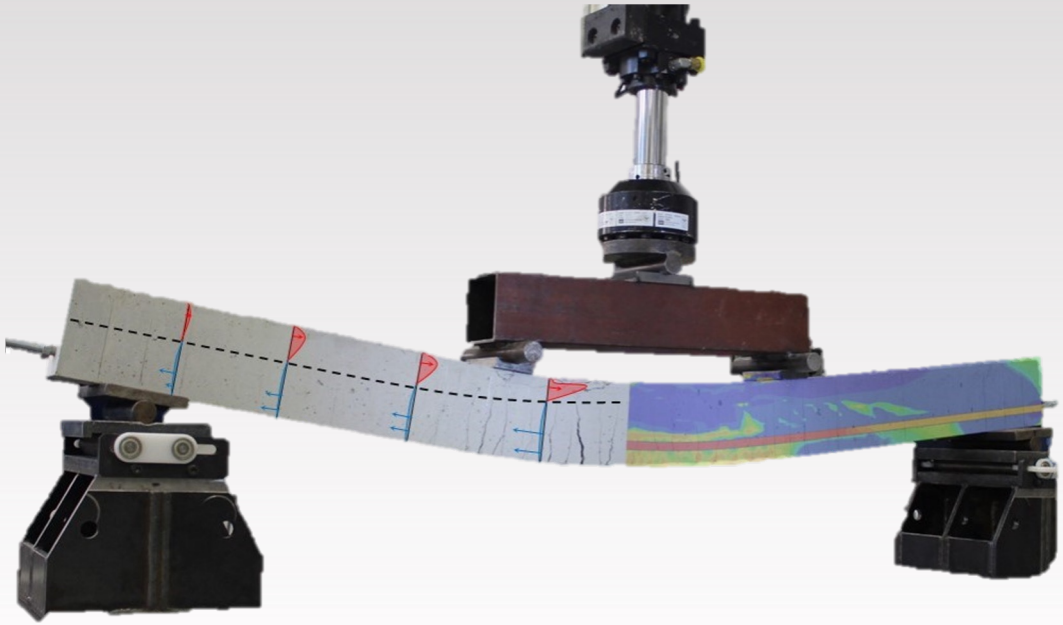
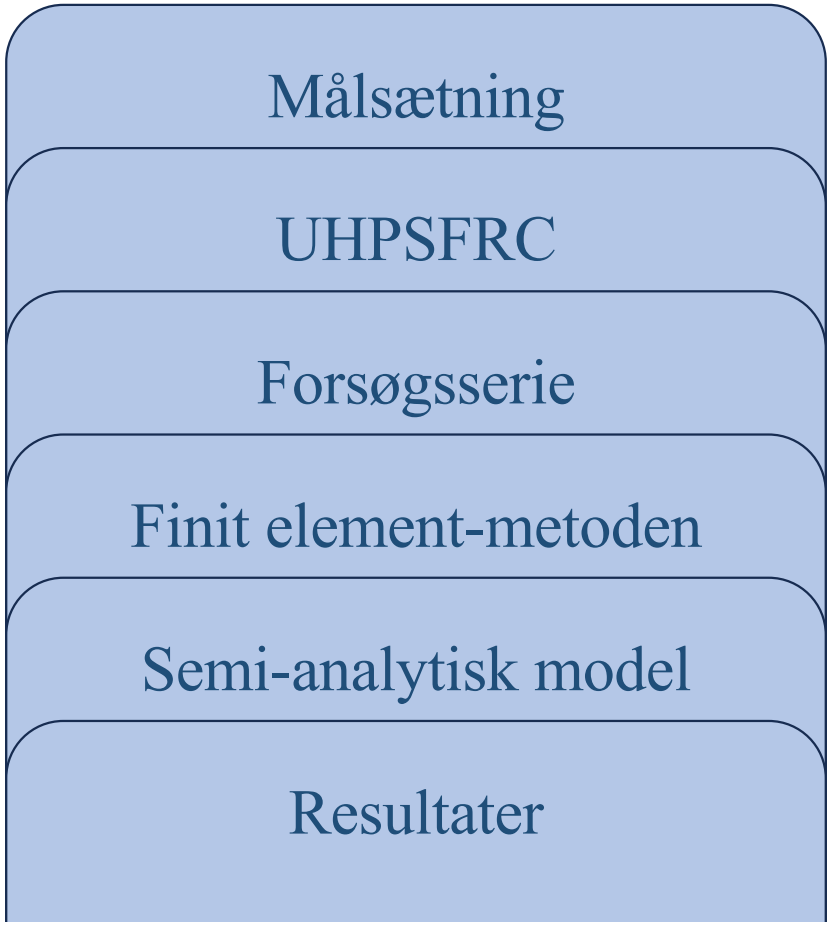
Deformationer af UHPSFRC-bjælker med forspændt armering



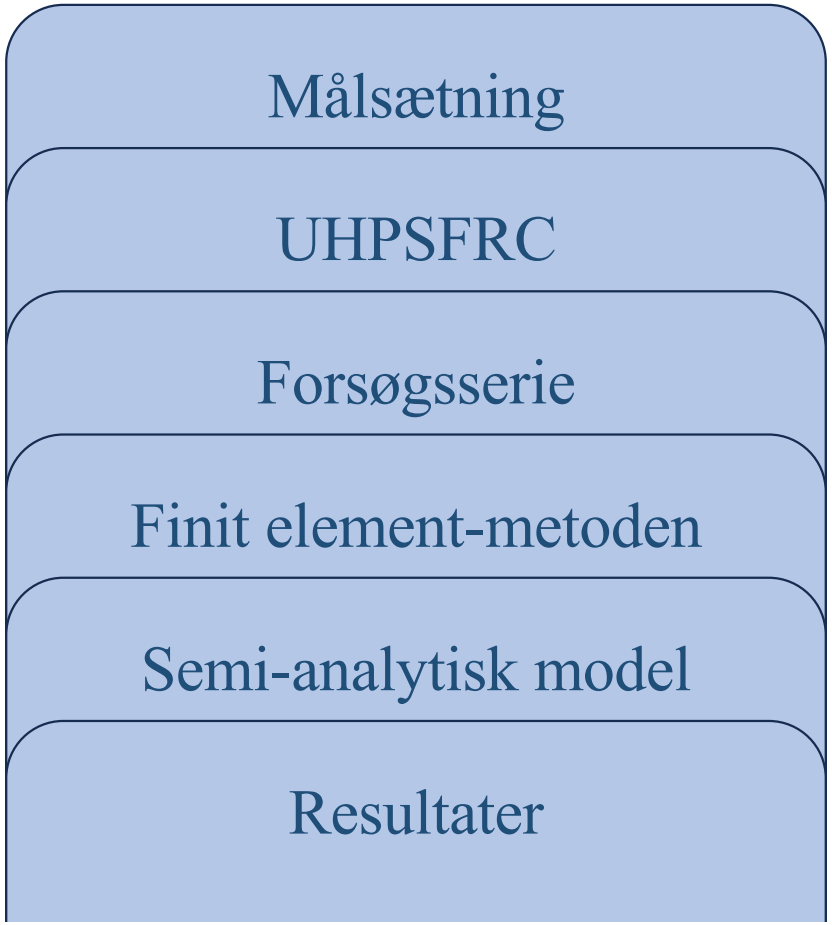
Daniel Peter Brosbøl

Rasmus Juul Larsen

Agenda


Målsætning
UHPSFRC
Forsøgsserie
Finit element-metoden
Semi-analytisk model
Resultater

Agenda


Målsætning
UHPSFRC
Forsøgsserie
Finit element-metoden
Semi-analytisk model
Resultater

Målsætning

1. Modellering af opspændte UHPSFRC bjælker
2. Indflydelsen af opspænding
3. Sammenligning af modeller og forsøgsresultater

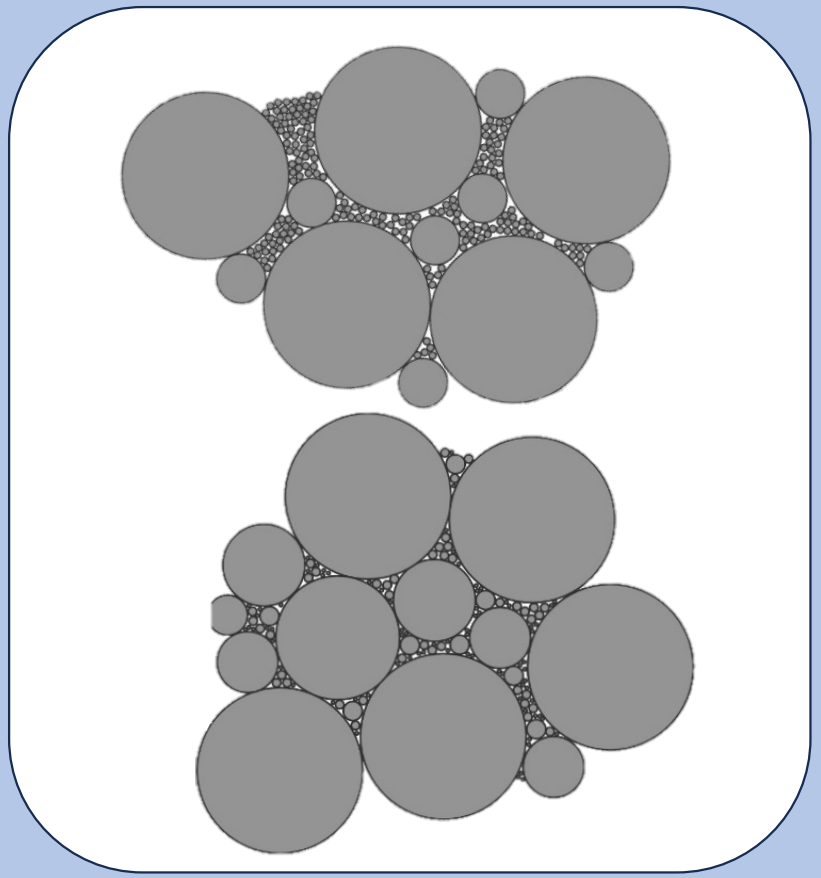
Målsætning

1. Modellering af opspændte UHPSFRC bjælker
2. Indflydelsen af opspænding
3. Sammenligning af modeller og forsøgsresultater

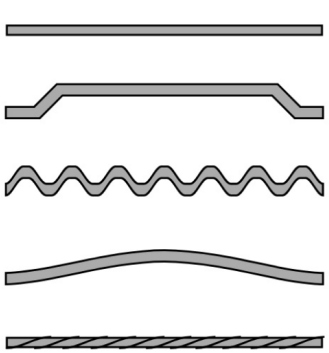
UHPSFRC

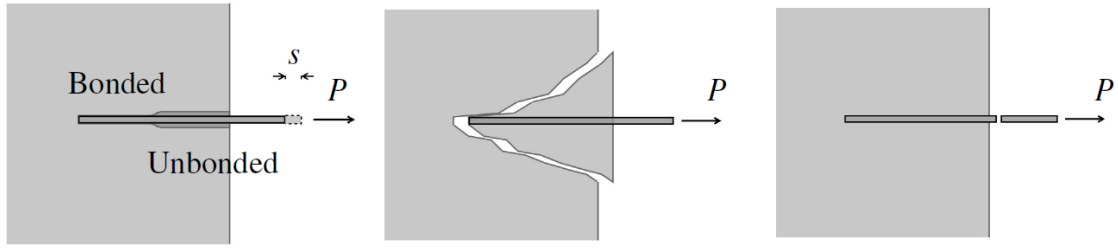
- UHPC
- Fibre
- Styrke parametre
- Opspændte Bjælker

UHPC

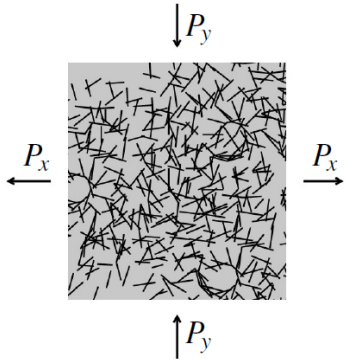


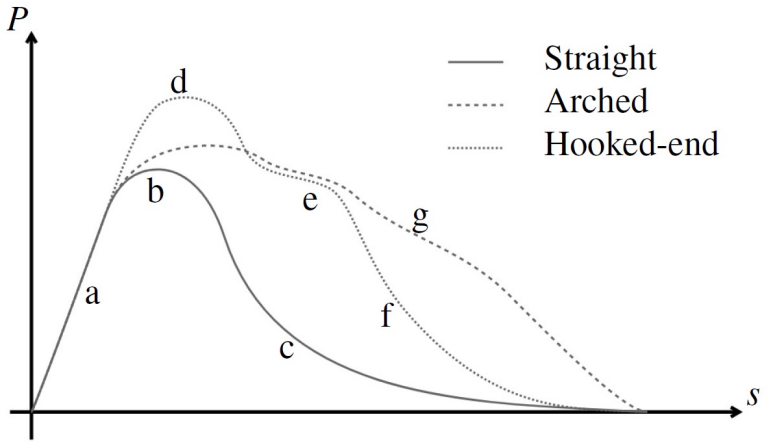
Fibre



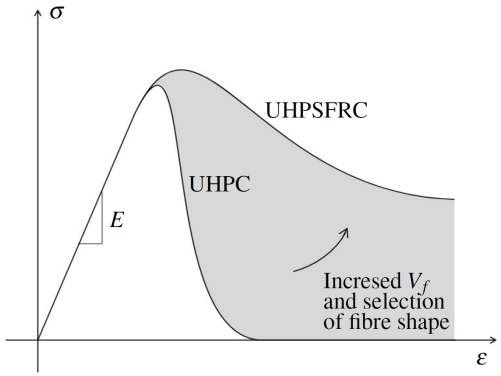


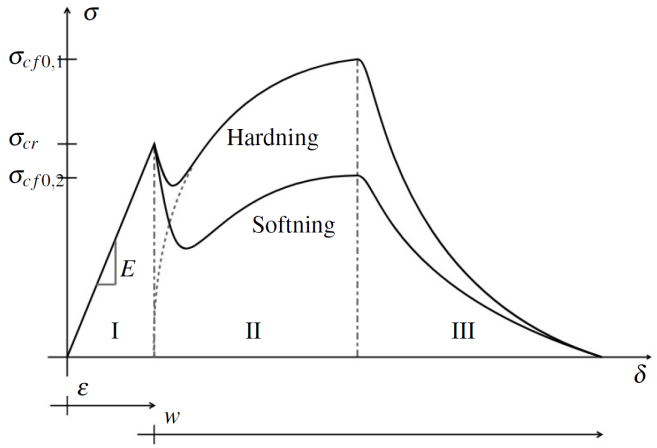
(a) Pull-out (b) Breakout (c) Fracture

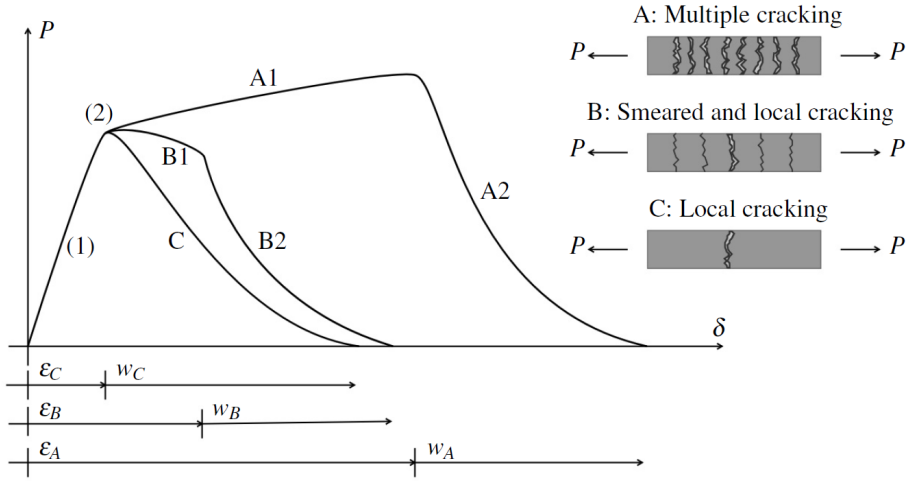




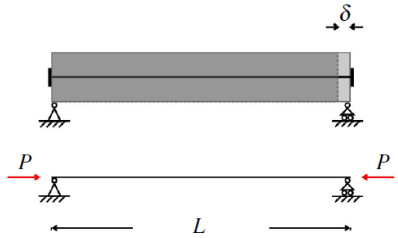
Styrke parametre



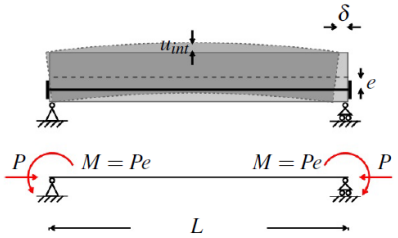




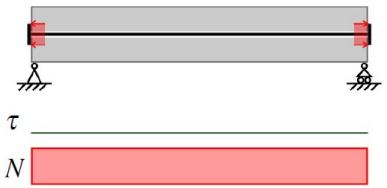
Opspændte bjælker



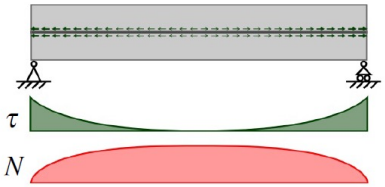
(a) Centered Tendon



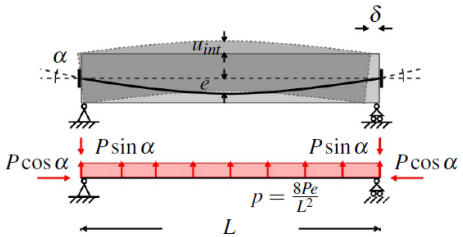
(b) Eccentric Tendon



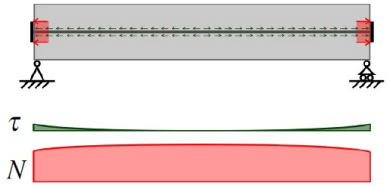
(a) Normal transfer



(b) Shear transfer



(c) Parabolic Tendon



(c) Normal transfer and shear transfer

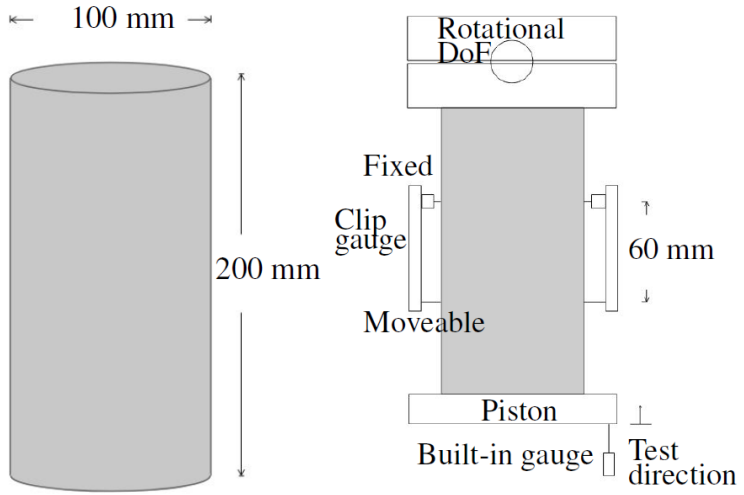
Forsøgsserie

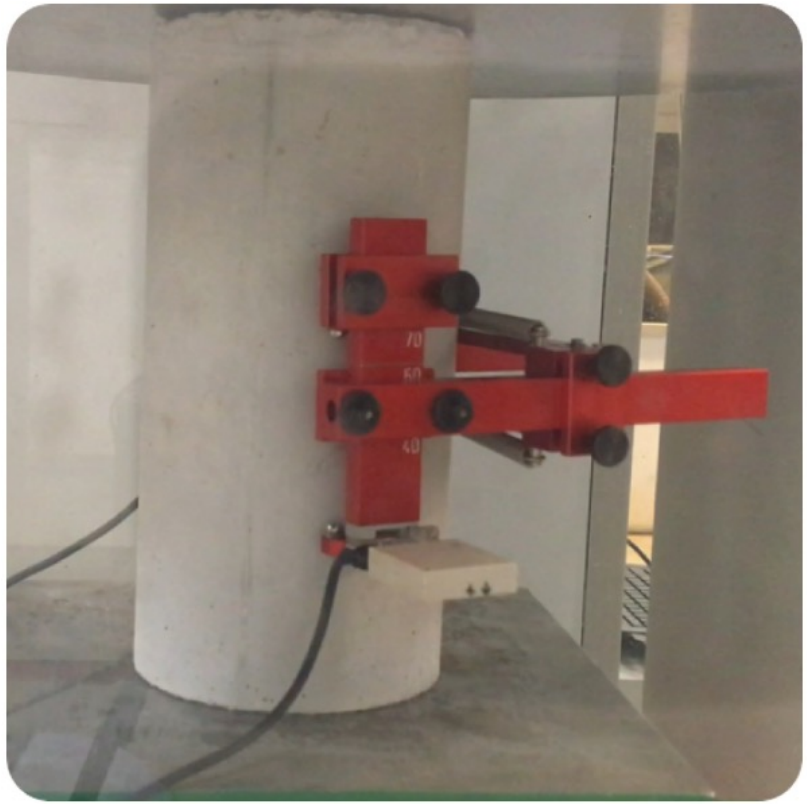
- Cylinder trykforsøg
- G_F-bjælke bøjningsforsøg
- Trækforsøg af armering
- Bjælke forsøg

Forsøgsserie

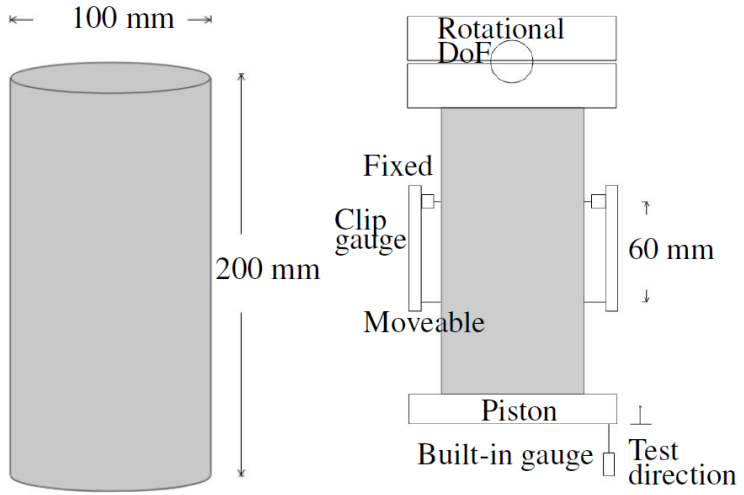
- Cylinder trykforsøg
- G_F-bjælke bøjningsforsøg
- Trækforsøg af armering
- Bjælke forsøg

