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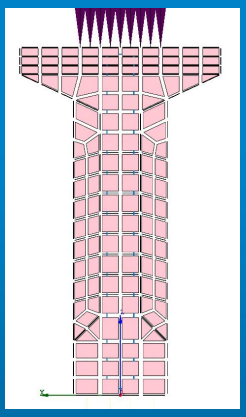
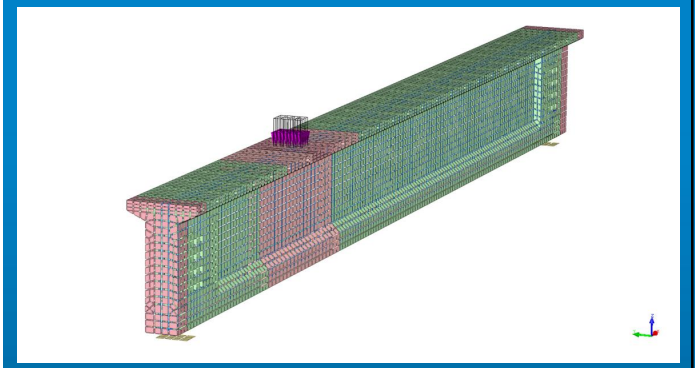
Shear capacity of a T-shaped prestressed concrete girder

Shen Ma

FE-code: TNO-DIANA v9.5
NLFEA-Guideline: Yes

Overview of DIANA model





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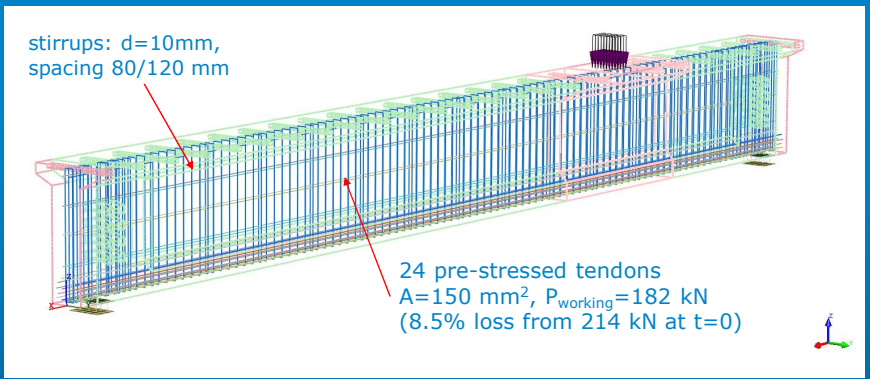
Overview of DIANA model



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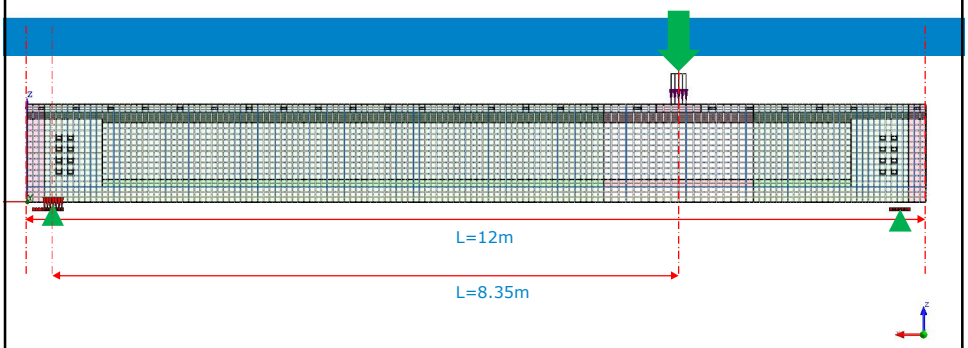
Dimension of the girder



