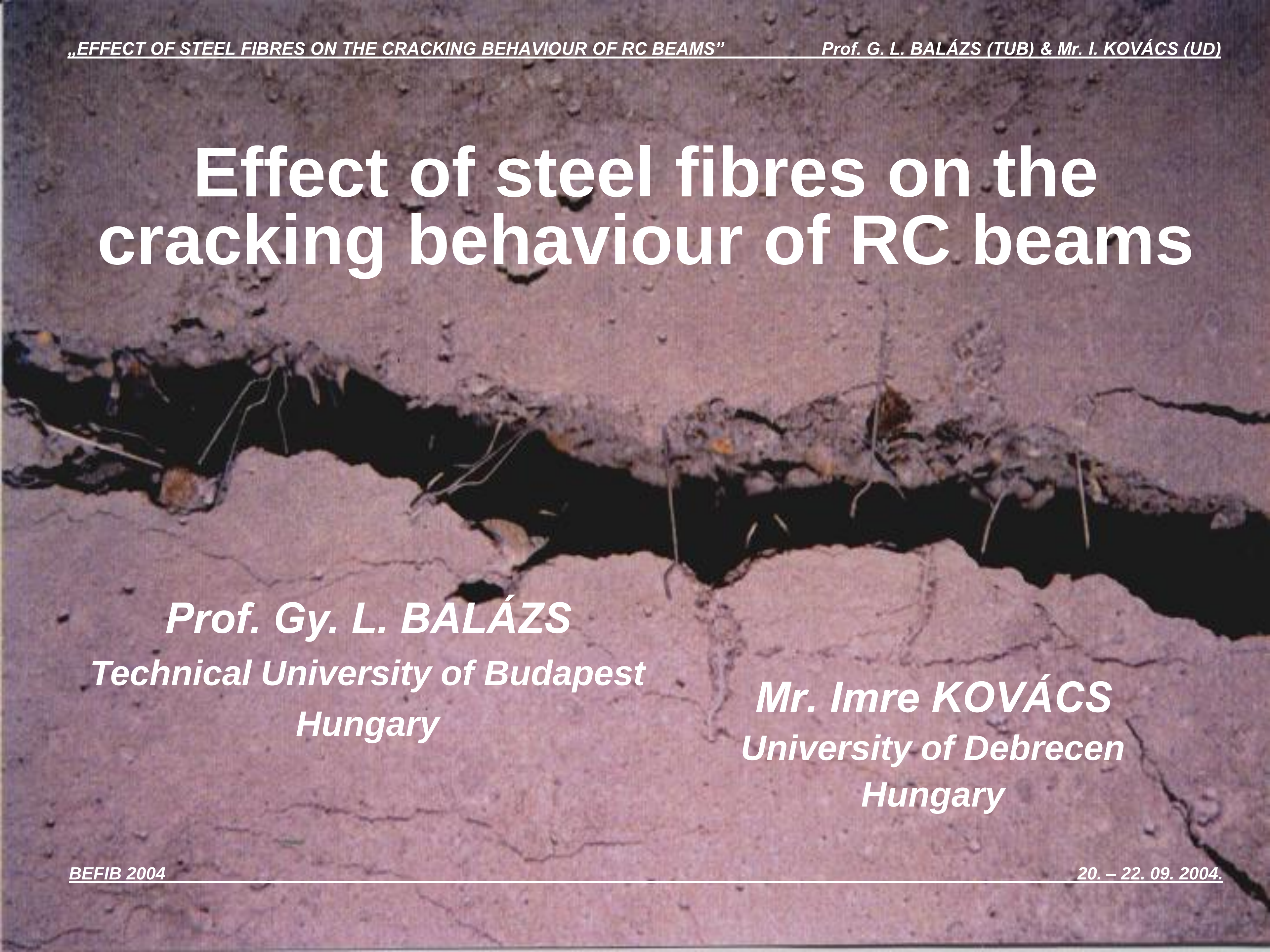

Effect of steel fibres on the cracking behaviour of RC beams

Prof. Gy. L. BALÁZS
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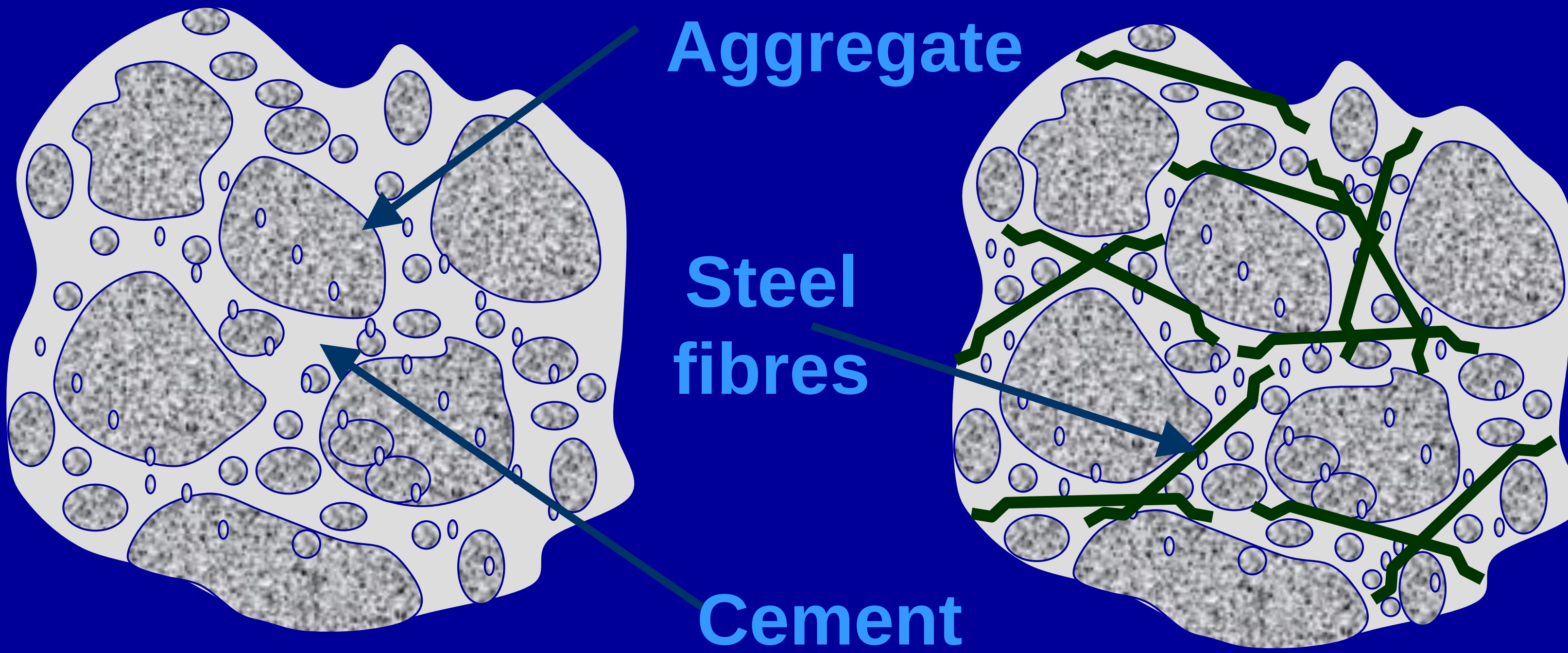
Steel fibre reinforced concrete

