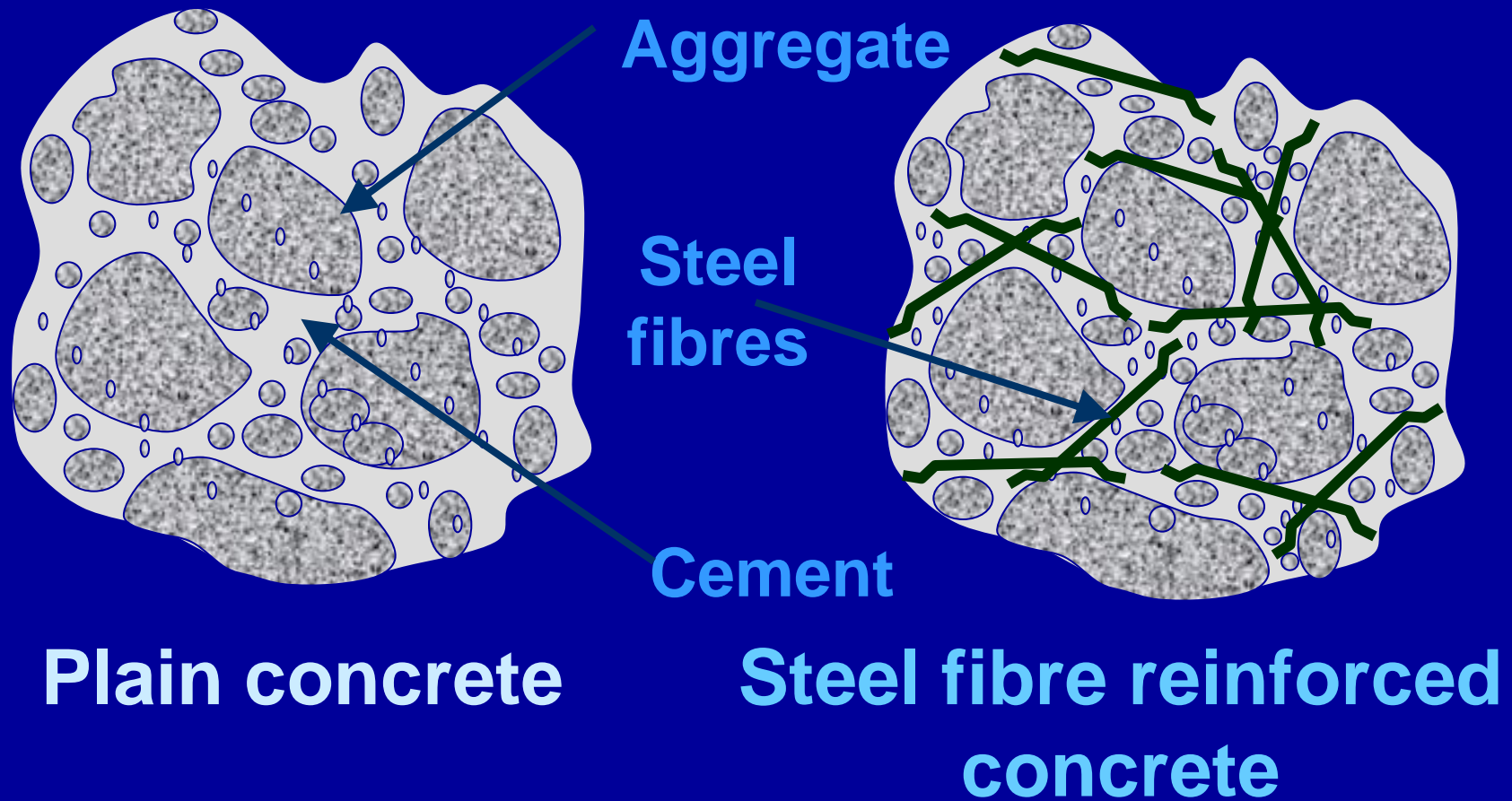


Steel fibres to improve structural performance of reinforced concrete members

Ass. Prof. I. KOVÁCS
University of Debrecen
Hungary

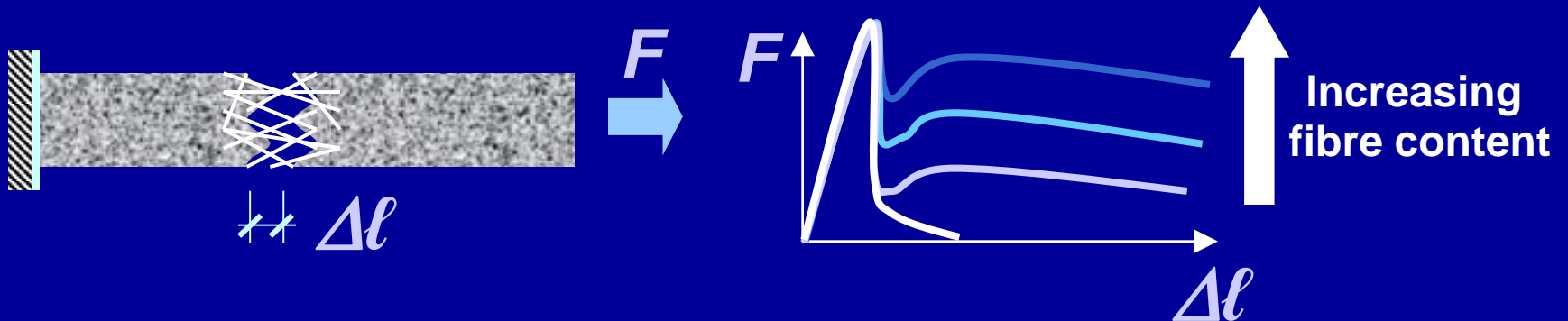
Prof. Gy. L. BALÁZS
University of Technology and
Economics Budapest
Hungary

