*Date: 27-06-2017*

*Place: Technical University of Denmark*

# Knowledge FOr Resilient soCiEty

## 11080 – Advanced Building Desing

*Technical University of Denmark*

*Department of Civil Engineering*

*(DTU-BYG)*

DTU Civil Engineering
Department of Civil Engineering

Co-funded by the
Erasmus+ Programme
of the European Union

- *Interdisciplinarity in Fire Design:*

  *11B12: Brandmodellering (IT Fire)*

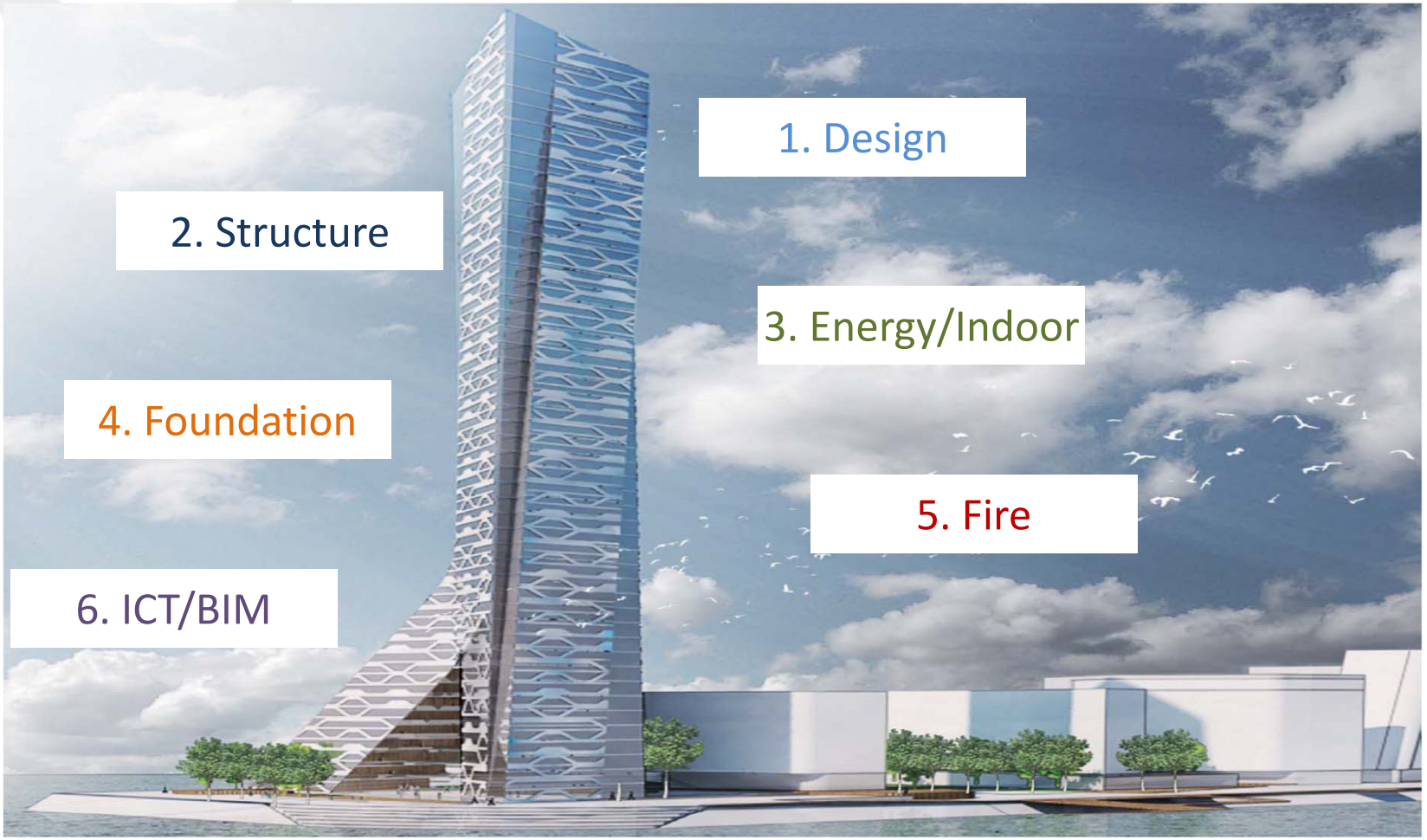
- *Interdisciplinarity in Building Design:*

