

Putting Fire Safety at the heart of the Renovation Wave into practice – Session IV: Performance based design

EU FSW, 16th November 2022

Diane Daems, Technical WG chair of Modern Building Alliance

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3 speakers

1. **Silvia Dimova**, DG Joint Research Center – The status and standardisation needs for Fire Safety Engineering approach in Europe
2. **John Barry**, Department of Housing, Local Government & Heritage, Ireland – Building Control and Fire Safety Engineering in Ireland
3. **Professor Patrick van Hees**, Lund University – Performance based design and why fire safety engineering is important in tomorrows world

Performance based design and Fire safety engineering are key elements of a holistic approach



Putting fire safety at the heart of the Renovation Wave into Practice

Performance-based design: status and standardisation needs for Fire Safety Engineering approach in Europe

S. Dimova, F. Sciarretta, G. Tsionis, F. Augendre

Joint Research Centre, European Commission

A. Athanasopoulou, L. Sousa

Formerly Joint Research Centre, European Commission

16 November 2022

Fire Safety Engineering – the tool for Performance Based Fire Design

ISO 13943:2017 (E) Fire safety – Vocabulary :

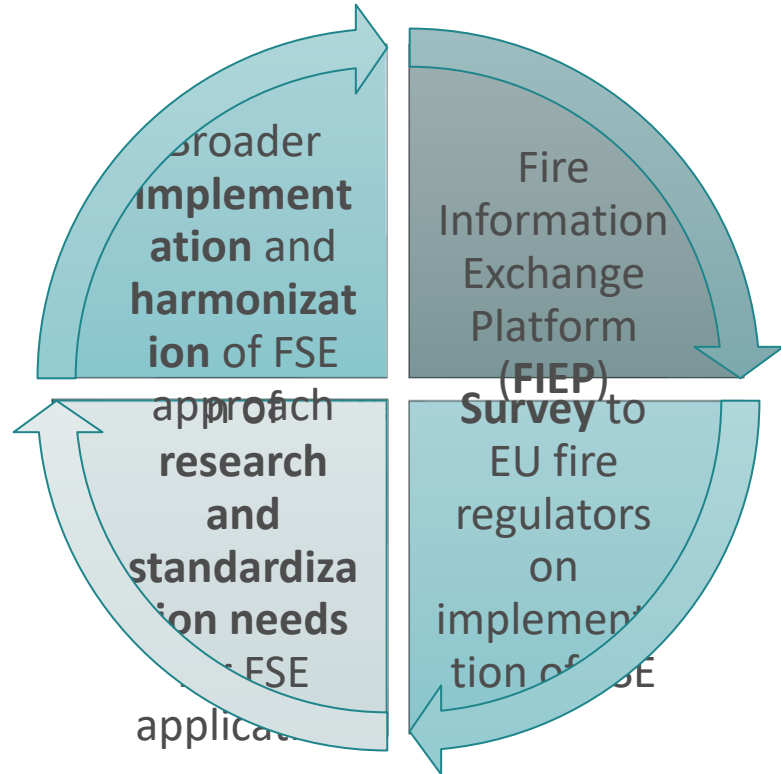
Fire Safety Engineering (FSE) is the **application of engineering principles, rules and expert judgment** based on a scientific appreciation of the :

- *fire phenomena,*
- *effects of fire, and*
- *reaction and behaviour of people,*

in order to:

- (a) save life, protect property and preserve the environment and heritage;**
- (b) quantify the hazards and risks of fire and its effects;**
- (c) evaluate analytically the optimum protective and preventative measures necessary to limit, within prescribed levels, the consequences of fire.**

Addressing the challenge of fire safety in Europe



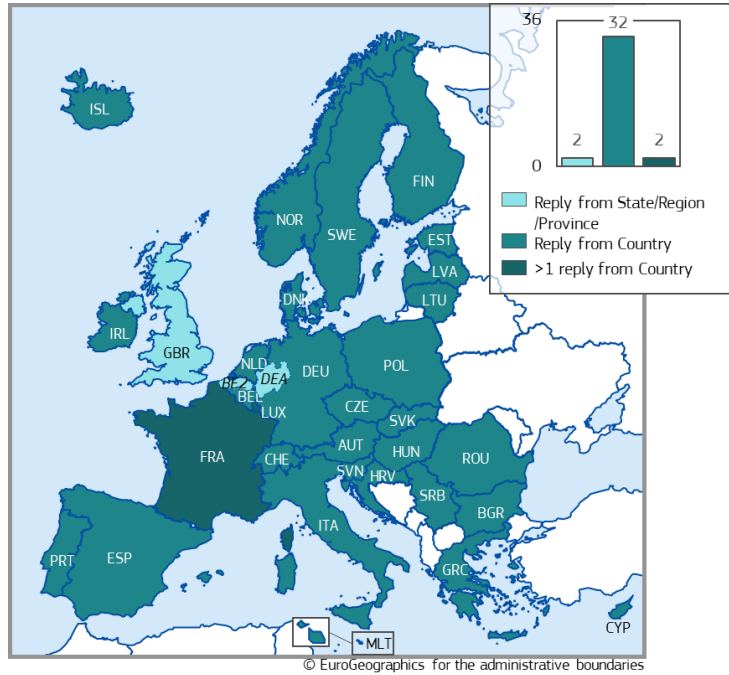
The European Commission facilitates improvements in fire safety practices.

Examples:

- **Fire Information Exchange Platform** led by DG GROW
- **Fire Safety Engineering (FSE) implementation project** by JRC

Enquiry on FSE implementation status in Europe

Contacted Countries and feedback



Performed by

- JRC and DG GROW, European Commission

Focus

- The built environment - excluding industrial buildings and related installations; 12 Technical Areas

Target responders

- Principal fire regulatory authorities in EU/EFTA MS.

Relevant work

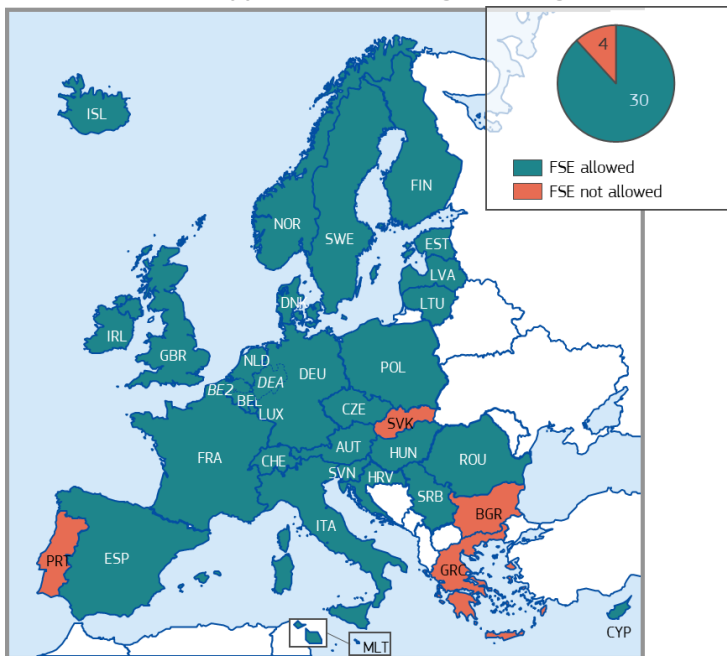
- Surveys made from ISO TC 92 and CEN TC

127.