Steel fibre reinforced concrete

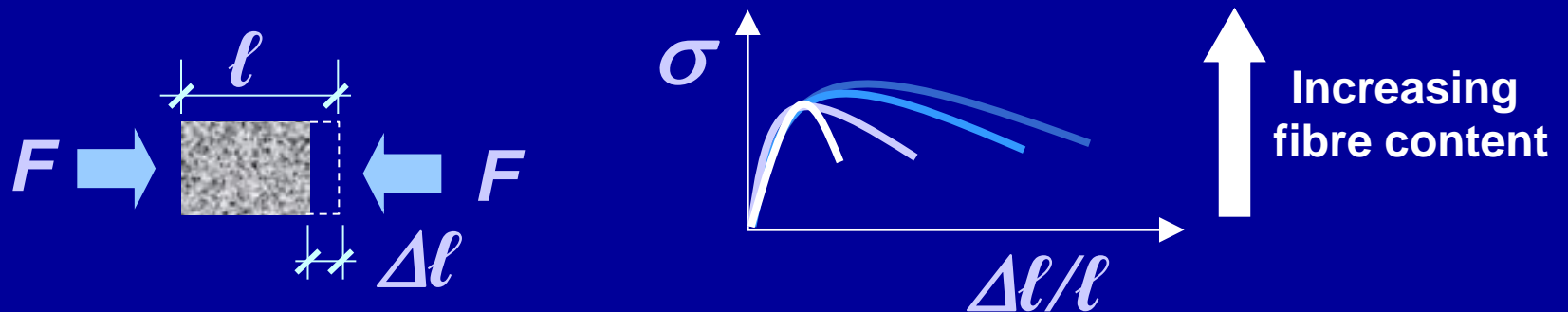


Observations

Tension

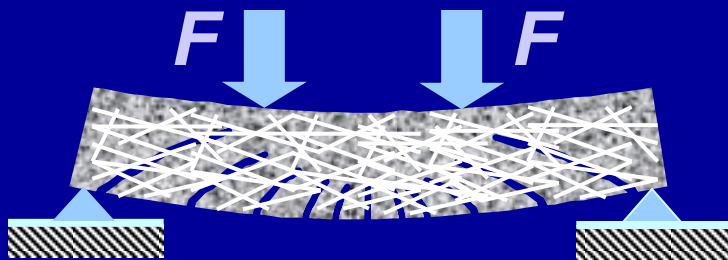


Compression

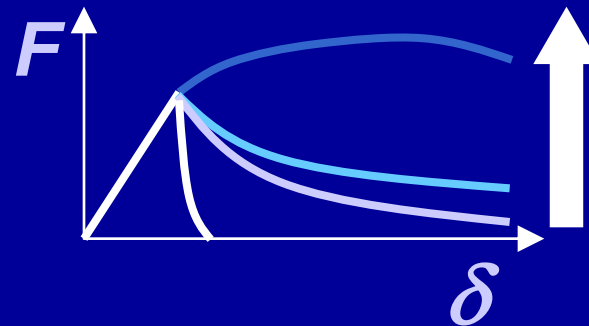


Observations

Bending

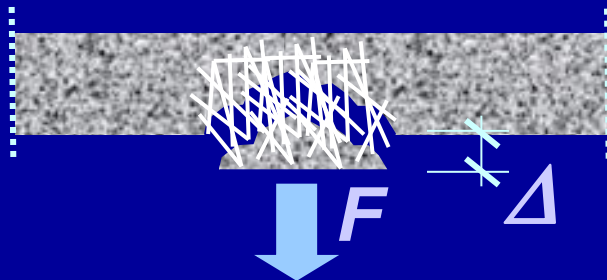


δ

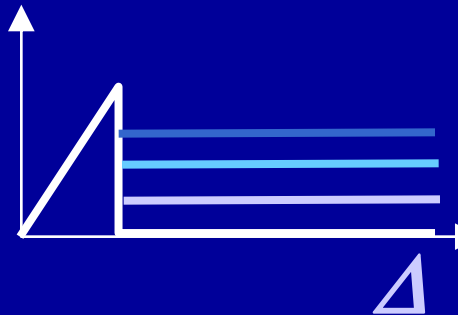


Increasing fibre content

Effect of local force



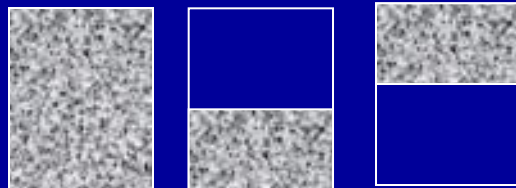
F



Increasing fibre content

Use of SFRC in a cross section

Steel fibre reinforcement in concrete members



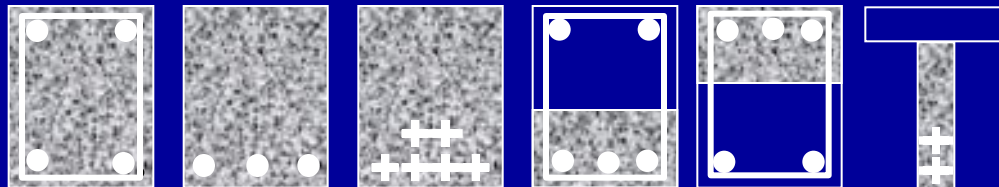
□ Concrete

■ Fibre reinforced concrete

● Reinforcing bar

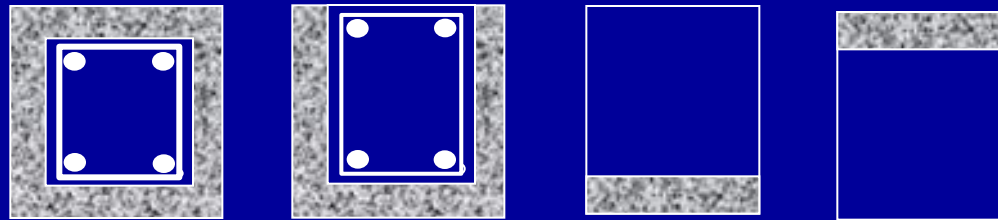
+ Prestressing

Steel fibre reinforcement in reinforced concrete and prestressed concrete members