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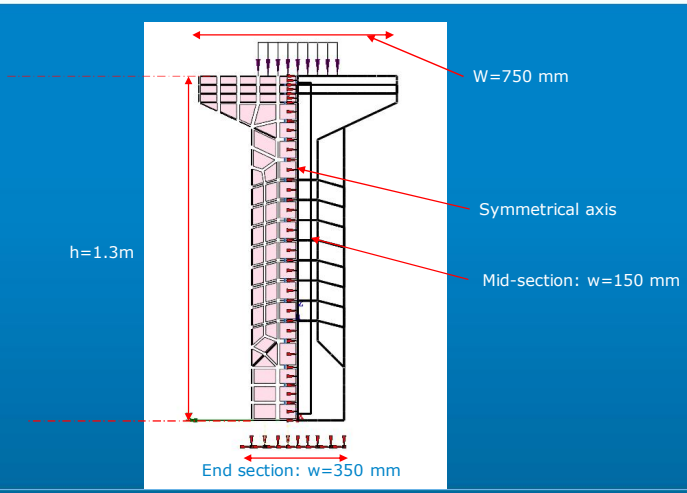
Dimension of the girder



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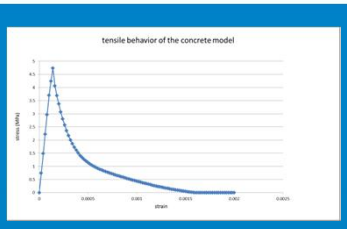
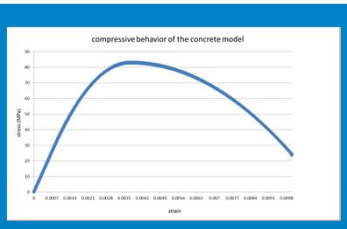
Material according to RWS-guideline



Tensile behavior, hordijk tension-softening curve

tensile strength 4.73 MPa, mean value;
aggregate size (unknown)
assumed dmax=16 mm;
fracture energy: Gf1= 0.132 Nmm/mm2;

poisson damage model applied;
lateral cracking influence applied by reduction curve JSCE12, min 40%

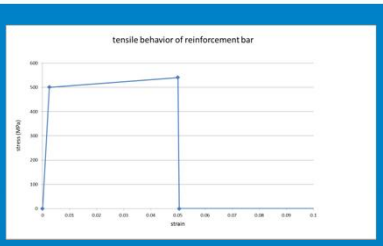


Compressive behavior, parabolic shape curve

compressive strength: f_{mean}=83 N/mm^2

fracture energy:
Gc=33 Nmm/mm^2, 250 times of Gf1

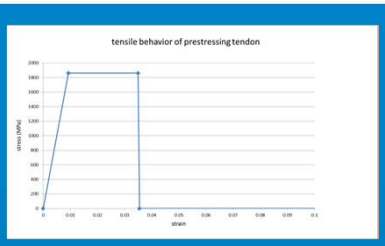
Material according to RWS-guideline



tension-hardening model, plasticity Von Mises

E=200000 MPa, f_{yk}=500 MPa, f_{tk}=540 MPa,
density 7850 kg/m3, Poisson ratio 0.3

$\varepsilon_{ultimate}$=5%



elastic-plastic model, Von Mises

E=200000 MPa, f_{yk}=1860 MPa, f_{tk}=1860 MPa,
density 7850 kg/m3, Poisson ratio 0.3

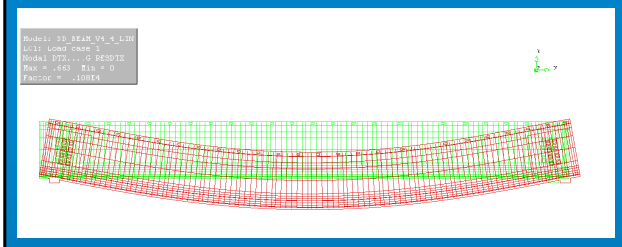
$\varepsilon_{ultimate}$=3.5%

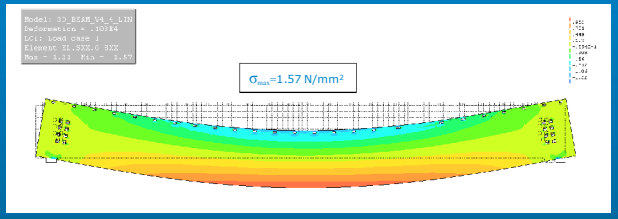
Load cases

Loading scheme and schedule:

1. Pre-stress (100%, 1 step)
2. Self-weight (100%, 1 step)
3. Testing load (arc-length method, SIZES 2(10) 0.5(300))

validation





validation

Load case 1 as example,

1. Self-weight,

Output file gives 52.02 N for the half-girder, one girder will be 104.04 kN
The given data of Girder CODE101: self-weight, 110.75 kN
The difference is: 110.75 kN – 52.02 kN*2=6.71 kN, which is -6% tolerance.

2. Normal stress in the cross-section of mid-span,

$M_{mid\text{-}span}$=1/8*Q*L= 1/8*52.02*2*12=156.06 kNm

σ_{max}= M/W_z=156.06*1E6 / 0.9605E+8 =1.62 N/mm2, which DIANA output shows 1.57 N/mm2.

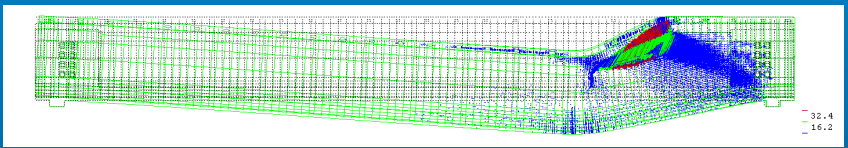
major results of the analysis

maximum load at failure.

F_{max}= 2766 kN

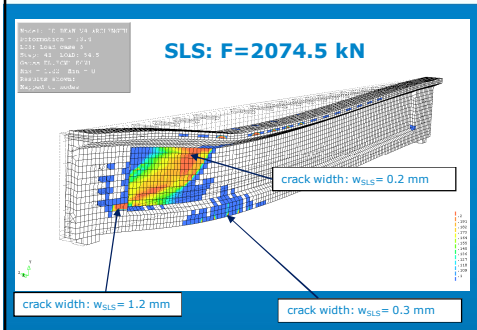
failure mechanism.

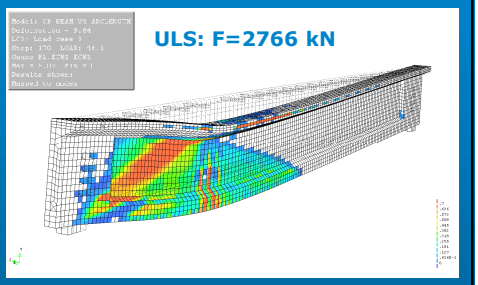
Shear failure, large diagonal shear cracking from the loading point to the nearest support.



the picture shows the cracking pattern in the snap-back stage.

Crack pattern





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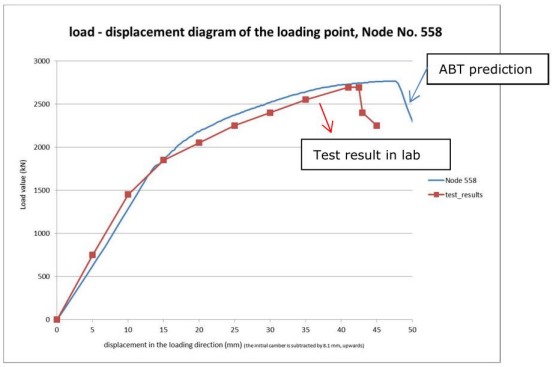
Fmax, ULS



Fmax = **2766** kN