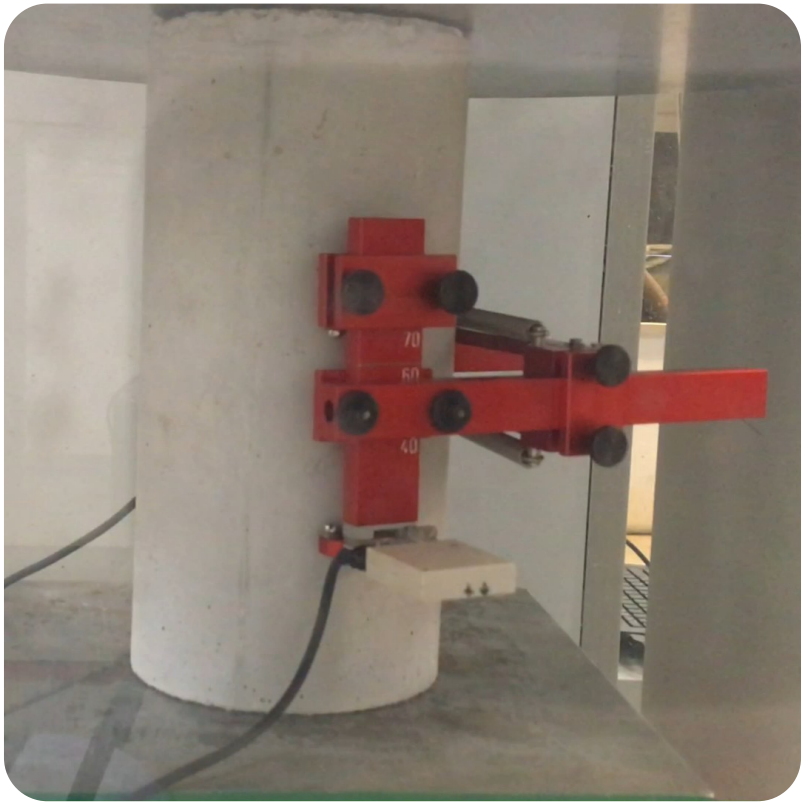
Cylinder trykforsøg



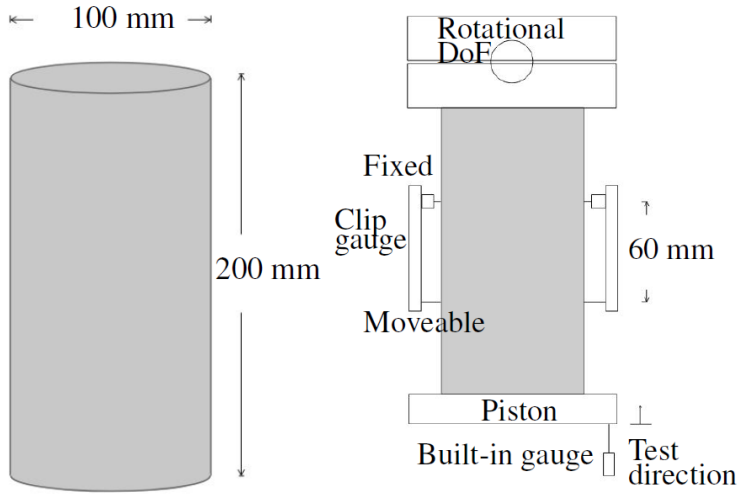


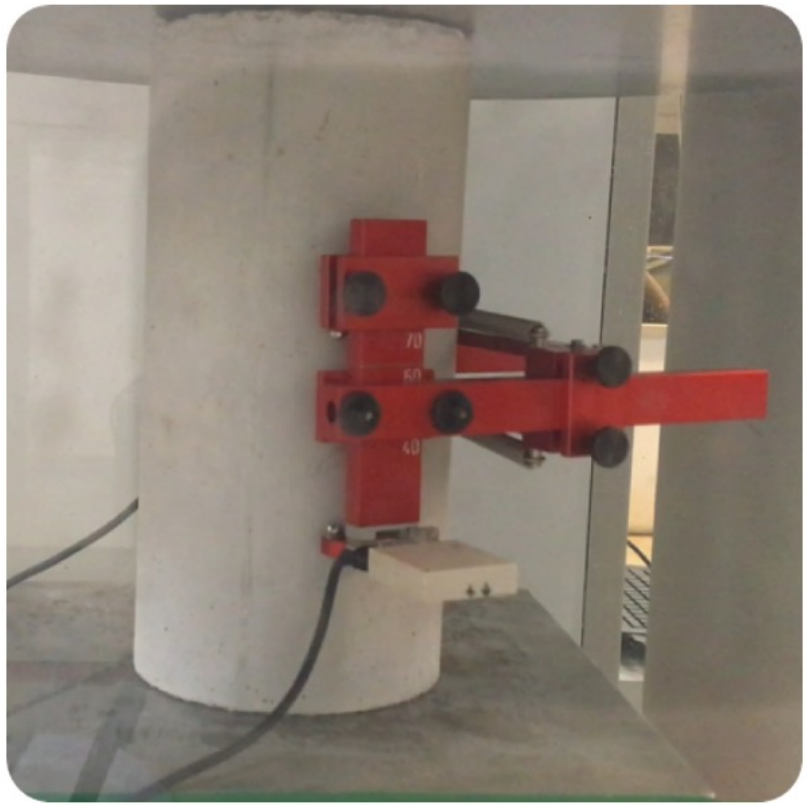
Cylinder trykforsøg



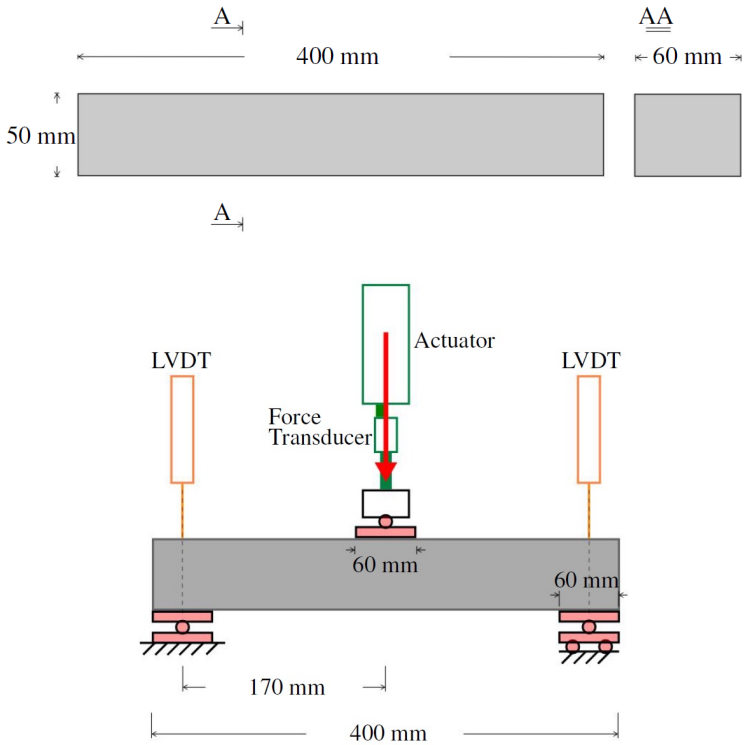


Cylinder trykforsøg

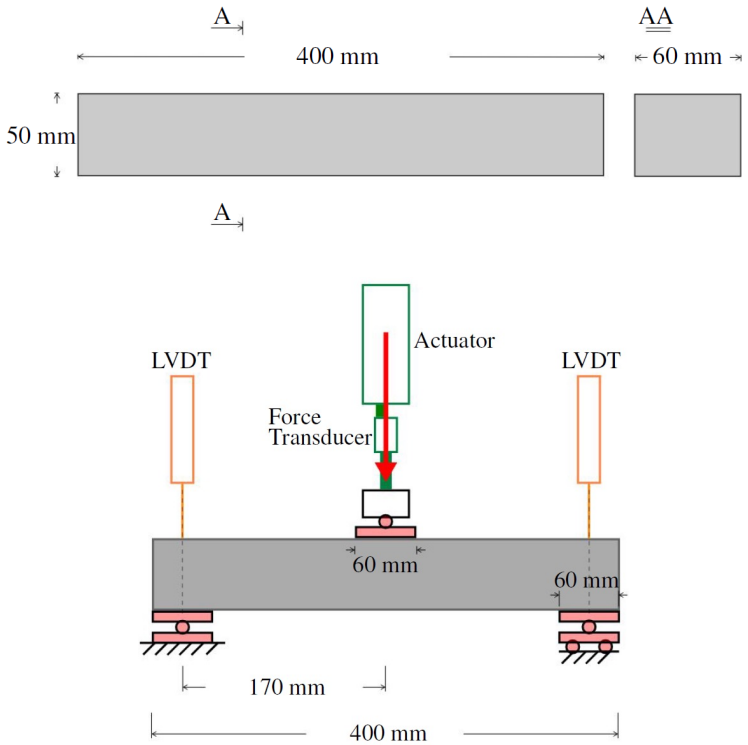




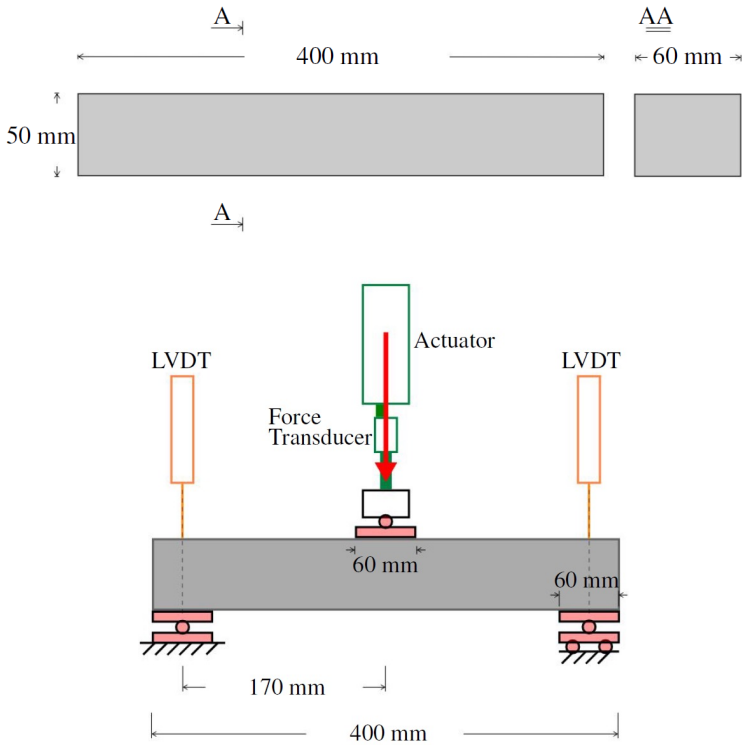
G_F-bjælke bøjningsforsøg



G_F-bjælke bøjningsforsøg



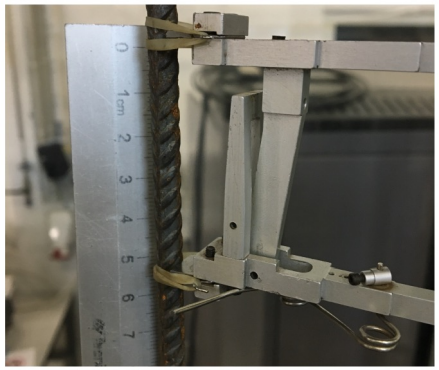
G_F-bjælke bøjningsforsøg



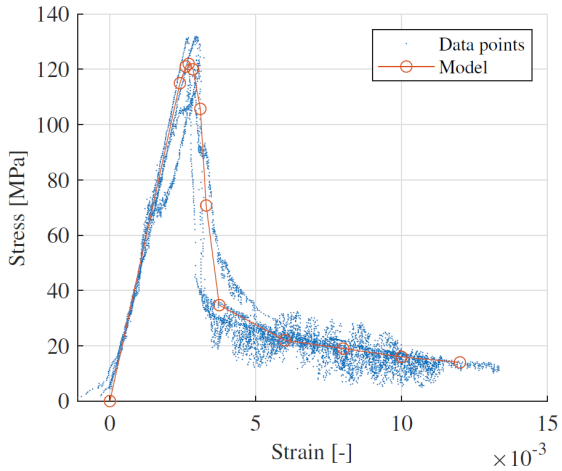
Trækforsøg af armering

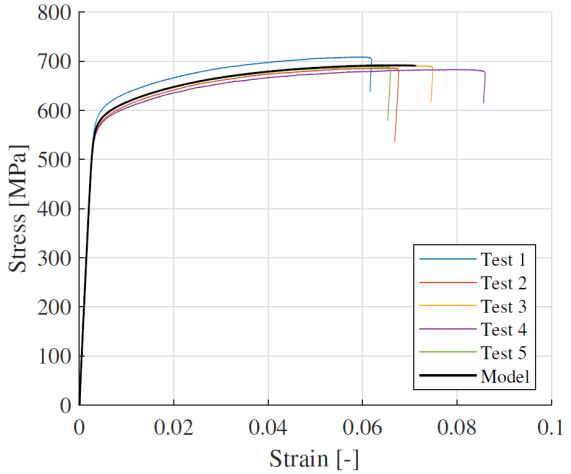
(a) Rebar

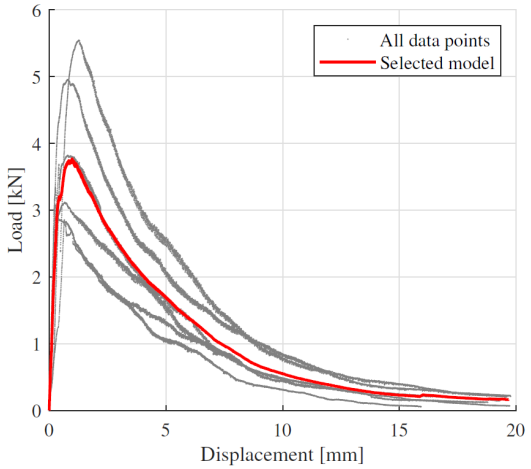
(b) Threaded rod

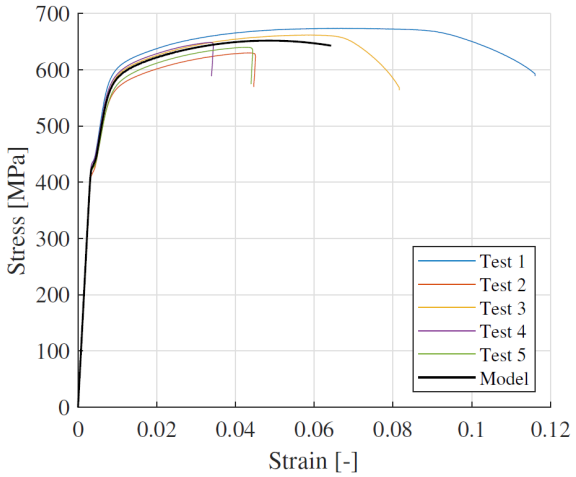


Data til modeller

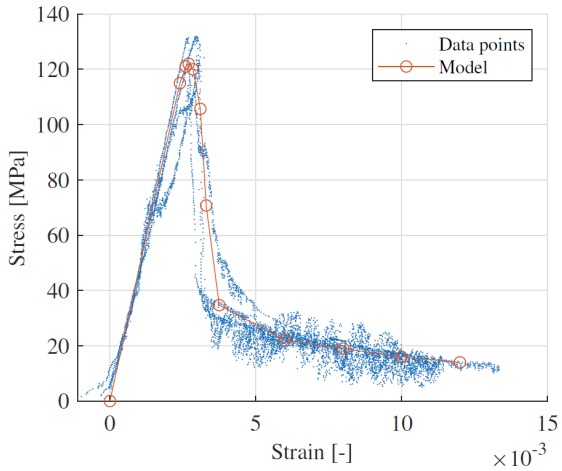


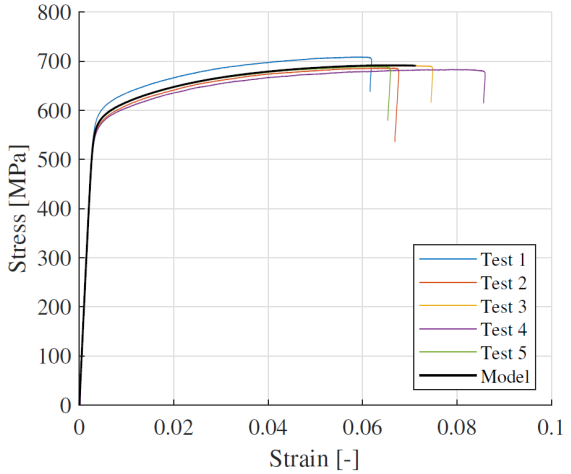


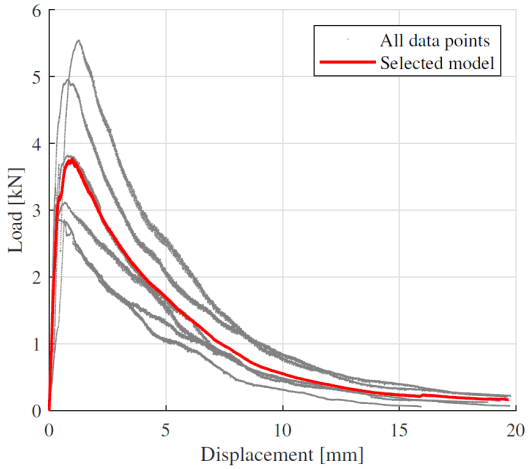


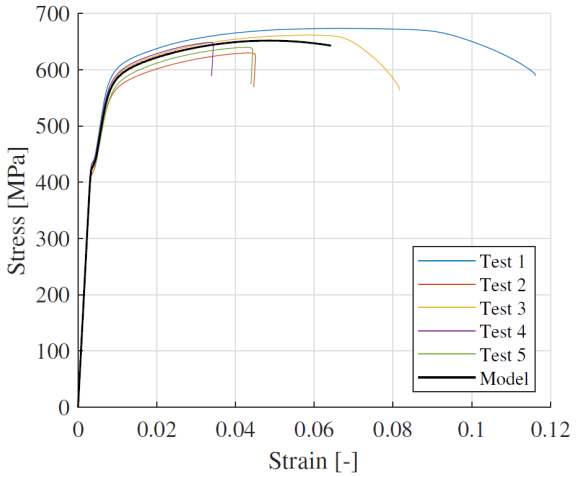


Data til modeller

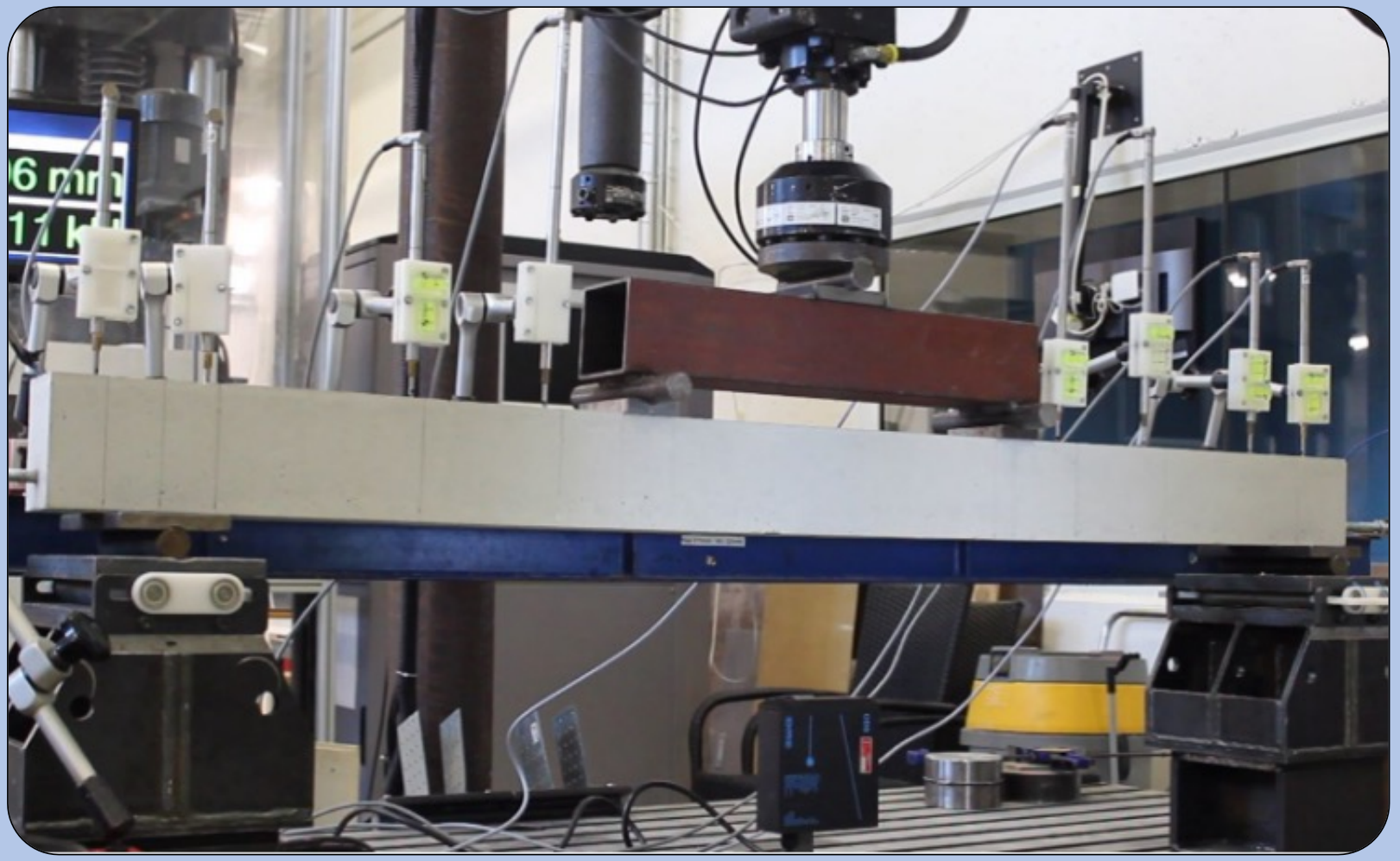








Bjælkeforsøg



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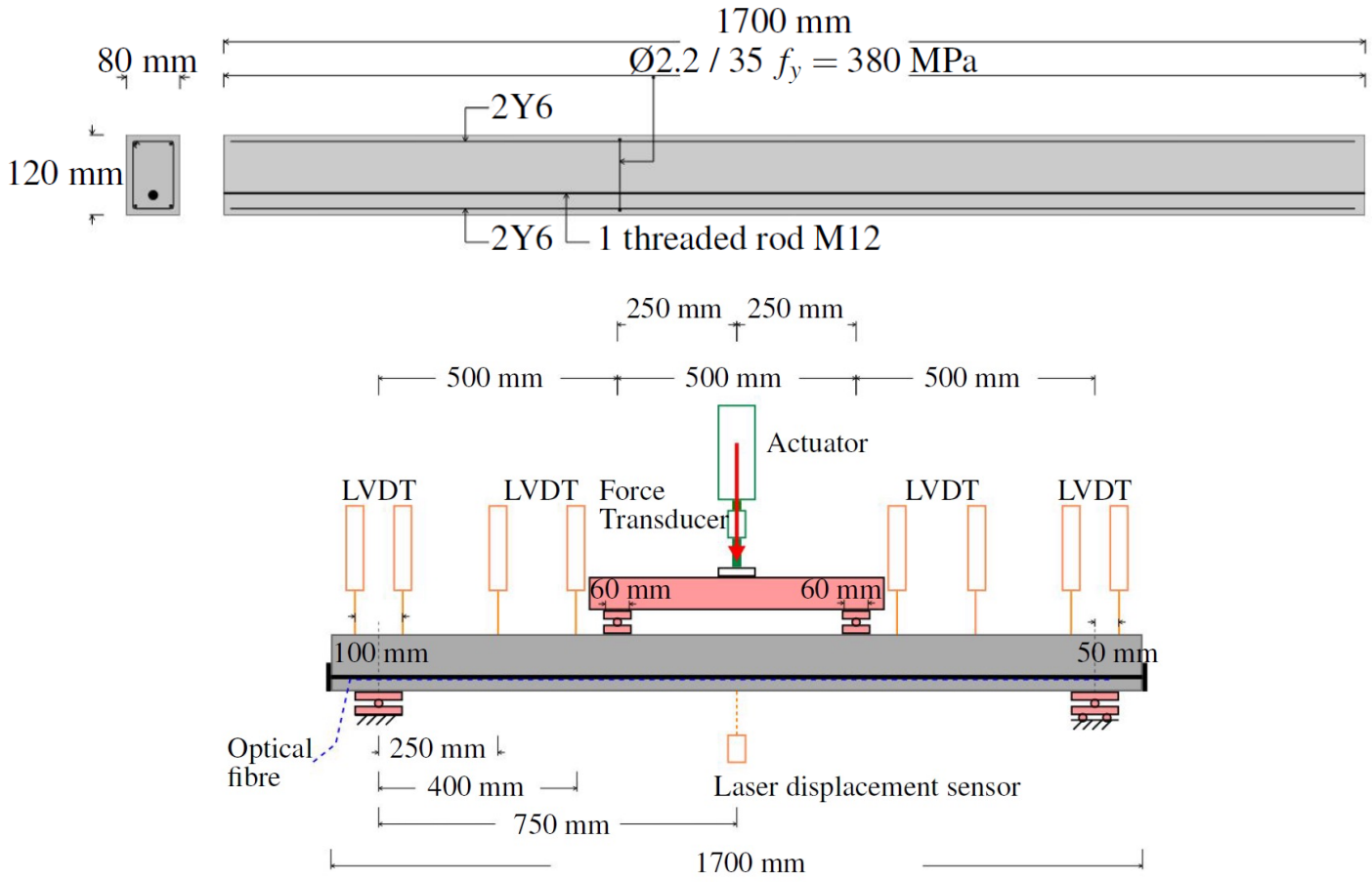