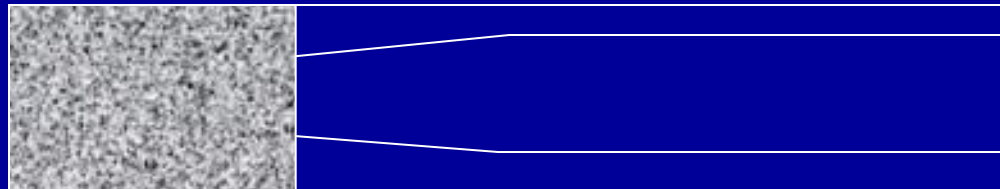


Use of SFRC in a cross section

Steel fibre reinforcement in repair and strengthening of concrete members

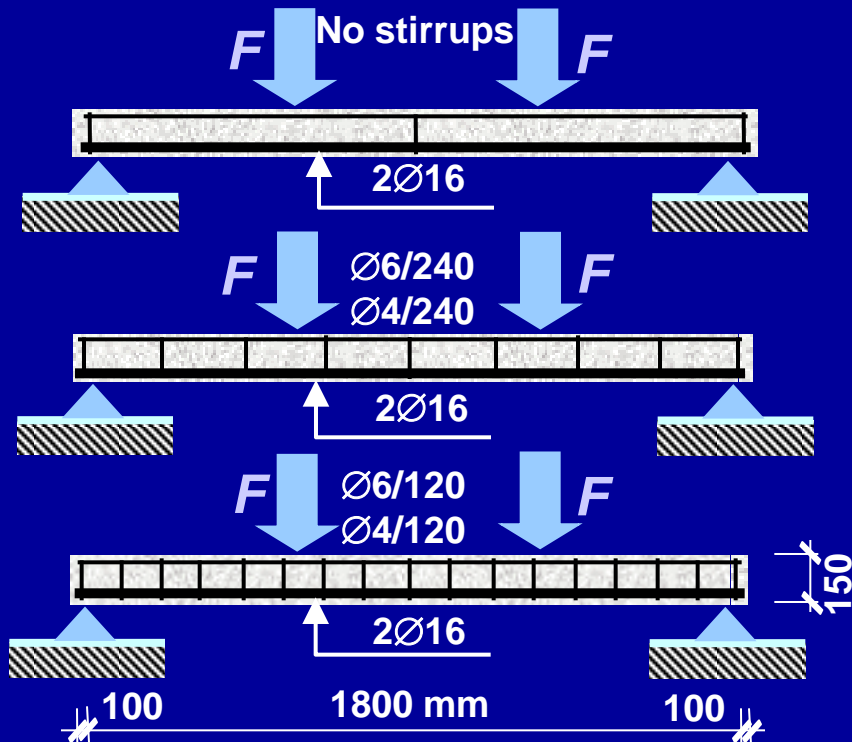


Steel fibre reinforcement in the end block region of prestressed member



Series of reinforced concrete beams

Reinforcing details

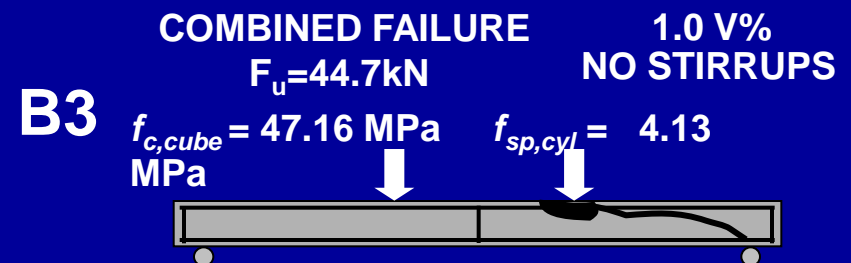
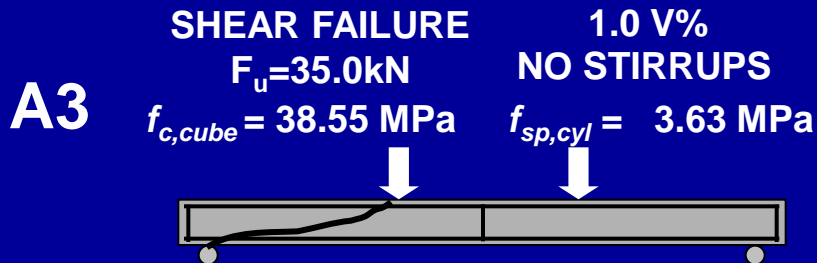
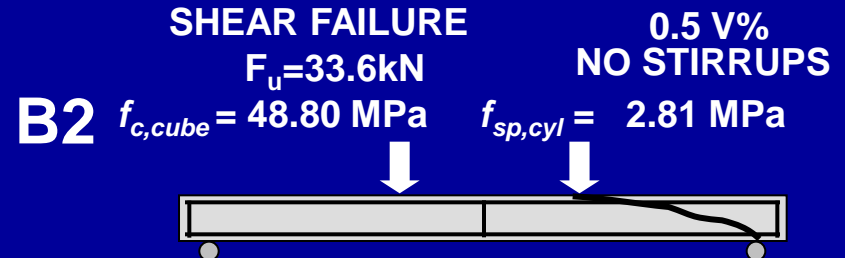
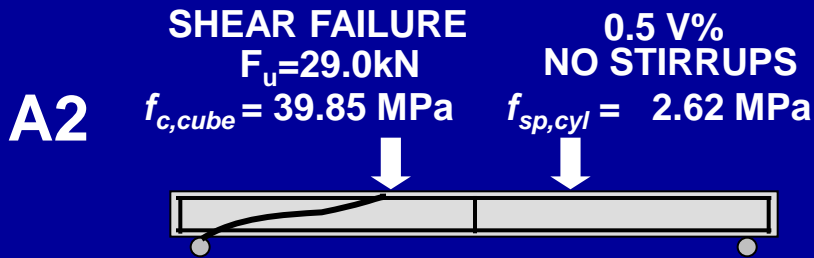
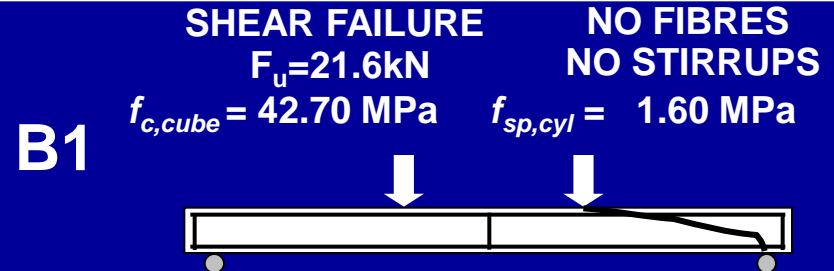
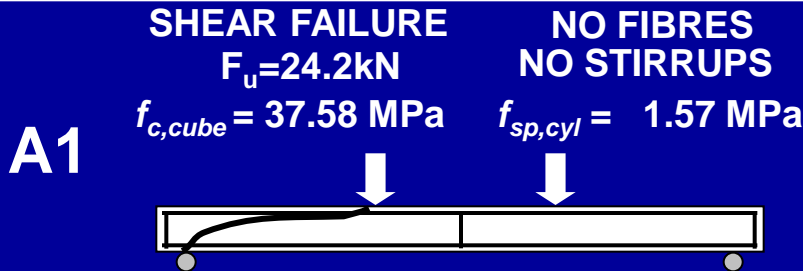


