Challenges in Performance Based Design

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Overview

Trends in FSE – Background

Focus on risks for fire development

Discussion on the different steps

» New materials/new areas

» Advanced modelling

» Energy conservation

Conclusions=Challenges

Background

Fire Safety Engineering has been used intensively in building applications within a fire performance based design

New areas such as marine applications (ships with composite instead of steel, trains)

New materials/products are introduced for which new challenges appear e.g. products based on technical textiles

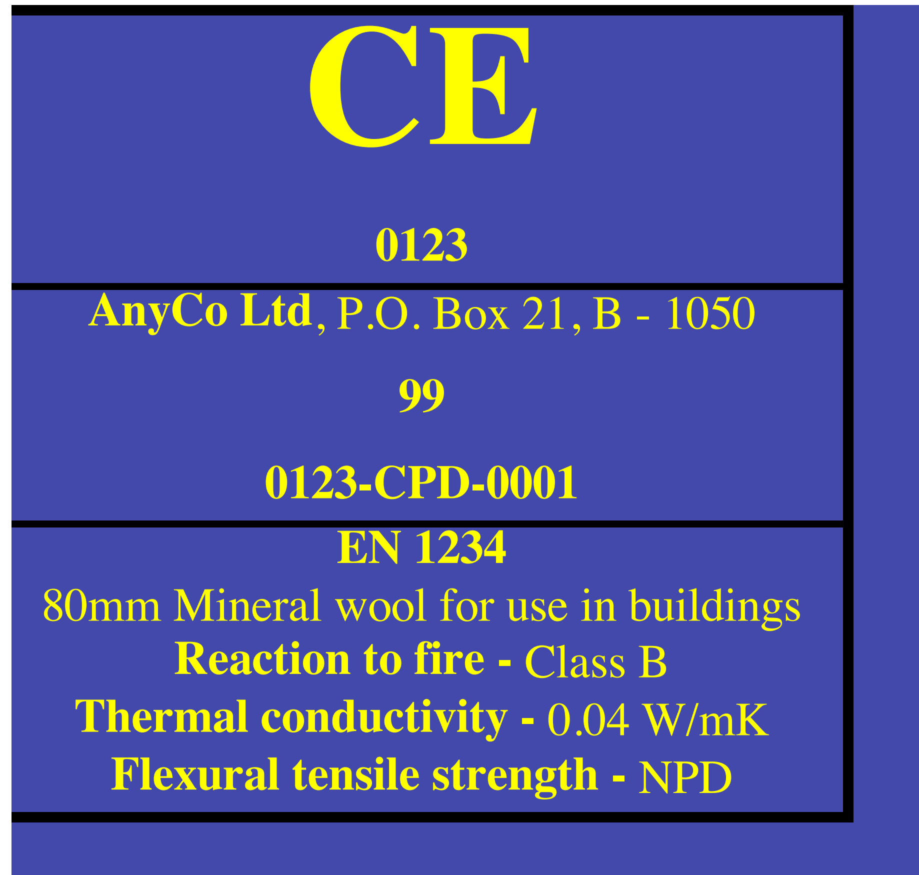
Picture:SP

Picture:Allianz

Difference between fire prescriptive and performance based solution

Prescriptive solutions are based on well defined criteria e.g. :

- A specific class for wall linings in evacuation routes e.g. Euroclass B
- A specific fire resistance of the enclosure e.g. REI 120
- A specific width of doors/ corridors for the evacuation routes
- A specific minimum path length to the nearest exit.



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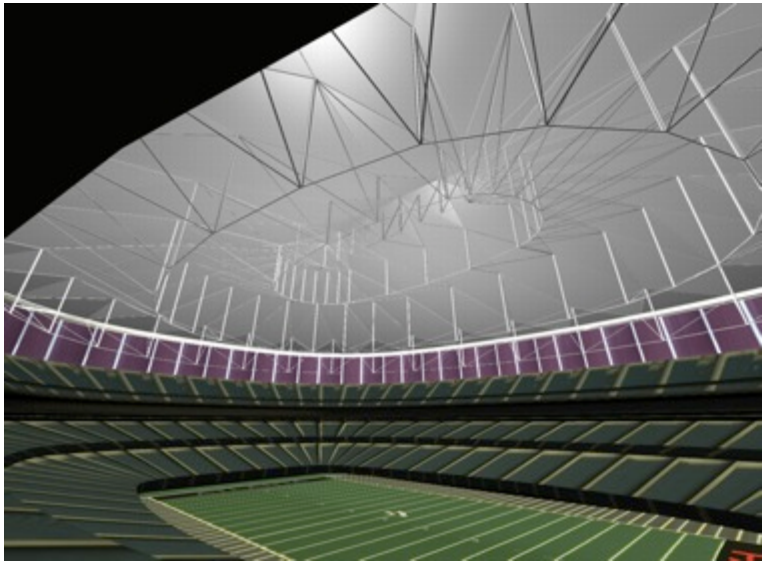
Fire performance based approach

