Cost-effective fire performance

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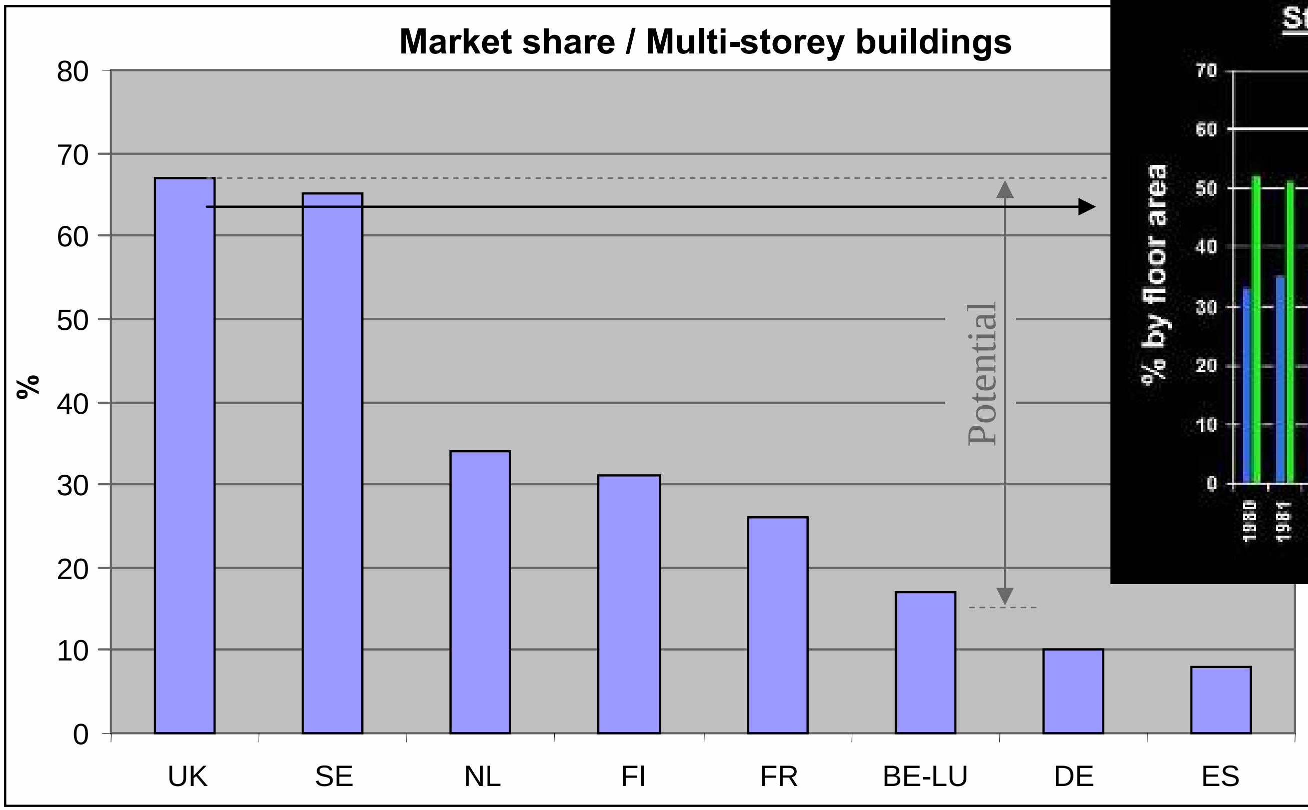
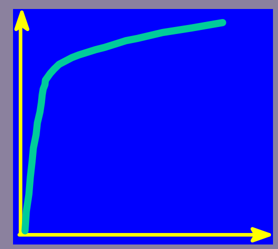
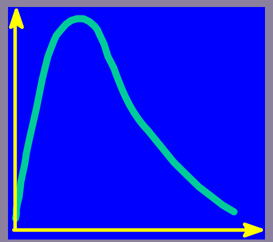
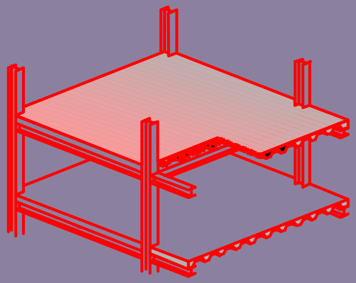
Cost-effective fire performance

- High potential of steel in multi-storey buildings



- One of the reasons explaining the differences: **Fire Safety Approach**.
- The present low market share in continental Europe is more particularly due to :
  - Weak knowledge from engineers and architects of the actual performances of the steel in case of fire, still mainly assessed through **knowledge from fire test on single element.**
  - **Fire Safety Engineering** not yet fully considered

Classical approach amongst "structural fire safety engineering" methods - Eurocodes 1, 3 and 4

	Prescriptive	Performance based
	standard fire 	natural fire 
	classification	fire safety eng.
	fire safety eng.	fire safety eng.

Classical approach based on ISO-834 heating curve

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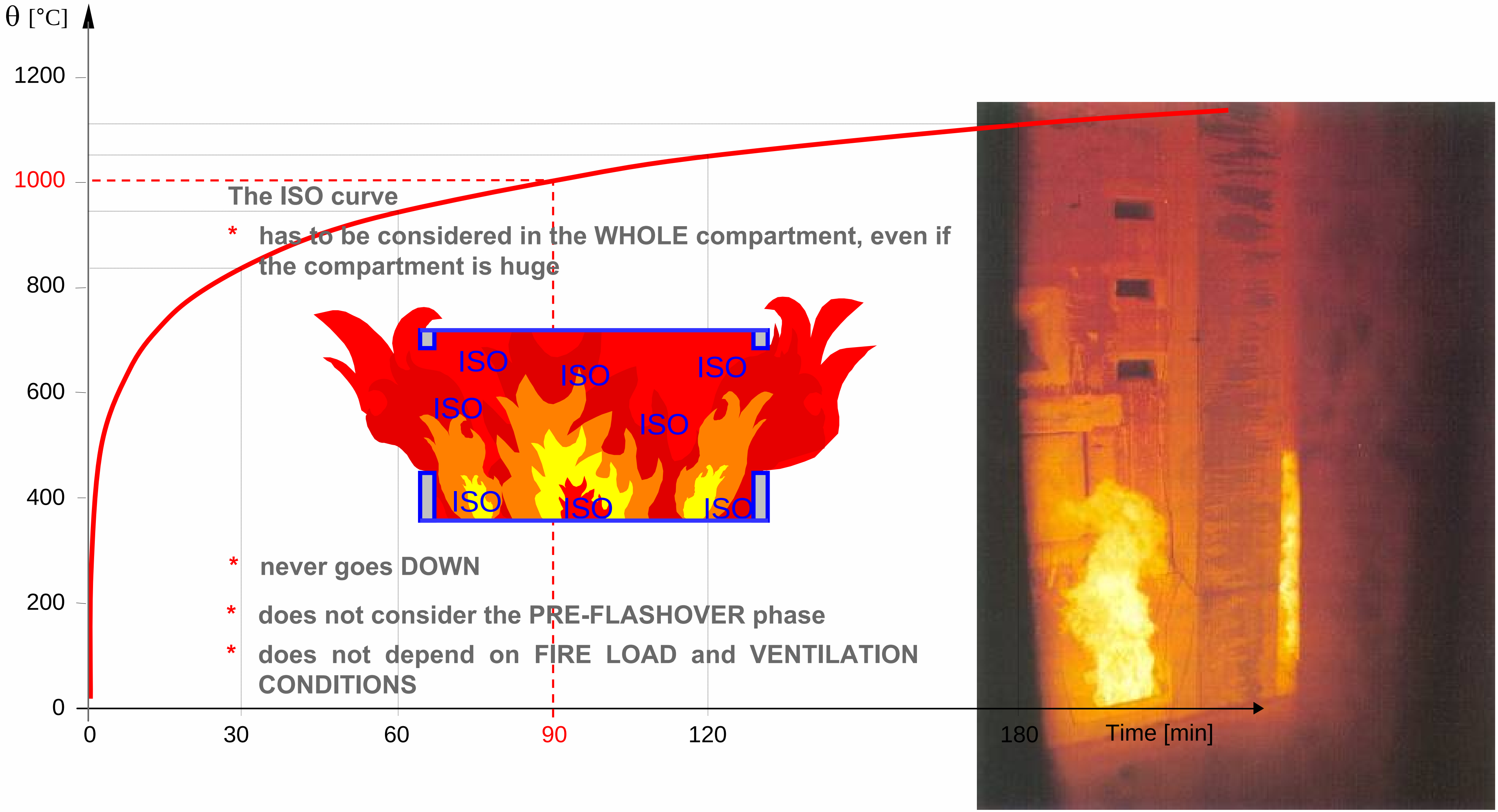
The ISO curve

* **has to be considered in the WHOLE compartment, even if the compartment is huge**

* **never goes DOWN**

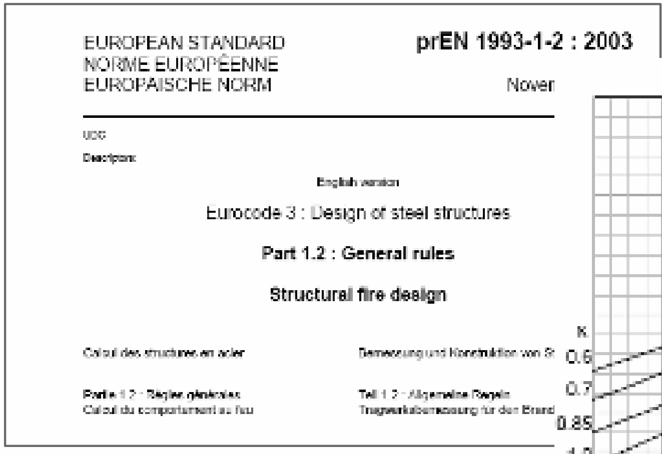
* **does not consider the PRE-FLASHOVER phase**

* **does not depend on FIRE LOAD and VENTILATION CONDITIONS**



Classical approach - Quick use of the Eurocodes

- Unprotected steel structures for fire resistance ≤ 30minutes
- R30 unprotected steel structures (Overdesign [S355,S460] ; benefit of the connections)


EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

prEN 1993-1-2 : 2003

Nover

English version

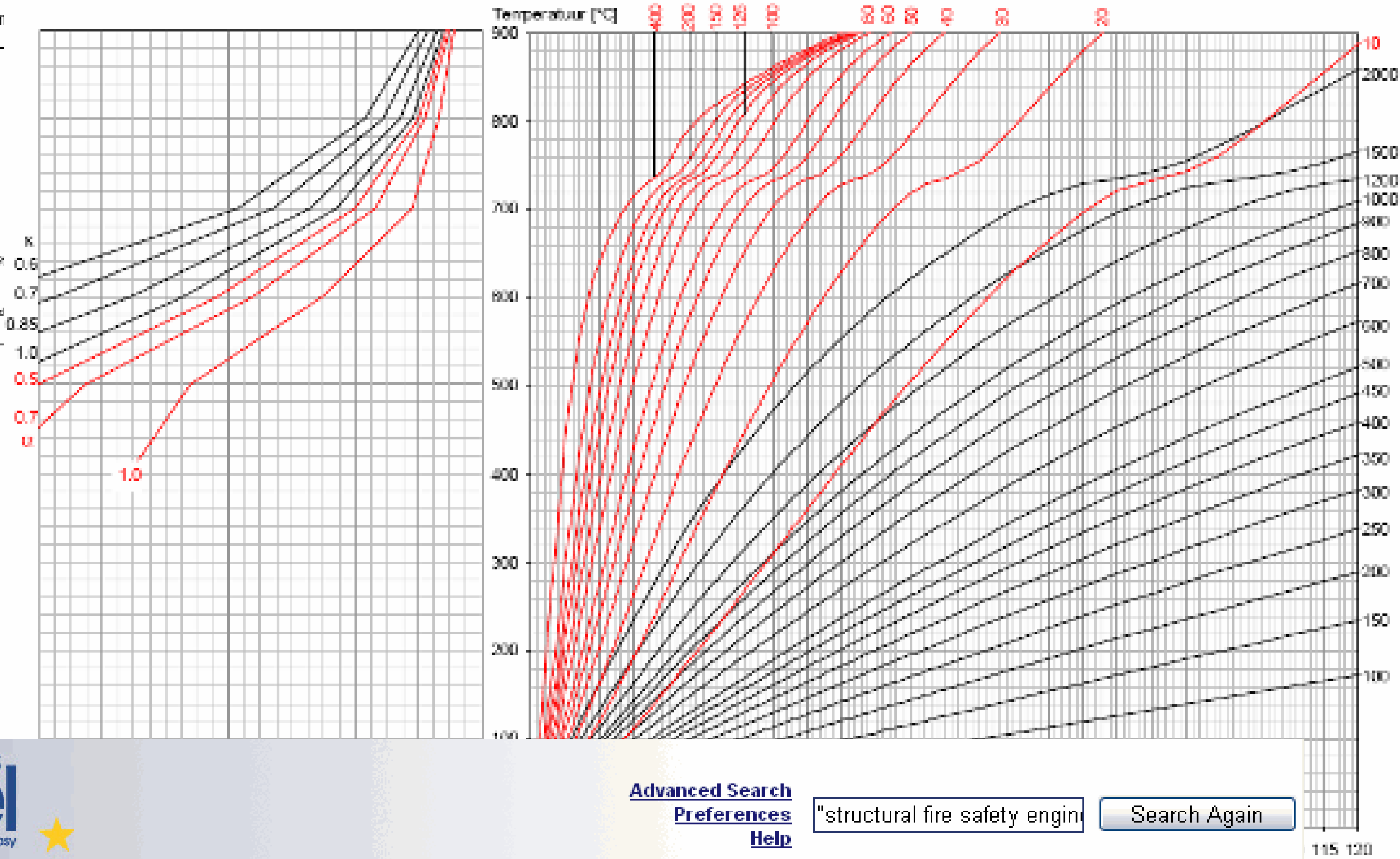
Eurocode 3 : Design of steel structures

Part 1.2 : General rules

Structural fire design

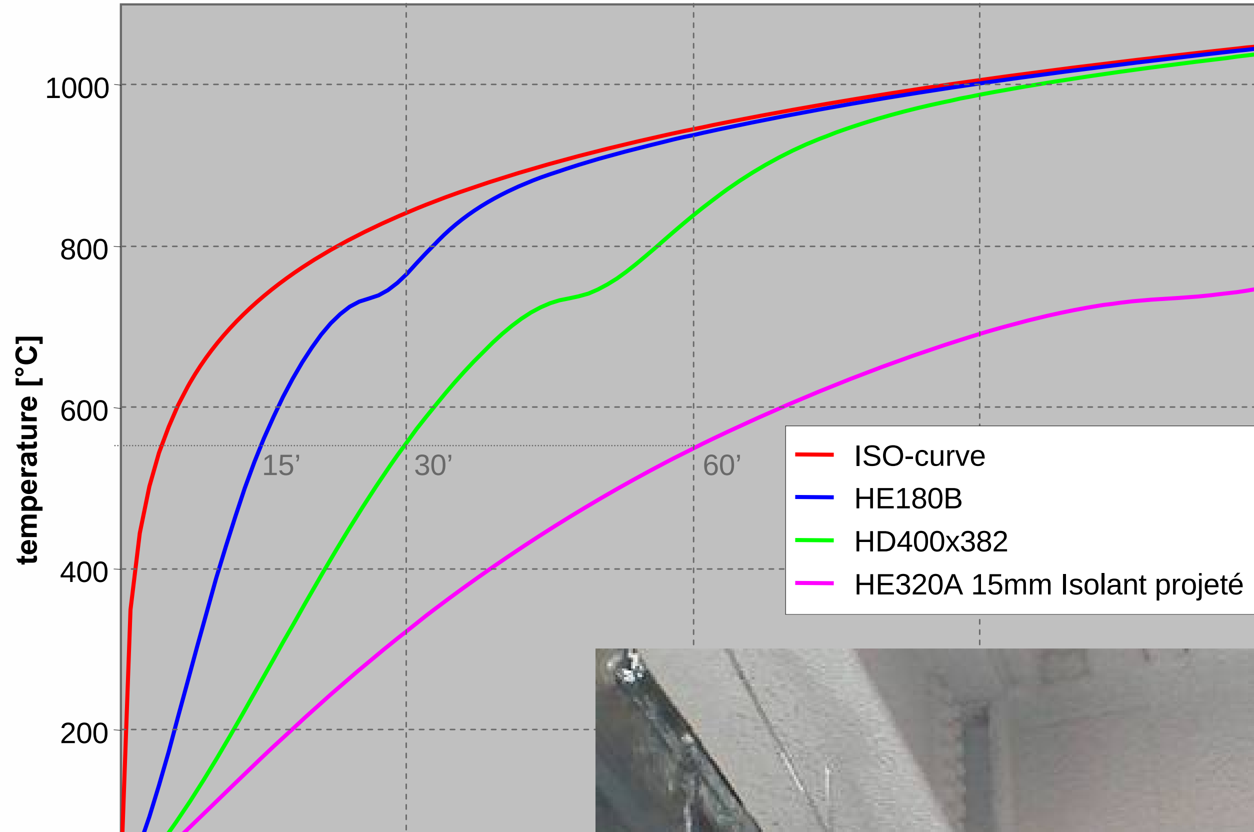
Calcul des structures en acier — Bemessung und Konstruktion von St

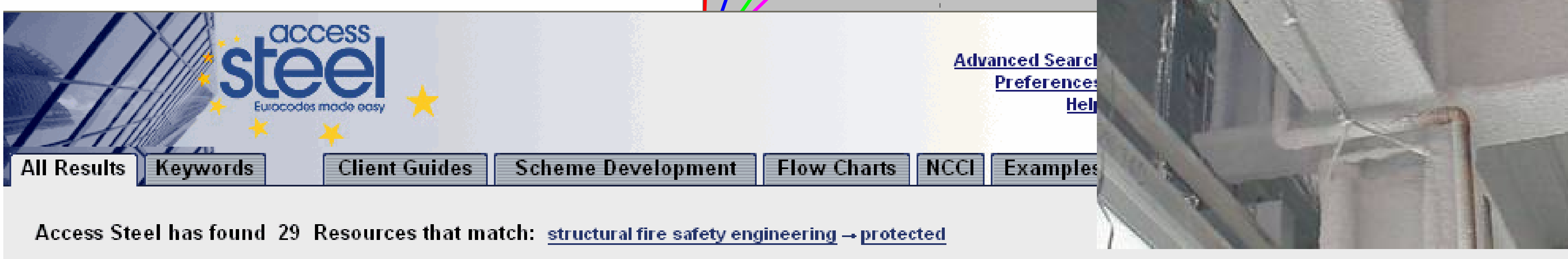
Partie 1.2 : Règles générales — Teil 1.2 : Allgemeine Regeln
Calcul du comportement au feu — Tragwerksbemessung für den Brand



