FIRE RESISTANCE HOLLOW CORE FLOORS

Ir. Arnold Van Acker

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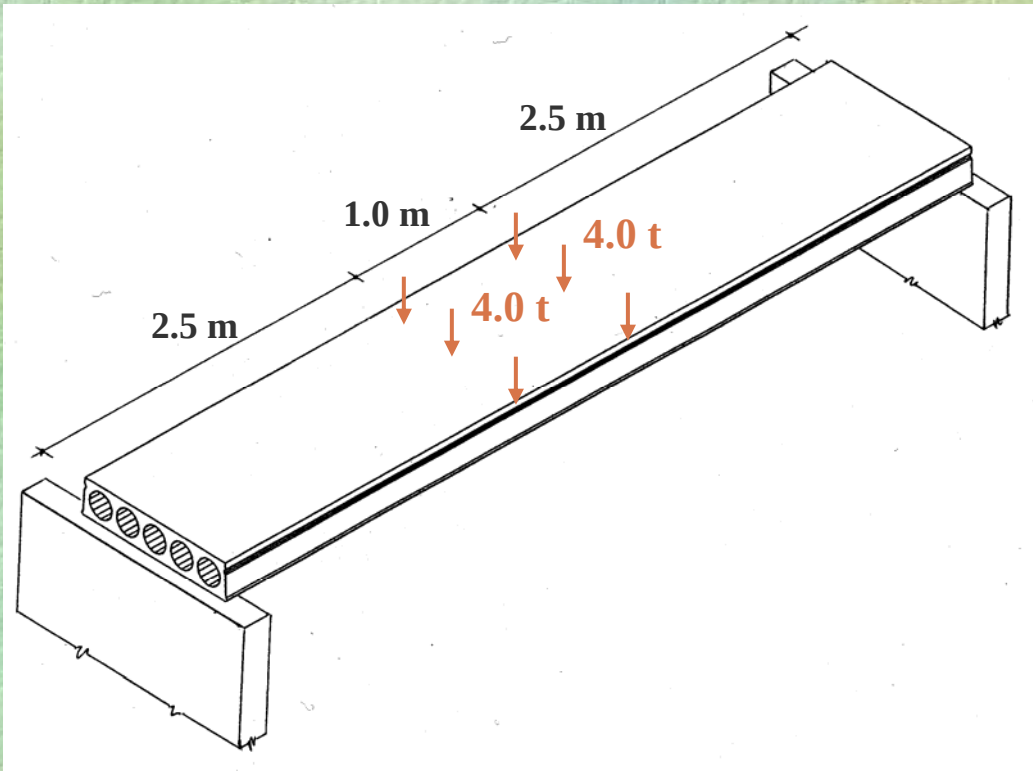
Overview fire test

- First tests in Belgium in 1971 on 265 mm slabs



- one single hollow core unit
- length 6.00 m

First test

- 6 smooth strands Φ 12.5
- Shear failure at 36 min

Second test

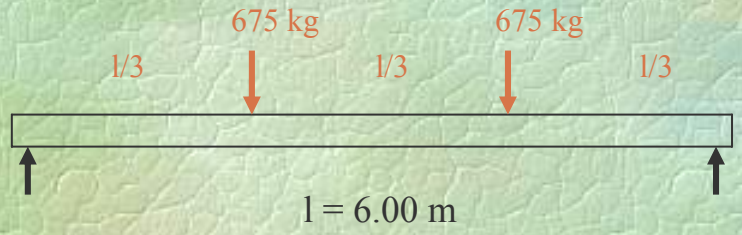
- 6 indented strands Φ 12.5
- Shear failure at 29 min.

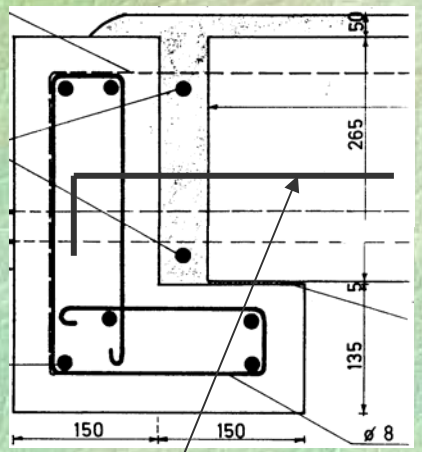
Third test

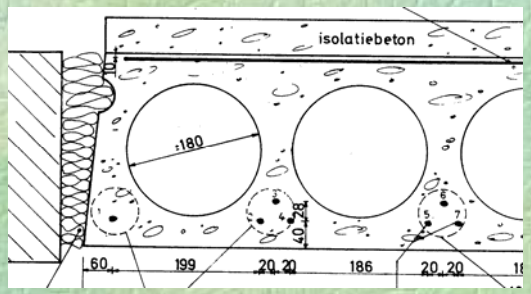
- 6 strands Φ 12.5 with oval central wire
- Shear failure at 33 min.

Overview fire test

- Test in Belgium in 1972 on 265 mm slab in light weight concrete





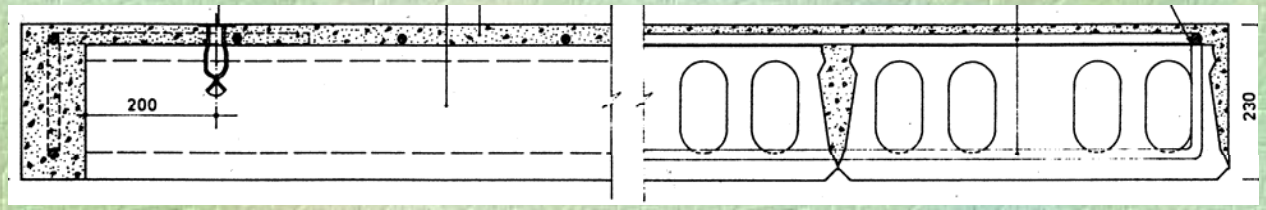


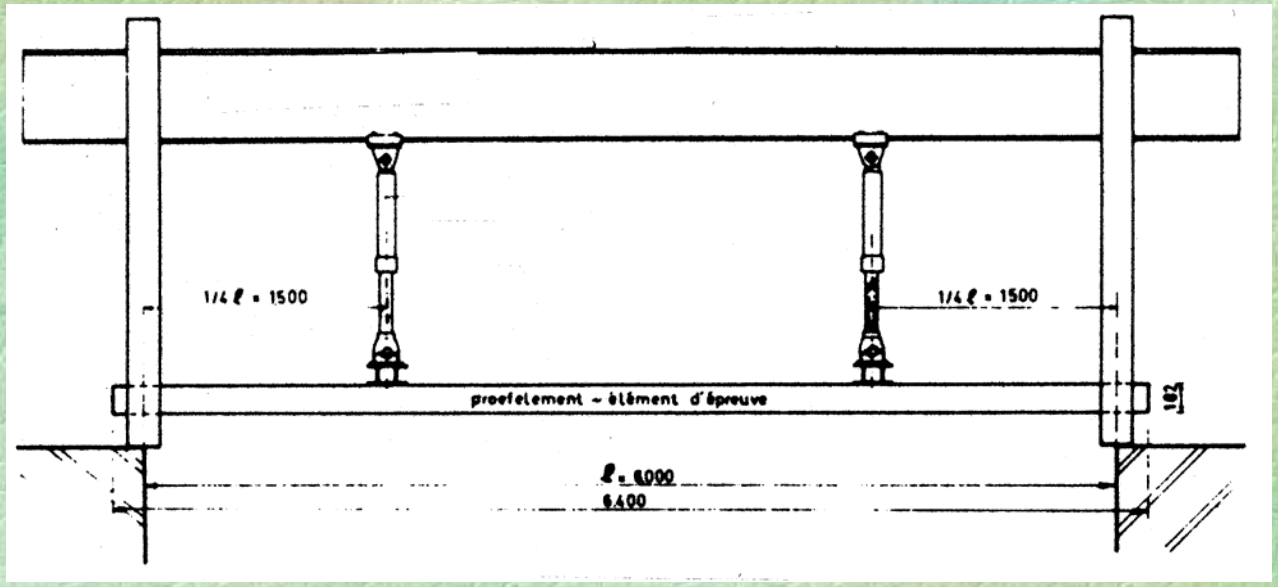
1 bar Φ 10 in 2 open sleeves

Failure: longitudinal splitting after 76 min. exposure

Overview fire test

- Tests in Belgium in 1980 on floor composed of 3 units of 600 mm width, with topping and end beam





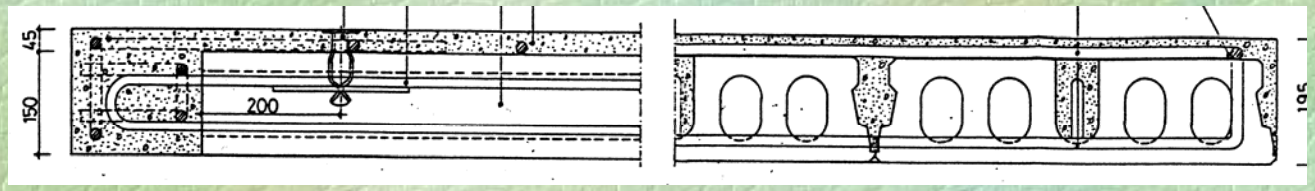
HC 15/600: bending > 1/30 after 76 min.

HC 20/600: bending > 1/30 after 126 min.