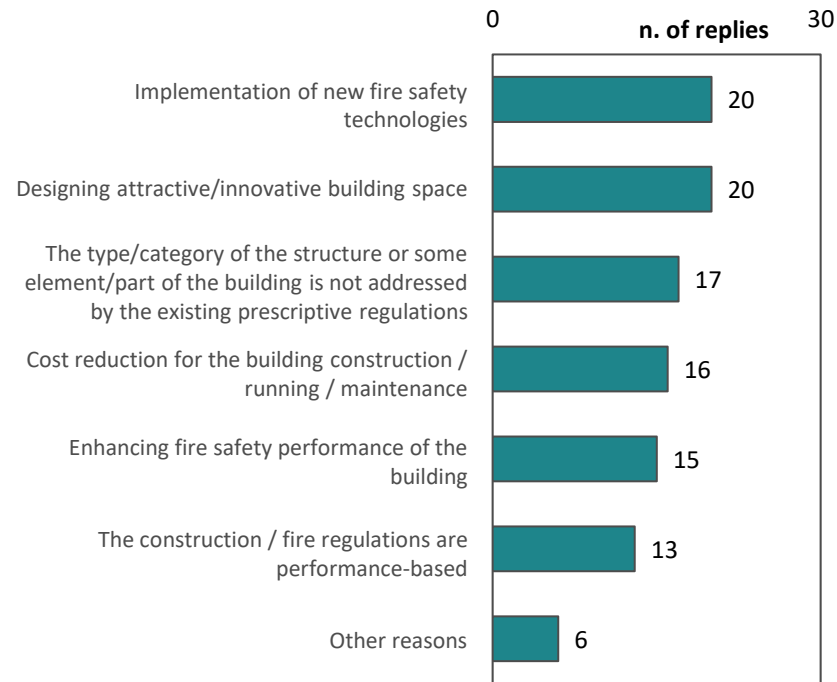
Analysis as of 08 November 2022

FSE approach allowance for construction works

Allowance of FSE approach in building fire design

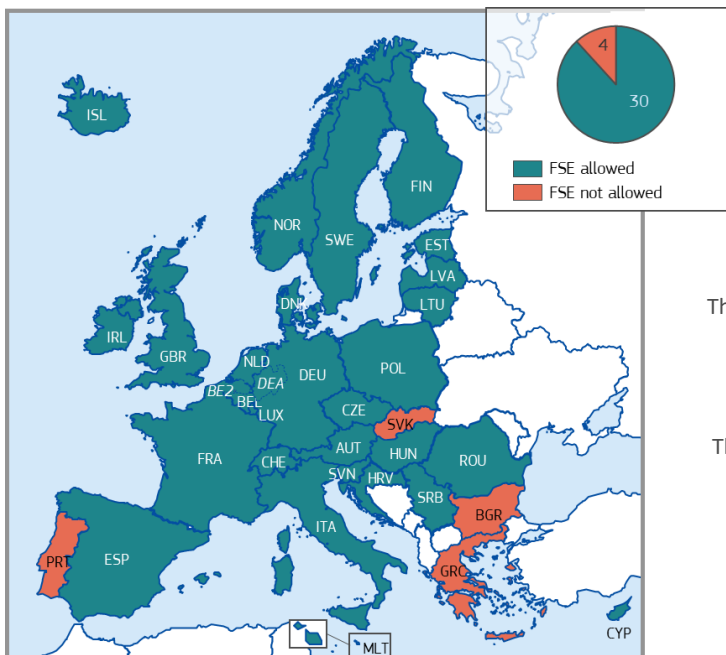


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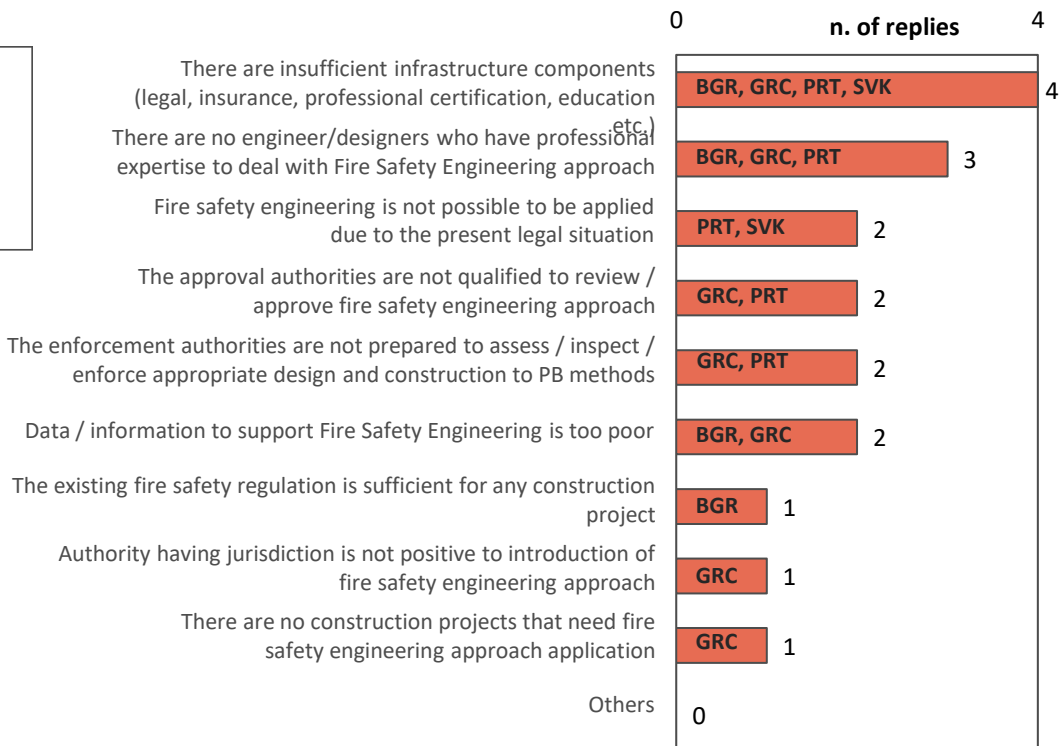


