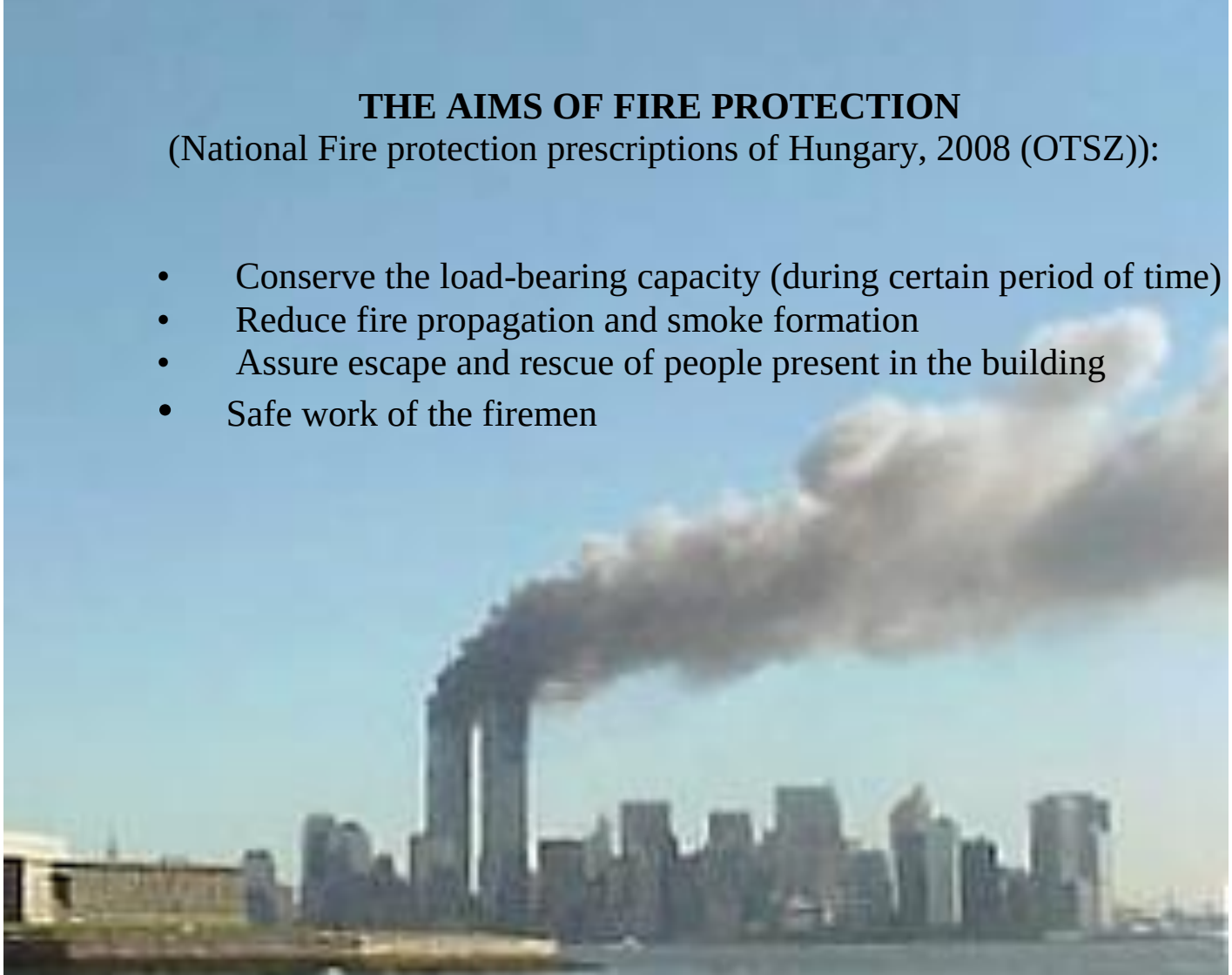
FIRE RESISTANCE DESIGN

THE AIMS OF FIRE PROTECTION

(National Fire protection prescriptions of Hungary, 2008 (OTSZ)):

- Conserve the load-bearing capacity (during certain period of time)
- Reduce fire propagation and smoke formation
- Assure escape and rescue of people present in the building
- Safe work of the firemen



FIRE PROTECTION ADVANTAGES OF REINFORCED CONCRETE STRUCTURES

(when compared with steel structures)

Concrete is incombustible
Concrete protects steel (thermal insulation, cooling)
The role of steel is small in critical structures (columns, slabs)
In beams arrangement of reinforcement in several rows better
Smaller slenderness (smaller risk of stability failure)