Classical approach based on ISO-834 heating curve

➡ Steel protection for fire resistance > 30minutes

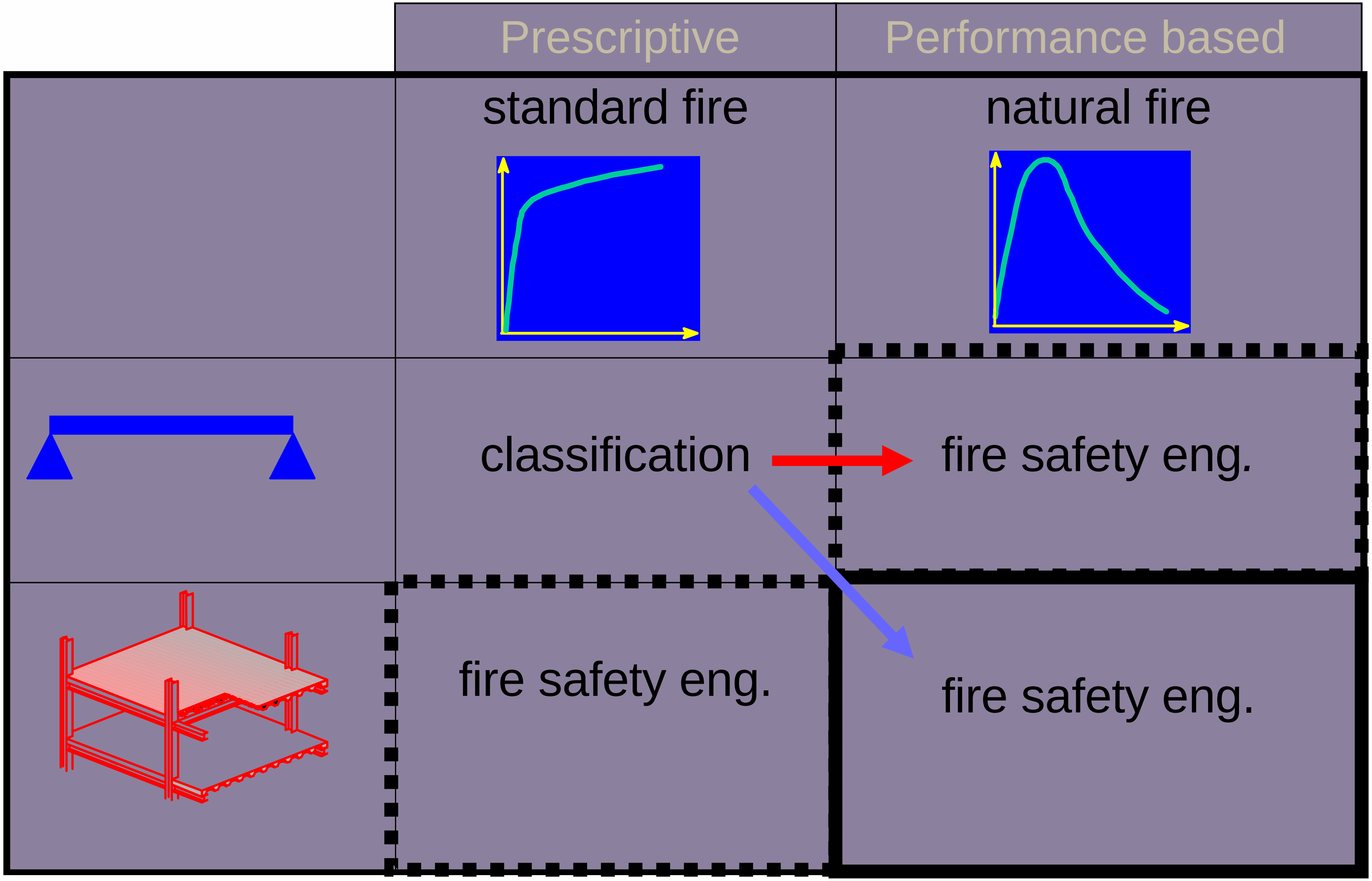




Additionnal cost of the protection > 40% of the finished steel cost

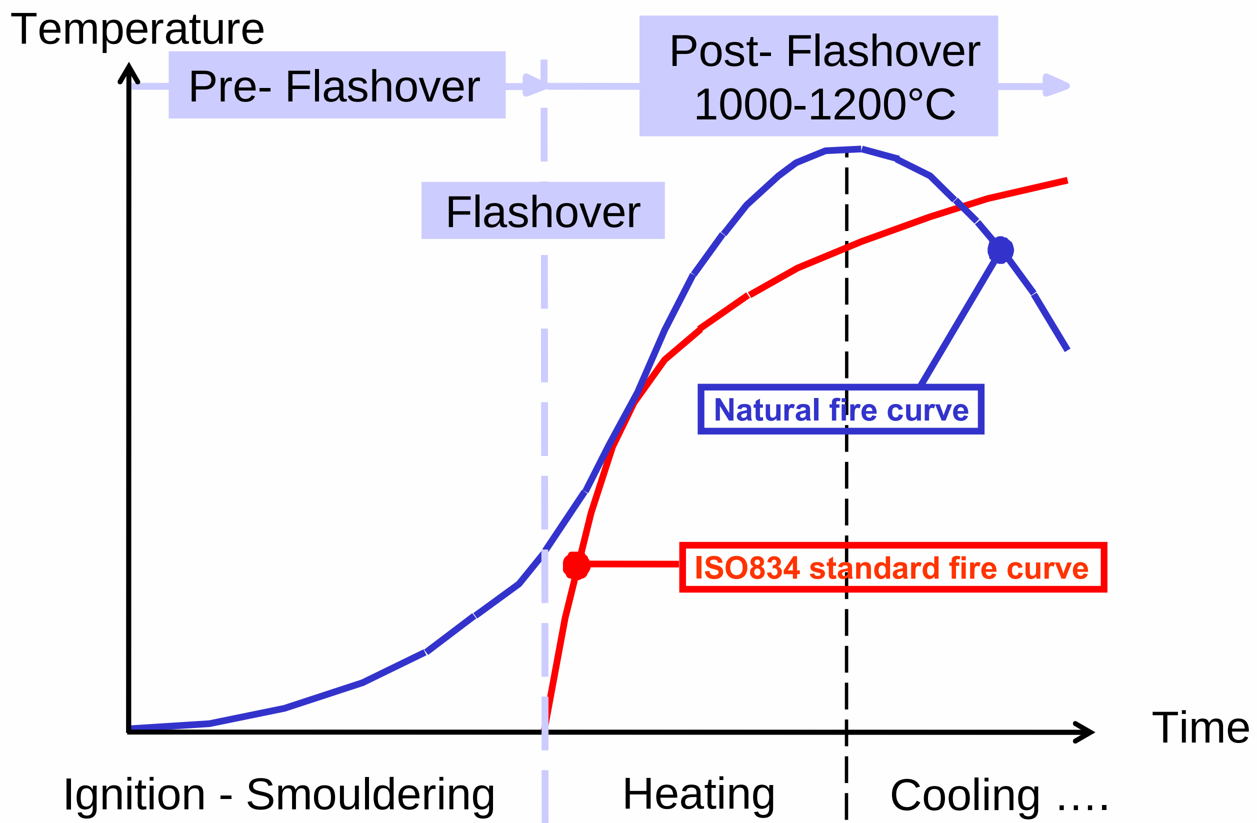
The protection must be optimized and applied where it is really needed.

The performance based “structural fire safety engineering” approach according to Eurocodes 1, 3 et 4



Fire Safety Engineering = Global Structural Behavior + Fire Development

Fire Engineering approach



~~Standard curve~~ → Scientific analysis based on :

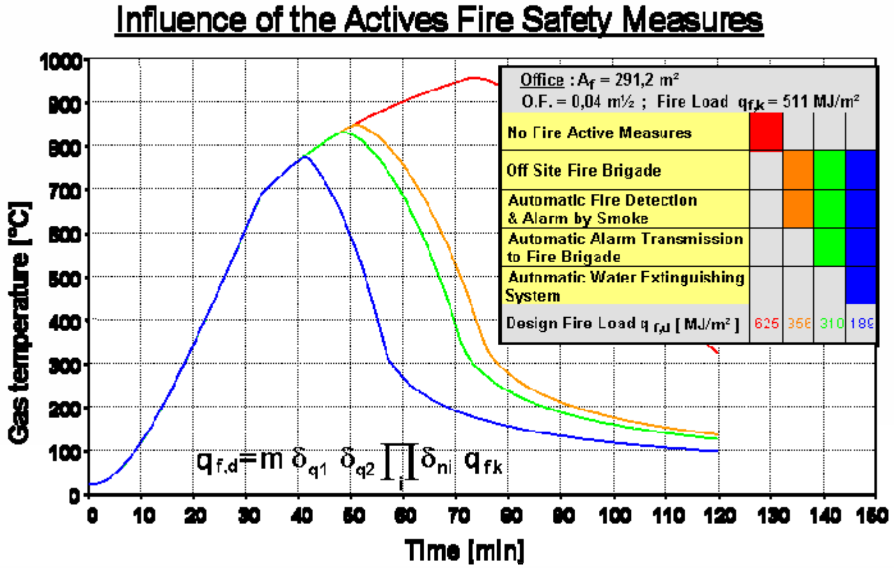
- Fire scenario
- Physical parameters influencing the fire development (fire load, ventilation, active fire fighting measures, …)

→ More controlled safety and more efficient solutions because better targeted

Fire Engineering approach

European research in the field of the fire engineering achieved between 1994 → 2006 allows to finalize the following technical developments :

- Fire safety concept evaluation based on natural fire.
- Required data for the fire development calculation methods (fire load [MJ/m²], fire spread, rate of heat release [kW/m²]).
- Definition of model scenario for usual buildings (offices, schools, shops,…).
- Take into account of the active fire fighting measures (sprinkler, smoke exhaust system,…).
- Air temperature field calculation method in case of fire.
- Steel temperature calculation method.
- Simulation of the behaviour of the structure submitted to the different fire scenarii and to the static loads.
- Building systems and technical solutions to guarantee that the structure survive the considered scenarii.



Fire Engineering approach

The implementation of the research results met

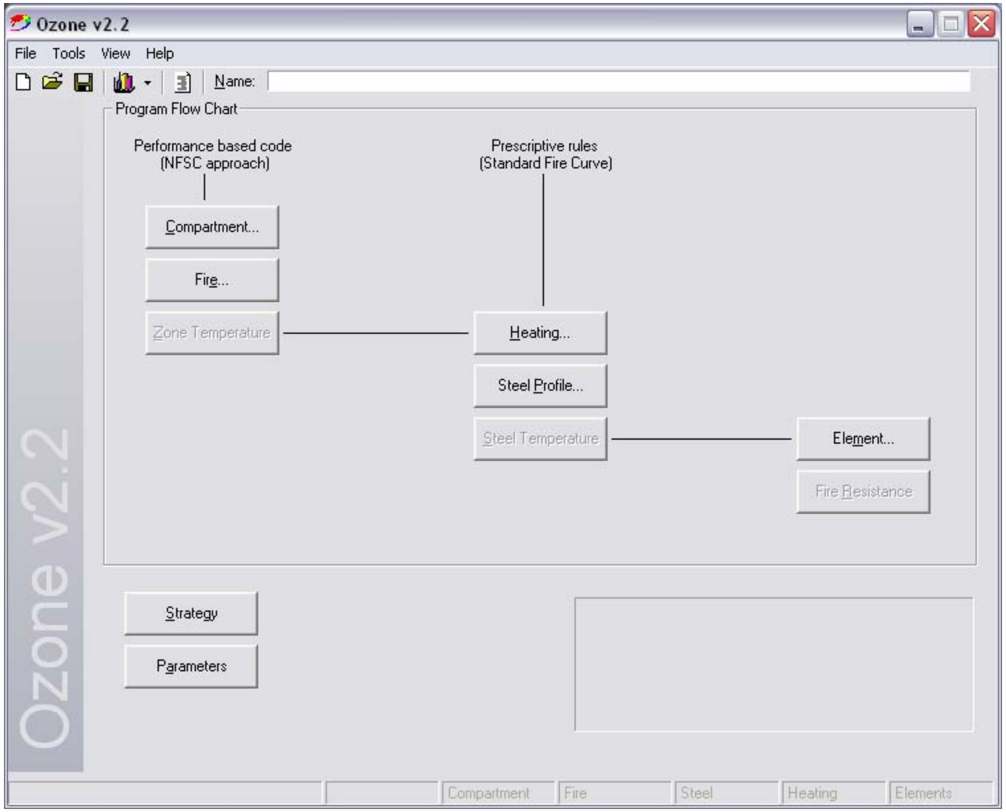
the following difficulties :

