than normal weight concrete with the same thickness, and therefore generally provides increased fire resistance [2]. Expanded polystyrene (EPS) was firstly used as an aggregate for concrete in 1957 [8].

In period from fifty years of the last century, a various number of lightweight aggregate concrete based on expanded polystyrene grains and basic concrete elements, cement and water, with addition of special patented chemical admixtures (retarding admixtures, accelerating admixtures, superplasticizers, high range water-reducers, air-entraining admixtures) is developed and available under different commercial names with wide range of application in buildings [10,11]. In this paper will be discussed one of them, known as Simprolit system. Simprolit system among other elements, developed thermal insulation plates of various thicknesses that have been used in Serbia and Russian Federation for insulation of buildings [1].

Insulation materials are the key tool in designing and constructing an energy sustainable buildings. They all have almost similar performance in their insulation capability, but what distinguish them from each other are their abilities, such as fire or frost resistance, steam permeability or mechanical strength.

This paper therefore presents an importance of the thermal insulation material selection in complete building system, comparing almost new thermal insulation material with the most commonly used thermal insulation materials such as mineral wool and EPS - Styrofoam. In the first row will be presented their behavior under the fire load.

2. BUILDING SISTEM AS FIRE RESISTIVE

Construction systems and thermal insulation of materials must meet the conditions such as durability and resistance to fire [15]. The fire resistance can be defined as the ability of structural elements to withstand fire or to give protection from it. This includes the ability to confine a fire or to continue to perform a given structural function, or both [3].

The fire resistance of the objects depends on the following states:

- the overall constructive solution of the applied thermal insulation system,
- the strength and bearing capacity of the base material from which building is being built,
- the way elements are attached to the object, such as screws, anchors, construction adhesives, cantilever retaining elements and ventilated façade,
- the characteristics of materials for the inner binding components as adhesive composite fibers, as well as the materials applied for the demineralization of components such as phenol and polymers, layers for insulation [14,15]
- the thickness of the selected thermal insulation material.

For example, when tested according to the procedures, concrete structural elements based on EPS have demonstrated greater fire endurance periods than equal equivalent-thickness members made from ordinary aggregate. Superior performance is due to a combination of lower thermal conductivity (lower temperature rise on unexposed surfaces), lower coefficient of thermal expansion (lower forces developed under restraint), and the inherent thermal stability developed by aggregates that have already been exposed to temperatures greater than 1100°C during pyroprocessing [2].

The thermal insulation materials must fulfill a number of strict requirements including:

- low density,
- humidity resistance,
- good steam permeability,
- fireproofing,
- frost resistance,
- non-toxic,
- acceptable costs [7,9].

3. COMPARISON OF DIFFERENT THERMAL INSULATION MATERIALS

3.1. Simprolit as thermal insulation material

Simprolit is patented mixture of expanded polystyrene granules, Portland cement, water and patented admixtures. The technology of Simprolit polystyrene concrete production has been designed in the following manner: during preparation phase the Styrofoam balls are coated with a complex of admixtures – creating airtight and watertight membranes around these balls; after that, the special organic admixtures essential for good bonding between inert Styrofoam balls and cement are added; at the end, cement, water and other admixtures are added in order to regulate the designed properties of material [15]. This technology provides that Styrofoam granules have no contact with air, thus eliminating all poor characteristics of expanded or extruded polystyrenes (Styrofoam and Styrodur). Namely, these materials have a tendency to lose their compactness when exposed to air for a long period of time. In order to prove the above stated facts, the samples of Simprolit polystyrene concrete were taken from licensed producers in Moscow and tested at the Moscow State Center for Sanitary-epidemiological Supervision. The procedures of above described processes for result declared a non-flammable and a light-building material with an optimal ratio between mechanical characteristics and thermal conductivity [15,16].

3.2. The behavior of different thermal insulation materials under the fire load

Expanded polystyrene is developed in 40th years of the last century (Dow Chemical Company), known under the name „Styrofoam“. Thermo-insulated characteristics of this material, combined with hermetic cellular structure, have led to the application of material as a real thermal insulation material. The most commonly used thermal insulations systems nowadays are plates of expanded (Styrofoam) and extruded (Styrodur) polystyrenes.

Compulsive and self/extinguishing polystyrene burn in the presence of the fire, with the difference that self-extinguishing polystyrene extinguish itself off after the disappearance of ignition sources, but combustible continue to burn after removal of fire source. As testing results in IMS Belgrade showed, the horizontal burning rate for the most commonly used polystyrene is 6.4 mm/s and 25 m/h [15]. Vertically installed polystyrene burns in rate of 4-10 times higher than horizontal burning rate due to fact that burned Styrofoam falls into focus of flame, increasing the effect and speed of burning also by its own burning temperature. As example, it is demonstrated that time of combustion of pure Styrofoam from the first to the 10th floor takes about 25 minutes [1,10,15].

The plates of Styrofoam and Styrodur are stick and anchored to facade and through the plastic mesh, applied is decorative coating. The main disadvantage of such systems of thermo insulation, from the perspective of the fire hazard, is their potential ability to contribute to the propagation or spread themselves fire on the object facade – in the case that flame of fire come out of the facade which is the most common case. When subjected to the temperature higher than 80°C Styrofoam starts to dry out and evaporate. At the same temperature, there is usually crack appearance between the Styrofoam plates, i.e. in the area of mineral wool fireproofing joints [4,15].

Due to thermal effect of the flame on this insulation systems occurs polystyrene thermo-destructions, with separation of flammable gasses. Part of those gasses penetrating through the layer of decorative protective plaster, falls into the center of the flame and burns which effect on increasing of the flame intensity and its height. At the same time, it contributes to the reduction of time to the destruction of the glazed surface of the floor above, and the fire spread on current and floor above. In parallel, there is a destruction of decorative-protective plaster which fall off from the relatively large surface areas of thermo-insulated systems, which in terms of time free access of oxygen from the air, lead to rapid combustion of polystyrene plates with high temperature release – with all the further consequences [4,5].

Mineral wool has quite good thermal insulation properties and resistance to fire, comparing to the Styrofoam, and is declared as a non-flammable material with a flammable class A2-s1, d0 (Table1).

Through the researches it is demonstrated that Simprolit do not burn due to specific chemical process. Polystyrene granules coated with special admixtures and cement vaporize under high temperatures, leaving only concrete „truss“ which in prolonged fire load becomes porous cement stone with no smoke or flame appearing – keeping almost all of its physical and thermo-technical characteristics [14]. For example, as a result of the interrogation of fire resistance conducted in Serbia and the Russian Federation a single-layer Simprolit plates thickness 8 and 10 cm are resistant to fire more than 2 hours on the temperature of 1180°C (EI120) according to the standard SRPS U.J1.090 and general conditions regarding SRPS ISO 834 [6].

Table 1 – Comparison of the fire resistance characteristics of different thermal insulation materials

Thermal insulation material	Flammability class	Maximum temperature value [°C]
Expanded polystyrene (EPS - *Styrofoam*)	B-s2,d0	85
Extruded polystyrene (XPS - *Styrodur*)	B-s1,d0	75
Mineral wool	A2-s1,d0	700
Thermo insulated Simprolit plates	A2-s1,d0	1180

From the table 1 it is clear that there is a difference in the contribution to the fire load from the various insulation materials if compared at an equal insulation value. The fire load is often one of the criteria in regulation and must be calculated at the design stage.

3.3. Other thermal insulation material characteristics

Simprolit thermal insulation plates have greater mechanical strength, at a load of over 3,500 kg/m^2 with deflection less than a millimeter, while the strength of the hard-pressed mineral wool is defined in its strain of 10% [10]. Between the other analog materials, it is obvious that Simprolit thermo insulated plates have no match when it comes to mechanical parameters (Table 2). Figure 1 presents the compressive strength of different thermal insulation materials considering their density.

While mineral wool, for example, with just 1% humidity increment, loses almost 20% of its thermal insulation ability, what cause a significant decrease of its thermo insulation characteristics, Simprolit is hydrophobic material with practically constant calculated humidity percentage from 4% (in environment with normal humidity) to 8% (in environment with air up to 99%). In the dry state, in the laboratory, in relation to the hard-pressed mineral wool, Simprolit thermal insulation plate has thermal conductivity coefficient value 0,042 W/mK, while mineral wool has 0,035 W/mK.

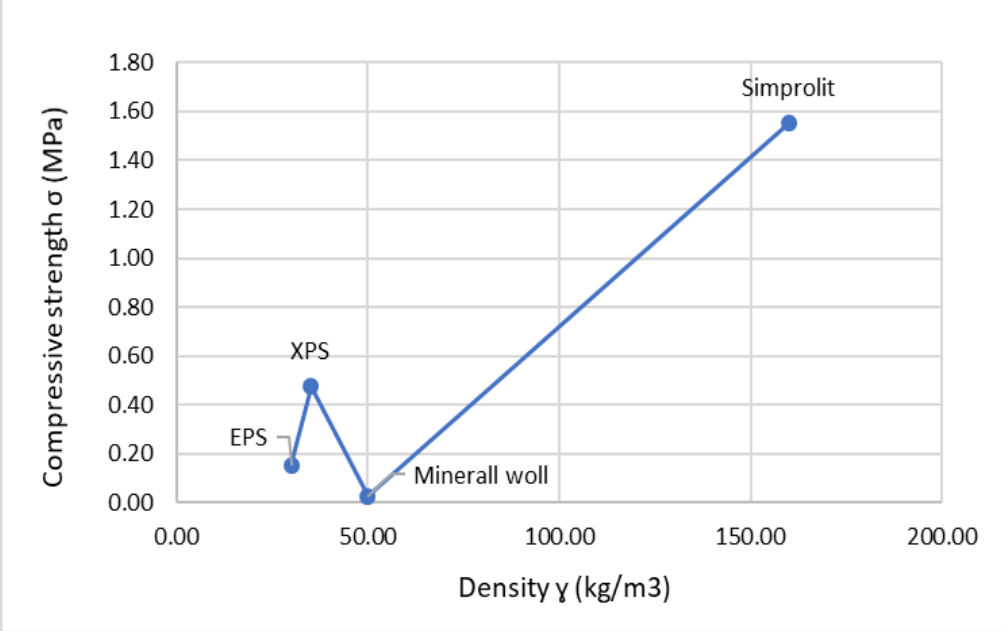

Figure 1 – Compresive strength considering to density of analyzed materials

Other common thermal insulation materials such Styrofoam and Styrodur have slightly better thermal conductivity. In the figure 2 is presented by diagram the value of thermal conductivity coefficient of those materials considering their density.

Thermal insulation Simprolit plates have composition and properties of main ingredients (expanded polystyrene granules, cement, admixtures and water) almost identical to the system for building insulation made of polystyrene (Styrofoam), so by their combining, homogeneous surface system without danger of cracks on the connections of different materials (polystyrene and mineral wool), can be achieved [12,15].

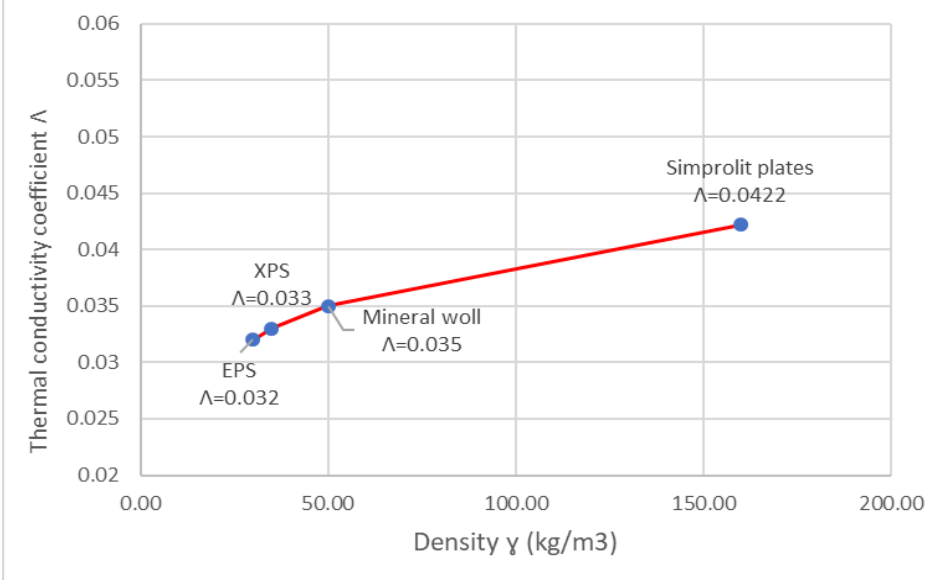

Figure 2 – Value of thermal conductivity coefficient considering to the material density

Based on the research of the thermo-insulating properties of the Simprolit plates, an account of balanced conditions of moisture distribution thought the insulated building layers is achieved. In that way, it is often said that walls insulated by Simprolit plates can „breathe“ with the value of steam permeability of between 0,110-0,135 mg/m·h·Pa [10]. On the other side, thermal insulation systems using mineral wool or Styrofoam are based on application of polymer-cement, which is a material with a high coefficient of steam-permeability resistance. As a result, a large amount of steam remains inside the thermal insulation layer.

Table 2 – Comparison of the thermal-insulation and mechanical characteristics of different thermal insulation materials

Thermal insulation material	**Density γ [kg/m³]**	**Thermal conductivity coefficient Λ [W/mK]**	**Steam permeability factor μ [-]**	**Specific heat capacity c [J/kgK]**	**Compressive strength σ [MPa]**
Expanded polystyrene (EPS - *Styrofoam*)	10-30	0,028 - 0,040	20 - 100	1500	0,060 - 0,250
Extruded polystyrene (XPS - *Styrodur*)	25-45	0,025 - 0,035	80 - 200	1280	0,250 – 0,700
Mineral wool	30-200	0,035 – 0,041	≥ 1,1	840	0,003 – 0,050
Thermo insulated Simprolit plates	160	0,0422	3,3361	1060	0,21 - 1,1

According to the research from the Institute for materials and structures – Faculty of Civil engineering in Belgrade, Simprolit plates at 50-cycle freeze-thaw test (from +15°C to - 20°C), loss a strength varies from 1,5% - 1,8%, what presents an improvement in relation to ability of frost resistance of commonly used thermal insulation materials such mineral wool and Styrofoam [9].

Above discussed characteristics of analyzed thermal insulation materials such as heat passing resistance, frost resistance, compressive strength and durability are presented by diagrams in figure 3.

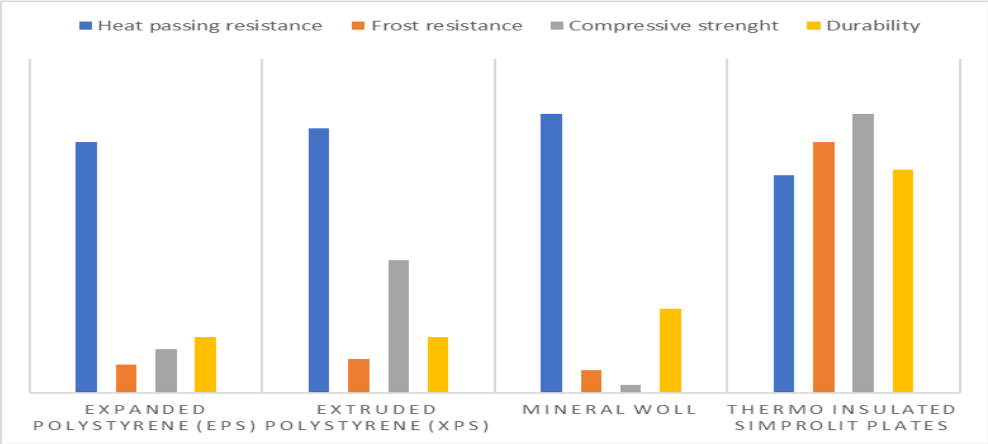

Figure 3 – Graphic overview of the thermal insulation properties of the analyzed materials

4. CONCLUSION

Systems and materials used for thermal insulation of buildings, in addition to its primary function of thermal insulator, must fulfill a whole spectrum of physics' requirements, such as durability, fire resistance and resistance to extreme climate conditions. Based on numerous of laboratory tests and their results, it can be concluded that they all feature similar performance in terms of insulating capabilities, but are significant different in their behavior to fire and moisture or mechanical properties. Taking into account above figures according to the conditions for fire resistive building systems and experimental results of testing of thermal insulation materials, the following observations can be concluded:

- Fire resistance of thermo-insulated objects depends not only on the degree of flammability of the applied materials for insulation, but primarily on the construction system of applied thermal insulation system in general;
- Polystyrene used as lightweight aggregate with special admixtures (commercially known as Simprolit) as structural material in thermo insulation of objects fulfils the required conditions - both from the aspects of bearing capacity and civil engineering physics (λ =0,0422 W/mK while compressive strength reach the value to 1,1 MPa);
- In comparison to most commonly used thermal insulation materials (mineral wool, Styrofoam, etc.), Simprolit thermal insulation plates are characterized by higher density, slightly higher thermal conductivity coefficient with relatively good thermal insulation properties, greater compressive strength, higher frost resistance and a fire resistance more than 2 hours [17]. Therefore, satisfied the necessary requirements for contemporary thermal insulations material and as fire resistive material that can be applied as building element.

Among the discussed topics, the aim of this paper was to emphasize properties of the new thermal insulation material in comparison with standard, in order to give a possibility to the designers to have an open mind in designing their objects, when it comes to the material selection. When discussing about application of not so commonly used materials, it is always necessary to be considered though the techno-economic analyses in order to build an optimal and sustainable buildings, what is a special topic and can be discussed in some of the future papers.

5. REFERENCES

[1] Bikbay M.Y., (2002), Lecture presented at the Second International Conference of Roof Structures and Insulation of Civil Engineering Objects and Communications, Moscow.

[2] Bilow N. David, P.E., S.E., (2008). *Fire and Concrete Structures*. Portland Cement Association 5420: pp. 1-10.

[3] Gustaferro A.H., Abrams S.M., Litvin Albert, (1970). *Fire resistance of lightweight Insulating Concretes*. Portland Cement Association. Old Orchard Road, Skokie, Illinois.

[4] http://www.eps.co.uk/pdfs/fire_booklet.pdf

[5] https://www.hindawi.com/journals/sv/2016/2391476/

[6] https://www.simprolit.rs/doc/filessertSOP10/mobile/index.html

[7] O.Desjarlais Andre, R.Zaar Robert., (2002), *Insulation materials: Testing and Applications:4th Volume*. West Conshohocken,PA: ASTM International.

[8] Ji-Hyung L., Sung-Hoon K., Yu-Jin H., Sung-Gul H., (2018). *Structural Behavior of Durable Composite Sandwich Panels with High Performance Expanded Polystyrene Concrete*. International Journal of Concrete Structures and Materials.

[9] Jevtić D., Zakić D., Savić A., (2007), *Testing of Different Types of „Simprolit" Plates – Lightweight Concrete Elements*, 1st International Congress of Serbian Society of Mechanics, ISBN 978-86-909973-0-5: pp. 393-399.

[10] Jevtić D., Zakić D., (2009). *Experimental testing of certain thermo-physical and mechanical properties of EPS concrete*, Materijali i konstrukcije 52, UDK:666,973 = 864: pp. 35-45.

[11] Jevtić D., (2013). *Special concretes and mortars and their application in repair*. Savremeni materijali i postupci sanacije građevinskih objekata (ISBN 978-86-82307-21-1): pp:19-30.

[12] Muravljov M., Jevtić D., Zakić D., Dević M., (2005). *Simprolit sistem za utopljavanje fasada i zaštitu objekata od požara*, IV savetovanje SGITS-a. Ocena stanja, održavanje i sanacija građevinskih objekata i naselja: pp. 433-440.

[13] Muravljov M., Jevtić D., Zakić D., (2003). *Testing of different types of „Simprolit" plates – an example*. 10th International Symposium of MASE: pp. 393-400.

[14] Muravljov M.., Jevtić D., Zakić D., Dević M., (2005). *Simprolit sistem za utopljavanje fasada i zaštitu građevinskih objekata od požara.* IV savetovanje SGITS-a „Ocena stanja, održavanje i sanacija građevinskih objekata i naselja. Zlatibor: pp. 433-440.

[15] Simprolit catalogues and publications.

[16] Zakić D., Jevtić D, Živković S., Dević M., (2005), Testing of „Simprolit" Thermo-insulation and Steam Conduction System for Flat Roofs. *11th International Symposium of MASE*: pp. 393-400.

[17] Živković S., Jevtić D., Radonjanin V., (2005), Istraživanje na području materijala i njihove primene, Materijali i konstrukcije 48 4: pp. 9-24. YU ISSN 0543-0798.

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RISK ASSESSMENT – GIS APPROACH

Abstract: Due to climate changes occurring in the world, which did not evade the Republic of Serbia, there are increasing risks of flooding. In the past five years, the Republic of Serbia has been affected by floods that caused great material damage. In order to estimate potential risk and exposure to these disasters, we can use many software on the market. One of these software is GIS application that enables us to visualize, edit and analyze geo-data. In this paper we tried to present the possibilities of this application on a practical example in one part of Novi Sad (Bistrica), on how much the Danube water level is affecting this part of the city. The paper presents an analysis of vulnerability of residents in Stojana Novaković Street in relation to the Danube water level rise. The street was randomly chosen because the whole settlement is at about the same altitude, with slight deviations.

Key words: risk, flood, GIS, Danube, Bistrica, damage, water level

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1. INTRODUCTION

Due to the climate changes worldwide, which include the Republic of Serbia as well, there are increasing risks of flooding, droughts, wildfires, etc. Lately the Republic of Serbia has been affected by extensive floods that caused great material damage. Flood implies temporary, partial or complete flooding over what is normally dry land due to overflow of rivers, streams, canals, lakes, etc., abundant atmospheric precipitation, storm-induced flood waves, mudflows, etc. In the Republic of Serbia, floods occur most often due to the overflow of high waters in the Morava and Drina basins, but frequent floods occur in the area of Vojvodina as well. In 2014, the Republic of Serbia was hit by unprecedented floods, a so-called 100-year floods that caused major material and non-material damage. A state of emergency had been declared. These catastrophic floods were specific, as they were preceded by abundant rainfalls that covered large areas – unparalleled by their intensity, duration and drainage. In just 24 hours, more than 100 litres of rain fell per square meter, with specifically large amount of rainfalls occurring between May 13 and May 15, the largest ever recorded since meteorological observations were conducted. Over a period of three days, more than 200 litres of water fell, mostly in Valjevo, Belgrade, Loznica and Novi Sad. This was also the rainiest May in history [13]. The historical annual average for that time of the year is about 70 millimetres of precipitation per square meter. However, in 2014, it reached 214 litres. Due to abundant rains and floods, large landslides occurred. Main roads and houses were damaged in Mali Zvornik, Bajina Bašta, Kosjerić, Gornji Milanovac, Požega, Čačak, Kraljevo, Valjevo and Belgrade. The Serbian town of Obrenovac was the most severely hit. It is located at the mouth of the Kolubara and Sava rivers, southwest of Belgrade. After the river level rose rapidly by seven meters, 90% of the town was inundated, with the water in some areas reaching the depth of several meters. The total value of destroyed goods in 24 affected municipalities covered by the Assessment was estimated to the amount € 885 million, with the value of losses reaching € 640 million, which gives a total amount of € 1.525 million, as shown in Table 1-1. This figure represents about 3% of the total gross domestic product of the entire country, and provides an insight in the scale of disaster caused by floods and landslides. Considering some municipalities that were not covered in the assessment (according to the data from a flood study in Serbia in 2014, done by the world bank grop and UN/Serbia [10]) of needs in the process of reconstruction, but were still affected to a certain extent, the estimated value of damage and losses should be increased from € 1.7 to € 1.8 million. It should be emphasized that 57% of the total consequences of floods represents the value of destroyed goods that need to be repaired or renewed, with the remaining 43% representing the losses in production. Production losses were estimated to occur in 2014 and 2015, as reconstruction and rehabilitation activities were predicted to be completed during that period.

Flood risks continue to threaten the Republic of Serbia, especially due to the fact that 18% of its territory consists of large river valleys where almost all major cities and settlements, such as Belgrade, Novi Sad, Kraljevo, Sabac, Smederevo, etc. are located. In 2018, the Republic of Serbia was hit by terrible floods, the consequences of which were not that severe as in 2014 floods, but significant damage still has occurred.

Preventive measures that can be taken in order to avoid flooding or mitigate their adverse impact are: [12]

- organizing water areas and flood defence by basins,
- reconstructing and maintaining facilities of the flood defence system in accordance with the applicable standards and norms
- calculating, collecting and spending water charges in a regular and purposeful manner (in accordance with the Law on Waters)
- making sure that investments in anti-erosion planning of basins and flood protection have not been completely suspended

- making sure that water management companies are more functionally connected and that their costs of maintaining facilities and implementing flood defence measures for the previous period were paid

Due to the lack of funds in recent years, dams and accumulations in Serbia have not been maintained in accordance with the standards and regulations, and greater damages can lead to large-scale disasters.

Bearing in mind climatic changes, manifested through more frequent and pronounced extremes, and the impact of urbanization in the Danube basin, it can be expected that in the near future floods will arise which will be historical regarding some of their features.