Barriers to FSE approach for construction works

Allowance of FSE approach in building fire design

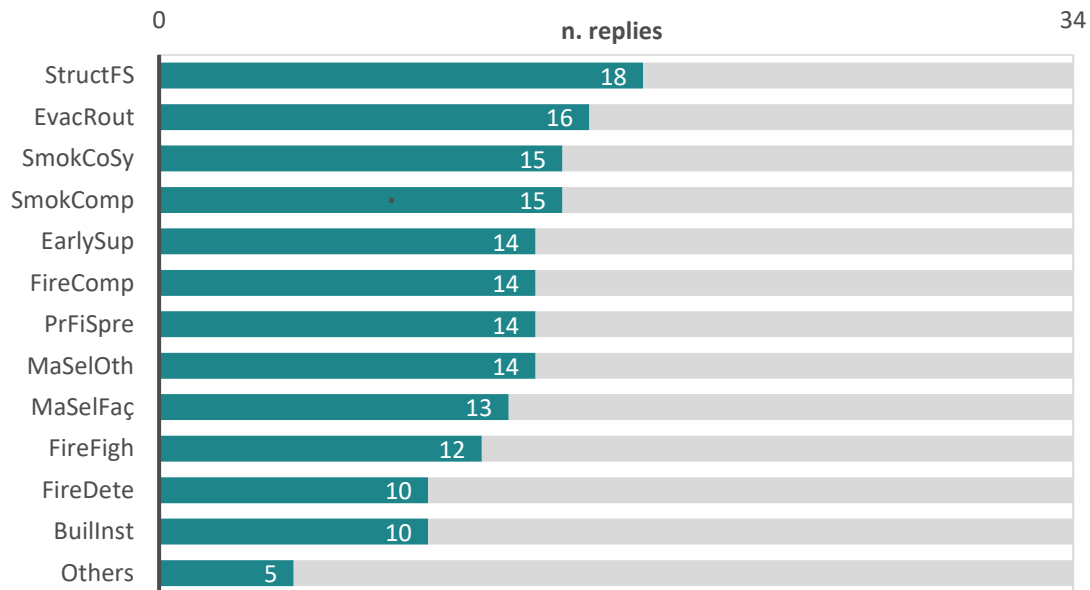


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Technical areas with most used PB solutions

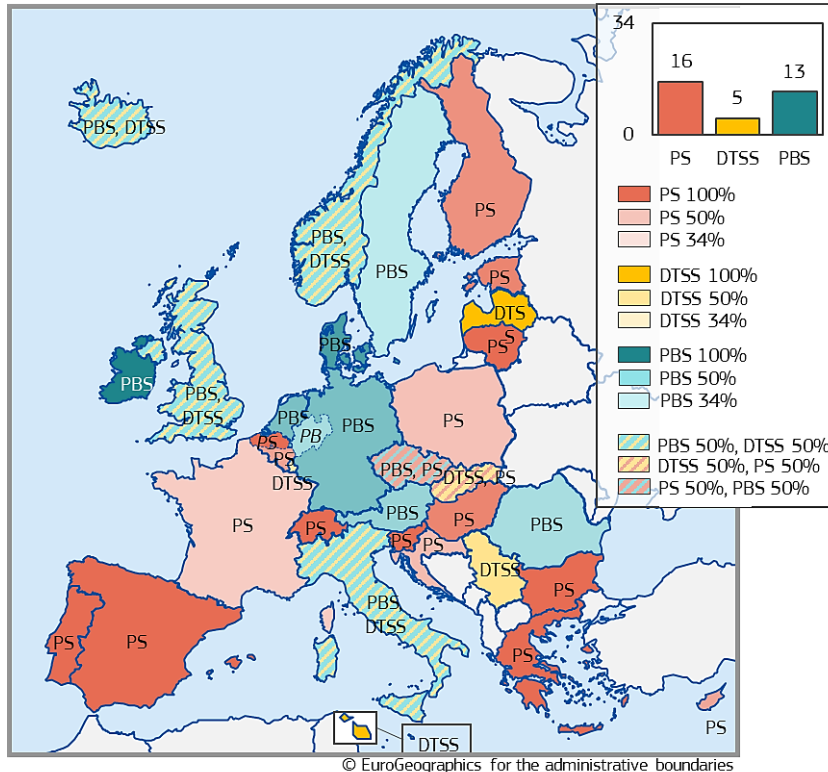
TAs included in FSE applications – FSE-allowing countries / regions



The technical areas in which performance-based solutions are most used:

- Structural Fire Safety,
- Evacuation Routes,
- Smoke Control Systems, and
- Smoke Compartmentation

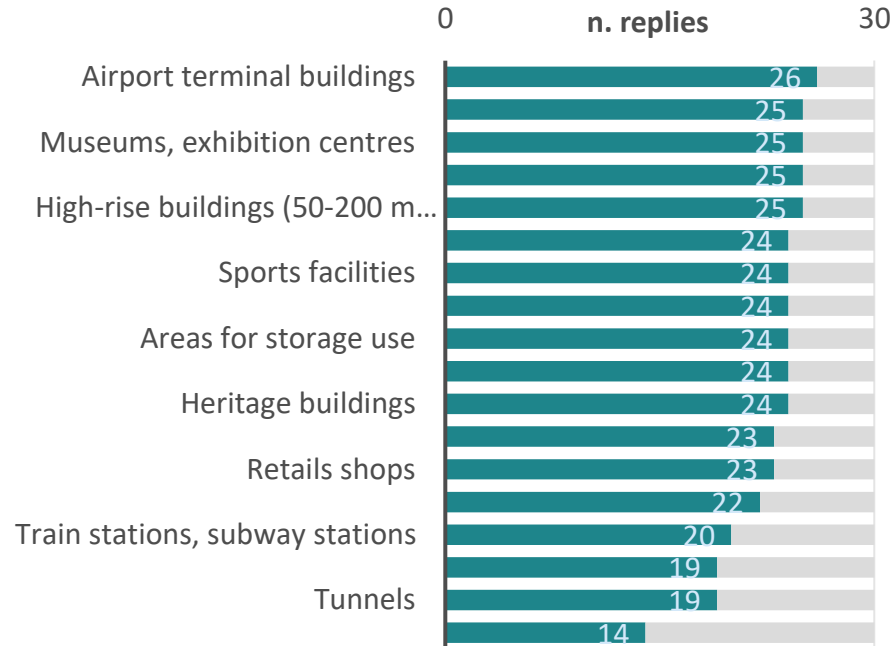
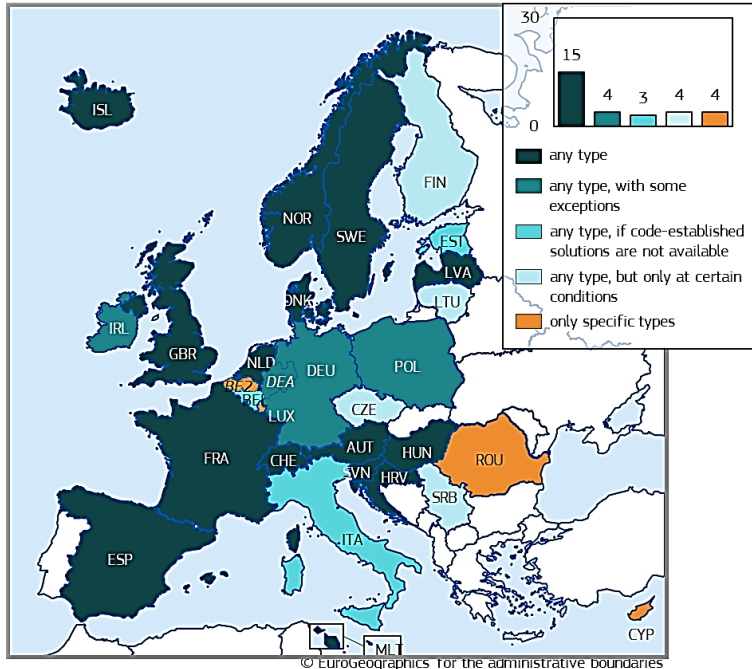
Prevailing approach in fire safety design



- **Prescriptive solutions (PS)** are predominant in the responding countries (40-50% of available solutions in the considered Technical Areas)
- **Performance-based solutions (PBS)** cover the **25-35%**
- **Deemed-to-satisfy solutions (DTSS)** cover the **20-30%**
- In some country there is parity between two of the three approaches