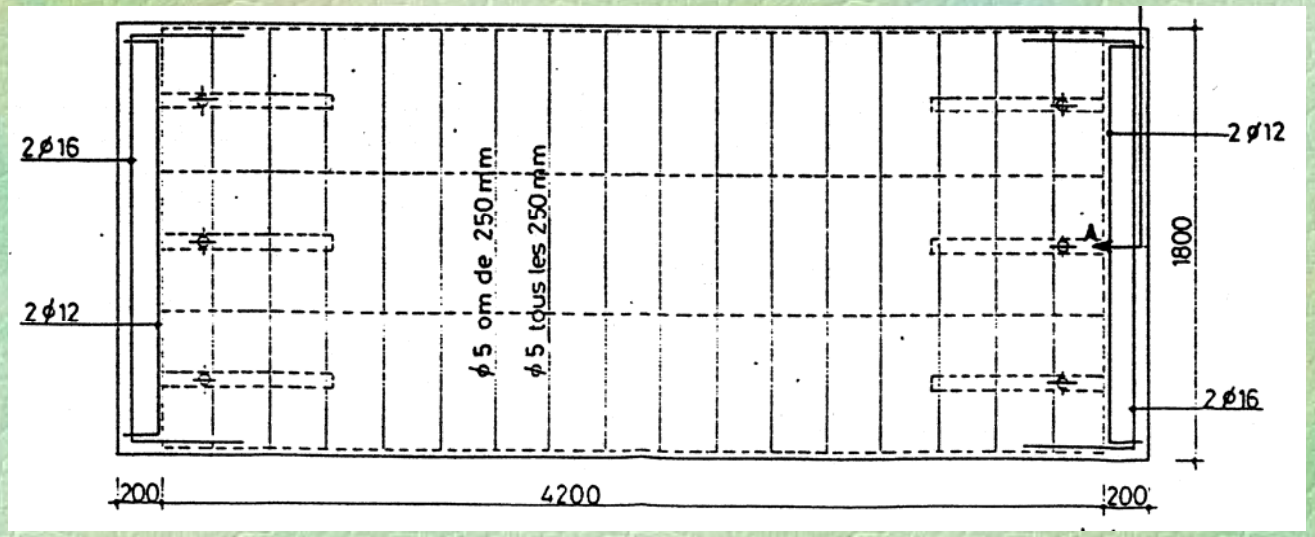
Cover strands 30 mm

Overview fire test

- Tests in Belgium in 1990 on floor composed of 3 units, with topping, end beam and bars in sleeves



HC 15/600:
bending > 1/30
after 182 min.



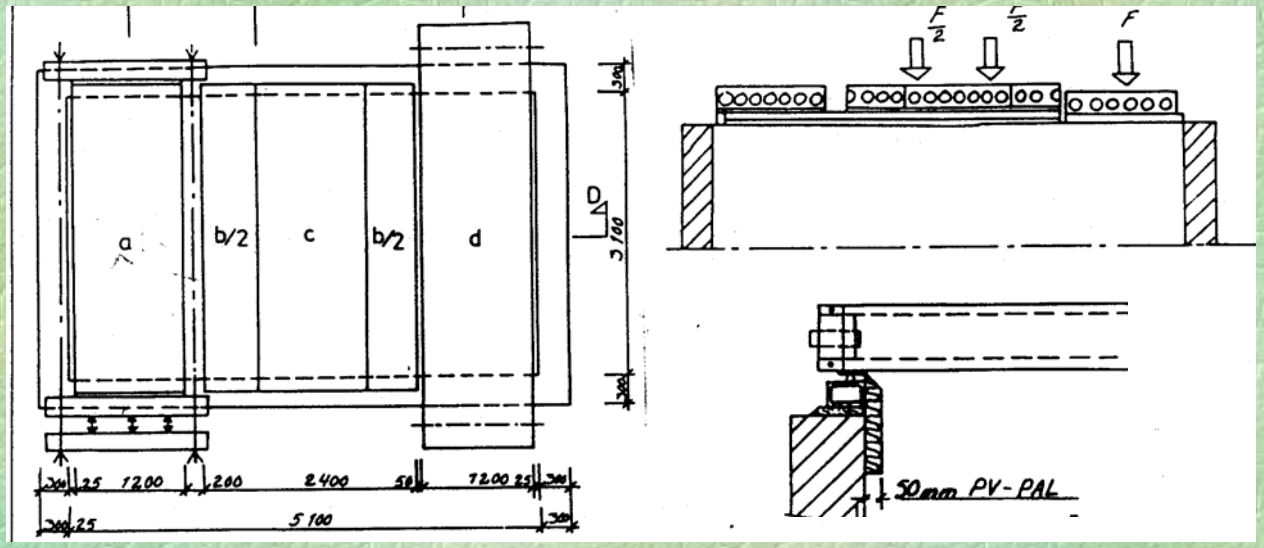
HC 20/600:
bending > 1/30

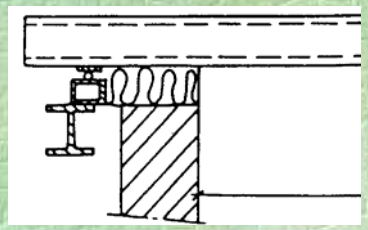
after 194 min.

Cover strands
45 mm

Overview fire tests

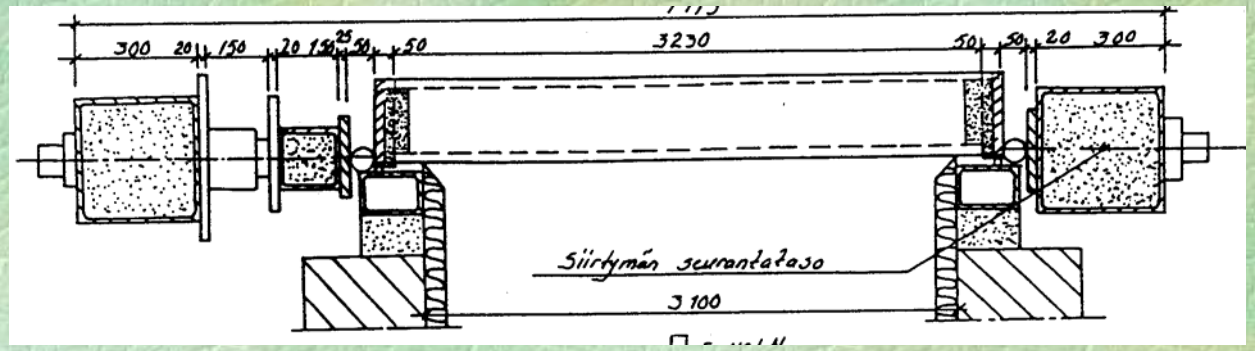
- Tests in Finland in 1985 - Rf 60 min.





Cover strands: 30 mm

Moisture: 2.3 %



Test loading:

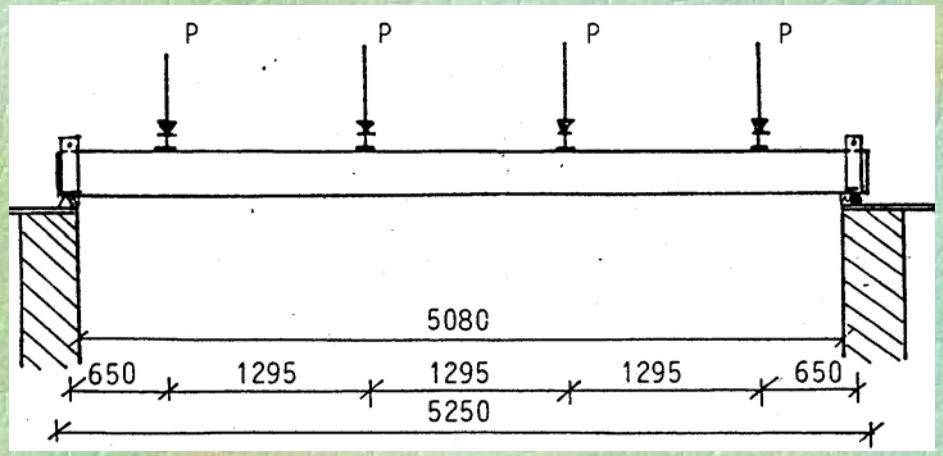
a : no loading

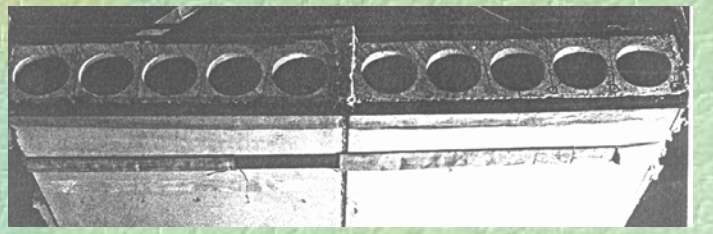
b/c : F = 40 kN in the middle of the span