There is a number of software available on the market that can be of great help in estimate potential risk and exposure to these disasters. One of them is the QGIS applications. In this paper, the QGIS application was used to determine the risk of flooding in one part of the city of Novi Sad, called Bistrica. More than 40.000 people live in this part of the city; it has three large kindergartens, one large elementary school, one school for children with special needs, medical centre, sports grounds, industrial zone, as well as many small companies. An analysis has been conducted as to determine how much the Danube level would need to rise to flood this part of the city. The paper presents an analysis of vulnerability of residents in Stojan Novaković Street in relation to the rise of the Danube level. The street was chosen by random selection, as the entire part of the city is at the same altitude and the data can be applied to the entire settlement of Bistrica, with slight deviations.

2. RISK MANAGEMENT

Risk management is a very complex process, which requires a set of methods to be used to address the risk problem. Risk management is a systematic process of identifying, analyzing and assessing risks in order to find the best way to treat them [1]. Risk management is a process that aims to protect property and reduce the potential for causing losses. It also represents a general management function that seeks to identify and assess risks and to understand their causes and consequences. In the process of risk management, it is essential to determine the own risk-bearing capacities, as well as to understand the risks that arise. Hazard identification and risk analysis are activities aimed at determining the likelihood for a risk to occur, as well as its intensity in the case of its occurrence. On the basis of the obtained results, a decision is made that regarding the way the risk will be handled: will the risk be reduced, transferred or avoided. The risk assessment itself is a highly subjective process; however, by following certain principles, subjectivity can be reduced to the lowest possible level. The risk management process consists of several steps, namely: setting the goals, identifying the risk, assessing the risk, considering the alternatives and choosing the appropriate risk management tool, applying the decision, assessing and re-examining, i.e. controlling. The first step is to identify the objectives of the risk management program [9]. In theory, steps of risk management are finely defined, but the situation in practice is different. In practice, all the steps are intertwined. Parallel to identifying the risk, factors that cause the harmful event and the consequences of the harmful event are also assessed [6]. At the same time, statistical data on similar events are collected in order to make risk assessment more accurate. Some risks are obvious, but there are also risks that are more difficult to spot and they are often overlooked. It is important to discover the source of risk, i.e. from where the risk can arise. After identifying and assessing the risk, it is necessary to consider and select techniques that could be used. The following are the risk control techniques [2, 3]:

- avoidance,
- reduction,
- retention,

- transferring,
- division,
- prevention,
- risk repression.

In the 2014 case, we could see that the Republic of Serbia did not take adequate preventive measures, and huge material damage occurred (Table 1).

Table 1: Estimation of the total value of damage and losses caused by floods [10]

	Flood effects expressed in millions of euros			
		Damage	Losses	Total
Social		**234,6**	**7,1**	**241,7**
	Flat	227,3	3,7	230,9
	Education	3,4	0,1	3,5
	Health	3,0	2,7	5,7
	Culture	1,0	0,6	1,6
Production		**516,1**	**547,6**	**1.063,6**
	Agriculture	107,9	120,1	228,0
	Manufacture	56,1	64,9	121,0
	Trade	169,6	55,2	224,8
	Tourism	0,6	1,6	2,2
	Mining and energy	181,9	305,8	487,7
Infrastructure		**117,3**	**74,8**	**192,1**
	Traffic	96,0	70,4	166,5
	Communication	8,9	1,1	10,0
	Water supply and cleanliness	12,4	3,2	15,7
General problems		**17,2**	**10,6**	**27,9**
	Environment	10,6	10,1	20,6
	Management	6,7	0,6	7,2
Total		**885,2**	**640,1**	**1.525,3**

Analyzing the data from the table, it can be seen that the Republic of Serbia suffered damage in the amount of € 1525.3 million and that it will take many years to recover. Finally, comparing the total value of damage and losses with the total population of the country, it can be said that the average damage per capita of population is about € 210.

Risk data, which gives us an insight into the situation, is very important for risk management. Data analysis needs to be carried out in order to effectively do the planning, designing and developing the process of securing the infrastructure. Finally, sovereign risk and insurance funding would be impossible without a detailed understanding of the average annual and likely maximum losses, and without uncertainty analysis [4]. The Republic of Serbia lacks an adequate archive of previous flood disasters, which leads to the problems and often results in underestimating the full price of these events to the national economy. Therefore, Serbia would benefit from the implementation of assessment of needs after disasters, including the damage and losses incurring after each disaster. This requires generating more risk information, as there was no comprehensive risk assessment at the level of the whole country [7]. In general, estimates were made only at the flooding locations, except for floods caused by torrential currents. Effective flood risk management requires better understanding the causes of different types of floods, the likelihood of their appearance, taking into account the extent, duration, depth and speed. In this context, it is also important to understand how the flood risk will evolve over time with respect to climate changes.

Floods that occurred in Serbia in 2014 show that early warnings should be timely and accurate and should be transmitted in the right way, that is, they should be understandable to everyone at risk. In order to minimize the flood risk, it is necessary to analyze the meteorological and hydrological events and to process the information in a way that will help in reducing the risk. In order to achieve this, it is necessary to apply modern information tools and applications. Today, there are a large number of these software available in the world, some of them are being paid for, but there are also free applications that can greatly help to capture the risk of floods on the basis of which preventive measures would be taken. In this paper, the GIS software with a special emphasis on Quantum GIS (QGIS) will be analyzed.

3. GEOGRAPHIC INFORMATION SYSTEMS

A Geographic Information System (GIS) is a system for managing spatial data and the associated features. GIS is an application that can help us in risk management, as shown in this paper. GIS allows users to analyze and edit spatial information. In addition to compiling and exporting graphic maps, it allows users to create maps with several layers. In a broader sense, GIS is a "smart map" tool that enables users to set interactive queries (user-generated research), analyze spatial information, and edit data. Modern GIS technologies use information in digital form. The most commonly used way of digitalization is translating the printed map or plan into digital form using CAD (computer-aided design) software, and geo-referencing capabilities. Digital copying involves drawing geographic data directly through aerials instead of using the outdated method of tracing geographic data by digitizer [8].

The GIS allows us to use a large number of different sources and a large number of different forms. Each data can be linked to a specific location, defined using coordinates of geographic latitude, longitude and altitude. Different data types in the form of maps can be entered into GIS.

Maps can be assembled in different formats and for different purposes. The GIS allows creating maps consisting of raster or vector layers.

The raster consists of rows and columns of cells, which are called pixels; each of them has one specific numerical value. In the case of an image, this numerical value represents the number of colour (colours are number-coded). When it comes to other information, the pixel value is also a spatial data. Since a single pixel has a single numerical value, the information the raster carries is roughly speaking equal to the number of its pixels.

Displaying information in a vector form refers to the geometry of forms (length, height, shape), whether they are linear or polygon entities, as well as their spatial position.

GIS programs are:

- Global Mapper
- ESRI ArcView
- MapInfo Professional
- Quantum GIS (QGIS)

3.1. QGIS approach

In this paper, QGIS was used to determine the risk of floods in one part of the city of Novi Sad, called Bistrica. An analysis has been conducted as to determine how much the Danube level would need to rise to flood this part of the city. More than 40.000 people lives in this part of the city, it has three large kindergartens, one large elementary school, one school for children with special needs, medical centre, sports grounds, industrial zone, as well as many small companies. The paper presents an analysis of vulnerability of residents in Stojan Novaković Street in relation to the rise of the Danube level. The street was chosen by random selection, as the entire part of the city is at the same altitude and the data can be applied to the entire settlement of Bistrica, with slight deviations.

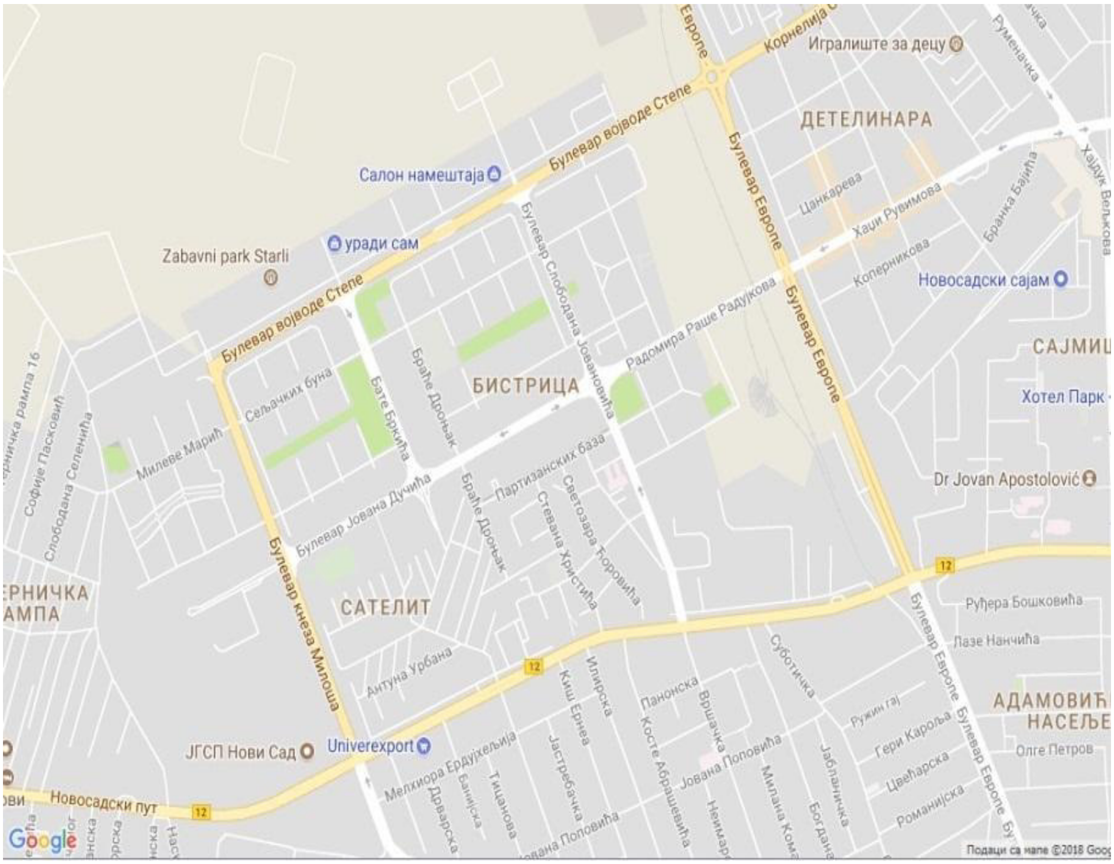

Figure 1- The settlement of Bistrica, Novi Sad shown in QGIS

Before analyzing the exposure to flood of people living in the Bistrica area, we will show the water levels of Danube in Novi Sad in 2018. The water level of the river is measured in such a way that the water level at a certain point on the river represents the water level measured from an arbitrarily selected point at the measuring point. The point from which the water level is measured is determined empirically and is designated as a zero point. Levels above and beneath that point, expressed in centimetres, are positive and negative values, respectively. Water levels are relative dimensions [5].

Tabela 2. Water level of the Danube near Novi Sad in 2018 [14]

Day:	I	II	III	IV	V	VI	VII	VIII
1	290	343	222	334	349	222	158	105
2	292	333	209	330	343	220	168	98
3	287	325	198	341	331	221	206	90
4	287	321	185	357	316	219	242	84
5	305	318	175	370	303	219	255	75
6	325	320	177	380	292	218	242	67
7	334	331	174	384	282	221	216	61
8	342	339	171	385	277	223	187	57
9	355	333	179	389	278	221	169	54
10	380	329	199	392	282	217	163	54
11	393	324	223	389	284	211	170	50
12	403	319	250	384	277	208	185	46
13	412	310	273	381	267	211	191	46
14	418	299	293	378	258	214	187	44
15	418	284	310	378	251	208	176	41
16	415	272	326	384	242	207	165	41
17	401	262	347	386	231	217	153	37
18	383	255	364	385	226	252	141	34
19	361	248	373	382	235	290	128	34
20	341	246	383	378	258	304	114	39
21	326	247	392	378	281	292	103	40
22	319	249	400	381	297	267	99	35
23	326	256	406	380	298	234	101	29
24	336	259	404	374	288	208	97	21
25	345	258	399	366	272	190	98	16
26	348	256	394	358	253	177	99	11
27	347	255	380	351	236	168	104	14
28	345	241	366	348	225	163	112	28
29	346		354	348	218	159	117	
30	349		344	350	219	161	120	
31	347		337		222		116	
Average	351	290	297	371	271	218	154	48

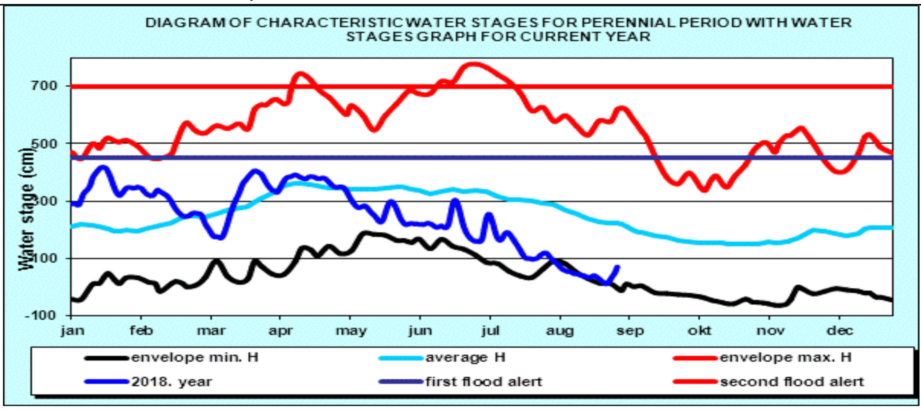

Figure 2 – Diagram of characteristic water stages for perennial period with water stages graph for 2018 [11]

When analyzing the level of the Danube River in Novi Sad it should be noted that the level of regular flood defence is 450 cm and that the level of 700 cm implies emergency defence. Analyzing the water level in 2018, we see that the Danube has not reached a level of regular flood defence, not to mention the emergency defence, but this does not mean that there is no possibility of flooding in Novi Sad [11]. Novi Sad has invested heavily in the construction of protecting lines against floods and therefore was not threaten in 2014. Novi Sad is monitoring the water level and could use the QGIS to predict the height of the Danube level that would endanger certain parts of the city.

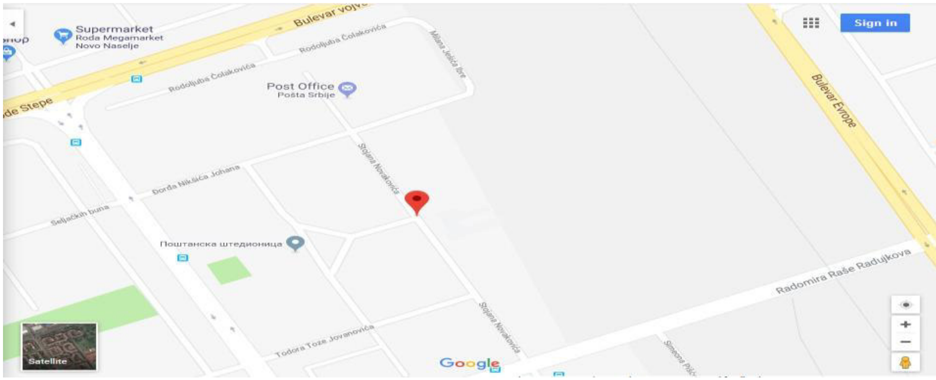

Figure 3 - Stojan Novakovic Street, Bistrica, Novi Sad, Google Earth[1]

The Danube level that threatens the city is about 700 cm (emergency defence). When analyzing the data in QGIS, it can be concluded that Bistrica will be threatened if the level of the Danube reaches 780 cm. On the basis of these data, preventive measures are undertaken to reduce the flood risk in Novi Sad, which would reduce the risk of inundation of Bistrica as part of the city. The data shows that Bistrica does not need to build a special flood protection system, since the remaining parts of the city are much

[1]https://www.google.rs/maps/place/Stojana+Novakovi%C4%87a,+Novi+Sad/@45.2560398,19.8033403,17z/data=!3m1!4b1!4m5!3m4!1s0x475b11b66ad5a791:0xf486d5b324f7cf0a!8m2!3d45.2560398!4d19.805529

more threatened by almost 80 cm. The paper is not aimed at presenting the flood risk in Bistrica, but rather the benefits offered by the QGIS application.

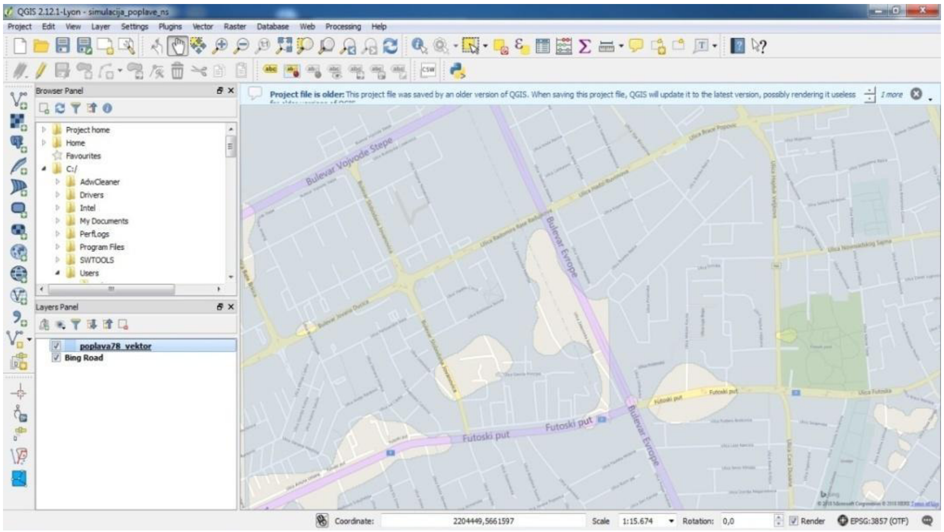

Figure 4 - The flooded settlement of Bistrica, the Danube 780 cm

The QGIS has the ability to display only on the basis of situation on the terrain. We do not know what the situation would be in the case the water started to backflow through sewer pipes. Also Novi Sad has one of the most modern flood protection system. In 2011, Novi Sad made a mobile dam that can be lifted by 80cm, which leads to the conclusion that this part of the city can hardly be inundated.

Flood risks in Bistrica have been assessed using Google maps, which are usually used in this application, making it the advantage of this application because all Google Maps, satellite imagery and Google Earth are free for use. In addition to Google maps, other available and free maps can be used, which makes this application accessible to everyone.

4. CONCLUSION

In order to minimize the impact of flooding, it is necessary to assess and identify the risks in order to determine preventive measures, it is necessary to keep a flood register that the Republic of Serbia lacks on the country level. In general, assessments were made only at flooding locations, except for floods caused by torrential flows. Preventive measures in Novi Sad are on a rather high level. Novi Sad has preventively built defence dams and mobile panels on the Danube, which can be additionally elevated by 80 cm and the entire river bank was regulated. Considering the preparedness of areas for floods by building defence dams and mobile panels the resilience of the area increases and reduces the overall risk of floods. However, despite the preventive measures, flooding still represent a threat in some parts of the suburban settlements of Novi Sad, primarily in settlements on the Srem side, such as Sremska Kamenica, Beocin, Ledinici, Rakovac. Using QGIS would help to determine which levels of the Danube are dangerous for these settlements, especially Sremska Kamenica where defensive embankments exist, but the danger still exists due to the shafts and spill pipes that are not set to adequate height. The Novi Sad settlement of Bistrica is threatened at a quota of 780cm, which we could see using the QGIS, and for this settlement no preventive measures are needed, because at the quota of 700cm, emergency defence measures are taken against floods in the city of Novi Sad. Bistrica will be flooded if the water level increase by 80cm compared to this quota. Benefits of the QGIS in flood risk assessment are primarily in providing true and usable data, and the application can be used free of charge and is based on real maps. The QGIS application should be used for risk assessment at the state level of the Republic of Serbia. The aim of this paper is to demonstrate the benefits of using the QGIS, but not the vulnerability of Bistrica itself.

5. REFERENCES

[1] Avdalović, V., Ćosić, Đ., Avdalović, S. (2008). *Upravljanje rizikom u osiguranju*, Fakultet tehniĉkih nauka Novi Sad.

[2] Ćosić, Đ. (2010). *Razvoj integralnog modela osiguranja u cilju smanjenja rizika od hazardnih pojava*— doktorska disertacija, Univerzitet u Novom Sadu, Fakultet tehniĉkih nauka.

[3] Khan, H., Vasilescu, L, G,. Khan, A., *Disaster Management Cycle* – A Theoretical Approach, 2006.

[4] Jametti, M, Ungern-Sternberg, T., (2010). *Risk selection in natural-disaster insurance*, in: Journal of Institutional and Theoretical Economics, Vol. 166, Iss. 2.

[5] Juan Carlos Villagrán De León., *Source 4 – Ranjivost, konceptualni i metodološki pregled*, Serija publikacija UNU-EHS Broj 4/2006

[6] Marović, B., Avdalović, V. (2004)., *Osiguranje i upravljanje rizikom*, Birografika a.d., Subotica.

[7] Marović, B., Avdalović, V. (2006). *Osiguranje i upravljanje rizikom*, Centar za automatizaciju i mehatroniku, Beogradska bankarska akademija, Fakultet za bankarstvo, osiguranje i finansije, Beograd.

[8] Popov, S., Sakulski, D., Miloradov, M., Jaksic, J., Turk, M., Miloradov, M. (2008). *Concepts of system based on ogc web services for management and decision support and monitoring floods*, International conference on water resources management systems, Novi Sad, septembar.

[9] Vujović, R,, (2009). *Upravljanje rizicima i osiguranje*. Beograd, Univerzitet Singidunum.

[10] UN/Srbia,World Bank Group, EU, (2014) Poplave u Srbiji 2014., Beograd, preuzeto sa sajta 11.8.2018 http://www.obnova.gov.rs/uploads/useruploads/Documents/Izvestaj-o-proceni-potreba-za-oporavak-i-obnovu-posledica-poplava.pdf, skinuto avgust 2018.

[11] Odeljenje za klimatske prognoze,informisanje i obuku Sektor Nacionalnog centra za klimatske promene (2015), Godišsnji bilten za Srbiju 2014., Beograd, preuzeto sa sajta http://www.hidmet.gov.rs/podaci/meteorologija/latin/2014.pdf, skinuto avgust 2018.

[12] http://www.hidmet.gov.rs/latin/hidrologija/godisnje/godisnjak.php?sifra=42035, skinuto 10.8.2018.

[13] Srbija Vode, Republički Hidrometerološki zavod Srbije, J. Černi, Univerzitet u Beogradu, (2014.), Poplave u Srbiji u maju 2014. godine, Beograd, preuzeto 9.8.2018. http://www.srbijavode.rs/ddownload/_params/file_id/5106.html, skinuto 11.8.2018

[14] http://www.hidmet.gov.rs/latin/hidrologija/izvestajne/prognoza.php?hm_id=42035, skinuto 10.8.2018

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PRODUCTION OF ECO FRIENDLY MATERIAL SOURCING FROM BIOMASS WASTE

Abstract: In light of concerns related to the sustainable use of natural resources and the negative effects of improper waste disposal, the beneficial use of municipal and industrial byproducts is the subject of growing interest. This paper presents the research that will be carried out in order to analyze the possibility of using ashes from combustion of biomass in cement composites. The results of the experimental research will define the possibility of using biomass ash, originating from Vojvodina, in cement composites, which will ensure sustainable management of this type of waste and give a new use value to this product in accordance with the principles of sustainable development. The research is supported by the IPA project: Agricultural waste - challenges and business opportunities.

Key words: biomass, waste, ash, cement composites, sustainable development

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1. INTRODUCTION

Concrete is one of the more acceptable materials from the aspect of consumed energy in relation to the acceptible durability of concrete structures. However, since production of concrete contributes to the total annual CO_2 emission of around 8%, the cement industry is trying to reduce the use of non-renewable, natural resources, and to introduce alternative types of fuels and raw materials during cement production. The concrete industry has great potential for a positive shift towards sustainable production and reduction of negative environmental impact. One of the possible strategies is the use of waste materials and by-products from other industries as valuable raw materials in the concrete industry.

The utilization of industrial and agricultural waste materials can be a breakthrough to make the industry more environmentally friendly and sustainable. Waste materials, such as fly ash, silica fume, ground granulated blast furnace slag, recycled concrete, post-consumer glass, recycled tyres, and recycled plastics, have been successfully used in concrete for decades [1]. Also, recent studies have shown the successful use of agricultural solid waste as mineral additive or aggregate in cement-based composites: paste, mortar and concrete. This contributes to energy saving, conservation of natural resources, and a reduction in the cost of construction materials. It also solves the disposal problem of the wastes, and, hence, helps environmental protection.