Hooked-end steel fibres	0 V%	0.5 V%	1.0 V%
No stirrups	A1	A2	A3
$\text{Ø}6/240$	A4	A5	A6
$\text{Ø}6/120$	A7	A8	A9
Crimped steel fibres	0 V%	0.5 V%	1.0 V%
No stirrups	B1	B2	B3
$\text{Ø}4/240$	B4	B5	B6
$\text{Ø}4/120$	B7	B8	B9

Failure loads and failure modes

**Hooked-end steel fibres
Dramix® ZC 30/5**

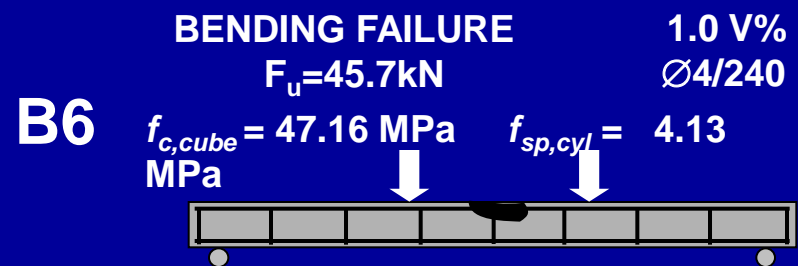
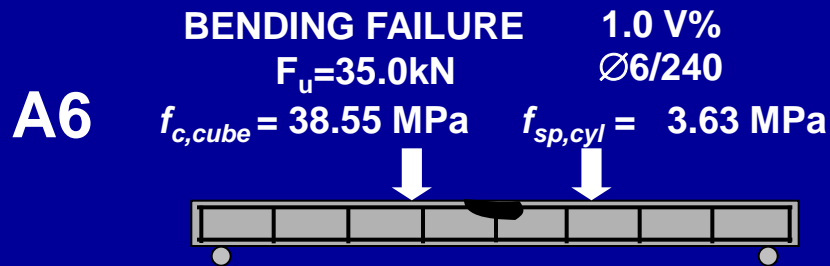
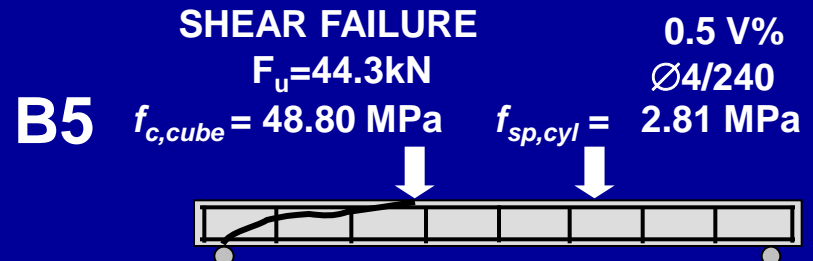
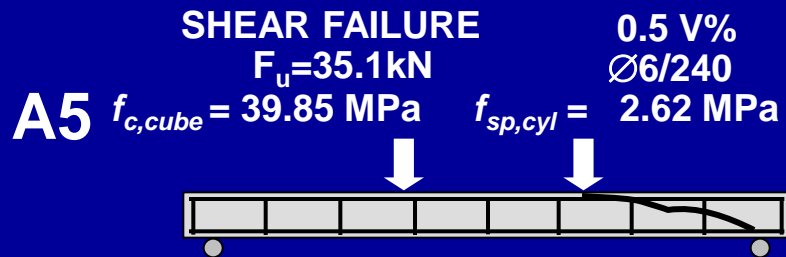
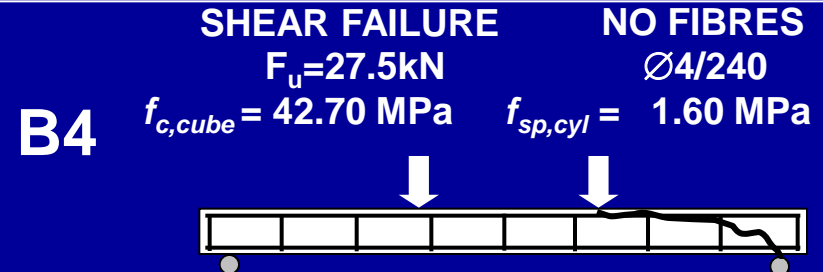
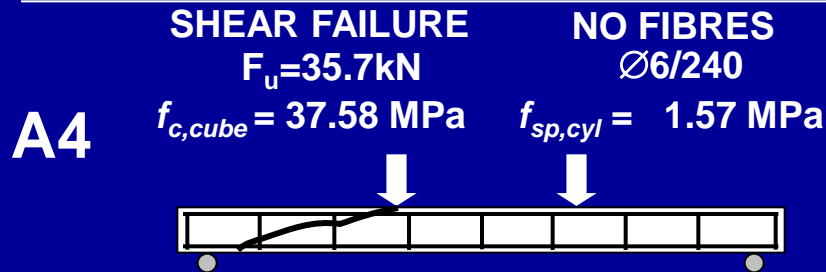
**Crimped steel fibres
D&D® ~ 30/5**