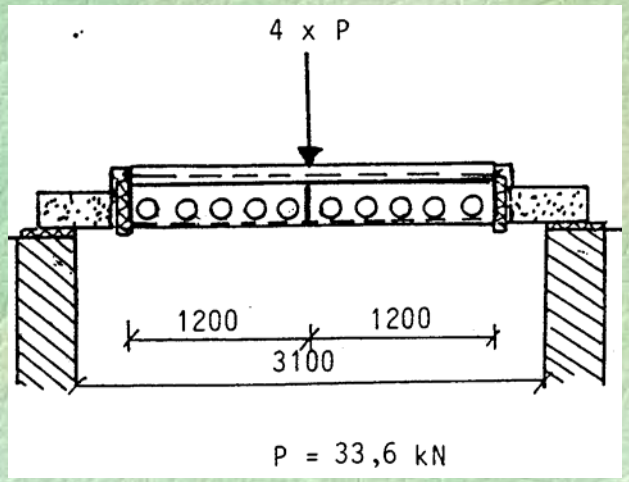
d : F = 84 kN in the middle of the span

Overview fire tests

- Tests in Finland in 1984 on HC 265 mm





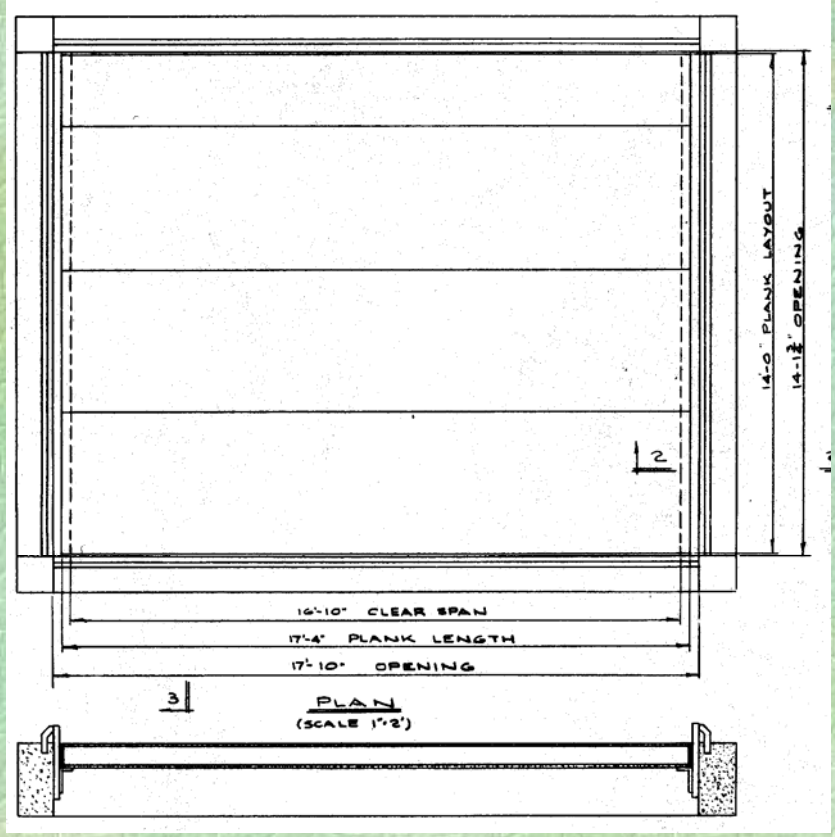


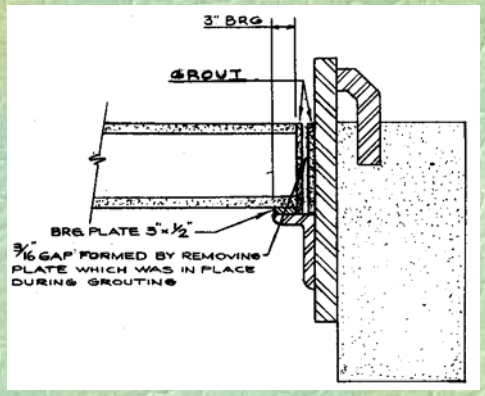
a: loading 10.8 kN/m²
axis distance 35 mm
Rf 60 min.

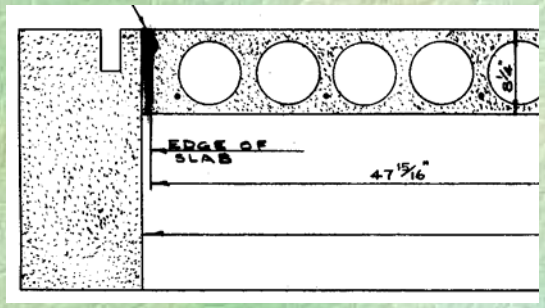
b: loading 1.25 kN/m²
axis distance 65 mm
Rf 130 min.