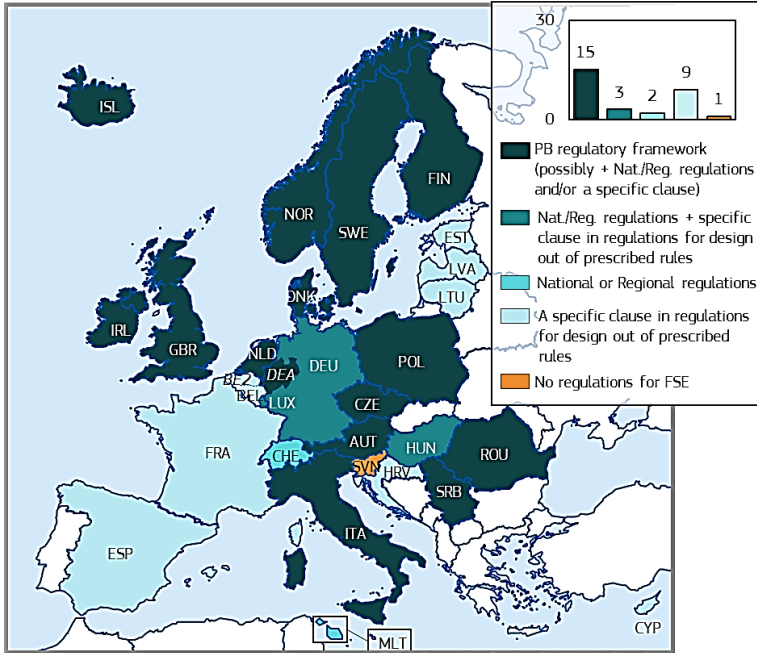
FSE approach covers many types of construction

Types of construction which FSE approach applies to



Regulatory framework and assessment methods

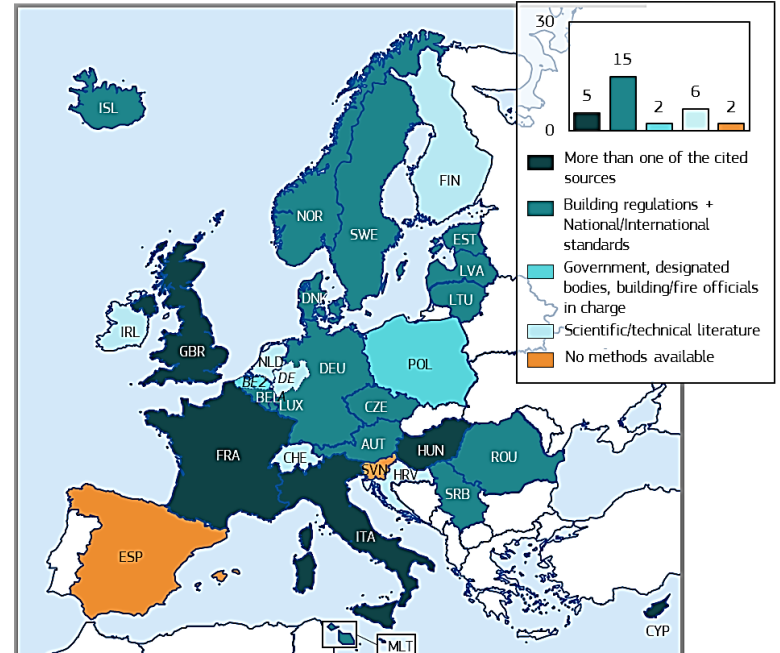
Regulatory framework allowing to apply FSE approach



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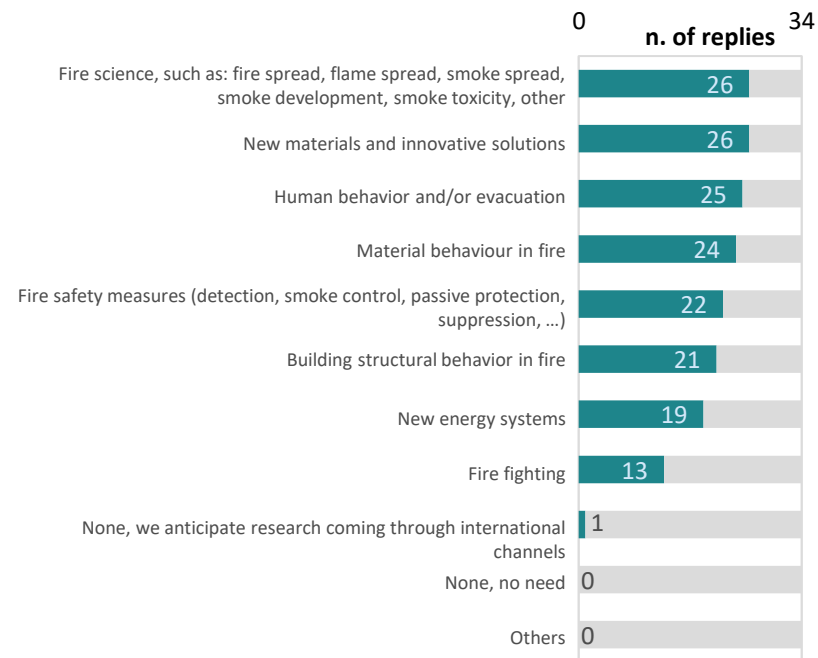
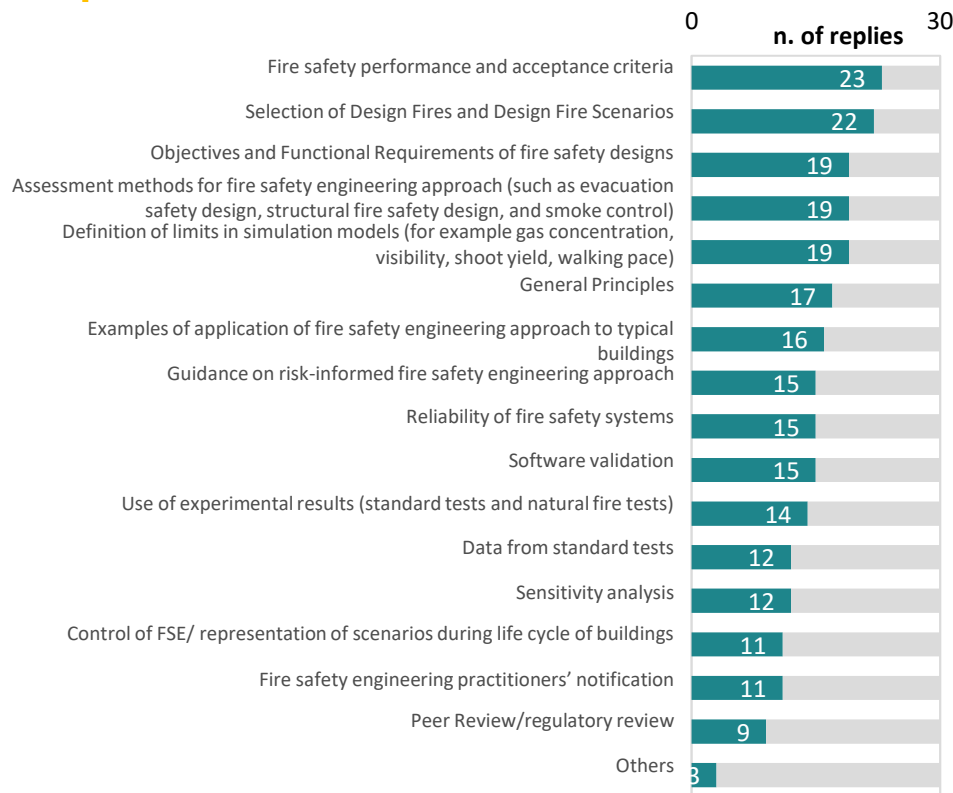
PB framework (Q9)	AUT	CZE	DEA	DNK	FIN	GBR	IRL	ISL	ITA	NLD	NOR	POL	ROU	SRB	SWE
PB solutions available (Q2)	52%	50%	46%	83%	21%	48%	100%	41%	50%	64%	44%	13%	46%	46%	38%