Biomass is the most common form of renewable energy, widely used in developing countries, but less than in the western part of the world. European Directive 2009/28/CE defines biomass as the biodegradable fraction of product, industrial and municipal waste and any residues of biological origin from agriculture (including vegetable and animal substances), forestry and related industries, such as fisheries and aquaculture [2]. Due to recent increases in production, waste products from biomass combustion are becoming a relevant environmental and economic problem. Substitution of cement in mortar and concrete, with ash generated by combustion of biomass (ash containing Al, Ca, Fe, Mg, Na, P, Si), as CO_2 neutral fuel, would reduce the negative impact of concrete industy on global warming, give new usa value and possibility of economic evaluation of biomass ash as a raw material. All these effects would be a powerful incentive for integrated management and sustainable utilization of large quantities of biomass ash originating from agriculture in Vojvodina and Serbia.

2. BIOMASS – RENEWABLE ENERGY SOURCE IN SERBIA

Biomass is considered to be the most promising source of renewable energy, and its by-products are increasingly used worldwide. Globally, bioenergy (including waste) accounted for 14% of the world's energy consumption in 2012 with roughly 2.6 billion people dependent on traditional biomass for energy needs [3]. Carbon dioxide emissions from biomass combustion are traditionally assumed climate neutral, i.e. the CO_2 released from biofuel combustion approximately equals the amount of CO_2 sequestered in biomass (simultaneously reabsorbed by growing plants).

Around the world, billions of tons of agricultural biomass waste are annually available but the utilisation is very low. Less than 100 million tons are utilised for energy each year and the rest is generally free-burned or allowed to rot, with consequent release of greenhouse gases [3]. This applies whether the crop is rice in Asia, sugar cane in Brazil, wheat in Australia, soybean in Argentina, cotton in Egypt or palm oil in Indonesia.

The Republic of Serbia now uses 35% of the total available technical potential of the renewable energy. So far the use of renewable energy in Serbia has been based on the production of electricity from large river flows and the use of biomass mainly for households heating and to a lesser extent in industry [4]. In the planned structure of primary energy production in Serbia in 2014, RES participated with 1,819 Mtoe, which accounted for about 17% of domestic primary energy production. Solid biomass takes the largest share - 58%, while the total availability of biomass in Serbia is around 13 million tons.

Agriculture is a major consumer but also can become energy producer. Bearing in mind the amount of biomass produced, and the possibilities for its utilization, the negligible amount of biomass that is currently used as an energy source. Table 1 provides an overview of the potential of biomass from agriculture in Serbia.

Table 1- The energy potential of biomass from the residue of agricultural production in Serbia [5]

	Biomass	Biomass for combustion (25% of total) (103 t)	Low thermal power (MJ/kg)	Equivalent value of light heating oil (103 t)
1	Wheat straw	743,75	144	247,92
2	Barley straw	103,13	14,2	34,87
3	Oat straw	6,4	14,5	2,21
4	Rye straw	3	14	1
5	Corn	1787,5	13,5	574,55
6	Seed corn	21,56	13,85	7,11
7	Grain ear	357	14,7	124,95
8	Sunflower stem	200	14,5	69,05
9	Sunflower shell	30	17,55	12,54
10	Soya straw	80	15,7	29,9
11	Rapeseed straw	75	17,4	31,07
12	Stalks of hops	1,98	14	0,66
13	Stalks of tobacco	0,26	13,85	0,09
14	The remains of cutting in orchards	289,44	14,15	97,5
15	The remains of cutting in vineyards	71,55	14	23,85
16	Manure	110	23	60,24
	TOTAL:	3880,57	14,26	1317,51

One of the problems associated to biomass combustion is related with the ash and it refers to its environmental management. Based on the physical, chemical and morphological properties, it is reported that this ash has a substantial potential for use as a pozzolanic mineral admixture and/or as an activator/binder in cement-based materials. Below is a brief overview of the different types of biomass ashes used in the experimental research available in the literature.

3. REVIEW OF DIFFERENT BIOMASS ASHES USED IN EXPERIMENTAL RESEARCH WORLDWIDE

Based on data from the literature, a range of characteristic types of biomass (and other) ashes was selected, including rice husk ash, palm sugar cane bagasse ash, oil fuel ash, groundnut shell ash, oyster shell ash, corn cob ash and coconut shell ash. Their origin and main points concerning their chemical composition is briefly discussed bellow.

3.1. Rice husk ash

Rice husk ash (RHA) is a by-product of combustion of grain husks of rice (Fig. 1-3). India is the world's second rice producer, immediately after China, with 104 million tons of rice produced annually [6]. RHA is classified as a highly reactive pozzolan, which is attributed to the high content of amorphous silica (more than 80-85%) and to the very large surface area. By grinding up to an appropriate particle size, the pozzolanic reactivity of RHA can be improved, reducing the adverse effect of the high carbon content in the ash, and increasing the homogeneity of the material [7]. RHA represents a significant improvement on the properties of both fresh and hardened concretes. The improvements in properties include the increased compressive and flexural strengths, the reduced permeability, the enhanced workability of concrete, and the reduced potential for efflorescence due to reduced calcium hydroxide.



Figures 1,2,3 – Rice waste – husks and generated ash

3.2. Sugar cane ash

Sugar cane bagasse ash (SCBA) is a by-product of sugar and alcohol production. India, along with Brazil, is the largest sugar cane producer in the world. About 380 million tons of sugar cane is produced annually in India, which means that a large amount of waste or ash is produced, also. Preliminary investigations have showed a favourable chemical composition of the ash for the use as a pozzolanic material, primarily due to the high content of silicon dioxide (≈78%) [8]. Research has sown that it can be advantageous to use it as a fine aggregate replacement in concrete to mitigate the disposal problem as well as to minimize the use of natural aggregates.

3.3. Palm oil ash

Palm Oil Fuel Ash (POFA) is by-product obtained by burning of fibers, shells and empty fruit bunches as fuel in palm oil mill boilers. Currently, in Malaysia, oil palm plantations cover three million hectares of land, and annually more than 15 million tons of palm oil is produced, generating 2.6 million tons of ash [9]. Uncontrolled disposal of this type of ash occupies valuable land, but also leads to pollution of the environment and disruption of human health. Due to a relatively high content of silica (55-65%), this pozzolanic material can be extremely reactive and can be used as a binder. Results indicate a good potential for improving the hardened properties and durability of concrete. It is recommended that the optimum replacement level of Portland cement with POFA is 20% to 30%.

3.4. Groundnut shells ash

Nigeria is one of the biggest producers of groundnut in the world, producing up to 1.55 million metric tonnes in 2008. Chemical analysis of ash obtained by combustion of groundnut shells (GSA) showed that the total oxide content (Fe_2O_3, S_iO_2 and Al_2O_3) was relatively low (≈25%), hence this material has poor poozolanic properties. It is usually used as a replacement of aggregate. With the increase of ash content in concrete, mechanical characteristics decrease, and it has been shown that concrete with this type of ash has extremely high absorption of water. The optimal amount of ash in concrete is, according to the researcher's recommendations, 30% by mass of sand and can be successfully used for concrete walls and foundations [10].

3.5. Oyster shells ash

The large amounts of abandoned oyster-shells in ostrea-culture have led to serious environmental problems and health hazards. Oyster shells ash can be used as substitutes for aggregates and cements in concrete due to the variety of shells that can be found in coastal areas around the world. In China, annual waste reaches up to 3 million tons of shell per year. The chemical composition of the burnt oyster is similar to the composition of lime, and can be used as a replacement of lime in mortars and concrete. The chemical composition of this type of biomass ash differs from agro-ash in the content of CaO (51-78%) and high loss of ignition (44%). The optimum amount of ash for replacement of aggregate or cement in cement composites is found to be up to 20% [11].

3.6. Corn cob ash

Corn is the world's most important grain, based on production volume. In 2016/2017, a production level of around 1.07 billion metric tons of corn was achieved. According to the Statistical Yearbook of Serbia in 2012, a total of 1,268,544 hectares were planted under corn. Corn cob ash (CCA) has been shown to be a suitable material for its use as a pozzolan, since it satisfied the requirement for such a material by having a combination of S_iO_2 and Al_2O_3 of more than 70% [1]. The results of previous experimental studies show that ash can be successfully used to replace cement by up to 10%, providing mechanical properties comparable to reference mortars and concrete.

3.7. Coconut shell ash

Annually, 40–50 million tones of coconuts are grown worldwide, while 15–20 million tones of husk are produced. Research has shown that coconut shells are one of the most promising agro wastes with possible uses as coarse aggregate in the production of concrete and can be used as a lightweight aggregate for producing lightweight concrete as well. A long-term study on the compressive strength of coconut shell aggregate concrete shows that this concrete, even at later ages (365 days), has good quality [1].

3.8. Sawdust ash

Sawdust is an organic waste resulting from the mechanical milling or processing of timber (wood) into various shapes and sizes. The dust is usually used as a fuel. The resulting ash known as saw-dust ash (SDA) is a form of pozzolana. It has been used for years for various purposes, among other things as an aggregate for lightweight concrete. Previous research has shown that with replacement up to 15% of the fine aggregate with sawdust ash, the compressive strength and tensile strength increase. Recent research results suggest also the use of this ash as partial replacement of cement up to a maximum of 10% by volume in all grades of cement [1].

3.9. Sunflower husk ash

Ukraine and Russia remain the top sunflower seed producers in the world. They produce almost half of the world sunflower seeds. Sunflower husks are the by-product of the dehulling of sunflower seeds and they are burned as fuel to power oil mills. With a high calorific value, sunflower seed husks can also be formed into pellets for use as a biomass fuel. Sunflower husk ash contains relatively low amount of amorphous silica, hence this type of ash has poor pozolanic activity. Researchers have discovered that by using sunflower husks, concrete properties can be improved by reducing its density while increasing its resistance to cracking during cold conditions. Optimal cement replacement level of 10% is recommended [12].

Based on the literature review, it can be concluded that the ash, produced by biomass combustion, can be successfully used in the design and the preparation of cement-based composites as a binder or aggregate replacement. The main reason that justifies the possibility of the application of biomass ashes as a binder lies in the chemical composition of the ash (Table 2). This type of ash contains large quantities of SiO_2 and Al_2O_3 and, in the presence of moisture, it can chemically react with calcium hydroxide at ordinary temperatures to form products having pozzolanic properties. Ashes with lower amount of these oxides (such as groundnut shell, sunflower husk ash ash oyster shell ash) can be used as partial aggregate replacement.

Table 2 - The chemical composition of different biomass ashes used in cement-based composites

Biomass	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	CaO (%)	Na_2O_3 (%)	K_2O (%)	LOI	SiO_2+ Al_2O_3+ Fe_2O_3 (%)
Rice husk ash [13]	87,0	1,08	2,58	1,25	0,08	1,0	5,71	**90,66**
Sugar cane ash [13]	78,3	8,9	3,6	2,2	0,1	3,5	2,7	**90,8**
Corn cob ash [14]	67,33	7,34	3,74	10,29	0,39	4,2	-	**78,41**
Sawdust ash [15]	65,42	5,69	2,16	9,82	0,04	2,38	4,89	**73,27**
Coconut shell ash [16]	45,05	15,6	12,4	0,57	0,45	0,52	-	**73,05**
Palm oil ash [13]	65,3	2,5	1,9	6,4	0,3	5,7	10,0	**69,7**
Groundnut shells ash [17]	16,21	5,93	1,8	8,69	9,02	15,73	4,8	*23,94*
Sunflower husk ash [18]	1,8	0,4	1,3	30,6	0,3	27,8	-	*3,5*
Oyster shells ash [19]	1,6	0,92	0,11	54,56	0,08	0,06	41,84	*2,63*

4. INVESTIGATION OF AVAILABILITY OF BIOMASS ASHES IN AP VOJVODINA WITHIN IPA INTERREG PROJECT

This research is supported with IPA Interreg project Agricultural Waste – Challenges and Business Opportunities (Eco Build), developed as a result of joint work of Faculty of Civil Engineering from Osijek and Faculty of Technical Sciences from Novi Sad. One of the main outputs of the project is a cooperation network between: biomass providers (farmers), biomass users (industrial companies that use biomass as an energy source), and engineering companies (cement and concrete factories) that would use biomass waste – biomass ash as new construction material. Within this cycle, higher-education institutions will conduct research on possibilities of biomass ash application in cement-based composites/disseminate results, whereas enterprises and SMEs will provide biomass waste and learn how to manage it usefully. Within this project, the availability of different types of biomass ashes in AP Vojvodina was investigated and their classification and cataloguing was conducted. A brief overview of the received information and data on companies that use biomass as energy source, types of biomass ashes and their availability are given in Table.

Table 3 - Availability of biomass ashes in AP Vojvodina

Company	Biomass type	Temperature of combustion	Types of biomass ashes	Produced quantities of ash per year (tons)
Mitrosrem Sremska Mitrovica	wheat straw soya straw	600-650°C	1. ash from boiler furnace 2. ash from multiciklon 3. fly biomass ash	15
Soya Protein Bečej	wheat straw soybean shells	700-900°C	1. ash from boiler furnace 2. ash from multiciklon 3. fly biomass ash	**1100**
The Veterinary Institute Subotica	agro pellets of wheat straw and soya straw	450-550°C	1. ash from boiler furnace 2. ash from multiciklon 3. fly biomass ash	240
Hipol Odžaci	agro pellets of soya straw	800-1000°C	1. ash from boiler furnace 2. ash from multiciklon 3. fly biomass ash	700
Victoria Starch Zrenjanin	agro pellets of wheat straw and soya straw	unknown	1. ash from boiler furnace	9
Almex-IPOK Zrenjanin	agro pellets of wheat straw and soya straw	700-900°C	1. ash from boiler furnace 2. ash from multiciklon 3. fly biomass ash	**1100**
KNOT-AUTOFLEX Bečej	wheat straw soya straw	unknown	1. ash from boiler furnace	60
Fishery Lovćenac	soya straw	unknown	1. ash from boiler furnace 2. ash from multiciklon	9
			Total	**3233**

Based on the obtained data, it can be concluded that, at this moment, available amount of biomass ashes in Vojvodina, is 3233 tons per year. It includes: 15 tons of wheat straw ash, 1100 tons of mixed wheat straw and soybean shell ash and cca 2050 tons of agro-pellet ash (700t of soya straw agro pellet ash, and 1350t of ash of agro pellet from a mixture of wheat and soy straw). A small amount of ash is deposited on the unregulated landfill in the company's circle, and the largest quantity of ash is disposed in containers and transported to municipal landfills, occupying valuable land and polluting the environment. These ashes can be potentially used as mineral additive and/or aggregate in cement based composites, which depends on their chemical composition and consequently pozzolanic activity.

5. CHEMICAL COMPOSITION OF COLLECTED BIOMASS ASHES AND EXPERIMENTAL PHASES

In previous chapter, it was stated that companies use following harvest residues as energy products for obtaining heat energy: pure wheat straw (WSA), mixed wheat and soya straw (WSSA) and soya straw (SSA). Samples of biomass ashes were collected and their chemical composition was determined. View of the ashes after preparation (sieving and grinding) is presented in Figures 4-6.

Figure 4 – Wheat straw ash

Figure 5 – Mixed wheat/soya straw ash

Figure 6 - Soya straw ash

A content of oxides: S_iO_2, Al_2O_3, Fe_2O_3 has the greatest significance for a pozzolanic activity of biomass ashes. Materials with very high silica content and large surface area intensively react with the water and the calcium hydroxide, generated during the hydration of cement, to produce additional C–S–H, which is the main strength contributing compound in cement-based composite. The chemical composition of tested biomass ashes is given in Table 4. Ashes WSA and WSSA have relatively high content of these oxides, exceeding 50%, while soya straw ash is characterized with lower silica content (13.8%).

Table 4 - Chemical composition of biomass ashes

Biomass ash	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	CaO (%)	Na_2O_3 (%)	K_2O (%)	LOI	SiO_2+ Al_2O_3+ Fe_2O_3 (%)
WSA	53.21	4.00	2.69	13.45	0.41	12.05	10.19	**59,9**
WSSA	51.93	0.19	1.39	14.28	0.43	18.43	9.27	**53,5**
SSA	13.80	1.76	1.45	47.53	0.07	5.23	18.60	*17,0*

With respect to the chemical composition, higher amorphous silica content results in the higher pozzolanic reactivity of ashes. Therefore, ashes WSA and WSSA can be potentially used as a cement replacement in cement based composites, while activity of SSA should be improved by additional grinding or stimulating its pozzolanic activity by using of hybrid mineral admixture with high amount of amorphous silica.

Following phases of the experimental research will include:

1) Testing the pozzolanic activity and activity index of collected biomass ashes,
2) Improving pozzolanic activity of soya-based biomass ash,
3) Preparation of eco-mortar, where optimal replacement level of cement with biomass ashes, from the aspect of basic physical, mechanical and durability properties, will be determined,

4) Preparation of eco-concrete, where optimal replacement level of cement with biomass ashes, from the aspect of basic physical, mechanical and durability properties, will be determined,
5) Life cycle analysis of biomass ashes – assessment of environmental impacts associated with all the stages of a product's life.

6. CONCLUSIONS

The concrete industry has a great potential for a positive shift towards sustainable production and reduction of negative environmental impact. One of the possible strategies is the use of waste materials and by-products from other industries as valuable raw materials in the concrete industry. Various types of biomass, from agro-industrial processes, produce ash through their combustion (as rice husk ash, palm oil fuel ash, sugar cane bagasse ash, corn cob ash etc.) which under certain conditions (chemical configuration, level of fineness) can have a similar pozzolanic activity to coal fly ash and be used as pozzolanic materials replacing cement.

Conducted investigation of availability of biomass ashes in AP Vojvodina has shown that available amount reaches over 3200 tons per year. These ashes are usually deposited on landfills, occupying valuable land and causing the environmental problems. Testing the chemical composition revealed relatively high amount of amorphous silica (S_iO_2) for wheat straw-based biomass ashes, hence this material can potentially used as a mineral additive/binder in cement-based composites, replacing a part of cement and, thus, solving it improper disposal. Regarding soya-based ashes, additional experimental research has to be carried out in order to improve its poor pozzolanic activity, which is the result of low silica content.

The results of the presented experimental research should enable and define the scope of the use of ash generated from the combustion of biomass in Vojvodina in cement-based composites. This will create new use value for this waste material, which represents the waste product in the process of energy production from agricultural biomass and enable the creation of conditions for sustainable development in this segment of the economy.

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7. REFERENCES

[1] Shafigh Payam, Mahmuda Bin Hilmi, Zamin Jumaat Mohd, Zargar Majid. Agricultural wastes as aggregate in concrete mixtures – A review. *Construction and Building Materials* Vol. 53: 110-117.

[2] Cabrera Manuel, Galvin Adela, Agrela Francisco, Dolores Carvajal María, Ayuso Jesús. Characterisation and technical feasibility of using biomass bottom ash for civil infrastructures. *Construction and Building Materials* Vol. 58: 234-244.

[3] World Energy Resources Bioenergy | 2016, assessed on 24th June, 2018.

[4] Milosavljević Dragana, Pavlovic Tomislav, Mirjanić Dragoljub, Piršl Danica. Current state of the renewable sources of energy use in Serbia. *Contemporary Materials (Renewable energy sources)* VI−2: 170-180.

[5] Brkić Miladin, Janić Todor. Prikupljanje, skladištenje i briketiranje biomase u poljoprivredi. Časopis za procesnu tehniku i energetiku u poljoprivredi Vol. 6: 14-17.

[6] Hasparyk Nicole, Monteiro Paulo, Carasek Helena. Effect of silica fume and rice husk ash on alkali-silica reaction. *ACI Structural Journal* Vol. 97: 486-492.

[7] Ki Bong Park, Seung Jun Kwonb, Xiao Yong Wang. Analysis of the effects of rice husk ash on the hydration of cementitious materials. *Construction and Building Materials* Vol. 105: 196-205.

[8] Paris Jerry M., Roessler Justin G., Ferraro Christopher C., DeFord Harvey D., Townsend Timothy G. A review of waste products utilized as supplements to Portland cement in concrete. *Journal of Cleaner Production* Vol. 121: 1-18.

[9] Abdus Salam, Mohd Jumaat. Utilization of palm oil fuel ash in concrete: a review. *Journal of Civil Engineering and Management* Vol. 17: 234-247.

[10] Nwofor T.C., Sule S. Stability of groundnut shell ash (GSA)/ordinary portland cement (OPC) concrete in Nigeria. *Advances in Applied Science Research* Vol. 3: 2283-2287.

[11] Jnyanendra K. P., Sanjaya K. P., S.S. Basarkar. Concrete using agro-waste as fine aggregate for sustainable built environment – A review. *International Journal of Sustainable Built Environment* Elsevier Vol. 5: 312-333.

[12] Waqas Sarwar M., Nasir A., Rashid H., Aleem M., Ali R., Shakeel A. Environment friendly construction techniques using sunflower husk, rice husk and their ashes. *Journal of global innovation in agricultural and social sciences* Vol. 4: 117-120.

[13] Demis S., Tapali J.G., Papadakis V.G. An investigation of the effectiveness of the utilization of biomass ashes as pozzolanic materials. *Construction and Building Materials* Vol. 68: 291-300.

[14] Adesanya D.A., Raheem A.A. Development of corn cob ash blended cement. *Construction and Building Materials* Vol. 23: 347-352.

[15] Raheem A.A., Olasunkanmi B.S., Folorunso C.S. Saw Dust Ash as Partial Replacement for Cement in Concrete. *Organization, technology and management in construction* Vol. 4: 474-480.

[16] Madakson P.B., Yawas D.S., Apasi A. Characterization of Coconut Shell Ash for Potential Utilization in Metal Matrix Composites for Automotive Applications. *International Journal of Engineering Science and Technology* Vol. 4: 1190-1208.

[17] Olutoge B., Adeleke J. Characteristics Strength and Durability of Groundnut Shell Ash (GSA) Blended Cement Concrete in Sulphate Environments. *International Journal of Scientific & Engineering Research* Vol. 4: 2013-2122.

[18] Radeka M., Zekić V., Milić D., Malešev M., Radonjanin V. Physical, chemical and pozzolanic properties of biomass ash. *Proc. of* the 13th *International Conference* iNDIS - Planning, design, construction and building renewal: 114-127.

[19] Monita O., Annisa A. M., Lita D. Mechanical properties of seashell concrete. *Procedia Engineering* Vol. 125: 760 – 764.

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THE FIRE PROTECTION PLAN OF THE HIGHER EDUCATION TECHNICAL SCHOOL OF PROFESSIONAL STUDIES IN NOVI SAD

Abstract: The paper deals with the preparation of the Fire Protection Plan for Buildings of Category II of Fire Vulnerability. The Fire Protection Plan for Buildings is drafted according to the Law on Fire Protection “Official Gazette of the RS”, no. 111/09 and 20/15 and according to the Rulebook on the Manner of Preparation of The Content for the Fire Protection Plan in the Autonomous Province, Local Self-Government Units and Entities Classified under the First and Second Category, “Official Gazette of the RS” no. 73/2010 The fire protection plan for the school building included technical fire protection and prevention measures which should be taken to prevent the occurrence of fires, or their containment, localization and extinguishing at the initial phase, in case the fire still occurs in spite of applied technical measures.

Key words: Fire, protection, plans, prevention measures,

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1. INTRODUCTION

The danger of fires is always present. They can start in any environment and circumstances which contain all the factors or elements required for burning and fire. Even though the source of the fire can be a self-combustion or self-ignition process, the basic cause of a fire is human negligence, neglect or intention. Preventive fire protection is ensured by planning and implementation of preventive measures and actions to efficiently prevent occurrence of fire, and in the case of actual fires, to minimize risks to the life and wellbeing of people and damage to material property and the environment and to contain the fire to the place of its occurrence. For the purposes of protection of persons and property from fire, and based on the Law on Fire Protection ("Official Gazette of the RS", no. 111/2009 and 20/2015 of 20th February, 2015), in force since 4th March, 2015, it was stipulated that all legal entities and entrepreneurs must possess a fire protection plan, should they be classified into the Category I and II of fire vulnerability. The goal of this paper is to determine measures to achieve maximum protection against fire on the basis of the fire vulnerability assessments, purpose of the building, type, amount and the physical and chemical characteristics of materials present at the location. The fire protection plan for the school building includes technical fire protection and preventive measures which should be taken to prevent the occurrence of fires, or their suppression, localization and extinguishing at the initial phase, should the fire still start in spite of the applied technical measures. The plan stipulates prevention measures to remove the risks for creating conditions that cause fires and explosions or to minimize these risks. To establish efficient fire protection, the proposed solutions are financially realistic, technically feasible and technologically modern.

2. CURRENT STATE REVIEW

Building surface: 2614.84 m^2: Administration building surface - 844.96m^2, Laboratory building surface - 1319.88m^2.

- Number of employees: Around 70 professors, non-teaching and hired staff.
- Type of technology for buildings and other structures

The basic activity of the School is higher education of the I degree of professional studies for bachelor professional studies, higher education of the II degree of studies for specialist professional studies, education of adults in various areas, publishing, general mechanical works, engineering, designing in various areas and research and development in technical, technological and multidisciplinary sciences, etc.

The number and name of buildings and other structures: the building complex includes two buildings, the building which consists has a basement, ground floor and the first floor that are used for computer laboratories, a lecture hall, the archives and school administration (hereinafter: the administration building) and the building which consists of the ground floor and the loft, where the half of the of the total surface of the entire building excluding the loft, holds the amphitheater, mechanical workshop, technical maintenance facilities, chemistry and physics laboratories, computer laboratory, printing press and offices of professors (hereinafter: the laboratory building).