Overview test results

- Tests Underwriters USA

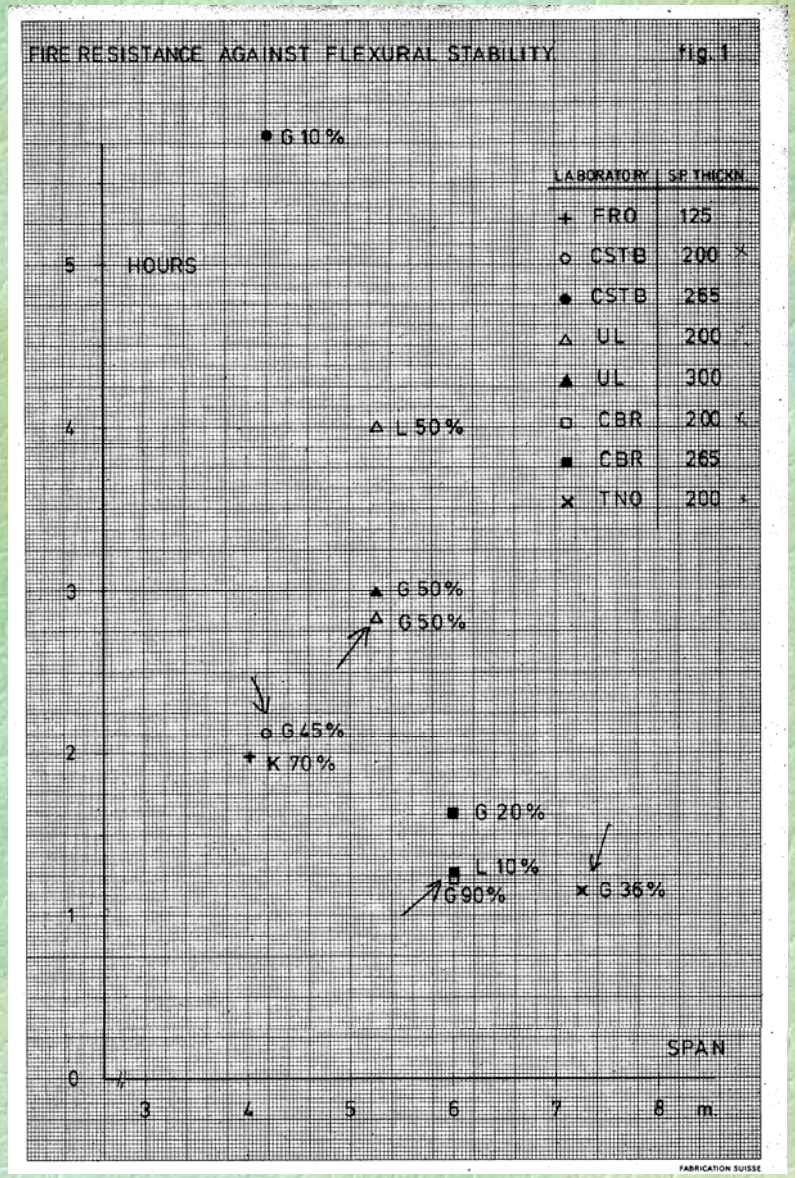


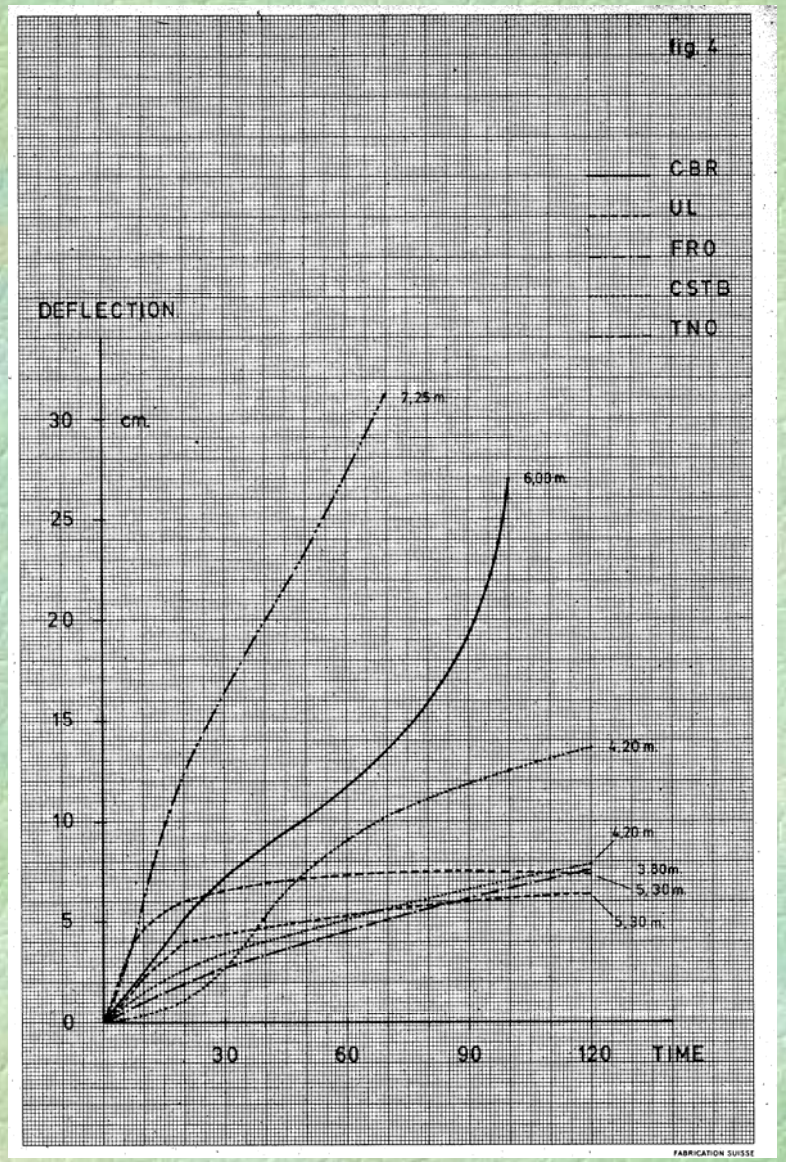




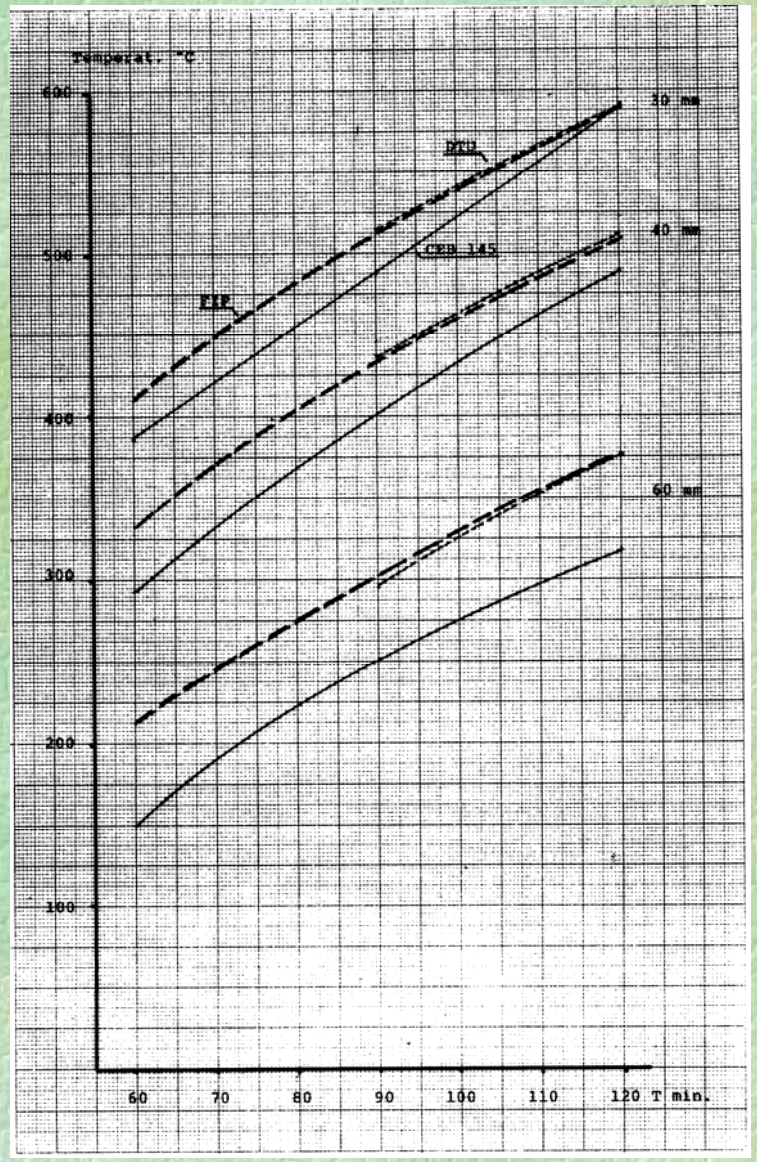
Concrete frame around test floor

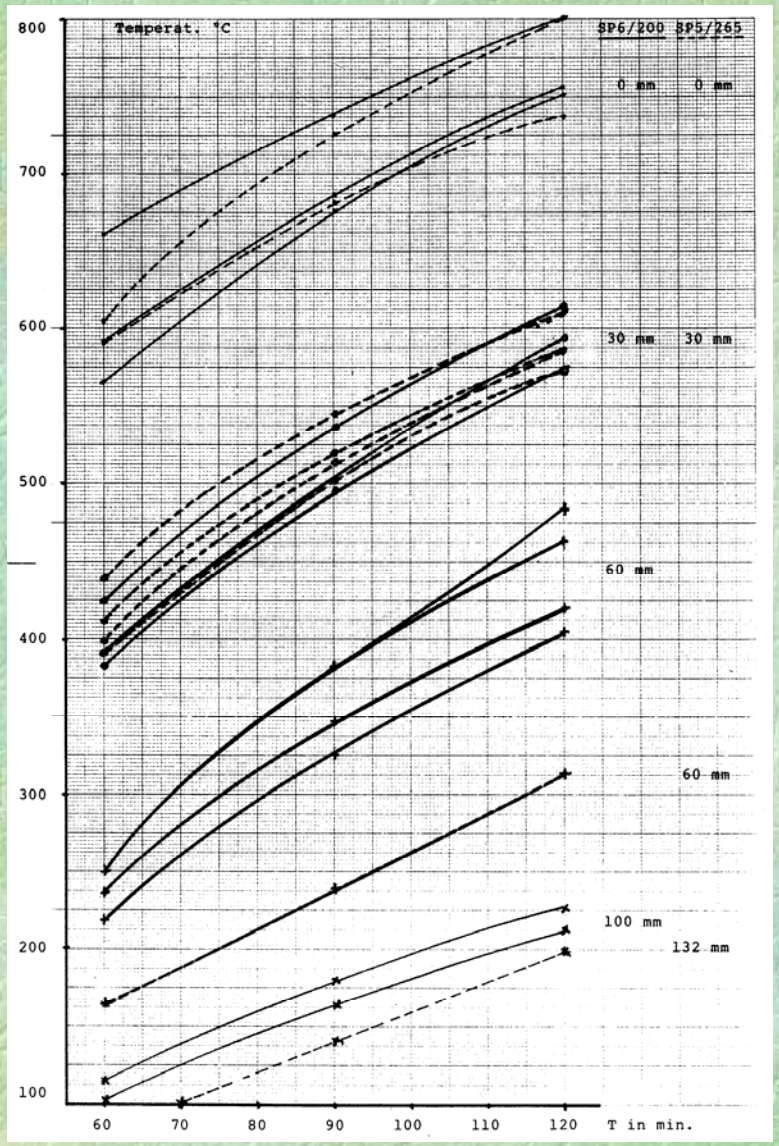
Test results HC world wide





Temperature profiles

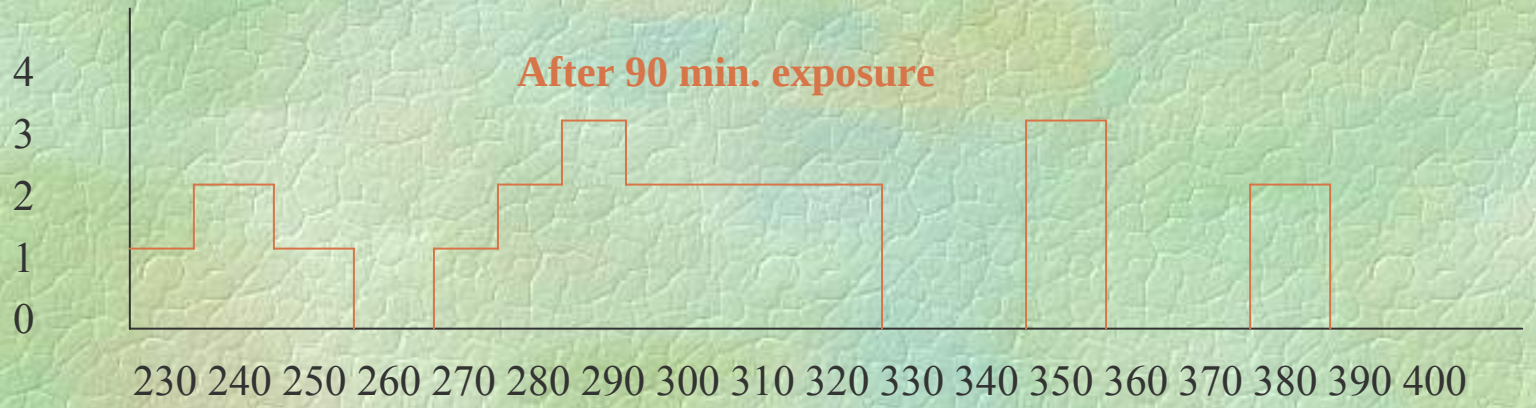


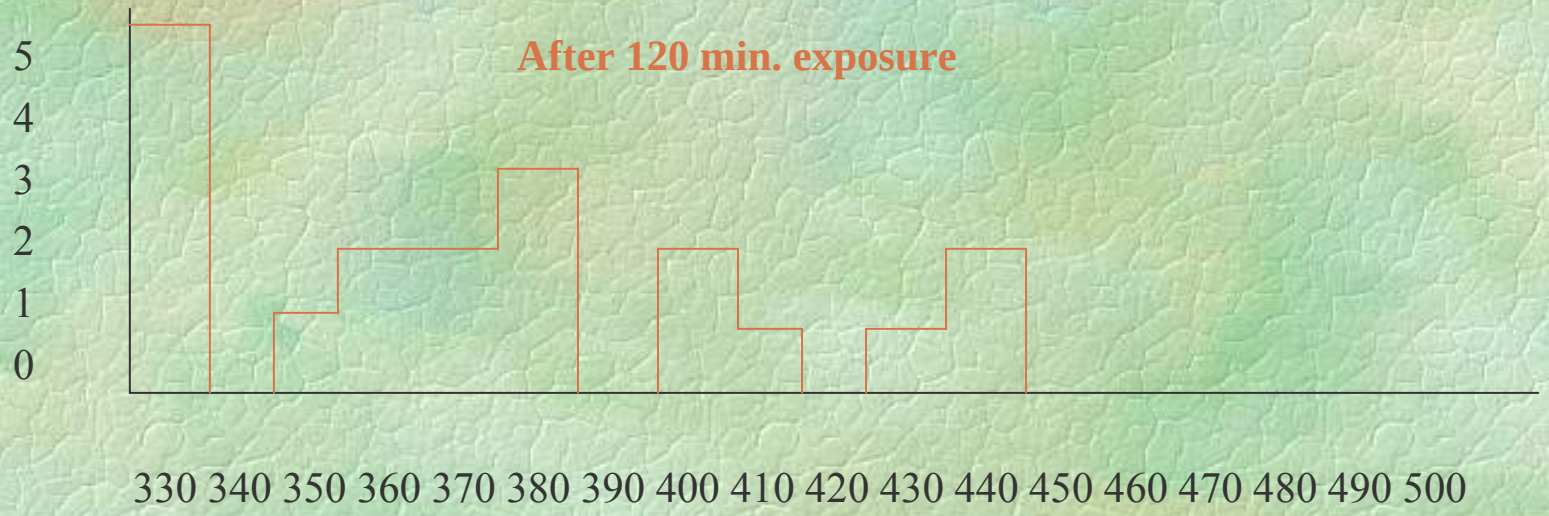


Temperature profiles

- Large dispersion temperature measurements

Registered strandtemperatures in HC 400 - axis distance strands 55 mm





Influencing parameters

- Slab thickness
- Cover on strands
- Connection reinforcement at support
- Topping
- Obstruction thermal dilatation
- Concrete strength
- Moisture content
- Type of aggregates