  *1080 Advanced Building Design*



Co-funded by the
Erasmus+ Programme
of the European Union

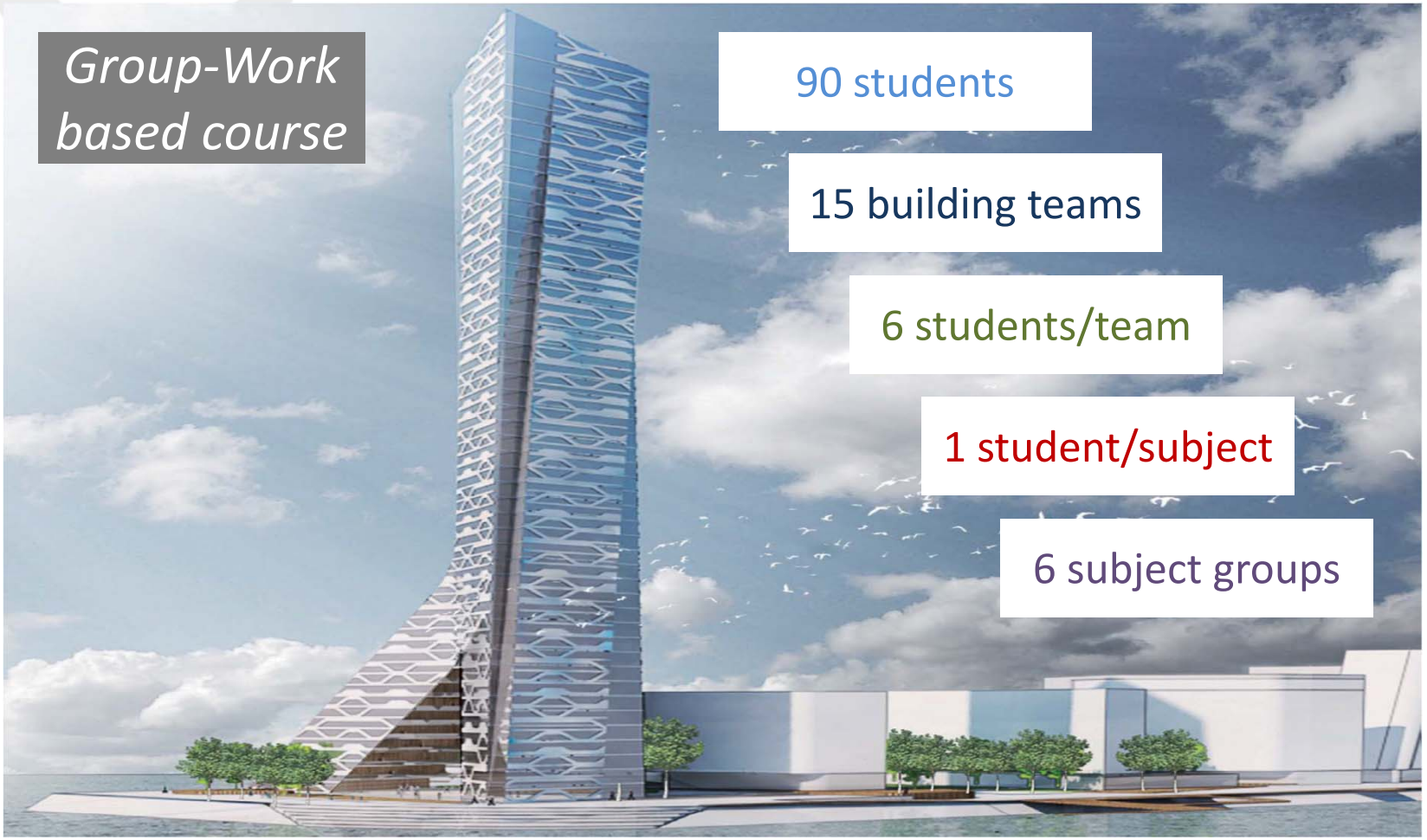
# *11080 - Advanced building design*






Co-funded by the
Erasmus+ Programme
of the European Union

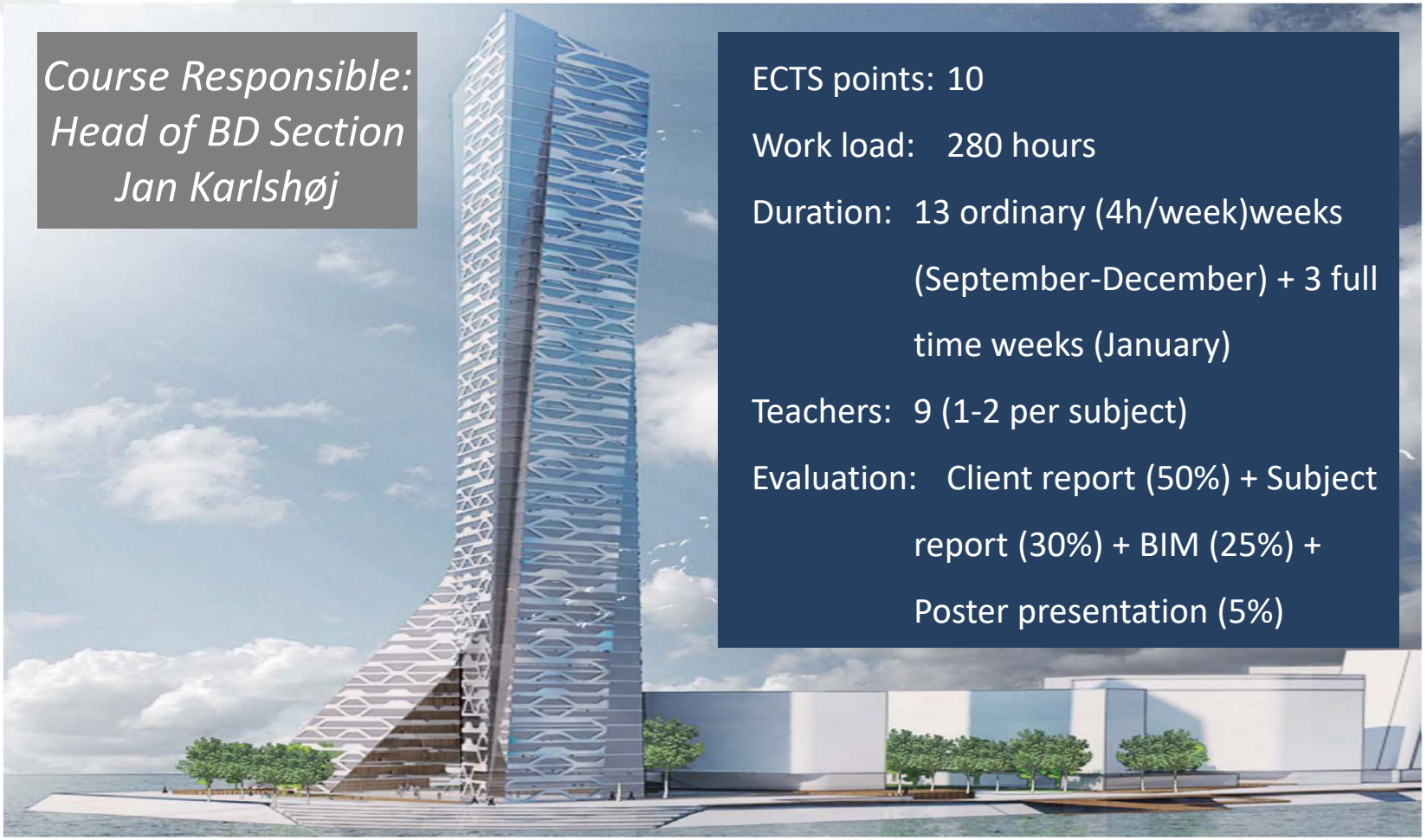
# 11080 - Advanced building design






Co-funded by the Erasmus+ Programme of the European Union

# 11080 - Advanced building design



*Course Responsible:*
*Head of BD Section*
*Jan Karlshøj*

ECTS points: 10

Work load: 280 hours

Duration: 13 ordinary (4h/week)weeks (September-December) + 3 full time weeks (January)

Teachers: 9 (1-2 per subject)

Evaluation: Client report (50%) + Subject report (30%) + BIM (25%) + Poster presentation (5%)



Co-funded by the
Erasmus+ Programme
of the European Union

# 11080 - General information

[The course aims at giving students] “an understanding of **integrated building design** and the way specialized competences can be used collaboratively within multidisciplinary project teams to create a **design that fulfils many functional requirements simultaneously**. Going beyond mere analysis of a given construction, students will apply their additional competences to construct **solutions to open-ended problems**. Students will work in groups to solve realistic design jobs that accurately reflect the demands of the construction industry. Students will also work with **digital building design methods**.”

## 6 design subjects and 1-2 teacher per subject:

Subject 1: Design (architecture)

Subject 2: Building structure

Subject 3: Building services

Subject 4: Geotechnical engineering

Subject 5: Fire Safety

Subject 6: Project Management and ICT Coordination

## Group-work based course:

- 6 students in each group
- Each student is responsible for a subject
- All students are responsible for a good integration among subjects and for the final design (partly – see evaluation)



Co-funded by the
Erasmus+ Programme
of the European Union

# 11080 - Learning objectives

A student who has met the objectives of the course will be able to:

**a.** **Collaborate** with other specialists

b. Analyze a **client's requirements** inspired by System Engineering

c. Participate in developing a design management scheme to enable the project team to work together towards common goals and deadlines

d. Use **3D object-oriented building models** and associated IT tools to develop a detailed design solution

**e.** **Integrate various technical requirements into a functional building design** that satisfies the client brief

**f.** **Produce technical reports** documenting the fulfilment of specific functional requirements, such as indoor climate, energy performance, structural performance, fire and safety performance, acoustic performance and constructability

g. Justify and defend **design decisions**

h. Develop an outline design and project proposal

i. Present a final design to internal assessors

j. Recognize the need to develop **alternative solutions** and iterations in the design process in accordance to System Engineering



Co-funded by the
Erasmus+ Programme
of the European Union

# 11080 - Task and assignments

## MAIN TASK

To replace a proposal for a hotel and residential building called ***Lighthouse Building T*** at the Aarhus waterfront with a project proposal for an **office** tower. The office tower must comply with the Building Class **2020** requirements according to Danish Building Code 2010.