The entire building consists of the following organizational and technical units: administration offices, teacher's lounge, coffee kitchen, space under the stairs with storage rooms and hallways, parking spaces in the yard between the two buildings, office space (administration, utility services and similar), workshop, chemistry and physics laboratory, lecture hall, computer laboratory, server room, archives, sanitary facilities, watchman room with a fire-control (FC) system central for automatic fire reporting (see table number 1 and illustrations 1 and 2).

From the aspect of fire protection, these functionally connected units are especially important: Storage room and workshop, located on the ground floor of the business premises.

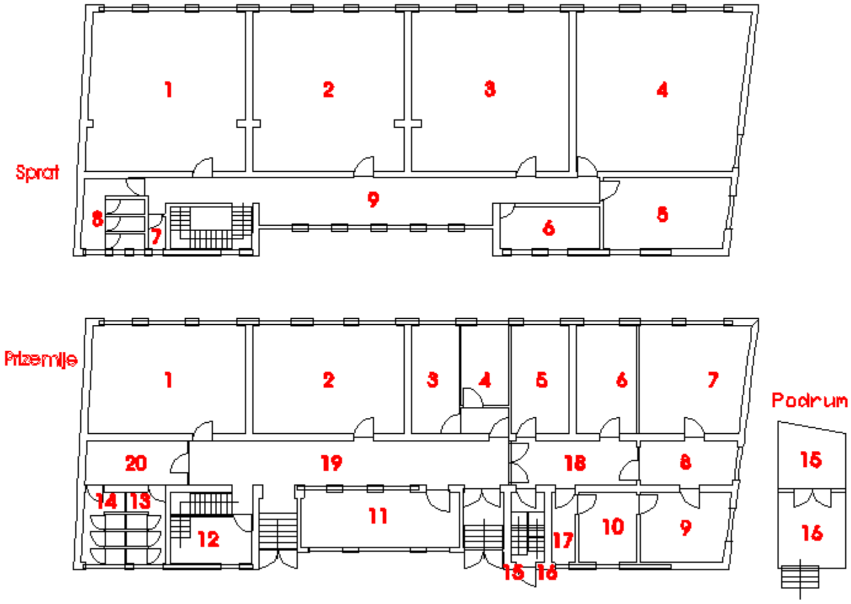

Figure 1 – Administration building plan, basement, ground floor and first floor, source: HETSPSNS

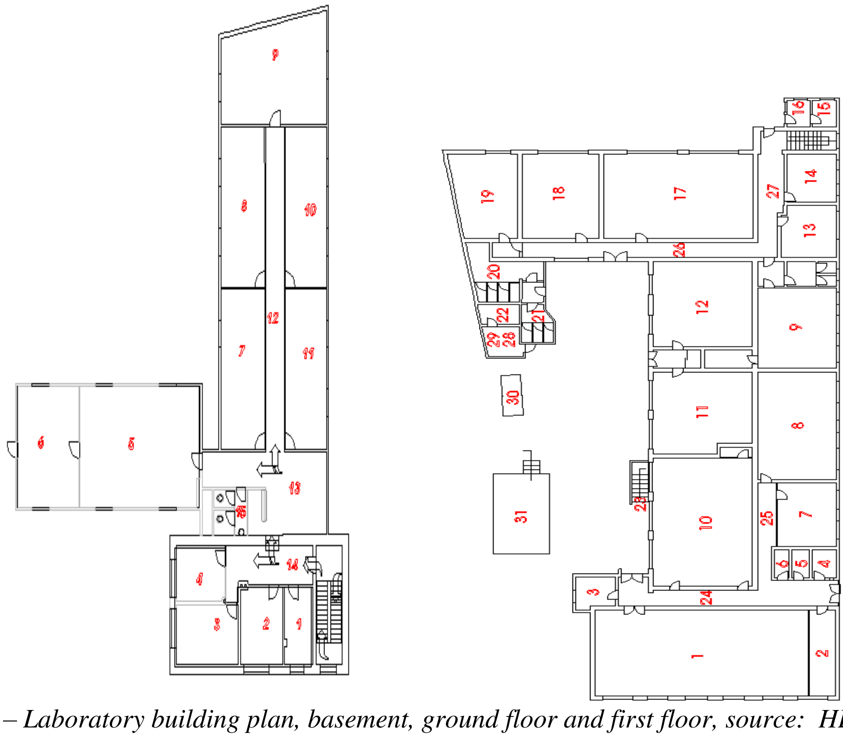

Figure 2 – Laboratory building plan, basement, ground floor and first floor, source: HETSPSNS

The building holds these flammable materials: paper; wood and wood panels (solid wood panels, plywood, particle board, raw (colored) and refined, MDF, HDF and similar); textile, artificial leather, eco-leather, upholstery, plastic canvas and small amounts of glue; flammable gases - butane; nitro dyes; paint thinners.

There is a possibility for the occurrence A, B and C category fires.

The hazard zone or the space in danger of explosions is the space with high likelihood of occurrence of an explosive concentration of flammable gases, fumes from flammable liquids or dust mixed with the air in concentrations higher than the acceptable concentration. The danger zones for occurrence of technological explosions are: the chemistry and technology laboratory - the laboratory has butane installations and there is a chance of explosions; the welding workshop (autogenous welding) - basic risk of managing acetylene at atmospheric pressure or pressure which is not much higher than the atmospheric conditions for all flammable gases. The possibility of explosion can be caused by accidental intake of air or ignition of flammable gas...

The central heating system of the School is connected to the city heating system. The heating bodies are radiators, the system in question is reliable with respect to the danger of starting and spreading of fires from fumes, water or other media.

The building, equipment and devices in the building were installed and configured in accordance to legal regulations that guarantee fundamental principles of reliability and safety of this technological facility. The obligations of the facility owner are to periodically control and test the equipment to ensure its safe operation in accordance with legal requirements. The determined deficiencies need to be removed immediately.

The school building was built of fire-resistant, non-flammable materials. If maintenance is regular and the building is used properly, there is no great threat of fire occuring.

The construction system of the building which holds the warehouse and workshop consists of reinforced concrete, while the supporting structure for the gallery is pre-fabricated (columns and beams). The structure and columns between the floors, together with the walls of the gallery facing the warehouse and workshop were covered with Rigips RF plasterboards with a mineral wool filling d = 5cm, protected by appropriate coatings to achieve the requiered fire resistance of 90 minutes. On the floor of the laboratory building, which is pre-fabricated, the structure beams are visible and they can be the potential soure of fire. The floor with professors' offices is covered with a network of sprinklers. The building is protected from atmospheric discharges with lightning rod installations.

In the sense of construction, the space is divided into fire sectors by walls, ceilings and doors of certain levels of fire resistance. The door on the fire resistant wall is resistant to fires, and attested according to SRPS. J1 160 supplied with the self-closing device, above which is a fire resistant wall up to the ceiling between floors. The main supply distributions on areas of passage through various fire resistant walls or ceilings are well enclosed by non-flammable materials. Separation of the warehouse and workshop space from other spaces was executed by fire resistant walls 2x, while the separation of the warehouse and the workshop from the communication space and the upstairs gallery was executed by fire resistant walls and ceiling 1.5x and fire resistant doors 1x. The construction system of the building which holds the warehouse and workshop consists of armored concrete, while the supporting structure for the gallery is pre-fabricated (columns and beams). The structure and columns between the floors, together with the walls of the gallery facing the warehouse and workshop were covered with Rigips RF plasterboards with a mineral wool filling d = 5cm, protected by appropriate coatings to have the requiered fire resistance of 90 minutes.

Asphalt road was laid up leading to the facility, but the passage for large vehicles is difficult, extending the time of arrival of the fire fighting teams. The plateau for the fire fighting vehicles meets all of the standards of the Rulebook of Technical Norms for Existing Roads, Turnarounds and Plateaus Designed for Fire Fighting Vehicles in the Vicinity of Buildings with Increased Risk of Fire ("Official Gazette of the RS", no. 8/95) in respect of the capacity of the roads and plateau (13 kN of basic pressure) and the lowest width of the road for one-way traffic of vehicles (3.5 m) or for two-way traffic

(6 m). The distance to the Fire Station (Jovana Subotića) is 3 km, and considering the distance and the average speed of the fire truck is around 50 km/h, the waiting time for the arrival of fire fighters is approximately 8 minutes (time for the call is 3 minutes, preparation time for the departure is 1 minute, and the time for movement of vehicles is 4 minutes). The roads are shown in Illustration 3.

Figure 3 – The plan of the School with existing roads, source: author

The building is connected to the waterways network of the public utility company "Water Supply and Sewage" Novi Sad for the required sanitary water and standpipe (Picture 4). The building has a standpipe and exterior hydrants shown on Picture 4: The manhole holds the valve to open the hydrants, contents of the hydrant box with a hose, wrench and two-piece hydrant extension on the plateau and an above ground hydrant in the yard of the laboratory building.

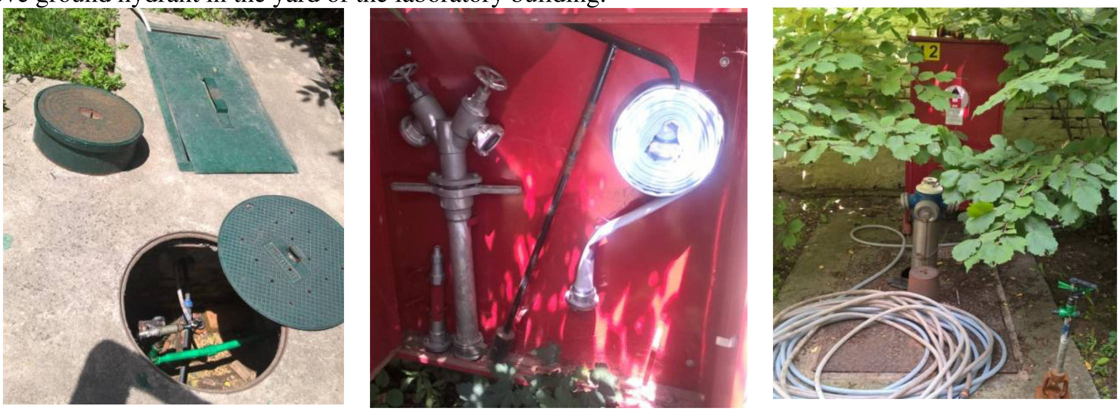

Figure 4 – Underground hydrant, contents of one hydrant box and above ground hydrant, source: author

The building has systems to report, detect and extinguish fires on the upper section of the laboratory building which is pre-fabricated and which is protected by a sprinkler system. Picture 5 shows the coverage of the sprinkler network on the upper floor, as well as the maintenance schedule.

The power supply for the building is enabled by a low voltage distribution network, by underground to the connected metering point. The point of connection onto the low voltage distribution network is a cable connection box on the exterior facade of the building, according to the conditions of the competent power supply distribution company "EPS DISTRIBUCIJA" ltd, Belgrade.

Distribution cabinets with automatic switches are installed on every floor of the building. All installed cables have insulation of conductors and jacket made of heat resistant PVC materials. The cable intersections are designed for the allowed charges, conditions for laying of cables, thus excluding the possibility of them overheating. All cars have a special yellow and green conductor which is connected to the protective contact in monophasic and triphasic OG connectors. All cables and lines are protected from short circuits by appropriate switches. All electrical installation lines are laid on the wall by using cable clamps. All equipment and tools for mechanical protection are appropriate for the location of installation.

Figure 5 – Sprinkler network with the card for regular maintenance; source: author (photographed on 28th May, 2018)

Communication means are land and mobile telephones.

The service for physical-technical security was organized according to clearly defined rules, duties and obligations.

The water for extinguishing fires is supplied from the city water supply network. The local water supply network is considered a reliable source of water required to extinguish a fire, there are no alternative sources for the water supply.

The technical equipment for fire protection includes equipment and tools for extinguishing, rescuing, fire detection, alerting and reporting to the FC system central, medical equipment and others.

Equipment and resources which the School possesses include: Fire extinguishers type S; Fire extinguishers type CO_2; Hydrant installations, more specifically: Inner pipe (diameter Ø = 52 mm) and wall-mounted hydrants with connectors for fire hoses (diameter Ø = 52 mm) and a nozzle (diameter Ø = 12 mm) (10 pieces); outer installation for 2 hydrants. The entire standpipe consists of 8 wall-mounted hydrants located on three floors: Two wall-mounted hydrants in the amphitheater; eight wall-mounted hydrants in school hallways; one hydrant on the plateau between the school buildings; one hydrant in the yard of the laboratory building. The building does not have a device to increase pressure (hydra-cell).

Fixed system for automatic fire alerts (one section of the building is covered, the one protected by the sprinkler system), but the entire building is covered by video surveillance.

All employees perform alerts on fire detection and fires, including all other disturbances on the building in general, the equipment and installations which could cause danger to life and wellbeing of people and property. Detection and reporting of fires, as well as alerting can be performed by automatic and manual fire alerts, on the fire extinguishing dashboard and alarms. Fires can be reported personally by phone to: the director or persons with special responsibilities, trained evacuation and rescue managers and the FEP officer. The same procedure is performed in case of danger of any kind of natural disasters. There are appropriate devices for detection and reporting of fires on sight in case of any unwanted events.

Fire can happen during the working hours and outside of working hours. If it happens during the working hours, it is usually detected on time so its localization and elimination can start. The employees in the vicinity are obligated to begin fire localization with available means and fire extinguishers, above all so as not to endanger themselves or others in the vicinity. On these occasions they must notify: the competent fire fighting unit, school management, the MoI and the Fire and Explosion Protection Officer.

In case the fire was detected late and cannot be extinguished with available means, fire extinguishers, hydrants, the competent fire fighting unit, the MoI, the school director and the Fire and Explosion Protection Officer are informed immediately. Until the arrival of the fire fighting unit, the director or managers of work units organize the available manpower, issue tasks and manage fire extinguishing, evacuation, rescue of people and carrying out of material assets from the burning buildings. Before extinguishing any fires on electrical and electronic devices, the power supply for the building must be shut down, as water cannot be used to extinguish fire on live cables and devices. If they are extinguished by water, a spray of fine water particles or water mist is used, depending on how close one can approach the fire.

3. THE FIRE VULNERABILITY ASSESSMENT

The fire vulnerability assessment is the procedure of determining the level of fire or explosion vulnerability and appropriate protective measures. The measures for prevention of starting and spreading of fire are determined on the basis of assessment, along with the measures for successful fire extinguishing. The fire risk assessment method was developed for the purpose of enabling a systematic assessment of fire risk in existing and new buildings. It is based on a combination of prevention, likelihood of occurrence and exposure to fire-related hazards. Starting from the defined fire scenario, the method performs prediction of fires, the degree of exposure of buildings and their contents to the risk and determination of the consequences. The area of fire protection includes a sequence of methods to evaluate fire risks and many of them have been confirmd in practice and have been used in our country and globally for many years.

The surface of the complex of the Higher Education Technical School of Professional Studies is 2614.84 m^2, as presented in Illustration 6. Asphalt road was laid leading to the facility, but the passage for large vehicles is difficult which extends the time of arrival of the fire fighting crews, thus it requires a regulatory parking system in the vicinity to ensure that the entrance is always accessible. Illustrations 7, 8 and 9 show the primary shortest access route for fire fighting units and two alternative routes.

According to SRPS TP 21-2003, evacuation roads are determined, while it is also required to follow all mentioned recommendations for the design of the building. According to the recommendations of SRPS TP 21, the preparation time for evacuation is: For residential buildings.....10 minutes; for business premises.......5 minutes; for public institutions......3 minutes (except for stadiums and sports halls, where the time is 2 minutes). After the report of the accident is done, if it is determined it is not a false alarm, all employees and visitors are notified. Evacuation managers must ensure that the evacuation exits are set in the position which does not obstruct persons to exit the building and begin evacuation The Higher Education Technical School of Professional Studies in Novi Sad regulated the manner of evacuation from the building (Illustrations 10, 11).

3.1. The fire protection measures that must be performed require significant financial investments which the subject of fire protection - legal entity should ensure through separately allocated funds

The fire protection measures which must be implemented immediately and which require significant financial investments refer to: the construction of fire exit stairs from the floor of the administration building, from the classrooms on the first floor; construction of the fire exit stairs from the floor of the laboratory building; removal of wooden stairs which lead onto the roof of the administration building and installation of fire resistant stairs; reconstruction of the floor of the administration building loft; removal of the room from the hallway in front of the classroom on the floor of the administration building; removal of the bars from the ground floor of the administration building and from a section of the ground floor of the laboratory building.

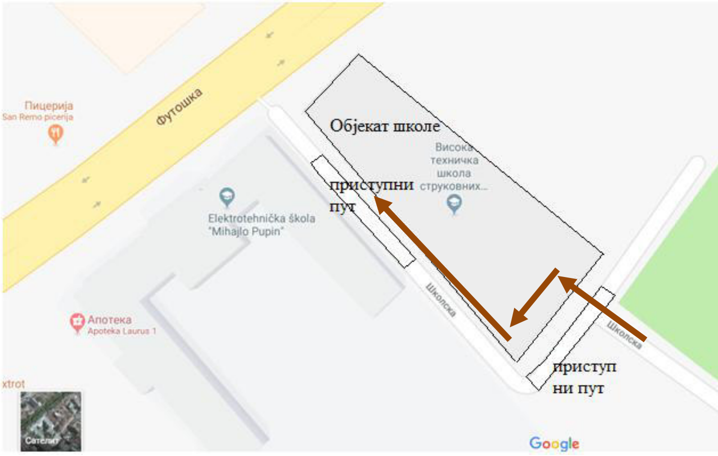

Figure 6 – Micro location with access roads, Source: author, https://www.google.com/maps/

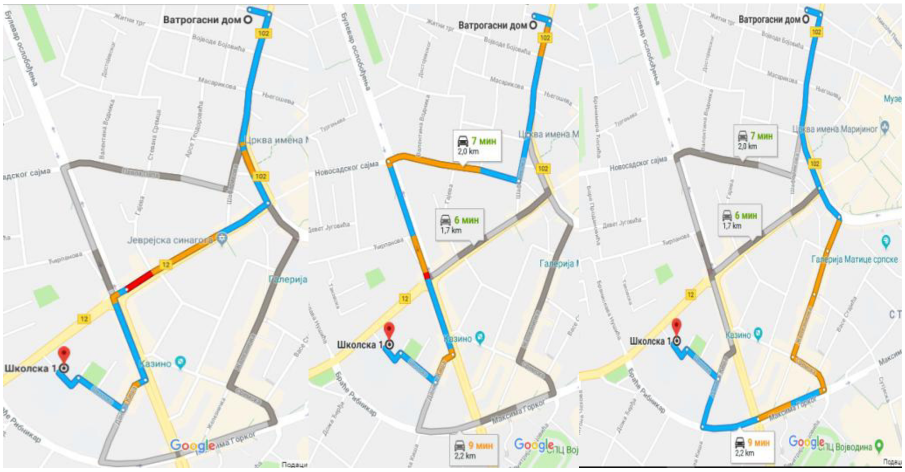

Figure 7, 8, 9 – Primary route, first alternative route, second alternative route of movement of the fire fighting team; Source: author, https://www.google.com/maps/

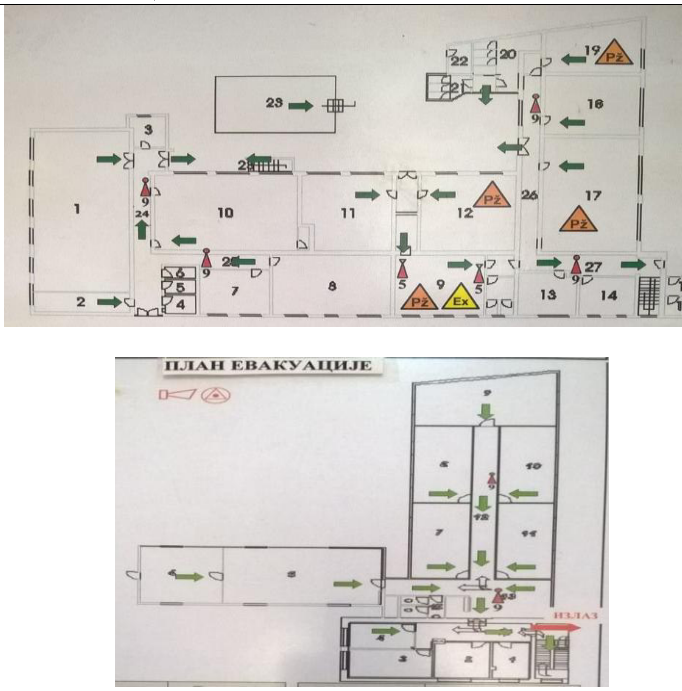

Figure 10 – Evacuation route from the ground floor of the Laboratory building, from the first floor of the Laboratory building, with room numbers; source: author

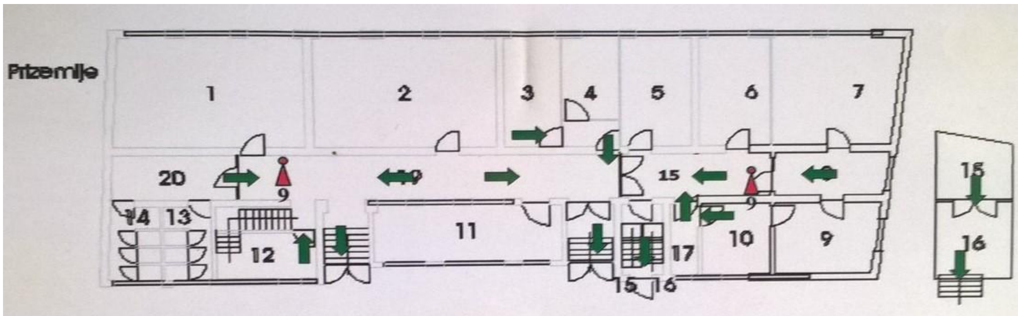

Figure 11 – Evacuation route from the ground floor of the Administration building; source: author

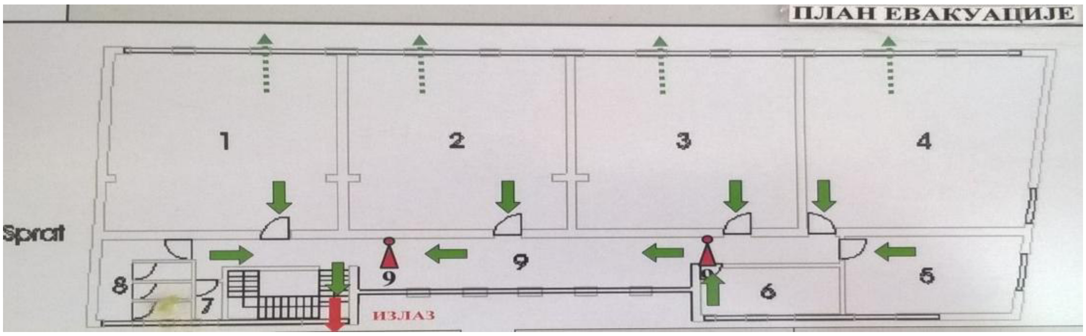

Figure 12 – Evacuation route from the first floor of the Administration building with explained symbols; source: author

4. CONCLUSION

For the past 20 years, fires in Serbia have been shown an exponential increase. The principle of prevention and fire protection may not be accompanied by social awareness, but is included by legal regulations to a great extent. Implementation of the Law can significantly improve the success of extinguishing new fires. Prevention in terms of fire protection is ensured by planning and implementation of preventive measures for purposes of efficient protection of human lives, material assets and the environment.

The Rulebook on the Manner of Preparation and the Content for the Fire Protection Plan in the Autonomous Province, Units of Self-Government and Entities Classified under the First and Second Category of Fire Vulnerability determine the manner of drafting of the Protection plan. The Higher Education Technical School of Professional Studies in Novi Sad performs education for tasks related to fire protection as one of the leading institutions of this kind. The School meets all of the conditions prescribed by this Rulebook. The entire facility is equipped with fire extinguishers and the employees attended fire protection training and know how to react in case of danger. Some of the mentioned items that should be technically modified, for instance the evacuation route from the floor of the administration building and the floor of the laboratory building, followed by construction of fire exit stairs and reconstruction of the ceiling in the administration building, purchase of windows resistant to mechanical impacts after the proposed removal of the bars from the ground floor, all require significant financial investments and serious reconstruction. Also, as part of legally stipulated regulations, the School organized and implemented evacuation drills, which trained the students who attended the School to be significantly more prepared to react in situations of crises and danger. The School is a rare example, if not the only example of this practice. The degree of implementation of fire protection measures in the School carried out by of the employees and in the technical sense is on a satisfactory level, and by correcting the mentioned deficiencies, it could show a growth tendency and set standards for tasks related to fire protection.

5. LITERATURE

[1] Law on Fire Protection “Official Gazette of the RS“ no. 111/2009

[2] The Rulebook on the Manner of Preparation of the Content for the Fire Protection Plan in the Autonomous Province, Self-Government Units and Entities Categorized in the First and Second Category, (“Official Gazette of the RS” no. 73/2010)

[3] JUS TP 21, Technical Recommendations for Urban and Civil Engineering Fire Safety Measures for Residential, Commercial dnd Public Buildings, the Institute for Standardization, Belgrade, 2002.