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) and more cost-efficient designs



Picture: Tensinet

General approach (SFPE guide)

Define Scope, Goals and Objectives

Define Performance Criteria

Define Design Fire Scenario

Run Trial Designs

Check with performance criteria

Choice of Design

Example Trial design for establishing safe evacuation - Deterministic

Choice of Fire Scenario and Design Fire

↓

Calculation of smoke and fire spread by means of a zone model or CFD code

↓

Calculation of the available evacuation time by means of evacuation models

Developing Design fire scenarios - 1

Can include a wide range of scenarios which **should be reduced to a selected group** of scenarios which are considered as design fire scenarios.

A fire scenario represents one of a set of fire conditions that are thought to be **threatening to a building**.

So it should include **state of the art of the building**, its content and its occupants at time of ignition of resultant fire

Developing Design Fire scenarios - 2

Factors that affect fire development

Use of fire scenario characteristics

- Defining components (gather pre-data)
- Making assumptions (lack of pre-data)
- Building characteristics
- Occupants characteristics
- Fire characteristics

Different tools are given to identify both failure modes and effect analysis, what-if, failure analysis, historical data, statistics. - Are they valid for all buildings?

Developing Design Fire scenarios - Definition

Probabilistic approaches includes using probabilities coming from

- Statistics such as fire frequency, initiation frequency
- Hazard and failure analysis (see risk course)
- System availability and reliability
- Risk evaluation (overall assessment)

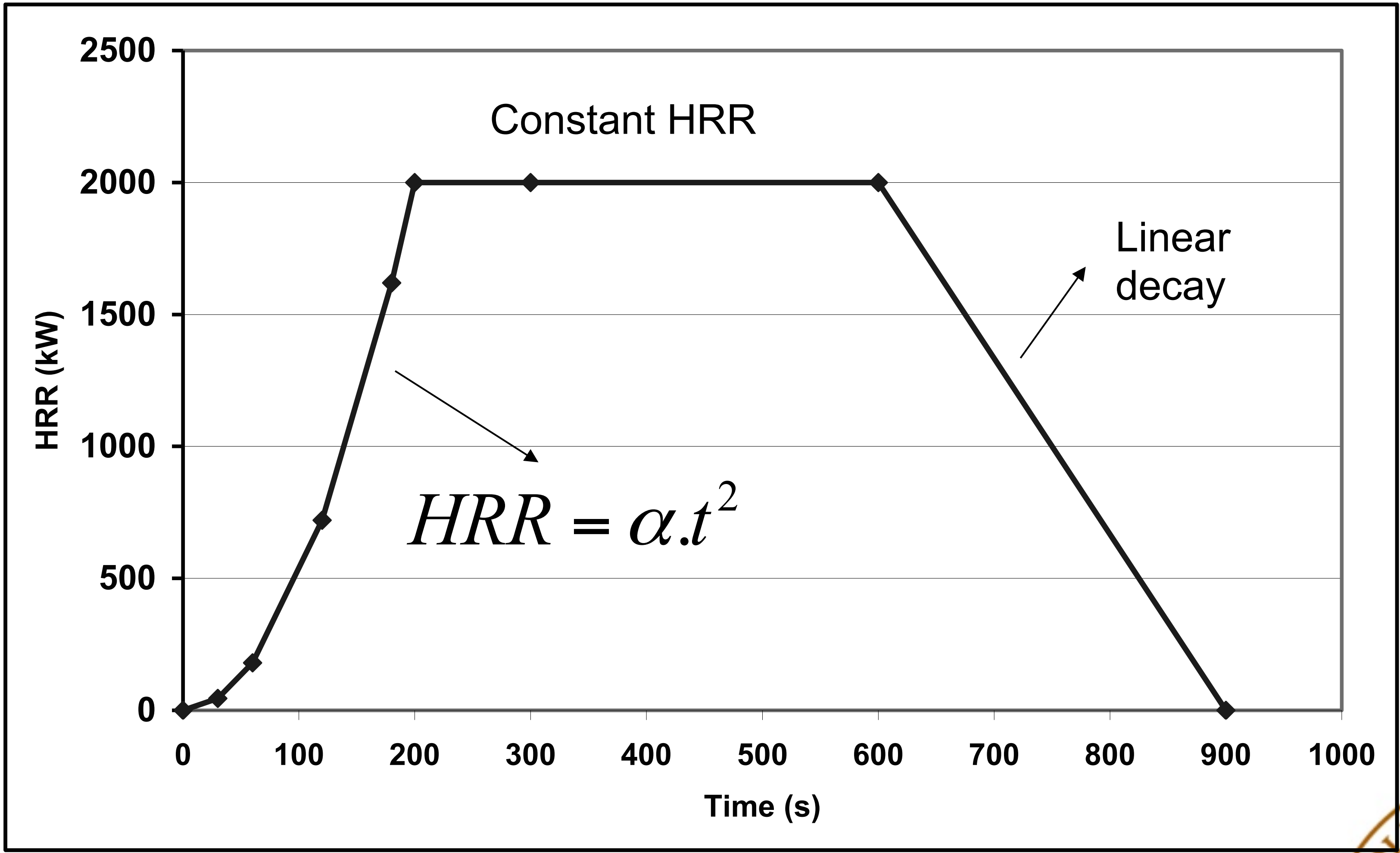
Deterministic approaches use calculation methods, test data for each scenario is needed