Failure loads and failure modes

**Hooked-end steel fibres
Dramix® ZC 30/5**

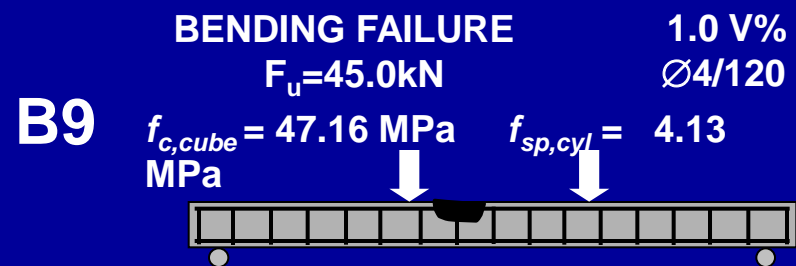
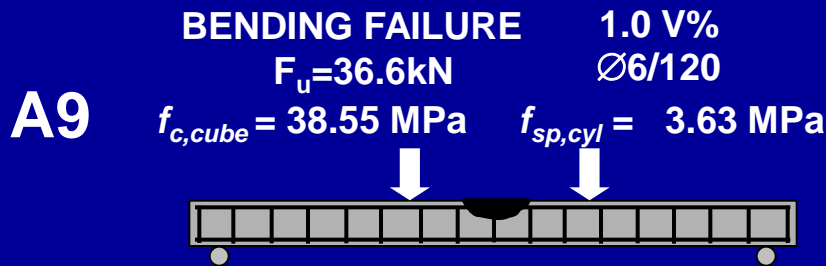
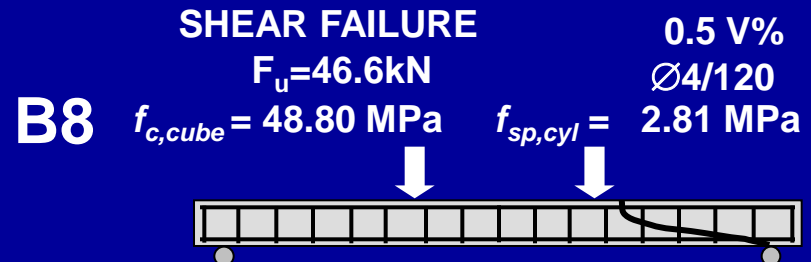
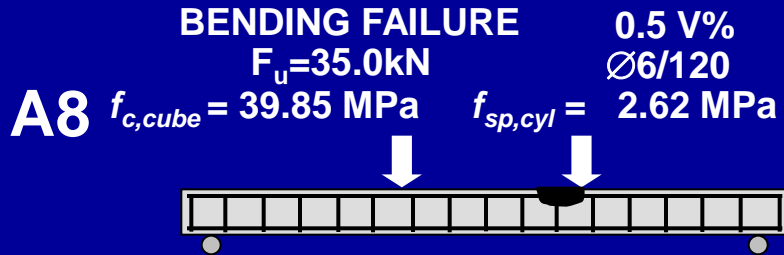
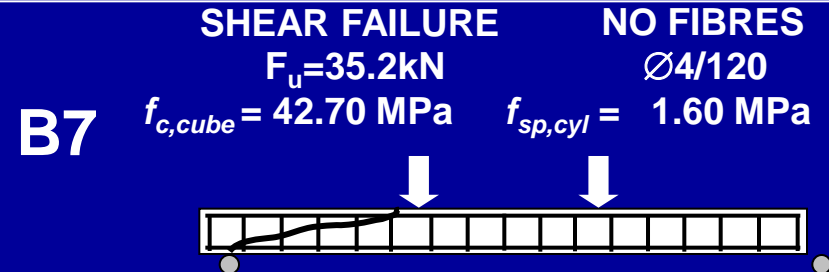
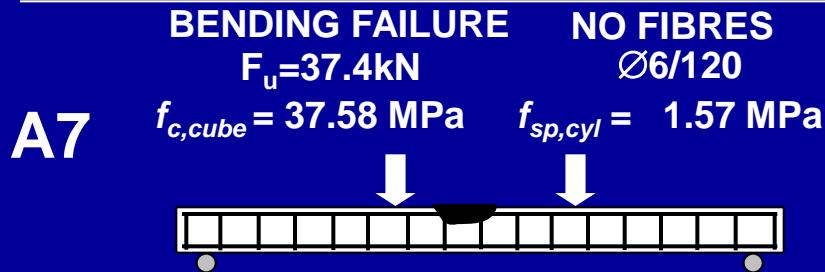
**Crimped steel fibres
D&D® ~ 30/5**



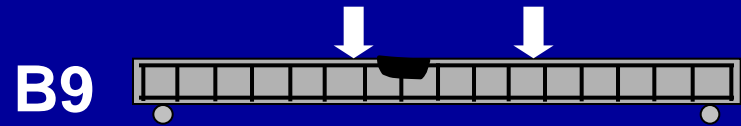
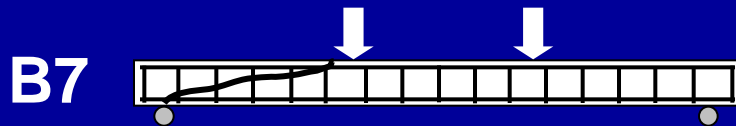
Failure loads and failure modes