Prevailing sources of assessment methods for the 12 TAs



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FSE standardisation & research needs



Analysis as of 08 November 2022

Preliminary observations and conclusions

Most EU/EFTA MS **allow** for FSE approach in the national building regulations

BUT

Prescriptive methods are largely prevalent in practice throughout the countries

- FSE approach is not fully implemented in the different technical areas, even in case of recent updates of regulations
- FSE approach is usually adopted because of the unavailability of prescriptive approach

in certain cases, e.g. strategic buildings (hospitals, airports, ...) and projects with particular characteristics (height, area, complexity, ...)

Preliminary observations and conclusions

- Regulations and referenced standards (e. g. Eurocodes) are the most frequent sources for calculation methods for FSE approach application.
- In many countries FSE approach is applied to a wide range of construction types.
- The role of technical education & research on FSE related topics is crucial in all countries.
- There is consensus among EU MS on research needs and topics requiring technical guidance and standardization in

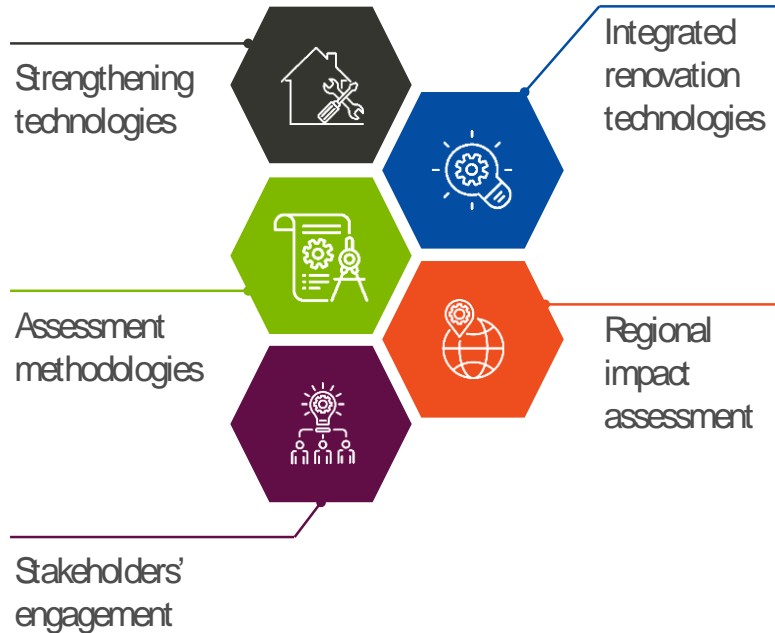
Next steps and the future

- Publication of a **JRC technical report** on the status and standardization needs for FSE application (November/December 2022).
- Publication of JRC technical report(s) on (i) standardization needs for FSE incorporation in MS regulation and (ii) definition of needs for guidance and training for professionals by the end of 2024.

Policy requirements for integrated renovation

- **Renovation Wave** / key principle 'high health and environmental standards' for building renovation: **ensure fire and seismic safety**
- Proposal for recast of the **Energy Performance of Buildings Directive**: to address healthy indoor climate conditions, **fire safety and risks related to intense seismic activity** in long-term renovation strategies and in major renovation of buildings
- National **recovery and resilience plans** of Croatia, Italy, France, Romania and Slovenia, and 2020 **long-term renovation strategies** of Croatia, Cyprus, Hungary, Italy, Romania, Slovenia and Spain recognise seismic safety

Example of integrated renovation: the pilot project on seismic and energy renovation



European Parliament pilot project 'Integrated techniques for the seismic strengthening and energy efficiency of existing buildings' led by JRC according to Commission Decision C(2019) 3874.

Technical solutions that :

- reduce **seismic risk**,
- **increase energy efficiency** and
- produce a significant **positive environmental impact**.

More information

<https://buildings-renovation-makerspace.jrc.ec.europa.eu>

Project output (by December 2022)

Technical guidance

- Identification of **European buildings most needing seismic and energy retrofit**
- **Technologies for the combined** seismic and energy **upgrading** of existing buildings
- **Novel technologies** for the seismic upgrading of existing European buildings
- **Methodologies for the assessment** of the combined seismic and energy upgrading of existing buildings and application to case studies
- **Policy measures** for seismic and energy upgrading of buildings in EU Member States
- **Prioritising EU regions for building renovation**: seismic risk, energy efficiency, socioeconomic vulnerability
- Building renovation in the EU: **scenarios and impact assessment**

More information

<https://buildings-renovation-makerspace.jrc.ec.europa.eu>

Thank you



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Building control and fire safety engineering in Ireland

John BARRY

National Directorate for Fire and Emergency Management
Department of Housing, Local Government and Heritage

Regulatory framework

Design and construction of buildings

Building Control Act, 1990

Building Regulations, 1992 - 12 parts, A – M – Part B fire safety

Operation and management of buildings in use

Fire Services Acts 1981 and 2003

Part B – fire safety

Essential requirements B1 to B5

B1 Means of escape in case of fire

B2 Internal fire spread (linings)

B3 Internal fire spread (structure)

B4 External fire spread

B5 Access and facilities for the fire service

Fire Safety

B

Building Regulations 2006

Technical Guidance Document



Rialtas na hÉireann
Government of Ireland

Prepared by the Department of Housing, Planning and Local
Government

housing.gov.ie

Reprinted Edition
2010
Amendments & Corrections
Incorporated

Means of escape in case of fire.	B1	A building shall be so designed and constructed that there are adequate means of escape in case of fire from the building to a place of safety outside the building, capable of being safely and effectively used.
Internal fire spread (linings).	B2	For the purpose of inhibiting the spread of fire within a building, the internal linings - (a) shall have, either a rate of heat release or a rate of fire growth and a resistance to ignition which is reasonable in the circumstances (b) shall offer adequate resistance to the spread of flame over their surfaces
Internal fire spread (structure).	B3	(1) A building shall be so designed and constructed that, in the event of fire, its stability will be maintained for a reasonable period. (2) (a) A wall common to two or more buildings shall be so designed and constructed that it offers adequate resistance to the spread of fire between those buildings. (b) A building shall be sub-divided with fire resisting construction where this is necessary to inhibit the spread of fire within the building. (3) A building shall be so designed and constructed that the unseen spread of fire and smoke within concealed spaces in its structure or fabric is inhibited where necessary. (4) For the purposes of sub-paragraph 2(a), a house in a terrace and a semi-detached house are each to be treated as being a separate building.
External fire spread.	B4	The external walls and roof of a building shall be so designed and constructed that they afford adequate resistance to the spread of fire to and from neighbouring buildings.
Access and facilities for the fire service.	B5	A building shall be so designed and constructed that there is adequate provision for access for fire appliances and such other facilities as may be reasonably required to assist the fire service in the protection of life and property.