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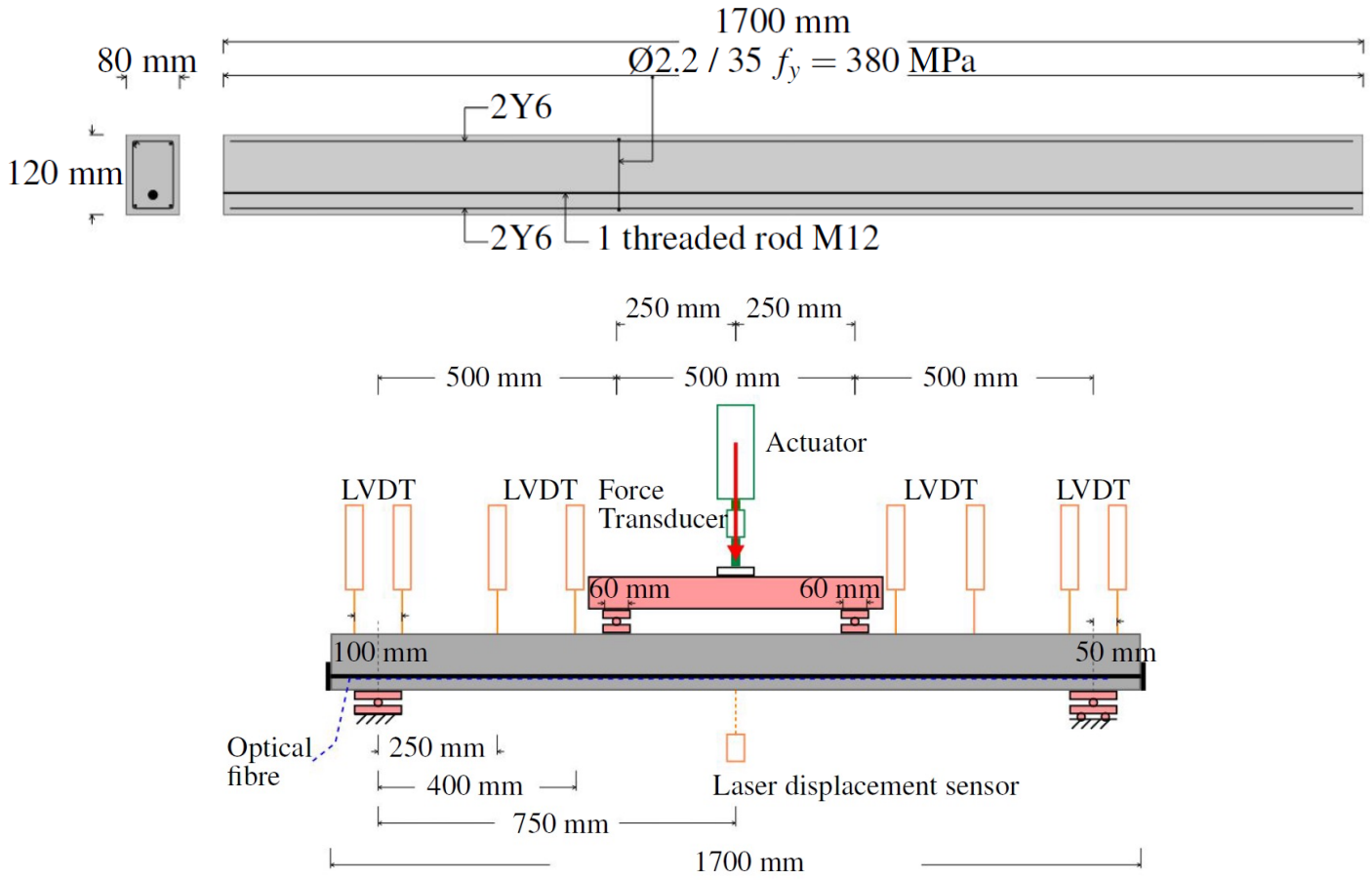
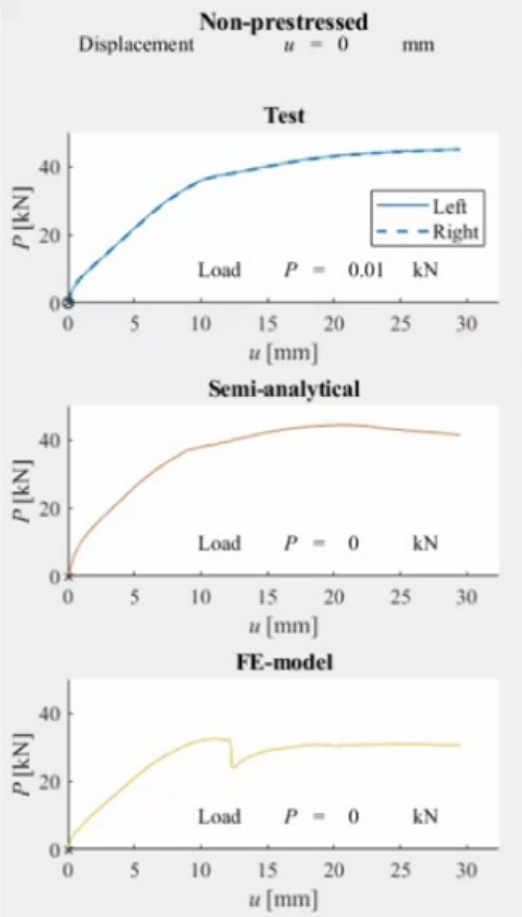
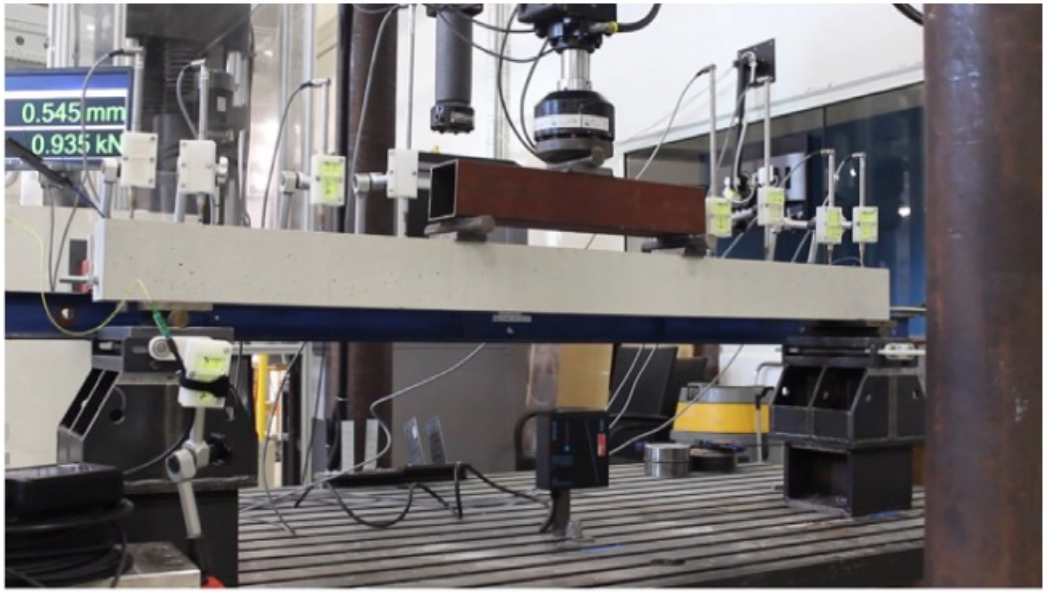


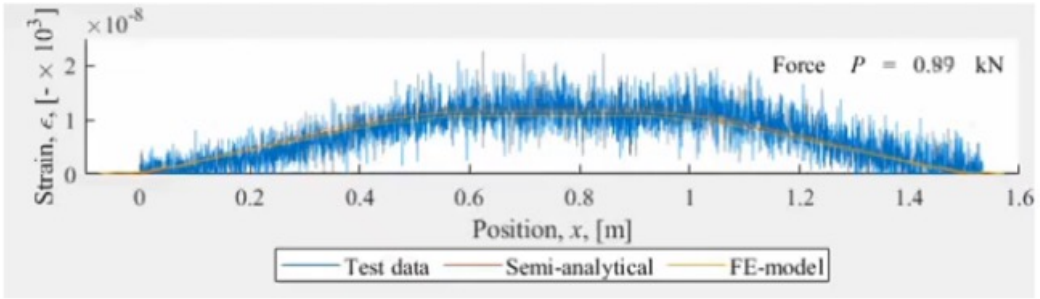
Forberedelse

- Armeringsarbejde
- Opspænding
- Støbning

Slapt armeret







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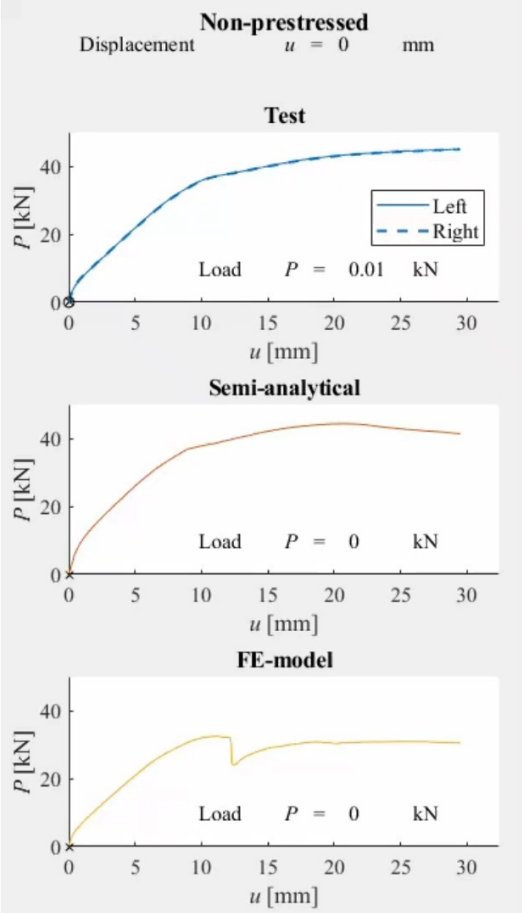

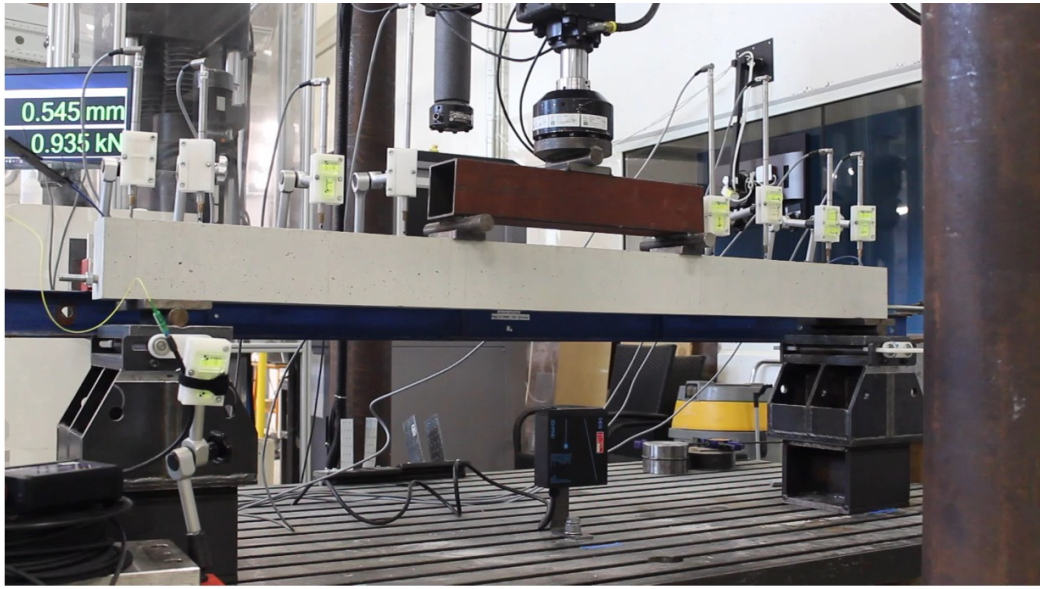

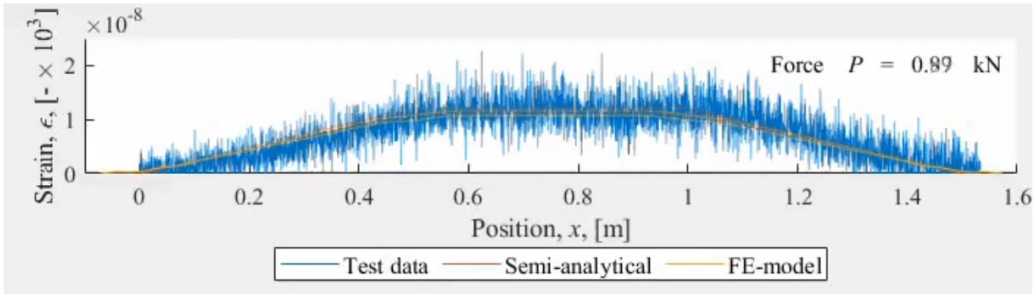

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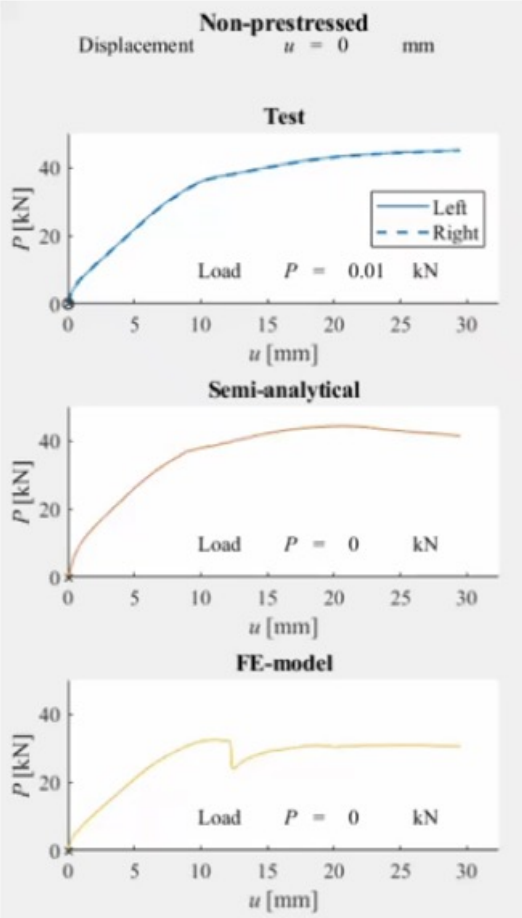
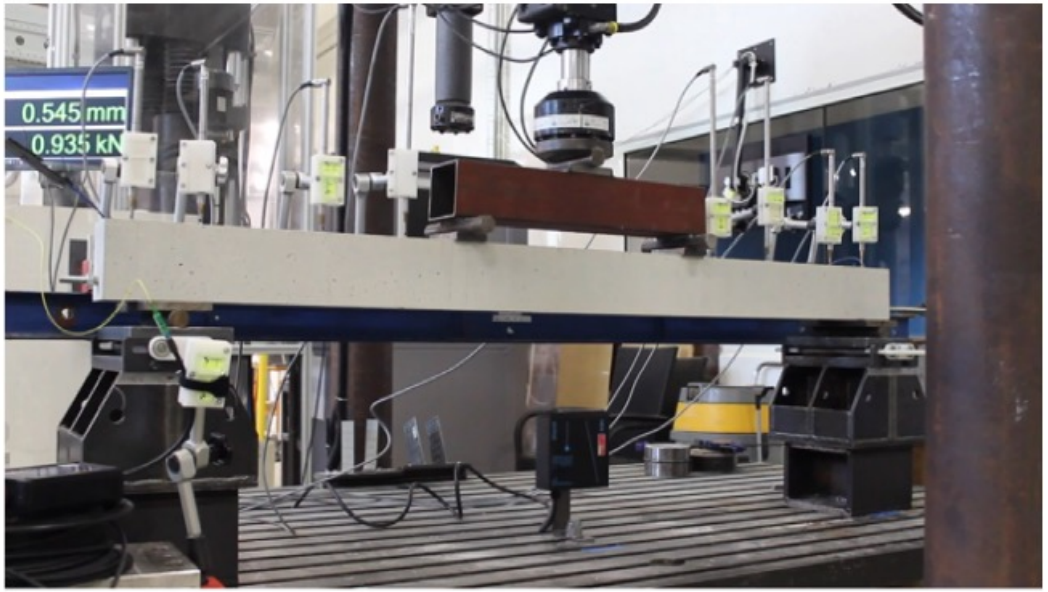
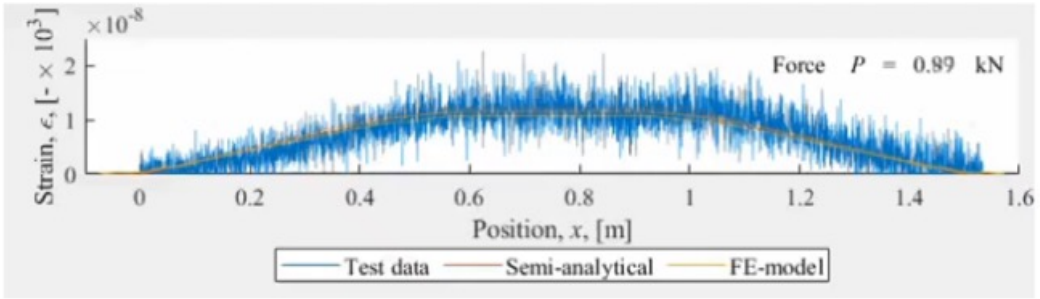
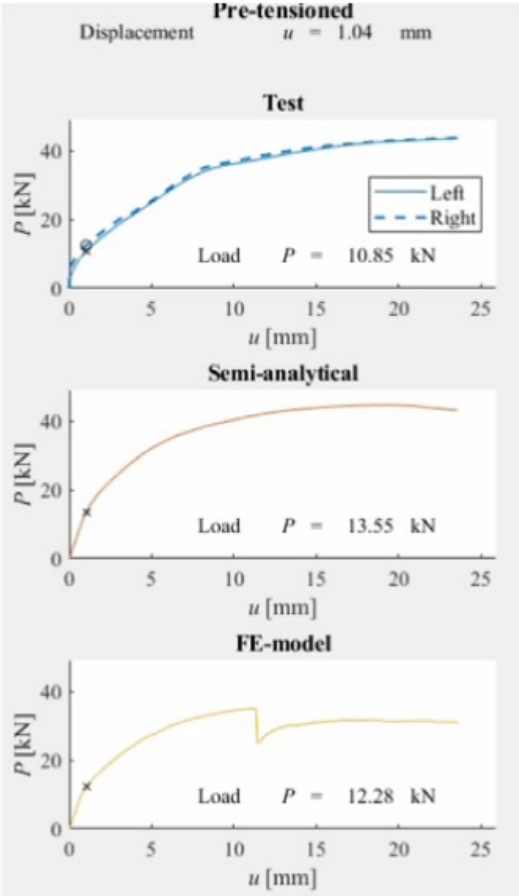
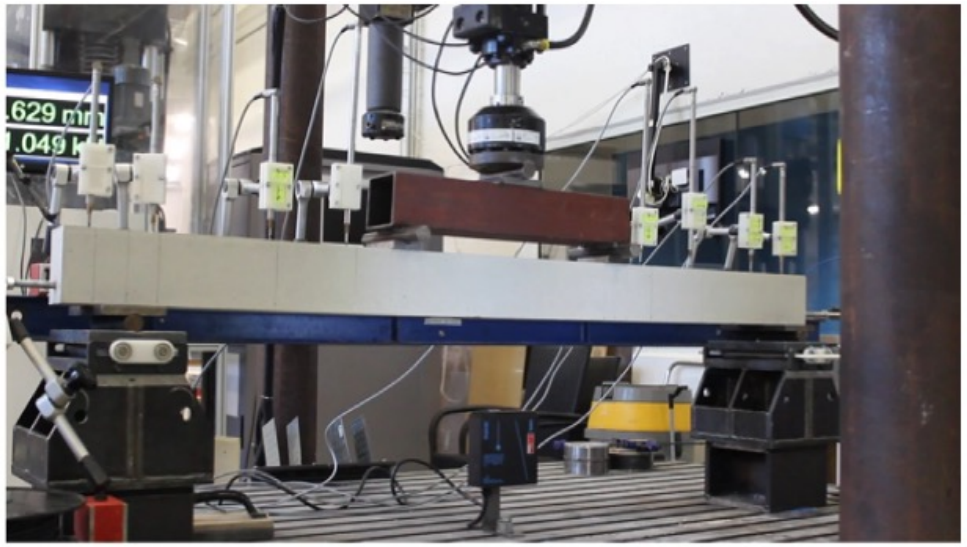


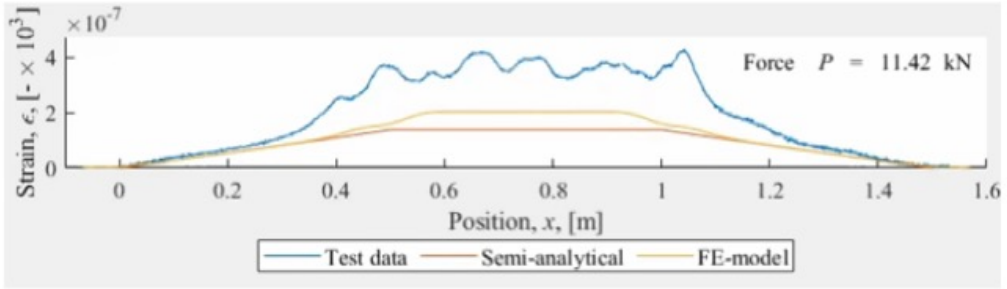




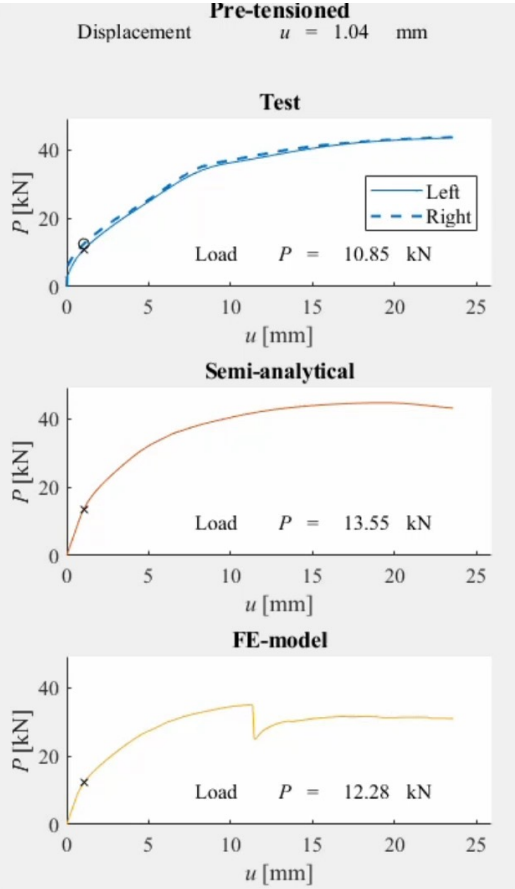
Før-spændt

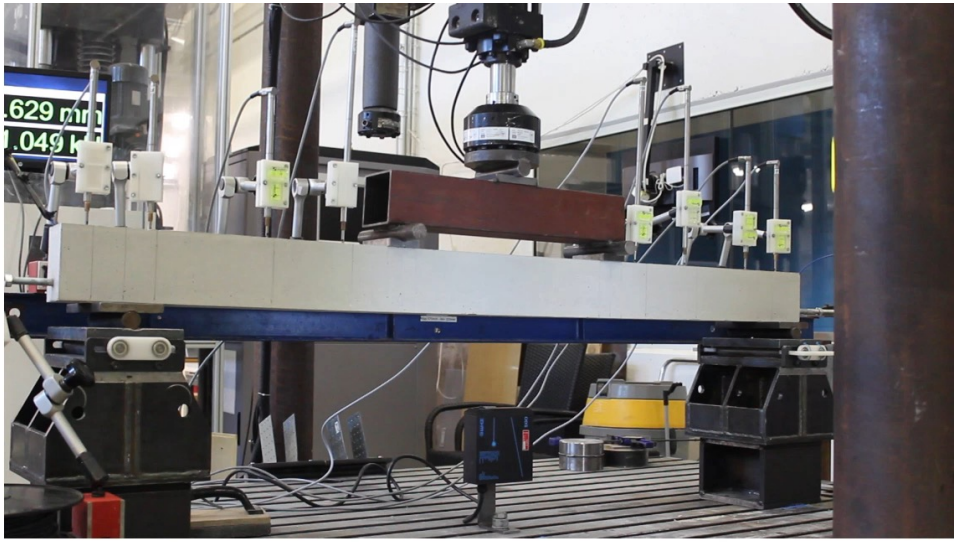

Pre-tensioned
Displacement u = 1.04 mm
Test
P [kN]
u [mm]
Left
Right
Load P = 10.85 kN
Semi-analytical
Load P = 13.55 kN
FE-model
Load P = 12.28 kN

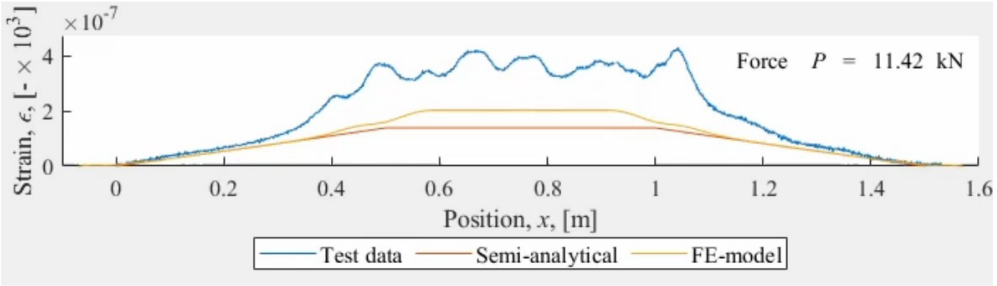



Strain, ϵ, [- × 10^-3]
×10^-7
Force P = 11.42 kN
Position, x, [m]
Test data
Semi-analytical
FE-model

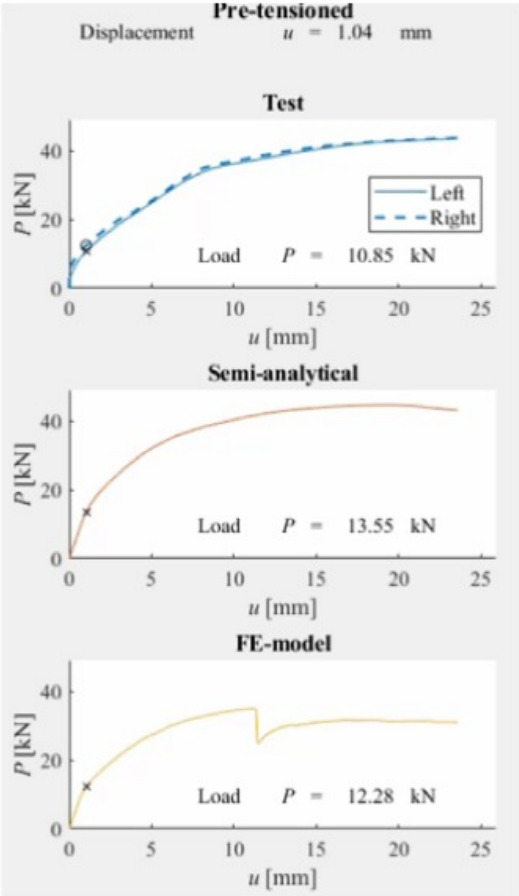
Før-spændt

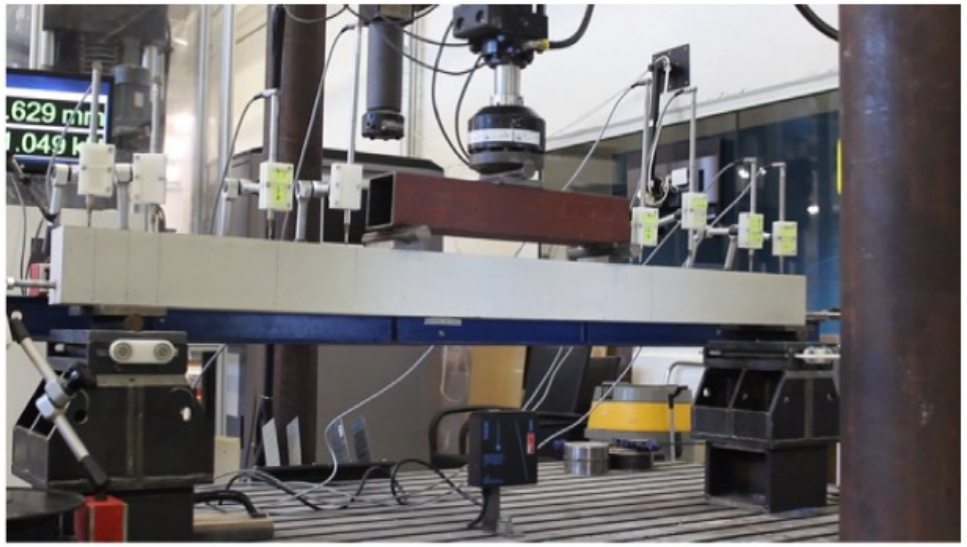

Pre-tensioned
Displacement u = 1.04 mm
Test
P [kN]
u [mm]
Left
Right
Load P = 10.85 kN
Semi-analytical
Load P = 13.55 kN
FE-model
Load P = 12.28 kN