**Hooked-end steel fibres
Dramix® ZC 30/5**

**Crimped steel fibres
D&D® ~ 30/5**

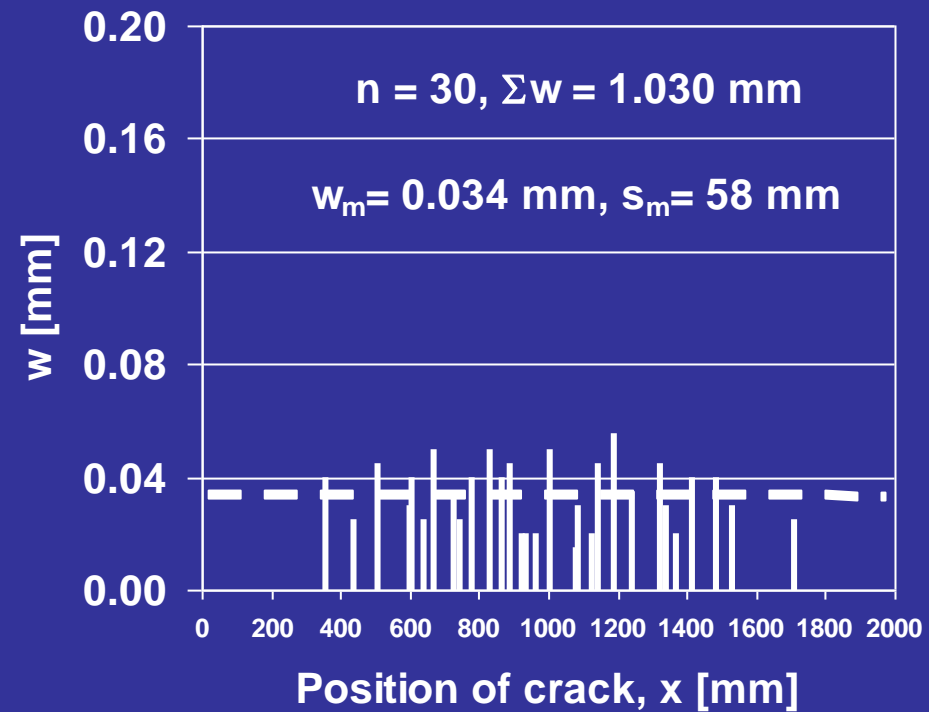
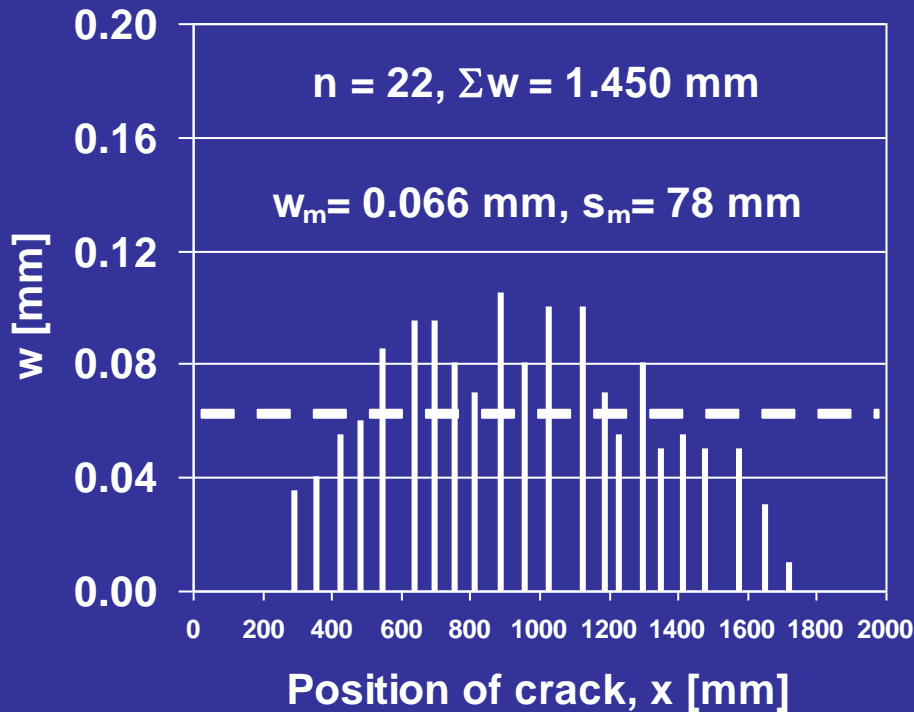


Crack development

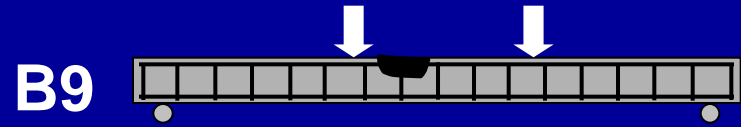
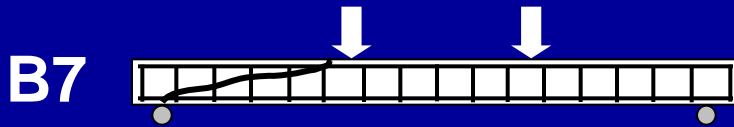