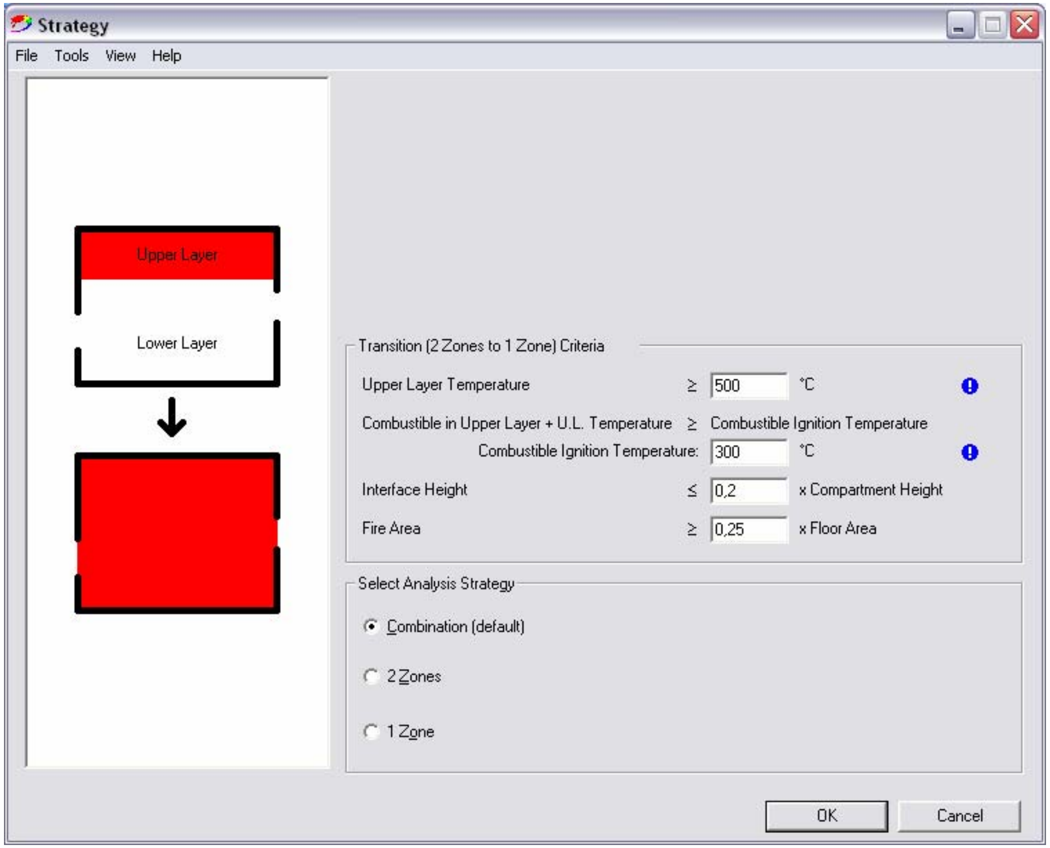
- Existing regulations and standards based on standard fire.
- Habits and a priori in the minds of the professionals of construction.
- Different regulations depending on the countries and even on the regions.
- Low expertise of engineers, architects and authorities in that domain.
- Lack of training in that domain.
- No userfriendly calculation tools.

solved by :

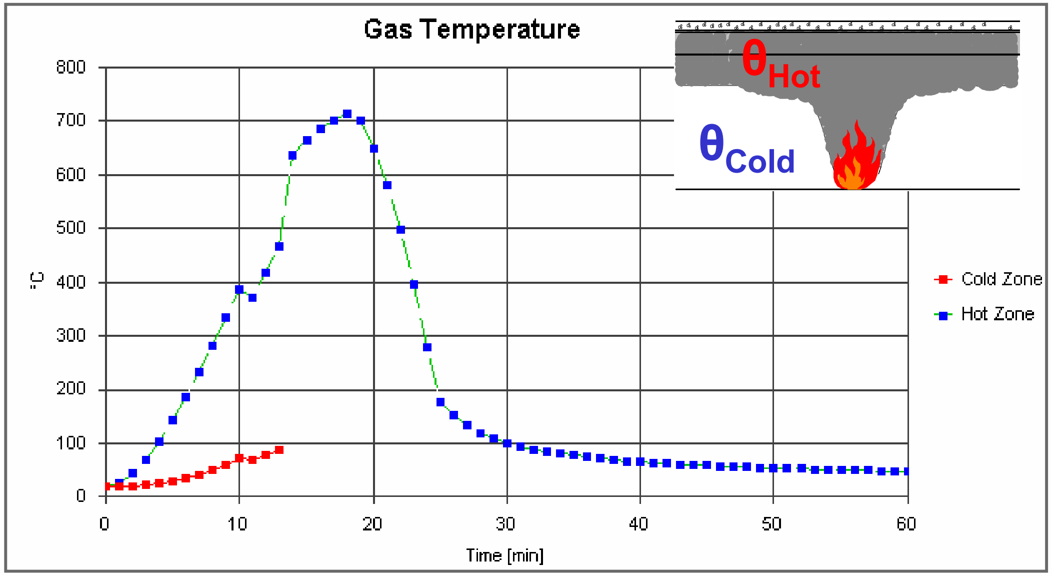
- The natural fire was introduced in the Eurocodes, particularly Eurocode 1 - Fire Part.
- The fire engineering has been dealt with in decree and regulations in different european countries .
- Userfriendly calculation tools were developed (Ozone), and put on the site www.arcelor.com/sections
- Trainings were, and are organized (DIFISEK).
- A network of competent and qualified engineering offices in the field of fire engineering was developed (SECURE with STEEL).

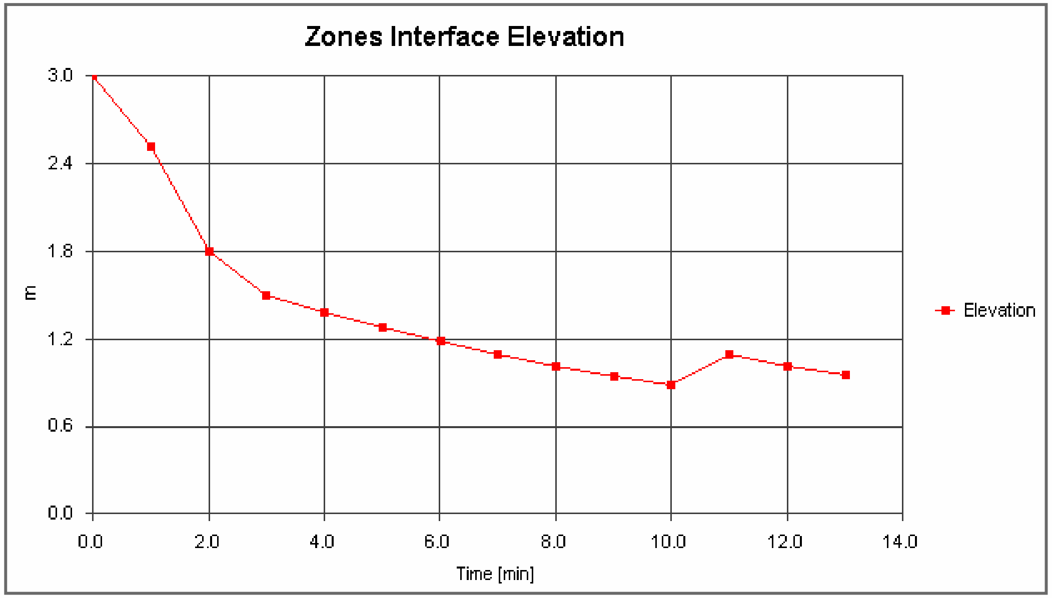
Ozone
Natural Fire calculation according to EC1 Fire Part

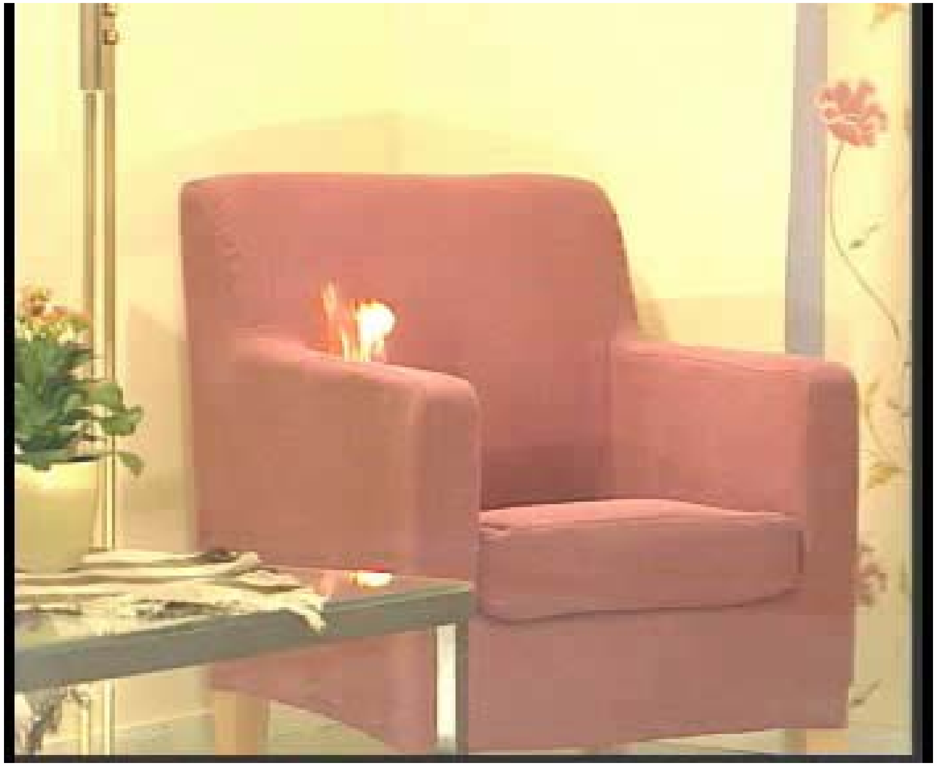




Ozone
Natural Fire calculation according to EC1 Fire Part







DIssemination of FIre Safety Engineering Knowledge
DIFISEK (2006) et DIFISEK+(2008)