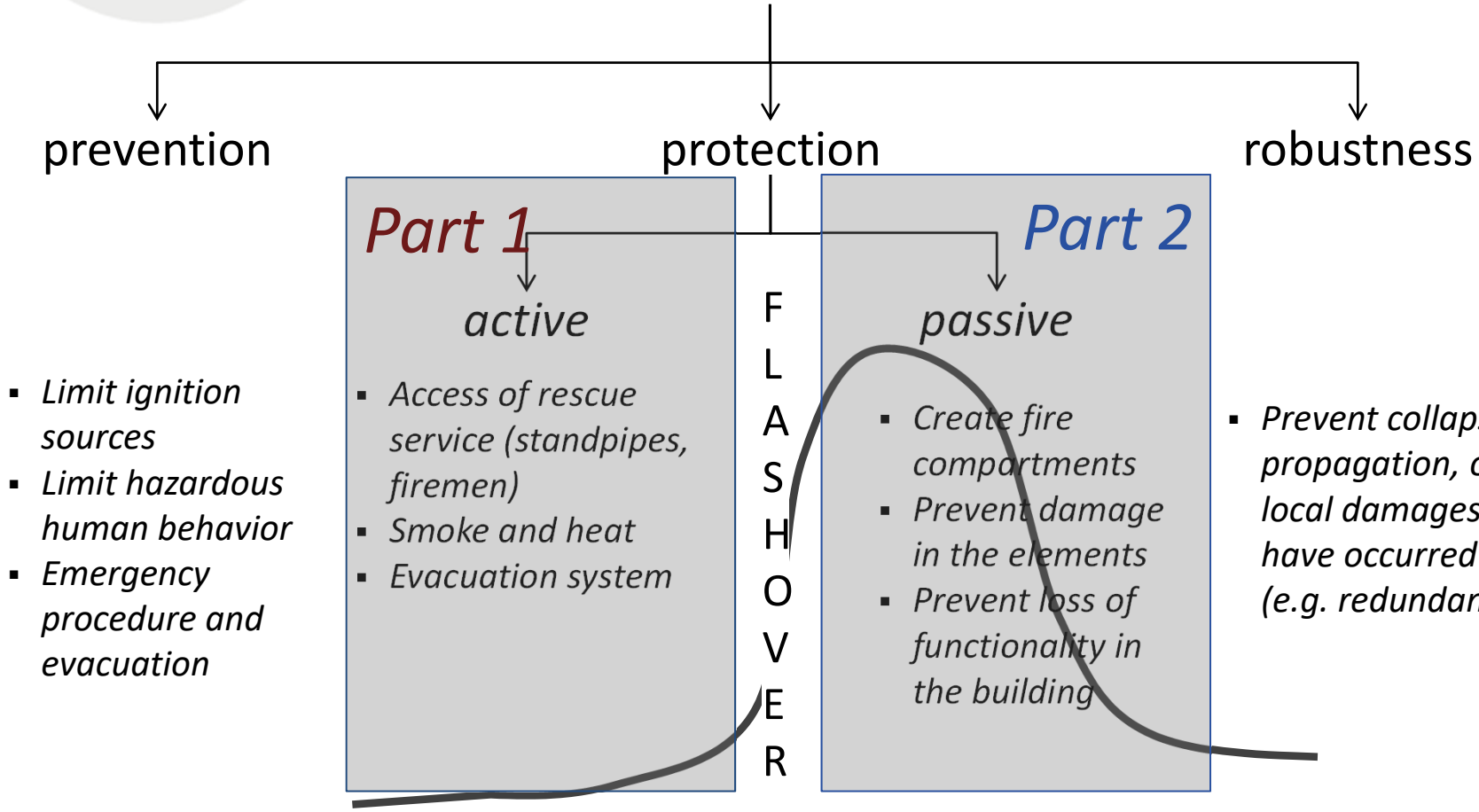
## SPECIFIC ASSIGNMENTS

| | |
|---|---|
| 2-week team contract: | team members and subject responsible |
| 5-week memo: | main design strategies for each subject |
| 7-week presentation: | initial project proposal and design choices - *FOR FEEDBACK* |
| 13-week report: | Part 1: 1 client report + Part 2: 6 subject reports - *FOR FEEDBACK* |
| 13-week BIM: | Building Information Models of the building - *FOR FEEDBACK* |
| 13 week review: | each group review another group's 13-week report - *FOR FEEDBACK* |
| 3-week report: | 1 client report + 6 subject reports for each group - *FOR EVALUATION* |
| 3-week BIM: | Builiding Information Models of the building - *FOR EVALUATION* |
| 3-week poster: | Presentation of the final building design - *a kind of oral examination* |