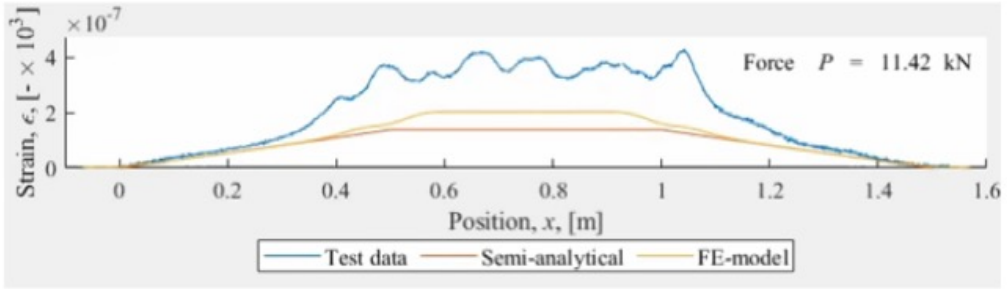



×10^-7
Strain, ϵ, [- × 10^3]
Force P = 11.42 kN
Position, x, [m]
Test data
Semi-analytical
FE-model

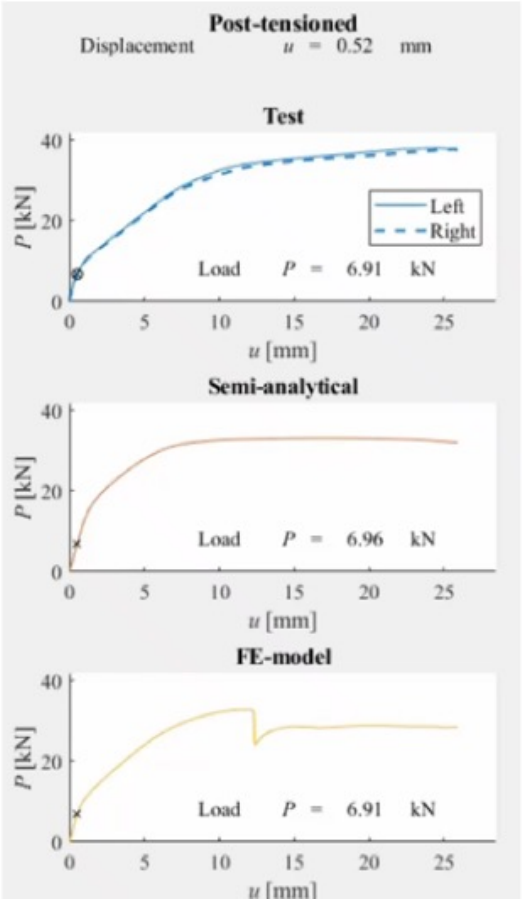
Før-spændt

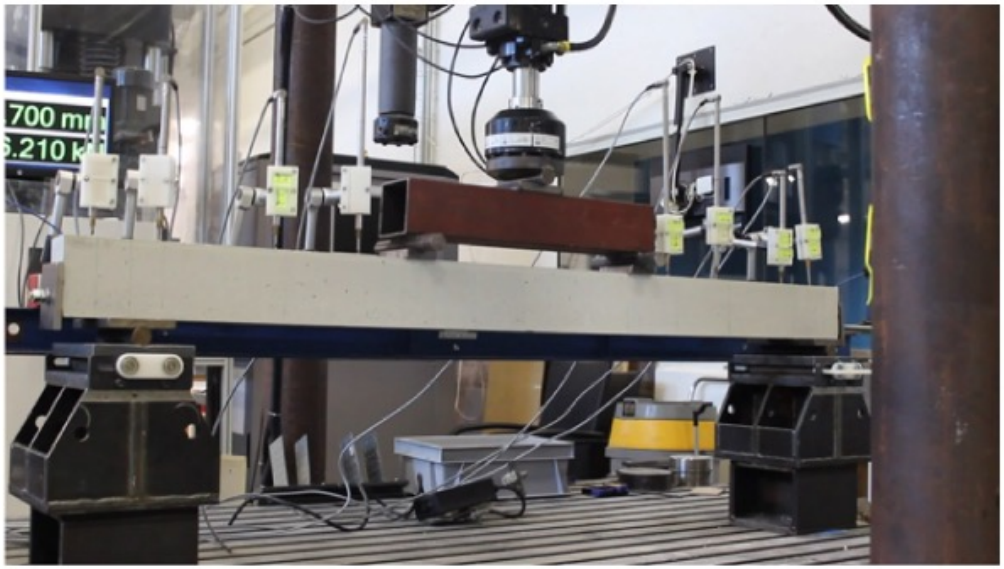

Pre-tensioned
Displacement u = 1.04 mm
Test
P [kN]
u [mm]
Left
Right
Load P = 10.85 kN
Semi-analytical
Load P = 13.55 kN
FE-model
Load P = 12.28 kN

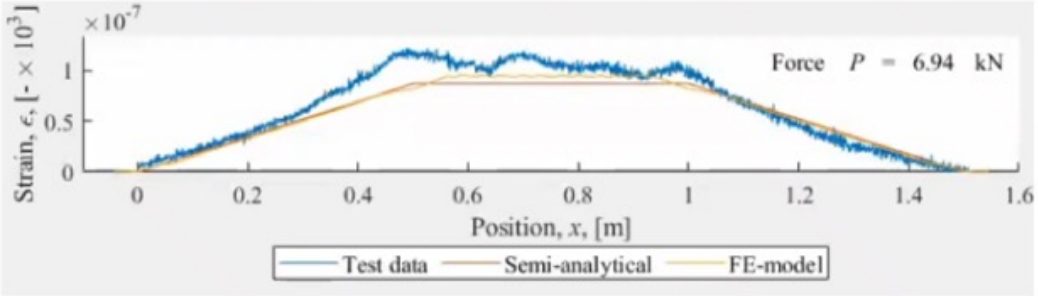



Strain, ϵ, [- × 10^-3]
×10^-7
Force P = 11.42 kN
Position, x, [m]
Test data
Semi-analytical
FE-model