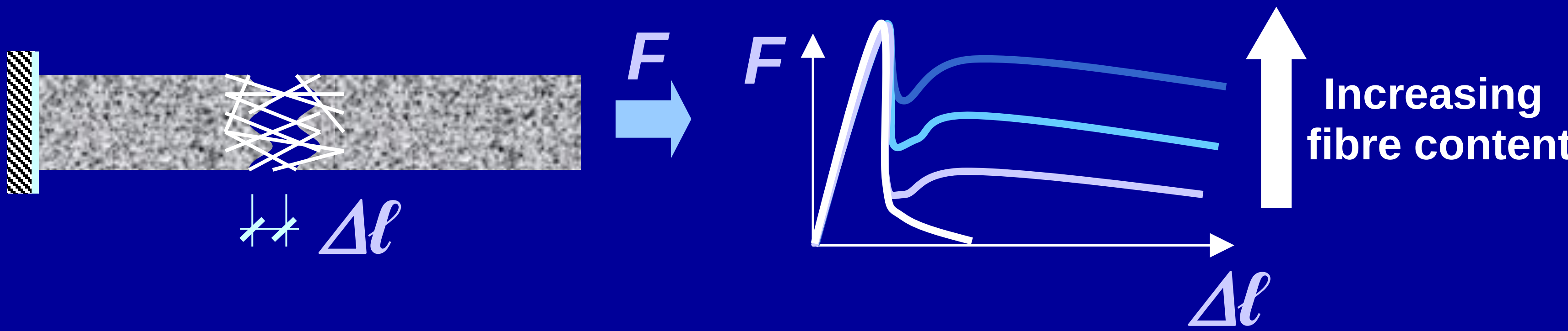


Plain concrete

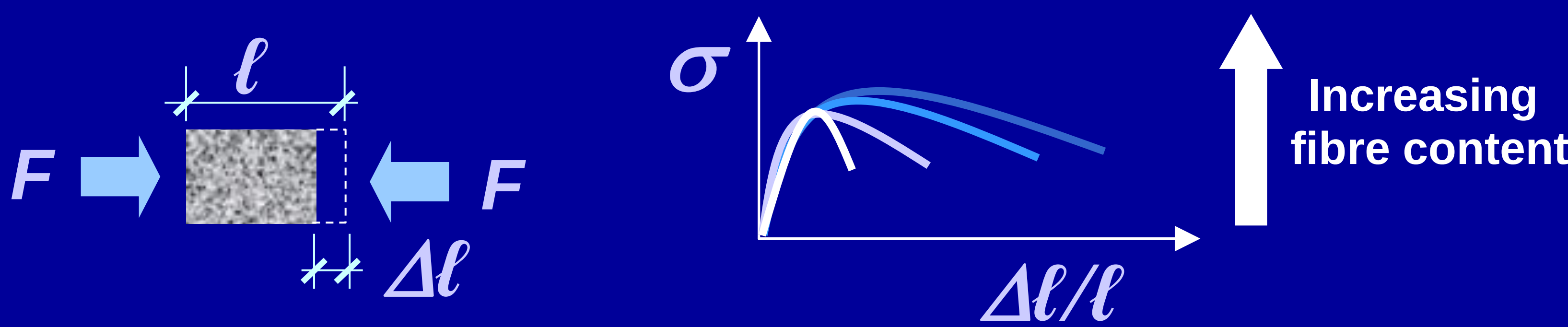
Steel fibre reinforced concrete

Observations

Tension

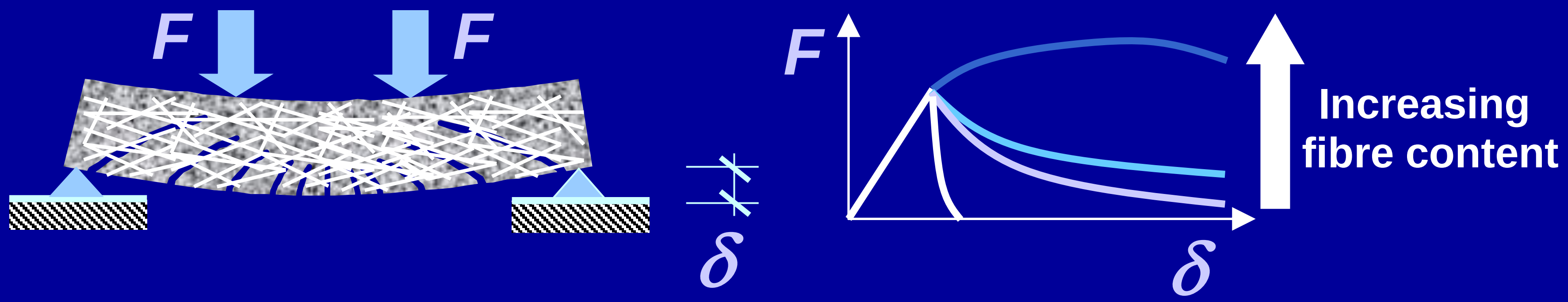


Compression

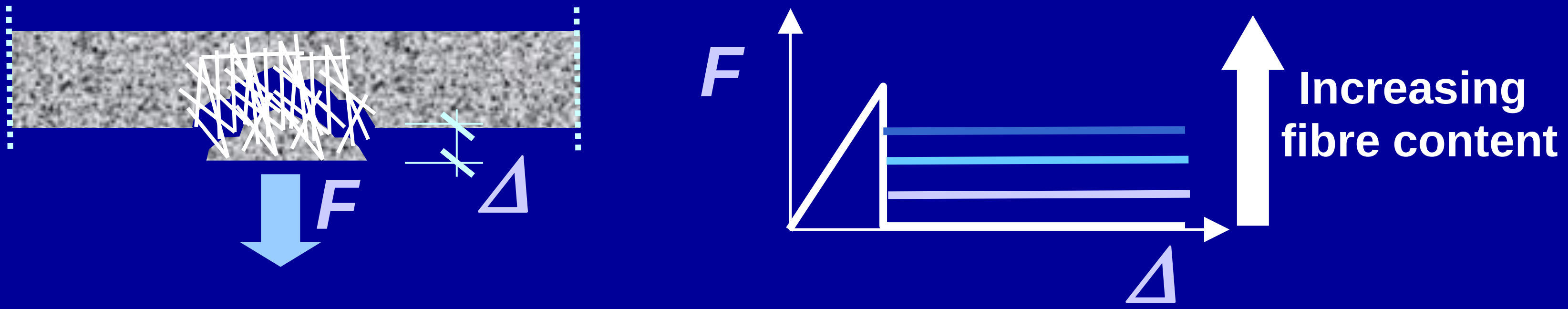


Observations

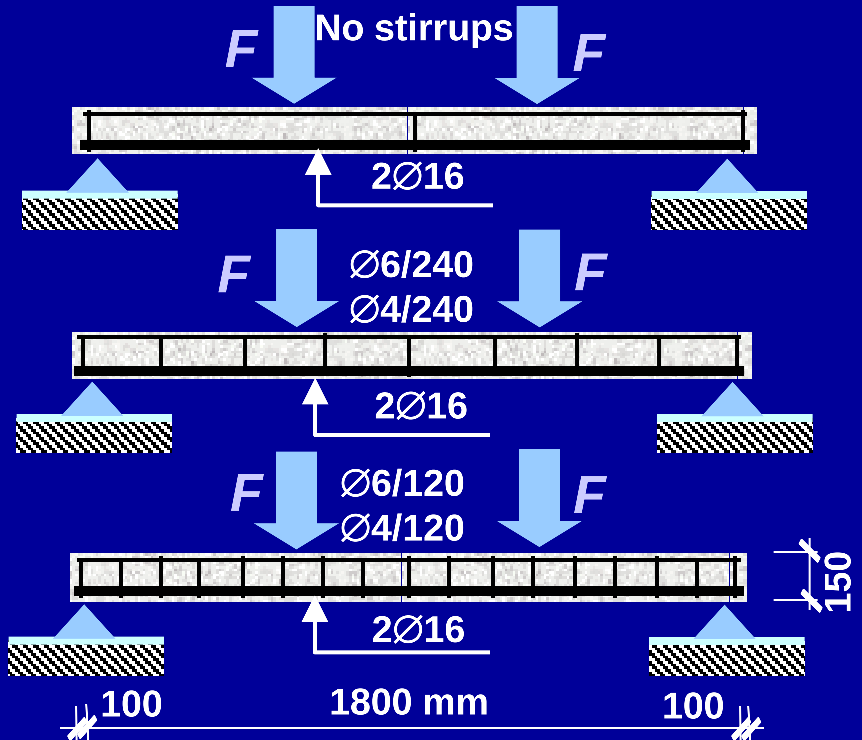
Bending



Effect of local force



RC beam tests



Hooked-end steel fibres	0 V%	0.5 V%	1.0 V%
No stirrups	A1	A2	A3
∅6/240	A4	A5	A6
∅6/120	A7	A8	A9

Crimped steel fibres	0 V%	0.5 V%	1.0 V%
No stirrups	B1	B2	B3
∅4/240	B4	B5	B6
∅4/120	B7	B8	B9

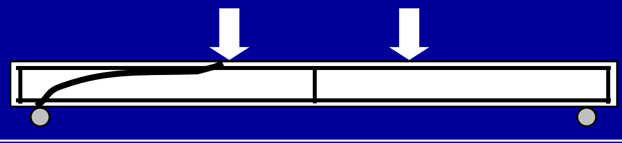
Failure loads and failure modes

Hooked-end steel fibres Dramix® ZC 30/.5	Crimped steel fibres D&D® ~ 30/.5

A1

SHEAR FAILURE
F_u=24.2kN
$f_{c,cube}$ = 37.58 MPa

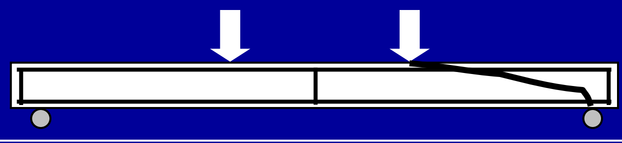
NO FIBRES
NO STIRRUPS
$f_{sp,cyl}$ = 1.57 MPa



B1

SHEAR FAILURE
F_u=21.6kN
$f_{c,cube}$ = 42.70 MPa

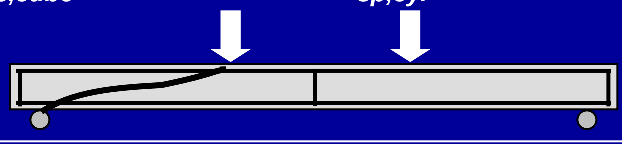
NO FIBRES
NO STIRRUPS
$f_{sp,cyl}$ = 1.60 MPa



A2

SHEAR FAILURE
F_u=29.0kN
$f_{c,cube}$ = 39.85 MPa

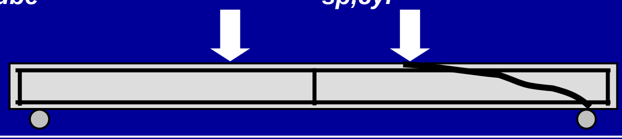
0.5 V%
NO STIRRUPS
$f_{sp,cyl}$ = 2.62 MPa



B2

SHEAR FAILURE
F_u=33.6kN
$f_{c,cube}$ = 48.80 MPa

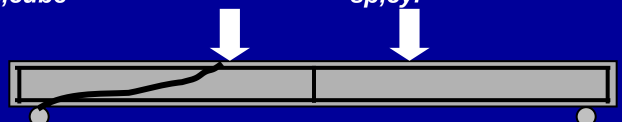
0.5 V%
NO STIRRUPS
$f_{sp,cyl}$ = 2.81 MPa



A3

SHEAR FAILURE
F_u=35.0kN
$f_{c,cube}$ = 38.55 MPa

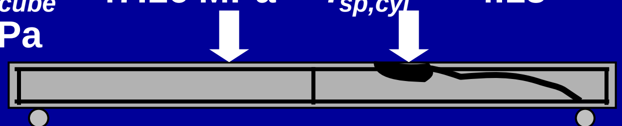
1.0 V%
NO STIRRUPS
$f_{sp,cyl}$ = 3.63 MPa