Essential requirements B1 to B5

Technical Guidance Document B – fire safety (2006) – TGD B

Compliance with TGD B – *prima facie* evidence of compliance with fire safety requirements of Building Regulations

Other approaches permissible – but must demonstrate compliance with requirements of Building Regulations

Alternative approaches

- Fire safety engineering may be used to demonstrate adequacy (The use of engineering principles to protect people and property from fire)
- Can provide a more fundamental solution than traditional prescriptive approaches
- May be the only viable means of achieving a satisfactory standard in some large buildings, complex buildings, works in existing buildings
- Qualitative assessment, quantified analysis
- Probabilistic, risk-based approach
- Deterministic – worst credible scenarios, factors of safety
- Comparison of performance with TGD B-compliant solutions

Alternative approaches

- Fire safety engineering – for example, BS 7974:2019 Application of fire safety engineering principles to the design of buildings – code of practice
- Advanced approach – BS 9999:2017 Fire safety in the design, management and use of buildings – code of practice
- Use of alternative approaches for part of design
 - for example, means of escape, structure, facilities for fire services

Design approaches

- Majority of buildings – application of prescriptive approach in TGD B
- Remainder – mainly TGD B, with partial alternative approach
- Infrequent – fully engineered design

Timeline / history

- 1981 – Stardust fire, Dublin – 48 fatalities
- 1980s – development of fire safety engineering among fire officers and designers
 - third level educational institutions
- 1990 – Building Control Act
- 1992 – Building Regulations
- 2000s – Building boom

Use of fire safety engineering – some considerations

- Critical analysis by regulatory bodies of designs
 - Assumptions
 - Consistency
 - Factors of safety
 - Modelling
 - Reliance on management of building over its lifetime
 - Maintenance of fire safety systems
 - Plan in event of fire
 - Staff training
 - Control of building works



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Performance based design: the need for fire safety engineers and role of standards

PATRICK VAN HEES, LUND UNIVERSITY



Overview

- Why is fire safety engineering important
- Background Performance Based Design
- Challenges for PBD
- Educational needs
- Conclusions





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Why Fire Safety Engineering is Important in Tomorrow's World



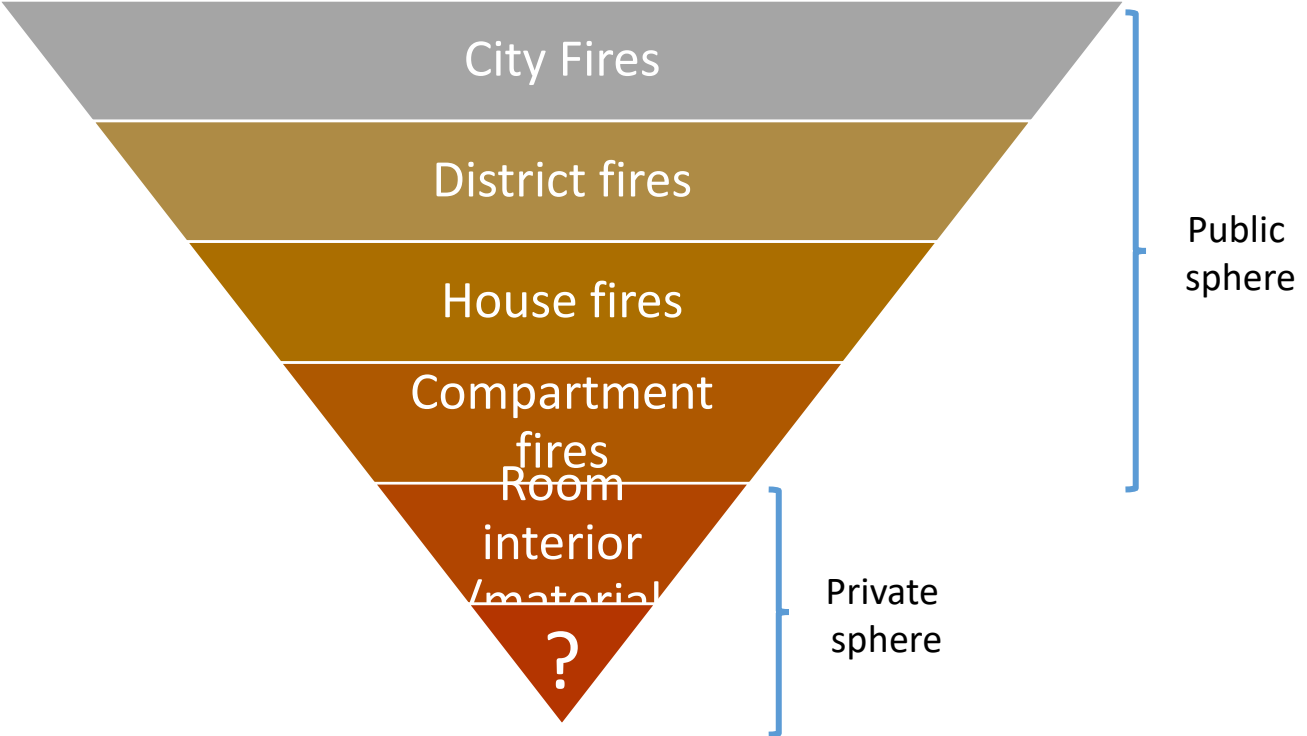
Fire Safety – Historical



Great Fire of London (1666)



House fire (photo: MSB)



Fire Safety (Buildings) – Today



The Gherkin, London

Innovative Buildings



Multifunctional buildings

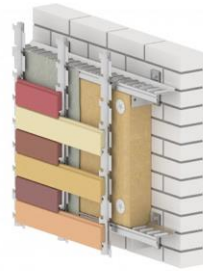
Green buildings

Digitalisation

New threats

Complex systems

+ ..+ .. +.....

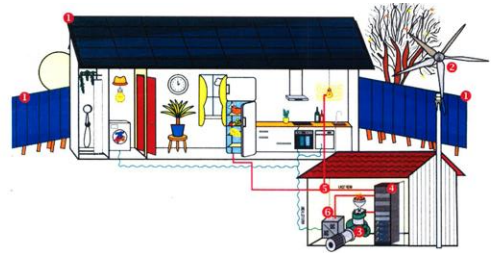


Facade systems



Emporia, Malmö

MULTIDISCIPLINARY APPROACH
IMPERATIVE



Digitalisation, ZEB



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IAFSS Agenda 2030 for a Fire Safe World - The future

White Paper from the international Association of Fire Safety Science

[HTTPS://WWW.SCIENCEDIRECT.COM/SCIENCE/ARTICLE/PII/S0379711219303509](https://www.sciencedirect.com/science/article/pii/S0379711219303509)





The Fire Problem...