Quite often combinations are used!

Developing Design Fire scenarios - Characterising

- Process will lead to fire design curve and includes:
  - Building characteristics (components, numbers, features, structural components, fuel load, protections systems, egress components, services, operations, fire department, environmental factors)
  - Occupants characteristic (human behaviour, response, occupant loads, evacuation time, egress flows)

Example of a design fire



Picture:Lund University

Methods to define design fire

- Defined by the regulator ?
- Real scale test of the fire scenario including items of building products and content.
- Combination of HRR data of items of building content and building products obtained in full scale test data using so called open calorimeter techniques
- Modelling by means of empirical models using small scale test data such as given from the cone calorimeter test.
- Modelling by means of flame spread models within advanced CFD codes.
- Probabilistic approaches
- ….. Magic numbers?...

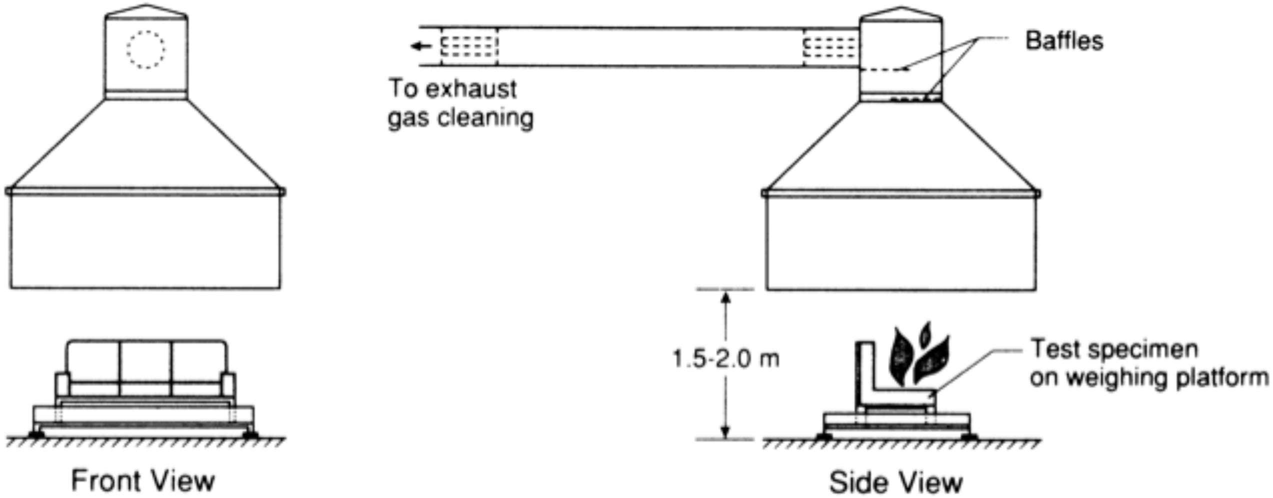
Methods for real scale data - 1

Room test e.g. using ISO 9705 either with linings or even completely furnished (in place)