B3

COMBINED FAILURE
F_u=44.7kN
$f_{c,cube}$ = 47.16 MPa

1.0 V%
NO STIRRUPS
$f_{sp,cyl}$ = 4.13 MPa



Failure loads and failure modes

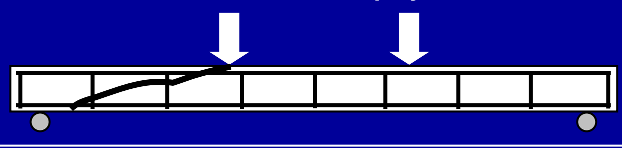
Hooked-end steel fibres
Dramix® ZC 30/.5

Crimped steel fibres
D&D® ~ 30/.5

A4

SHEAR FAILURE
F_u=35.7kN
$f_{c,cube}$ = 37.58 MPa

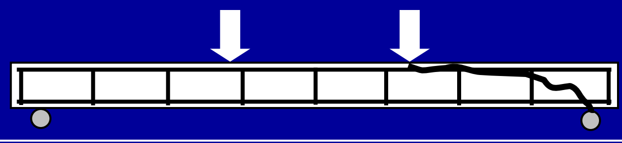
NO FIBRES
∅6/240
$f_{sp,cyl}$ = 1.57 MPa



B4

SHEAR FAILURE
F_u=27.5kN
$f_{c,cube}$ = 42.70 MPa

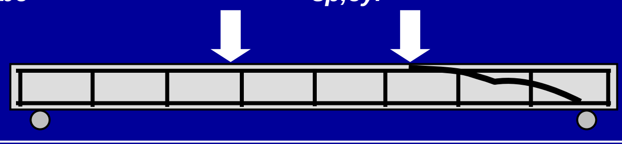
NO FIBRES
∅4/240
$f_{sp,cyl}$ = 1.60 MPa



A5

SHEAR FAILURE
F_u=35.1kN
$f_{c,cube}$ = 39.85 MPa

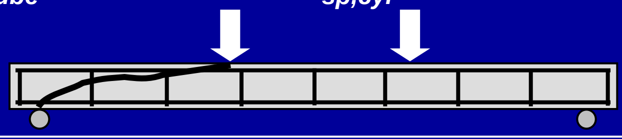
0.5 V%
∅6/240
$f_{sp,cyl}$ = 2.62 MPa



B5

SHEAR FAILURE
F_u=44.3kN
$f_{c,cube}$ = 48.80 MPa

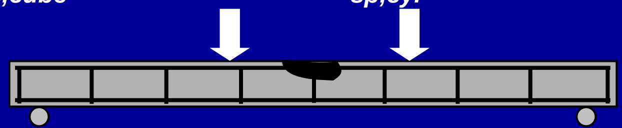
0.5 V%
∅4/240
$f_{sp,cyl}$ = 2.81 MPa



A6

BENDING FAILURE
F_u=35.0kN
$f_{c,cube}$ = 38.55 MPa

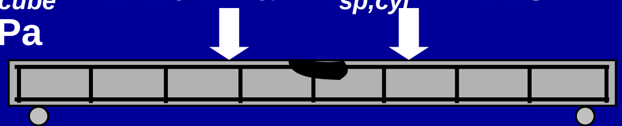
1.0 V%
∅6/240
$f_{sp,cyl}$ = 3.63 MPa



B6

BENDING FAILURE
F_u=45.7kN
$f_{c,cube}$ = 47.16 MPa

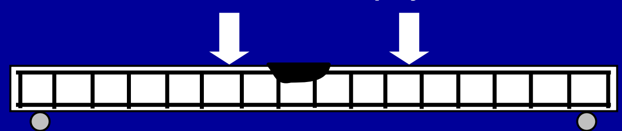
1.0 V%
∅4/240
$f_{sp,cyl}$ = 4.13
MPa



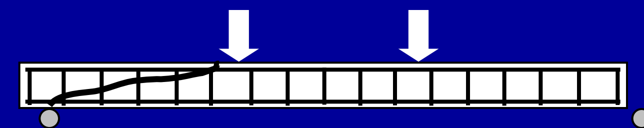
Failure loads and failure modes

Hooked-end steel fibres Dramix® ZC 30/.5	Crimped steel fibres D&D® ~ 30/.5

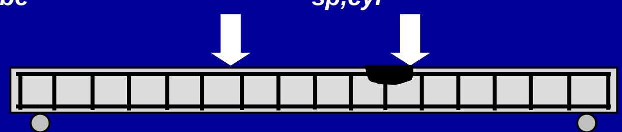
A7
BENDING FAILURE
F_u=37.4kN
NO FIBRES
∅6/120
$f_{c,cube}$ = 37.58 MPa $f_{sp,cyl}$ = 1.57 MPa



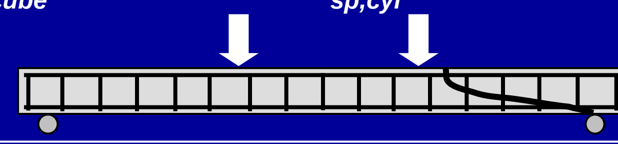
B7
SHEAR FAILURE
F_u=35.2kN
NO FIBRES
∅4/120
$f_{c,cube}$ = 42.70 MPa $f_{sp,cyl}$ = 1.60 MPa



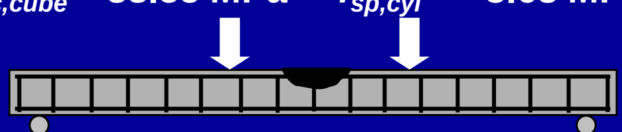
A8
BENDING FAILURE
F_u=35.0kN
0.5 V%
∅6/120
$f_{c,cube}$ = 39.85 MPa $f_{sp,cyl}$ = 2.62 MPa



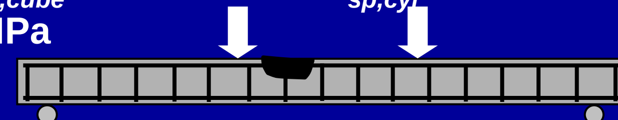
B8
SHEAR FAILURE
F_u=46.6kN
0.5 V%
∅4/120
$f_{c,cube}$ = 48.80 MPa $f_{sp,cyl}$ = 2.81 MPa



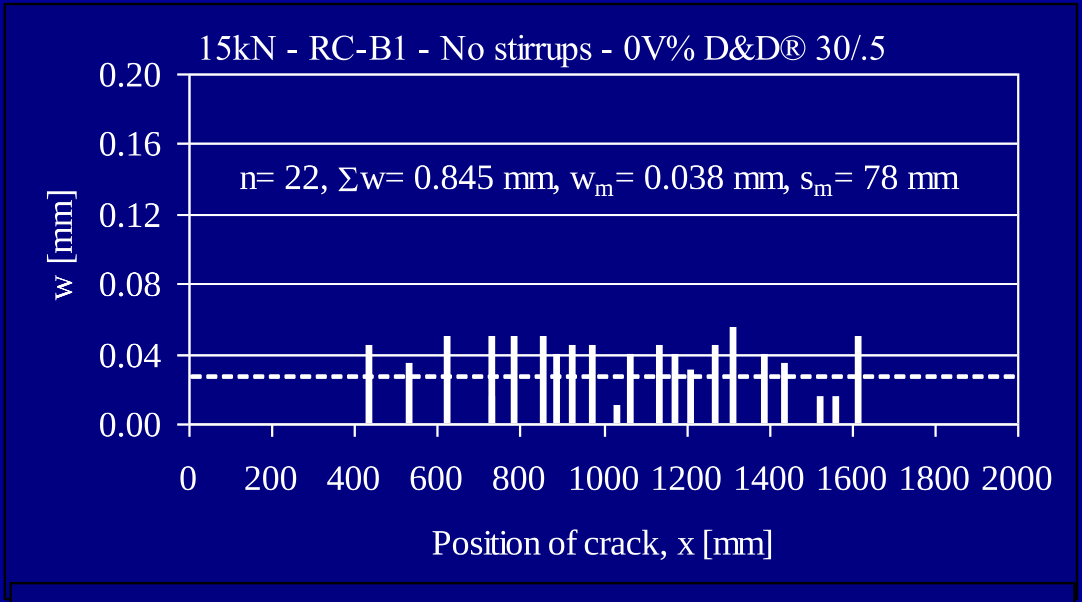
A9
BENDING FAILURE
F_u=36.6kN
1.0 V%
∅6/120
$f_{c,cube}$ = 38.55 MPa $f_{sp,cyl}$ = 3.63 MPa

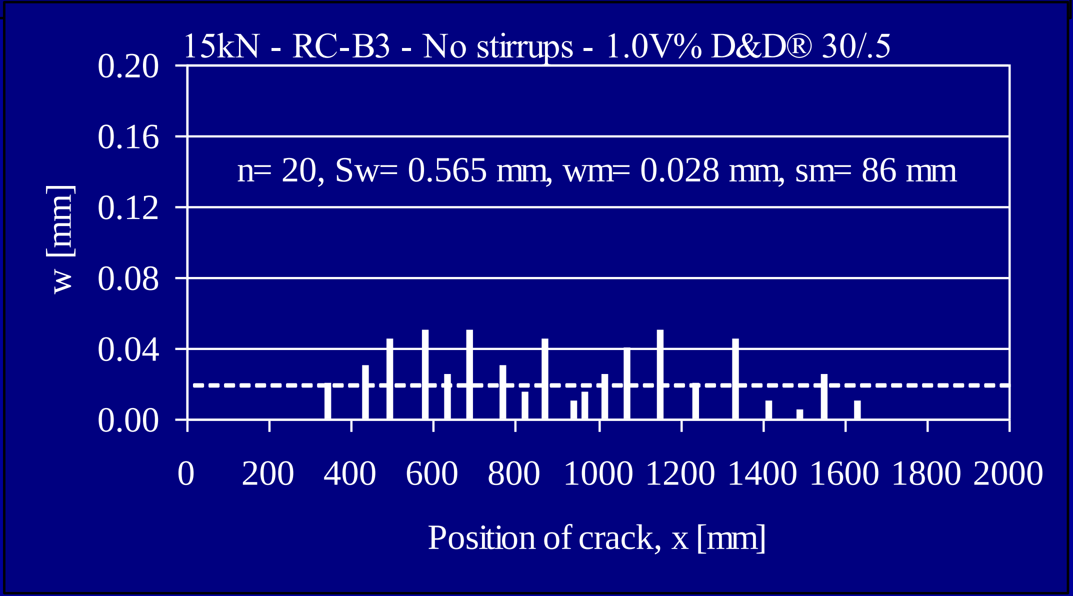


B9
BENDING FAILURE
F_u=45.0kN
1.0 V%
∅4/120
$f_{c,cube}$ = 47.16 MPa $f_{sp,cyl}$ = 4.13 MPa