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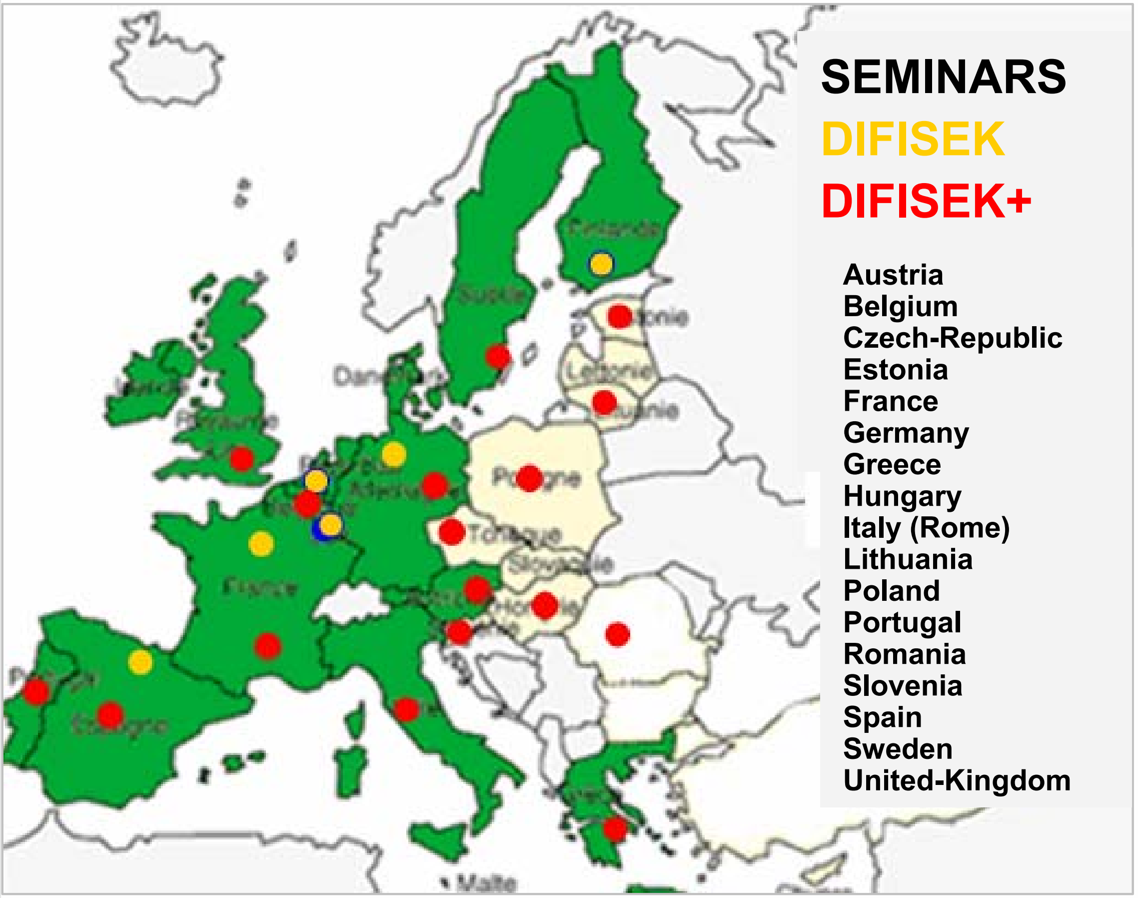


Treated topics

Part 1:	Thermal & Mechanical Actions
Part 2:	Thermal Response
Part 3:	Mechanical Response of Structures in Fire
Part 4:	Software for Fire Design
Part 5-1:	Worked Examples
Part 5-2:	Illustration of Completed Projects

Available tools for further dissemination

http://www.arcelormittal.com/sections/DIFISEK/DIFISEK_welcome.html

- All Presentations and Syllabus in PDF - WP1 to WP5 (17 languages)
- Database for Fire Design Software (UK)

'Fire Safety Engineering' application to buildings in G-D of Luxembourg

Medical Centre - Eich ; G-D Luxembourg

SECURE with STEEL in Europe

25 European engineering offices specialized in Fire Engineering assisted by 9 universities and/or research centers

ArcelorMittal

- ARUP, Fire University of Edinburgh (United Kingdom)
- DGMR, Hamerlinck Advies bureau, Cauberg-Huygens (The Netherlands)
- Swedish National Testing & Research Institute (Sweden)
- Schmitt Schtumpf Fruhauf & Partner, Universität of Hannover (Germany)
- Greisch, Technum, Steel Information Centre, University of Liège (Belgium)
- Bernard Ingenieure (Austria)
- Keonn (Poland)
- Studio di Ingegneria delle Strutture (Italy)
- CTU Prague (Czech Republic)
- MP Ingénieurs ETH Zürich (Switzerland)
- NB35, LABEIN (Spain)
- Tal Projecto, Lda GIPAC, Lda University of Aveiro (Portugal)
- Schroeder & Associés (Luxembourg)
- Arches-Etudes, E2C Atlantique, Terrell International (France)

ACCESS STEEL
CHOICE OF FIRE ENGINEERING STRATEGY

All Results | Keywords | Client Guides | Schem

Access Steel has found 14 Resources that match: stru

1 - 10 Sort results by: Relevance | Title | Date

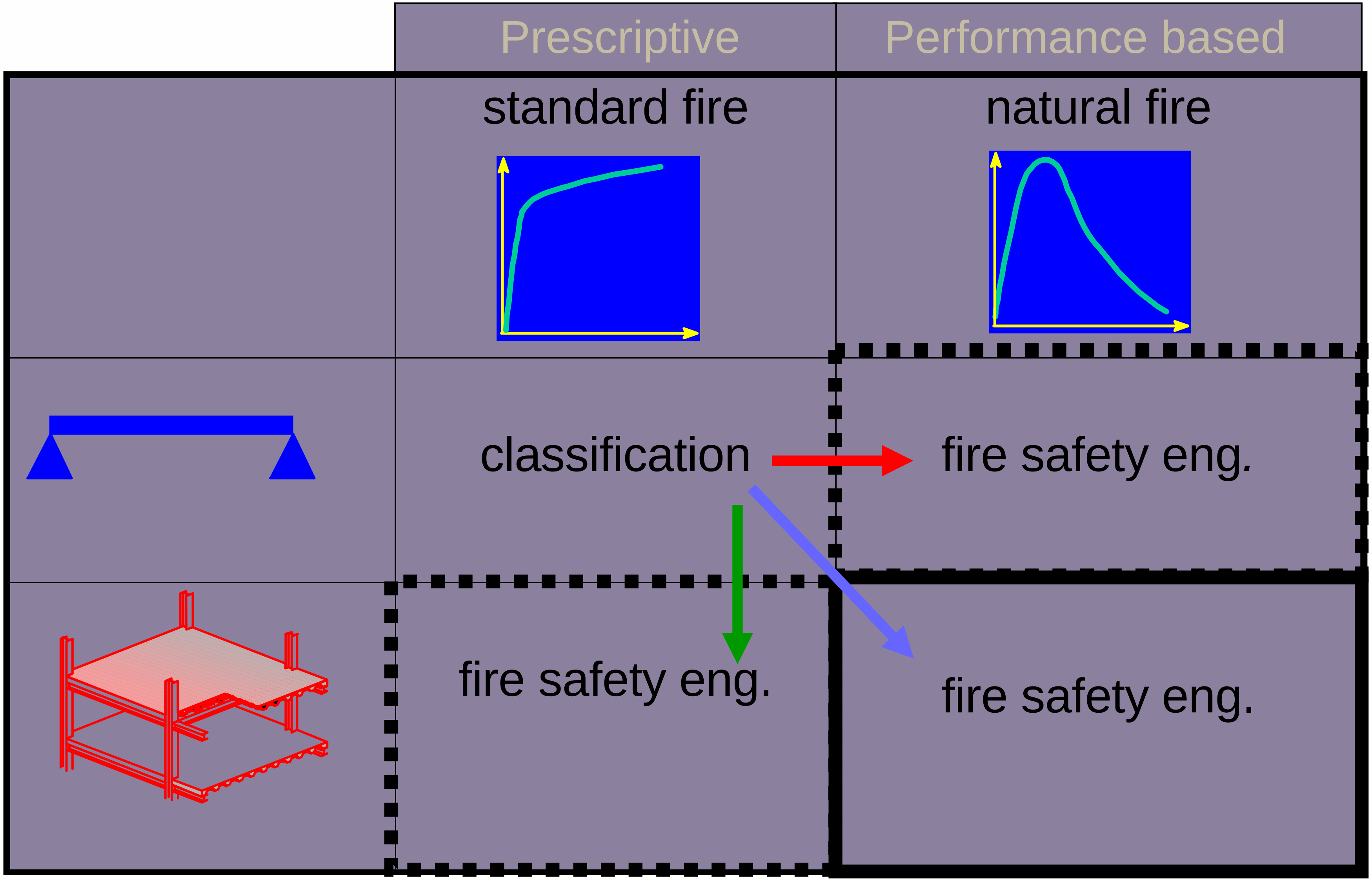
1. **Scheme Development: Overview of firesafetyst**
   SS020 Describes the main concepts of firesafety. Su regulatory requirements. Introduces firesafetyengine and the use of the section factor to calculate fire prot
2. **Scheme development: Selection of appropriate**
   SS041 This document presents guidance on the fire appropriate for single-occupancy houses.
3. **Scheme Development: Firesafetystrategy for m**
   SS008 Outlines the principal and practical requireme Introduces fireengineering and covers passive fire pr partially protected steelwork
4. **Scheme development: Selection of appropriate**
   SS040 This document presents guidance on the fire appropriate for specific conditions for multi-storey off

Scheme development: Selection of appropriate fire engineering strategy for multi-storey commercial and apartment buildings
SS040a-EN-EU

Table 2.1 Guidance on choice of design approach for a specific multi-storey building of conventional proportions, without an atrium