Picture:SP

Methods for real scale data - 2

Establishing the HRR from a full sized item in a open calorimeter (in place) ISO 24473



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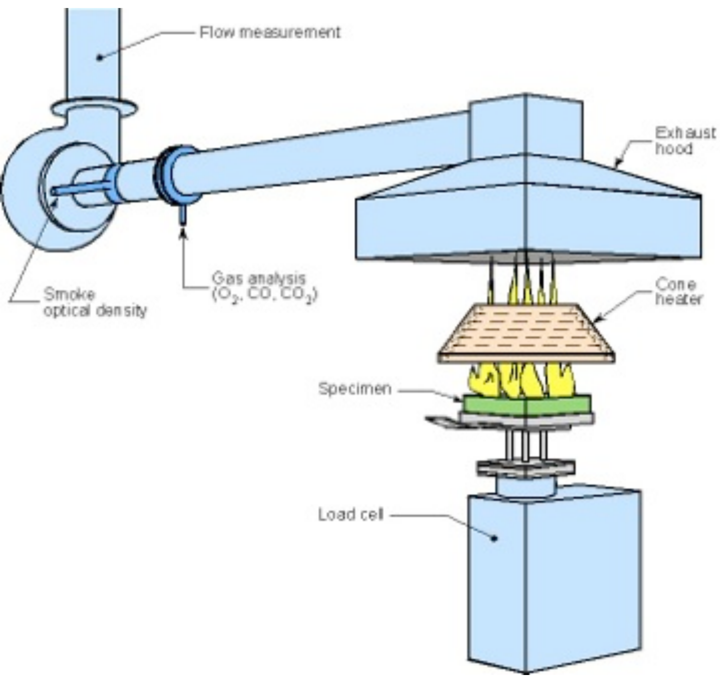
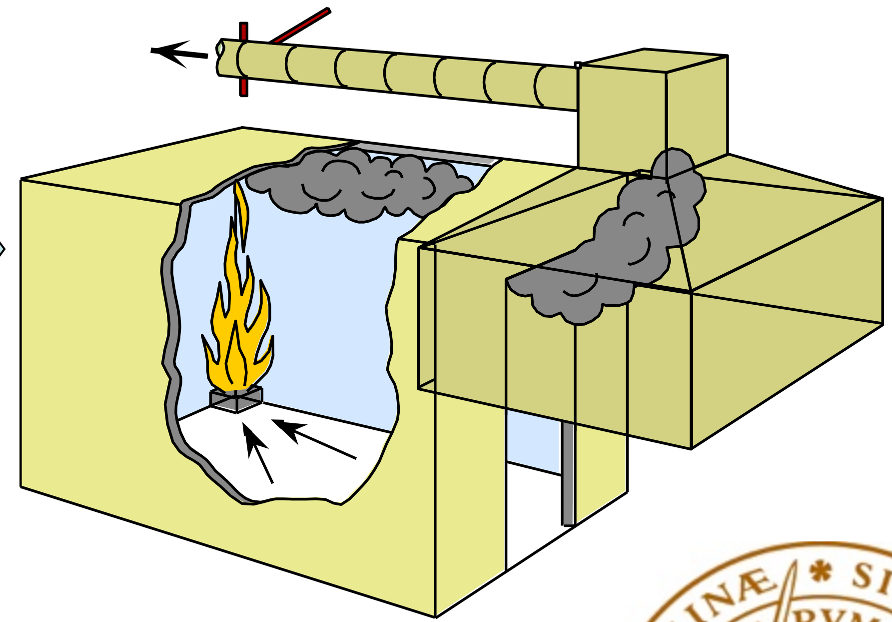
Type of models 1 – Semi empirical models

Semi Empirical models as cone tools (link between the cone and a specific scenario e.g. room corner)