Co-funded by the
Erasmus+ Programme
of the European Union

# Fire Safety Strategies





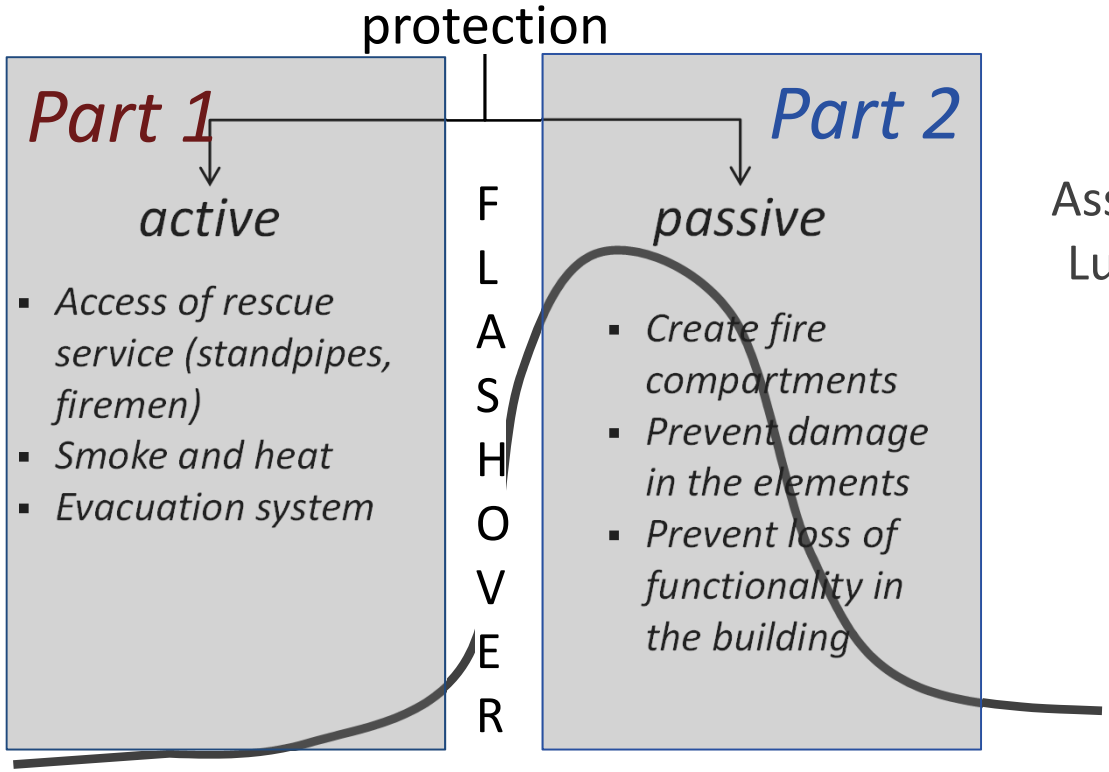

Co-funded by the Erasmus+ Programme of the European Union

# SMOKE MANAGEMENT AND EVACUATION

Teacher:
Associate Prof.
Anne Dederichs

# STRUCTURAL FIRE SAFETY DESIGN

Teacher:
Associate Prof.
Luisa Giuliani






Co-funded by the
Erasmus+ Programme
of the European Union

# SMOKE MANAGEMENT AND EVACUATION

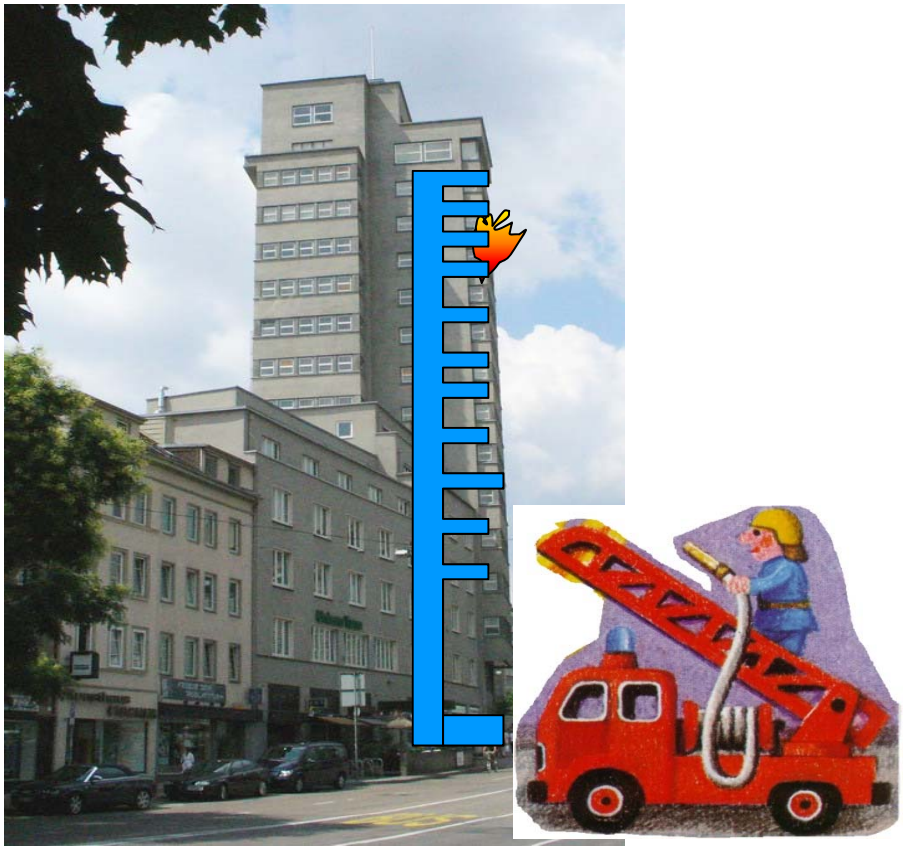
PRESCRIPTIVE

PERFORMANCE-BASED

## *Part 1*

*active*

- *Access of rescue service (standpipes, firemen)*
- *Smoke and heat*
- *Evacuation system*





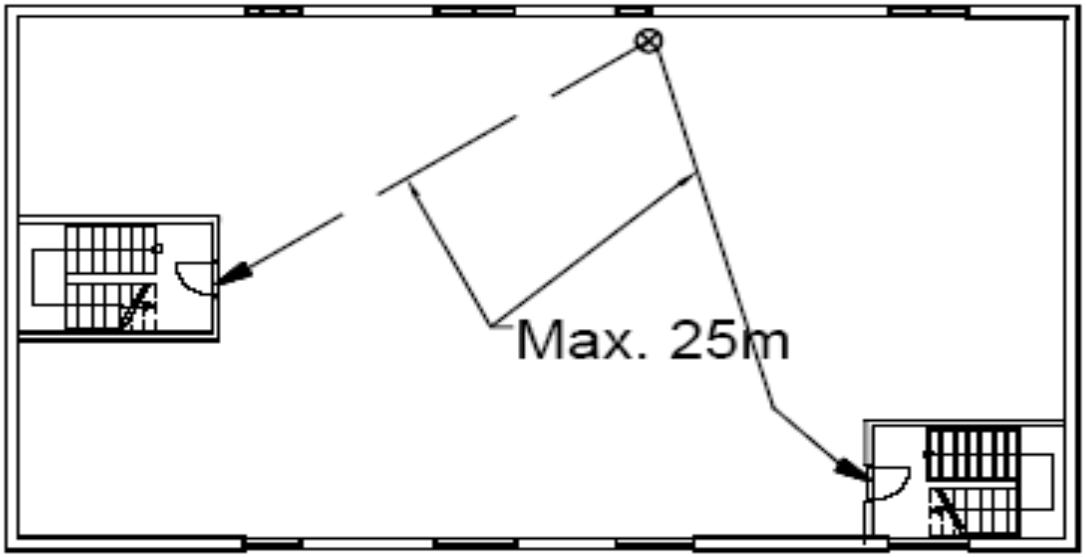
Co-funded by the Erasmus+ Programme of the European Union

Ensure evacuation and access of the rescue service. Consider smoke spread, passive and active fire protection and operation and maintenance. In particular:

a. For traditional parts of the building you should apply the prescriptive (Eksempelsamling)
b. For untraditional parts, you need to proof that people can evacuate without being affected by critical conditions, by selecting relevant scenarios, calculating the ASET and RSET conditions and present an event tree for risk assessment

# Prescriptive design:

- Max. 25 m to exit
- for <150m$^2$ and <50 persons: 1 door directly to the outside or 2 opposite doors to safe place
- >50 persones: 2 doors leading to 2 independend exit paths leading to the outside