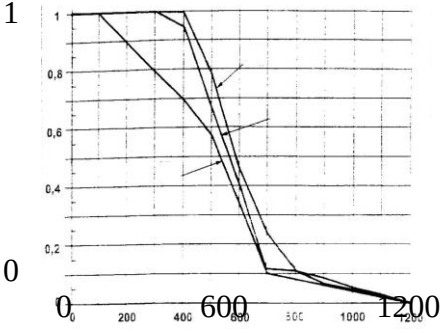
STRENGTH REDUCTION OF STEEL AND CONCRETE IN FIRE

Reinforcement

Partially reversible changes
rapid thermal expansion
strength reduction

$$f_{yk}(\Theta) = k_s \cdot f_{yk}(20°C)$$

k_s – temperature diagram

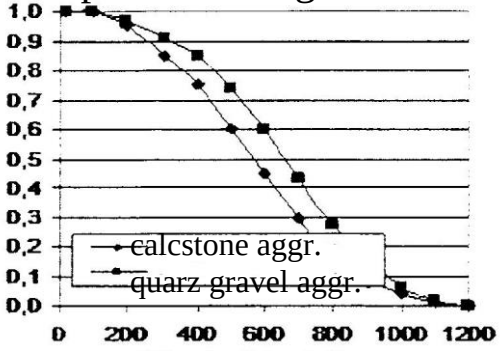


Concrete

Irreversible physical and chemical changes
(blast damages, splitting)
Strength reduction

$$f_{ck}(\Theta) = k_c \cdot f_{ck}(20°C)$$

k_c – temperature diagram



NORMATIVE FIRE CURVE (EN1991-1-2)

$$\Theta = 20 + 345 \cdot \log_{10}(8t + 1)$$

t: Time (Min.)	15	30	60	90	120	180	240
Θ: Temperature (˚C)	739	842	945	1006	1049	1120	1153

COMBINATION OF LOADS AND EFFECTS TO CONSIDER IN FIRE

Exceptional combination of effects

The reduced load intensity to consider in fire, approximately:

$$E_{d,fi} = \eta_{fi} \cdot E_d$$

where:

$$\eta_{fi} \approx \frac{G_k + \psi_{1,1} Q_{k,1}}{\gamma_G G_k + \gamma_{Q,1} \psi_{1,1} Q_{k,1}}$$

Safe upper value:

$$\eta_{fi} = 0{,}7$$

(Condition: $Q_{k,1} / G_k > 0{,}5$)

THE WAY OF FORMULATION OF FIRE ENDURANCE REQUIREMENTS OF BUILDINGS

according to the National Fire Protection Prescriptions of Hungary, 2008

- Ranging in **fire danger classes** (A to E)
- Ranging in **fire endurance grades** (I to V)
- Determining the fire endurance requirements and fire endurance limits (for ex.: REI 120**)**

FIRE SECTIONS, FIRE DANGER CLASSES OF ROOMS, BUILDINGS AND CONSTRUCTIONS

Fire danger class		Examples
sign	definition	
A	Fire and blast dang-erous in an increased degree	Rooms, places, buildings where fire and blast-dangerous materials in any state can be present (for ex.: great capacity accumulator charger rooms, presence of liquids with under 21˚C ignition point
B	Fire and blast dangerous	Powder forming blast dangerous mixture with the air, rooms, places or buildings where presence of liquids with ignition point between 21-50˚C can occure (for ex.: powder chamber)

C	Fire dangerous	Solid materials with ignition point under 300˚C , liquid mineral oil by-products with ignition points between 50-150˚C (for ex gas oil, petroleum), rooms, places and buildings where non-combustible but combustion nourishing gases can be present (for ex.: gasoline stations, communal building s above 500 people capacity)
D	Moderatel y fire dangerous	Solid materials with ignition point above 300˚C (for ex. hard coal), rooms, spaces, buildings where liquids of above150˚C flash point can be present;; offices, dwellings and buildings for animal keeping under 50 people capacity
E	Not fire dangerous	Rooms, spaces and buildings where exclusively non-combustible materials are present, where the temperature of the materials does not increase above 300˚C.

FIRE ENDURANCE GRADES

the level of danger in case of fire

Function and details, height etc. of the building/fire section (characteristic types of buildings)	**The lowest fire endurance grade** that can be prescribed
High-rise buildings, medium high building designed for staying of masses, with pavement level above 13,65 m.	**I.**
Infant′s nursery, kindergarten, medium high building, multi-storey cellars, more than two level high buildings for handy-capped people	**II.**
Schools, dwelling and communal buildings more than two level high, with top pavement level under 13,65 m, max. two level high buildings for handy-capped people.	**III.**

Roofed spaces without vertical space separations, cellar-ground floor+1 storey high (or with built-in attic) dwelling or rest-house, single-storey communal building with 25 to 30 people capacity.	**IV.**
Single storey rest-house, family house and public building of max.25 people capacity	**V.**

FIRE RESISTANCE LIMITS

The minimum time interval prescribed for the fulfilment of the given fire resistance requirement (for ex. R)