[4] Regulation on the Fundamentals, Measures and Conditions for Classification of Organizations and Agencies in Appropriate Fire Vulnerability Categories “Official Gazette of the RS“ no. 58/89 and 4/90

[5] The Rules of Fire protection of the Higher Education Technical School of Professional Studies in Novi Sad

Dragana PRIDRAŠKI[1]
Branko BABIĆ[2]

PRACTICAL TRAINING FOR STUDENTS OF CIVIL PROTECTION FOR PARTICIPATION IN PROTECTION AND RESCUE OPERATIONS

Abstract: The paper deals with the training of students at the civil protection and rescue study course for emergencies in practical forms such as skiing, scuba diving and alpinism training. The training was performed according to the training curriculum, the instructors were professionals in the Army of Serbia, the Gendarmerie and instructors from Kopaonik. The training was conducted in the period from 2009 to 2017 and over the cycle of eight years and it included around 120 students who underwent all three kinds of training. This provided a great contribution to the system of protection and rescue during emergencies in the Republic of Serbia.

Key words: Skiing, scuba diving, alpinism, training, system for protection and rescue

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1. INTRODUCTION

Civil protection and rescue operations during emergencies is a study program which deals with theoretical and practical training in the area of the defence system of the Republic of Serbia, with particular focus on civil defence and the system of protection and rescue of the population, material and cultural property during emergencies [1].

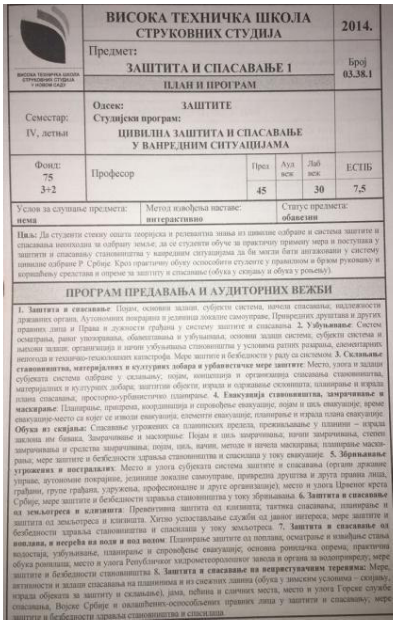
To acquire the necessary knowledge from the area of primary and secondary education on the subject of personal and collective protection, citizens are educated and trained for preventive protection and rescue. The training is performed within primary and secondary education to acquire knowledge on the dangers from natural and other disasters and protection from them, in accordance with the special law and appropriate program.

The members of civil protection services are educated and trained to perform tasks of civil protection through courses, seminars, trainings, exercises and safety drills.

2. THE CURRICULUM

The curriculum for the study course on civil protection and rescue operations during emergencies was accredited in 2012. The training program consists of lectures and exercises shown on Picture 1. Training in skiing and scuba diving was performed during the second year of studies (winter and summer semesters), while the training in alpinism was conducted in the third year (6th semester). The skiing training was completed at Kopaonik, the scuba diving training was performed in a swimming pool, in Bela Crkva and on the Dobrodol lake on Fruška gora, while the alpinism training was organized at Orlovo Bojište at Fruška gora.

Apart from the students of the School, the training was also attended by students from St Petersburg during the international exchange.



ВИСОКА ТЕХНИЧКА ШКОЛА СТРУКОВНИХ СТУДИЈА У НОВОМ САДУ	ВИСОКА ТЕХНИЧКА ШКОЛА СТРУКОВНИХ СТУДИЈА					2014.
	Предмет: ЗАШТИТА И СПАСАВАЊЕ 1					Број 03.38.1
	ПЛАН И ПРОГРАМ					
Семестар: IV, летњи	Одсек: ЗАШТИТЕ Студијски програм: ЦИВИЛНА ЗАШТИТА И СПАСАВАЊЕ У ВАНРЕДНИМ СИТУАЦИЈАМА					
Фонд: 75 3+2	Професор	Пред	Ауд веж	Лаб веж		ЕСПБ
		45		30		7,5
Услов за слушање предмета: **нема**	Метод извођења наставе: **интерактивно**			Статус предмета: **обавезни**		

Циљ: Да студенти стекну општа теоријска и релевантна знања из цивилне одбране и система заштите и спасавања неопходна за одбрану земље, да се студенти обуче за практичну примену мера и поступака у заштити и спасавању становништва у ванредним ситуацијама да би могли бити ангажовани у систему цивилне одбране Р. Србије. Кроз практичну обуку оспособити студенте у правилном и брзом руковању и коришћењу средстава и опреме за заштиту и спасавање (обука у скијању и обука у роњењу)

ПРОГРАМ ПРЕДАВАЊА И АУДИТОРНИХ ВЕЖБИ

1. Заштита и спасавање: Појам, основни задаци, субјекти система, начела спасавања, надлежности државних органа, Аутономних покрајина и јединица локалне самоуправе, Привредних друштава и других правних лица и Права и дужности грађана у систему заштите и спасавања. **2. Узбуњивање**: Систем осматрања, раног упозоравања, обавештавања и узбуњивања, основни задаци система, субјекти система и њихови задаци; организација и начин узбуњивања становништва у условима ратних разарања, елементарних непогода и техничко-технолошких катастрофа. Мере заштите и безбедности у раду са системом. **3. Склањање становништва, материјалних и културних добара и урбанистичке мере заштите**: Место, улога и задаци субјеката система одбране у склањању; појам, концепција и организација спасавања становништва, материјалних и културних добара; заштитни објекти, израда и одржавање склоништа; планирање и израда плана спасавања; просторно-урбанистичко планирање. **4. Евакуација становништва, замрачивање и маскирање**: Планирање, припрема, координација и спровођење евакуације; појам и циљ евакуације; време евакуације-место са којег се изводи евакуација; елементи евакуације; планирање и израда плана евакуације **Обука из скијања:** Спасавање угрожених са планинских предела, преживљавање у планини – израда заклона им бивака. Замрачивање и маскирање: Појам и циљ замрачивања; начин замрачивања, степен замрачивања и средства замрачивања; појам, циљ, начин, методе и начела маскирања; планирање маскирања; мере заштите и безбедности здравља становништва и спасилаца у току евакуације. **5. Збрињавање угрожених и настрадалих**: Место и улога субјеката система заштите и спасавања (органи државне управе, аутономне покрајине, јединице локалне самоуправе, привредна друштва и друга правна лица, грађани, групе грађана, удружења, професионалне и друге организације); место и улога Црвеног крста Србије; мере заштите и безбедности здравља становништва у току збрињавања. **6. Заштита и спасавање од земљотреса и клизишта**: Превентивна заштита од клизишта; тактика спасавања, планирање и заштита од земљотреса и клизишта. Хитно успостављање служби од јавног интереса; мере заштите и безбедности здравља становништва и спасилаца у току земљотреса. **7. Заштита и спасавање од поплава, и несрећа на води и под водом**: Планирање заштите од поплава, осматрање и извиђање стања водостаја; узбуњивање, планирање и спровођење евакуације; основна ронилачка опрема; практична обука ронилаца; место и улога Републичког хидрометеоролошког завода и органа за водопривреду; мере заштите и безбедности становништва **8. Заштита и спасавање на неприступачним теренима:** Мере активности и задаци спасавања на планинама и из снежних лавина (обука у зимским условима – скијању, израда објеката за заштиту и склањање), јама, пећина и сличних места, место и улога Горске службе спасавања, Војске Србије и овлашћених-оспособљених правних лица у заштити и спасавању; мере заштите и безбедности здравља становништва и спасилаца

Figure 1 – The curriculum for the subject Protection and Rescue 1

Third year students first need to pass the theoretical part of the training before starting the part of the course pertainig to rock climbing. Following this, practical training is performed on Fruška gora where there are adequate conditions for this training [3]. Picture 2 shows the activities during the practical training sessions.

Figure 2 – Training - scuba diving, alpinism, skiing [3]

3. TRAINING OF STUDENTS ON THE HIGHER EDUCATION TECHNICAL SCHOOL OF PROFESSIONAL STUDIES IN NOVI SAD

Students of the Higher Education Technical School of Professional Studies in Novi Sad had mandatory **alpinism** training held at the end of May every year. Apart from our students, the training was also attended by students from the Russian Federation. The training instructor was Obrad Kuzeljević, member of the Gendarmerie. The training lasted two days. The first training day (Picture 3) included theory, introduction and handling of the equipment. After the theoretical part, there was a knot tying presentation, to enable safe rappelling down the rock without any injuries and falls. After the theoretical section and the presentation, training continued on the Petrovaradin fortress, where there is a 15 m rock used for practical exercises, so the teams could prepare for different kinds of rocks. Each student was informed and trained how to safely rappel down the rock. During rappelling down the rock, participants use the descending device "Grigri", static rope and safety knots such as the overhand and the figure eight knots.

Figure 3 – Training of students in alpinism [3]

The second training day (Picture 4) took place at Orlovo bojište on Popovica, Fruška Gora. The rock formations at Orlovo bojište are 50 m high. After the successful preparation of equipment, the rappelling started. To perform the exercise as fast as possible, rappelling was carried out in pairs, together with students from Russia.

When they reached the ground, instructors explained how to perform the exercise of technical rope ascending, which is climbing up the rope with the Grigri device.

Figure 4 – The alpinism exercise with students [3]

Professional climbing equipment was used during this exercise (Picture 5): clothes, pants, gloves, shoes - boots (one-piece and two-piece boots) and all accompanying equipment: static rope, single rope, half rope, twin rope, helmet, sit harness, chest harness, one-piece harness, carabiners, Grigri...

Figure 5 – Part of the climbing equipment [5]

The **scuba diving** training (Pictures 8 and 9) was conducted in a swimming pool and in open waters, on the lakes of Bela Crkva and the Dobrodol lake. The professional equipment used for the training was purchased by the School for the purposes of this training. The training was conducted according to the curriculum by the Scuba Diving Club Mornar from Novi Sad, a professional club whose members come from the River Flotilla of Novi Sad. The first day - theoretical lecture about the equipment used for scuba diving in the Scuba Diving Club Mornar in Petrovaradin. The second day of the training was held at the swimming pool where they learned how to put on suits and use the other equipment. Apart from this, they learned how to breathe without the mask. The third day - putting on and using the entire equipment during a dive, along with the oxygen tanks. The fourth day - practicing buddy breathing in pairs which is performed with two people breathing from one regulator. This is performed if one of the tanks is emptied during dives into deep waters. This is the reason for scuba diving in pairs. The fifth day - practicing taking off a part of the equipment under water, as well as rescuing a person in case of any incidents. After this, students practiced taking off their entire equipment under water and leaving it on the bottom of the pool. During the dive out, the person was supposed to remember where the equipment was, so they could be able to return it onto themselves without additional means [3]. After the pool training, the students made their first dive in open waters. During the first visit to the lake, the equipment was prepared, they were divided into teams so all of them could reach the bottom of the lake with their instructor and assistants. The visibility was bad due to rain two days before the dive. Two or three students were accompanied by one instructor. Students had to be tied together by rope so they would not get lost. Depth was monitored over the depth meter.

As in alpinism, all required training equipment was used (Picture 6): Diving suit, mask, flippers, snorkel, belt with weights, buoyancy vest, diving tanks, hydraulic compressor, diving boots, gloves, socks and hood , manometer, depth meter, diving watch, diving knife, underwater lamps, signal flags and buoys....

Figure 6 – Diving equipment [10]

During training, special attention was paid to diving illnesses – barotauma (affecting ear, sinuses, lungs), arterial gas embolism, decompression injuries; proper use of decompression tables; treatment measures for diving illnesses. Treatment of decompression illnesses was performed in the barometric chamber (Picture 7), and one of the barometric chambers is located at the River Flotilla in Liman IV in Novi Sad [6], which the students visited.

Figure 7 – Barometric chamber [3]

Figure 8 – Scuba diving training for students - swimming pool [3]

Figure 9 – Scuba diving training for students - open waters [3]

Skiing training was organized at Kopaonik. A mandatory part of training was a lecture concerning first aid - lecture and practical segment of first aid (Picture 10). Apart from our students, the training was also attended by students from Bulgaria and the Russian Federation. A representative of the Red Cross City Organisation form Subotica was the first lecturer (at the time a student of the Higher Education Technical School). The following practical procedures were covered: How to apply bandages and immobilize injured body parts; how to approach a person who is unconscious; how many exhales and cardiac massages to perform to help an injured person; how to transport the injured from the ski track... [3].

Figure 10 – First aid training for students [3]

The second training day included the introduction and renting equipment, skiing on a hill near the hotel and preparing students for the ski slope (Picture 11). The third training day included going out onto the ski slopes. The first ski path was “Mašinac” which is one of the easiest on Kopaonik, in essence, a track for beginners. With the help of their instructors, the students received an overview and explanation of skiing techniques and an introduction to the equipment. During the fourth day - the group visited all ski paths and ski lifts [3].

Figure 11 – Ski training for students [3]

Skiing equipment (Picture 12) was rented, and set in a way to alleviate risks of injuries. The skiing equipment includes: skis with bindings, ski boots, ski poles, ski jacket, ski pants, ski cap, ski gloves, ski glasses, sun glasses, protective cream, waxes [22].

Figure 12 – Skiing equipment - part [24]

4. CONCLUSION

Civil protection is an organized response of the state to various disasters which could pose a risk to people, animals, property, cultural heritage, environment. It includes planning (organizing) and implementing measures and activities, their monitoring and financing, education and training for the personnel, international cooperation, etc. Measures and activities of civil protection aim to protect and save lives during natural disasters (earthquakes, land slides, rockfall, strong winds, hail, fog, drought, blizzard), technical-technological disasters (ionizing radiation, chemical contamination, fires, traffic accidents, work accidents), consequences of terrorist attacks, war and other disasters. All of this is performed in accordance with national and international laws, principles of humanitarian rights and the ratified conventions and declarations.

The Higher Education Technical School of Professional Studies was established in 1959, when it was founded by Decision of the Provincial Council of the Assembly of the Autonomous Province of Vojvodina, with the address at 1 Školska Street. In 1974, Civil Protection was formed within the Department for Protection.

In 2007, the school received accreditation and became the Higher Education Technical School of Professional Studies with fourteen bachelor and seven specialist professional study courses, re-accredited in 2012 and 2017.

The school developed close cooperation with the State Fire Prevention Service of the Ministry for Emergencies of the Russian Federation through the University of Saint Petersburg, which is performs activities pertaining to protection and rescue during emergencies. For several years, a group of our final year students of civil protection has been having practice exercises with students in their fire brigades and centers for training of rescuers (Saint Petersburg, Vitegra, Murmansk), and students from the Russian Federation come to Serbia to perform training in scuba diving, alpinism and skiing with our students of civil protection.

We believe that the school has provided a humble contribution to the education of young people in the field of preparation for action in emergencies. Upon completing their studies, students can find employment in one of the local self-goveremnents, in some companies and other legal entities, and of course in MoI, at the Division for Emergencies. The performed training is certainly a good starting point for further education in the field of protection and rescue of the population as well as their material possessions and cultural heritage.

5. LITERATURE

[1] http://vtsns.edu.rs/odsek-zastite/#cz

[2] http://prezentacije.mup.gov.rs/svs/HTML/inspekcijski%20nadzor2.html

[3] Author

[4] http://gss.rs/

[5] Training instruction materials for alpinism 2017.

[6] Training instruction materials for scuba-diving 2016.

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BEHAVIOR OF FIBER REINFORCED CONCRETE EXPOSED TO FIRE LOAD

Abstract: Concrete is a complex composite whose behavior in fire load depends of all component materials. In this paper are analyzed investigations undertaken so far at the area of fiber reinforced concrete (FRC) behavior in the exposure to the high temperatures. The type, quantity and size of fibers in these concretes directly affect its physical-mechanical properties, before and after exposure to fire. The most favorable behavior showed the so-called, hybrid fiber reinforced concrete (steel + polypropylene), taking into account spalling, ductility, and mechanical properties at high temperatures.

Key words: fiber reinforced concrete, fire load, physical-mechanical properties, spalling, ductility, hybrid fiber reinforced concrete

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1. INTRODUCTION

A fire load falls into a group of dynamic loads that suddenly arises and whose effect on construction objects as well as humans can be fatal. For this reason, it is necessary to get acquainted with the basic characteristics of building materials and their behavior in exposure to very high temperature. Concrete is the building material that has the widest application of all materials. Since it is composite material, its mechanical properties depend on each component. Namely, each component affects on its resistance and behavior after exposure to elevated temperatures. Many researchers around the world have studied the behavior of this material at fire loads, and on the basis of the concrete mix composition, obtained results that favor or damage the concrete resistance after the fire load. Primarily, its physical-mechanical properties in high-temperature exposure depend on the type of aggregates, cement type, water-cement ratio, ratio of aggregate used in relation to cement and the amount of free water in concrete mix [3]. Concrete has a low thermal conductivity value which makes it highly resistant to high-temperature because the heat itself is spreading slower to the internal structure and slower gets to an armature that is very sensitive to fire load [9].

Most of the concrete mix is precisely the aggregate, and it is necessary to know which types of aggregates show the best behavior under conditions of very high temperature. Studies have shown that aggregate based on dolomite, limestone and aggregate of recycled bricks and granulated slags show good properties at elevated temperatures [5]. On the other hand, an aggregate having a higher percentage of quartz grain shows unfavorable properties at fire load [5]. It has also been found that additions to concrete such as granulated slag, fly ash and silica fume provide a good fire resistance [5]. A lower water-cement ratio improves the properties of concrete exposed to high temperatures [18]. It has been shown that the reduction in compressive strength as well as the modulus of elasticity with a higher water-cement ratio (w/c = 0.6) is greater than with a lower water-cement ratio (w/c = 0.28-0.35) [18]. However, concrete with lower water-cement ratio is more exposed to spalling at lower temperatures than concrete with a higher factor, where the spalling occurs at significantly higher temperatures. When the concrete humidity is increased, possibility of concrete spalling increases.

Fiber reinforced concrete is particularly interesting in view of the fact that in such concrete mix can vary the type, shape and amount of fiber. Many scientific papers have studied the influence of steel [6,7,810,13,16], polypropylene [7,11,15], hybrid (combination of steel and polypropylene) [7,11], carbon and glass [2,4,12,14,17] fibers, and the results showed that generally fiber reinforced concrete exhibits greater resistance to exposure and after exposure to high temperatures rather than non-fiber-containing concrete. This paper summarizes the results of these researches, and gives the advantages and disadvantages of each of the above mentioned fibers. Many researchers have used various methods of testing and preparing specimens for the experimental part of the research. Namely, some researches examined the basic mechanical properties of the specimens at room temerature previously exposed to high temperatures, as opposed to some of the research results were obtained on hot specimens [11].

2. BEHAVIOR OF FIBER REINFORCED CONCRETE EXPOSED TO FIRE

Fiber reinforced concrete has found extensive application in the construction industry primarily due to its characteristics that improve the toughness and ductility of concrete. The advantage of fiber reinforced concrete is multiple. This concrete also increases some mechanical properties of concrete such as tensile, flexural and shear strength, then reduces uncontrolled cracking, strengthens concrete frost resistance and increases wear resistance. In view of the above mentioned advantages of concrete, it has particularly found application in the construction of objects on roads such as tunnels, bridges etc. This concrete has also exhibited good properties when exposed to some dynamic loads, so its application is significant on objects exposed to high temperatures or sudden fire exposure. After exposure to fire, the bond between the fibers and the structure of the concrete mixture is reduced, and the characteristics of the concrete such as stiffness and strength are reduced. It fractures after reaching the critical temperature, which is different for each type of fiber.

2.1. Steel fiber reinforced concrete

Steel fibers improve the mechanical properties of concrete, and are one of the most commonly used types of fibers. It is often used instead of concrete reinforcement, but it is most commonly used as a lining in tunnels, concrete slabs in building construction and as a base for traffic infrastructure objects. Its positive properties in concrete depend primarily on the volume fractions in the concrete mix, as well as the aspect ratio (l/d). The most commonly used is the proportion of steel fibers in concrete mass of 0.25% up to 2.5% with a diameter of 0.25 to 0.76 mm and aspect ratio of 50 to 100.

Based on scientific papers [6,7,8,10,11,13,16], this type of fibers advantageously influences the mechanical properties after exposure to fire. Namely, compressive strength, tensile strength and flexural strength, elasticity modulus, and toughness are improved by applying these fibers after exposure to fire in relation to non-fiber concrete. Based on the research [6], the fiber reinforced concrete with the steel fibers and recycled aggregate significantly reduces the cracks width caused by the heating of the specimens, and if the amount of fiber is larger the width of the cracks are smaller. Residual compression strength at temperatures of 200˚C, 400˚C and 600˚C is repetitively 85%, 59% and 31% of the initial value on room temperature. After exposure to the temperature of 600°C residual compressive strength of fiber reinforced concrete with steel fibers in volume fractions up to 1.5% is 1.92 times higher than without steel fibers [6]. On the other hand, drop of the stiffness due to heating is greater than the drop of the compression strength, while the loss of toughness is smaller, with in mind that on temperature of 200˚C toughness is growing even for a moment [6].

Based on the research of mechanical properties of ordinary concrete and fiber reinforced concrete with steel fibers, the fiber reinforced concrete exhibited a higher compressive, tensile and flexural strength [16]. It is believed that the increase in compressive strength of fiber reinforced concrete with steel fibers compared to ordinary concrete is 6-10%, the tensile strength 0-12% and the flexural strength 0 to 20%, as shown in Figures 1, 2 and 3 [16].

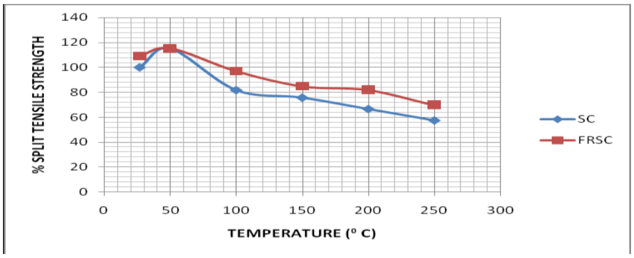

Figure 1- Comparison of variation split tensile strength with temperature for SC and FRSC [16]

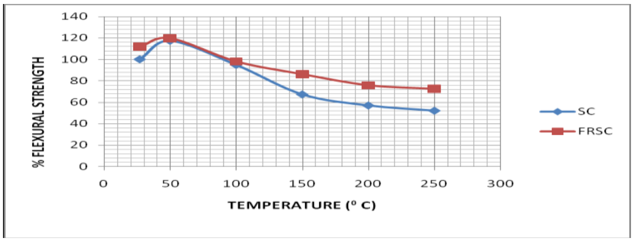

Figure 2 - Comparison of variation flexural strength with temperature for SC and FRSC [16]

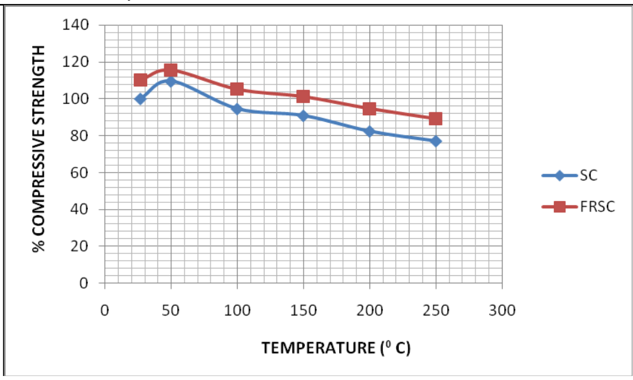

Figure 3 - Comparison of variation compressive strength with temperature for SC and FRSC [16]

The addition of steel fibers on concrete mass of 1% and 2% improves compressive strength when the temperature reaches 400˚C, but the ductility drops faster after reaching the maximum strength value over the non-fiber concrete [15]. Similarly, these concrete can reach higher temperature values than those without fibers but the cooling is much slower [15]. If 1% of short steel fibers are added, the post-cracking residual flexural strength increases in concrete at room temperature but also at temperatures up to 800˚C, but on the other hand there is incensement the explosive spalling concrete until the fracture [8]. In fact, some studies show that steel fibers slightly affect the compression strength while considerably affect the tensile strength at temperatures around 400˚C [10,11]. Tensile strength at higher temperatures is much more susceptible to volume fraction and aspect ratio than to its type [10]. Kim has proven that the loss of tensile strength is much greater than the compressive strength at 700˚C, while the toughness loss is smaller [10]. Increasing the content of these fibers from 0% to 1% increases the tensile characteristics of concrete as well as toughness [10]. If the aspect ratio of these fibers is observed, it has been found that the fiber reinforced concrete with the aspect ratio l/d = 80 hooked and twisted show better tensile strength and toughness than the hooked fibers with the aspect ratio l/d = 60. This increase is higher if the volume fraction in the concrete mix is higher [10].