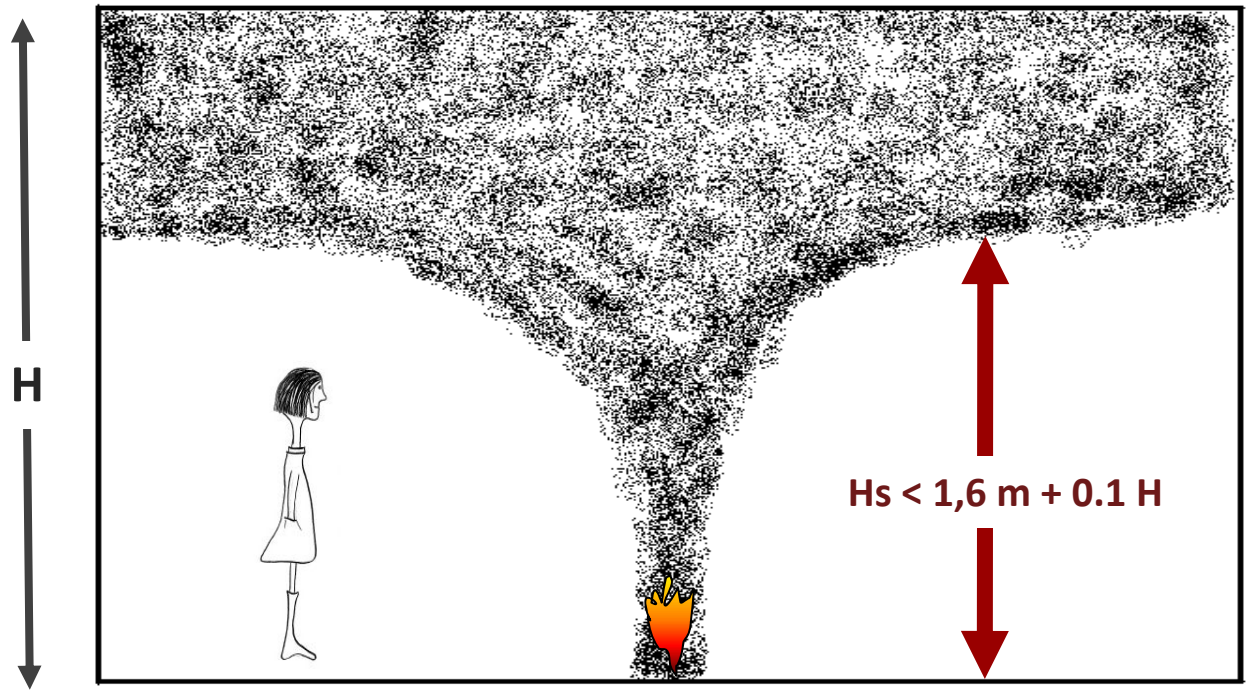

Brandcelle mere end 50 personer

# Performance-based design:

CRITICAL FIRE SCENARIO

TENABILITY CRITERIA (ASET)

- Visibility
- Radiation
- Temperature
- Smoke layer



| Tenability criteria | Comments |
|---|---|
| **Visibility criteria**<br>In fire cell less than 150 $m^2$:<br>The optical density (D/L) > 2,0 db/m<br>(measured at 2 m above the floor)<br><br>In escape routes and fire cells larger than 150 $m^2$<br>Optical density (D/L) > 1,0 db/m<br>(measured at 2 m above the floor). | Visibility of at least 5 m<br><br>Visibility of at least 10 m |
| **Radiation**<br>A short time radation intensity of > 10 $kW/m^2$ OR<br>Long lasting exposure to radiation ($E_{maks}$) > 2,5 $kW/m^2$ OR<br>A total energy due to radiation of > 60 $kJ/m^2$ besides the energy from a radiation source with intensity of 1 $kW/m^2$. | Up to 4 sec |

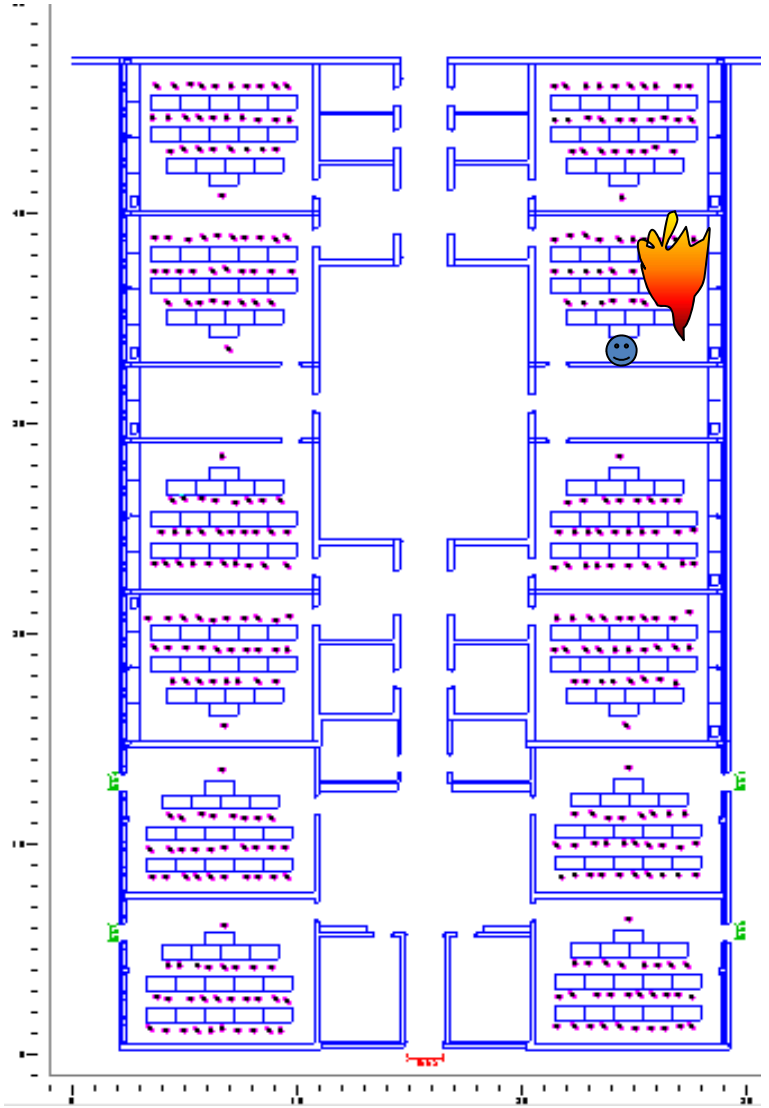
| Tenability crtiteria | Comments |
|---|---|
| **Temperature**<br>Temperature under the smoke gas layer<br>> 80°C in escape routes | If the smoke gas layer is not established the temperature is measured at 2 m above the floor |
| **Height of smoke gas layer**<br>Height over floor to the gas layer should be<br>< 1,6 m + 0.1*H | H = ceiling height of room |

# Performance-based design:

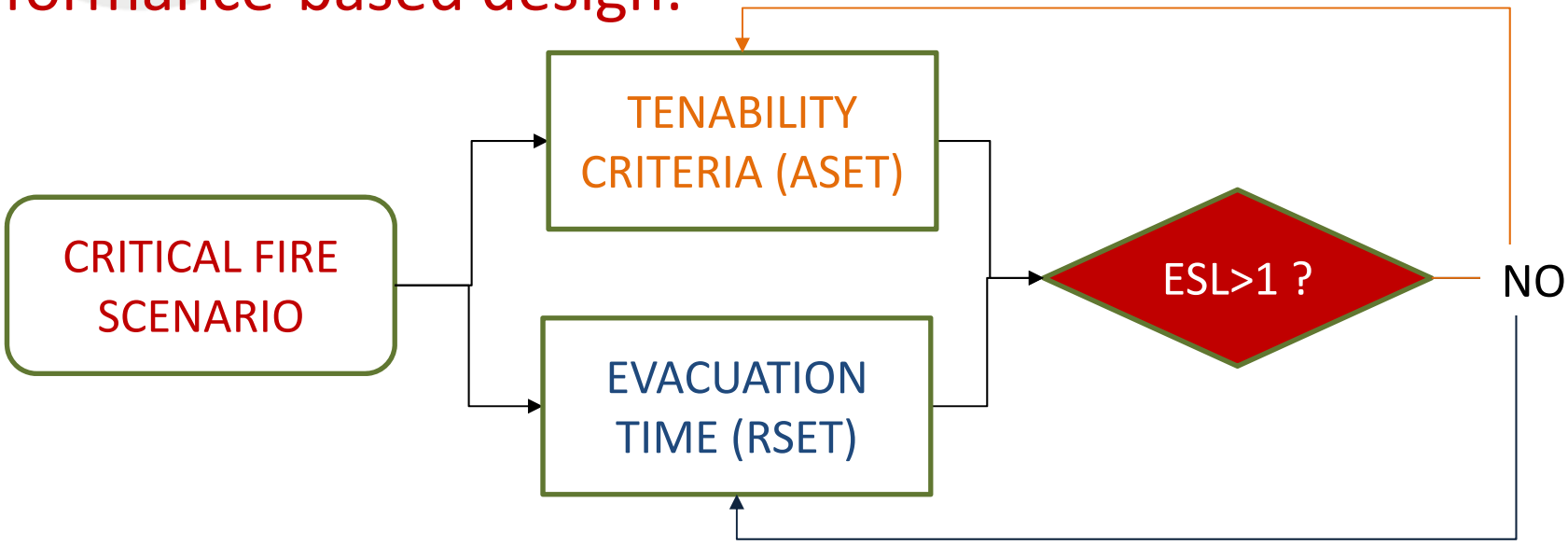
CRITICAL FIRE SCENARIO

TENABILITY CRITERIA (ASET)