20kN - RC-B7 - $\phi 4/120$ - 0V% D&D® 30/5

20kN - RC-B9 - $\phi 4/120$ - 1.0V% D&D® 30/5

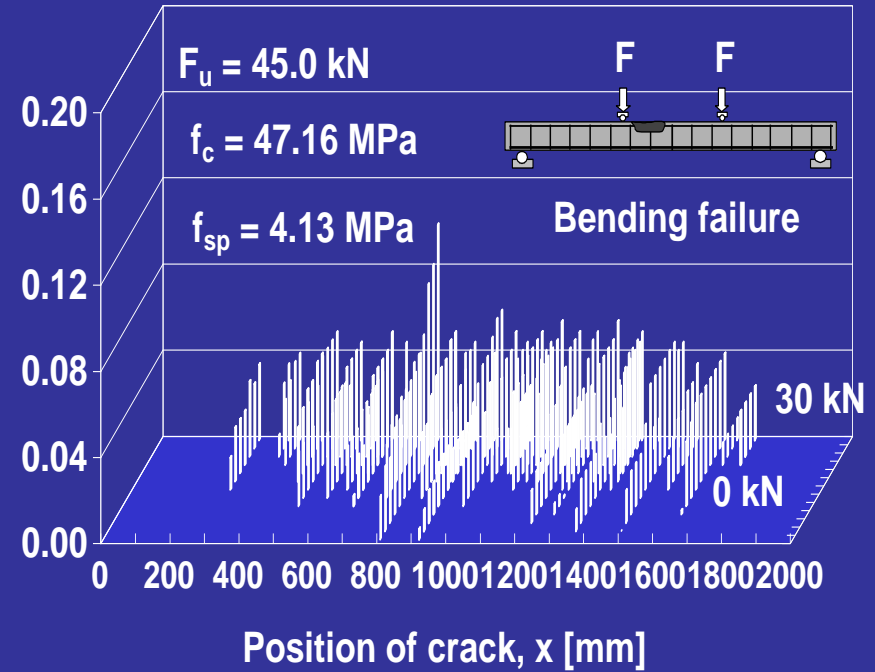
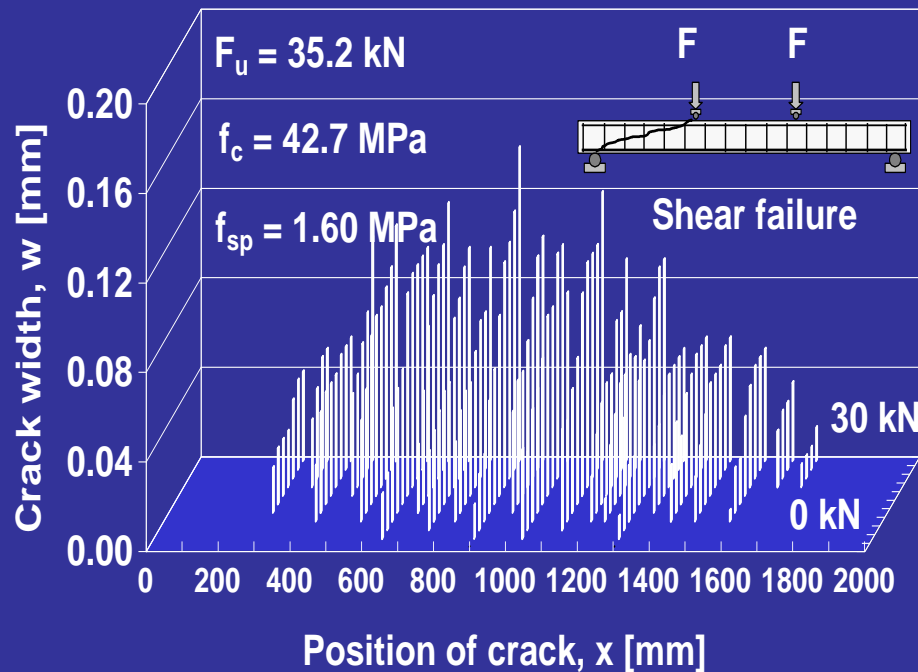