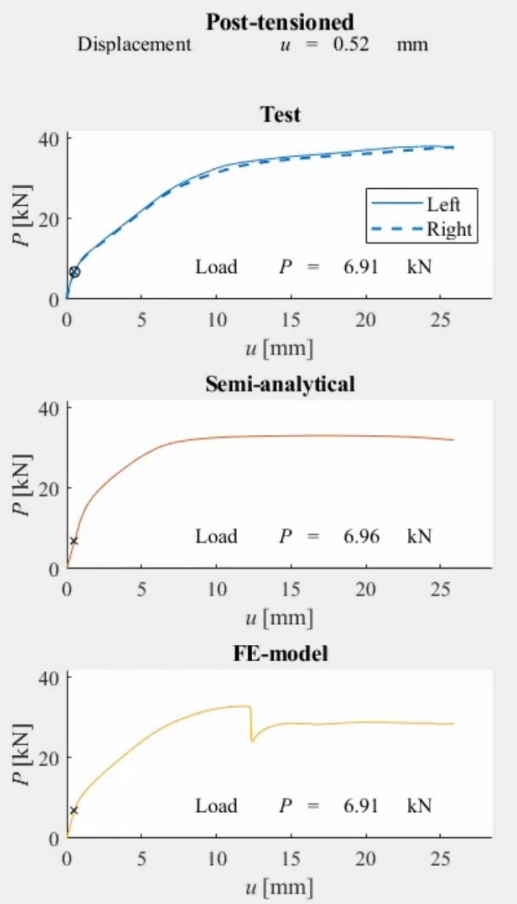
Efter-spændt

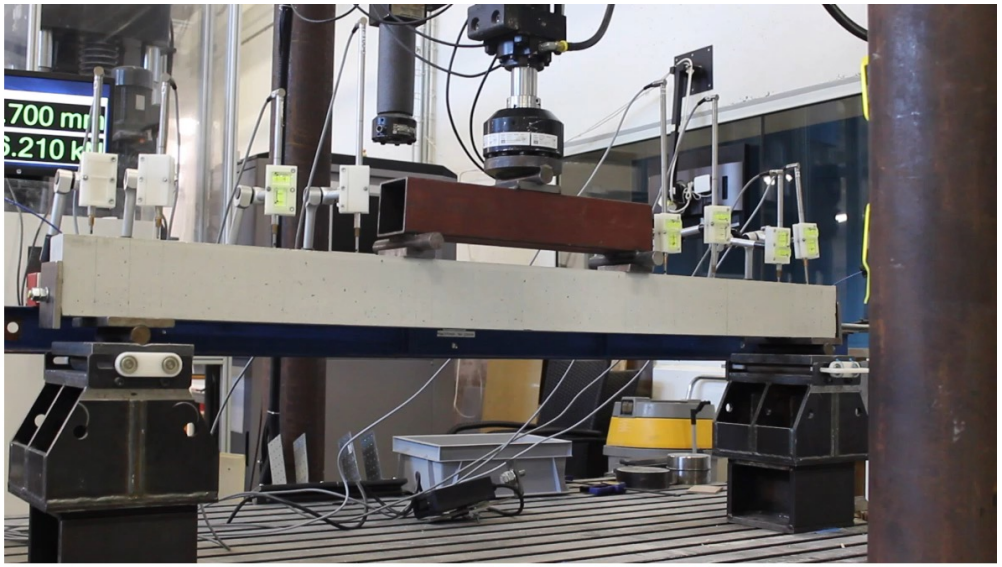


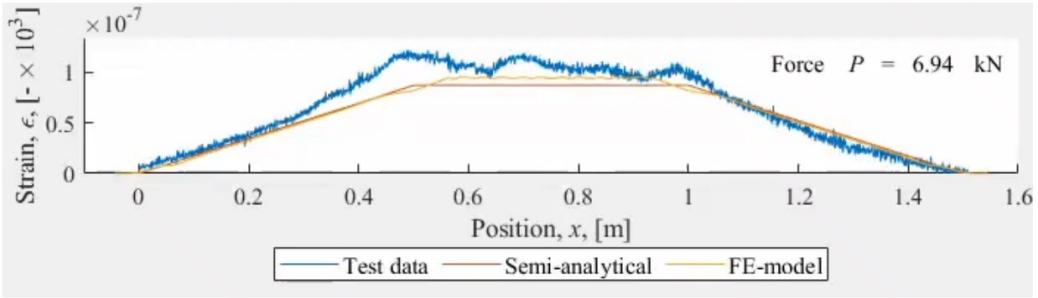




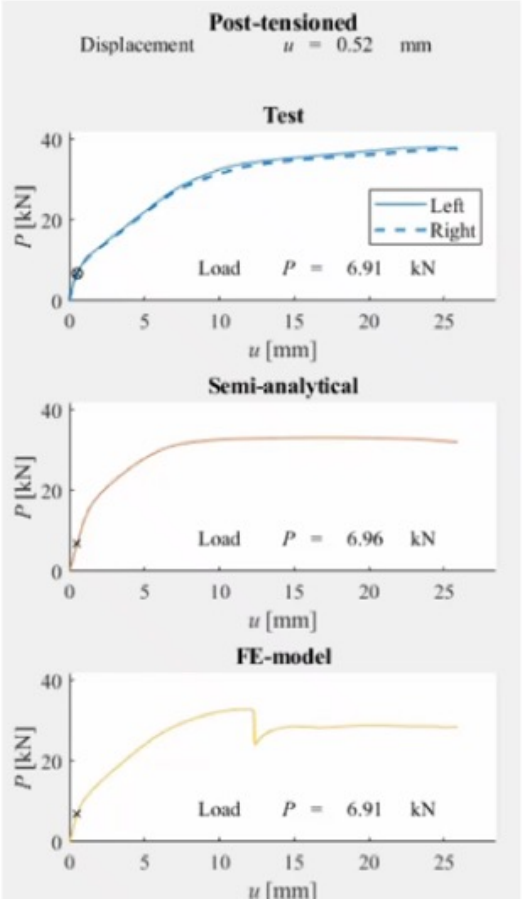
Efter-spændt

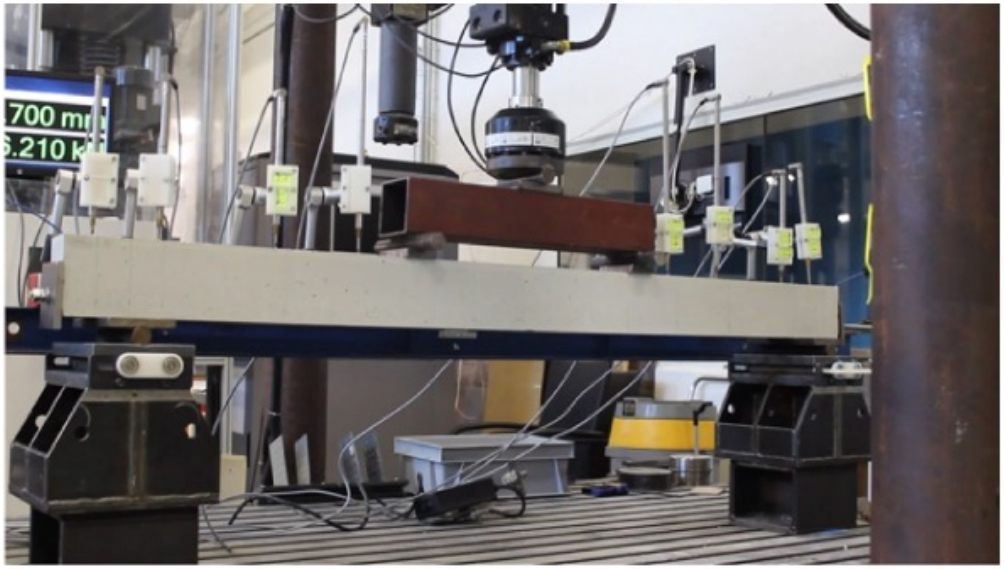


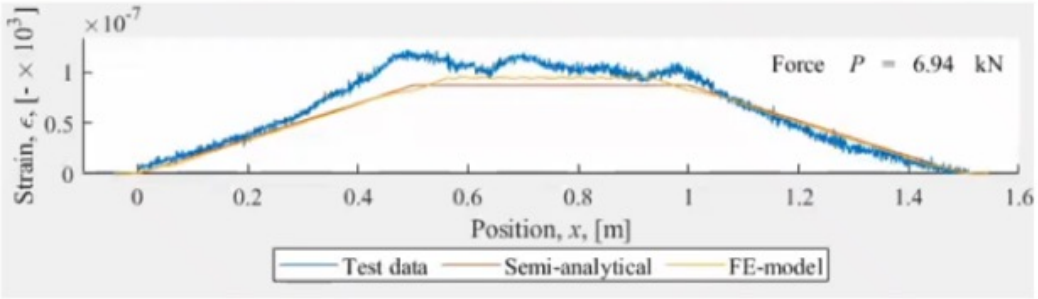




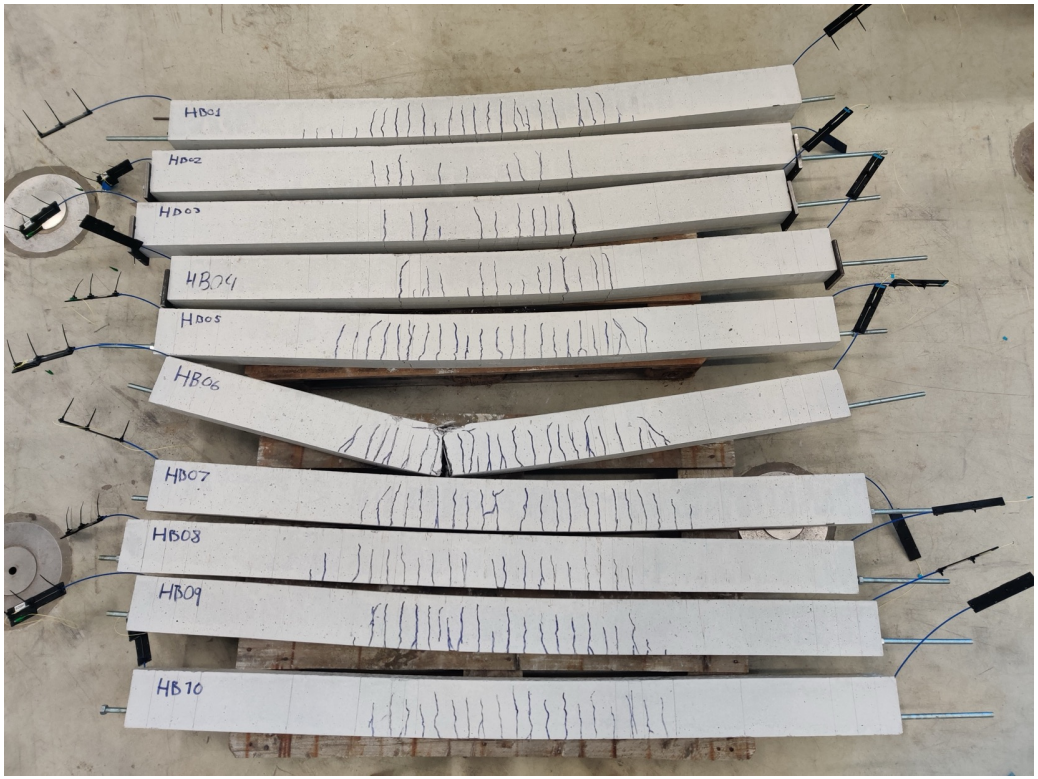
Efter-spændt



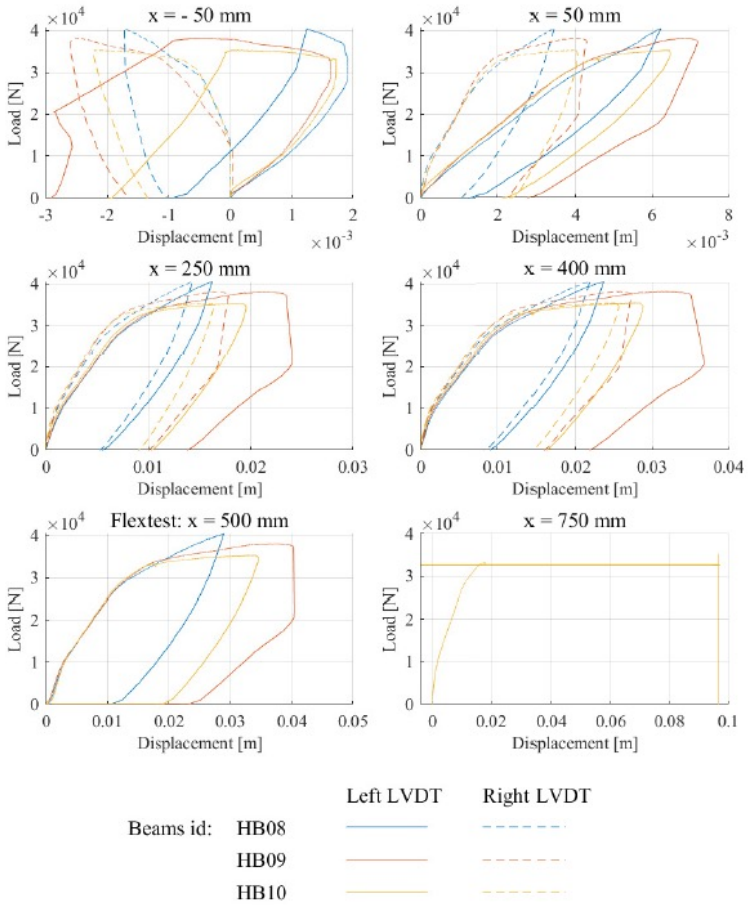


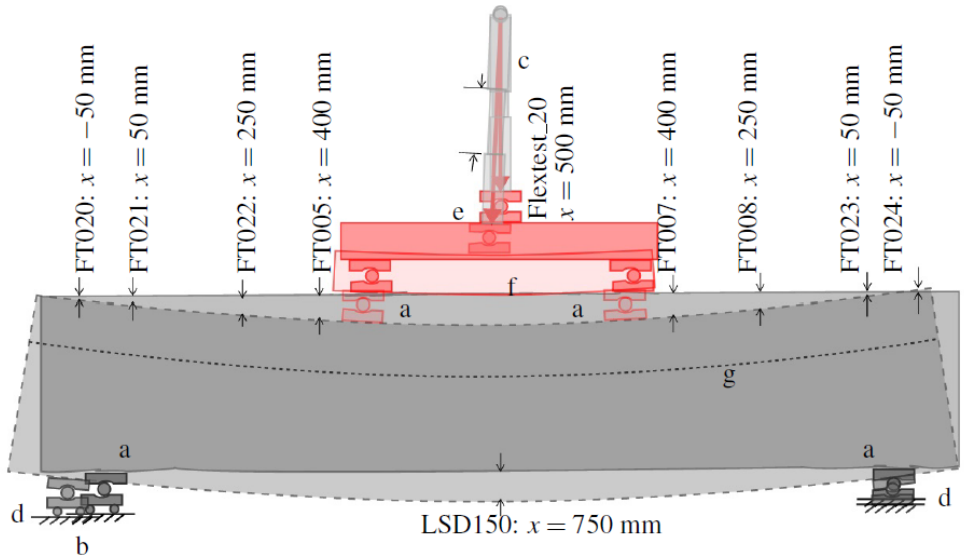


Revnemønster

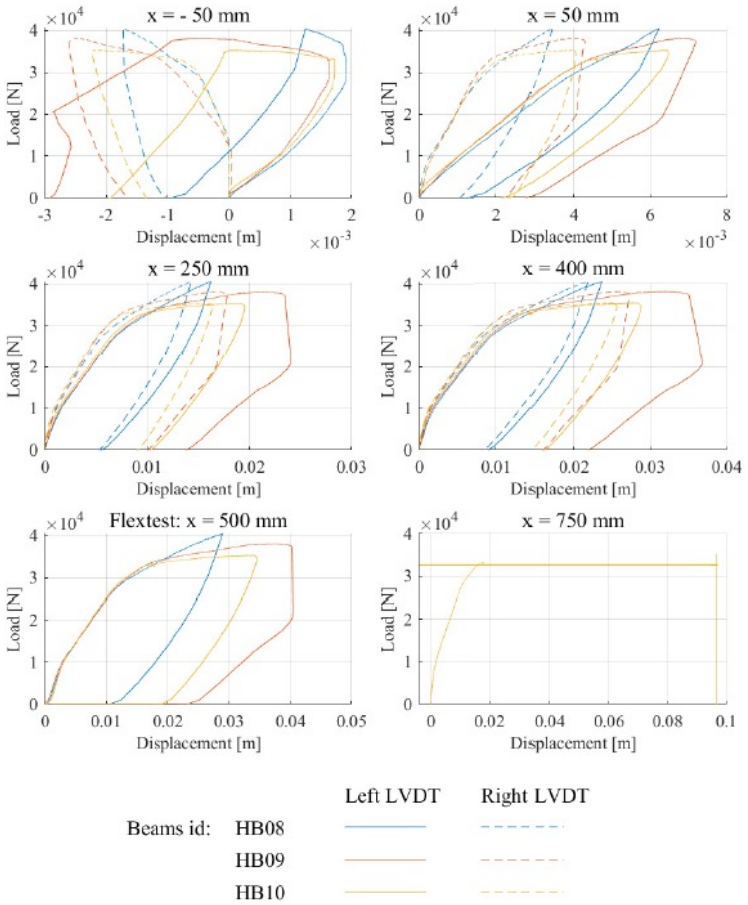


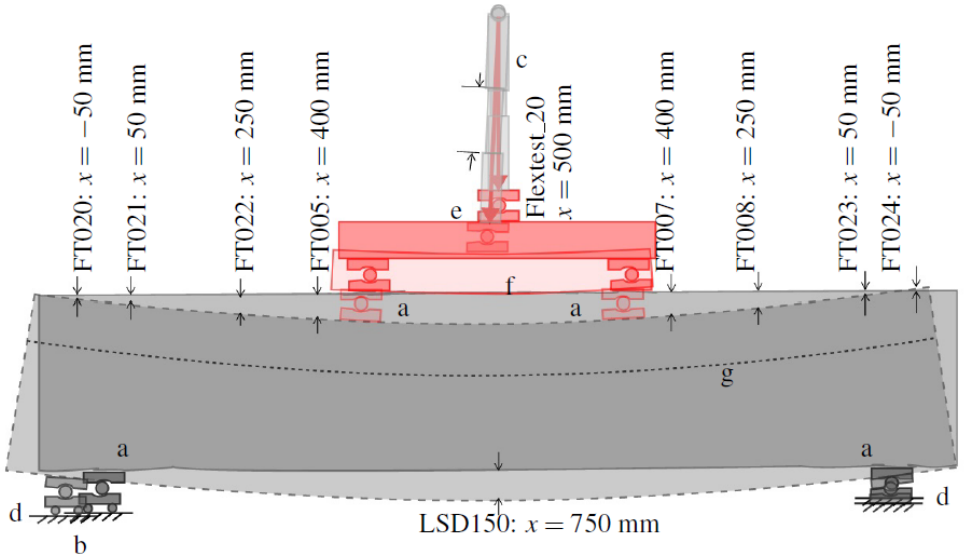
Optaget data



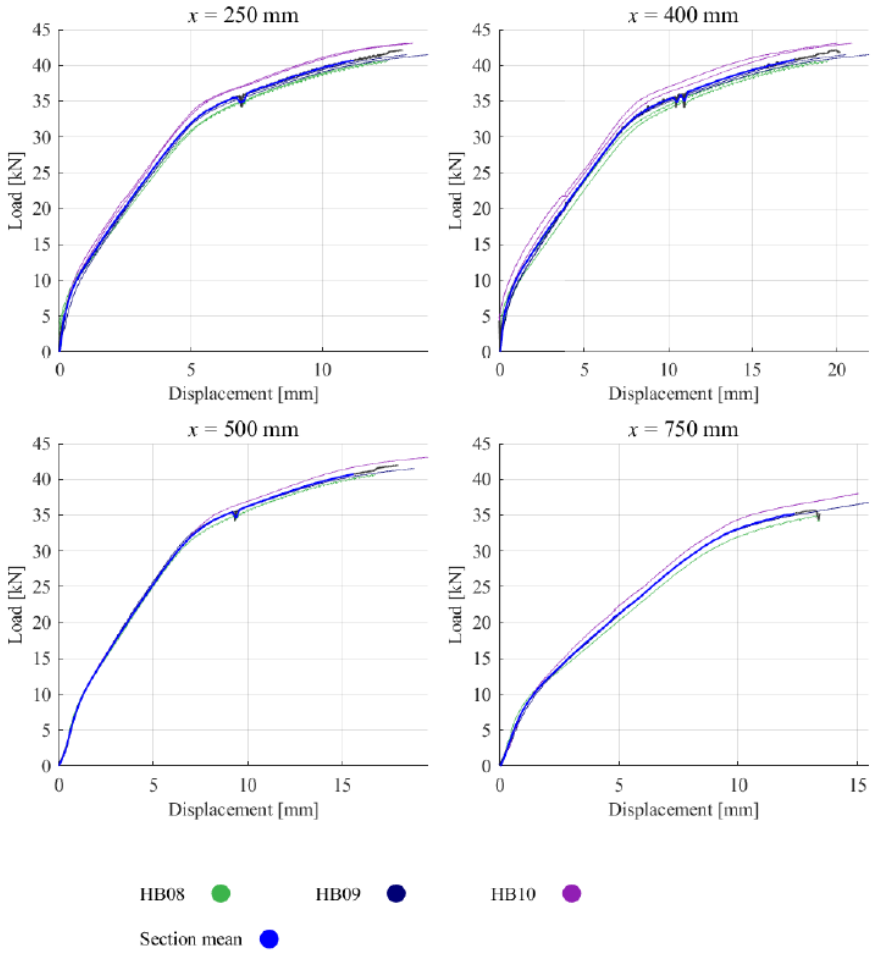


Optaget data

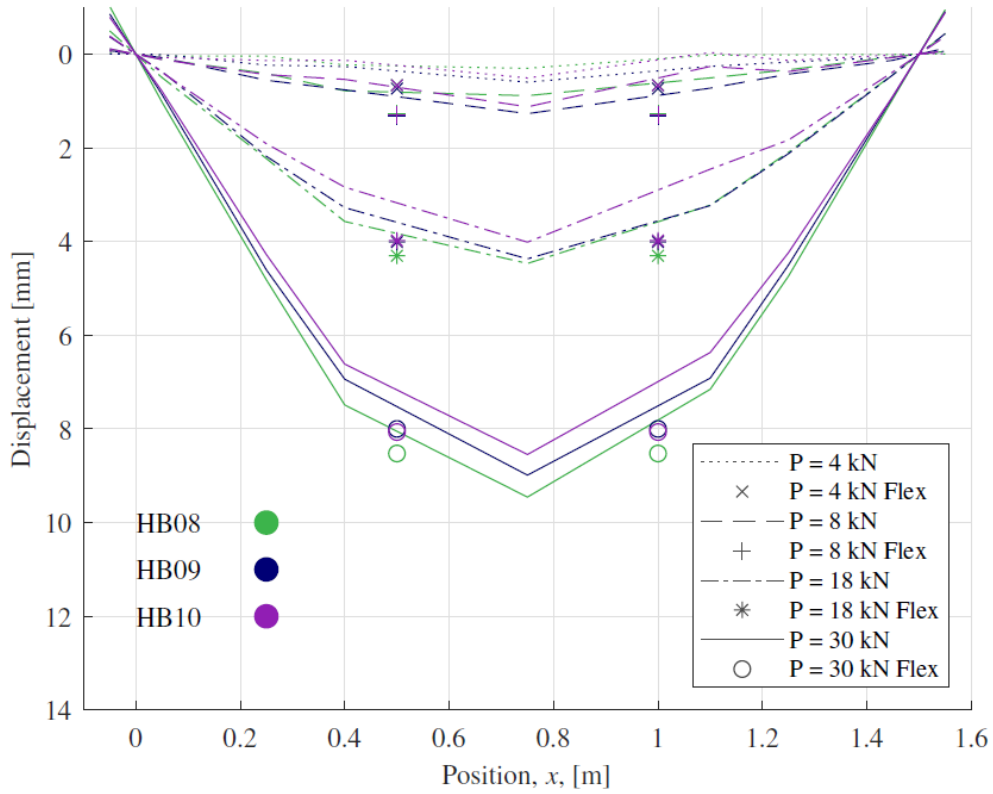




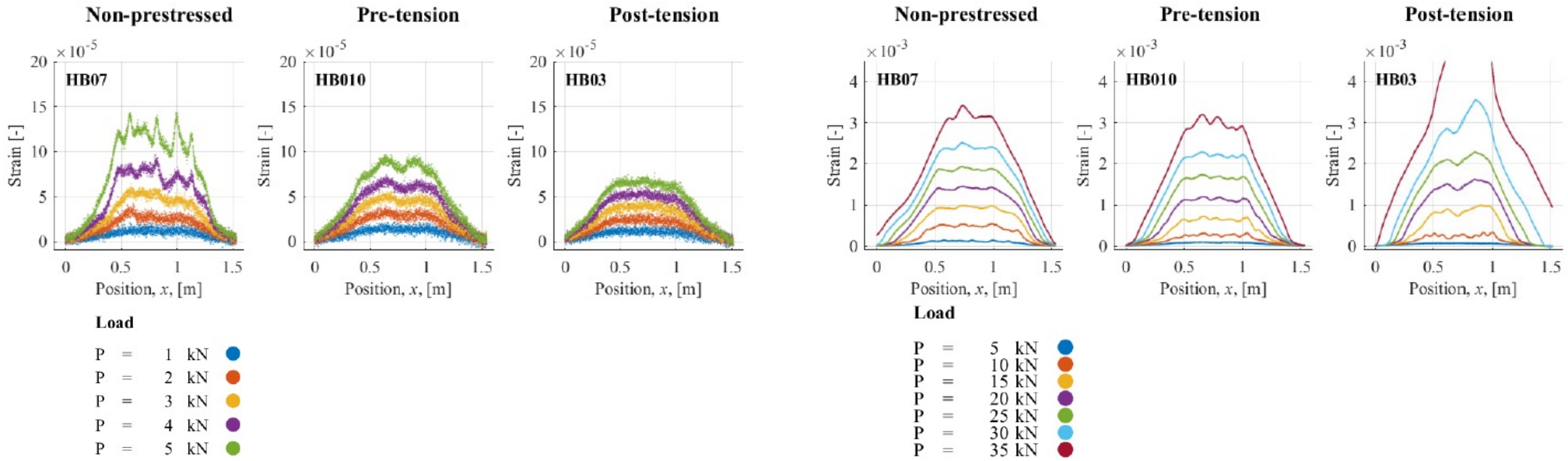
Arbejdskurve



Deformationsfigur

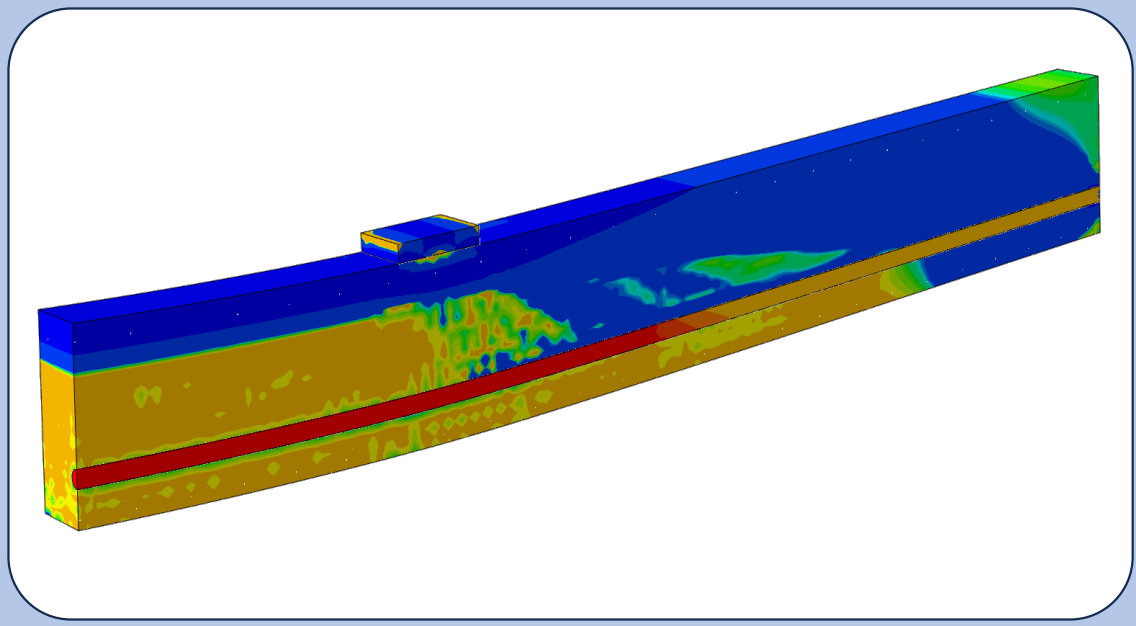


Tøjningsfordeling



Finit element-metoden

- Concrete Damaged Plasticity
- Elementer
- Randbetingelser
- Resultater
- Parameter studie



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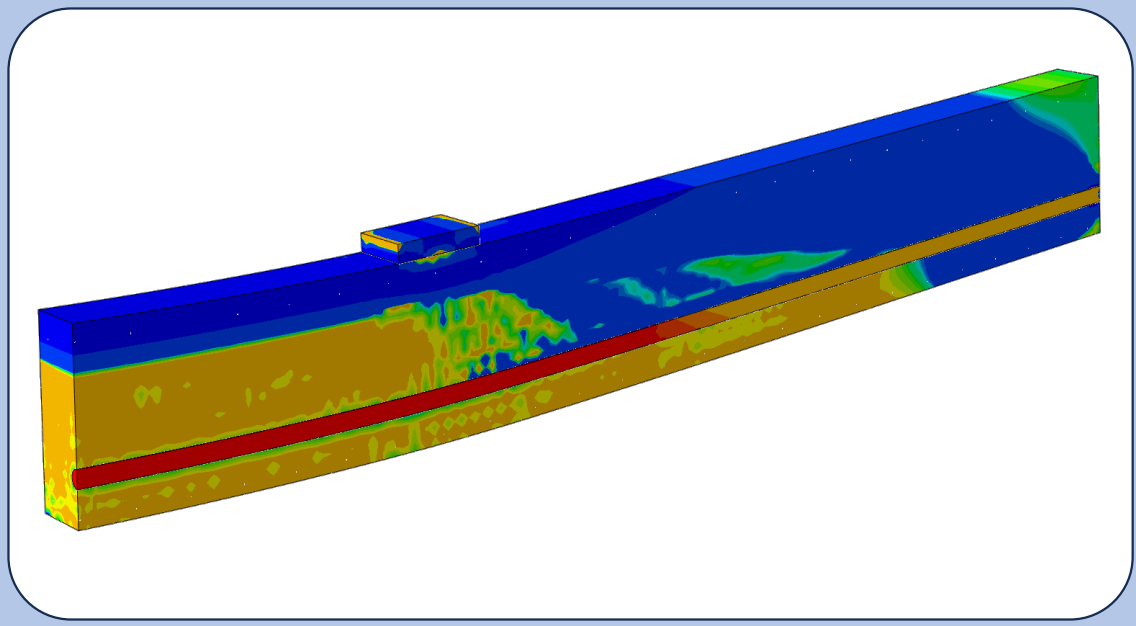
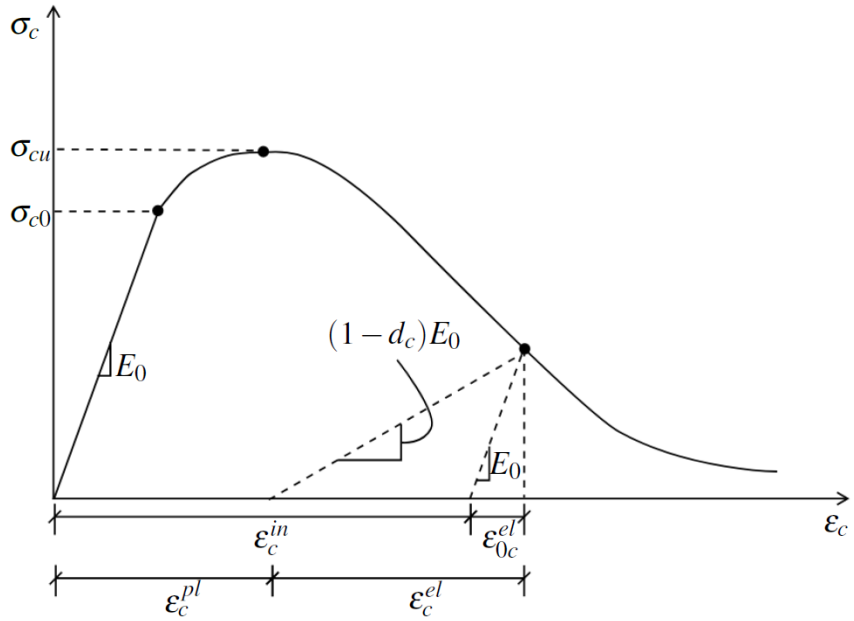
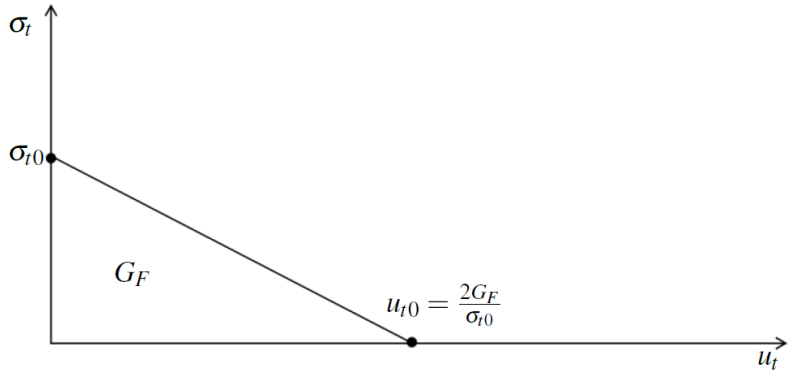
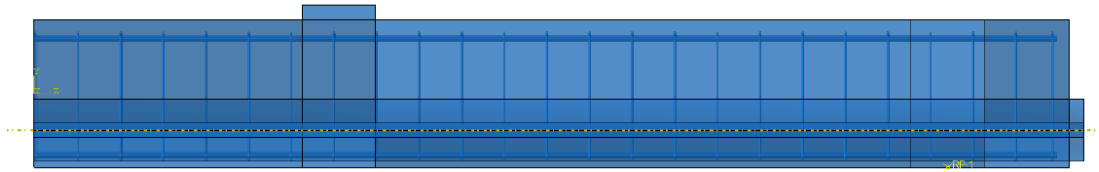