Rodrigues investigated reinforced concrete columns on fire load with polypropylene and steel fibers, that showed good properties primarily increased ductility with the presence of steel fibers at moments when in concrete are formed first cracks [13]. The substitution of steel fibers with steel reinforcement is not desirable, and particularly not on constructive elements such are the columns [13]. Choumanidis has come to the conclusion that from all of the fibers, steel fibers exhibit the best properties when first cracks in concrete are formed [7]. Burrati proved that steel fibers exhibit greater toughness than synthetic, while Sideris investigated high performance concrete and concluded that adding these fibers does not eliminate spalling of concrete exposed to elevated temperatures. Choumanidis came to the conclusion that the steel fibers at high temperatures show the best mechanical properties such as compressive strength, flexural strength and high ductility at room temperature and elevated temperatures [7].

2.2. Polypropylene fiber reinforced concrete

Synthetic fibers have multiple uses in construction. Namely, these fibers increase spalling resistance of the concrete and thus improve the properties of concrete after exposure to elevated temperatures. Polypropylene due to its physical and mechanical properties reduces permeability and capillary porosity using the optimal amount of polypropylene 0,7 kg/m^3 [15]. Likewise, the ability of polypropylene to reduce the crack in concrete is reflected in the fact that when the temperature is reached between 80°C and 130˚C the polypropylene begins to melt filling the cracks, creating channels that allow the water in the concrete to escape from the concrete and thus prevent stresses water vapor within the concrete structure [15].

Some studies have shown that the compressive strength of concrete with addition of polypropylene in a ratio of 1% and 2% relative to the cement paste is greater than the compressive strength with addition of steel fibers in the same proportion and smallest for concrete without fibers after exposure to high temperatures up to 400˚C [15]. The same research has shown that concrete without fibers before and after exposure to fire shows explosive and more sudden fracture with wider and deeper cracks than concrete with polypropylene and steel fibers [15]. Under normal environments conditions, concrete with additions of polypropylene fibers reaches higher strength values, but also higher values of deformations after exposed to elevated temperatures then the concrete without additions [15]. The best behavior of this concrete is with 1% of these fibers [15]. Concrete with polypropylene fibers achieves significantly lower temperature compared to concrete with steel fibers and non-fiber concrete [15]. Figure 4 shows cylindrical samples of concrete with steel and polypropylene fibers before and after exposure to high temperature.

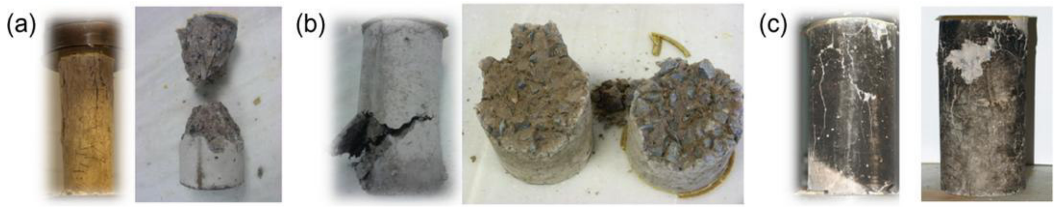

Figure 4 – Compression test in cylinder specimens before the fire test with (a) steel (b) polypropilene, (c) compression test in specimens with steel fibers after the fire test [15]

On the other hand, some researchers argue that polypropylene has negative effects on mechanical properties of concrete after exposure to high temperatures [11]. The compressive strength, modulus of elasticity and tensile strength using polypropylene decreases at high temperatures [11]. Namely, it is considered that polypropylene does not have great influence on the compressive strength at temperatures of 200°C and 400°C but at 600°C significantly increases the compressive strength [11]. Siders and Manita [7] have shown that polypropylene in self compacting concrete exhibits extremely high resistance to spalling at high temperatures. Choumanidis concluded that polypropylene fibers with longer fibers exhibit the same or slightly improved tensile and ductile strength characteristics at room temperature, but at higher temperature all characteristic are lost [7]. Use of polypropylene with short fiber concrete shows better mechanical properties than polypropylene with long fibers [7].

2.3. Hybrid (steel+polypropylene) fiber reinforced concrete

Hybrid fiber reinforced concrete is a concrete created by mixing several types of fibers to improve the basic characteristics of concrete. Given the fact that each type of fiber has its advantages and disadvantages by mixing it we can get concrete of the improved characteristics. The most commonly used hybrid concrete is a combination of polypropylene and steel, and most of the scientific work is focusing on the application of this fiber reinforced concrete as a preventive protection of the concrete from fire.

From previous research it is clear that steel fibers improve mechanical properties, ductility and toughness when exposing concrete to fire, on the other hand polypropylene affects its spalling resistance. By combining these two types of fiber the concrete gets both improved mechanical properties as well as the resistance to cracking, and reducing the spread of the cracking.

Choumanidis investigated hybrid fiber reinforced concrete with a combination of short and long polypropylene fibers, short polypropylene and steel fibers and long polypropylene and steel fibers [7].

The results showed that the combination of short steel fibers and polypropylene is the best option for improving the mechanical properties and ductility of the concrete, while the lowest resistance and ductility on high temperatures showed have concrete with long and short polypropylene fibers [7]. Although polypropylene fibers reduce ductility in hybrid fiber reinforced concrete at elevated temperatures, their application are significant from the aspect of protecting the concrete from spalling. If hybrid concrete is added volume fraction of 1% polypropylene and 1% steel fibers it is possible to increase the performance of concrete at high temperatures as well as retain the initial mechanical properties [11].

2.4. Fiber reinforced polymer reinforced concrete (carbon and glass fibers)

Fiber reinforced concrete reinforced with polymers has significant characteristic, which is resistance to corrosion as well as to the conditions of the external environment. It used in construction infrastructure, parking garages, industrial and multipurpose structures. Namely, it can be used as a replacement for concrete reinforcement, but also as a material for reconstruction and repair of buildings. Since it is more expensive then reinforced concrete, shows lower modulus of elasticity, but greater tensile strength and it is little explored its behavior under long-term loads like fire load [19]. By increasing the temperature, the characteristics of these fibers (stiffness, strength, matrix-fiber bond) are reduced. The American Institute for Concrete (ACI) has defined the T_g temperature, the glass-transition temperature, which represents the temperature at which the fiber starts to melt, and the range is 65-120˚C [1]. A key role in these concrete plays a binding matrix, usually of epoxy or vinyl esters, and the most commonly used fibers are carbon, glass and aramid [4].

By increasing the temperature above T_g, the binding matrix is not able to transmit the load to the fibers, and such material exhibits large losses of mechanical characteristics and stability up to the fracture [12]. It should be noted that fibers in this type of concrete may bear much higher temperatures than its matrix and in the case of a load in longitudinal direction of glass fibers, they may still receive these loads up to about 980°C [12]. The matrix of epoxy loses compressive strength when the temperature is over T_g, while a similar case is for the tensile strength and shear. Gluguri investigated the shear strength of different epoxides and concluded that the loss of this strength at 80˚C was 30% of the initial at room temperature [14]. When FRP is used as a replacement for reinforcement, the protective layer of concrete should be twice as big as the protective layer of the classic reinforcement in the concrete [14].

Experimental study of specimens containing carbon and glass fibers may retain its stiffness even 90% of the initial exposing to temperature below 350˚C, while the tensile strength at a given temperature is about 45% and 35% of the initial for glass and carbon [17]. Blontrock came to the conclusion that the strength reduction is linear with increasing temperature and that its value is zero after reaching 500°C for carbon and 550˚C for glass. Diagram stress-strain is also linear up to the fracture of specimens [17]. Other studies examined the uniaxial compressive strength of cylindrical specimens, fiber reinforced with carbon and glass fiber, and came to the conclusion that at temperatures of 100°C there is a small drop in strength of these specimens [2]. By increasing the temperature to 200˚C the strength decrease is very high. A significant loss of the connection between the fibers and the concrete matrix takes place precisely at 200˚C temperature, a loss of connection is higher in carbon than glass fibers [2]. Some studies show that loss of tensile strength at 250°C is more than 20% for carbon and glass fibers [12]. Kodur and Baingo compared the concrete reinforced with this fibers and reinforced concrete and found that the loss of strength at 200°C temperature is 50% of the initial, while for the concrete loss of the same strength is at 700˚C for steel at 500˚C [12]. Katz found that in concrete reinforced with these fibers, the drop of the matrix strength is 80-90% than initial when the temperature was between 20-250°C, while for the same temperature value drop for steel is 38% [12]. Tensile strength loss is 20% for carbon fiber and glass fibers, while aramid is up to 60% at 250°C. Examination of glass fiber specimens at temperatures ranging from 0˚C to 325˚C showed a drop in strength of 53%, bending strength 94% and shear 79% [12].

3. CONCLUSION

The use of fiber reinforced concrete is topic of many researchers all around the world. His role and behavior at high temperatures has not yet been sufficiently researched, and this area is yet to see its expansion in the future. From the previous research we have come to the following conclusions:

- Steel fibers improve mechanical properties in concrete after exposure to higher temperatures compared to concrete without these fibers. All researchers have come to the conclusion that increased residual compressive strength, tensile strength, bending strength, stiffness, ductility, but spalling of concrete at high temperatures has also increased. These fibers also reduce the formation and further widening of the cracks. Tensile strength is more dependent on its volume fraction in concrete and aspect ratio than on its type;
- Polypropylene fibers according to some researchers slightly improve residual mechanical characteristics; while according to others reduce these characteristics in relation to the concrete without additives exposed to high temperatures. This fibers reduces the spalling in the concrete as well as the vapor pressure which is generated by the heating of the specimens, thereby also preventing cracking in the concrete;
- Hybrid fibers improve the residual mechanical characteristics and reduce spalling in concrete after exposure to elevated temperature. This combination of fibers showed the best behavior in concrete when exposed to fire;
- The mechanical characteristic of the fiber reinforced concrete which is reinforced with carbon and glass fibers depends on the binding matrix which loses its characteristics at temperature near T_g. Any temperature over the T_g value causes the binding matrix to lose its properties and the connection between these fibers, which adversely affects the behavior of this concrete in the fire load. The mechanical properties are at a satisfactory level at temperatures below 200˚C although the polymer matrix has suffered significant losses.

4. REFERENCES

[1] ACI 440.1R-06. (2006). *Guide for the design and construction of structural concrete reinforced with FRP bars.* Michigan: American Concrete Institute. Farmington Hills.

[2] Al-Salloum Y. A., Elsanadedy H. M., Abadel A.A. (2011). Behavior of FRP-confined concrete after high temperature exposed. *Construction and Building Materials* Vol. 25: pp. 838-850.

[3] Balázs G.L., Lublóy E., Czoboly O. (2014). Possible observations on concrete after high temperature loading. *International conference Contemporary achievement in civil engineering. Journal of Faculty of Civil Engineering,* Subotica, ISSN 0352-6852. pp. 579-586.

[4] Bisby L.A. (2003). *Fiber behaviour of fibre-reinforced polymer (FRP) reinforced or confined concrete. Doctoral Thesis.* Ontario: Queen´s University, Department of Civil Engineering.

[5] Broćeta G., Malešev M., Radonjanin V., Slijepčević M., Zrnić D. (2017). The Influence of aggregate types on the concrete fire resistence. *1st International Sympozium K-FORCE. Book of Proceedings*: pp. 304-310.

[6] Chen G.M., He Y.H., Yang H., Chen J.F., Guo Y.C. (2014). Compressive behavior of steel fiber reinforced recycled aggregate after exposure elevated temperatures. *Construction and Building Materials* Vol. 71: pp. 1-15.

[7] Choumanidis D., Badogiannis E., Nomikos P., Sofianos A. (2016). The effect of different fibres on the flexural behavior of concrete exposed to normal and elevated temperatures. *Construction and Building Materials* Vol. 129: pp. 266-277.

[8] Czboly O., Lublóy E., HlavičkaV., Balázs G., Kéri O., Szilágyi I. M. (2017). *Journal of Thermal Analysis and Calorimetry* Vol. 128: pp. 1453-1461.

[9] Hager I. (2013). Behavior of cement concrete at high temperature. *Bulletin of the Polish Academy of Sciences Technical Science* Vol. 61 No.1: pp. 1-10.

[10] Kim J., Lee G.P., Moon D.Y. (2015). Evaluation of mechanical properties of steel-fiber-reinforced concrete exposed to high temperatures by double-punch test. *Construction and Building Materials* Vol. 79: pp. 182-191.

[11] Novák J., Kohoutková A. (2017). Fiber reinforced concrete exposed to elevated temperature. *Materials Science and Engineering* 246: pp. 1-7.

[12] Robert M., Benmokrane B. (2010). Behaviour of GFRP Reinforcing Bars Subjected to Extreme Temperatures. *Journal of Composites for Construction ASCE* Vol. July/August: pp. 353-360.

[13] Rodrigues J.P.C., Láim L., Correia A.M. (2010). Behavior of fiber reinforced concrete columns in fire. *Composite Structures* Vol.92: pp. 1263-1268.

[14] Saafi M. (2002). Effect of fire on FRP reinforced concrete members. *Composite structures* Vol. 58: pp. 11-20.

[15] Serrano R., Cobo A., Prieto M.I., González M.N. (2016). Analysis of fire resistance of concrete with polypropilene or steel fibers. *Construction and Building Materials* Vol. 122: pp. 302-309.

[16] Srinivasa Rao K., Rakesh Kumar S., Laxmi Narayana A. (2013). Comparison of performance of standard concrete and fibre reinforced standard concrete exposed to elevated temperatures. *American Journal of Engineering Research (AJER)* Vol. 02: pp. 20-26.

[17] Wang Y.C., Wong P.M.H., Kodur V. (2003). Mechanical properties of fibre reinforced polymer reinforcing bars at elevated temperatures. *SFPE/ASCE Specialty Conferences: Designing Structures for Fire*: pp.183-192.

[18] www.theconstructor.org/concrete/factors-concrete-performance-during-fire/19025/

[19] Zlámal M., Kučerová A., Štěpánek P. (2013). Effect of fire on FRP reinforced concrete structures. *Central Europe towards Sustainable Building. Low-tech and high-tech materials and technologies for sustainable buildings*: pp. 1-9.

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SEISMIC RESISTANCE ANALYSIS OF RESIDENTIAL MASONRY BUILDING

Abstract: This paper presents the seismic resistance analysis for a multistory masonry residential building in Banja Luka, regarding the bearing capacity of structural elements that are crucial for the transfer of lateral seismic forces. The building is built before the appliance of the construction regulations in seismic areas, regarding the region of the building location. The seismic analysis according to domestic regulations - Rulebook on technical standards for construction of high buildings in seismic areas and according to the American guidelines FEMA 310 is shown. Also, seismic evaluation of the building is given. It was shown that masonry buildings built before 1964, generally, do not meet the criteria for aseismic design, defined in today available national and international regulations. A recommendation for constructive reinforcement of the building is given. The principles of application, as well as the advantages and disadvantages of application of FEMA 310 guidelines are outlined, on example of masonry building.

Key words: aseismic design, masonry building, seismic resistance, seismic regulations, FEMA 310

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1. INTRODUCTION

Many buildings in use date from the time when seismic analysis in applicable guidelines was not defined, and for many existing buildings, the original capacity in terms of accepting seismic forces was temporarily reduced by damage in earthquakes from the past or in some other ways. Determining seismic resistance of existing objects has to be done in order to protect users of such objects, in case of future earthquakes. The largest earthquake-related damages and victims are the result of damage and demolition of existing buildings, which are not designed according to aseismic rules [1,2,15].

This paper will briefly outline the principles of the seismic resistance analysis for the existing multistory masonry building, according to the Rulebook on technical standards for construction of high buildings in seismic areas [13], and the first tier seismic evaluation according to the American document FEMA310 [6]. This document is mainly developed for seismic analysis of existing objects, and it is probably the most advanced seismic evaluation procedure developed [4,5,9,11].

Seismic evaluation of existing objects is more difficult task than the design of new objects. Many data remain unknown, and many assumptions have to be made, so evaluation can be rather conservative. In order to gain data, detailed visual screening of the object is needed [6,7] and many experimental research have to be performed [6]. For rough, quick evaluation, in analysis, linear methods can be used, as shown in this paper, but for realistic results of evaluation, person performing the evaluation has to use nonlinear methods [10].

The masonry building with rigid diaphragms being analyzed, was constructed prior to the application of the Rulebook on technical standards for construction of high buildings in seismic areas and does not have any vertical reinforcement. In our region, the use of reinforced concrete in masonry buildings starts in the eighties of the twentieth century [1].

2. SEISMIC ANALYSIS OF MASONRY BUILDING

Usually, in the event of an earthquake, masonry objects are considered more sensitive than the objects made with reinforced concrete or steel. This can be concluded when the number of demolished facilities after an earthquake is considered. However, taking into the account that among these objects is a large number of old masonry objects, built before the beginning of the construction with reinforced concrete or steel, and without knowing the rules of aseismic design, this is not exactly the case. Masonry objects, if properly designed, can show good behavior in earthquakes. The most important factors influencing seismic resistance of the masonry objects are load bearing system, quality of the built-in materials and the quality of the performed works [1,2,12,15].

Masonry walls are heterogeneous elements, composed of bricks and mortar, able to transmit large compressive stress, however, without additional reinforcement, their ability to receive shear and tensile stress is much lower than the ability of concrete elements. Tensile strength of the masonry walls is only about 8% of their pressure strength. For the purpose of economical design, masonry objects need to be reinforced with reinforced concrete elements or in some other way, in order to receive lateral, seismic forces.

Based on the damage analysis of the buildings after the earthquake, the good and bad sides of certain construction types can be observed, and their collapse mechanisms can be established. Also, today, by carrying out various experimental analysis on masonry walls and models, parameters that determine the seismic resistance of masonry structures are clearly defined. In earthquakes, masonry buildings without the use of reinforcement, generally collapse as a result of the disconnectedness of individual walls. If unconnected, each wall acts for itself, and collapse occurs as a result of their individual least resistance. If walls are connected, the fracture mainly occurs due to the low tensile strength of the wall. The result is diagonal crack, one, if the earthquake is of impact type, and two if it is oscillatory [1].

2.1. Seismic analysis according to domestic regulations - Rulebook on technical standards for construction of high buildings in seismic areas

Generally, masonry structures can be analyzed according to the permitted stress method and according to the limit state method. According to the permitted stress method, on the basis of the designed loads in the construction, first cross-section forces are determined, and then, by dimensioning or checking the stresses in the elements with the assumed cross-sections, it has to be proven that the generalized stresses in the observed cross-section are less than the permitted stresses $\sigma \leq \sigma_{per}$. Permitted stress is defined as a ratio of medium compression strength of a material gained according to laboratory testing and safety coefficient which can vary form 1,3 to 4. In our region, according to the permitted stress method, only buildings with height up till 5 stories, and with a luminous floor height up to 2,75 m can be analyzed [12,13,14].

According to the Rulebook, for masonry structures, calculation of masonry walls resistance to shear is mandatory, and if for the observed course of seismic action, the buildings width and height ratio is greater than 1,5, the walls must also be checked for bending, where the increase of the permitted stresses prescribed for vertical load is allowed to be up to 50% [13].

The seismic force calculation can be performed by an equivalent load method or a dynamic analysis method [13]. According to the method of equivalent static load, each masonry building is calculated on the effect of a horizontal seismic force with total intensity of:

$$S=K\cdot G \tag{1}$$

Weight of the object G, represents the weight above the upper edge of the foundation, and in the case of buildings with rigid diaphragms (concrete), this is the weight above the upper edge of that construction. Weight G is determined as the sum of the constant load, snow loads and useful load which is in most cases up to 50% of the prescribed moving load. Wind load is not taken into account [13].

Coefficient K is the total seismic coefficient, whose value must not be less than 0,02, and it is calculated as follows:

$$K=K_0\cdot K_s\cdot K_d\cdot K_p, \tag{2}$$

where:

K_0 – coefficient of object category,

K_s – seismic intensity coefficient,

K_d – dynamic coefficient,

K_p – coefficient of ductility and damping.

The values of these coefficients are defined by the Rulebook [13].

Seismic forces to which the masonry buildings are exposed to are accepted with share walls, so when the total seismic force S is calculated, it is necessary to perform the force distribution to each individual wall. Force S can act in the longitudinal and transverse direction of the object, and as an inertial force always acts in the center of mass. For distribution on individual walls, the distance of the center of mass from the center of the stiffness has to be calculated. The distribution gives us concentrated forces, which for each element represent the total seismic load.

Further, the distribution of these seismic forces is carried out by the height of the individual share wall, which can be implemented for objects with a maximum of 5 floors using the expression:

$$S=S_i\cdot(G_iH_i/\Sigma G_iH_i), \qquad (3)$$

where:

S_i – individual seismic forces of the walls in the i-th direction,

G_i – weight of the i-th floor,

H_i – height of the floor from the upper edge of the foundation.

By permitted stress method, main tension stress σ_0 in individual sharing walls, on some floor, is determined by the form:

$$\sigma_o=\sqrt{((\sigma_n/2)^2+(1,5\tau)^2)}- \sigma_n/2 \leq \sigma_{0,per} \qquad (4)$$

where:

σ_n – average normal stress from the vertical load,

τ – average sharing stress from the seismic force S, for that wall,

$\sigma_{0,per}$ – permitted main stress.

For full brick, according to table number 4 in the Rulebook on technical standards for construction of high buildings in seismic areas, $\sigma_{0,per}$=0,09 MPa.

2.2. Seismic analysis according to the American guidelines FEMA 310

Seismic resistance evaluation according to the manual FEMA310, starts from the general characteristics of an object, considered to be seismically favorable, and further analysis is performed in order to gain more detail control and evaluation, in case of non-fulfillment of the general, initial conditions, or in case of doubt in the correctness of a particular element or parameter of the construction material.

The evaluation according to this document is done in three levels (tiers): Screening phase, Evaluation phase, Detailed evaluation phase [6]. Evaluation at first and second level can be conservative, as many raw assumptions are used in analysis. The person performing the evaluation should also consider details that cannot be included in the list of criteria, which may adversely affect the seismic resistance of the object being evaluated.

According to the first level of evaluation, by using the short checklists defined for the various types of objects, the items related to the constructive system of the object, the system for accepting lateral forces, and for connections are controlled.

In this paper quick check is presented in order to check the correctness of the system for accepting lateral forces, ie the quick calculation of the carrying capacity of the lateral walls will be presented.

So, when filling out a particular checklist of the first level of evaluation, quick calculation checks are required, in order to determine if the lateral-force-resisting system has sufficient strength and/or stiffness. A checklist statement guides us to the particular quick check procedure.

The pseudo-lateral force is calculated for the purpose of quick check in the first level of the evaluation, but also for the further evaluation of second level. This force is used in linear analysis and provokes the expected deformation of the construction in the designed earthquake.

Total pseudo lateral force, in case of an object with a basement, in the given horizontal direction is determined by the equation:

$V=C \cdot S_a \cdot W,$ (5)

where:

C – modification factor related to the object ductility,

S_a – response spectral acceleration at the fundamental period of the building in the direction under consideration,

W – total dead load and anticipated live load.

Story pseudo lateral force is determined:

$Vj=(n+1)/(n-1)W_j/W \cdot V,$ (6)

where:

n – total number of floors above ground level,

j – number of the floor,

W_j – total dead load and expected moving load above the level j,

W – total dead load and expected moving load,

V – pseudo lateral force, according to expression (5).

Response spectral acceleration S_a is determined based on the spectral acceleration map or it can be alternatively determined for specific location, based on geological soil characteristics and seismological characteristics of the site, for the return period of 2500 years. It is defined by the expression:

$Sa=S_{D1}/T \leq S_{DS},$ (7)

where:

$S_{D1} = 2/3\ F_V \cdot S_1$ – design spectral response acceleration parameter at a one-second period, (8)

$S_{DS} = 2/3\ F_a \cdot S_s$ – design short-period spectral response acceleration parameter, (9)

Fv and Fa – site coefficients based on the class of soil given tabulary in the Manual,

S_1 – spectral response acceleration parameter at a one-second period,

S_s – short-period spectral response acceleration parameter,

T – fundamental period of vibration of the building (defined by equation (10)),

Fundamental period of vibration of the building T, is determined by the expression:

$T = C_t \cdot h_n^{3/4},$ (10)

where:

C_t – coefficient that depends on the type of the object (for the subject object Ct =0,049),

h_n – height in m above the base to roof level.

There are no spectral acceleration maps in our region of living, so the values S_{D1} and S_{DS} must be determined on the basis of existing maps for the return period of 2500 years and our applicable rulebooks [8,15], with the experience of the person giving the assessment.

The average shear stress in the walls is calculated by the equation:

$v_{sr}=(V_j/A_w)/m,$ (11)

where:

V_j – story shear force for level j, calculated according to the expression (6),

A_W – summation of the cross-sectional area of all shear walls in the direction of seismic force (openings are taken into consideration),

m – modification factor given in the Manual tabulary.

3. EXAMPLE OF SEISMIC ANALYSIS FOR MULTISTORY RESIDENTIAL MASONRY BUILDING

This chapter will show the results of the calculation for the residential masonry object, according to the Rulebook on technical standards for construction of high buildings in seismic areas, according to the permitted stress method, and also a quick check of a system for accepting lateral forces will be performed, according to the first tier evaluation defined in FEMA310 Manual.

This object, as it will be shown, does not meet the conditions for aseismic design according to either of these two documents, regarding the carrying capacity of the lateral walls.