Crack development



RC-B7 - $\phi 4/120$ - 0 V% D&D[®] 30/5

RC-B9 - $\phi 4/120$ - 1.0 V% D&D[®] 30/5



Proposal for crack spacing

Plain concrete

$$s_{rm} = 50 + 0.25k_1k_2 \frac{\emptyset}{\rho_r}$$

0.5 V% steel fibre content

$$s_{rm} = 45 + 0.25k_1k_2 \frac{\emptyset}{\rho_r}$$

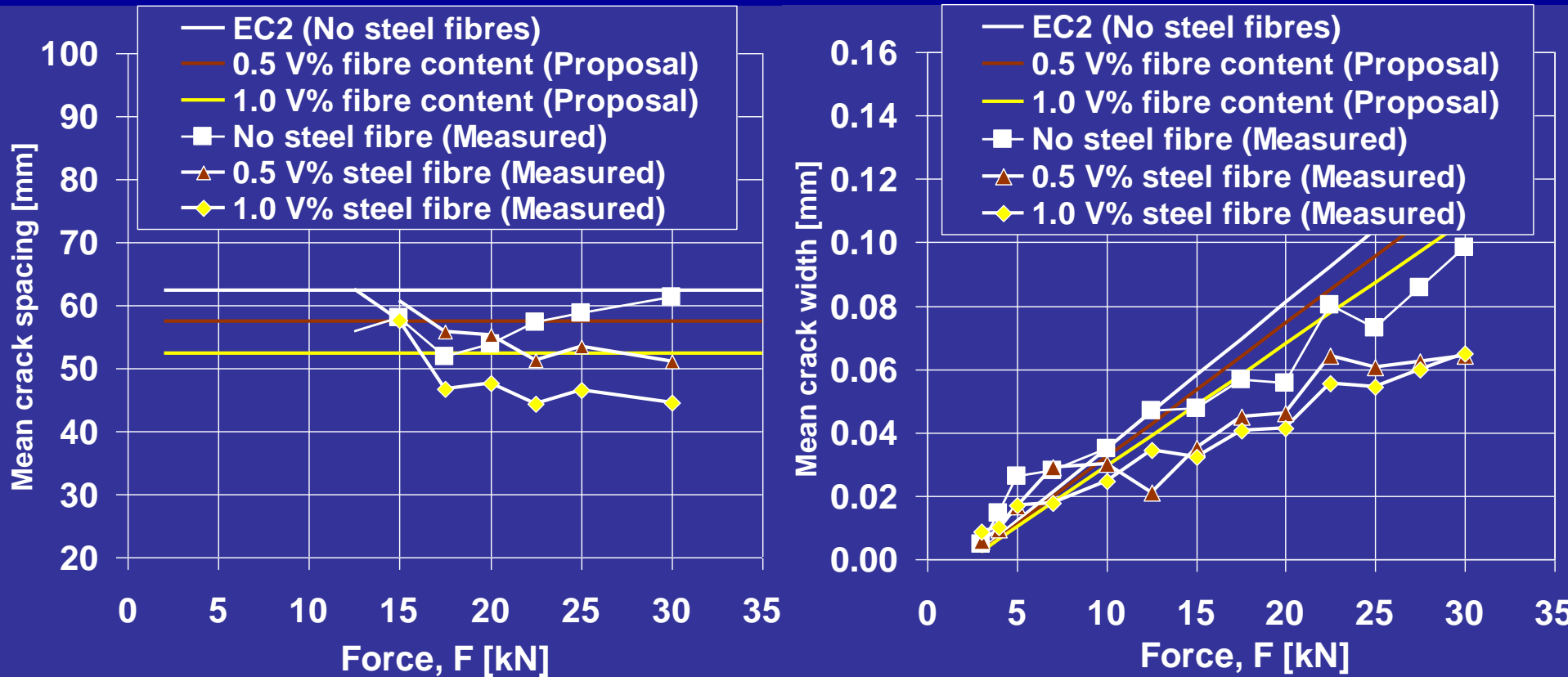
1.0 V% steel fibre content

$$s_{rm} = 40 + 0.25k_1k_2 \frac{\emptyset}{\rho_r}$$

Crack width

$$w_k = \beta s_{rm} \varepsilon_{sm}$$

Crack spacing and crack width



Conclusions

Failure modes and failure loads

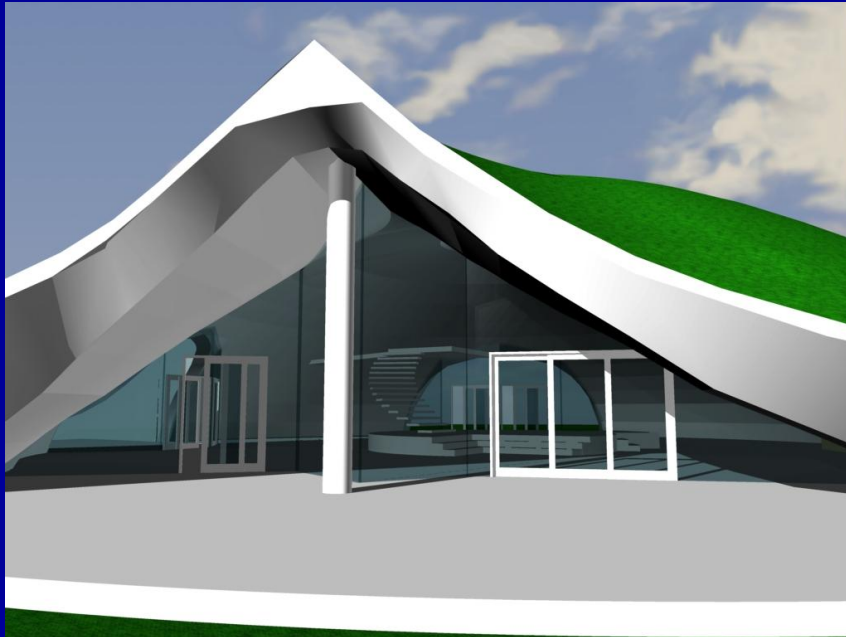
- 1) Steel fibre reinforcement can effectively be used to improve shear capacity of plain concrete in beams made with no stirrup reinforcement.**
- 2) If reinforced concrete beams contain the required amount of conventional shear reinforcement, hence fail in bending, the addition of fibre does not considerably increase the failure load.**
- 3) With sufficient amount of fibres the failure mode could be changed from shear failure to bending failure.**
- 4) Steel fibres do not only increase shear capacity but also provide substantial post-peak resistance and ductility in conventional reinforced concrete members**

Conclusions

Cracking behaviour

- 1. Steel fibres in concrete beams provide uniformly distributed cracks.**
- 2. More cracks developed in beams containing steel fibres than in case of beams made of plain concrete and consequently smaller crack spacing was observed.**
- 3. Significant reduction of average crack width was observed by the use of steel fibres.**
- 4. Cracking characteristics was not significantly effected by the type of fibre.**
- 5. A modification to the crack spacing formula by EC2 was developed in order to consider the effect of steel fibres.**

Structural application of model

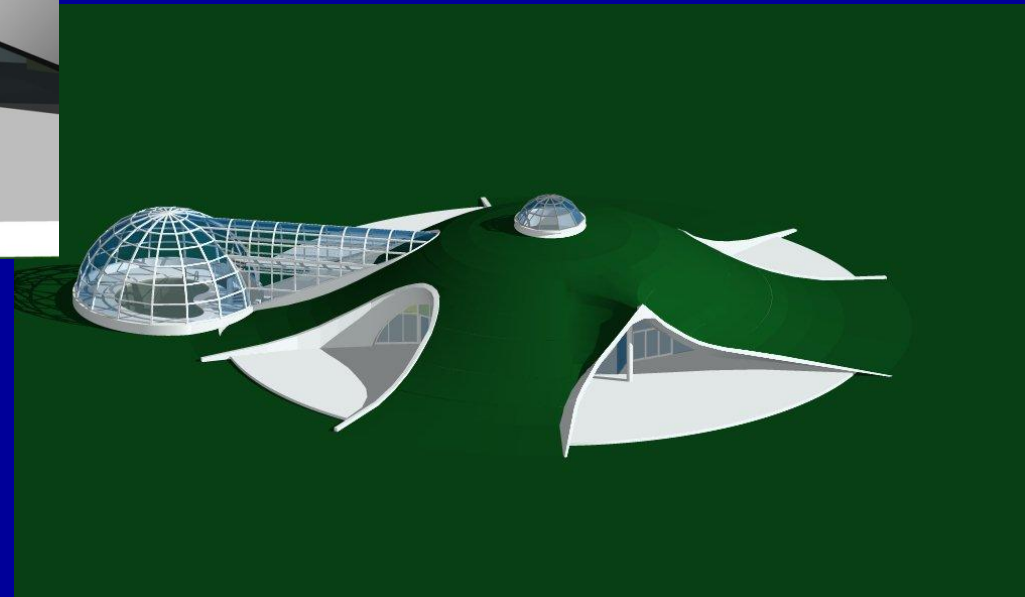


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Imre KOVÁCS PhD structural engineer



Steel fibres to improve structural performance of reinforced concrete members

THANK YOU FOR YOUR KIND ATTENTION!

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