- **WHO** – 180 000 burn deaths annually, vast majority in low and middle-income countries but situation in developed countries is also troubling
- **Europe** – 3 500 killed in fires annually, at least 70 000 injured
- **Developed countries** – cost of fire >1% GDP
- **US** – total annual cost of fire close to 2% GDP

... in September 2018 IAFSS called stakeholders to dialogue which ultimately resulted in the IAFSS Agenda 2030 for a Fire Safe World, published in Fire Safety Journal !

Reference: <https://www.sciencedirect.com/science/article/pii/S0379711219303509>

A hand is shown holding a small, vibrant globe. The globe is a cross-section of a sustainable world, featuring a green grassy hillside on top with wind turbines, houses, trees, and people. Below the surface, there is a blue body of water with a fish, two white birds, and a splash. The background is a bright blue sky with white clouds and a cluster of colorful balloons. A semi-transparent circular overlay on the left side of the image contains the text.

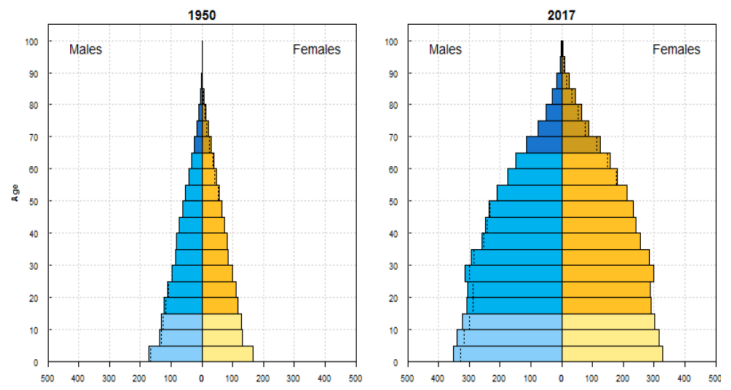
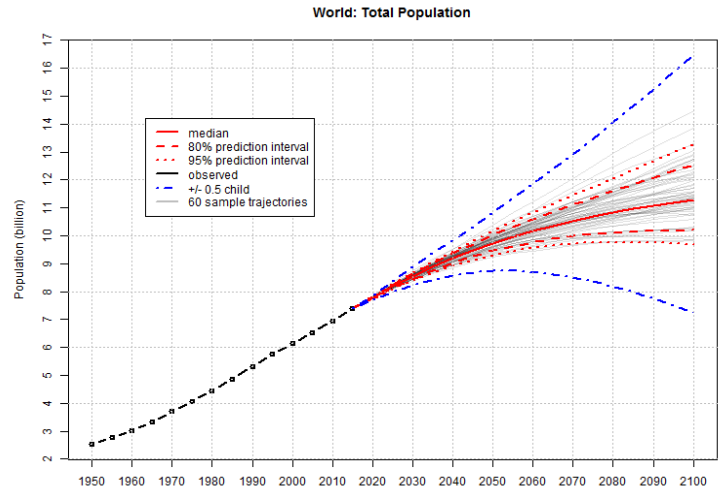
Climate change,
resiliency and
sustainability

An aerial night view of a city with numerous skyscrapers and residential buildings. The city is overlaid with a complex network of glowing white lines and nodes, representing a global or urban network. The lines connect various points across the city and extend towards the horizon. The overall color palette is dark blue and black, with bright white and light blue highlights from the city lights and network lines.

Population
growth,
urbanization and
globalization

Demographics

- Population expected to continue to grow until (at least) 2050-2100
- Large movement of people
- Aging society
- Demographic potential in developing countries and demographic debt in first world countries
- Increased international dependencies
- Globalization exacerbates critical situation created by population growth and urbanisation

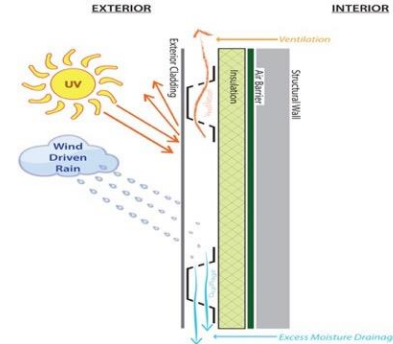


Source: UN Dept of Economic and Social Affairs. Population Division, 2017



Tall Buildings, New materials

- More complex egress, due to increased number of tall building, denser urban areas, increased population with reduced mobility
- More complex suppression activities, limited access, sensitive environments, hard surfaces in cities
- New materials, need for better understanding of their fire safety
- Holistic aspect is necessary !
- Performance and risk based engineering is important – Traditional templates do not work



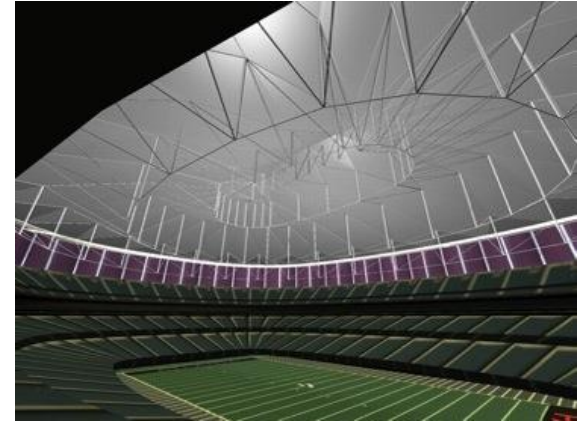
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- Why is fire safety engineering important
- Background Performance based design
- Challenges for PBD
- Educational needs
- Conclusions



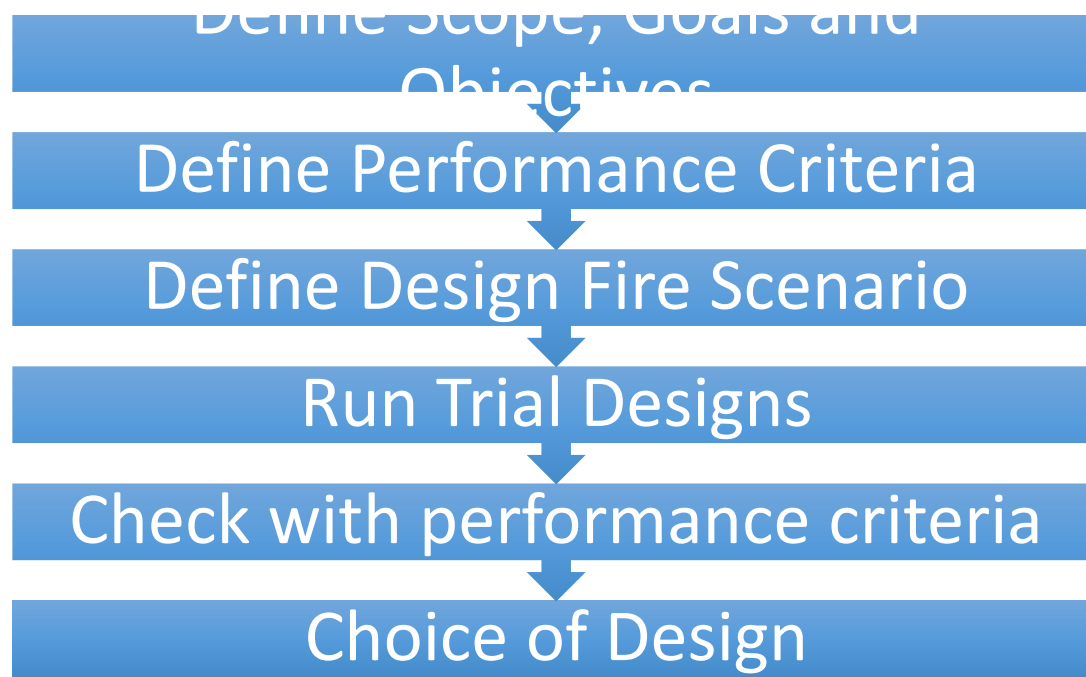
Key aspect: Performance Based Design

- Performance-based regulations design an objective, but do not say how it should be accomplished
- Objectives can be e.g. safe evacuation within a specified time, structure stability within a specified time
- This option allows more flexible solutions (large public areas), more cost-efficient designs and solutions for complex facilities which are impossible to tackle by prescriptive solutions