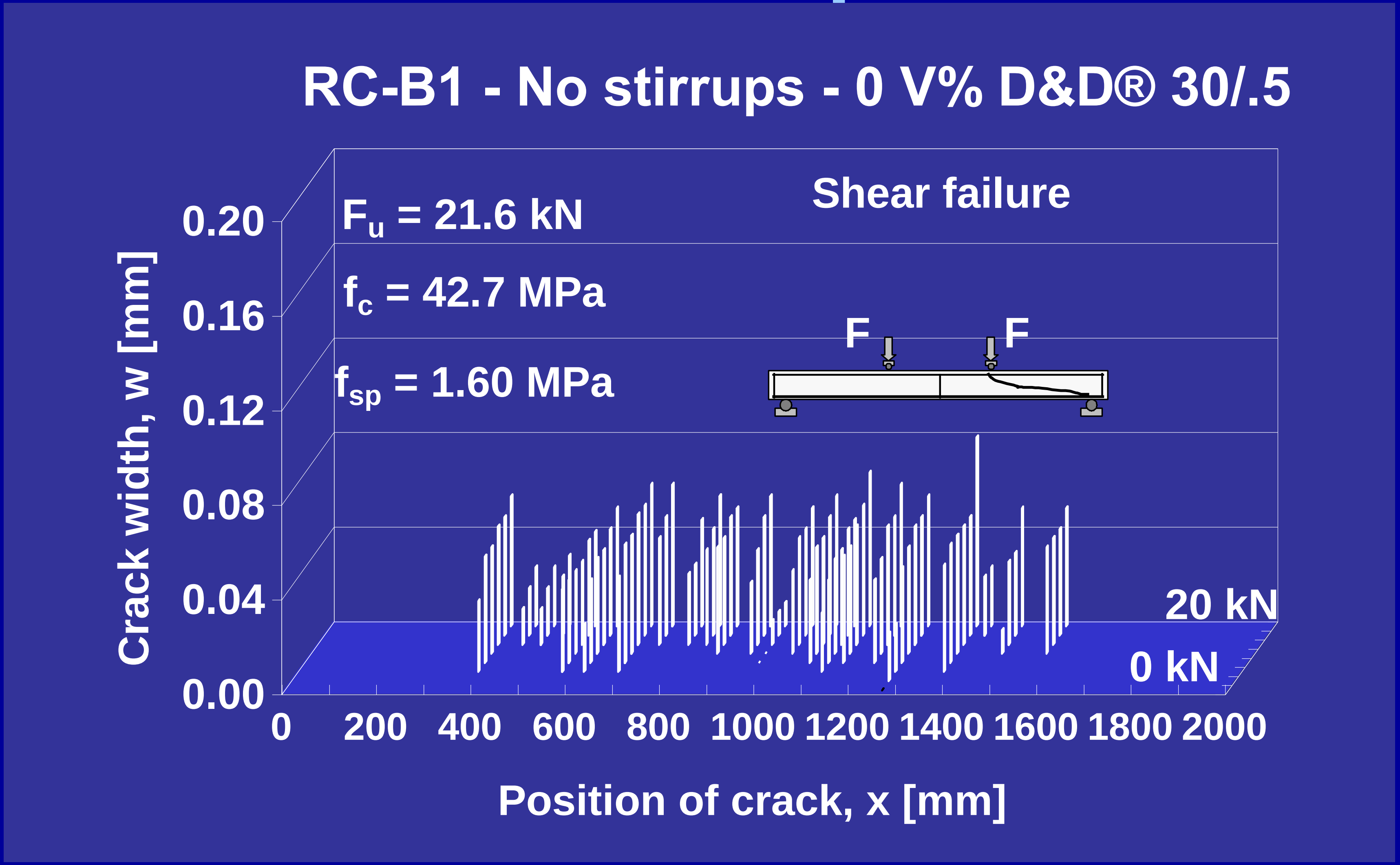


Crack development

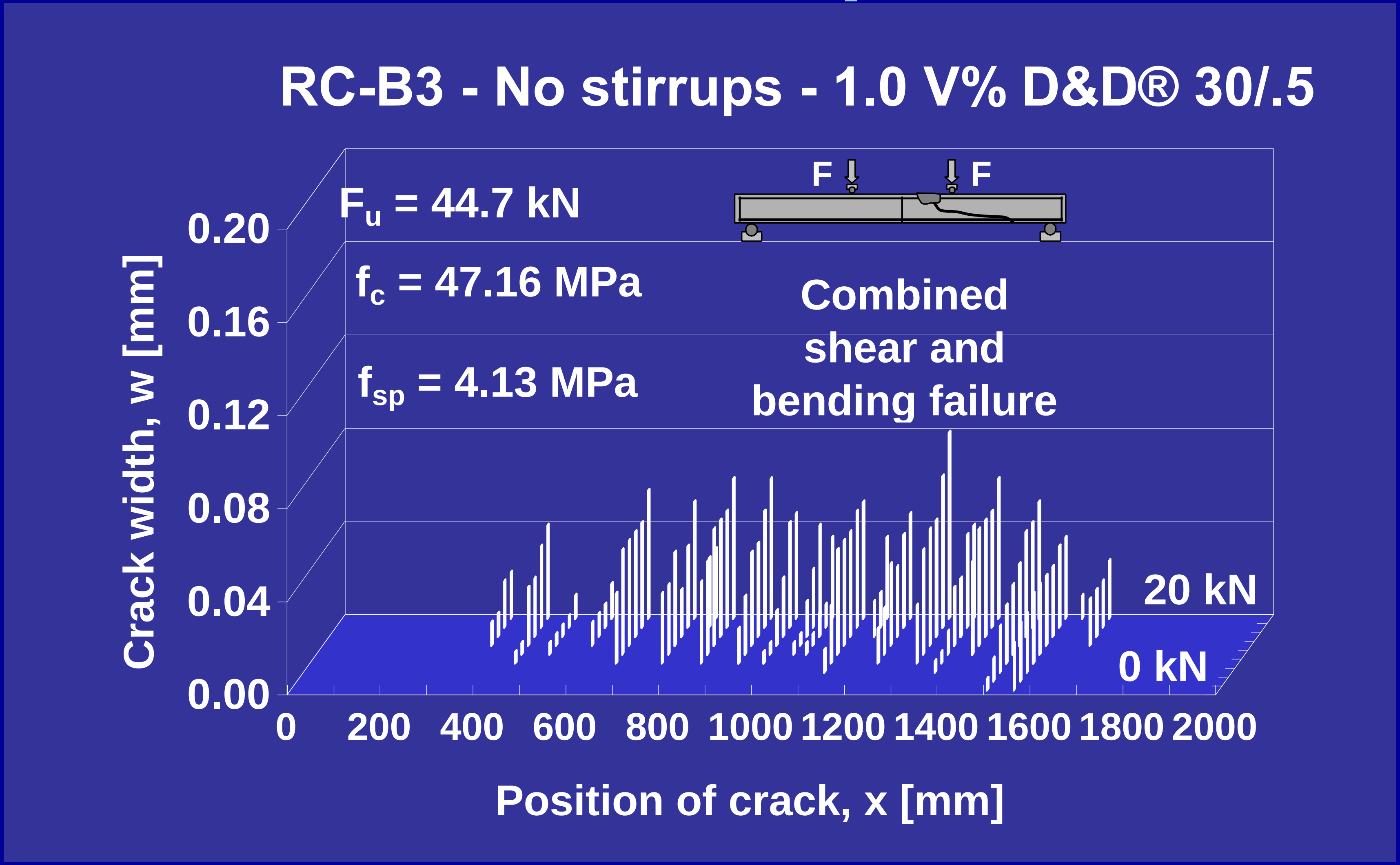




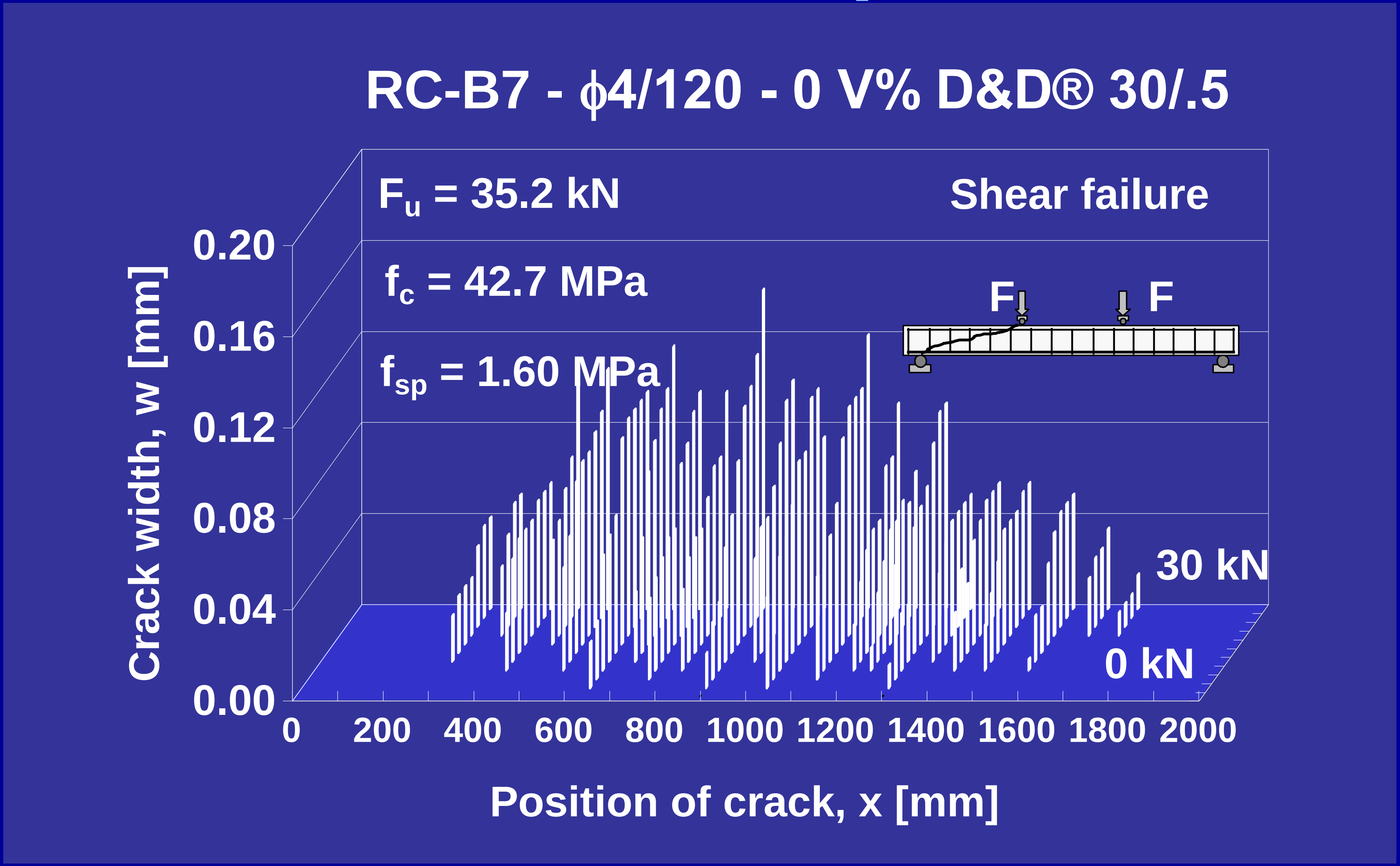
Crack development



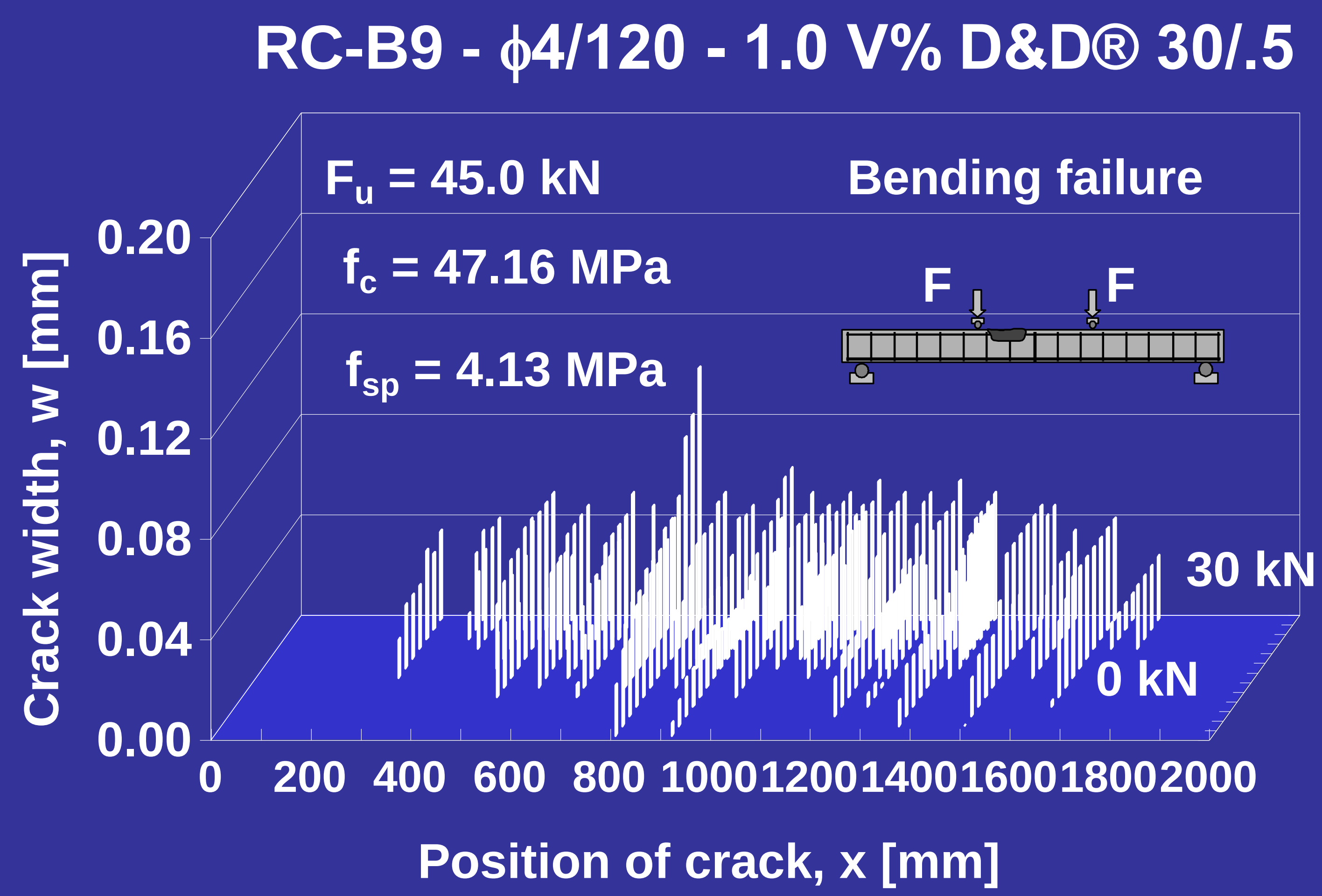
Crack development