EVACUATION TIME (RSET)



# Performance-based design:



# STRUCTURAL FIRE SAFETY DESIGN

ELEMENT DESIGN, STANDARD FIRE

ELEMENT DESIGN, PARAMETRIC FIRE

GLOBAL RESPONSE, FIRE SCENARIOS

## *Part 2*

*passive*

- *Create fire compartments*
- *Prevent damage in the elements*
- *Prevent loss of functionality in the building*



Co-funded by the Erasmus+ Programme of the European Union

## 11080 – Subj. 5.2 Post FO Fire Design

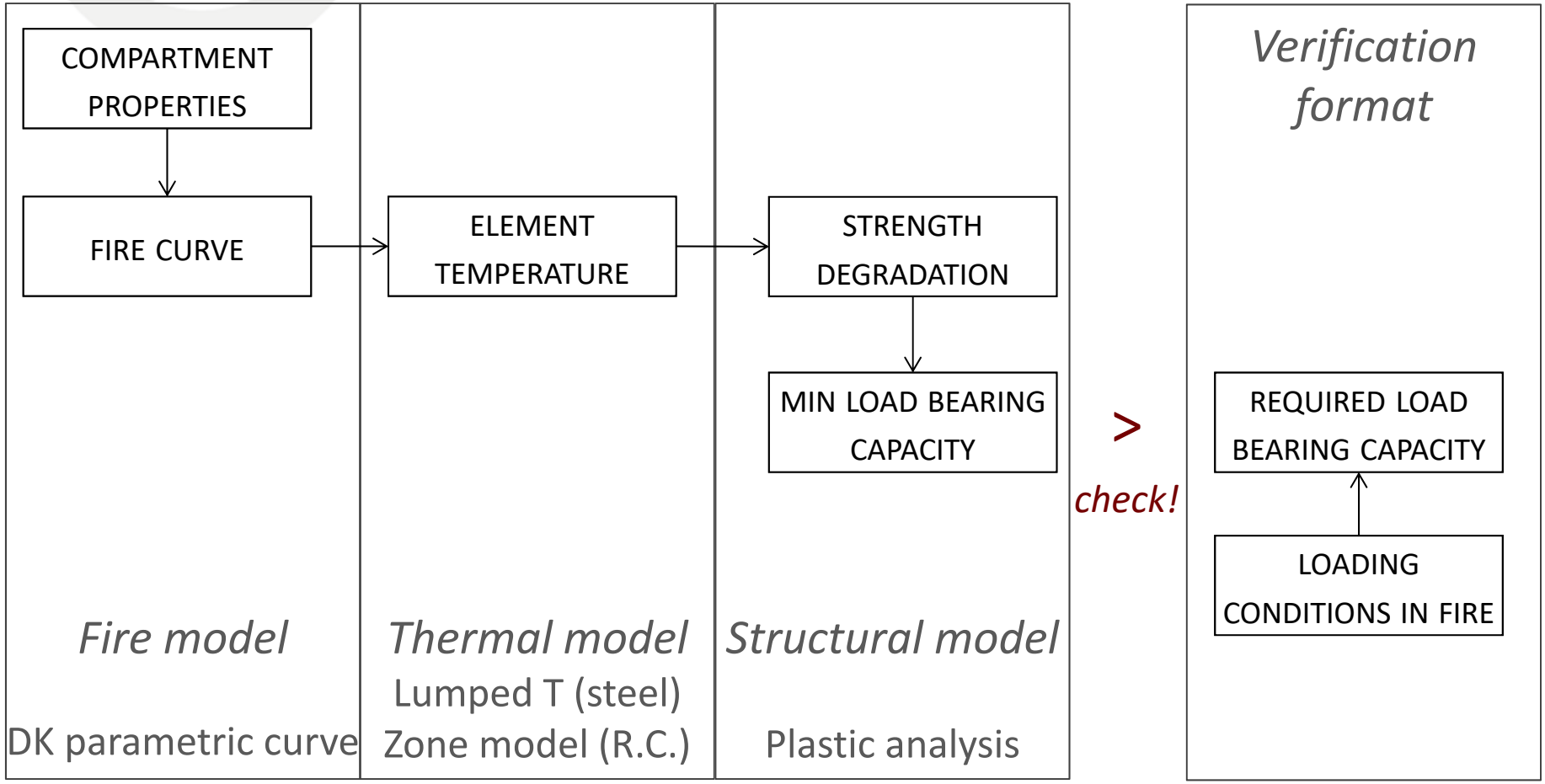
Design structural elements to resist a fully developed fire in the compartment (Danish parametric curve).

1. Identify critical compartments (high fuel load, low thermal inertia, low ventilation, as well as large/high compartments)
2. Identify critical elements (utilization factor and maximum heating temperature) and at least:
   - 1 beam, 1 column, 1 floor slab, plus possible key elements for structural robustness
3. Design/verify the critical elements against fire
4. Suggest modification for improvements/optimization