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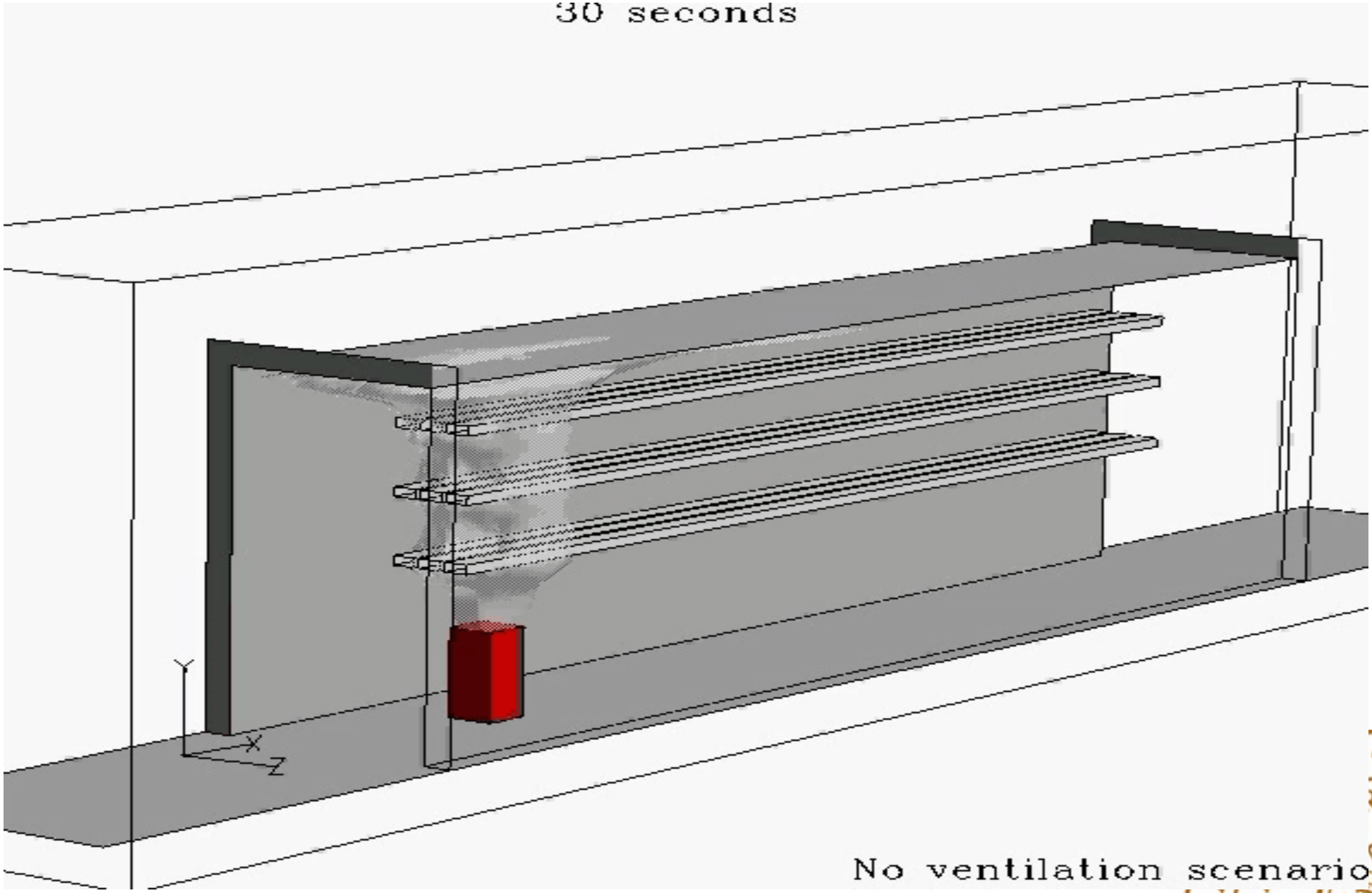
Cone tools