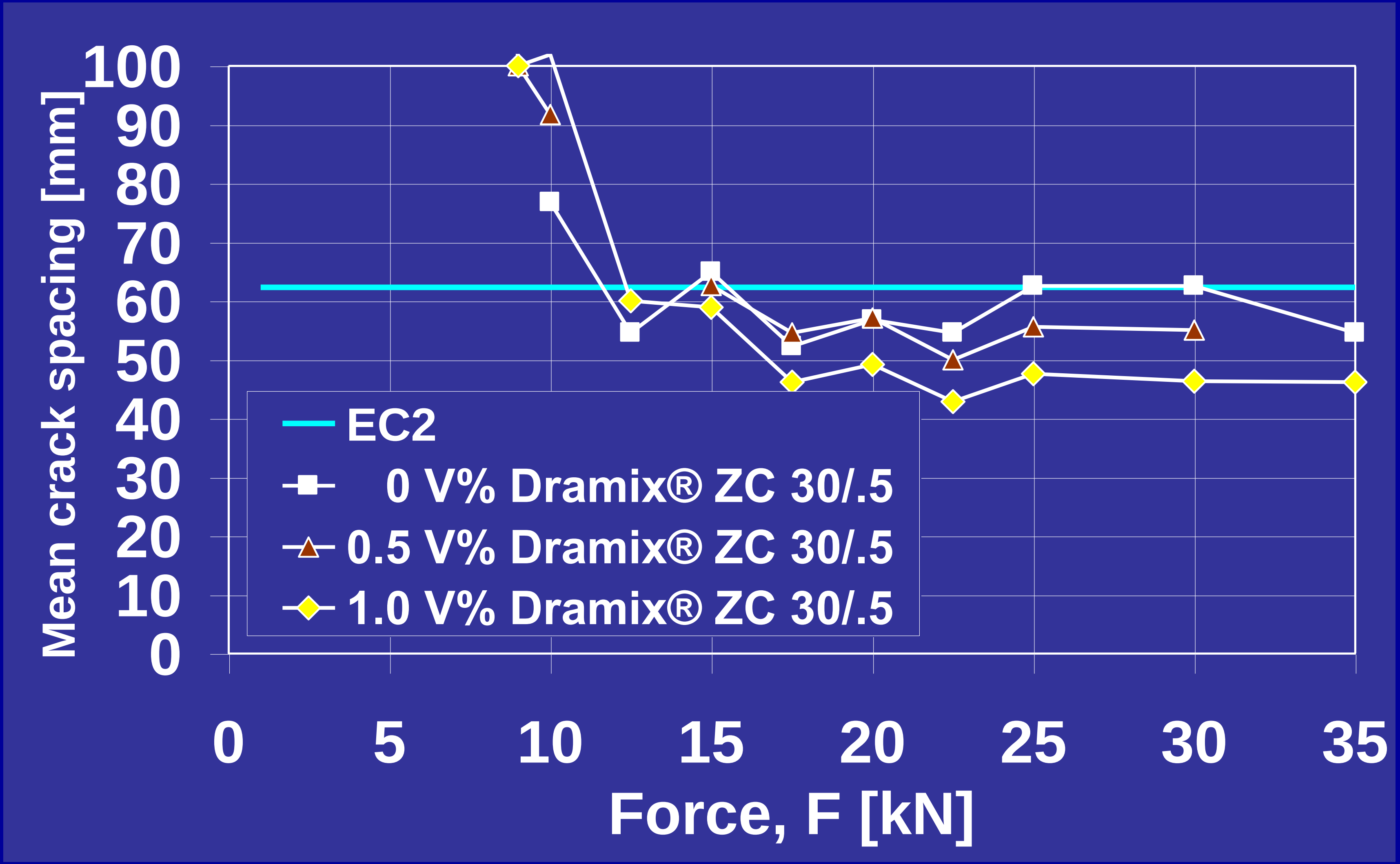
Crack development



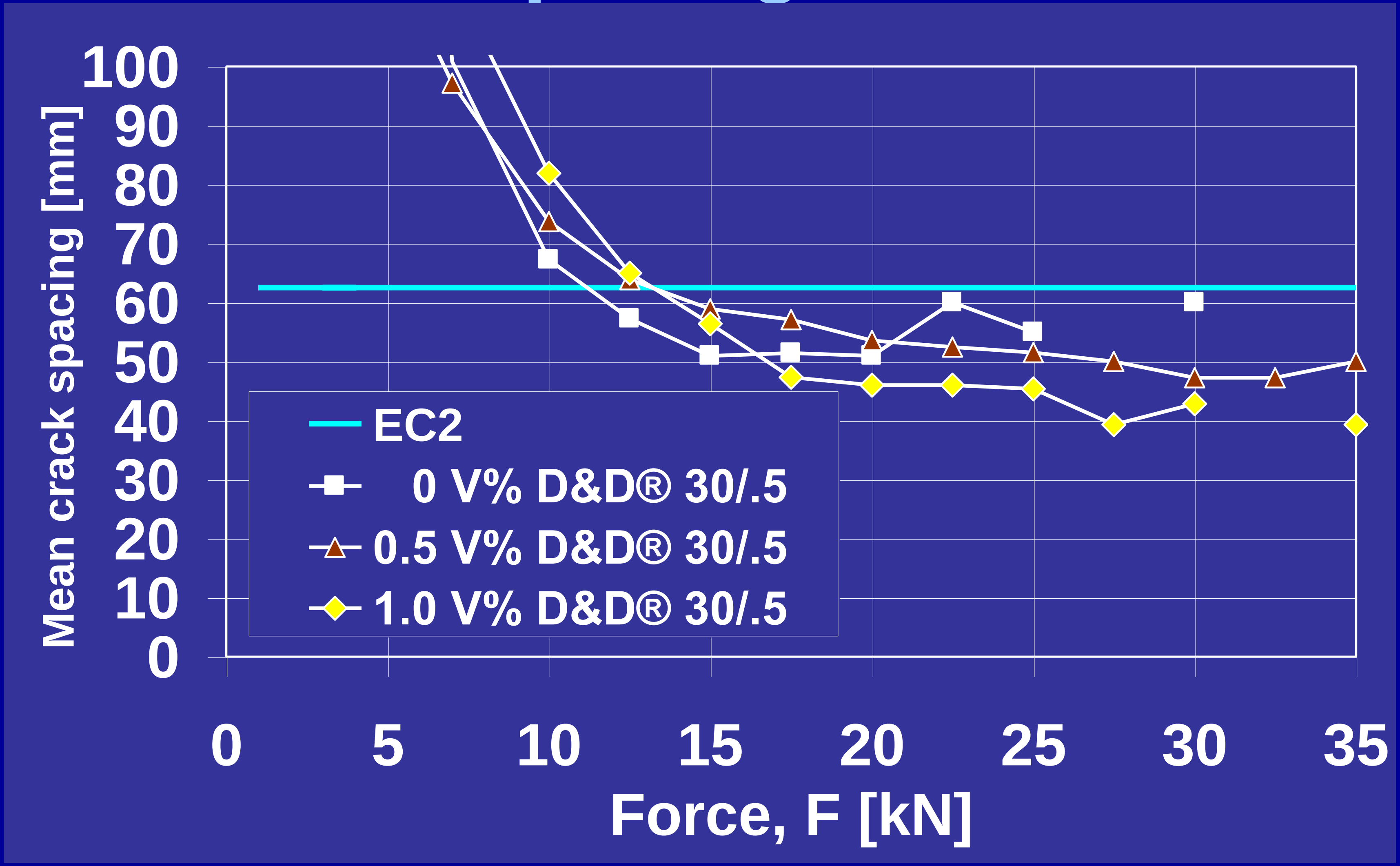
Crack development



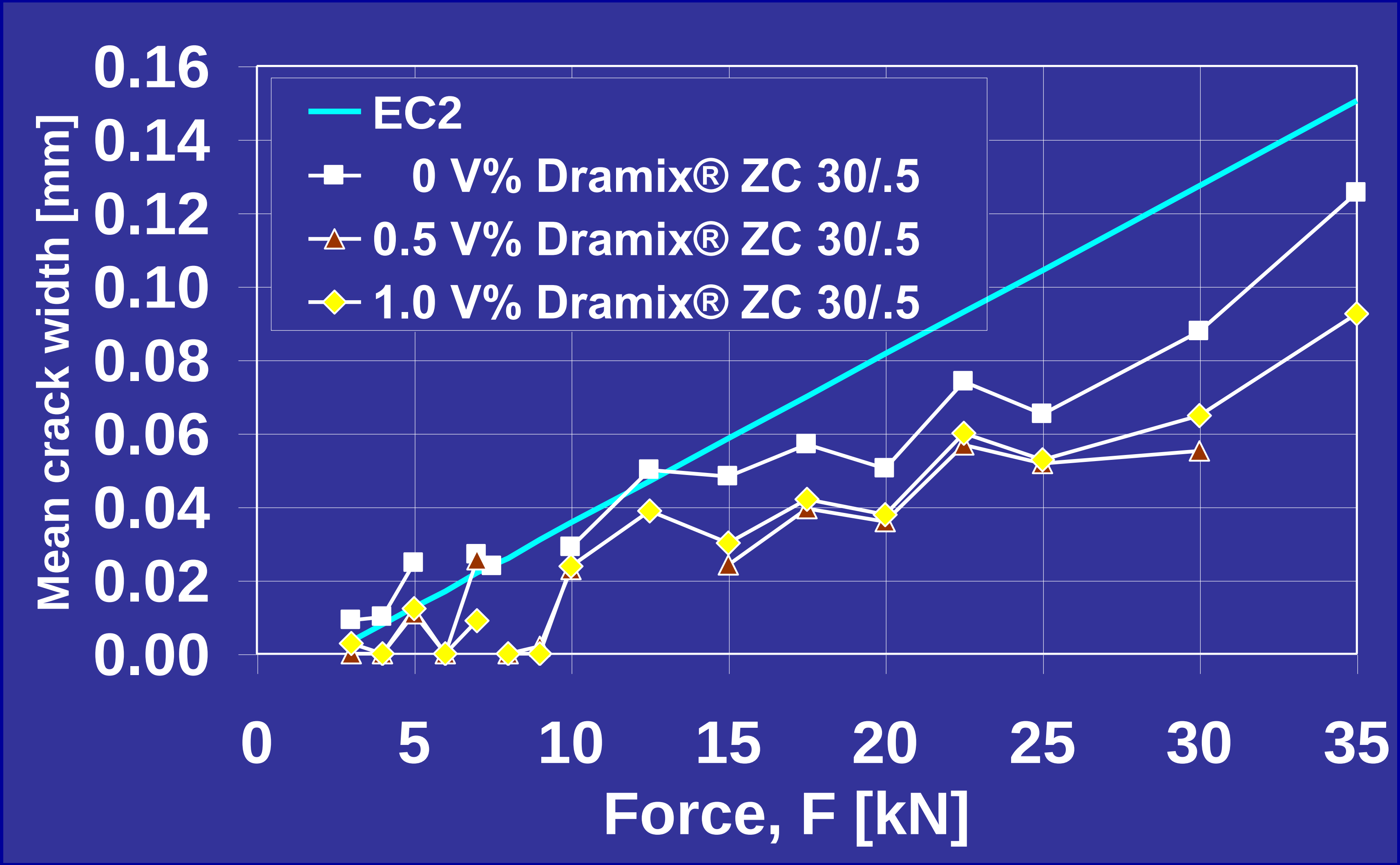
Crack spacing Series A