		Standard fire methods				Performance based methods		
		A. Manufacturers data	B. EC4 Data for Composite construction	C. Simple calculations.	D. Advanced calculations.	E. Simple calculations.	F. Advanced calculations.	
1.	Building size– floor area per storey							This is related to potential economies which will be greater in relation to the additional design work for larger buildings.
	Small, < 200 m^2	✓✓						
	Medium	✓✓						
	Large, >2 000 m^2	✓	✓	✓	✓		✓	
2.	Building Height							Taller buildings have greater potential for economy and longer fir resistance periods
	Up to 5 storeys	✓✓				✓		
	6+ storeys	✓	✓	✓	✓		✓	
3.	Taking benefit from active fire fighting measures							Some national regulations and/or local authorities allow the presence of these measures to reduce fire loads
	Detection, alarm and smoke exhaust	II	II				✓✓	
	Sprinklers	II	II			✓	✓✓	
4.	Benefit from structural reserve							Implicit reserves of strength, for example from semi-rigid connections, and reduced exposure to fire increase the potential value of more advanced approaches
	Economically sized for strength in cold design	✓✓					✓	
	Significantly oversized for strength in cold design,			✓✓		✓		
	Additional reserve available from behaviour not used for cold design, e.g. slab as membrane	II			✓		✓✓	

The "structural fire safety engineering" approach
Eurocodes 1, 3 et 4

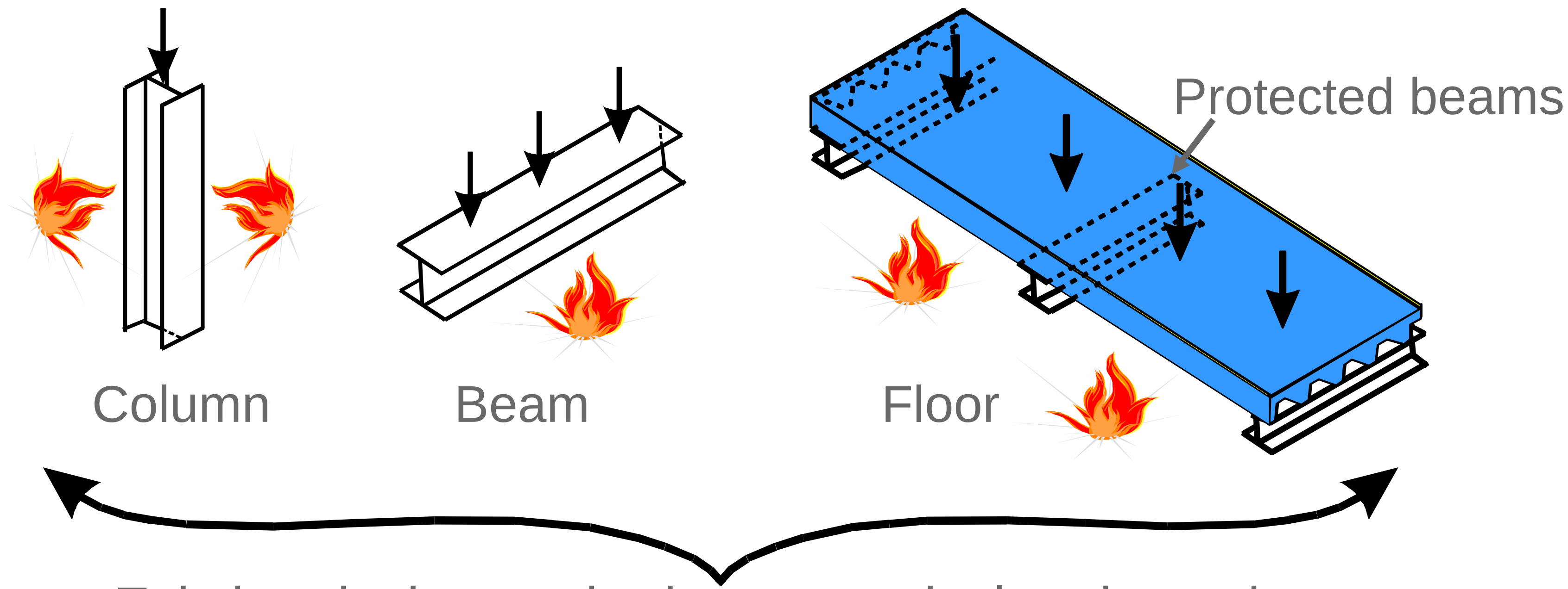


Test in Cardington (UK)

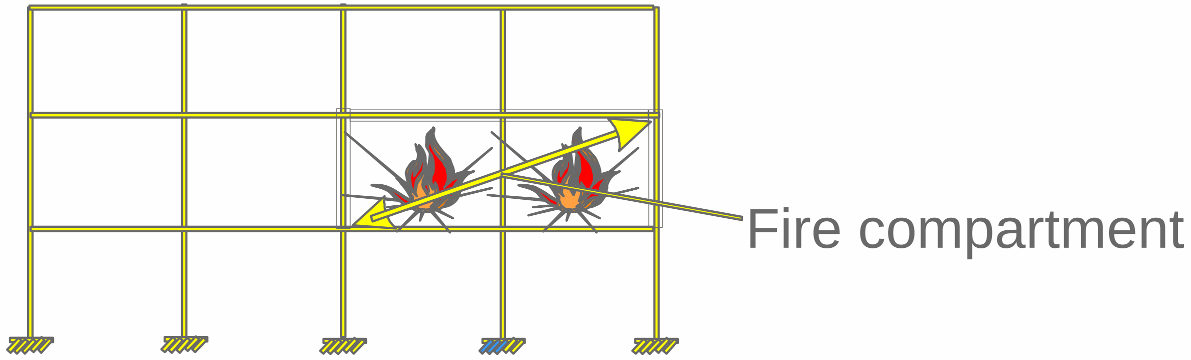
Test in Cardington (UK)

- Maximum steel temperature about 1150°C
- Fire calculation by element provides a failure at 680°C
- Why did the structure survive ?

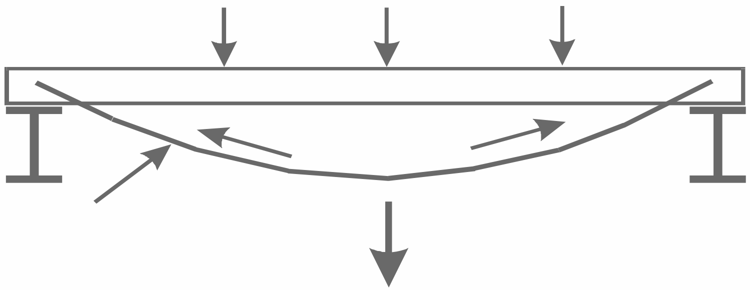
Test on single elements



Existing design methods assume isolated members will perform in a similar way in actual buildings