Type of models 2

CFD models for more flexible solutions



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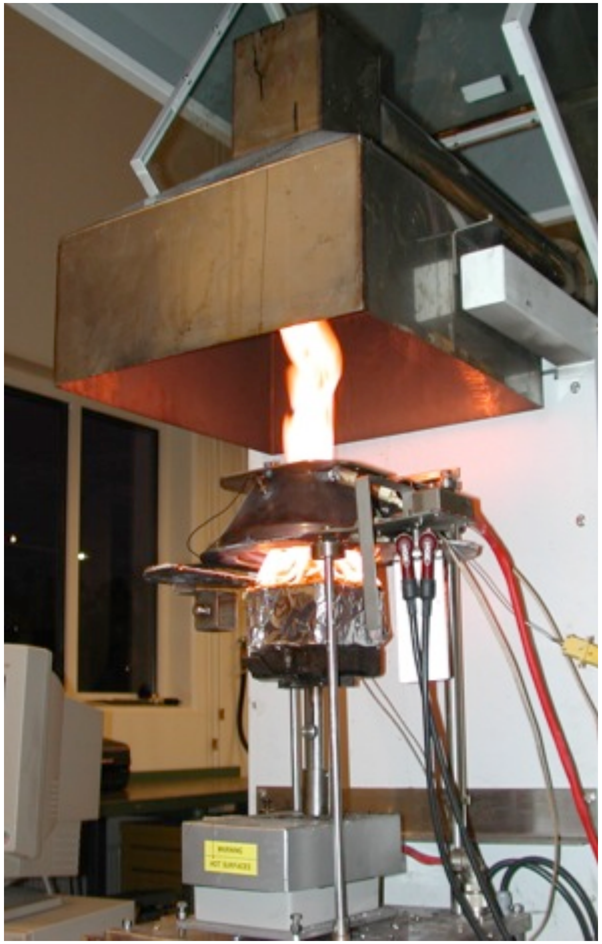
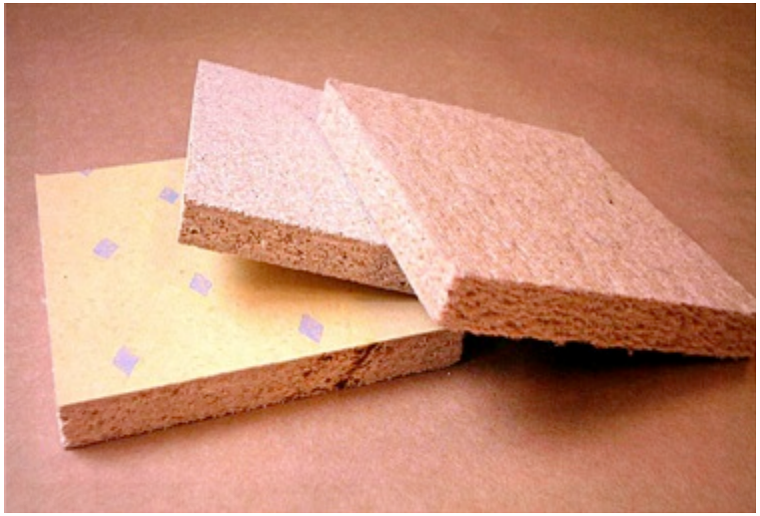
Test Methods for modelling

Cone calorimeter using small items of building materials or components of products (furniture, composites)





Pictures: SP

Use for new materials: What to consider?

Many of the FSE techniques are possible to use for these materials BUT!! Consider the following!!

When using models:

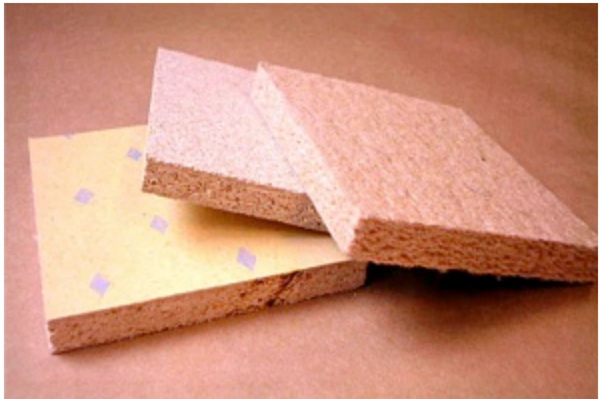
Are the models thoroughly being validated for the materials ?

Check the applicability of the model by running some different products at different scale levels

Are the small scale tests applicable for the materials i.e. can they be mounted in a realistic way?

Can you obtain the input data for the CFD models for your new material

Input-data Which product can be tested ?