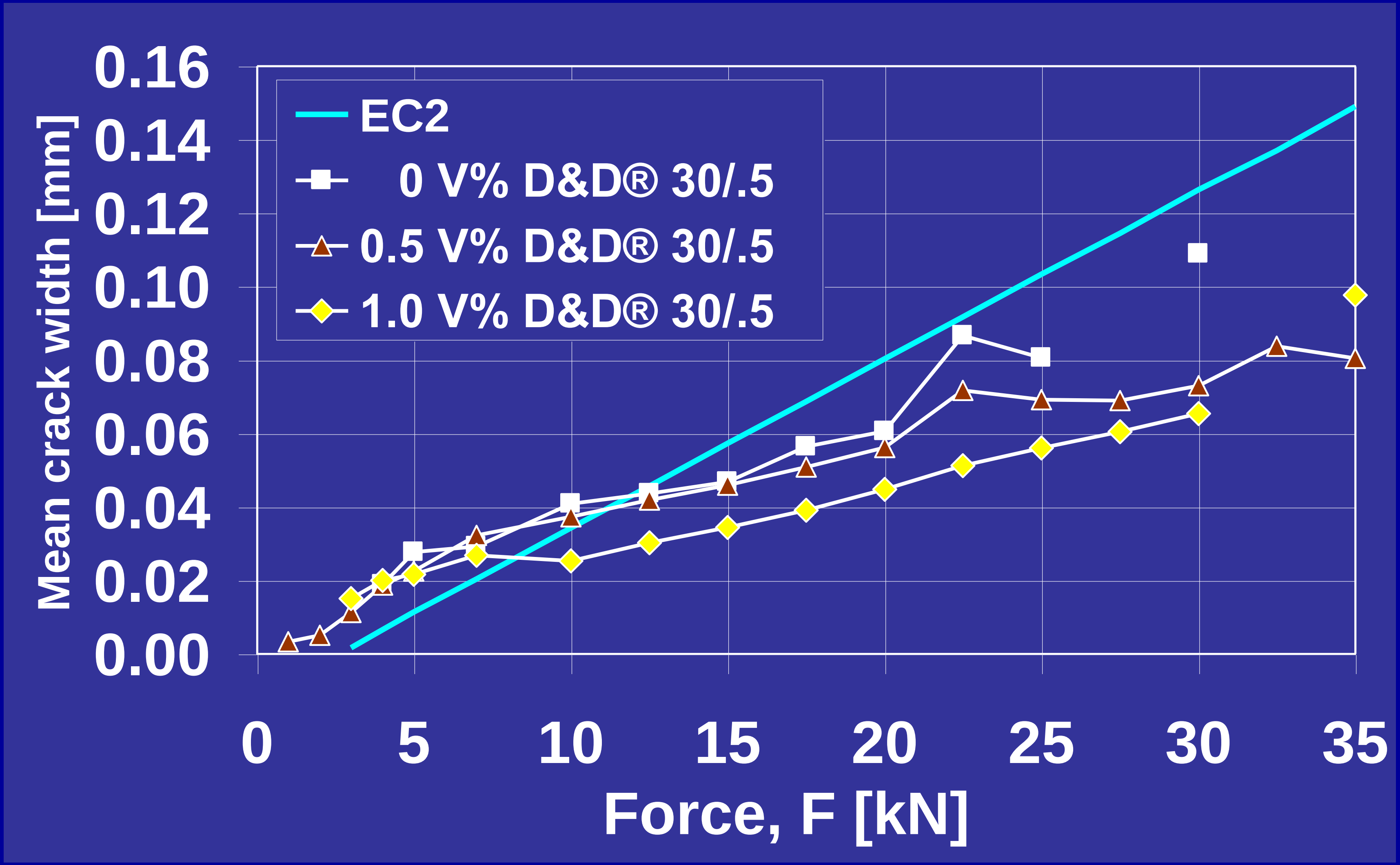
Crack spacing Series B



Crack width Series A



Crack width Series B



Crack spacing

Plain concrete

$$s_{rm} = 50 + 0.25 k_1 k_2 \frac{\varnothing}{\rho_r}$$

0.5 V% steel fibre content