Co-funded by the
Erasmus+ Programme
of the European Union

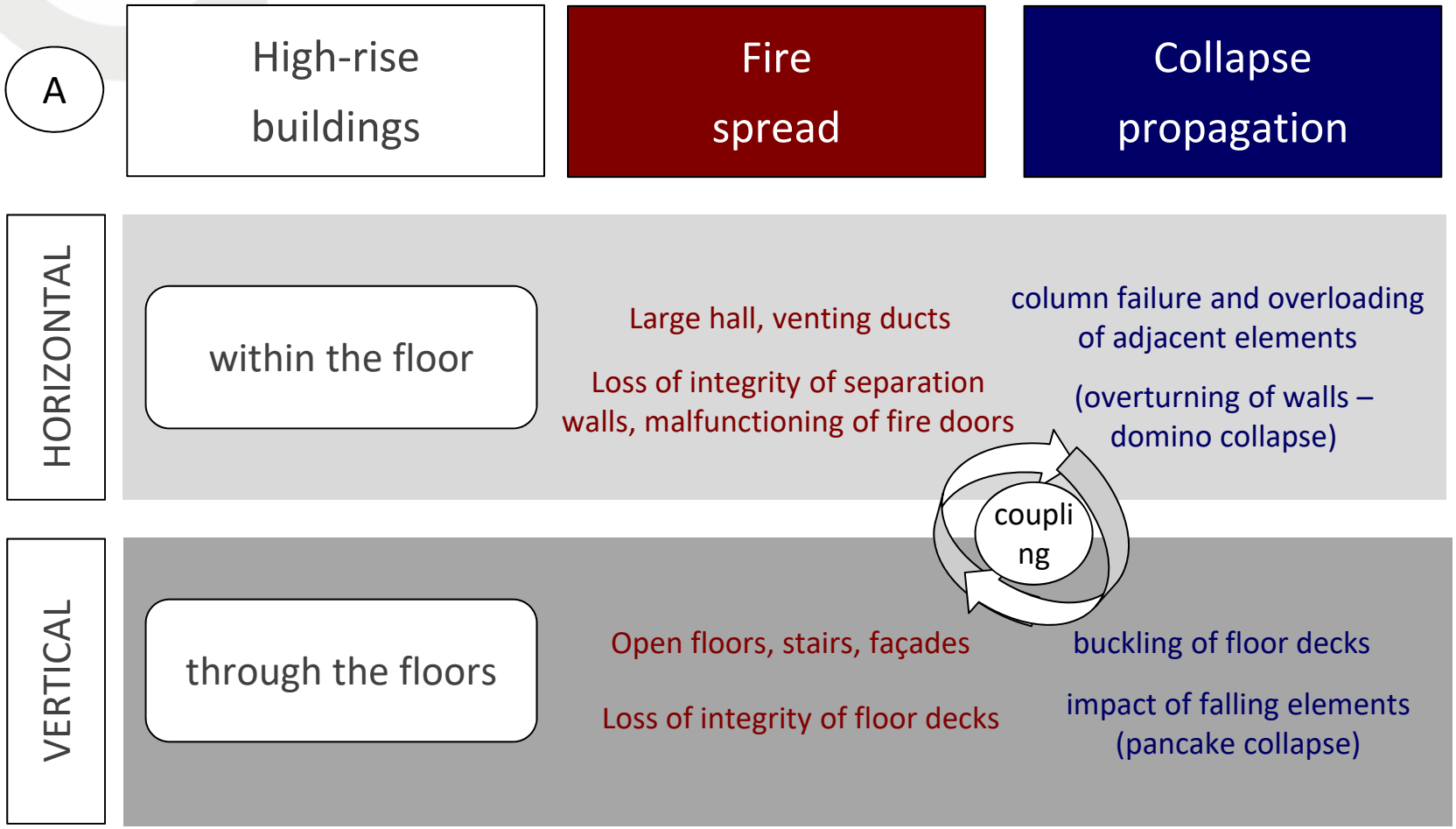
# 11080 – Subj. 5.2 Post-FO Fire Design






Co-funded by the Erasmus+ Programme of the European Union

# 11080 – Subj. 5.2 Post-FO Fire Design







Co-funded by the Erasmus+ Programme of the European Union

# 11080 – Subj. 5.2 Post-FO Fire Design






Co-funded by the
Erasmus+ Programme
of the European Union

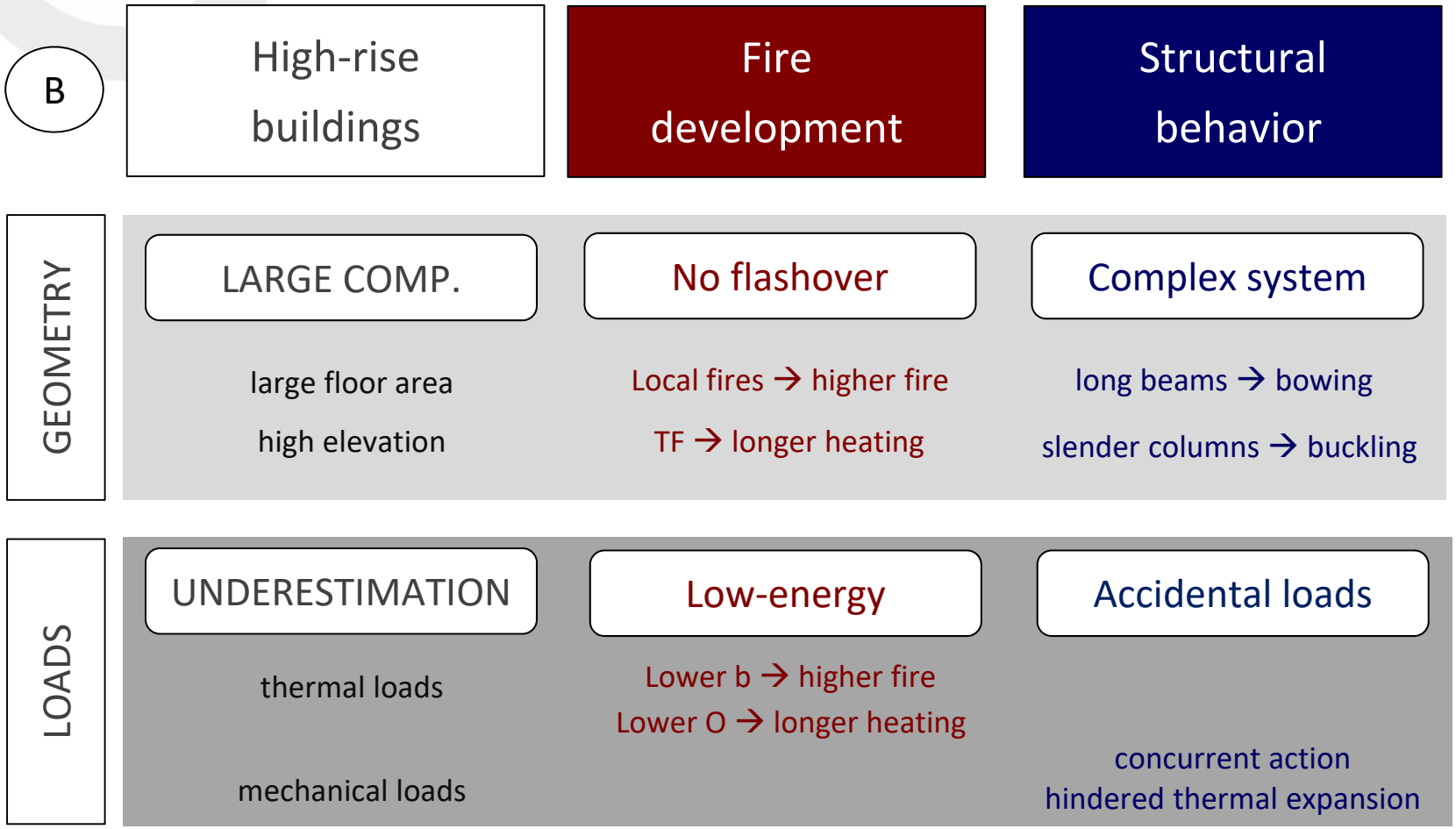
# 11080 – Subj. 5.2 Post-FO Fire Design






Co-funded by the
Erasmus+ Programme
of the European Union

# 11080 – Subj. 5.2 Post-FO Fire Design






Co-funded by the Erasmus+ Programme of the European Union

# Inter-relations between Subj.5 and other subjects

**Subj. 1: Architectural design**

- the design of staircases and rescue staircases influences the evacuation time;
- the distribution of spaces determines the choice and size of compartments;
- the intended destination of usage influences the loads and the resistance class;
- the presence of suspended ceiling influences the height of the smoke layer;
- type and amount of insulations may be incompatible with aesthetic or architectonic needs.