First conclusions

- Shear is governing for slabs without support connections
- Bending failure when adequate connections
- Difficult to reach Rf 120 at some laboratories
- Large dispersion temperature registrations in same slab

More recent fire tests

- **Premature shear failure : tests in France, Denmark and Holland**

  ⇨Phenomenon

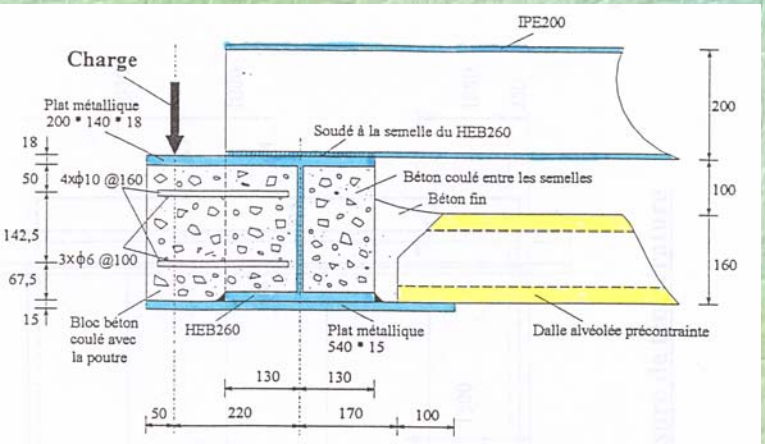
  ⇨ Real behaviour during a fire

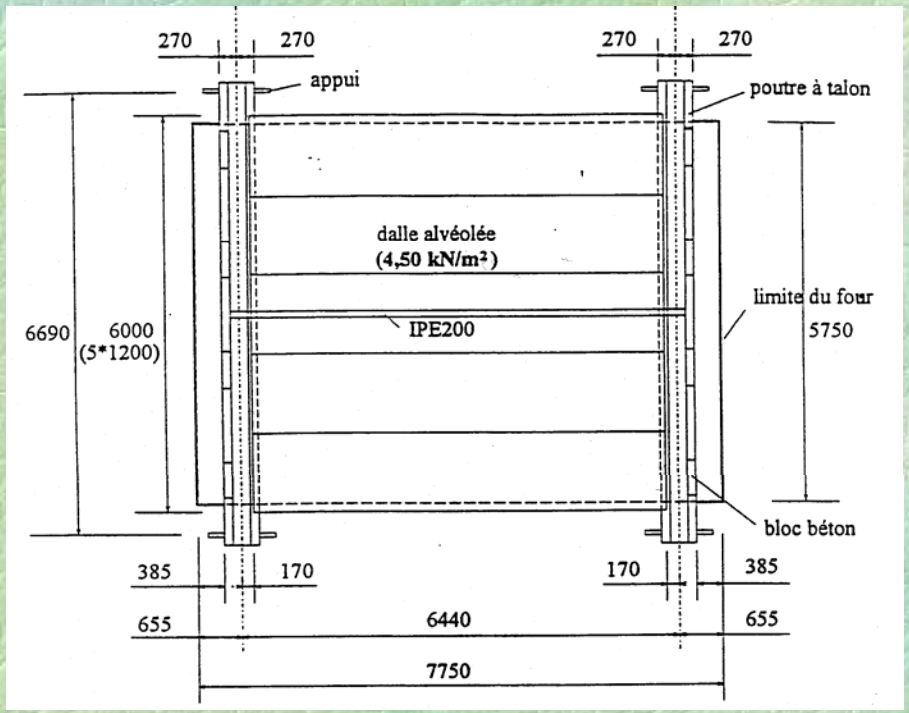
  ⇨ Research on shear capacity HC under fire

  ⇨ Recommendations for fire tests

More recent tests

❑ Tests CTiCM France



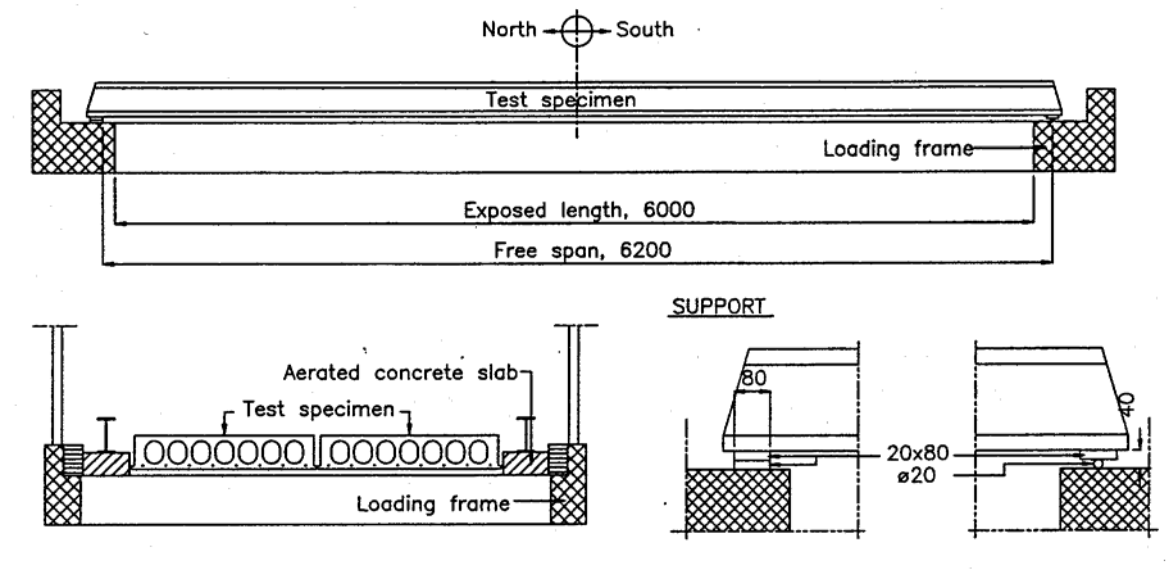


Shear failure HC slabs after

32 minutes fire exposure

More recent tests

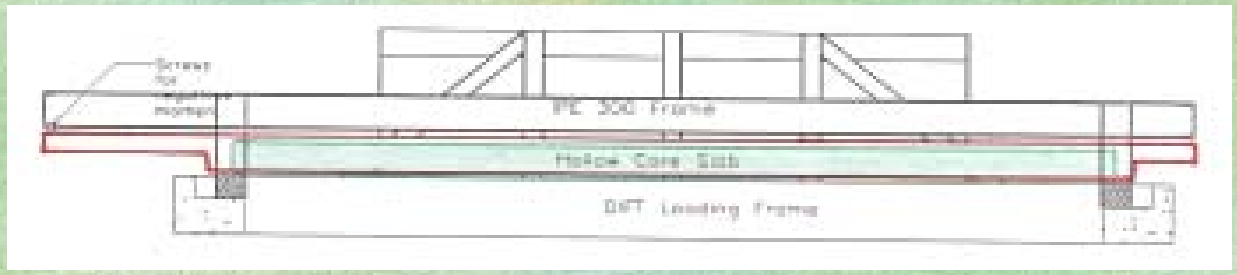
- Tests Danish Institute of Fire Technology

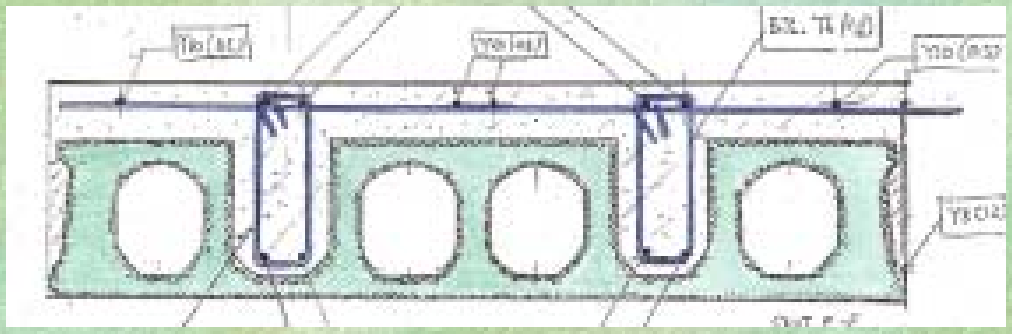


Test results:	**HC 185**	**22 min. shear failure**
	HC 220	**26 min. shear failure**
	HC 270	**21 min. shear failure**