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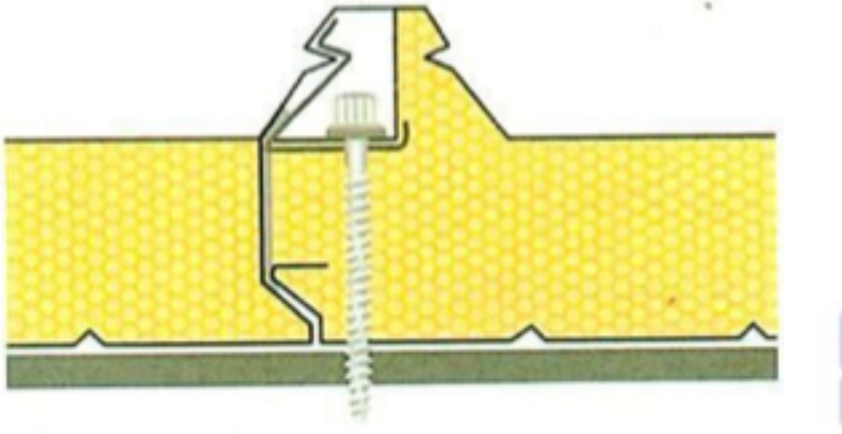

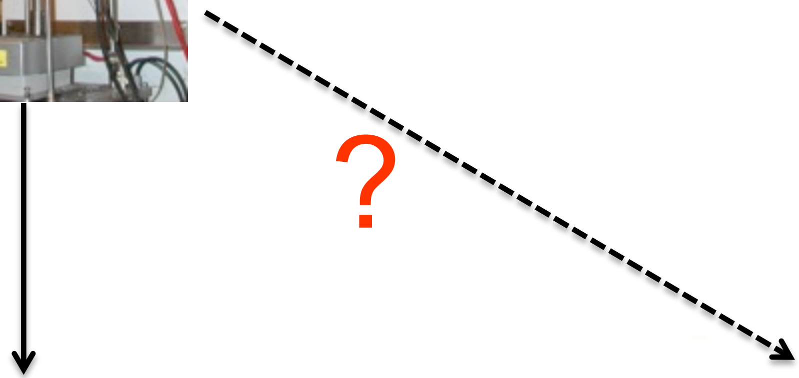

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New energy demands challenges in fire safety design

Higher thermal insulation means more use of new insulation materials and often also combustible insulation (thickness effectiveness)

How does complex systems perform?

Reduced natural ventilation can lead to underventilated fires

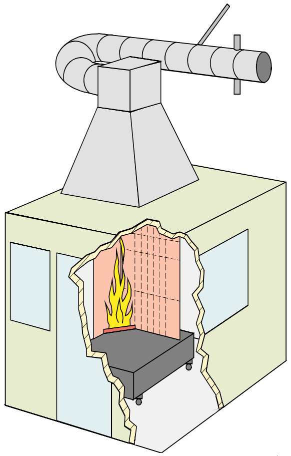
How well perform the models?

How deal we with this in PBD?

Energy Demands – cont.

- Knowledge is available on traditional room fires but many fire developments spread inside a construction.
- Need for more knowledge on constructions fires.
- Need to learn from real fires by cases studies – new project at Lund University

Which fire scenario are covered ?



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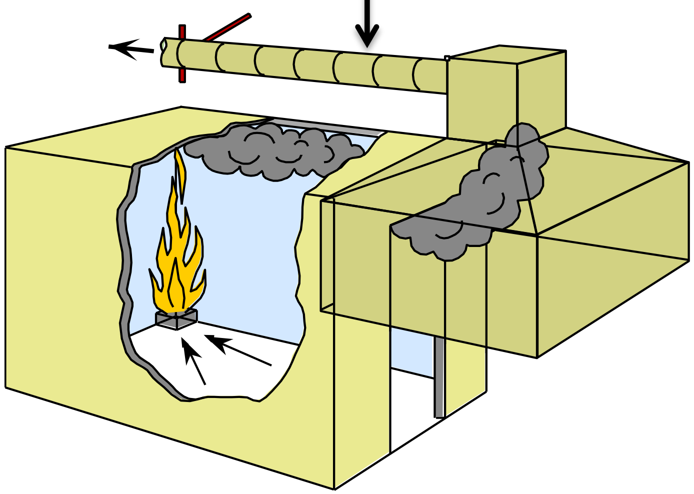

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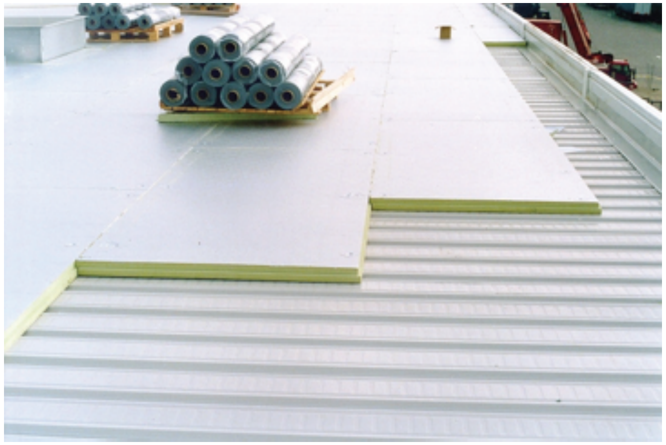
Reaction to fire - Challenges

Fire development becomes more and more a question of the a whole system and no longer of single products or materials.

e.g. Sandwich panels, façades, roofs, etc.