Co-funded by the
Erasmus+ Programme
of the European Union

# Inter-relations between Subj.5 and other subjects

**Sub. 2: Building structure**

- Consistency with the structural and static scheme used in subj. 2 calculations!
- modifications on the element size or material required by fire verifications affect the weight and stiffness of the structure assumed in subj.2 and may therefore require to recalculate the structure for the final design.

**3: Building Energy**

- when designing the pipe system, pay attention fire compartments and possible escape of smoke and fire from holes and venting in the walls;
- consider installations for fire extinguishing and overpressure in staircases



Co-funded by the
Erasmus+ Programme
of the European Union

# Inter-relations between Subj.5 and other subjects

**Sub. 4: Geotechnical design**

- Limitations of fire spread and evacuation from the underground parking lot (subj. 5.1);
- Boundary conditions of the bottom columns influences subj. 5.2 calculations.

**Sub. 6: Management**

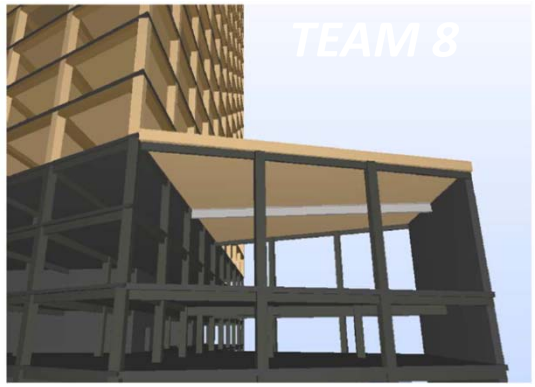
- Evacuation strategy: cost for training staff and occupants, alarm maintenance
- Active measures: cost of installing and maintaining of the sprinkler system etc.
- Passive measures: cost of insulation and sustainability aspect (toxic paint etc.)

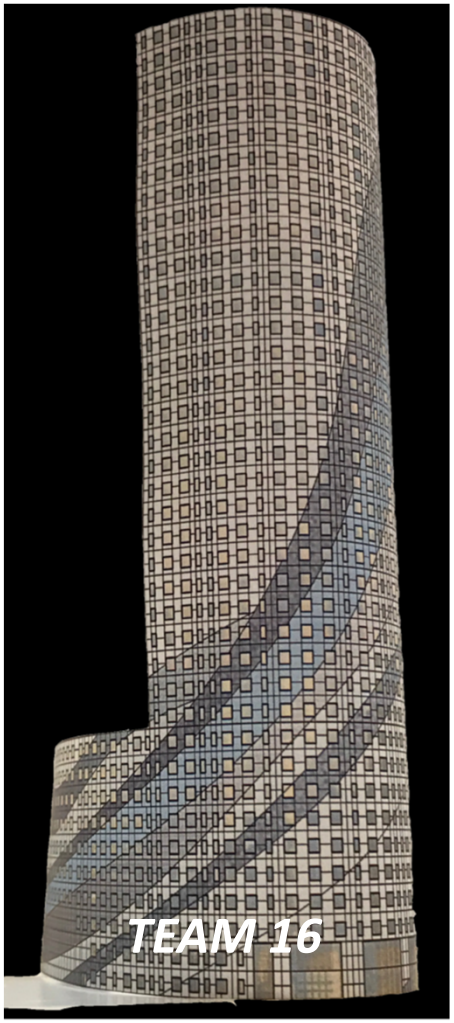


Co-funded by the
Erasmus+ Programme
of the European Union

# 11080 - Some projects in autumn 2016

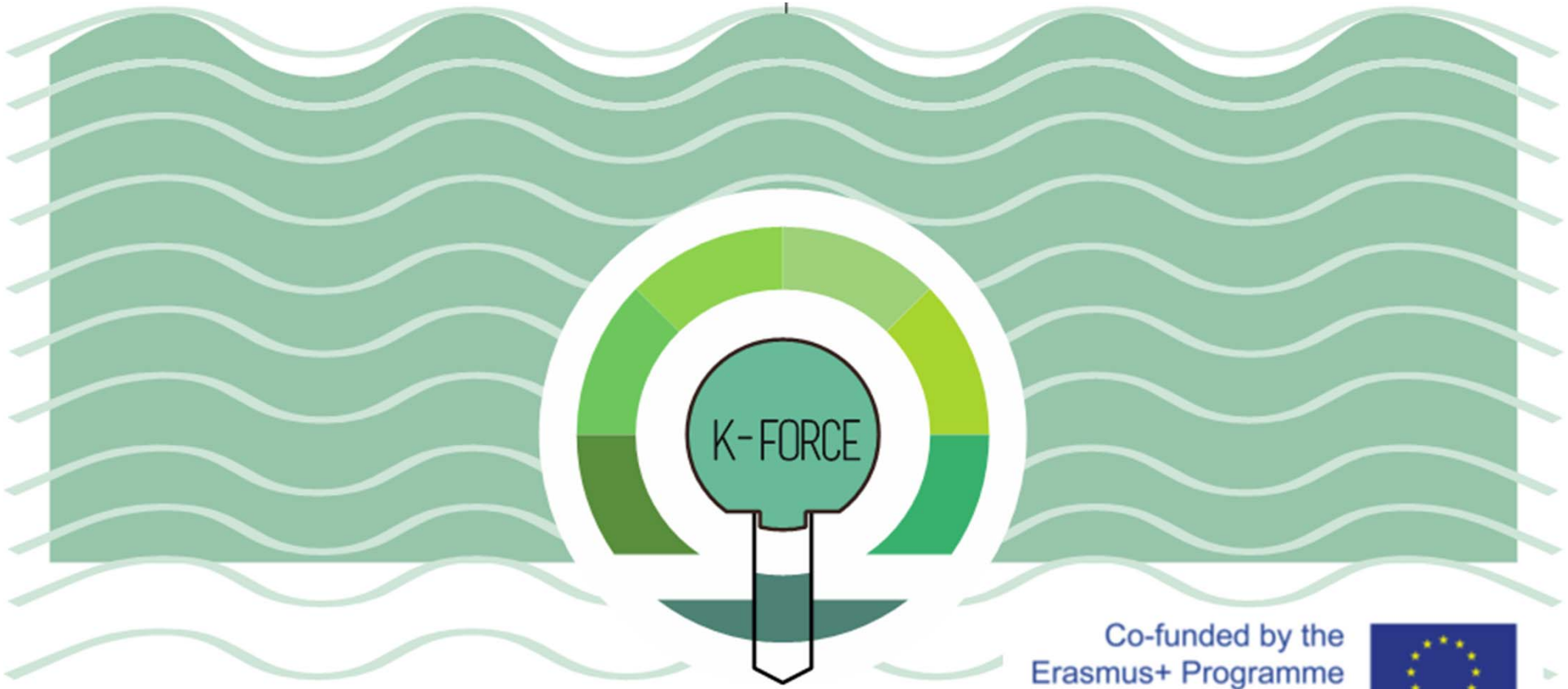





DTU Civil Engineering
Department of Civil Engineering

Co-funded by the
Erasmus+ Programme
of the European Union




# Thank you for your attention

*Luisa Giuliani, Ph.D., P.E. - lugi@byg.dtu.dk*

*Associate Prof. at DTU-BYG (Civil Engineering Department)*

**Knowledge FOr Resilient soCiEty**