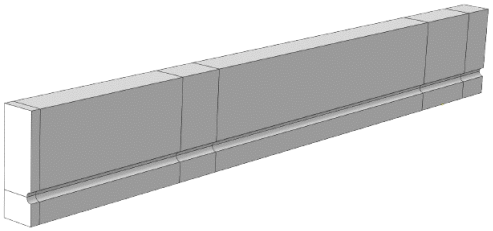
Concrete Damaged Plasticity

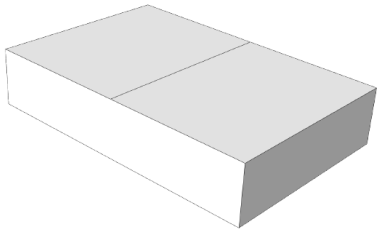


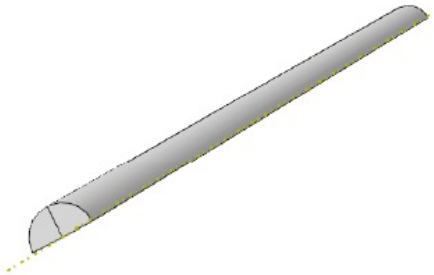


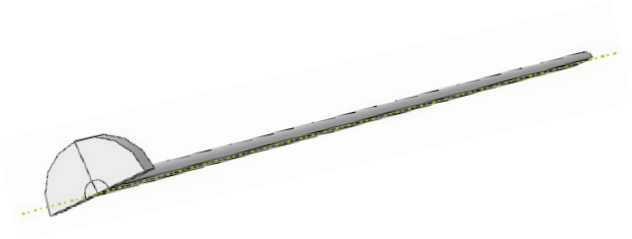
Elementer



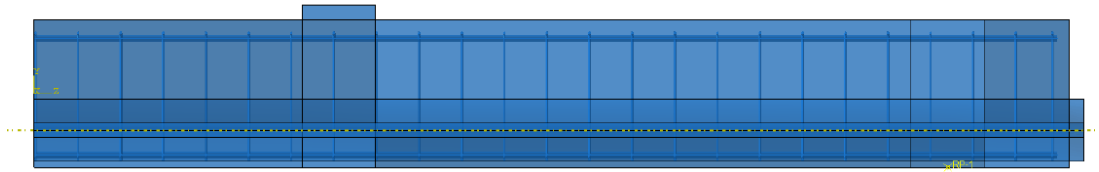


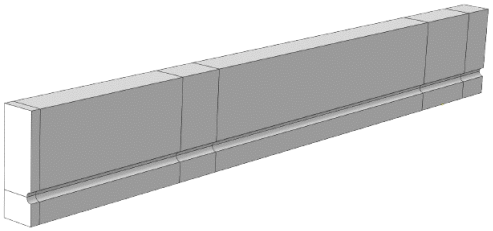


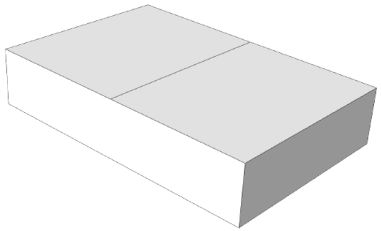


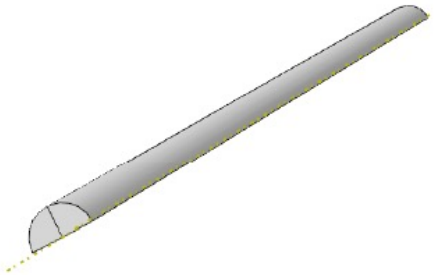


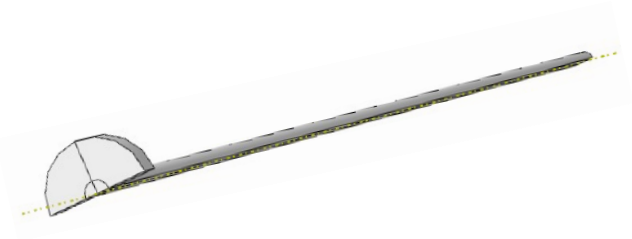
Elementer



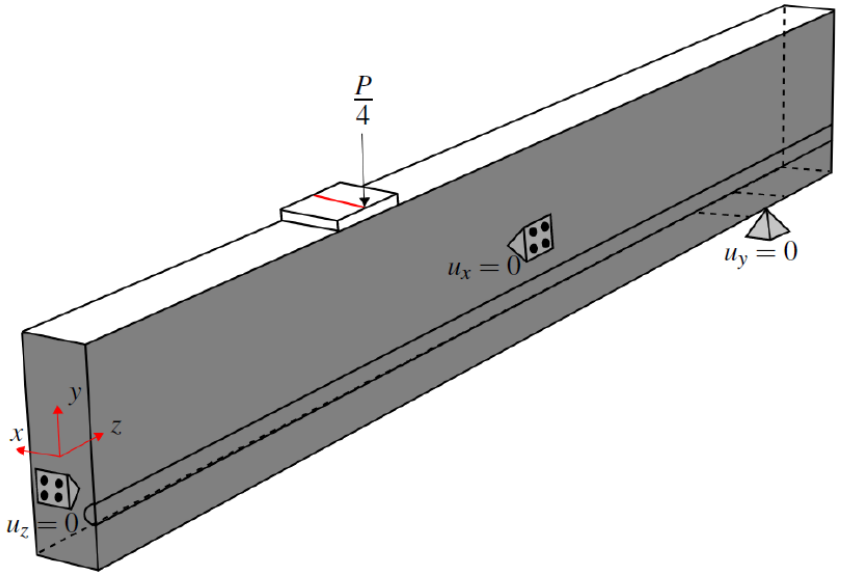




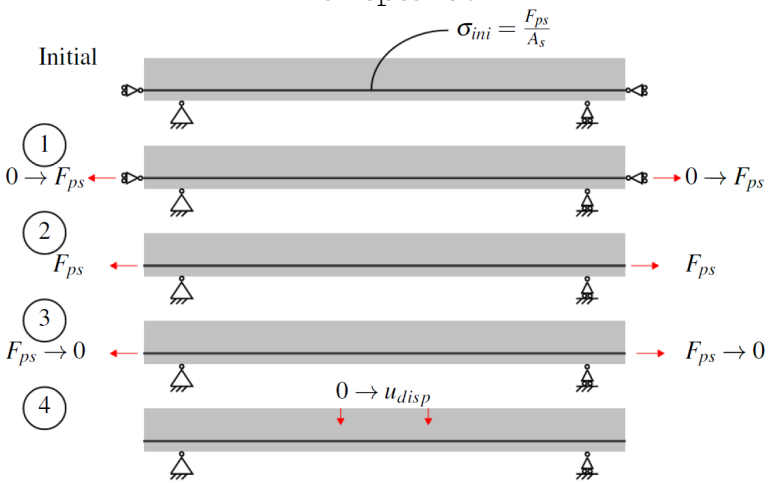




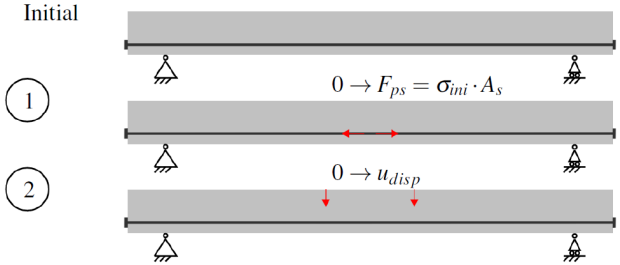
Randbetingelser



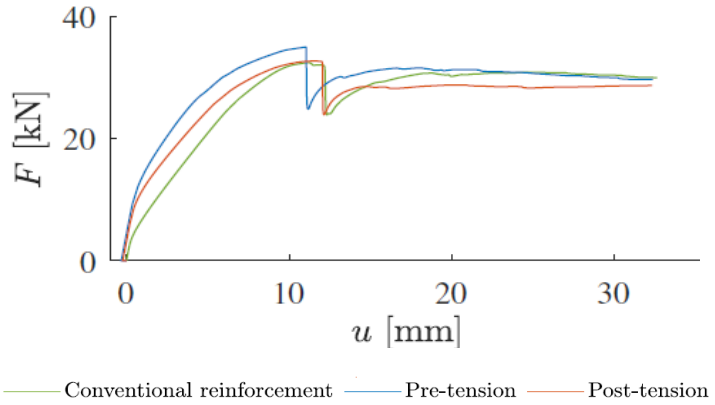
Før-spændt



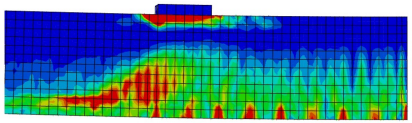
Efter-spændt



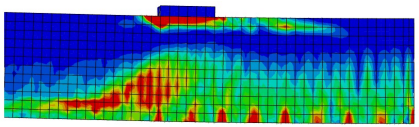
Resultater

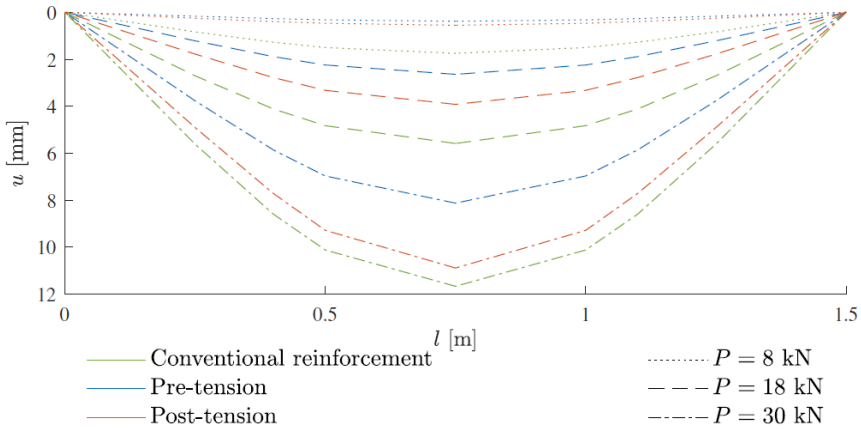


Før fald i last



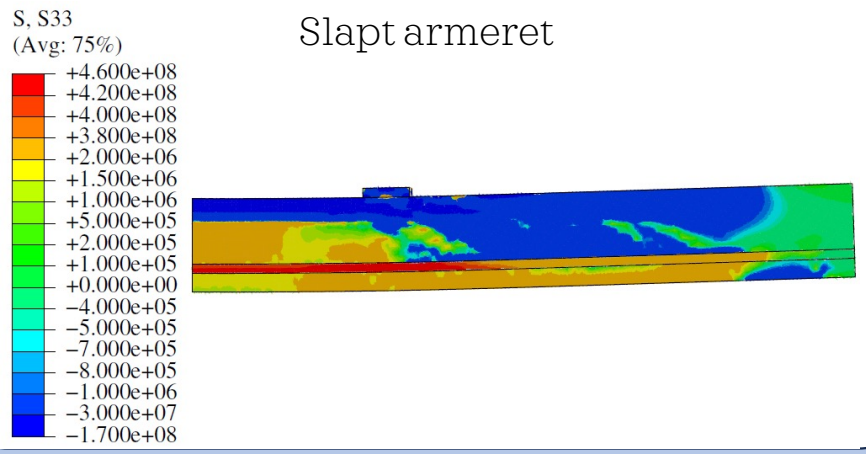
Efter fald i last



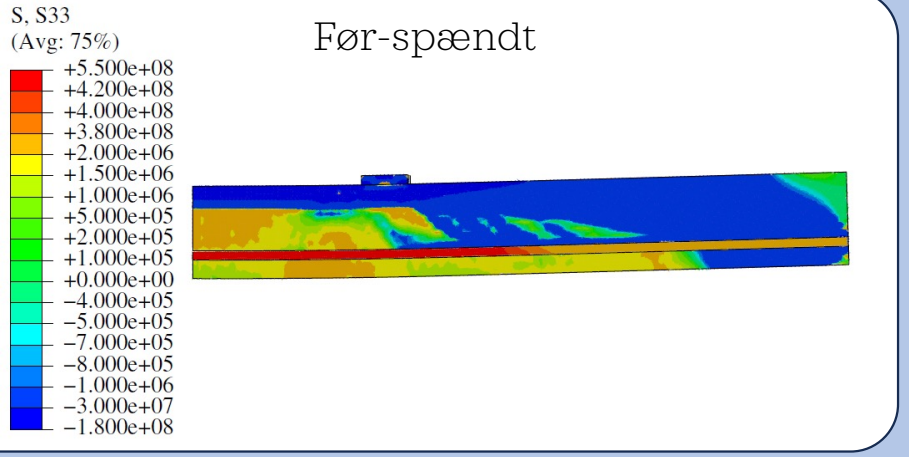


Spændinger i længde retningen

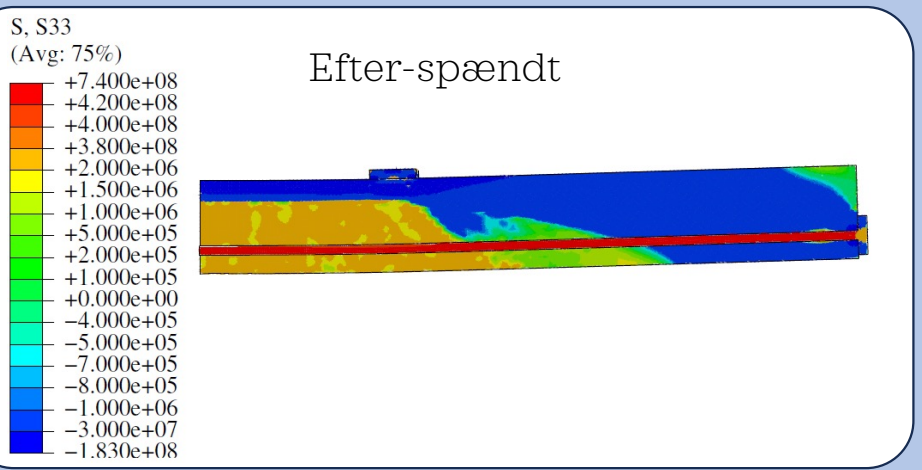
Slapt armeret



Før-spændt

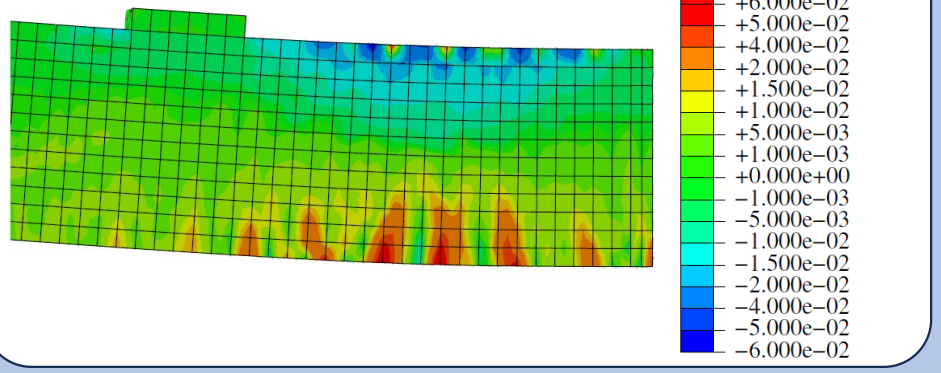


Efter-spændt



Tøjninger i længde retningen

Slapt armeret



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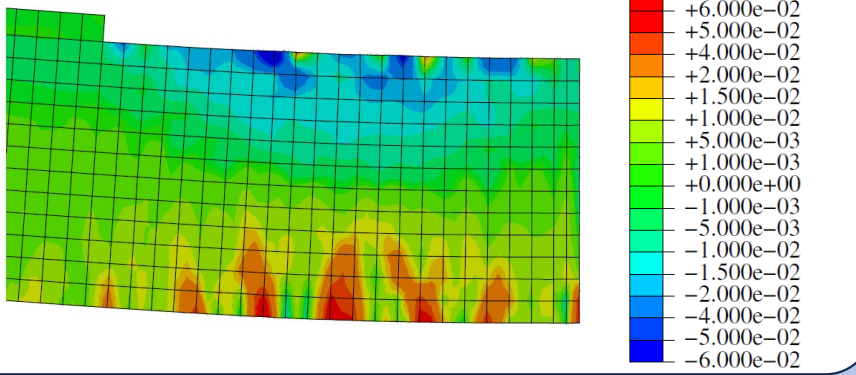
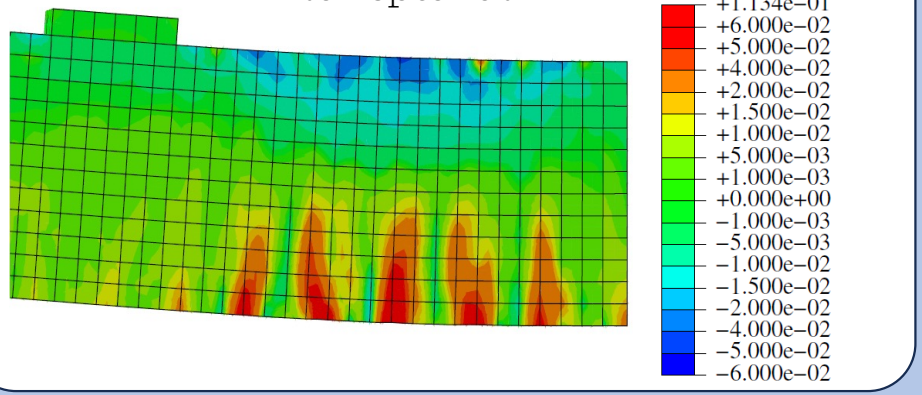
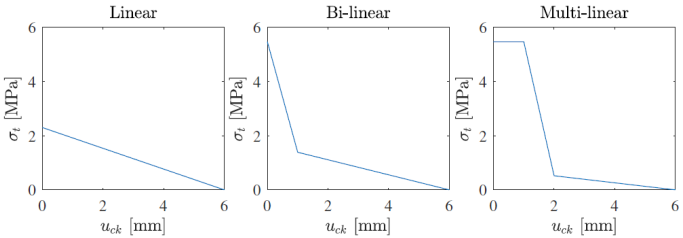
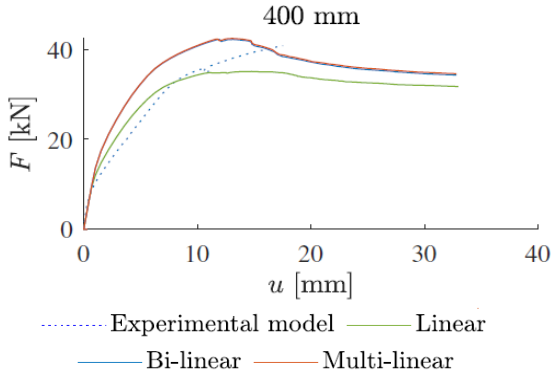


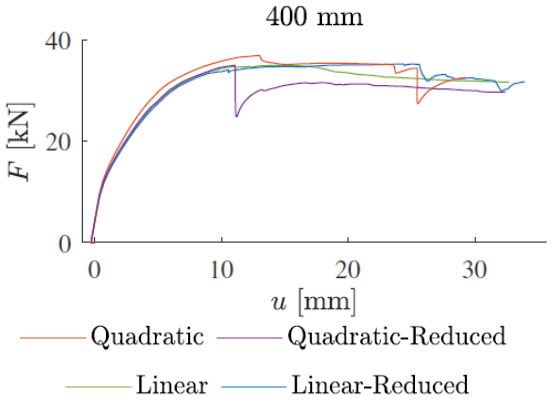
Efter-spændt

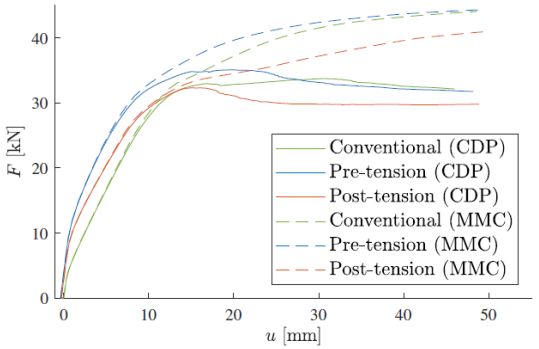


Parameter studie



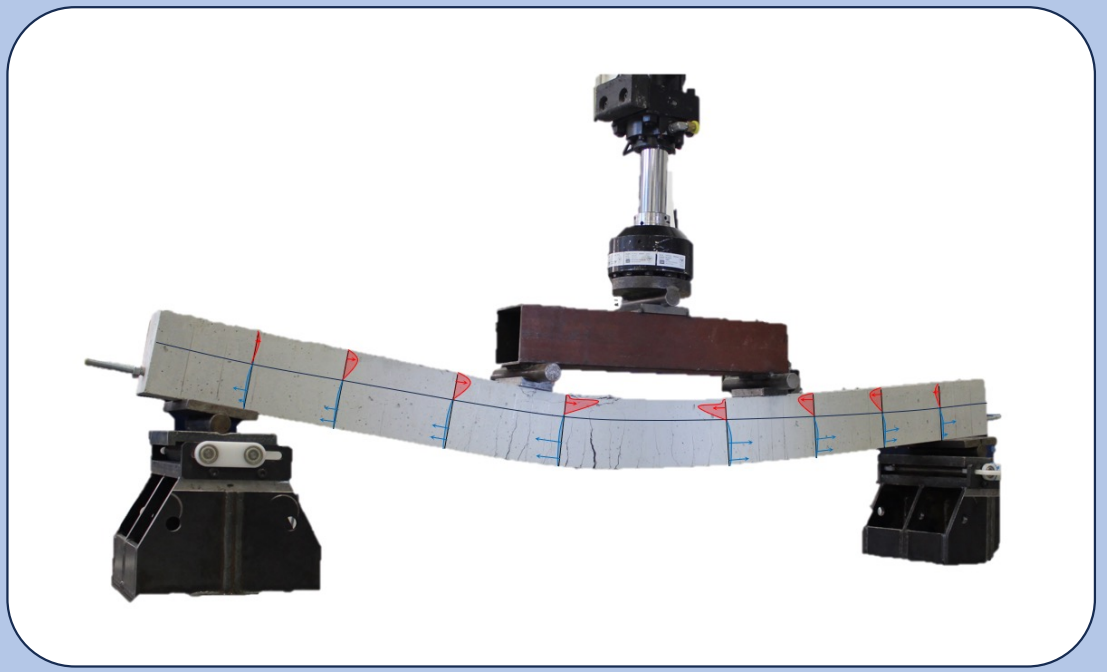






Semi-analytisk model

- Idé og forudsætninger
- Beregningsgang
- Moment-krumnings relationen
- Virtuelt arbejdes princip
- Modellering af træk
- Output



Semi-analytisk model

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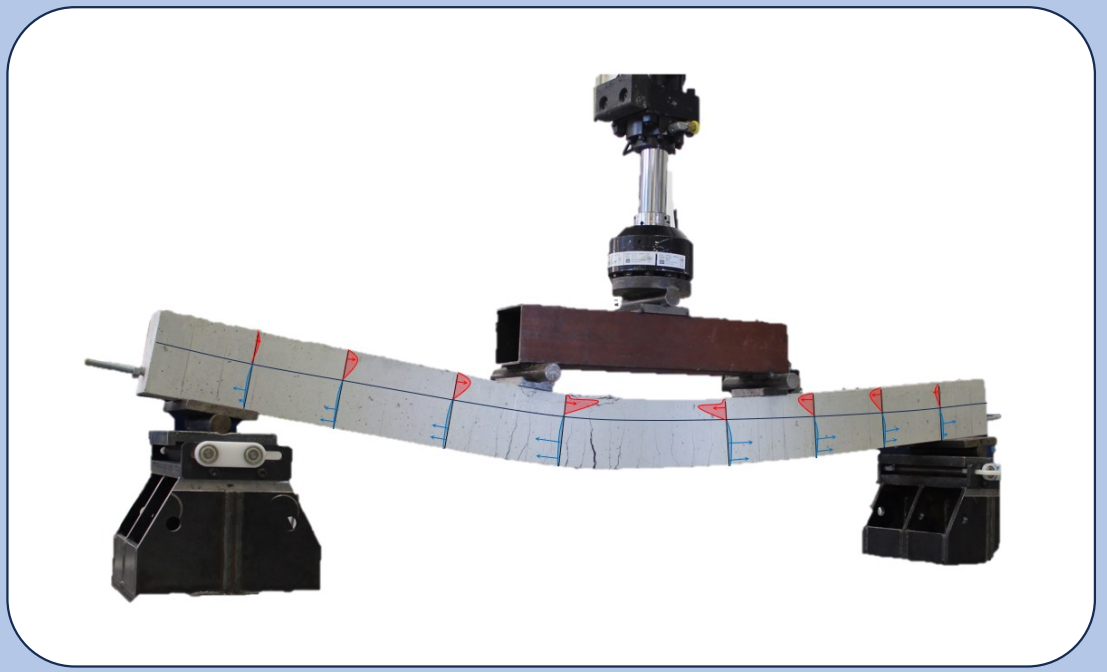
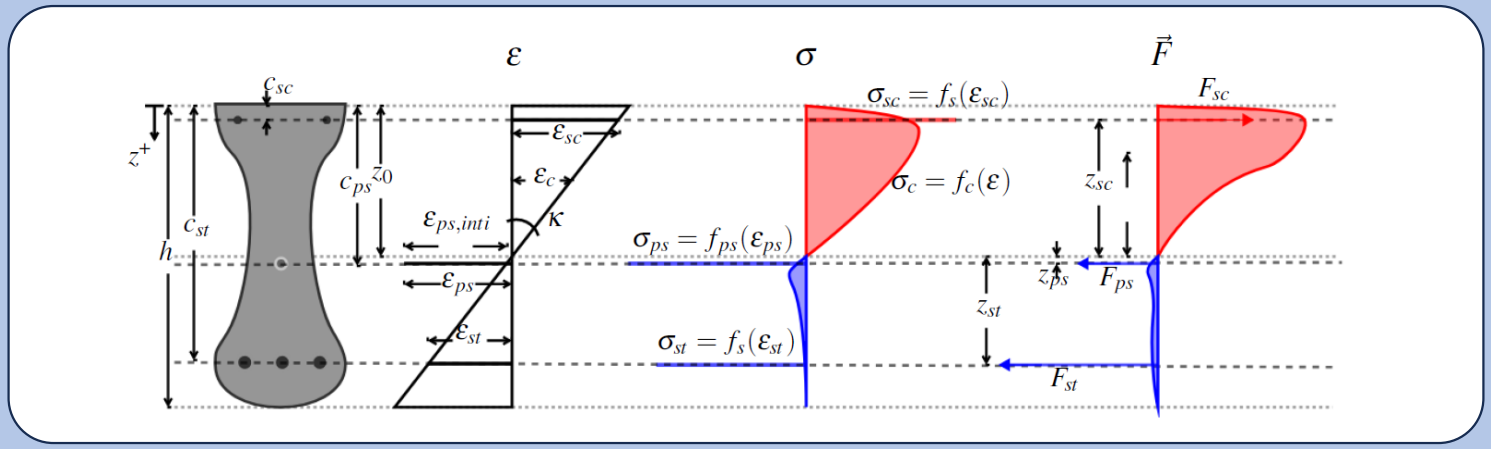
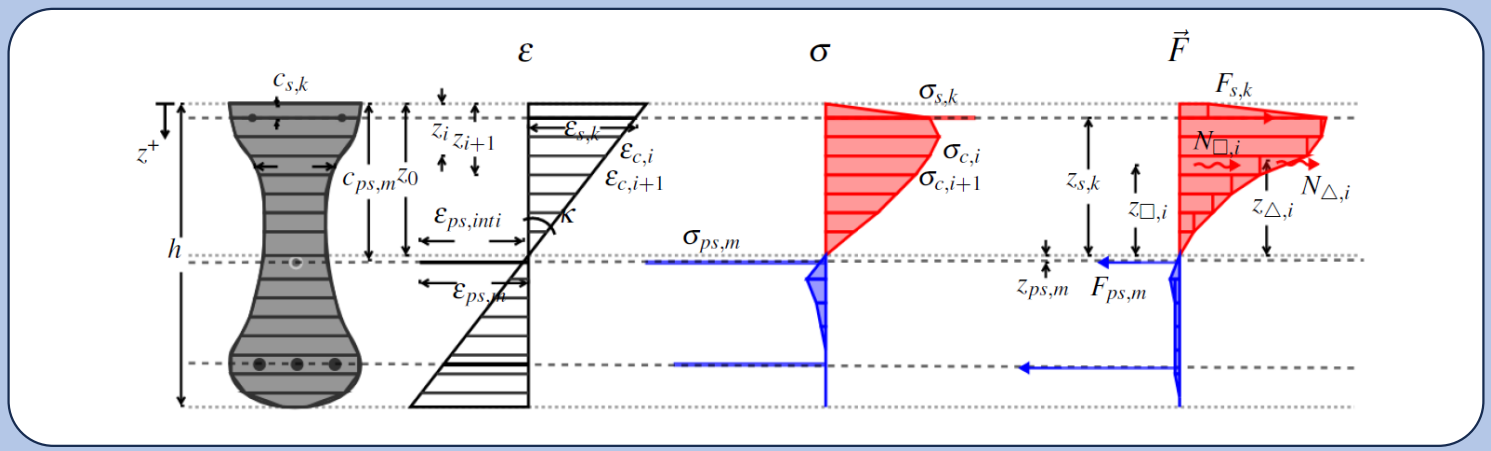
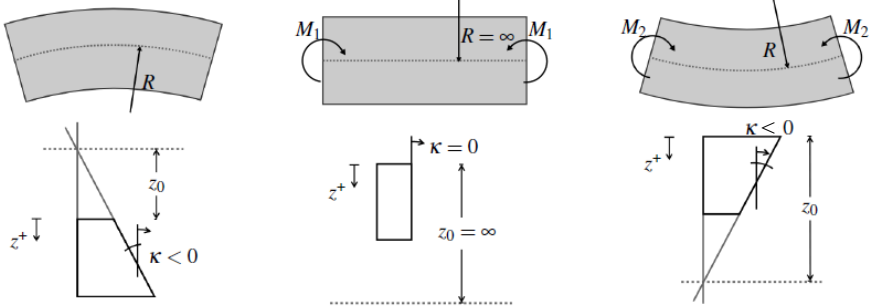