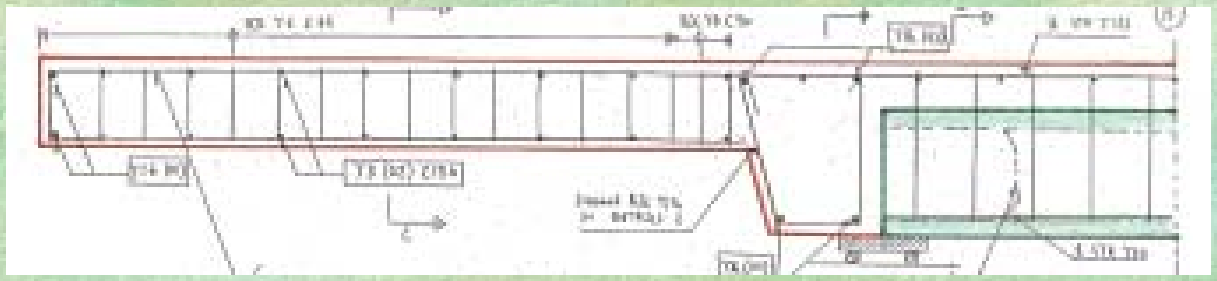
More recent tests

- **Tests Danish Institute of Fire Technology**



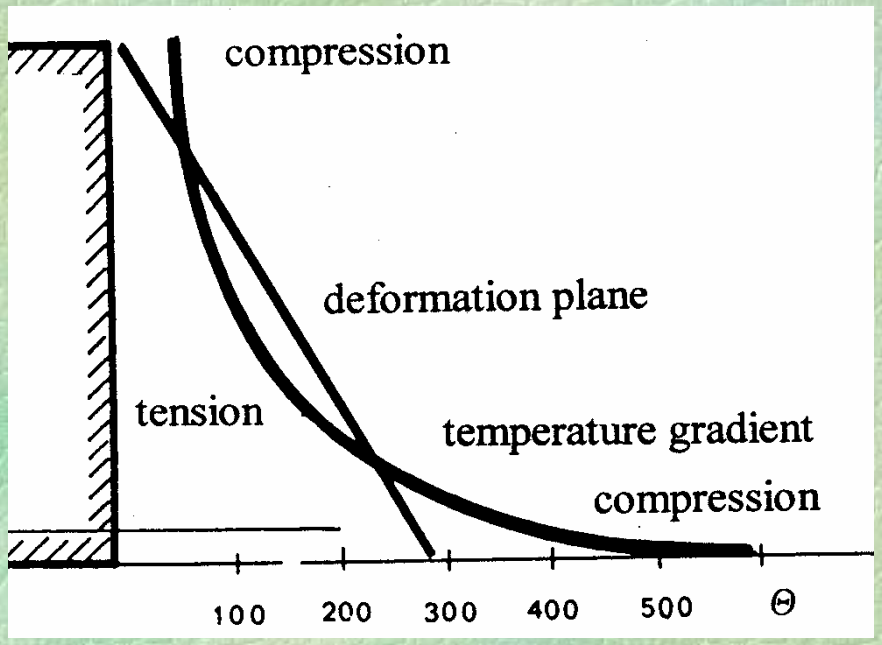


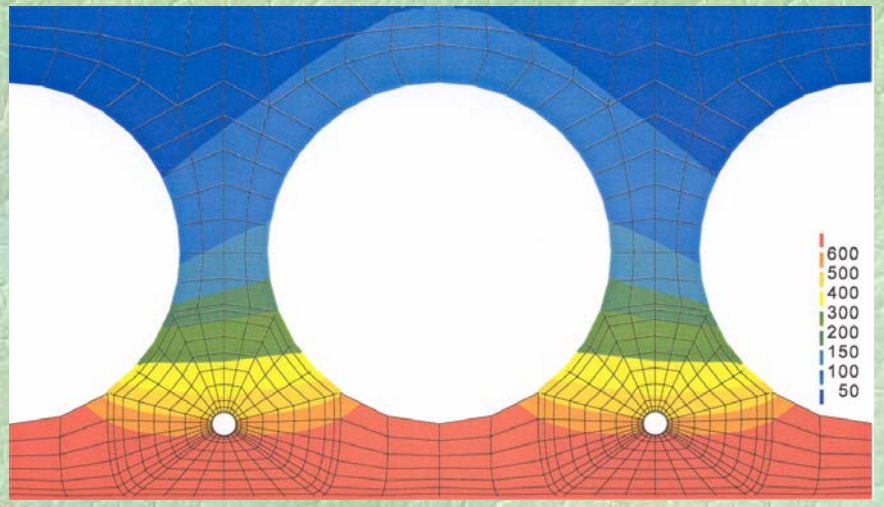
Hollow core floor with cast in-situ cantilever Loading 23 kN/m²

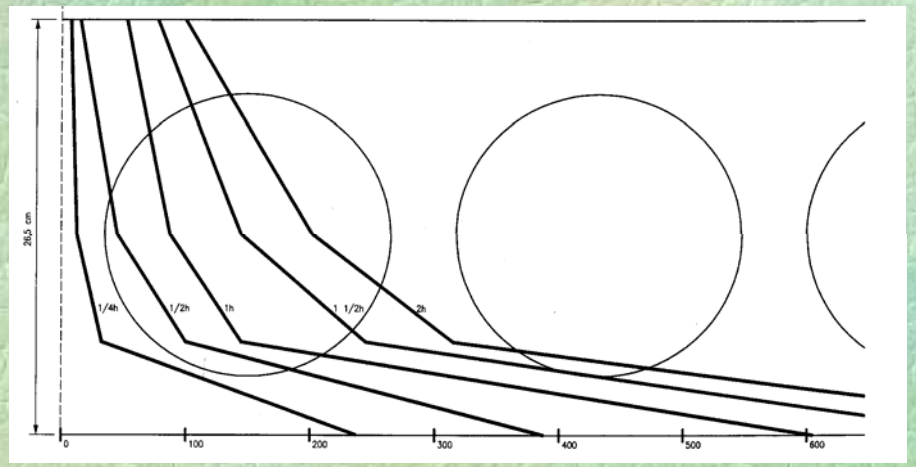


Phenomenon

- **Tensile stresses in webs due to gradient**

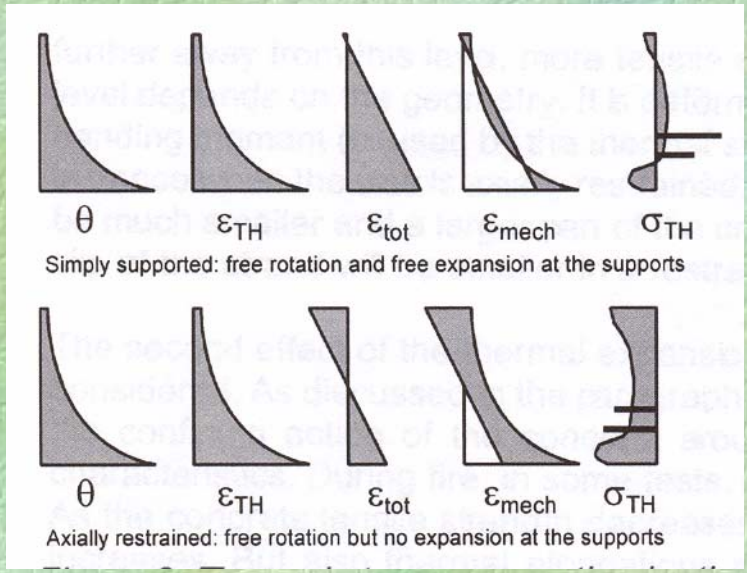




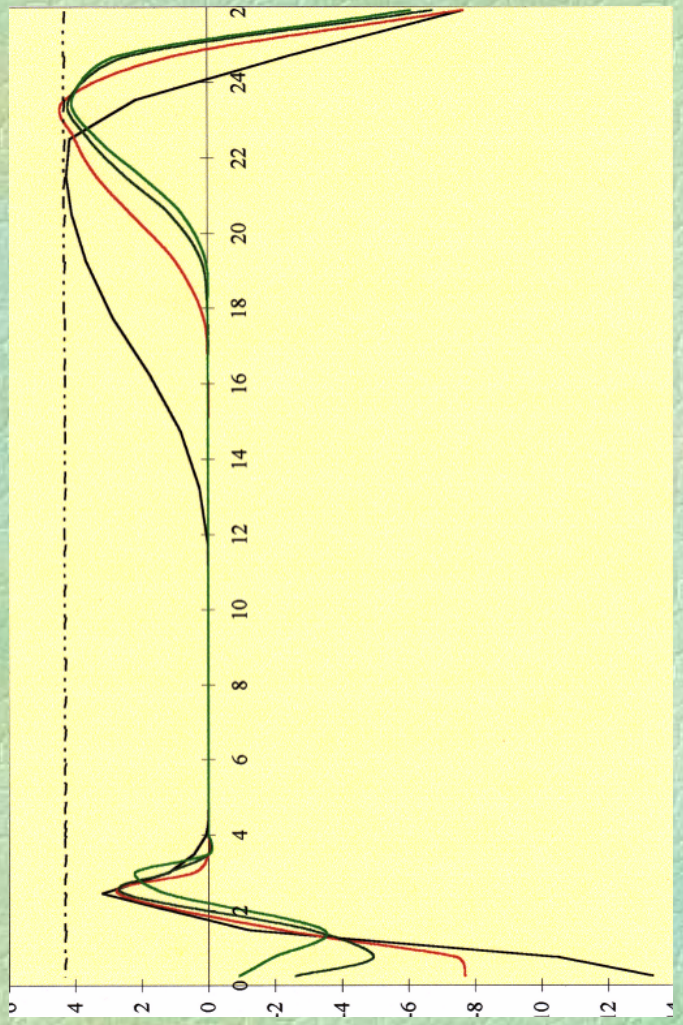


Induced thermal stresses

Tensile stresses exceeding concrete strength after already 20 minutes



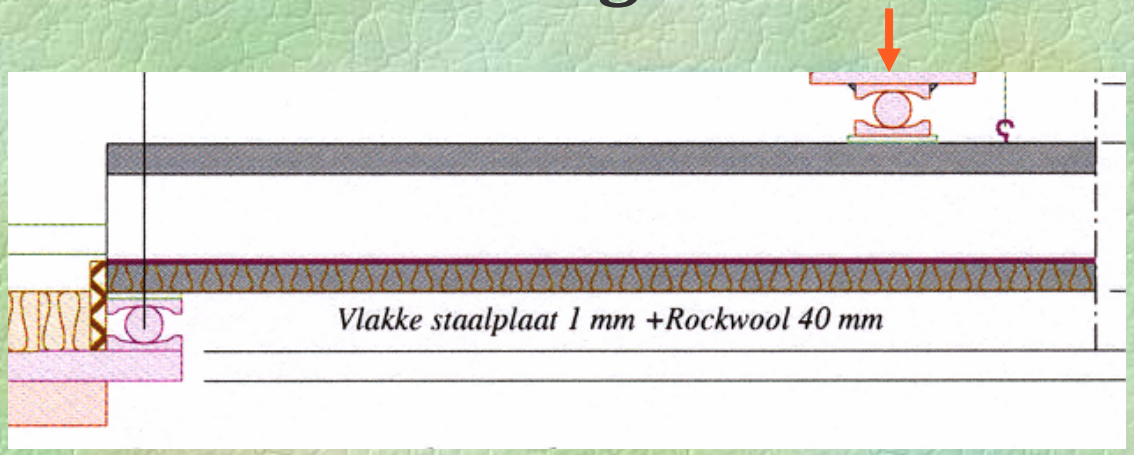
Test TNO Delft

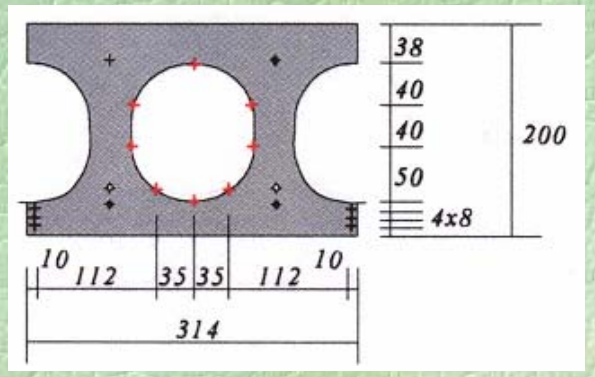


Calculation Univ. Liège (B)