3.1. Description of the construction

The object has basement and tree floors, with overall base dimensions of 28,5/12 m. The construction is a combination of transverse and longitudinal load-bearing masonry walls. The basement walls are made with concrete, 30 and 40 cm wide. The floor masonry walls are 25 cm wide, made of full brick 25/12,5/6 cm. Diaphragms are made of reinforced concrete with thickness of 12 cm, and they rely on brick walls over horizontal beams 25/25 cm.

Vertical communication is achieved by a triple console staircase. The basement of the object is below its central part. The foundations are made of unreinforced concrete 40 to 50 cm wide, and the depth of funding is 2,10 m, on the part of the object with basement, and 1,6 m on other parts [3].

Figure 1 – The subject object

The object is symmetrical, the area of the walls in the transverse direction is A_{tr}=16,41 m^2, and in the longitudinal direction is A_{long}=9,68 m^2. The total surface area of the object is A_{obj}=342 m^2, so the percentage of the area in the transverse direction is 4,80%, and in the longitudinal direction 2,83%. The total length of the bearing walls is L=106,36 m, and their total surface area is A=26,59 m^2.

On site location, it is noted that the façade mortar is damaged on several places, and also the bad condition of the vertical and horizontal gutters is noted, which may have the effect of reducing the bearing capacity of the walls by washing the mortar from the joints. Some minor cracks have been noted, which can be repaired by injection [3].

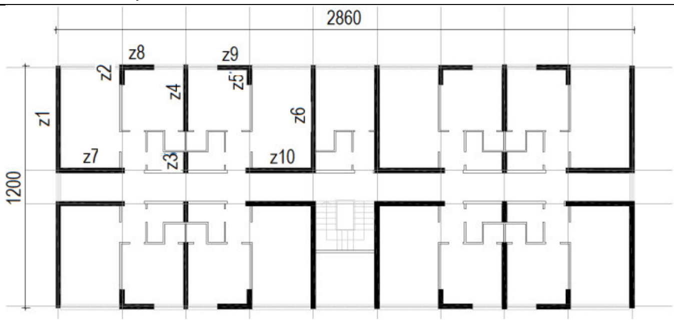

Figure 2 – The baseplate base

The analysis of the bearing capacity of the object in terms of lateral force resisting system is made under the assumption of „healthy“ walls.

3.2. Seismic analysis results according to domestic regulations - Rulebook on technical standards for construction of high buildings in seismic areas

The object is symmetrical, which is an advantage in terms of seismic analysis, and for quick analysis the center of mass and stiffness is considered to coincide.

As the basement construction is solid, the weight of the object for this analysis is counted as the weight of the part of the object above the basement line. For seismic analysis, the weights are calculated on the levels of the diaphragms, and the total weight is calculated for the ground floor level:

$Q=G+P=10348,66+1822,29=12170,95$ *kN*

As the structure is symmetrical, the calculation is made only for the walls indicated on Figure 2.

After the distribution of seismic forces by the height, according to the expression (3), in Table 1 the values of the obtained main stresses are shown, calculated according to the expression (4), for a longitudinal and transverse direction.

Table 1- Main stresses for individual ground floor walls

Wall	g (kN/m)	p (kN/m)	g+p (kN/m)	d (m)	σ_n=(g+p)/d (kN/m^2)	τ (kN/m^2)	σ_0 (kN/m^2)
W1	76,31	5,94	82,26	0,25	329,02	148,34	112,21
W2	147,10	25,61	172,71	0,25	690,85	148,34	65,46
W3	186,14	45,57	231,71	0,25	926,83	148,34	50,65
W4	98,34	13,60	111,94	0,25	447,75	148,34	91,76
W5	139,76	23,95	163,71	0,25	654,85	148,34	68,45
W6	102,64	15,58	118,22	0,25	472,87	148,34	88,23
W7	111,17	21,13	132,30	0,25	529,20	251,47	196,15
W8	116,10	19,95	136,05	0,25	544,21	251,47	193,00
W9	112,73	19,24	131,97	0,25	527,88	251,47	196,43
W10	112,53	23,45	135,98	0,25	543,93	251,47	193,06

From the calculation results shown in Table 1, it can be seen that several stress values are greater than the permissible values defined by the Rulebook [13]. For full brick 25/12/6,5, $\sigma_{0,per}$ = 90 kN/m^2 [13].

These exceedances are mostly happening in the case of walls in the longitudinal direction, as their participation in total wall area is a lot less than the participation of the walls in the transverse direction.

3.3. Tier 1 seismic evaluation results according to the American guidelines FEMA 310

Under the checklist statement at the first level of evaluation, according to FEMA310, in order to check lateral-force-resisting system capacity, it is necessary to perform a quick calculation, according to the procedure defined in the clause 2.2.

There is no spectral acceleration map in our region of living, so the maximum acceleration at the site can be determined according to the orientational formula proposed by Murphy and O'Brien [1]:

$$\log a_t = 0{,}25 \cdot I + 0{,}25, \tag{12}$$

where I is degree of seismicity by Merkal, so for the ninth seismic zone [16], it can be assumed that the short-period spectral response acceleration parameter is $S_S=a_t/g=0{,}320$.

Based on equation (9), as well as for $Fa=2{,}276$ (in this case), design short-period spectral response acceleration parameter is $S_{DS} = 0{,}486$. For design spectral response acceleration parameter at a one-second period, it may be approximate to take that $S_{D1} \approx 0{,}7 \cdot S_{DS} = 0{,}340\ g$.

Based on equation (10), and for $h=8{,}8\ m$ and $Ct=0{,}049$, the fundamental period of vibration of the building is $T=0{,}25\ s$, and for $S_{D1}=0{,}340\ g$, according to the equation (7), the response spectral acceleration is $Sa= 1{,}36$. This response spectral acceleration $S_a= 1{,}36$ is greater than $S_{ds}=0{,}486$, so according to the condition defined in equation (7) $\rightarrow S_a= S_{ds} =0{,}486$.

In equation (5) factor C is defined tabulary in the document, and for this type of object $C=1{,}1$ and W – total dead load and expected moving load at the level of the ground floor in this case is $W=G+P/2+S= 12674{,}8\ kN$.

From the above defined parameters, and equations (5) and (6), story shear force for ground floor level is $V=6775{,}9\ kN$.

For the considered case modification factor m, defined tabulary in the Manual, is 1,5.

From all the above defined parameters, and from equation (11) we get $v_{sr} = 0{,}17\ MPa$, which is more than the value defined by the condition of the checklist statement, which is $0{,}10\ MPa$. So, a quick check condition for the lateral system, on the first tier of evaluation, is not fulfilled.

4. ANALYSIS AND DISCUSSION OF RESULTS WITH PROPOSALS FOR STRUCTURE STRENGTHENING

It has been shown that the object in question, although having a relatively regular basis and having a rigid diaphragm, does not meet the conditions defined in Rulebook on technical standards for construction of high buildings in seismic areas, neither the basic requirements regarding the acceptance of lateral forces, according to the rough assessment of the first tier of evaluation, defined in the Manual FEMA310.

Based on the analysis according to the Rulebook, it can be noticed that the walls in the longitudinal direction do not meet the requirements of the Rulebook, as it is expected, since their participation in total area is almost twice as less than the participation of the walls in the transverse direction. By analysis according to the Rulebook, stress values in individual walls were obtained.

According to the Rulebook on technical standards for construction of high buildings in seismic areas, the stresses in the longitudinal walls are over 100% higher than the permissible stress values, which are 0,09 MPa. Medium stress exceeding for all walls is around 40%.

Based on the document FEMA310, with a quick check we get the value of the shear stresses for the total surface of the walls, which is compared to the defined value of permissible stress for masonry walls. In the case of rehabilitation, meaning the apparition of those walls which do not meet the requirements for receiving the shear forces, ie whose stress values exceed the permissible values, further analysis is necessary. So, by quick check, we do not get the values for the individual walls, but the averaged value of the shear stresses for the whole wall area.

According to the document FEMA310, averaged value obtained for the object walls is for 70% higher than permissible defined value, which is for this type of walls 0,1 MPa.

For the purpose of rehabilitation, reinforcement with reinforced-concrete elements, ie reinforced-concrete pillars and canvas, is suggested.

5. CONCLUSIONS

The masonry building with rigid diaphragms, being analyzed, was constructed prior the application of the Rulebook on technical standards for construction of high buildings in seismic areas, and, as shown, does not meet the requirements for the aseismic design according to this document. Also, according to a rough evaluation by Manual FEMA310, at the first tier, after performing a quick check control defined by the Manual, the evaluated building did not meet the requirements for lateral bearing capacity of the sharing walls.

Generally, in both of these documents, design recommendations in seismic areas are based on simple and proper solutions of the object basis, uniform distribution of supporting walls in both directions, bonding of the walls, the application of simple constructive systems, rigid floor structures, etc [1,13], and further, the guidelines for the calculation are given, using equivalent static or dynamic analysis, relative to the desired level of precision.

According to Rulebook on technical standards for construction of high buildings in seismic areas the method of equivalent static load is a simpler and faster method than the dynamic analysis method, but it is also rather conservative.

Document FEMA310 is mainly defined for evaluation of existing objects. Application of the document FEMA310 in the first and second levels of evaluation is conservative, a simplified way to determine seismic resistance of existing buildings, which is based on many experiential data and encompasses the most important parameters of buildings, which may affect seismic resistance. The instructions are simple to apply, but they are partially adapted to American rules. However, if it is necessary to roughly evaluate a number of objects in the short term, it is recommended to use the checklists defined within the first level of the evaluation of Manual FEMA310, as these lists clearly point to the elements that need to be checked as well as the evaluation criteria [11]. For the object reconstruction higher level of analysis is needed, and nonlinear methods are recommended [10].

For existing buildings constructed prior to the application of the Rulebook on technical standards for construction of high buildings in seismic areas, it is necessary to check if they meet the applicable requirements of the Rulebook, as this document is mandatory. However, in order to get quick identification of the damage and bearing capacity of the elements for receiving lateral forces, for the existing objects, as well as the identification of damage and condition of the object after the earthquakes, it is recommended to apply the FEMA310 document at first or second level of evaluation.

Similar objects as object being analyzed herein, in the area of Banja Luka, are mostly upgraded and reconstructed, but also many remained in their original state. As shown, after performed analyses, in case of an earthquake, they are threat to their users, and they have to be analyzed and reconstructed.

6. REFERENCES

[1] Ančić, D., Fajfar, P., Petrović, B., Szavits-Nossa, A., Tomaževič, M. 1990. *Zemljotresno inženjerstvo – visokogradnja*. Beograd: DIP „Građevinka knjiga".

[2] Aćić, M., Ćirović, G. 2009. The role and the significance of construction in reduction of seismic risk. *International conference on earthquake engineering*. Banja Luka: Institute for Construction Banja Luka – ZIBL.

[3] Beleslin, R. 2010. *Project for upgrading and reinforcement of the masonry building P0+P+2*. Banja Luka: „Ars Tectonica" d.o.o.

[4] C. Rai, D. 2005. *Review on documents on seismic evaluation of existing buildings*. Kanpur: Indian Institute of Technology

[5] C. Rai, D. 2005. *Seismic evaluation and strengthening of existing buildings*. Kanpur: Indian Institute of Technology

[6] *Fema 310 – Handbook for the Seismic Evaluation of Buildings*. 1998. Federal management agency and American society of civil engineers.

[7] *FEMA P-154 – Rapid Visual Screening of Buildings for Poptential Seismic Hazards: A Handbook*. 2015. Federal management agency and American society of civil engineers.

[8] Herak, M., Herak, D. 2009. Analyses of seismicity as input for earthquaqe hazard studies in Bosnia and Herzegovina. *International conference on earthquake engineering*. Banja Luka: Institute for Construction Banja Luka – ZIBL.

[9] Kehoe, B. 2004. Standardizing seismic evaluation of existing buildings, *13th World conference on Earthquaqe Engineering,* Vancouver.

[10] Kreslin, M., Fajfar, P. 2010. Seismic evaluation of an existing complex RC building, *Bulletin of Earthquake Engineering*, European Association for Earthquake Engineering.

[11] Latinović, M., Lazić, Ž., Broćeta, G. 2018. Seismic evaluation of existing buildings according to document FEMA 310. *Contemporary Theory and Practice in Construction XIII*. Banja Luka: Faculty of Architecture, Civil Engineering and Geodesy.

[12] Muravljov, M., Stevanović, B. 2003. *Zidane i drvene konstrukcije zgrada*, Beograd: Građevinski fakultet.

[13] *Rulebook on technical standards for construction of high buildings in seismic areas*, Official Journal SFRJ, no 31/81, 49/82, 29/83, 21/55 i 22/90.

[14] *Rulebook on technical standards for masonry walls*, Official Journal SFRJ, no 87/91.

[15] Tomaževič, M. 2009. Earthquake resistant design of masonry buildings: 40 years after the Banja Luka earthquake. *International conference on earthquake engineering*. Banja Luka: Institute for Construction Banja Luka – ZIBL.

[16] Trkulja, D. 2009. Banjalučki zemljotresi, *International conference on earthquake engineering*, Banja Luka: Institute for Construction Banja Luka – ZIBL.

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STRESS DISTRIBUTION IN CONCRETE CHIMNEYS DUE TO ELEVATED TEMPERATURES

Abstract: In high industrial reinforced concrete chimneys, there is a constant appearance of high temperatures in the interior due to burning gases that are released into the atmosphere. Since the outside temperature of the environment is much smaller than the inside temperature, tensile and compressive stresses, which are not negligible, appear in the walls of the chimney. Aim of this paper is to show a simplified approach to calculate appearing stresses due to the mentioned temperature difference.

Key words: concrete structures, chimney, high temperatures, tensile stress, compressive stress.

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1. PROBLEM BASICS

Reinforced concrete chimneys have constantly elevated – high temperatures on the inside due to constatnt fire gases which are being relised to the atmosphere. The chimney outside temeperature is far less then the inside, wich causes tensile and compressive stresses which can't be neglected [5,6]. In this paper the averaged part of the chimney (1 m in height, presumed all chimney charactersitics are the same) and the cross section of the chimney – the ring will be absorved. The ring will be divided to n rings equal thicknes d:

$$\frac{d_{ring}}{n} = d_1 = d_2 = \dots = d_n = \quad d \tag{1}$$

Change of the temperature through the cross section of the rings wall will be assumed as linear, i.e.:

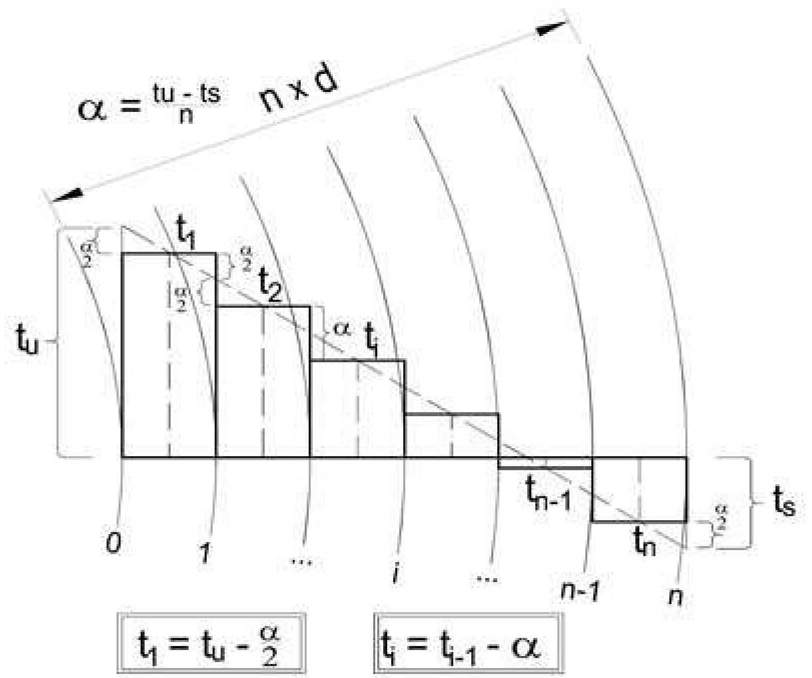

Figure 1 – Ring temperature distribution

2. STRESS AND STRAIN ANALYSIS

For the analised ring the following insignia will be used:

$r_{iu} = r_{i-1}$ - inside radius of the ith – ring

$r_{is} = r_i$ - outside radius of the ith – ring

$r^{(i)}$ - middle radius of the ith– ring

$d_i = d$ - ring thickness

The known relations for the ring will be used:

$$O_i = 2 \cdot \pi \cdot r_i \ , \ O^{(i)} = 2 \cdot \pi \cdot r^{(i)} \tag{2}$$

Th inside and the outside radius of the i – ring can be shown in the function of the middle radius of the i – ring:

$$r_{i-1} = r^{(i)} - \frac{d}{2}, \quad r_i = r^{(i)} + \frac{d}{2}, \quad r_i - r_{i-1} = d \tag{3}$$

2.1. Influences from external load

If the pressure on the inner edge q_0 is applied to the ring (1), then the tensile forces appear in the ring as shown on Figure 1.:

$$Z_1 = q_0 \cdot r_0 \tag{4}$$

The load acting on the inner edge can be reduced to the middle line of the ring, acoording to:

$$q_1^{\ Z} = q_0 \cdot \left(1 - \frac{d}{2 \cdot r^{(1)}}\right) \tag{5}$$

If pressure q_1 is applied to the outer edge of the ring, then the pressure forces appear in the ring [1,2,7]:

$$P_1 = q_1 \cdot r_1 \tag{6}$$

and if this load is reduced to the middle line of the ring :

$$q_1^{\ P} = q_1 \cdot \left(1 + \frac{d}{2 \cdot r^{(1)}}\right) \tag{7}$$

That is, if q_0 and q_1 act simultaneously, then the resulting stress σ_1 in the middle of the ring 1:

is obtained by:

$$\sigma_1 = q_1^{\ Z} - q_1^{\ P} = q_0 \cdot \left(1 - \frac{d}{2 \cdot r^{(1)}}\right) - q_1 \cdot \left(1 + \frac{d}{2 \cdot r^{(1)}}\right) \tag{8}$$

$$F_1 = Z_1 - P_1 = \sigma_1 \cdot r^{(1)} = q_1^{\ Z} \cdot r^{(1)} - q_1^{\ P} \cdot r^{(1)} \tag{9}$$

The Convention on signs is shown in the Figure 2.

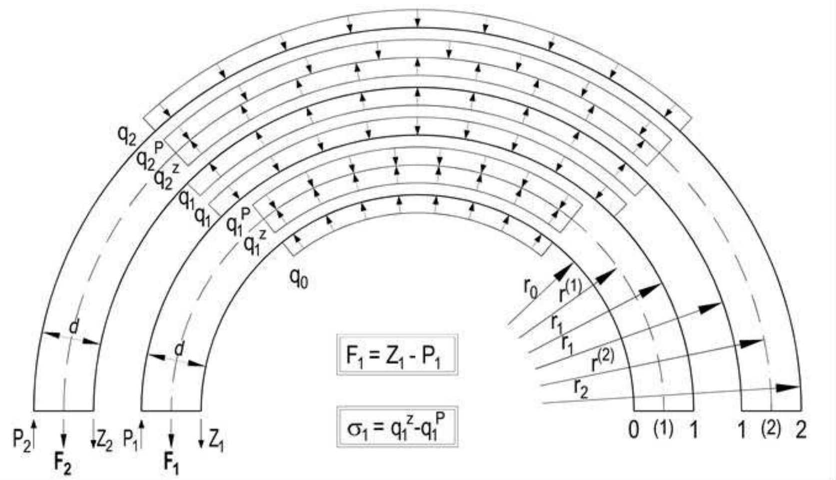

Figure 2 – Radial pressure and tensile stresses on the rings and resulting pressure and tensile forces in the particular ring [1]

The deformation (change) of the mean circumference $\Delta O^{(i)}{}_q$ of the ring due to the action of the radial load σ_i (tensile or pressure) is:

$$\Delta O_{i,q} = \varepsilon_i \cdot O^{(i)} = \frac{\sigma^{(i)}{}_{\tan}}{E_i} \cdot O^{(i)} = \frac{Z_i}{E_i \cdot A} \cdot O^{(i)} = \frac{\sigma_i \cdot r^{(i)}}{E_i \cdot h \cdot d} \cdot O^{(i)} \tag{10}$$

If this term is written with radius, then the deformation of the middle radius of the ring $\Delta r_{i,q}$ due to the action of the radial load q_1 [8]:

$$\Delta r^{(i)}{}_q = \frac{\sigma_i \cdot \left(r^{(i)}\right)^2}{E \cdot h \cdot d} \tag{11}$$

Where:

ε_i - dilatation of the ith-ring circumference,

$\sigma_{\tan}$ - tangential stress in the ith-ring cross section

h - height of the averaged concrete chimney (1 m),

E_i - module of elasticity (concrete $E_i = 315\ GPa$, steel $E_i = 210\ GPa$),

A - area of ring cross section ($A = h \cdot d$).

The change in the inner, outer and middle radius r_{i-1}', $r^{(i)}{}'$, r_i', due to the radial load action σ_i (here, the change in the thickness of the ring due to the action of the force is ignored, and the Poisson coefficient is not taken into account) is:

$$r_{i-1}'=r^{(i)}-\frac{d}{2}+\Delta r_{i,q},\ r_i'=r^{(i)}+\frac{d}{2}+\Delta r_{i,q},\ r^{(i)}'=r^{(i)}+\Delta r_{i,q} \tag{12}$$

The difference in the radius after the deformation caused by the forces is zero, since the above change has been neglected.

2.2. Influence from temperature

If the i-th ring is evenly warmed up or cooled, or if a constant temperature change t_i over the thickness of the ring is assumed, then the middle circumference of the ring will be elongated [4]:

$$\Delta O_{1,t}=\alpha_t\cdot t_i\cdot O^{(i)}=2\cdot\pi\cdot\alpha_t\cdot t_i\cdot r^{(i)}=2\cdot\pi\cdot\Delta r_{1,t} \tag{13}$$

The length of the middle circumference $O^{(i)}'$ of the i-th ring after deformation is:

$$O^{(i)}'=O^{(i)}+\Delta O_{i,t}=2\cdot\pi\cdot r^{(0)}+2\cdot\pi\cdot\alpha_t\cdot t_i\cdot r^{(0)}=2\cdot\pi\cdot r^{(i)}\cdot(1+\alpha_t\cdot t_i) \tag{14}$$

Analogously to the previous equation (14) can be written in the function of radius as:

$$r_1^{(i)}'=r^{(i)}\cdot(1+\alpha_t\cdot t_i) \tag{15}$$

The same principle is for the final elongated ring radius of the i-th ring:

$$r_{i-1}'=r_{i-1}\cdot(1+\alpha_t\cdot t_i)\ ,\ r_i'=r_i\cdot(1+\alpha_t\cdot t_i) \tag{16}$$

The difference in radius after deformation is:

$$r_i'-r_{i-1}'=(r_i-r_{i-1})\cdot(1+\alpha_t\cdot t_i)=d\cdot(1+\alpha_t\cdot t^0) \tag{17}$$

The change in the mean radius $\Delta r_{1,t}$ due to temperature t^0 change is:

$$\Delta r_{1,t}=r^{(i)}'-r^{(i)}=r^{(i)}\cdot(1+\alpha_t\cdot t_i)-r^{(i)}$$

that is:

$$\left.\begin{aligned}\Delta r^{(i)}{}_t&=r^{(i)}\cdot\alpha_t\cdot t_i\\ \Delta r_{i,t}&=r_i\cdot\alpha_t\cdot t_i\end{aligned}\right\} \tag{18}$$

2.3. Calculation of the forces in the ring

For the simultaneous effect of temperature changes in the ring axis t_i and the radial load σ_i, with the principle of superposition one obtains:

$$r_i'=r_i+\Delta r_{i,t}+\Delta r_{i,q}\ ,\ \ \Delta r_i=\Delta r_{i,t}+\Delta r_{i,q} \tag{19}$$

Individually for the iner and outer radius of the i-th ring:

$$\left.\begin{aligned} r_{i-1}{}' &= r^{(i)} - \frac{d}{2} + r_{i-1} \cdot \alpha_t \cdot t_i + \frac{\sigma_i \cdot \left(r^{(i)}\right)^2}{E \cdot h \cdot d} \\ r_i{}' &= r^{(i)} + \frac{d}{2} + r_i \cdot \alpha_t \cdot t_i + \frac{\sigma_i \cdot \left(r^{(i)}\right)^2}{E \cdot h \cdot d} \\ r^{(i)}{}' &= r^{(i)} + r^{(i)} \cdot \alpha_t \cdot t_i + \frac{\sigma_i \cdot \left(r^{(i)}\right)^2}{E \cdot h \cdot d} \end{aligned}\right\} \tag{20}$$

Since the outer radius of the ring *i-1* is equal to the inner radius of the ring, then one obtains:

$$r_{is}{}' = r_{i+1u}{}' \tag{21}$$

that is:

$$\underbrace{r^{(i)} + \frac{d}{2} + \left(r^{(i)} + \frac{d}{2}\right) \cdot \alpha_t \cdot t_i + \frac{\sigma_i \cdot \left(r^{(i)}\right)^2}{E \cdot h \cdot d}}_{r_{is}{}'} = \underbrace{r^{(i+1)} - \frac{d}{2} + \left(r^{(i+1)} - \frac{d}{2}\right) \cdot \alpha_t \cdot t_{i+1} + \frac{\sigma_{i+1} \cdot \left(r^{(i+1)}\right)^2}{E \cdot h \cdot d}}_{r_{i+1u}{}'}$$

When (21) is expressed over the middle radius, one obtains:

$$\frac{\sigma_i \cdot \left(r^{(i)}\right)^2}{E \cdot h \cdot d} - \frac{\sigma_{i+1} \cdot \left(r^{(i+1)}\right)^2}{E \cdot h \cdot d} = -\left(r^{(i)} + \frac{d}{2}\right) \cdot \alpha_t \cdot t_i + \left(r^{(i+1)} - \frac{d}{2}\right) \cdot \alpha_t \cdot t_{i+1} \tag{22}$$

If the following coefficients are introduced:

$$\left.\begin{aligned} \frac{\left(r^{(i)}\right)^2}{E \cdot h \cdot d} &= k_i \\ -\left(r^{(i)} + \frac{d}{2}\right) \cdot \alpha_t \cdot t_i + \left(r^{(i+1)} - \frac{d}{2}\right) \cdot \alpha_t \cdot t_{i+1} &= c_i \end{aligned}\right\} \tag{23}$$

one gets:

$$\sigma_i \cdot k_i - \sigma_{i+1} \cdot k_{i+1} = c_i \tag{24}$$

Asserting equation (8) in (24), one obtains:

$$\left[q_{i-1} \cdot \left(1 - \frac{d}{2 \cdot r^{(i)}}\right) - q_i \cdot \left(1 + \frac{d}{2 \cdot r^{(i)}}\right)\right] \cdot k_i - \left[q_i \cdot \left(1 - \frac{d}{2 \cdot r^{(i+1)}}\right) - q_{i+1} \cdot \left(1 + \frac{d}{2 \cdot r^{(i+1)}}\right)\right] \cdot k_{i+1} = c_i$$

Now, if coefficients are introduced:

$$1 - \frac{d}{2 \cdot r^{(i)}} = a_i \ , \ 1 + \frac{d}{2 \cdot r^{(i)}} = b_i \tag{25}$$

When include the coefficients from (25), one obtains:

$$\left[q_{i-1} \cdot a_i - q_i \cdot b_i\right] \cdot k_i - \left[q_i \cdot a_{i+1} - q_{i+1} \cdot b_{i+1}\right] \cdot k_{i+1} = c_i$$

$$q_{i-1} \cdot \left[k_i \cdot a_i\right] - q_i \cdot \left[k_i \cdot b_i + k_{i+1} \cdot a_{i+1}\right] + q_{i+1} \cdot \left[k_{i+1} \cdot b_{i+1}\right] = c_i \tag{26}$$

If the equation (26) is written in the matrix form:

$$[K]\cdot[Q]=[C] \tag{27}$$

In the developed matrix form (27), it can be written:

$$\begin{bmatrix} -(k_1b_1+k_2a_2) & k_2b_2 & & & & \\ k_2a_2 & -(k_2b_2+k_3a_3) & k_3b_3 & & & \\ & . & . & . & & \\ & & . & . & . & \\ & & & k_{n-2}a_{n-2} & -(k_{n-2}b_{n-2}+k_{n-1}a_{n-1}) & k_{n-1}b_{n-1} \\ & & & & k_{n-1}a_{n-1} & -(k_{n-1}b_{n-1}+k_na_n) \end{bmatrix}\cdot\begin{bmatrix} q_1 \\ q_2 \\ . \\ . \\ q_{n-2} \\ q_{n-1} \end{bmatrix}=\begin{bmatrix} c_1-q_0k_1a_1 \\ c_2 \\ . \\ . \\ c_{n-2} \\ c_{n-1}-q_nk_na_n \end{bmatrix}$$

Since the internal load and the external load are considered known (that is, they are constants), their values are classified in the matrix of free members $[C]$.