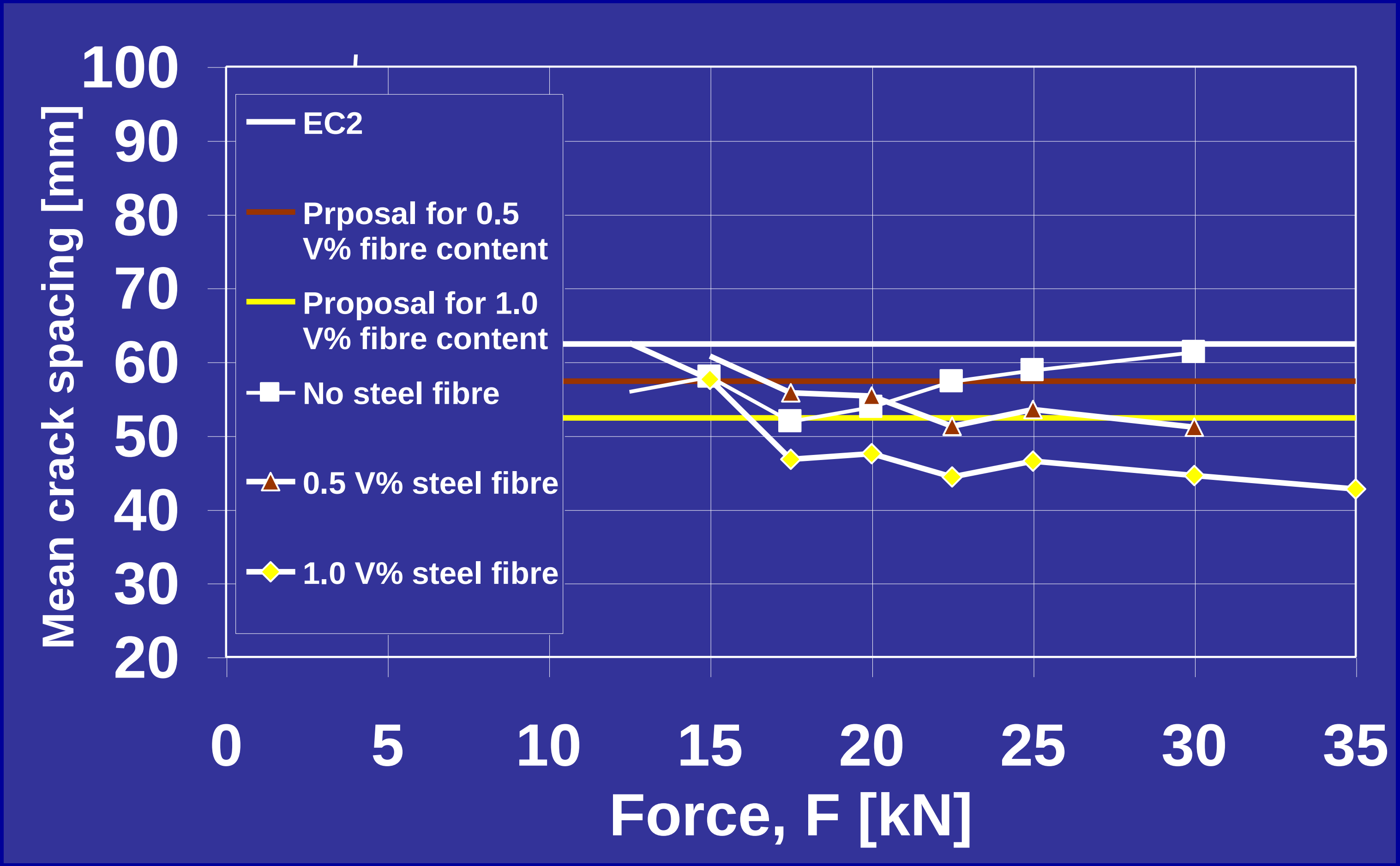
$$s_{rm} = 45 + 0.25 k_1 k_2 \frac{\varnothing}{\rho_r}$$

1.0 V% steel fibre content

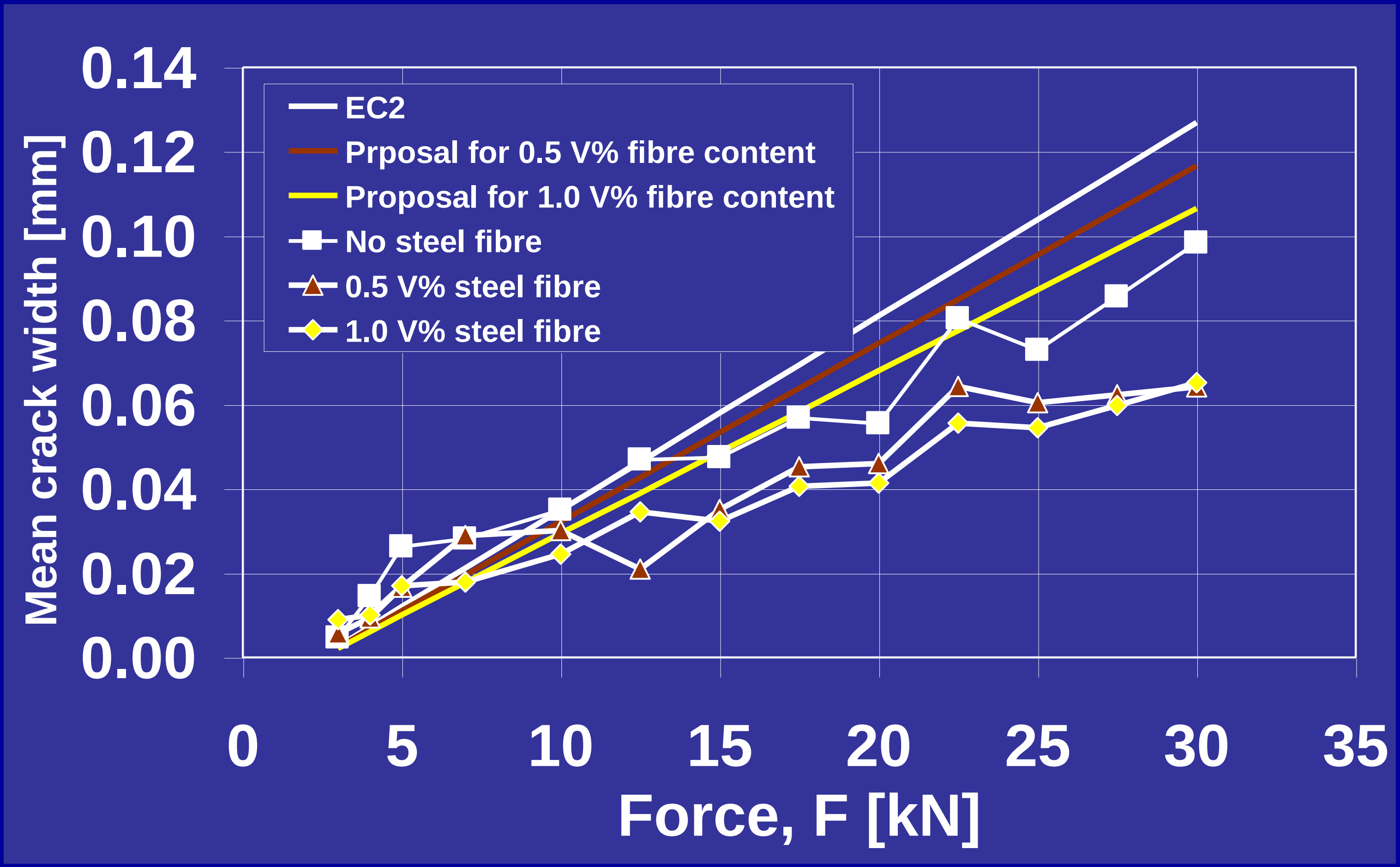
$$s_{rm} = 40 + 0.25 k_1 k_2 \frac{\varnothing}{\rho_r}$$