Research Fellinger

❑ Tests Fellinger at TNO The Netherlands

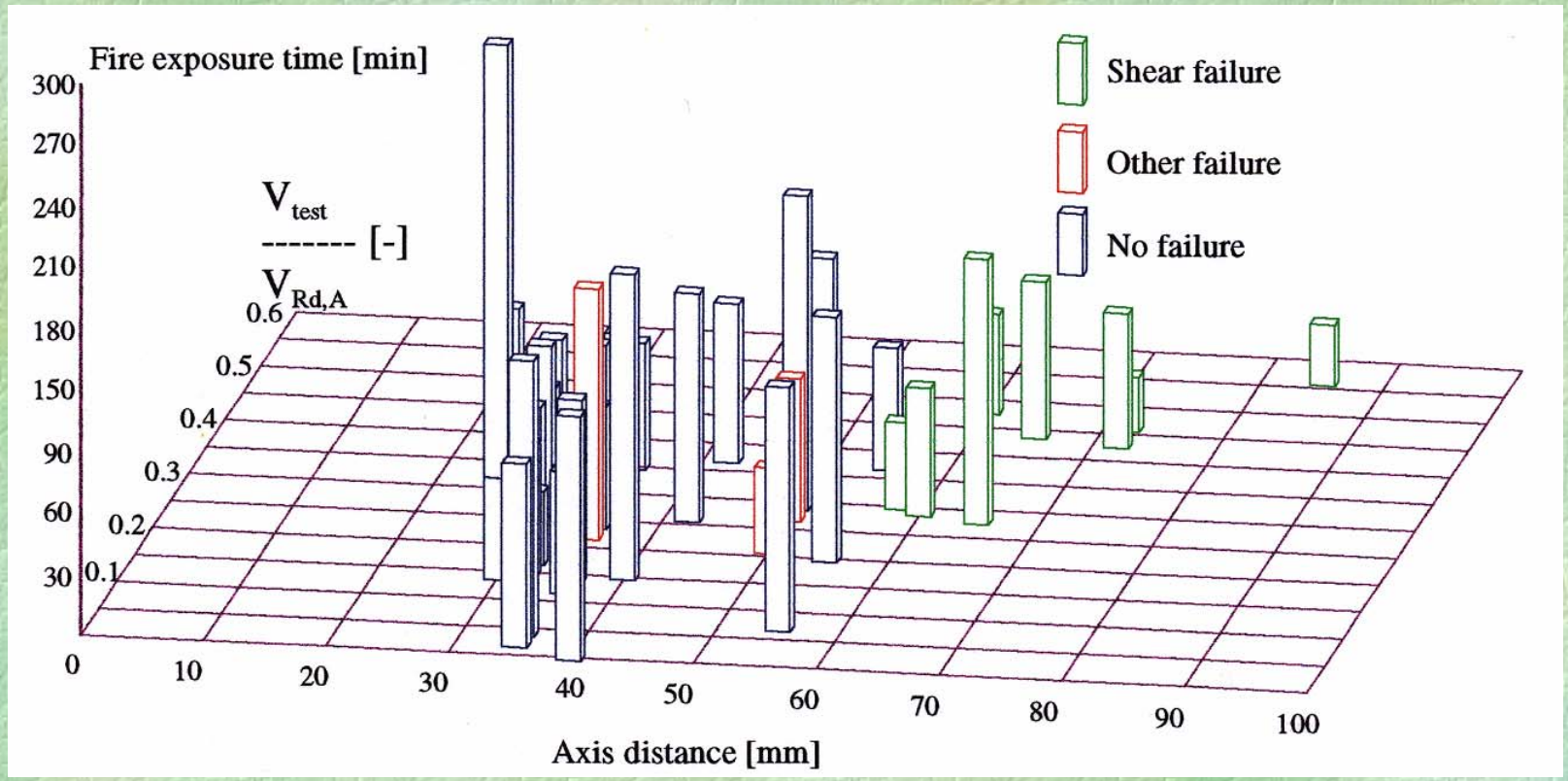




Tested units:	A 200	VBI slipform	B55	calcareous
	X 200	Spanbeton extrusion	B65	calcareous
	XB 200	Spanbeton		
	VX 265	Spanbeton		
	HVP 260	BetonSon extrusion	B65	Siliceous
	K 400	Dycore extrusion	B65	Siliceous

Research Fellinger TNO

- **Analysis existing HC test reports**



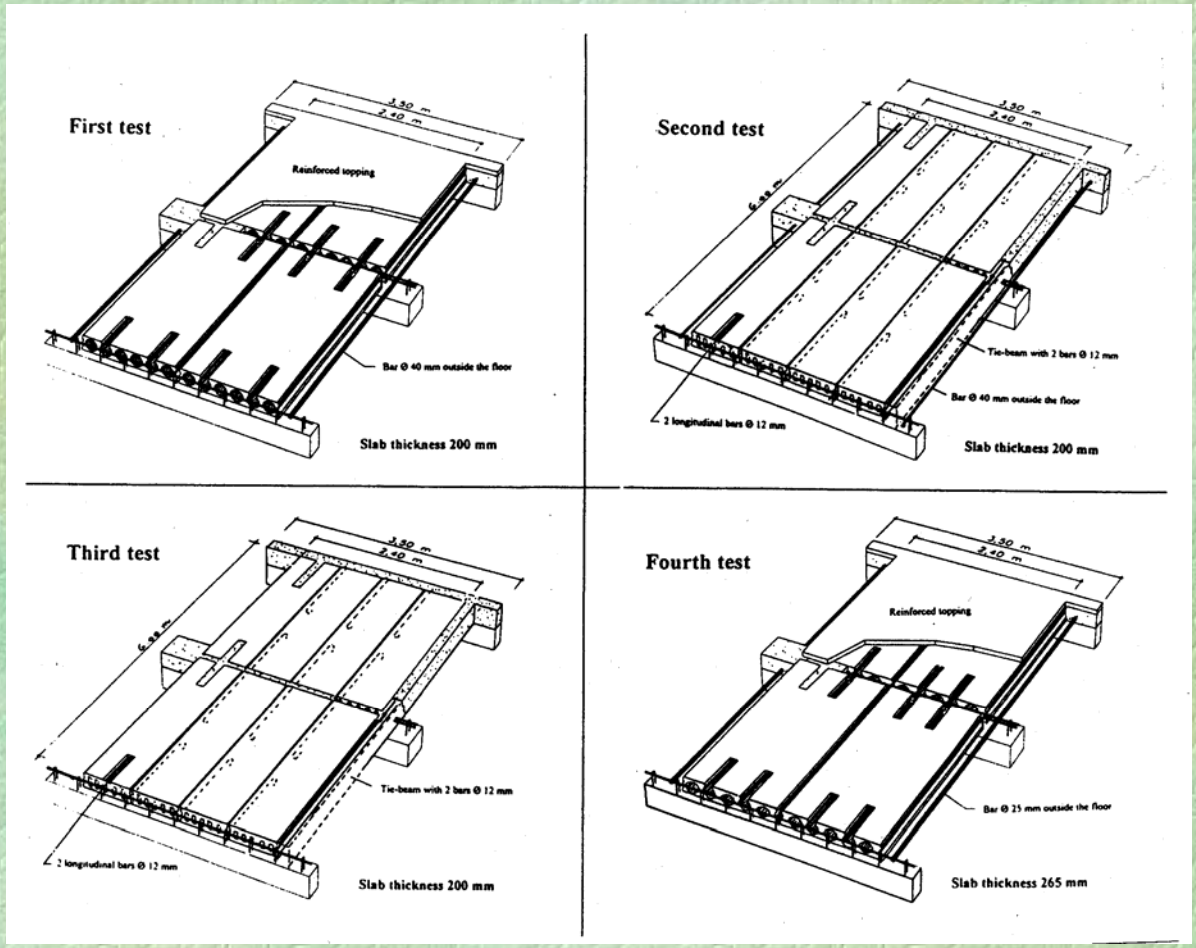
Influence axis distance and load factor on failure type

Test results TNO

Web	A200	loading:	22%	Rf :	96 min.	Failure: Anchorage
	X200		16%		125	Flexure
	XB200		18%		125	Anchorage
	XB200 Restrained		18%		159	Flexure
	VX265		23%		35	Shear-tension
	VX265		23%		25	Long. shear
	HVP260		23%		55	Shear-tension
	K400		23%		60	Shear-tension
	K400 Restrained		23%		30	Shear-tension
	K400 Filled Cores		23%		24	Shear-tension
Slab	XB200 filled cores		23%		117	Flexure
	K400		23%		33	Shear-tension
	VX265		23%		33	Shear-tension
	HVP260		23%		40	Anchorage
	HVP260		23%		42	Shear-tension
	HVP 260		23%		39	Shear-tension

Research shear resistance HC

❑ Programme carried out in Belgium



Loading: 100 kN

Test results:

T1: 83’ no failure

T2: 120’ no failure

T3: 120’ no failure

T4: 120’ no failure

Failure loading after tests:

T1 : 178/254 kN - bending

T2 : 292/324 kn - Bending

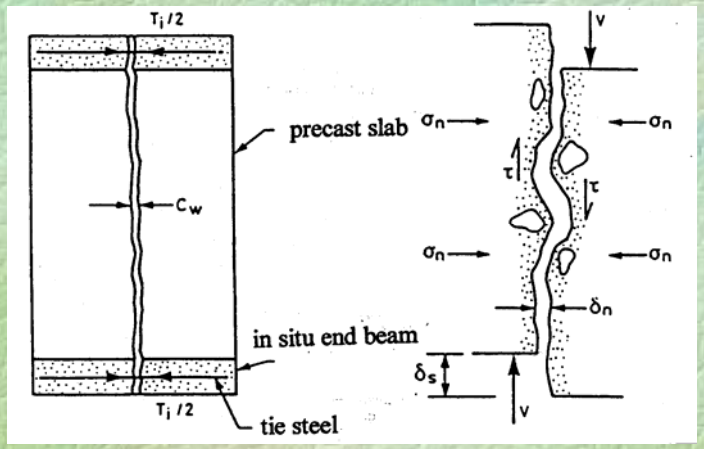
T3 : 267/254 kN - bending

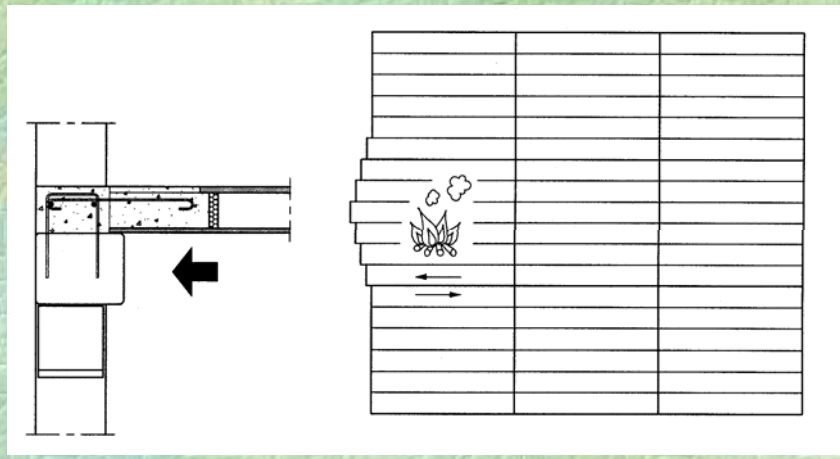
T4 : 305 kN - bending

305 kN - shear

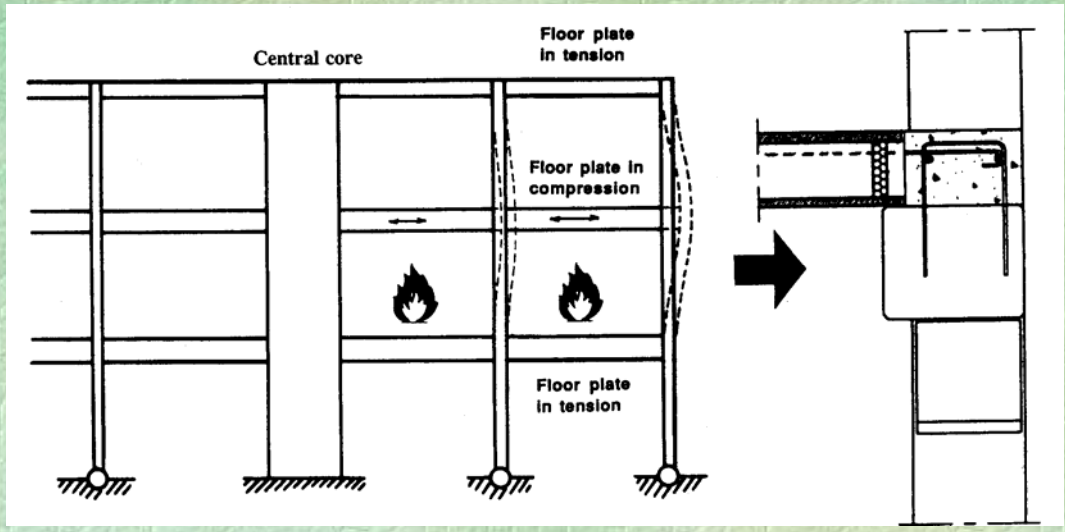
Design considerations

❑ Need for adequate connections





Interlocking effect enables to take up shear forces. This can be realised by:



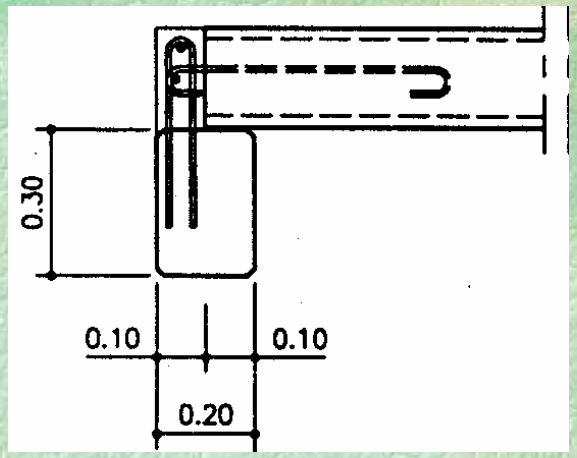
- Ties in casted open cores
- Ties in longitudinal joints
- Peripheral ties
- Reinforced topping
- Rigidity of the surrounding

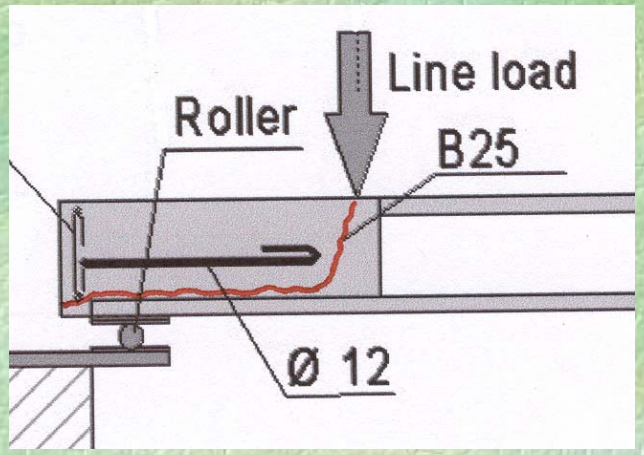
Open questions

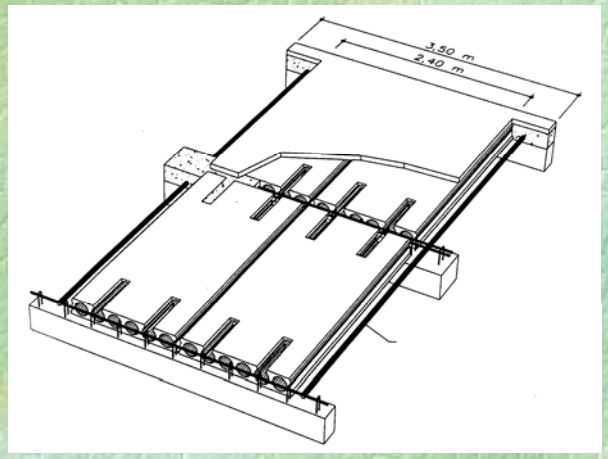
- Influence load percentage
- Fire resistance HC with non rigid supports
- Strategy to be followed by IPHA
  - ⇨ Dissemination existing knowledge
  - ⇨ Harmonisation national test procedures
  - ⇨ New specific test prescription in EN 1168 (longitudinal bars or concrete frame)
  - ⇨ etc.

Practical instructions for tests

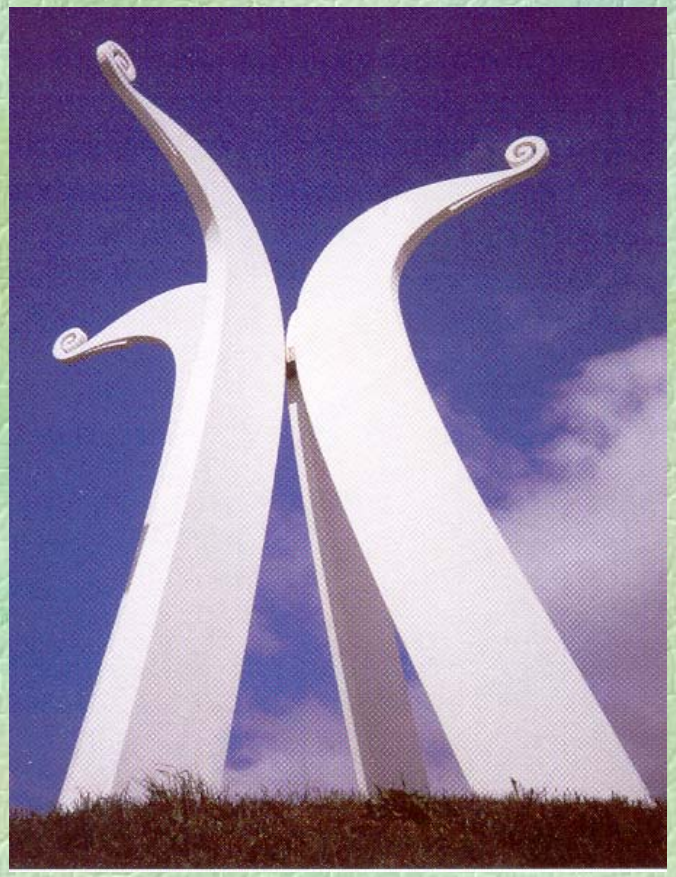
- Never perform tests on single slabs without connections
- The test unit should be composed of more than one slab
- The slabs should be connected to supporting beams
- Provide tie-bars in the longitudinal joints or in open casted cores
- Keep the moisture content of the unit below 2.5% by drying
- Simulate the restraining effect of the surrounding structure, e.g.by longitudinal bars along the edges of the test unit
- The topping should contain only longitudinal bars, since transverse bars will cause horizontal splitting of the slab.
- The test load should not be larger than 50% of the variable load at room temperature.







Hollow core floors: safe in fire



Thank you for
your kind attention