Such as: 15, 30, 60, 90, 120, 180, 240 Minutes

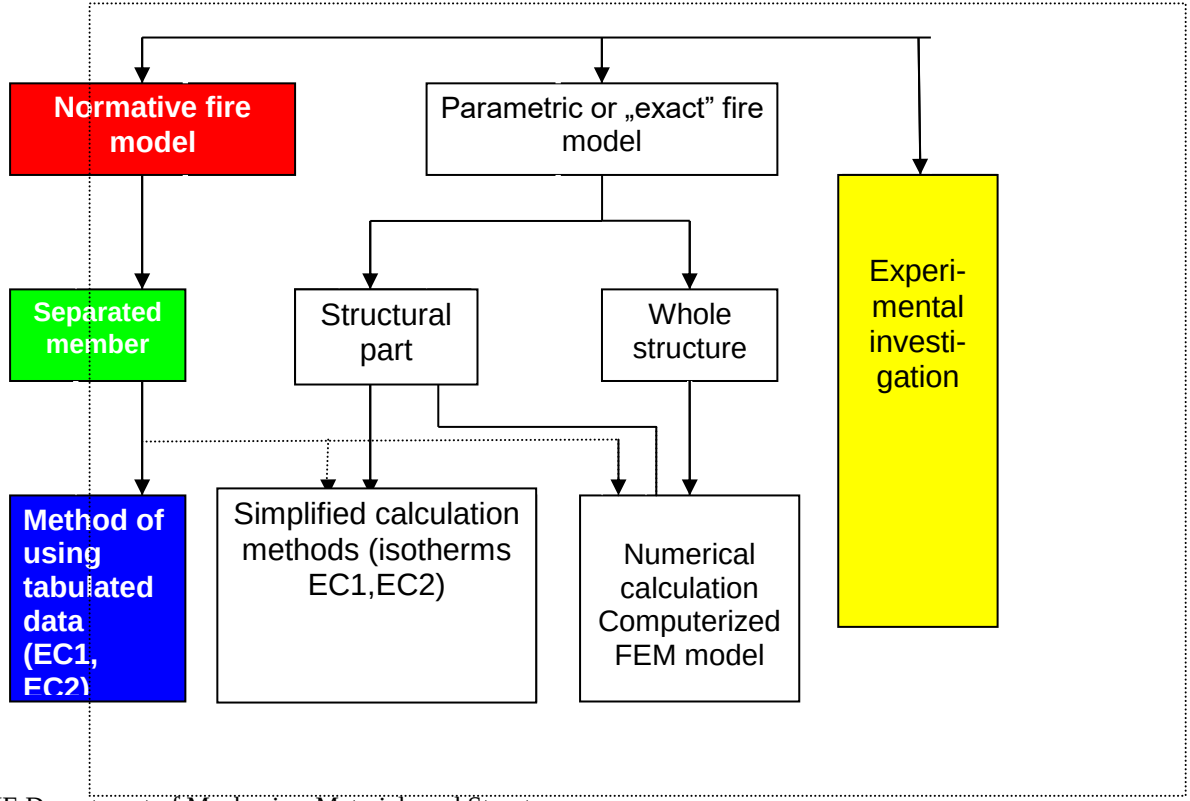
Examples:

- R 60 (beam, floor slab)
- REI 90 (wall)
- REI-M 240 (fire-wall)

- **R** : conserving the load-bearing capacity
- **E** : structural integrity (impeding fire propagation)
- **I** : insulation (limited warming up)
- **M** : mechanical hit-proof behaviour

The requirement **REI-M** means: bearing capacity + integrity + insulation + hit proof behaviour (fire-walls)

METHODS OF FIRE ENDURANCE DESIGN OF BUILDINGS



USE OF TABLES FOR FIRE RESISTANCE DESIGN

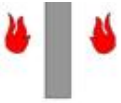
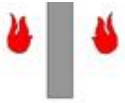
Input data is the prescribed fire resistance, for ex.:REI 90

To be checked /designed:

- Minimum dimension of the concrete cross-section (b_{min} or t_{min})
- Minimum distance between axis of bars and the surface (a_{min})
- Area of the reinforcement (by columns)

Elaborated tables in MSZ EN 1992-1-2:2005 for:

- Columns, pillars
- Walls (see next page!)
- Simple supported and continuous beams
- Slabs supported along the edges
- Flat slabs

Fire resis-tance require-ment and limit (Min)	Reinforced concrete walls			
	Wall thickness/concrete cover to axis of bars			
	One side fire 	Two side fire effect 	One side fire effect 	Two side fire 
	Exploitation rate: $\mu_{fi}=N_{Ed,fi}/N_{Rd}$			
	μ_{fi}=0,35		μ_{fi}=0,7	
REI 30	100/10**	120/10**	120/10**	120/10**
REI 60	110/10**	120/10**	130/10**	140/10**
REI 90	120/20**	140/10**	140/25	170/25
REI 120	150/25	160/25	160/35	220/35
REI 180	180/40	200/45	210/50	270/55
REI 240	230/55	250/55	270/60	350/60
REI-M	In case of impact resistance requirement (M) the lower limit of t_{min} and a_{min} is 140 mm and 25 mm respectively			

** Authoritative is the *a* value according to EN 1992-1-1 (durability)

See similar tables for columns and beams in the rc design aids!

END