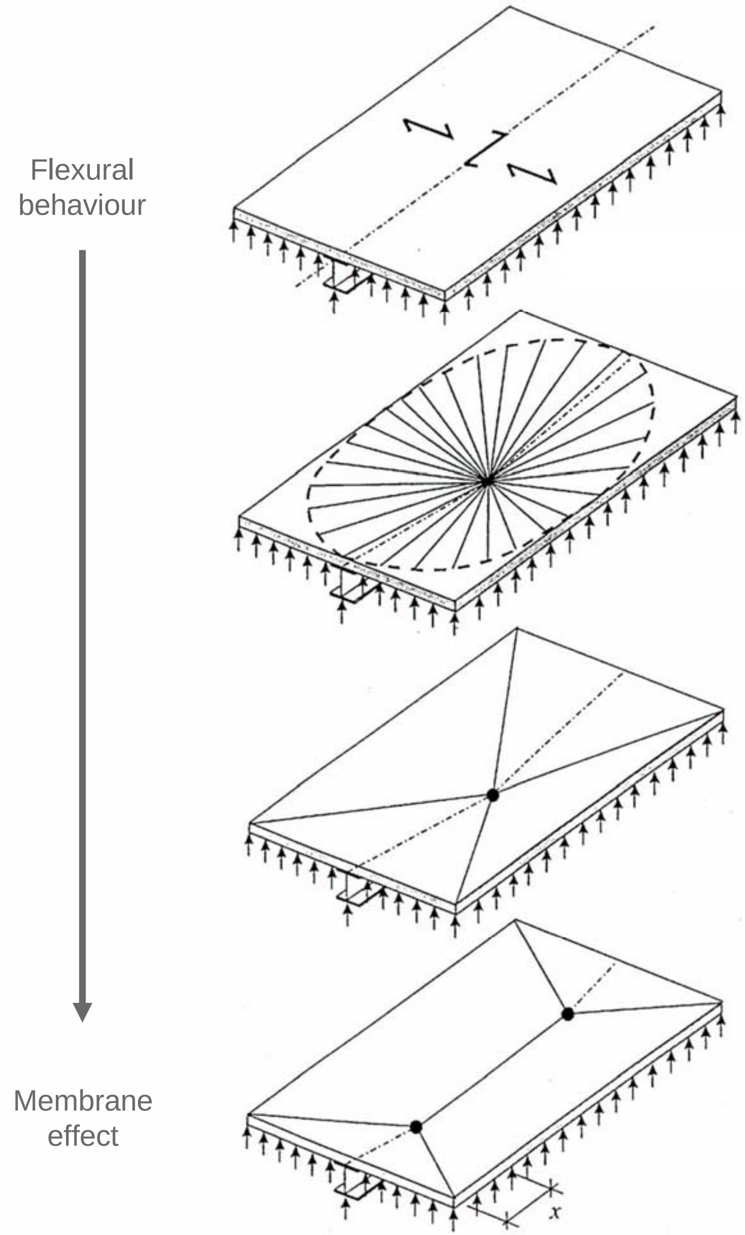


Real behaviour in a building

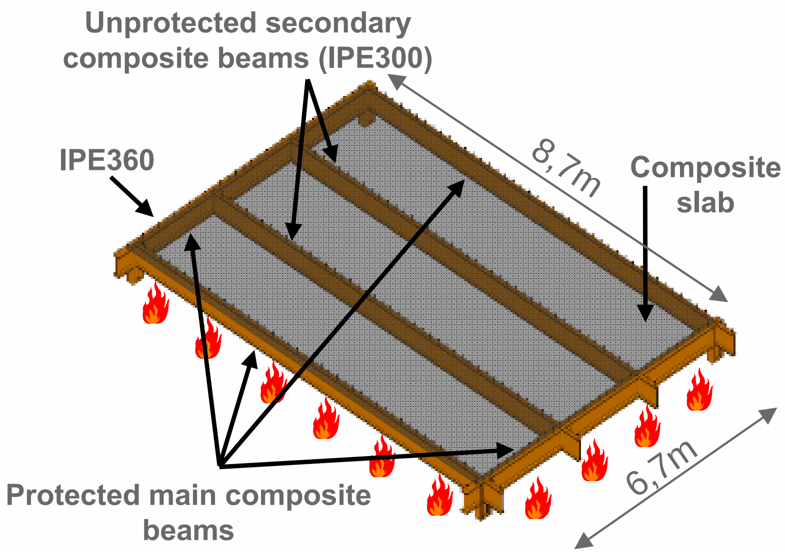


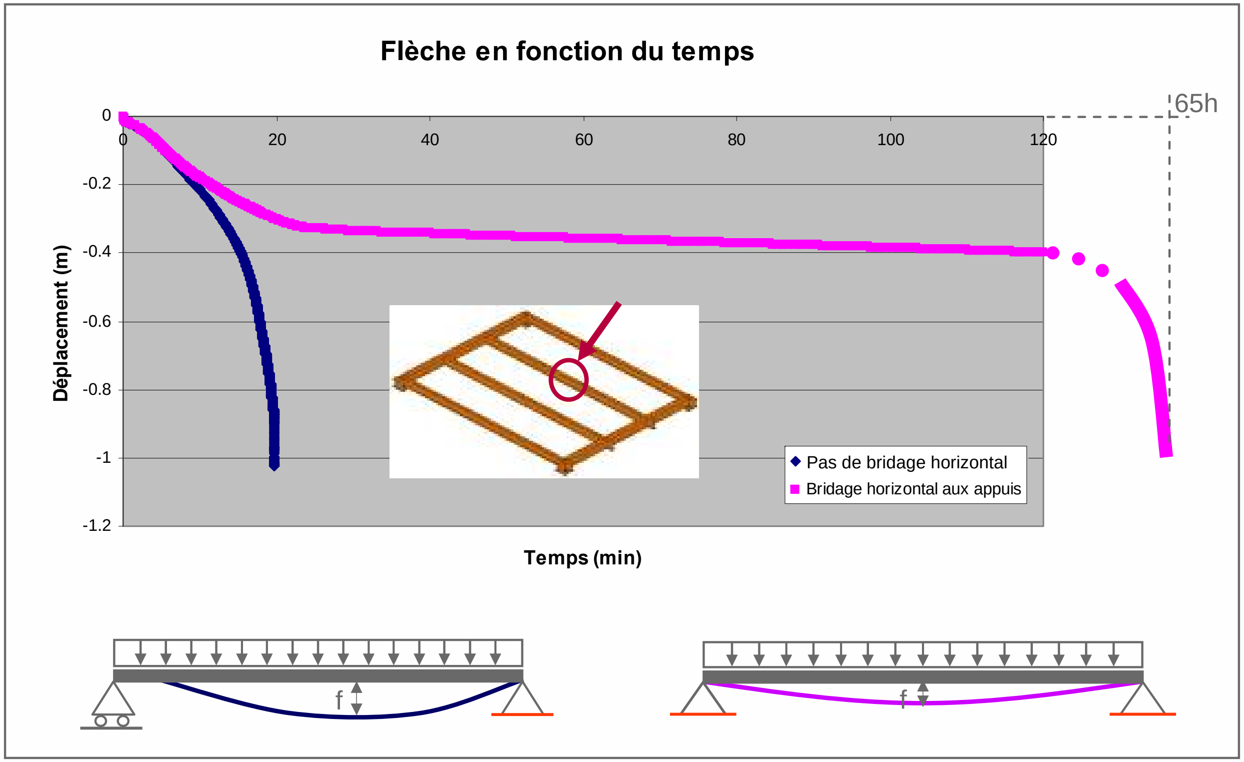
<u>Membrane effect</u>

- In a building, catenary behaviour of the steel beam acting compositely with the concrete slab.
- Higher is the deflection, higher is the membrane effect.



Membrane effect highlighted by the ISO fire test of today





Fire resistance of secondary beams calculated as single elements

EC4 Fire part

Critical temperature = 608 °C

Fire resistance = 16'

SAFIR Simulation

Fire resistance = 20'

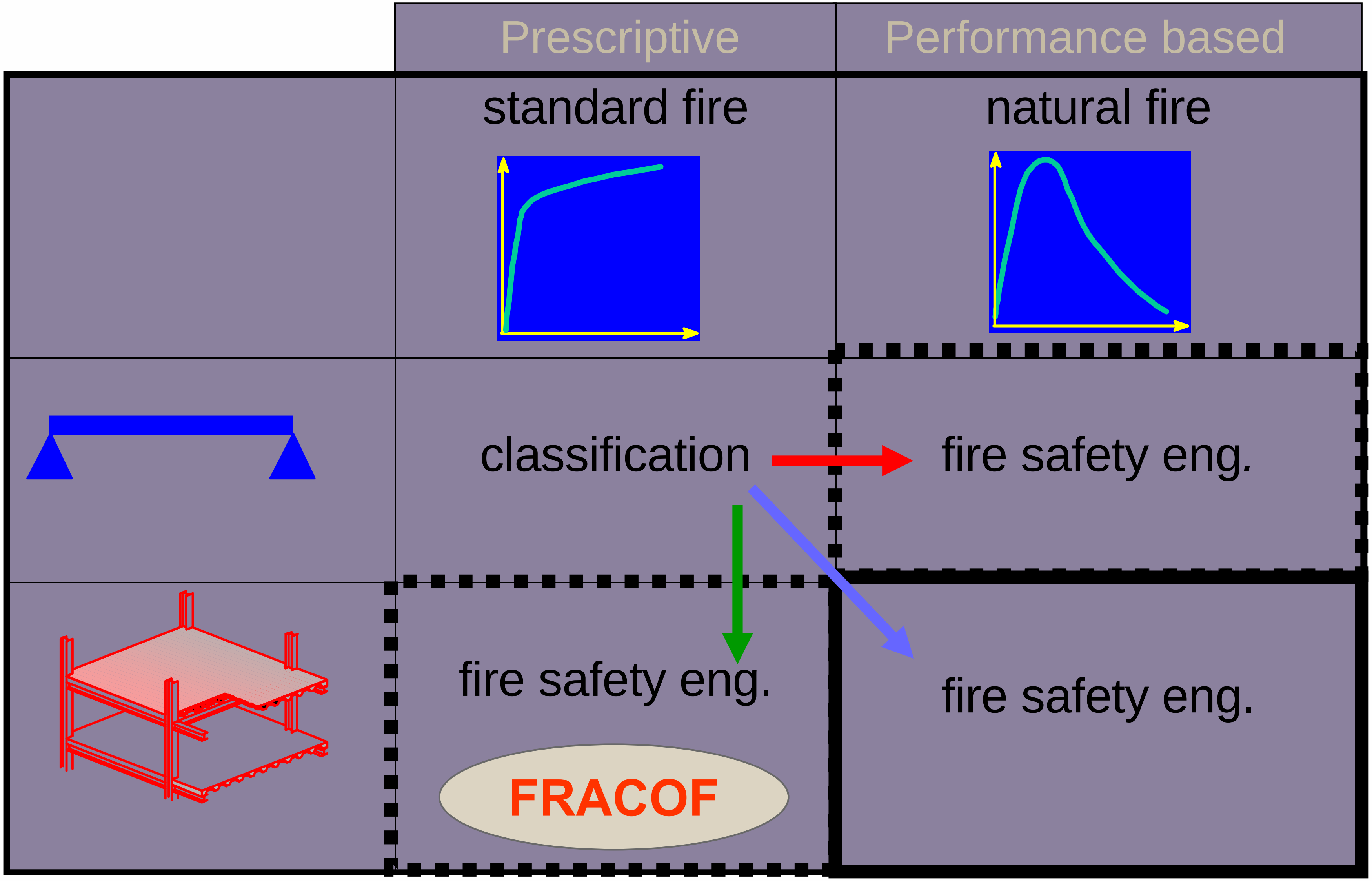
Fire Safety Concept:
Protected main beams, unprotected secondary beams