Crack width

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



Mean crack spacing [mm]
100
90
80
70
60
50
40
30
20
0
5
10
15
20
25
30
35
Force, F [kN]
EC2
Prposal for 0.5 V% fibre content
Proposal for 1.0 V% fibre content
No steel fibre
0.5 V% steel fibre
1.0 V% steel fibre



0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Mean crack width [mm]
EC2
Prposal for 0.5 V% fibre content
Proposal for 1.0 V% fibre content
No steel fibre
0.5 V% steel fibre
1.0 V% steel fibre
0
5
10
15
20
25
30
35
Force, F [kN]

Conclusions

- **Steel fibres increase shear capacity**
- **Crack spacing**

steel fibres reduce average crack spacing,

modified EC2 formula:

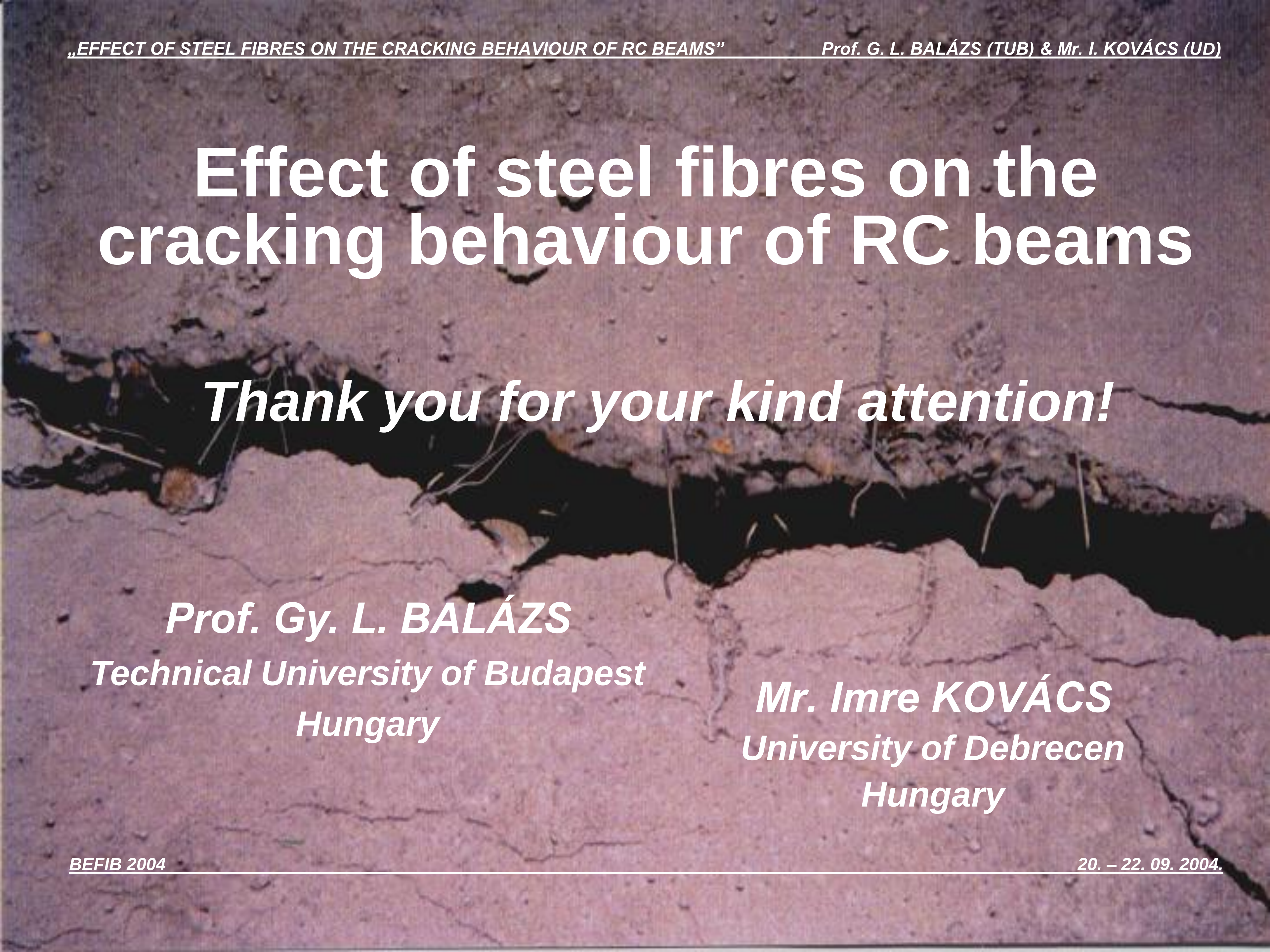
$$s_{rm} = C + 0.25 k_1 k_2 \frac{\varnothing}{\rho_r}$$

for 0 V% fibre content: C = 0.50

for 0.5 V% fibre content: *C* = 0.45

for 1.0 V% fibre content: *C* = 0.40

- **Crack width** $$w_k = \beta s_{rm} \varepsilon_{sm}$$



Effect of steel fibres on the cracking behaviour of RC beams

Thank you for your kind attention!

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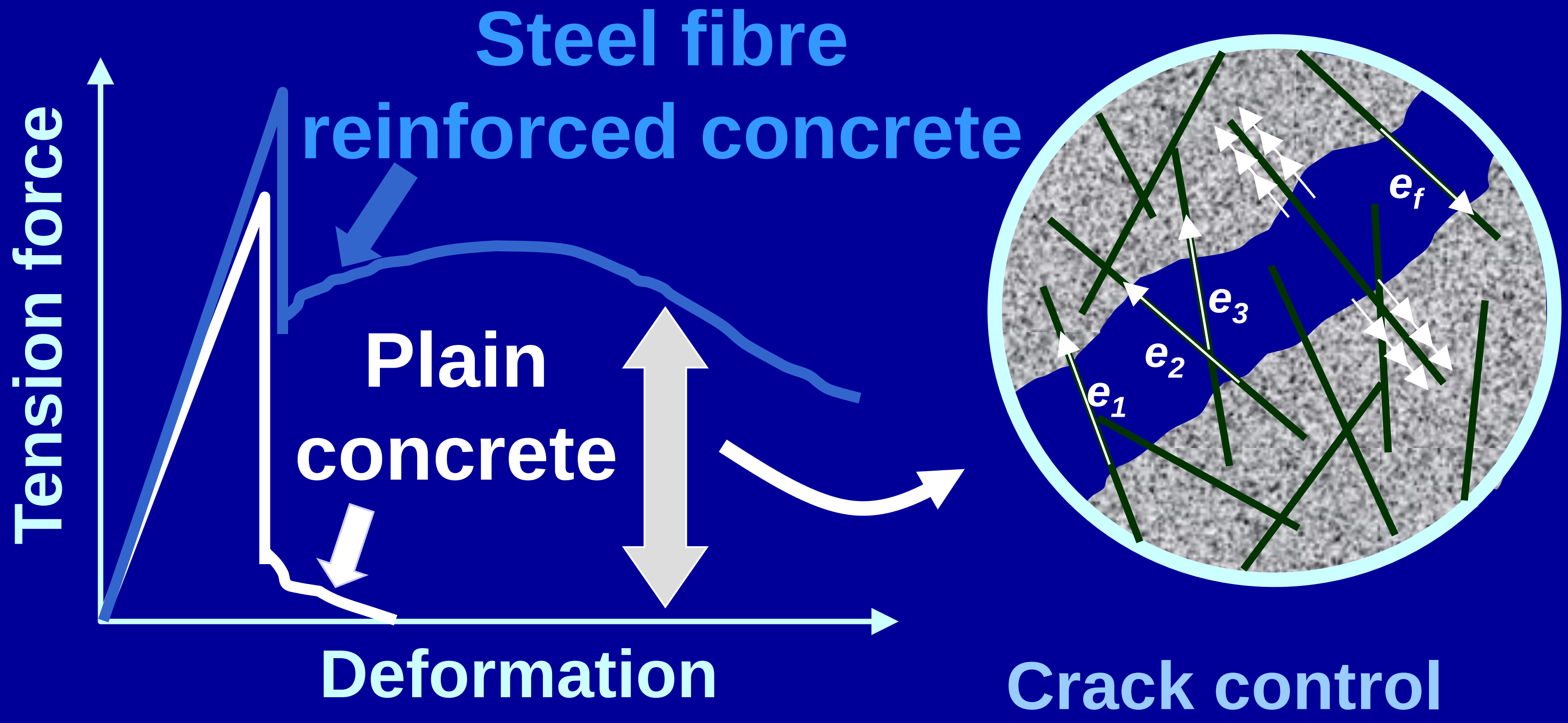
Hungary

Mr. Imre KOVÁCS
University of Debrecen
Hungary

Aknowledgement

- **MKM 150/94.** ***“Behaviour of steel fibre reinforced concrete beams”***
  Project of the Hungarian Ministry of Education
- **OTKA 16683** ***”Toughness of steel fibre reinforced concrete”***
  Project of the Hungarian Research Foundation
- **OTKA T025647** ***“Punching behaviour of steel fibre reinforced concrete slabs”***
  Project of the Hungarian Research Foundation
- **OTKA F025621** ***“Modelling of steel fibre reinforced concrete members”***
  Project of the Hungarian Research Foundation
- **OTKA T025652** ***“Concrete in the next century”***
  Project of the Hungarian Research Foundation



Steel fibre
reinforced concrete
Tension force
Plain
concrete
Deformation
e1
e2
e3
ef
Crack control