That is, now the stresses at the ends of the ring q_i are:

$$[Q]=[K]^{-1}\cdot[C] \tag{28}$$

Now, when the load values (stresses) are known, based on equations (8), (9) one obtains:

$$\left.\begin{aligned} \sigma_i = q_{i-1}\cdot\left(1-\frac{d}{2\cdot r^{(i)}}\right)-q_i\cdot\left(1+\frac{d}{2\cdot r^{(i)}}\right) \\ F_i=\sigma_i\cdot r^{(i)} \end{aligned}\right\} \tag{29}$$

The bending moment M in the middle of the ring RC cross-section can be obtained from the formula:

$$M=\sum_1^n M_i=\sum_1^n F_i\cdot\left[\left(r_0+\frac{n\cdot d}{2}\right)-r^{(i)}\right]=\sum_1^n \sigma_i\cdot\left(r^{(i)}\right)\cdot\left[\left(r_0+\frac{n\cdot d}{2}\right)-r^{(i)}\right] \tag{30}$$

The convention of the cross section forces is shown on Figure 3. The convention on the cross-sectional forces is:

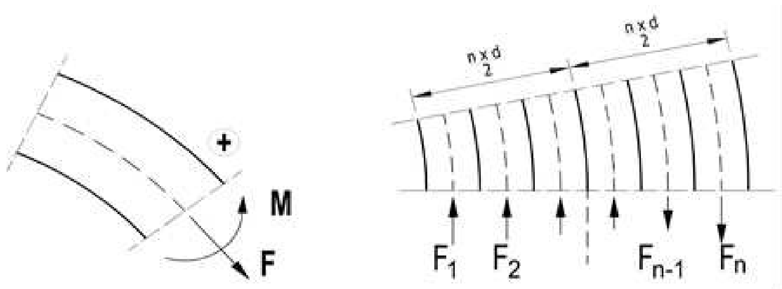

Figure 3 – Cross section forces

2.4. Numerical example

Concrete chimney with ring cross section is given with following geometrical and material characteristics:

Table 1 - Geometrical and material characteristics of the concrete cross section of the chimney

r_u [m]	$D=\sum d_o$ [m]	h [m]	n [-]	q_o [kN/m^2]	q_n [kN/m^2]	$t_u=t_o$ [°C]	$t_s=t_n$ [°C]	E_b [GPa]	α_t [1/°C]
3.0	0.30	1.0	10	0.00	0.00	200	10	31.5	10^{-5}

Using the above terms (26):

$$q_{i-1} \cdot [k_i \cdot a_i] - q_i \cdot [k_i \cdot b_i + k_{i+1} \cdot a_{i+1}] + q_{i+1} \cdot [k_{i+1} \cdot b_{i+1}] = c_i$$

for this case, a developed matrix form looks:

$$\begin{bmatrix} -(k_1b_1+k_2a_2) & k_2b_2 & & & & & & & \\ k_2a_2 & -(k_2b_2+k_3a_3) & k_3b_3 & & & & & & \\ & \cdot & \cdot & \cdot & & & & & \\ & & \cdot & \cdot & \cdot & & & & \\ & & & \cdot & \cdot & \cdot & & & \\ & & & & \cdot & \cdot & \cdot & & \\ & & & & & \cdot & \cdot & \cdot & \\ & & & & & & k_8a_8 & -(k_8b_8+k_9a_9) & k_9b_9 \\ & & & & & & & k_9a_9 & -(k_9b_9+k_{10}a_{10}) \end{bmatrix} \cdot \begin{bmatrix} q_1 \\ q_2 \\ q_3 \\ q_4 \\ q_5 \\ q_6 \\ q_7 \\ q_8 \\ q_9 \end{bmatrix} = \begin{bmatrix} c_1-\sigma_0k_1a_1 \\ c_2 \\ c_3 \\ c_4 \\ c_5 \\ c_6 \\ c_7 \\ c_8 \\ c_9-\sigma_{10}k_{10}a_{10} \end{bmatrix}$$

From the input data and on the basis of (18), (23), (25) one obtains:

Table 2 - Calculated values of the matrix [K]

Ring	$r^{(i)}$	d_i	t_i	E_b	α_t	$\Delta r_{i,t}$	k_i	a_i	b_i	c_i
1	3.015		190.5			0.00574	9.62×10^{-6}	0.99502	1.00498	-0.000576
2	3.045		171.5			0.00522	9.81×10^{-6}	0.99507	1.00493	-0.000581
3	3.075		152.5			0.00469	1.00×10^{-5}	0.99512	1.00488	-0.000587
4	3.105		133.5			0.00415	1.02×10^{-5}	0.99517	1.00483	-0.000593
5	3.135	0.03	114.5	3.15×10^{7}	1.0×10^{-5}	0.00359	1.04×10^{-5}	0.99522	1.00478	-0.000599
6	3.165		95.5			0.00302	1.06×10^{-5}	0.99526	1.00474	-0.000604
7	3.195		76.5			0.00244	1.08×10^{-5}	0.99531	1.00469	-0.000610
8	3.225		57.5			0.00185	1.10×10^{-5}	0.99535	1.00465	-0.000616
9	3.255		38.5			0.00125	1.12×10^{-5}	0.99539	1.00461	-0.000621
10	3.285		19.5			0.00064	1.14×10^{-5}	0.99543	1.00457	-

Now the matrix $[K]$ is formed:

$$\begin{vmatrix} -1.94E\text{-}05 & 9.86E\text{-}06 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 9.76E\text{-}06 & -1.98E\text{-}05 & 1.01E\text{-}05 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 9.96E\text{-}06 & -2.02E\text{-}05 & 1.03E\text{-}05 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1.02E\text{-}05 & -2.06E\text{-}05 & 1.05E\text{-}05 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1.04E\text{-}05 & -2.10E\text{-}05 & 1.07E\text{-}05 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1.06E\text{-}05 & -2.14E\text{-}05 & 1.09E\text{-}05 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1.08E\text{-}05 & -2.18E\text{-}05 & 1.11E\text{-}05 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1.10E\text{-}05 & -2.22E\text{-}05 & 1.13E\text{-}05 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1.12E\text{-}05 & -2.26E\text{-}05 \end{vmatrix}$$

On the basis of already known equations (20), (28), (29), (30) and if the dilation is written in the form:

$$\left.\begin{aligned} \varepsilon_i &= \frac{r_i\text{'-}r_i}{r_i} \\ \varepsilon^{(i)} &= \frac{r^{(i)}\text{'-}r^{(i)}}{r^{(i)}} \end{aligned}\right\} \tag{31}$$

Now, the results are formed:

Table 3 - Calculated values of the Forces and stresses

Results in the ring edges				*Results in the middle of the ring*					
n_o	q_i [m]	r_i' [m]	ε_i [‰]	σ_i [kN/m^2]	F_i [kN]	σ_{tani} [kN/m^2]	M_i [kNm]	$r(i)'$ [m]	$\varepsilon(i)$ [‰]
0	0	3.0031	1.0343	-	-	-	-	-	-
1	270.1948	3.0332	1.0430	-271.539	-818.69	-110.523	-2468.35	3.018	1.038661
2	474.0682	3.0632	1.0495	-207.540	-631.96	-66.356	-1924.31	3.048	1.046261
3	614.1644	3.0933	1.0542	-145.405	-447.12	-33.534	-1374.89	3.078	1.051858
4	692.9117	3.1233	1.0569	-85.062	-264.12	-11.885	-820.08	3.108	1.055512
5	712.6294	3.1533	1.0577	-26.443	-82.90	-1.243	-259.89	3.138	1.057277
6	675.5333	3.1834	1.0567	30.517	96.59	-1.449	305.70	3.168	1.057208
7	583.7412	3.2134	1.0540	85.880	274.39	-12.347	876.67	3.198	1.055356
8	439.2777	3.2434	1.0496	139.705	450.55	-33.791	1453.02	3.228	1.051772
9	244.0797	3.2734	1.0435	192.049	625.12	-65.638	2034.76	3.258	1.046502
10	0	3.3034	1.0358	242.965	798.14	-107.749	2621.892	3.288	1.039593

That is, the bending moment is obtained from:

$$M = \sum_{1}^{10} M_i = -444.52 \text{ kNm}$$

Sum of forces F_i shoud be equal to zero.

$$\sum_{1}^{10} F_i = q_0 - q_{10} = 0$$

Diagram of the forces *Fi* :

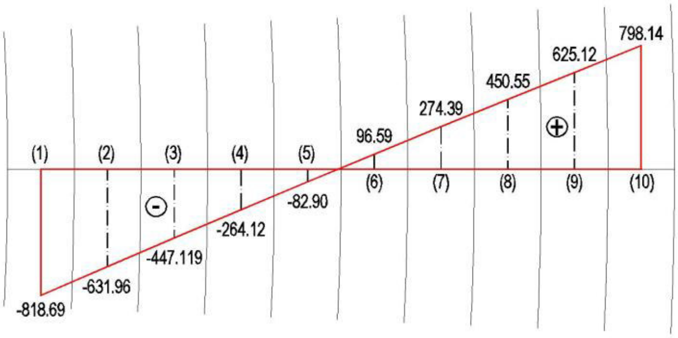

Figure 4 – F_i forces diagram

3. CONCLUSION

The presence of the difference of temperature in the thin walls of concrete chimney due to the fire can cause very large stresses [3]. These influences are not to be neglected and must be taken into account when forming reinforced concrete element – ring [4]. This is one simple linear aproximated procedure to calculate these temeperature stresses and a very good marker to show exactly the order of magnitude of these forces in the concrete ring cross section.

4. REFERENCES

[1] Байков В.Н., 1981. *Железобетонные конструкции - Специальний курс*. Москва: Стройиздат.

[2] Concrete Pipe Design Manual 2000. *American Concrete Pipe Association*. Texas.

[3] Geoffrey M. P, 1975. *Reinforced Concrete Chimneys and Towers*. Letchworth: The Garden City Press Limited.

[4] Manohar S. N., 1985. *Tall Chimneys – Design and construction*. New Delhi: Tata McGraw – Hill.

[5] Radosavljević Ž., Bajić D., 1990. *Armirani beton*. Beograd: Građevinska knjiga.

[6] Tomičić I., 1996. *Betonske konstrukcije*. Zagreb: DHGK.

[7] Улицкий И., 1972. *Железобетонные конструкции (расчет и конструирование)*. Киев: Издательство „Будвельник“.

[8] Wai-Fah C., Eric M. L., 2005. *Handbook of STRUCTURAL ENGINEERING*, New York: CRC Press.

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CULTURAL HERITAGE AND HISTORIC BUILDINGS HAZARD ASSESSMENT IN BOSNIA AND HERZEGOVINA

Abstract: Bosnia and Herzegovina has a large number of cultural heritage and historic buildings, which are exposed to natural and man-made hazards. A majority of those buildings do not have proper treatment in terms of hazards. In order to preserve and take care of our legacy it is important to properly assess and treat it. Aim of this paper is to show some examples of recently reconstructed cultural heritage and historic buildings, spanning from single edifices to vast sites, which preventive measures on hazards were introduced or do they have them at all, and what steps should be taken for future preservation of these kind of buildings and sites.

Key words: assessment, cultural heritage, historic buildings, natural and man-made hazards, treatment, preventive measures, preservation.

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1. INTRODUCTION

In Bosnia and Herzegovina there were a lot of historical overturns during the last couple centuries. This has caused the construction of many buildings, which were specific for the conquer ruling at that time. For instance, there are a lot of object from Ottoman period which lasted in BiH around 500 years. Also, there are a lot of Monasteries for time when Byzantine ruled these areas. Currently living people are mostly Islamic, Orthodox and Catholic confession. That is why Bosnia and Herzegovina is sometimes referred as "Bosnian pot". Current status of a lot of these cultural treasures is questionable. While there are bright examples where the local municipalities and the Government are taking good care of these objects, there are a lot of object who are on the verge of collapse. In this paper some examples of known cultural Heritages will be shown, their current preservation status and there natural and man-made hazard protection and assessment.

2. BOSNIA AND HERZEGOVINA CULTURAL HERITAGE BUILDINGS AND SITES

In the following part of the paper, selected examples of important historic sites and buildings are shown. The selection criteria are based on both their diversity of structure, size, building materials, weak points, historical and architectural values, and diversity of present hazards that have already produced some kind of damages. Moreover, all presented sites have status of the National monument in Bosnia and Herzegovina, and have been recently put in the process of the reconstruction. All reconstruction methods did not interfere with already existing materials and original methods used during the construction, but in cases where the situation allowed, new improvements have been introduced, prevalently for hazard prevention.

2.1. Kastel Fortress

Kastel fortress, sitting on the left bank of the Vrbas River, is located in Banja Luka downtown, with its roots dating back to Prehistoric age. An active phase was also during the Roman period, with only fragments preserved up until today, in terms of building heritage, like Early Christian basilica now located in one of the courtyards. During the Roman period, the settlement located on today's site of Kastel was named Castra, being on the important station on the salt road to Salona in Dalmatia, as indicated on Tabula Peutingeriana. The most of today's existing constructions on the site date back to Medieval period. At one moment being independent and in the territory under the domestic rulers, it in the end became the part of the Osman Empire in 1528. Afterwards, the Austro-Hungarians were the rulers, taking the fortress as important military site in 1878, serving to that use until 1959, when former Jugoslav army abandoned the premises. Since then, site has primarily cultural and social background, with sites for shows, exhibitions and corresponding services. It covers territory of 26610 m^2 [1].

Unfortunately, over the past decades, the site was not maintained properly and sufficiently, bringing some of the parts to total demolition and collapse. The most recent works are actually the only works in closer history that are thoroughly restoring Kastel's features, taking care of the current guidelines in terms of hazard risk assessment and prevention, which is in the case of Kastel flooding and fire. Those two were the sources of the most damages to the structures itself in non-war era.

Figure 1 – Kastel Fortress: view of the western walls before the recent reconstruction

Figure 2 – Kastel Fortress: damages to tower 1 after the fire

Figure 3 – Kastel Fortress: reconstruction details on typical tower and exterior wall

Figure 4 – Kastel Fortress: on the left - view of the inner courtyard after one stage of reconstruction [2] , on the right - view of the river bank walls that are still pending for reconstruction [3]

2.2. Church Javorani

Wooden log churches are one of the original features of this part of Dinara Mountain region, with is very distinctive role in creating the image of sacred and architecture in general. On the original examples is Saint Nichola's church in Javorani, near Kneževo, southern from Banja Luka. It was originally built in 1757, and restored with original architectural features and properties in 2005. Previously, it was repaired in 1824, as being testified on the wooden carving above the entrance door [4,5].

Its hazard risk assessment and prevention is prevalently link to it's the most obvious feature – construction material – wood. In comparison to some other fairly larger historic buildings, examples of these small, like this church, do not leave much space for implementation of contemporary systems for hazard prevention, or in this case fire extinguishing system without damaging its monumental architectural features.

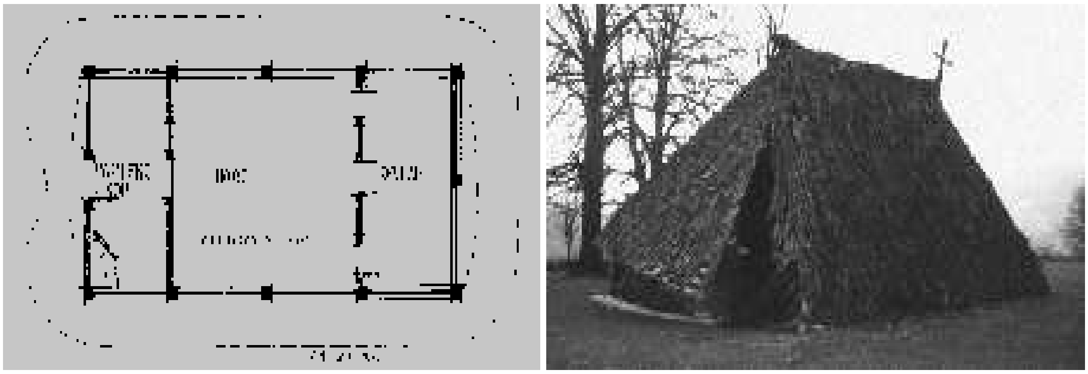

Figure 5 – Church Javorani: on the left - floorplan of the original church, on the right - view of the collapsed structure before the last reconstruction

Figure 6 – Church Javorani: view of the church and bell tower after the most recent reconstruction [6]

2.3. City Hall Vijećnica

Sarajevo City Hall, known as Vijećnica, is located in the city of Sarajevo. It was designed in 1891 by the Czech architect Karel Pařík, later continued by Alexanter Wittek and completed by Ćiril Iveković. It was initially the largest and most representative building of the Austro-Hungarian period in Sarajevo and served as the city hall [7].

The edifice was built in a stylistic blend of historical eclecticism, predominantly in the pseudo-Moorish expression, for which the stylistic sources were found in the Islamic art of Spain and North Africa. It was formally opened 20 April 1896, and handed over to the City Authority, which occupied the property until 1949, when it was handed over to the National and University Library of Bosnia and Herzegovina. During the civil was fights in 1992, a strong shelling caught the building leading to total destruction with following fires on book deposits and other valuable manuscripts.

The reconstruction started in 1996, but being one of the most challenging tasks of such kind in the recent history of Bosnia and Herzegovina, it lasted until 2014, when it was finally reopened on May 9, 2014.

Risk assessment linked to this building does not have any specific properties differing to other public buildings, but unfortunately it proved that under specific circumstances external factors can lead to series of chained reactions resulting in total collapse and demolition of properties kept inside the buildings. At least a fire, as one of those hazards can be prevented in future use and maintenance.

Figure 7 – City Hall Vijećnica: detailed view of the fire flames on the southern façade during the shelling [8]

Figure 8 – City Hall Vijećnica: detailed view of the fire flames on the southern façade during the shelling [9]

Figure 9 – City Hall Vijećnica: view of the southern façade after the reconstruction [10]

2.4. Mehmed Paša Sokolović Bridge

The Mehmed Paša Sokolović Bridge is a historic bridge in Višegrad, over the Drina River in eastern Bosnia and Herzegovina. It was completed in 1577. UNESCO included the bridge in its 2007 World Heritage List.

The Višegrad Bridge was commissioned by Grand Vizier Mehmed Paša Sokolović, who exercised power over a long period at the summit of the Ottoman Empire during the reign of three sultans as a tribute to his native region and a symbol of trade and prosperity. Construction of the bridge took place between 1571 and 1577. Major renovations of the bridge have taken place in 1664, 1875, 1911, 1940 and 1950–52. Three of its 11 arches were destroyed during World War I and five were damaged during World War II but subsequently restored [11].

It is characteristic of the apogee of Turkish monumental architecture and civil engineering. It numbers 11 masonry arches, with spans of 11 to 15 meters, and an access ramp at right angles with four arches on the left bank of the river. The 179.5 m long bridge is a representative masterpiece of Mimar Sinan, one of the greatest architects and engineers of the classical Ottoman period and a contemporary of the Italian Renaissance, with which his work can be compared. The UNESCO summary states: The unique elegance of proportion and monumental nobility of the property as a whole bear witness to the greatness of this style of architecture.

Figure 10 – Mehmed Paša Sokolović Bridge: view of the demolished arches in 1915 [12]

Figure 11 – Mehmed Paša Sokolović Bridge: view of the bridge during the last reconstruction [12]

Figure 12 – Mehmed Paša Sokolović Bridge: view of the central pile after the last reconstruction [12]

3. CONCLUSION

The number of cultural and historical buildings in Bosnia and Herzegovina is large. Cultural heritage buildings mentioned are the most known ones in BiH. One of these buildings (Mehmed Paša Sokolović Bridge) is listed as UNESCO World heritage, while all of them are National monuments of great importance for the country. As shown, all of them were devastated due to the hazardous phenomenon's, mostly floods, landslides and fires. As they are very important, the government is putting an effort in their sustainability. But there are a lot of cultural heritage buildings and sites, which have historical value that are collapsing due to the negligence. Their risk assessment is yet needs to be done, which is a very slow process.

4. REFERENCES

[1] http://old.kons.gov.ba/main.php?id_struct=6&lang=1&action=view&id=2474

[2] https://static.klix.ba/media/images/vijesti/b_171017070.jpg?v=1

[3] https://i.pinimg.com/originals/39/89/ea/3989eabb4ad72fa24ed6bd4500cc425f.jpg

[4] https://www.zapadnisrbi.com/zapadni-srbi/republika-srpska3/banjalucka-regija-bosanska-krajina/14-banjalucka-regija?showall=&start=13

[5] http://www.fmks.gov.ba/download/zzs/1956/9-1956.pdf, 155-158 page.

[6] https://en.m.wikipedia.org/wiki/Old_Church_of_St._Nicholas,_Javorani#/media/File%3ACrkva_brvnara_u_Javoranima2.jpg

[7] http://old.kons.gov.ba/main.php?id_struct=6&lang=1&action=view&id=2860

[8] https://www.radiosarajevo.ba/metromahala/teme/dan-kada-je-unistena-vijecnica-gledas-kako-propada-nemocan-da-uradis-bilo-sta/272503#lg=1&slide=0

[9] https://www.vijecnica.ba/bs/article/26/detalji-obnove

[10] https://www.vijecnica.ba/media/article/40/original/video.jpg

[11] http://old.kons.gov.ba/main.php?id_struct=6&lang=1&action=view&id=769

[12] https://en.wikipedia.org/wiki/Mehmed_Pa%C5%A1a_Sokolovi%C4%87_Bridge

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