How do we tackle this?



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Haeundae Highrise - Busan Marine City Korea – 2010

Foto: Koreabridge.net

Fire in schools – Attic fires

Foto Police Gotland

Conclusions – Challenges - Procedure

- Introduce harmonisation between different areas (transport, buildings) for PBD
- Develop more guidance for PBD else it will become prescriptive PBD ☺
- More Quality control.
- More knowledge for PBD with other objectives e.g. continuation of operation, functional performance of safety systems.

Conclusions – Challenges - Input

- Appropriate tests to cover all fire scenarios for PBD codes as input to design fires
- Good statistics to define probabilities for probabilistic designs and how to use them
- More feedback from real accidents – case studies
- Develop procedures to obtain reaction to fire/ fire resistance for other exposures then the traditional one.
- Ensure link between risk analysis and design fire

Conclusions – Challenges - Tools

- Appropriate tests for input in sub-models for fire and smoke spread (pyrolysis models etc.) in CFD for PBD
- Standardised ways to inform user of fire models on verification and validation in order to determine uncertainties.
- More knowledge on ALL uncertainties in the process.
- Establish procedures for safety margins, minimum safety levels

Conclusions

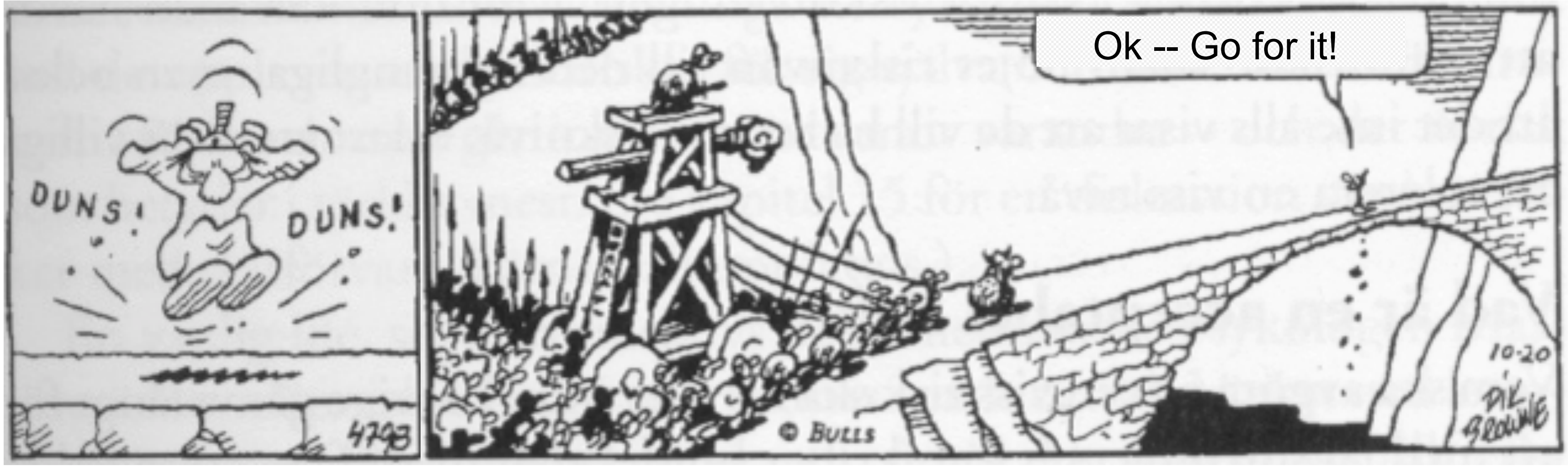
Educational challenges: Deep knowledge as well as practical experience by “performing” a PBD

The list is long and certainly not complete!!

These challenges should be tackled on international level!

Forums for this can be IAFSS, ISO, SFPE etc.

Risk for too large extrapolations ☺.



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