Idé og forudsætninger

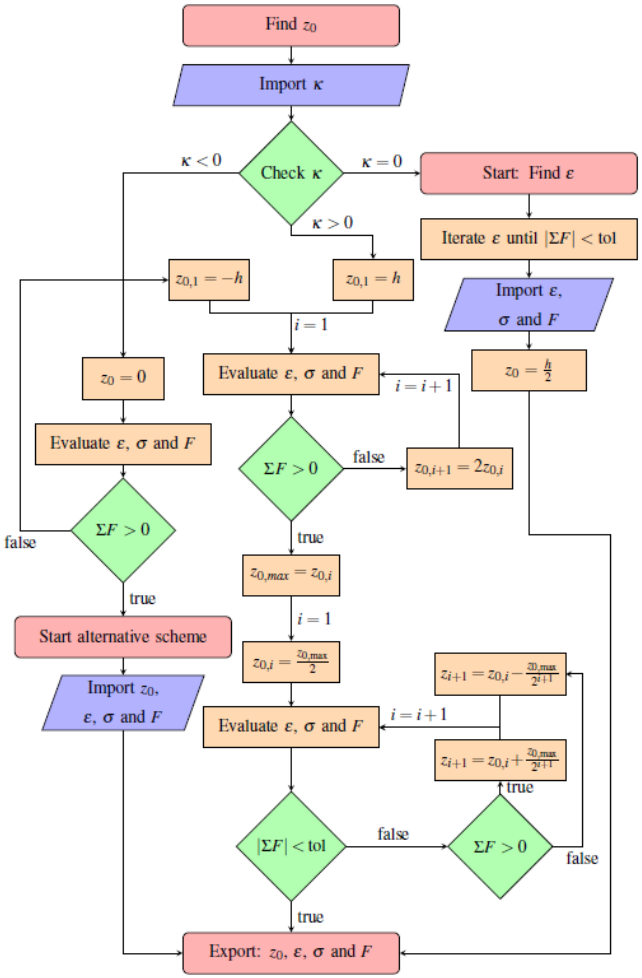




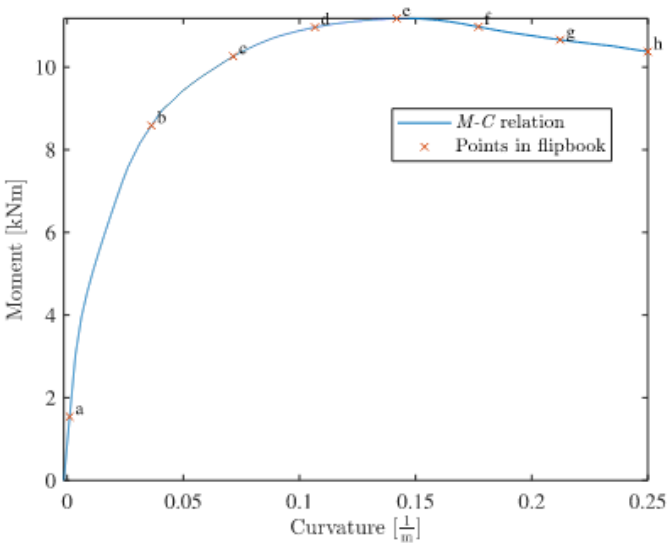
Beregningsgang

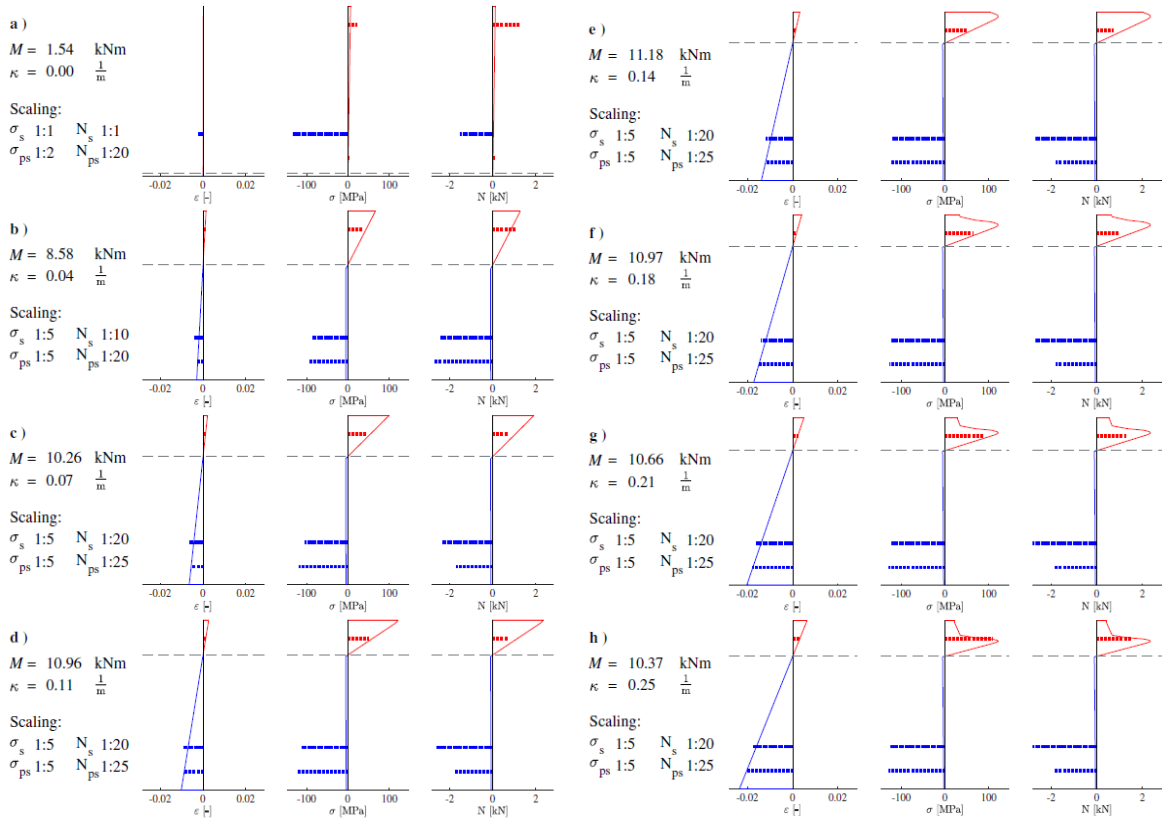


(a) $z_0 < 0$ (b) $z_0 = \infty$ (c) $z_0 > 0$

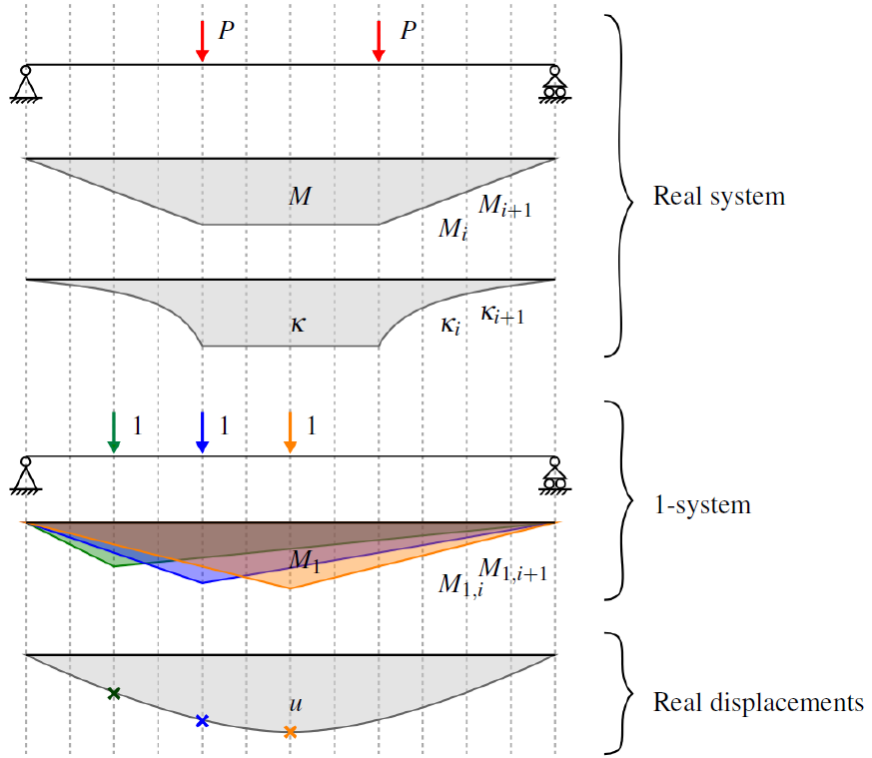


Moment-krumnings relationen





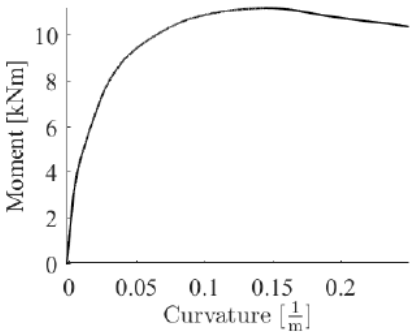
Virtuelt arbejdes princip

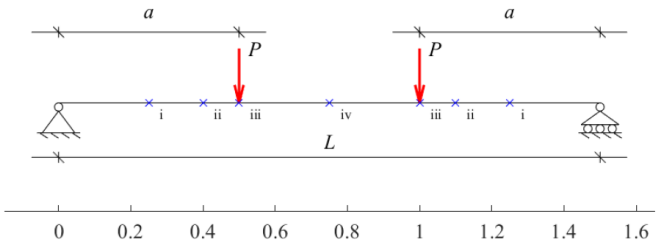


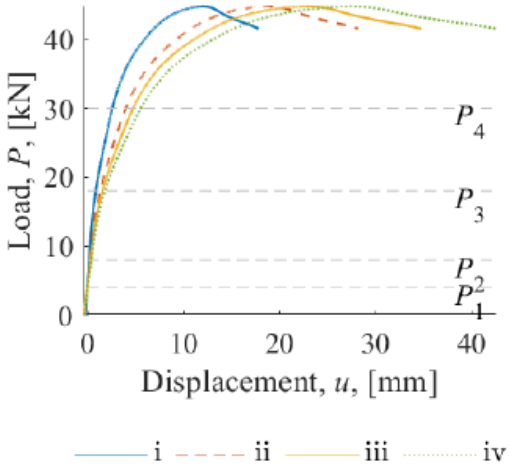
$$uP_1 = \int_L M_1(x)\kappa(x)\mathrm{d}x$$

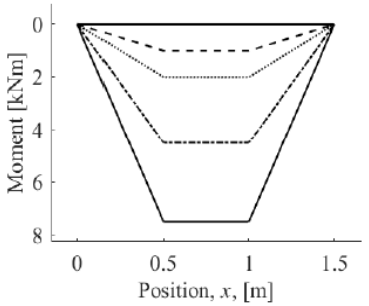
$$u_j P_{1,j} = \sum_{i=1}^{n-1} \frac{M_{1,i} + M_{1,i+1}}{2} \frac{\kappa_i + \kappa_{i+1}}{2} \Delta x$$

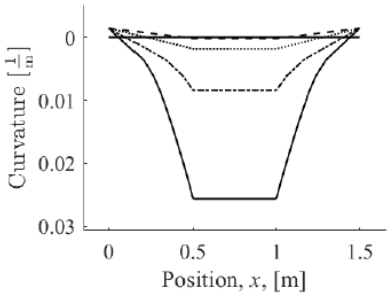
Output

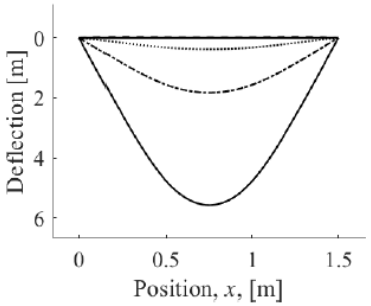

Moment [kNm]
Curvature [1/m]

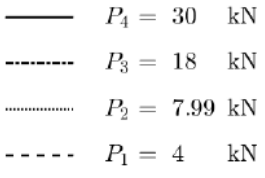

a
a
P
P
i
ii
iii
iv
iii
ii
i
L
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6


Load, P, [kN]
Displacement, u, [mm]
P4
P3
P2
P1
i
ii
iii
iv

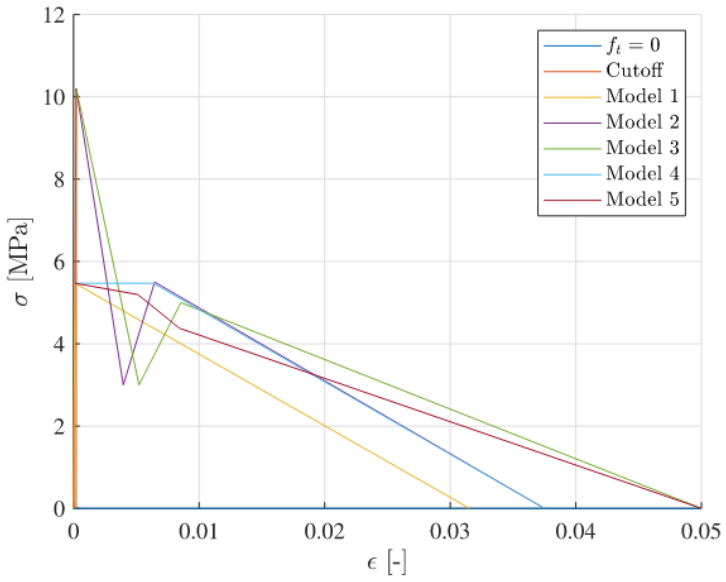

Moment [kNm]
Position, x, [m]

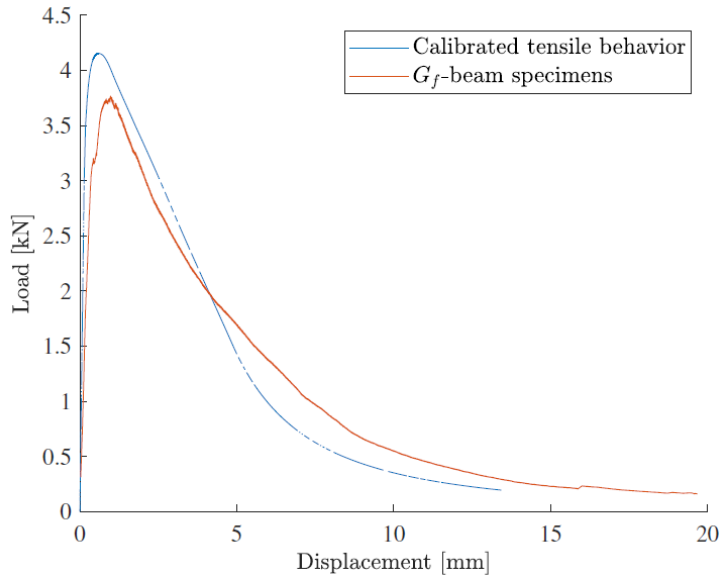

Curvature [1/m]
Position, x, [m]


Deflection [m]
Position, x, [m]

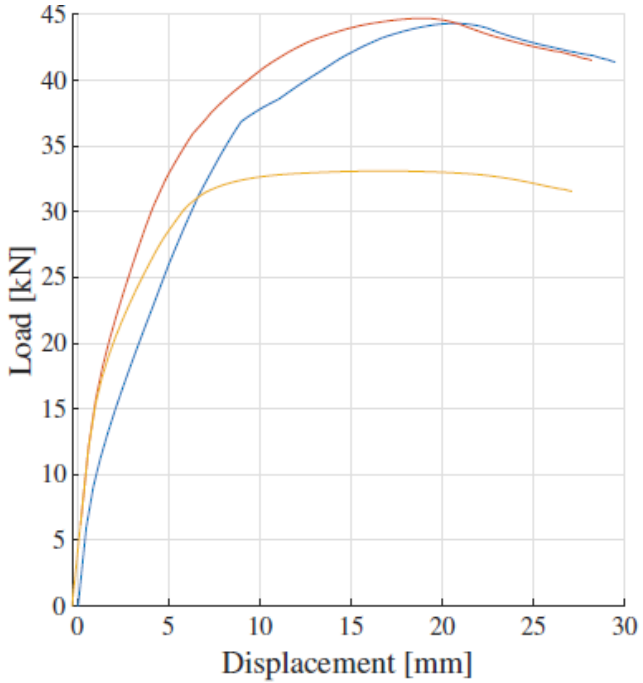

P4 = 30 kN
P3 = 18 kN
P2 = 7.99 kN
P1 = 4 kN

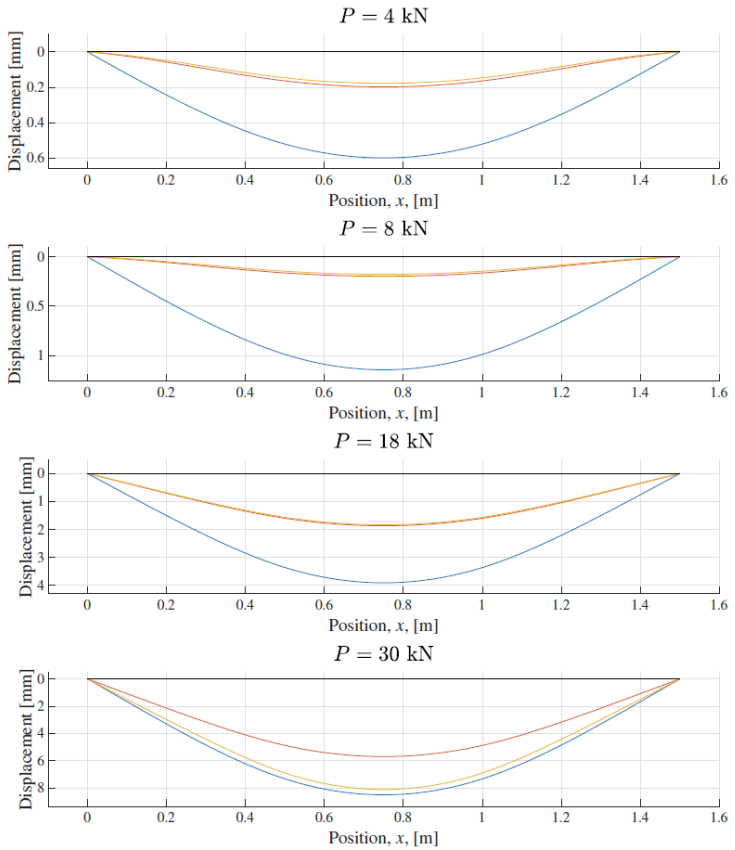
Modellering af træk





Resultater





Non-prestressed — Pre-tensioned — Post-tensioned

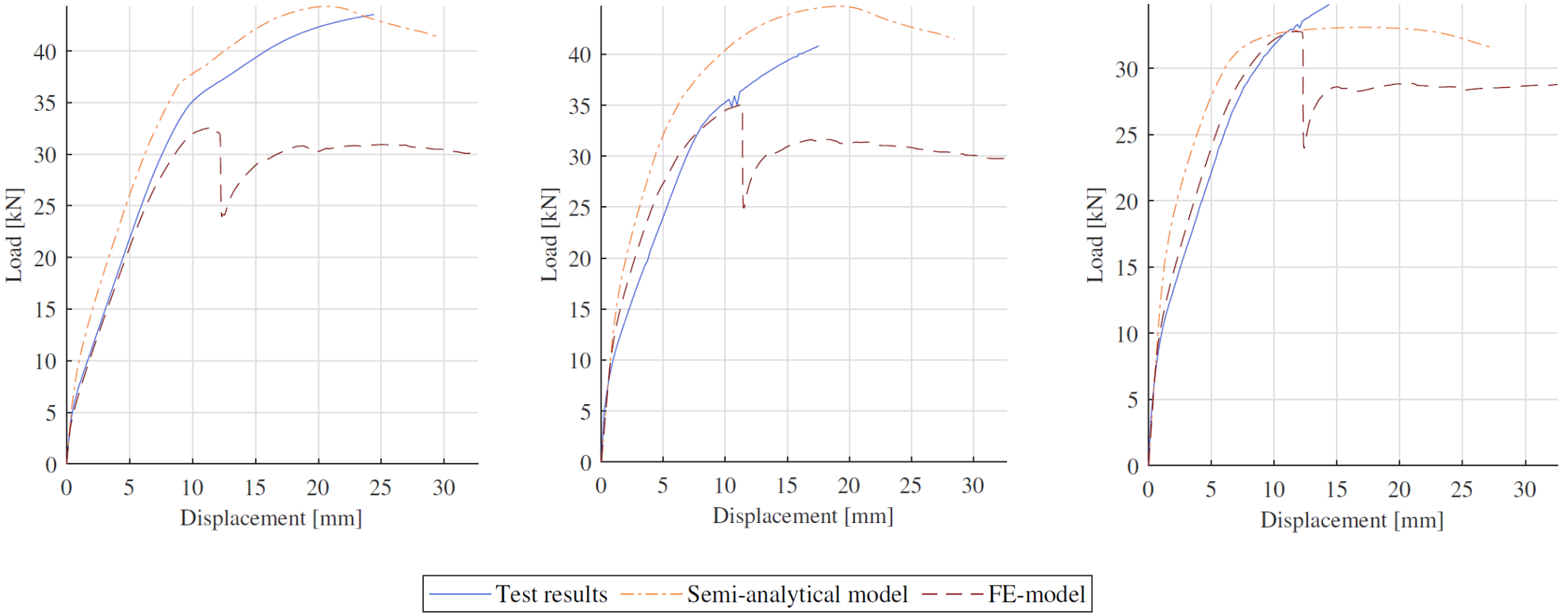
Resultater

- Arbejdskurver
- Deformationsfigurer
- Tøjningsfordeling

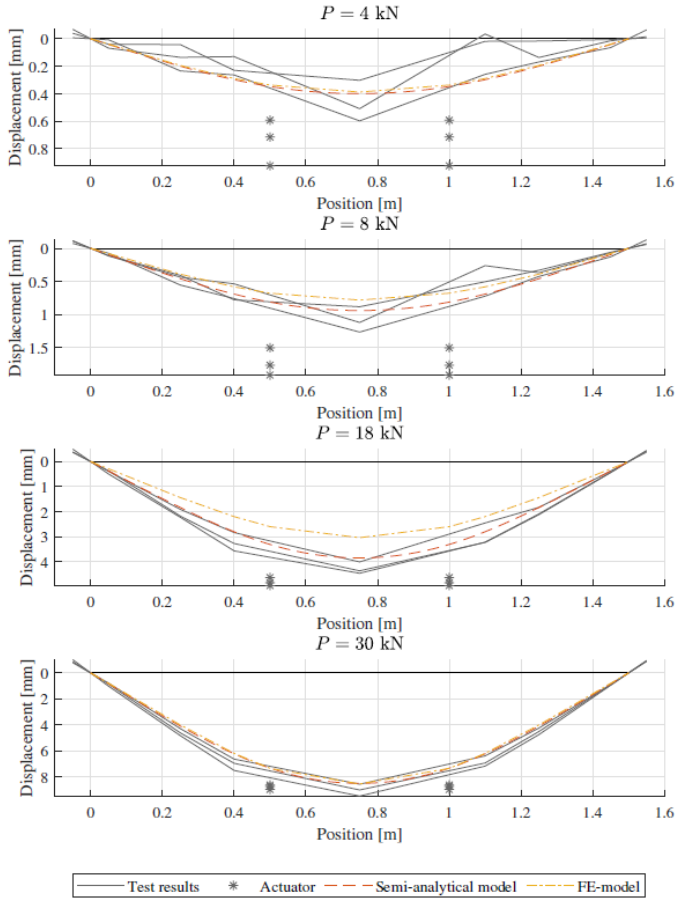
Resultater

- Arbejdskurver
- Deformationsfigurer
- Tøjningsfordeling

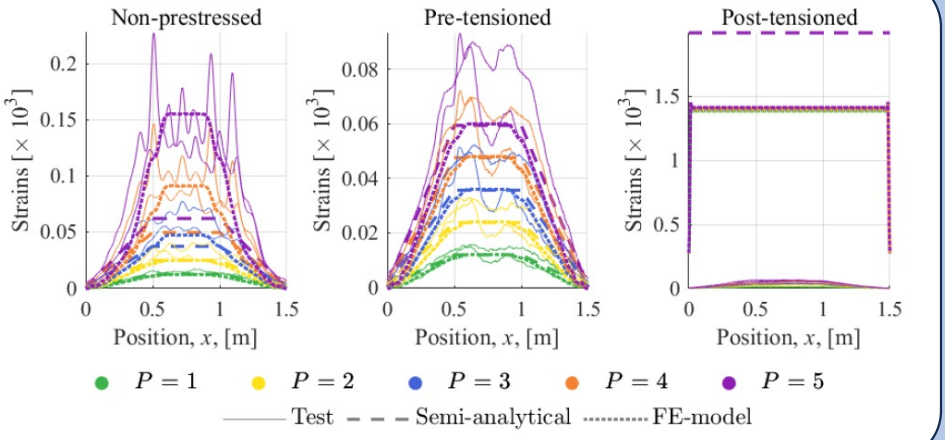
Arbejdskruver

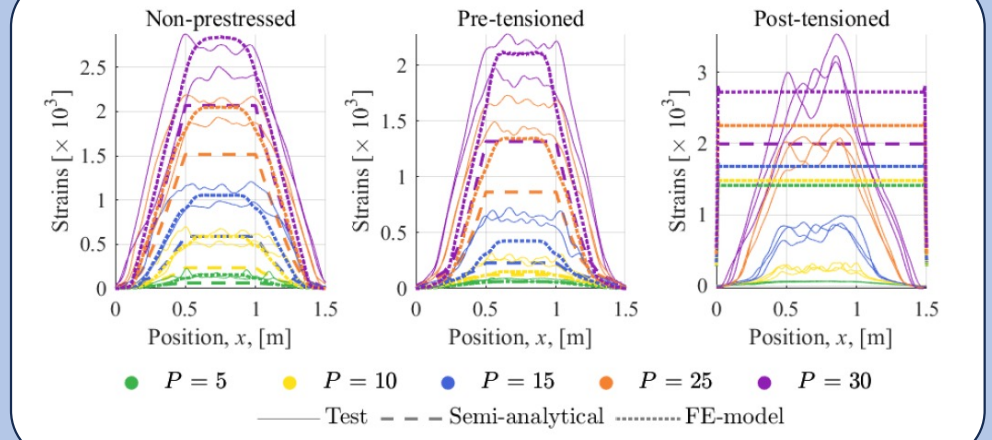


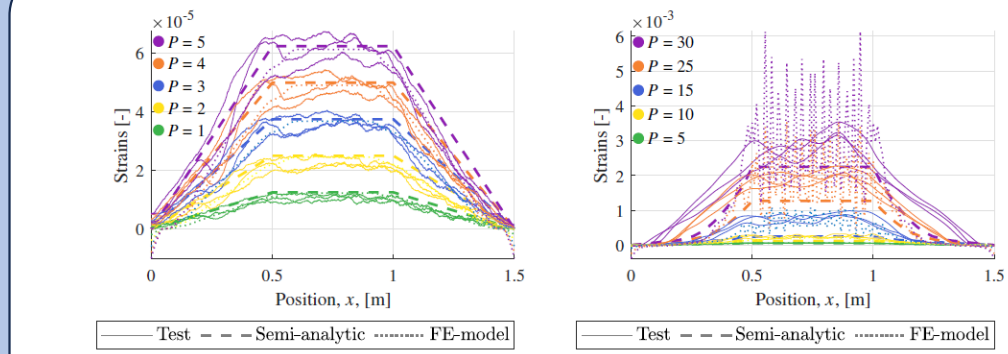
Deformationsfigurer



Tøjningsfordeling







(a) 1 kN - 5 kN

(b) 5 kN - 30 kN

Konklusion

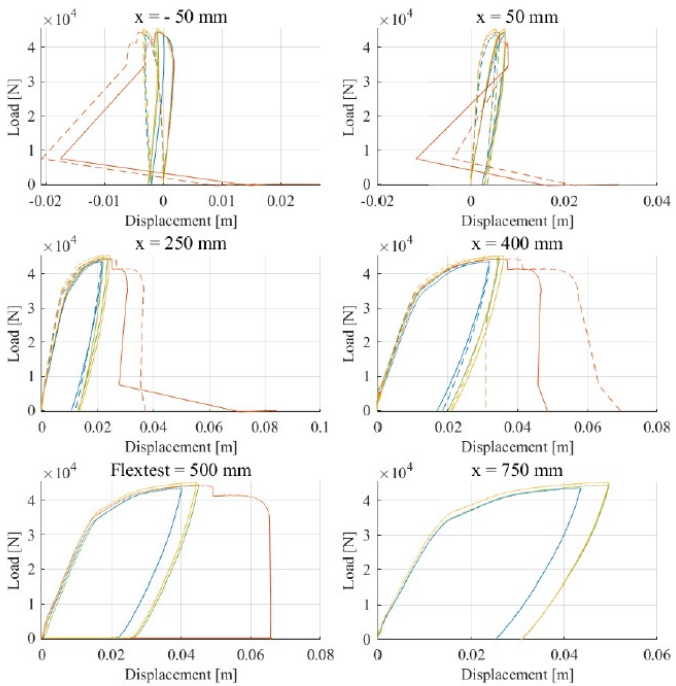
God overensstemmelse for den første del af arbejdskruven

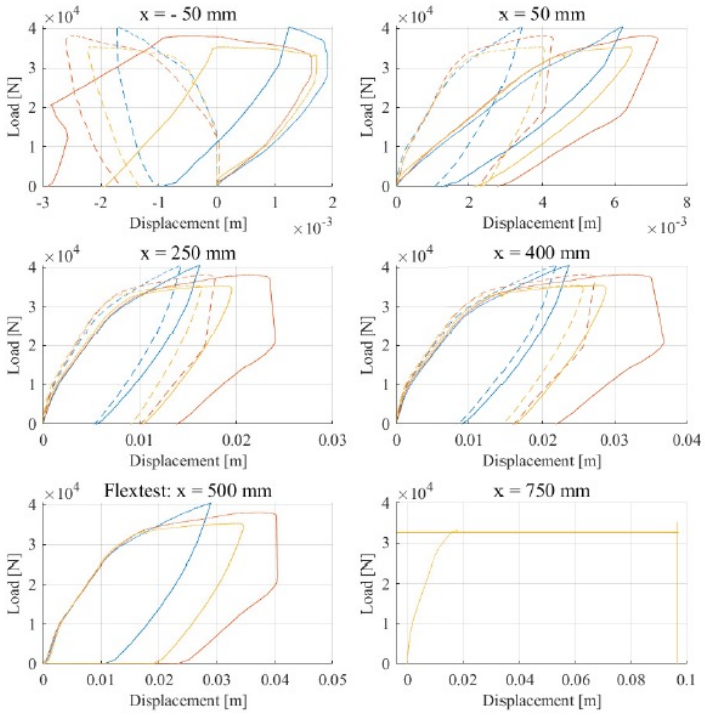
Væsentlig stivheds forskel på slapt armerede og opspændte konstruktioner