Picture: Tensinet

Key aspect in the process – Performance based design



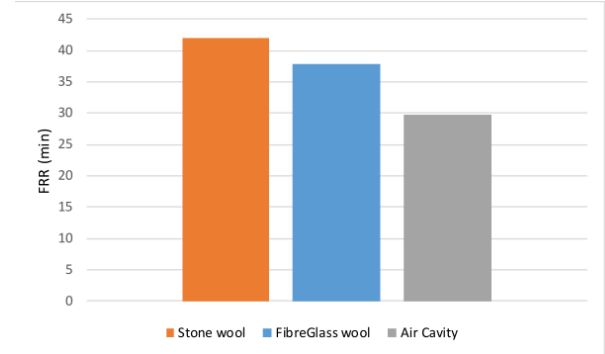
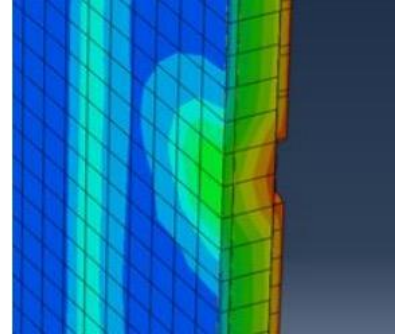
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Challenges – Design Procedure

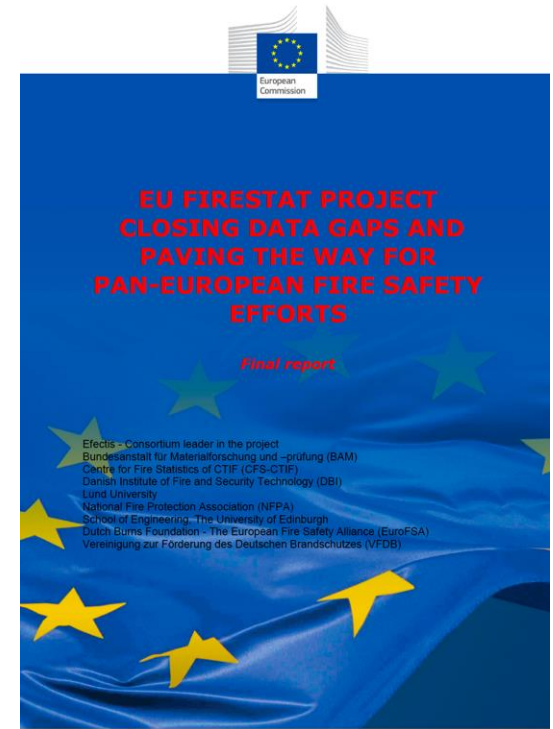
- More Quality control during the design process but also afterwards during running operations !!
- More guidance on design fires.
- More feedback from real accidents – case studies
- Synchronise with the other building properties such as insulation, humidity, structural stability, etc.



Pictures Lund University

Challenges – Design Procedure -Statistics

- Good statistics to define probabilities for probabilistic designs and how to use them.
- Standardisation and harmonisation is needed and a recent DG grow study has given us now possibilities to do so
<https://data.europa.eu/doi/10.2873/778991>
- The report gave 7 recommendations for further actions.
- Amongst them are standardisation, definitions, common collection systems, Cost benefit methods.



Picture EU

Challenges – Standardisation

- ISO TC92 SC 4 started in 1991 and has the major responsibility for standardisation in ISO and produced at this date 33 standards and have 5 standards under development
- Standardisation exists also in CEN TC 127 under WG8 with one published document
- Other organisation are also active in the process as regional or national level (e.g. NFPA standards, INSTA standards, etc)

Major challenge: Synchronisation and cooperation is needed

Schemarubrik



Picture Lund University

Other challenges - Ethics

- The use of functional performance criteria and trade-offs in FSE require high ethical codes of the engineer as it requires taking an independent position and a high level of self-criticism
- Ethics plays also a role in performing research of overall systems with different products, components and/or subsystems. Research should be on a broad basis and not on the basis of sponsoring by one player. An urgent need for overall independent research funding is needed

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Challenges in education

- Fire safety engineers need to control different aspects of knowledge in order to address fire safety
- These are e.g. fire dynamics, chemistry, combustion, structural behaviour, risk analysis, performance based design, advanced modelling, active and passive systems, human behaviour in fires, societal behaviour, communication techniques, etc. etc.
- The FSE engineer needs a multidisciplinary approach and capability to work together with other disciplines.
- However we educate mainly courses in the building environment and need also to look into transport i.e. trains, ships (SOLAS art. 19), airplanes, etc.



Picture Lund University

Challenges in education

- This put requirements on the educational teams so joined efforts are needed in order to lead to high quality engineers and PhD. Support is needed.
- Example of joined activities: International master of FSE between Gent, Edinburgh, UPC Barcelona and Lund with cooperation of ETH, Queensland, USTC China, WPI and Maryland. Will be funded by EU for another 5 years with at least 15 scholarships per year.
- But we need even specialist in certain areas such as transport systems, ships, modelling, constructions, etc. This needs even PhDs in engineering to act as specialist and joined PhD Research Schools in Europe and world-wide.



Picture Gent University

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Conclusions

- Fire behaviour of buildings products, content, barriers etc. should be addressed as **overall holistic system behaviour** taking into account all aspects not only fire.
- **Performance based design** is certainly needed to replace detailed regulations for design in health care facilities, industrial facilities, transport and renovation projects and to cover all fire safety goals such as safety of life, property protection, continuity of operation, environmental protection and to cover growing complexity and need for quality.



Picture Lund University

Conclusions

- Fire is a complex phenomenon with a combination of heat transfer, combustion, fluid dynamics, structural behaviour **and it is combined with** societal aspects and human behaviour. We need to realise this and prepare future engineers and PhDs in this overall **holistic approach**
- The **educational challenges** should be tackled on international level e.g. in international programs such as the International Master of Fire Safety Engineering or PhD schools for detailed specialization.
- **Forums** for international collaboration are needed e.g. for research IAFSS, for standardisation ISO and CEN, for engineering SFPE and IFE, etc. but they should be conducting more joint efforts together with regulators and industry.



Picture Lund University



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Thank you

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1. The wide majority of EU Member States allow performance based design and fire safety engineering
2. Performance based regulation gives building objectives, but does not say how. It allows more flexibility
3. There is a need for education, research and standardization on fire safety engineering in the EU



MODERN
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Safe and sustainable construction with plastics

Thank you!

Engage with us!



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