T Mobile Headquarters
Hatfield Hertfordshire

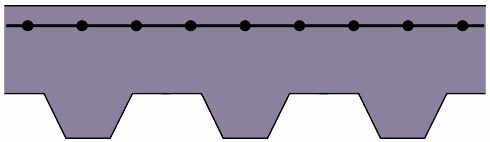
Buildings references

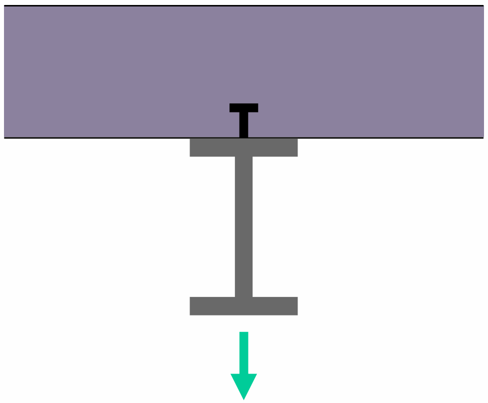
School in Turkey

The "structural fire safety engineering" approach
Eurocodes 1, 3 et 4



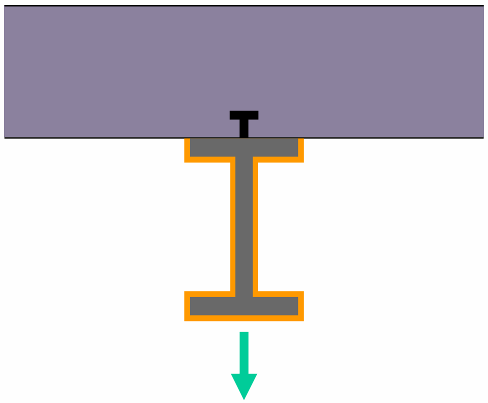
FRACOF Design



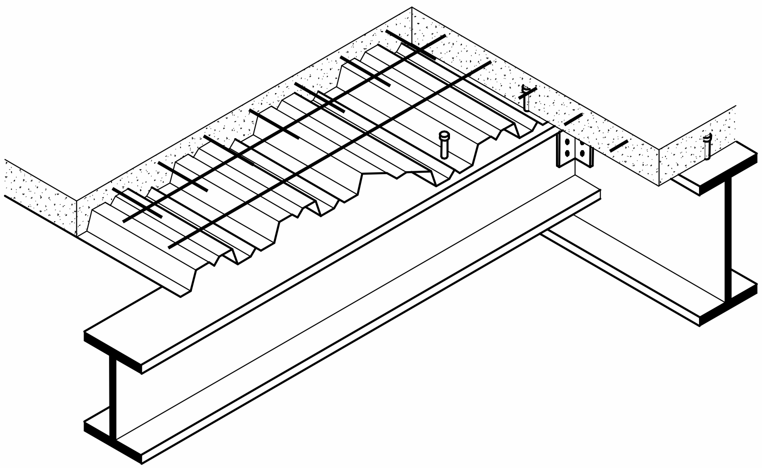


Unprotected Element

$R_{(single\ element)} < 30$



Protected Element

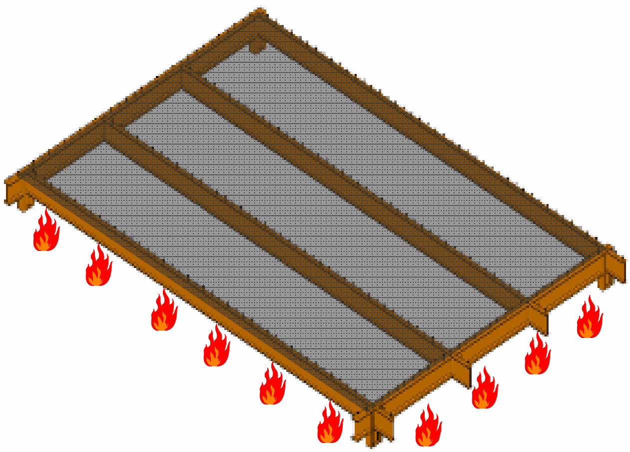


Test on the whole floor

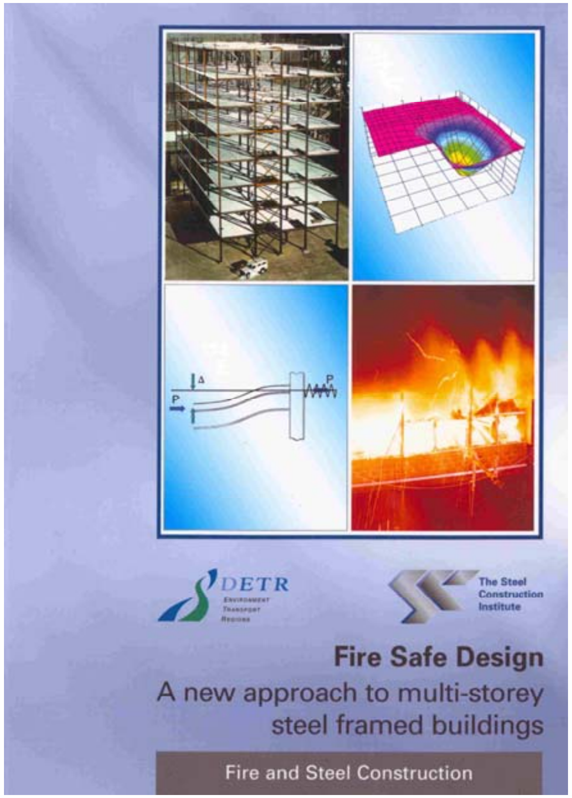
including connections

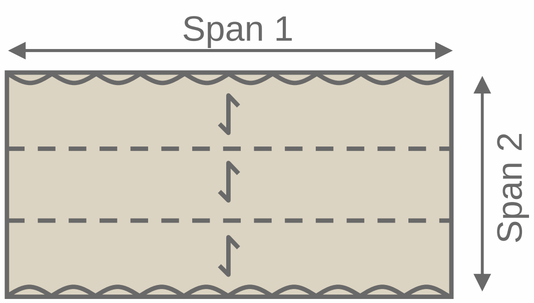
$R \geq 30$

$R = ?$



Example of Design Table

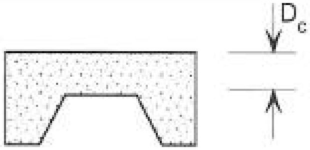




Span 1 = 9m ; Span 2 = 7m ; R120

Standard A-series mesh reinforcement
Reinforcement strength 500 N/mm²

R 90 R 120



Design Table 2			Mesh size, beam design factor and additional beam load (kN) for fire resistance, concrete type and span 1											
			90 minutes fire resistance						120 minutes fire resistance					
			Normal weight concrete 80 mm concrete depth			Lightweight concrete 80 mm concrete depth			Normal weight Concrete 90 mm concrete depth			Lightweight concrete 90 mm concrete depth		
Span 2 (m)	Imposed Load (kN/m^2)	Span 1 (m)	6.0	7.5	9.0	6.0	7.5	9.0	6.0	7.5	9.0	6.0	7.5	9.0
6.0	2.5 + 1.7	Mesh	A142	A193	A193	A142	A142	A193	A142	A193	A193	A142	A193	A193
		Beam	OK	OK	OK	OK	0.75	OK	OK	OK	0.99	OK	OK	OK
		Load	1	8	15	1	6	14	2	9	17	1	8	15
	3.5 + 1.7	Mesh	A142	A193	A193	A142	A193	A193	A142	A193	A252	A142	A193	A252
		Beam	OK	OK	0.93	OK	OK	OK	OK	OK	OK	OK	OK	OK
		Load	1	8	17	1	7	15	2	9	18	1	8	16
	5.0 + 1.7	Mesh	A142	A193	A252	A193	A193	A252	A193	A193	A252	A193	A193	A252
		Beam	0.83	OK	OK	OK	OK	OK	OK	0.89	OK	OK	0.84	OK
		Load	0	9	18	1	8	17	2	10	20	2	9	18
7.5	2.5 + 1.7	Mesh	A193	A142	A193	A142	A193	A193	A193	A193	A193	A193	A193	A193
		Beam	OK	0.80	OK	0.79	OK	OK	OK	OK	OK	OK	OK	0.98
		Load	6	14	26	4	13	23	7	17	28	6	15	25
	3.5 + 1.7	Mesh	A193	A193	A193	A193	A193	A193	A193	A193	A252	A193	A193	A252
		Beam	OK	OK	OK	OK	OK	0.86	OK	OK	OK	OK	OK	OK
		Load	6	16	28	5	14	24	7	18	30	6	16	27
	5.0 + 1.7	Mesh	A193	A193	A252	A193	A193	A252	A193	A193	A252	A193	A252	A252
		Beam	OK	OK	OK	OK	OK	OK	0.89	0.95	OK	0.84	OK	OK
		Load	7	18	31	6	16	28	7	20	34	6	18	31

FRACOF - Fire Resistance Assessment of partially Composite Floor

Economic fire design of steel beams in composite floor

Objective

That project will be a milestone in the strategy to develop the fire engineering. It will enable any engineers to use partially unprotected steel structure by using design tables/software approved by the Authorities.

Deliverables

There are three main deliverables for this project :

- Background Technical Report
- Design Guide
- Design Software

1. Background Technical Report
   To provide in-depth information on the development and verification of the design method.
2. Design Guide
   The design guide will consist of approximately 50 pages and will be based on the existing publication 'Fire Safe Design: A new approach to multi-storey steel-framed buildings'. The design guide will present the principles of the design process using this method.
3. Design Software
   The design software will be made available free of charge and will be distributed via the Steel Alliance website.

Dissemination

Through Steel Alliance + IPO's in Spain, Germany, Belgium, Italy, Luxembourg and the Netherlands, + DIFISEK, + 'Secure with Steel'

TEST SET-UP

Within the framework of project FRACOF, a composite floor of about 60 m², supported by four protected boundary beams and two unprotected internal beams, subjected to standard fire exposure for 2 hours.

LOADING CONDITIONS

- Self weights of slab, steel beams, etc
- Dead load: 170 kg/m^2
- Imposed load: 500 kg/m^2

MESH REINFORCEMENT

TEST MONITORING

AFTER 120 MINUTES….

Steel Alliance ArcelorMittal

AFTER 120 MINUTES…

Cracks in concrete

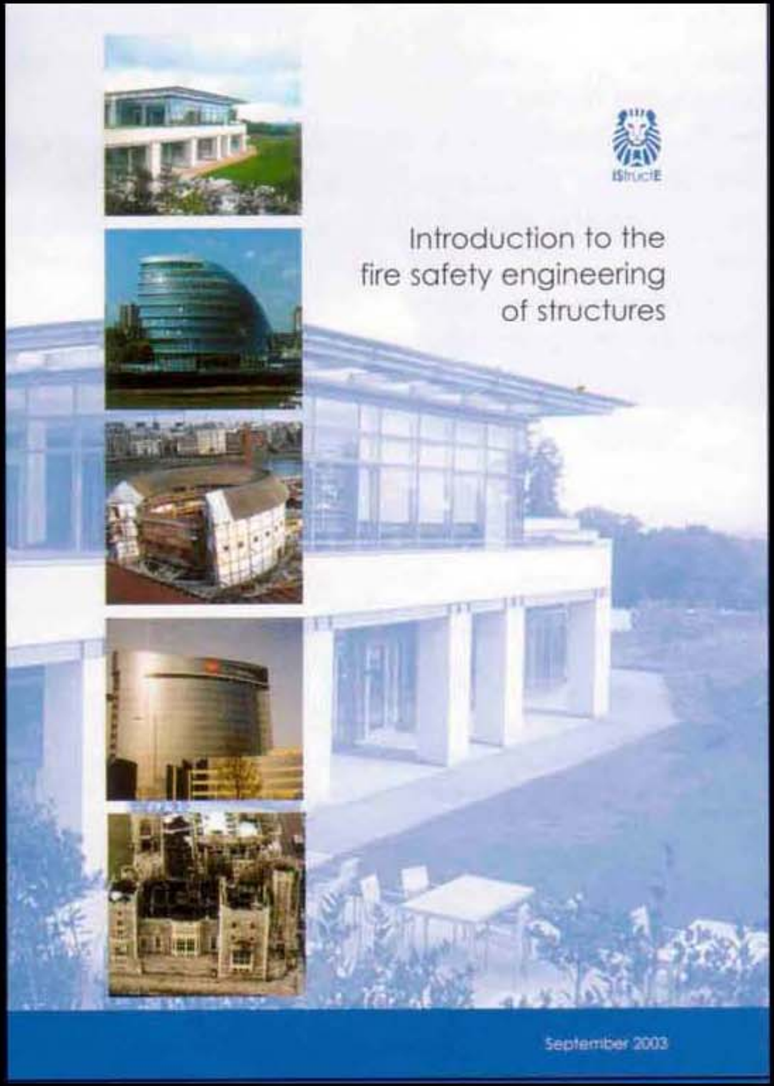
AFTER 120 MINUTES…

AFTER 120 MINUTES…

Steel Alliance ArcelorMittal

ArcelorMittal

Fire safety engineering is aimed at adopting a rational scientific approach which ensures that fire resistance/protection is provided where it is needed rather than accepting universal provisions which may over or under estimate the level of risk.



Institution of Structural Engineers