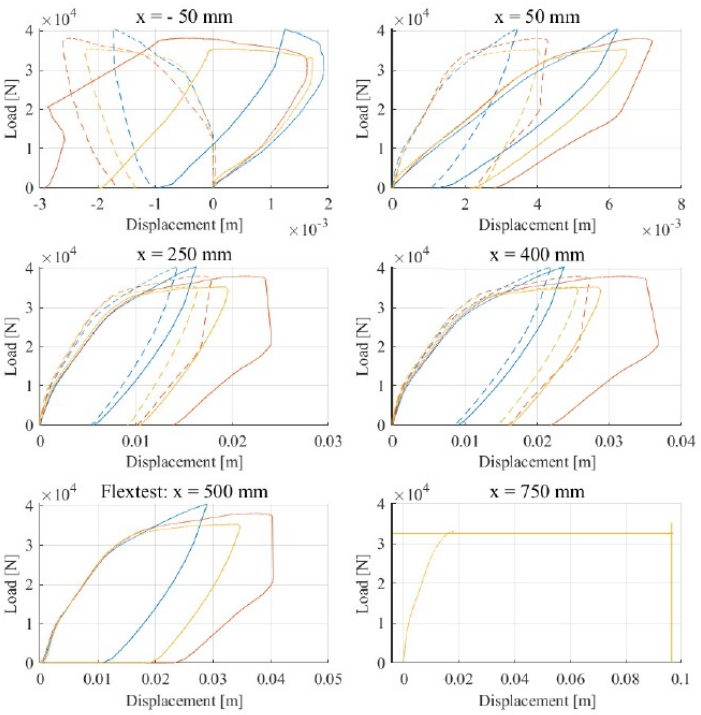
Modelleringsmetoderne kan bruges i videre udvikling

Tak

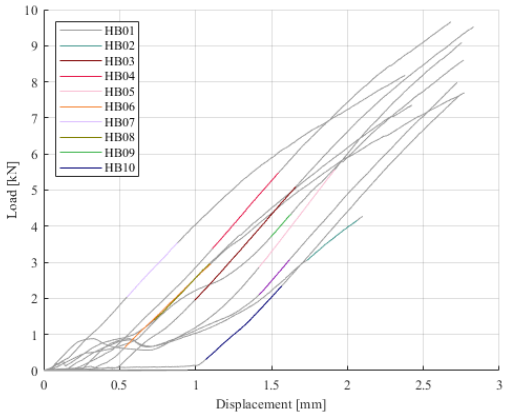
Bjælkeforsøg resultater

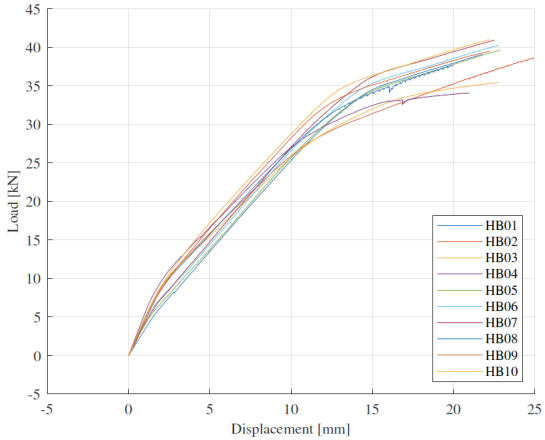


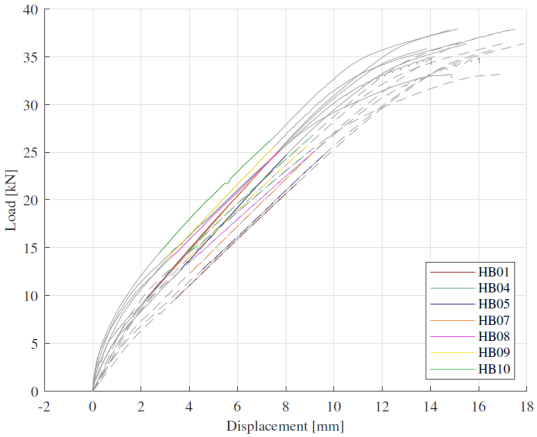


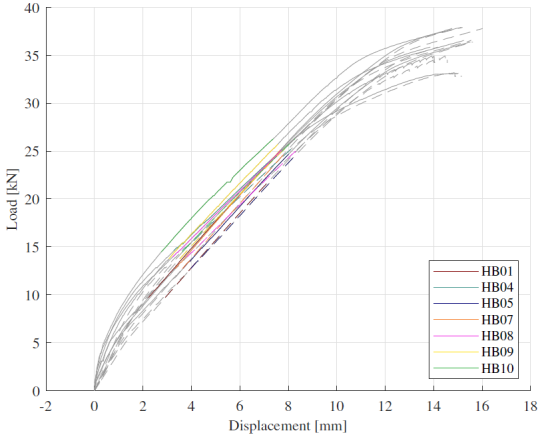


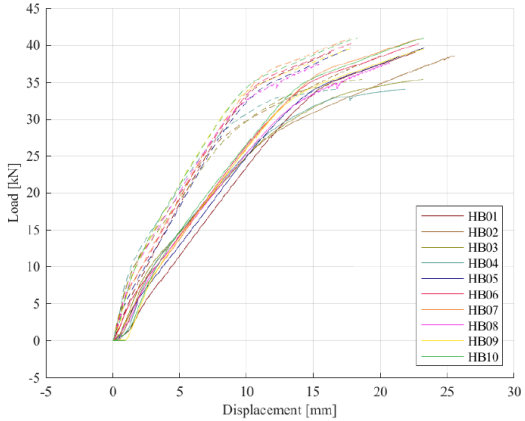
Bjælkeforsøg resultater



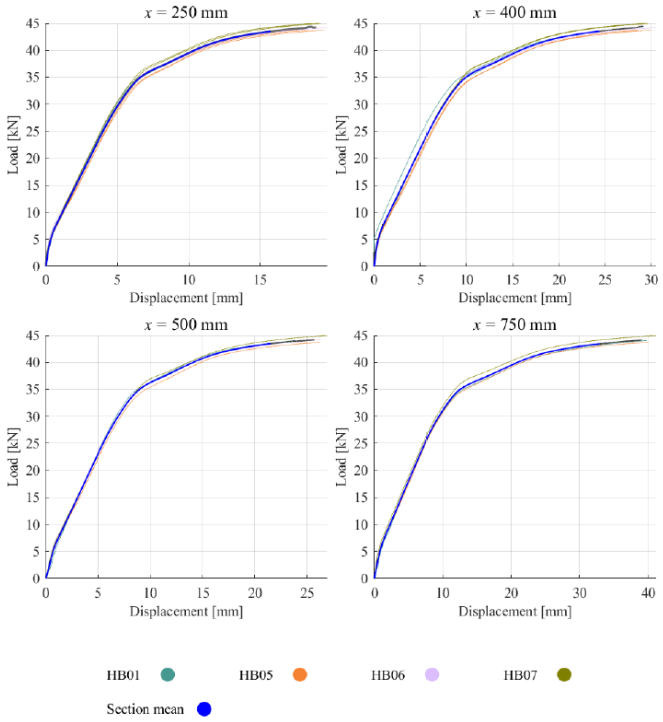


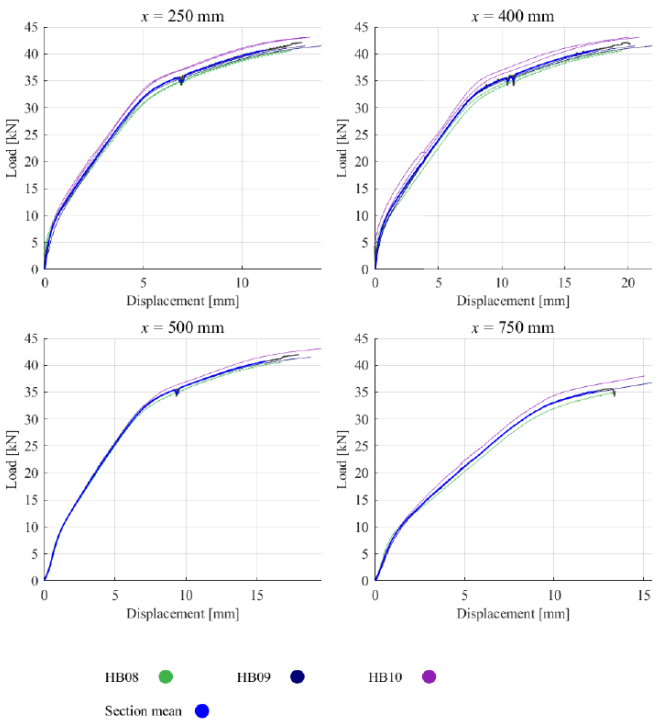


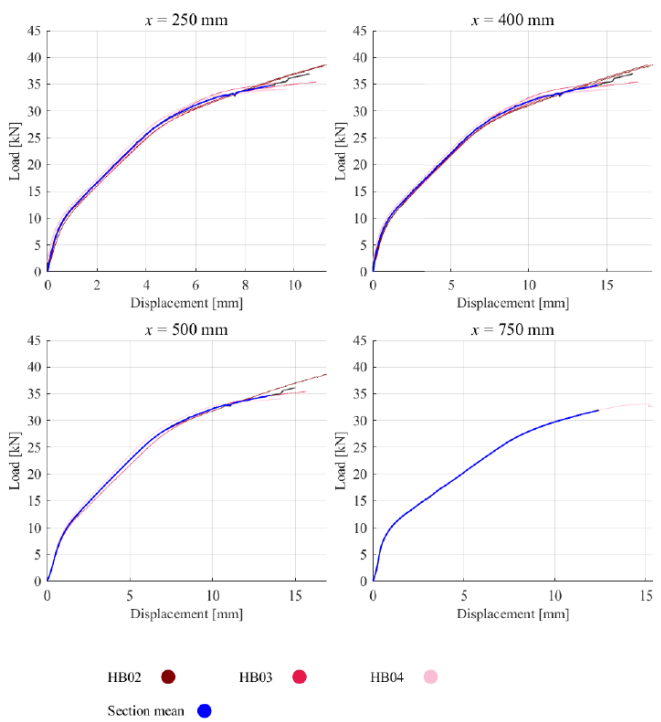




Bjælkeforsøg resultater







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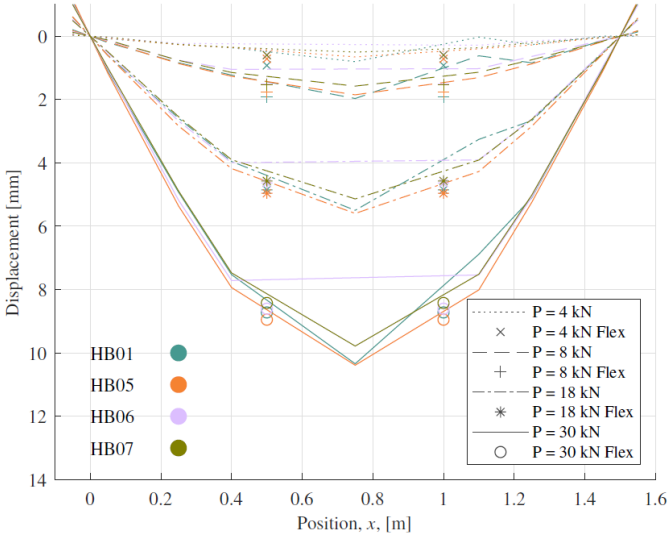

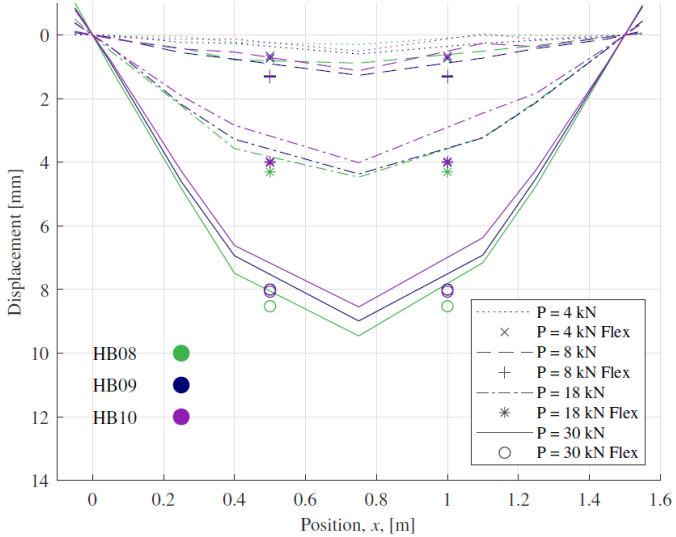

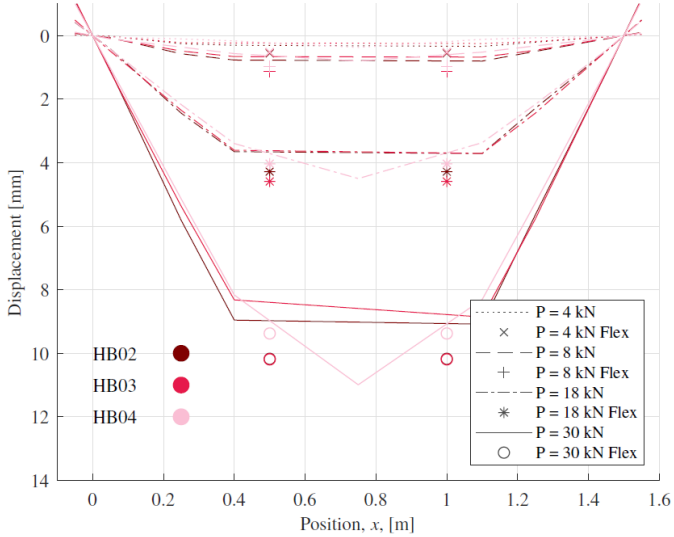

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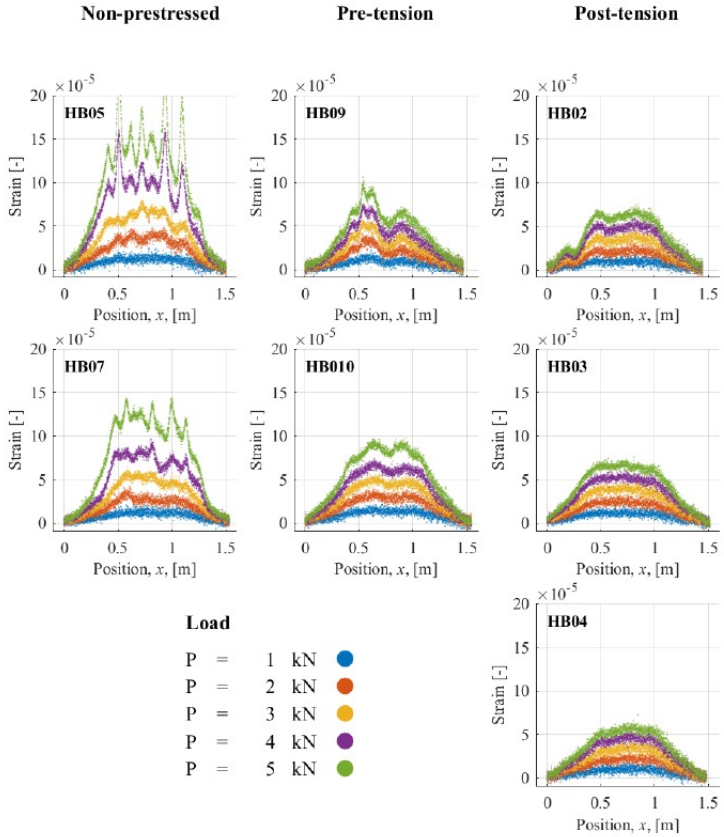
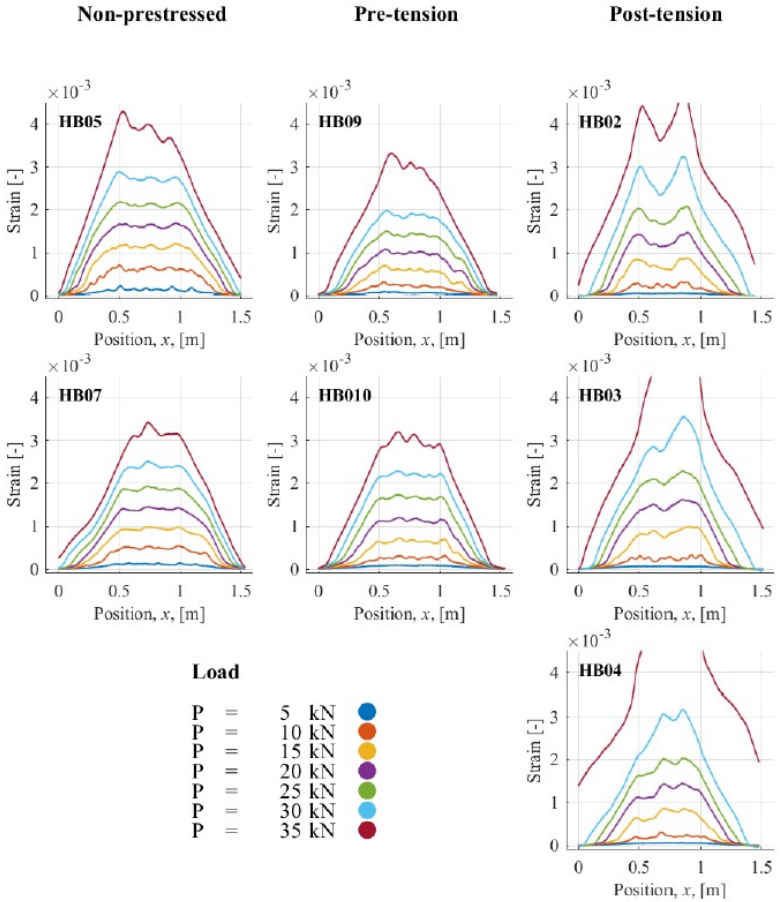
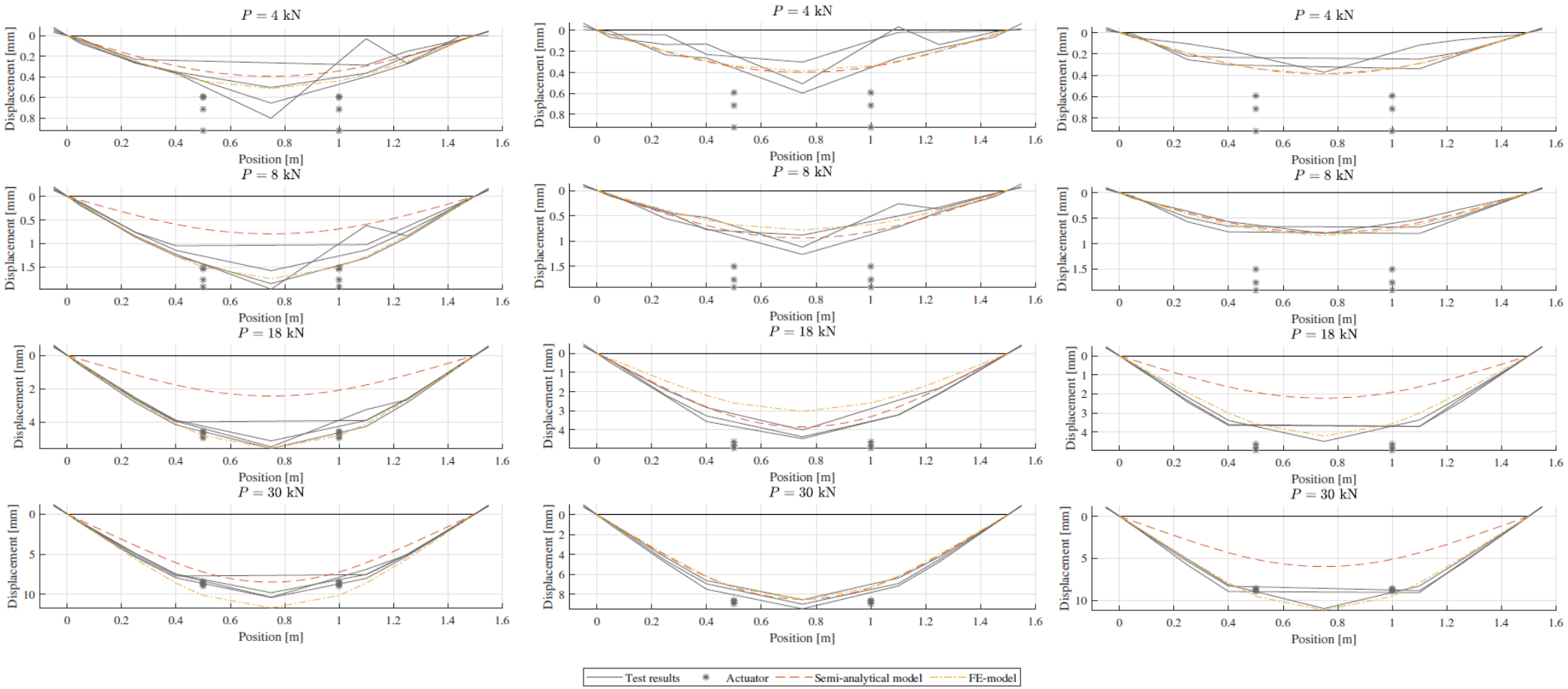
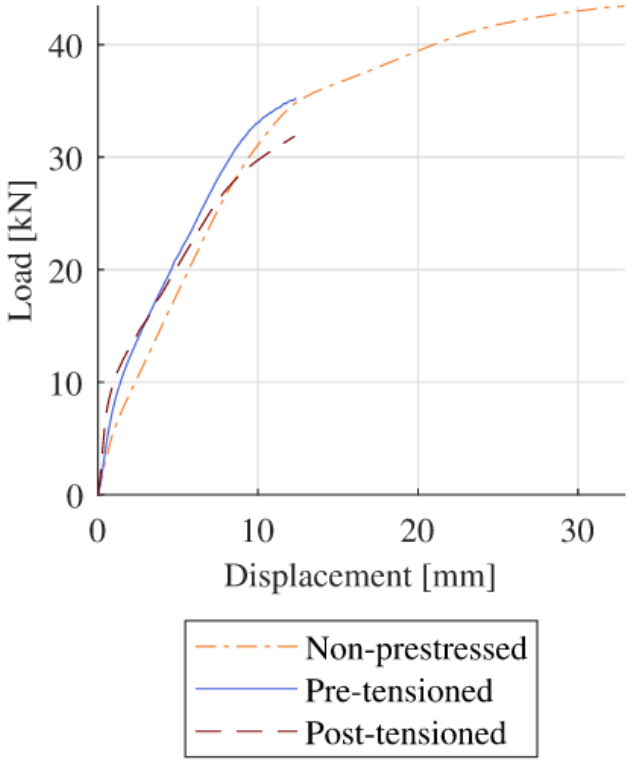




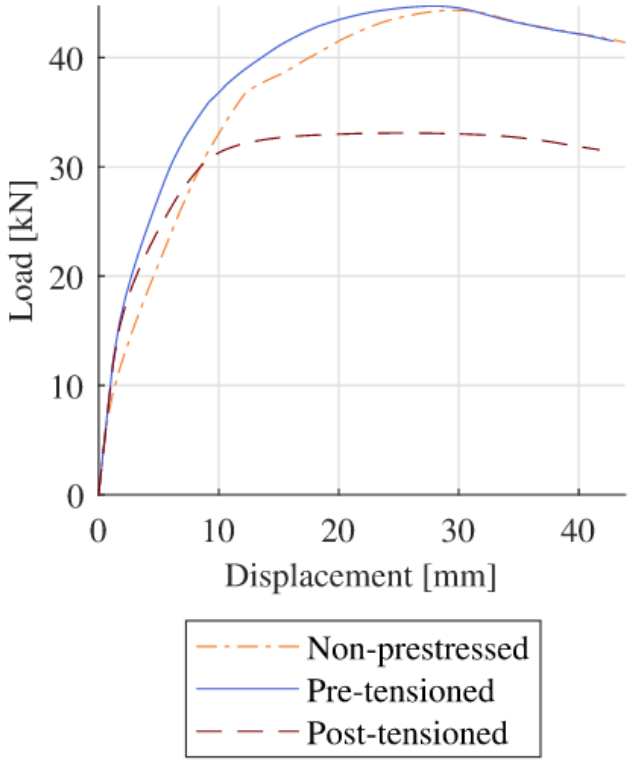
Resultat sammenligning



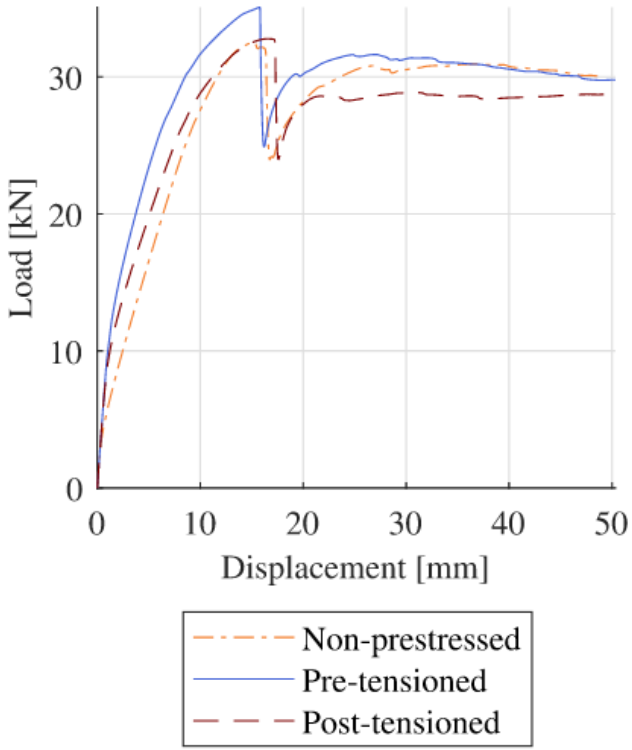
Resultat sammenligning



(a) Experimental campaign



(b) Semi-analytical



(c) FE-model