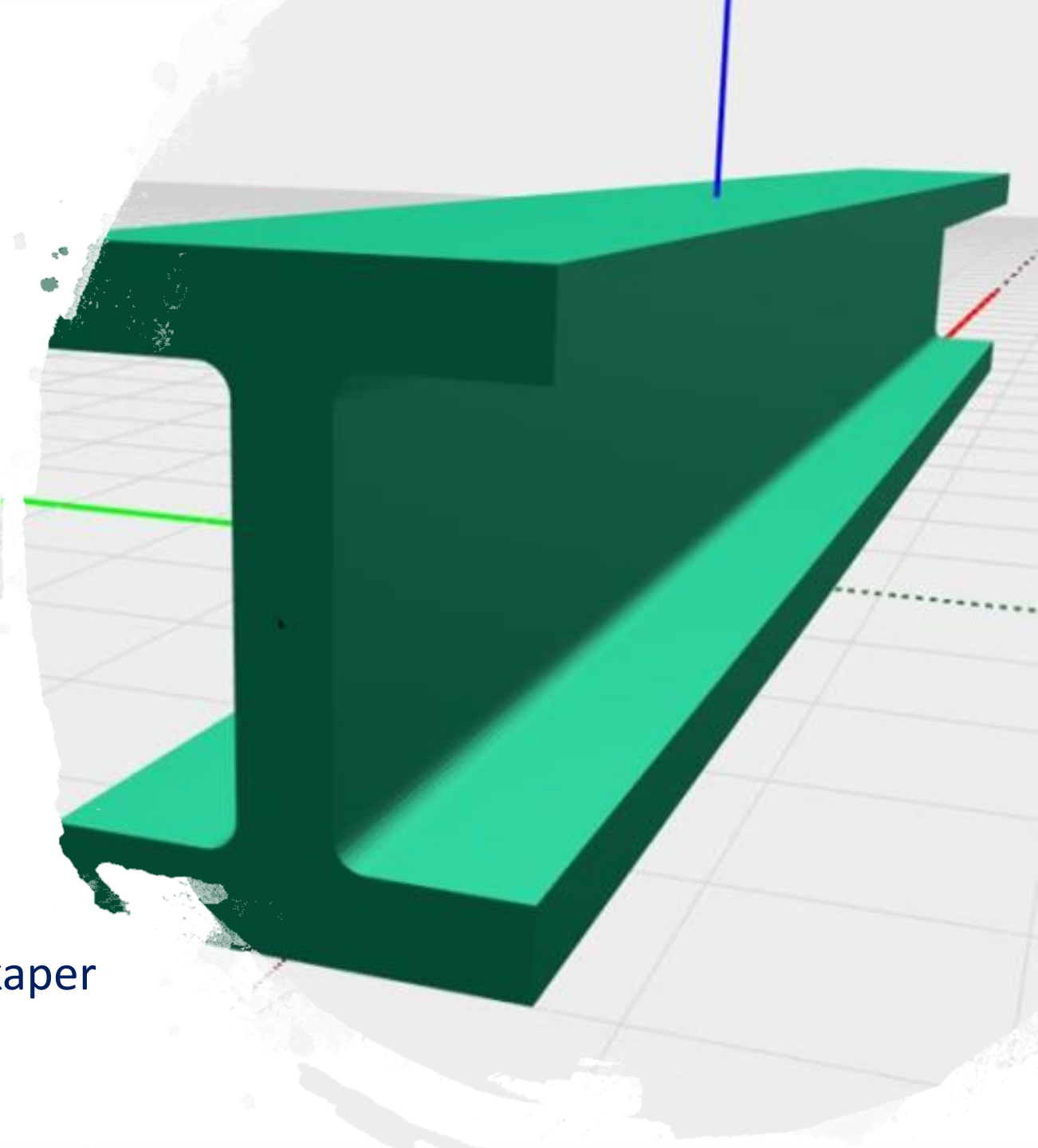
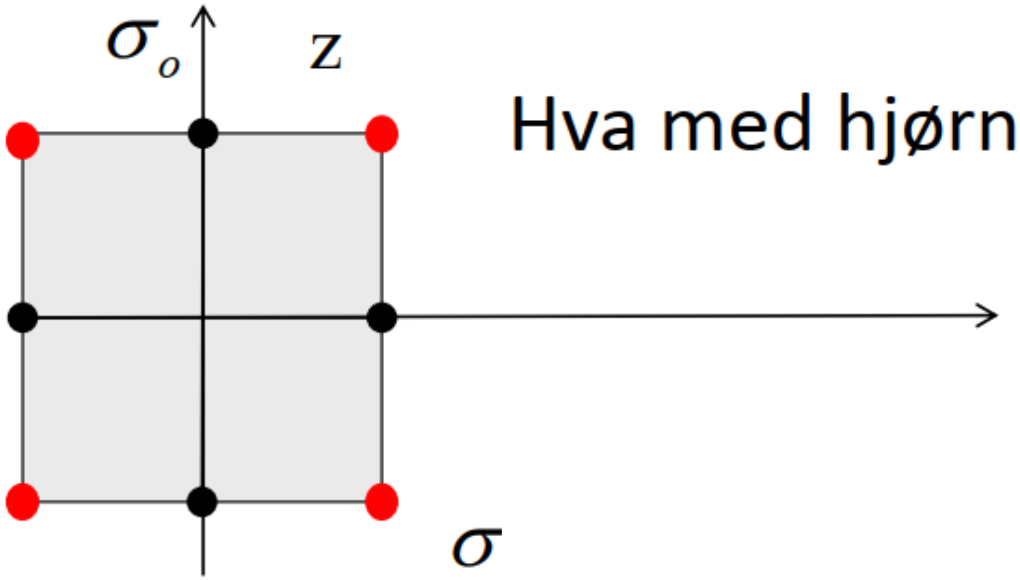


- Bjelker med tynnvegget tverrsnitt
- Bjelker med kontinuerlige, solide tverrsnitt
- Eksempler og validering av tverrsnittsegenskaper

Maksimale jevnføringsspenninger fra AquaEdit



Hva med hjørnepunkter markert i rødt ?

$$\sigma_o = \sigma_a + \sigma_{boz} + \sigma_{boy} = \frac{F}{A} + \frac{M_y}{I_y} \cdot z_u - \frac{M_z}{I_z} \cdot y_y$$

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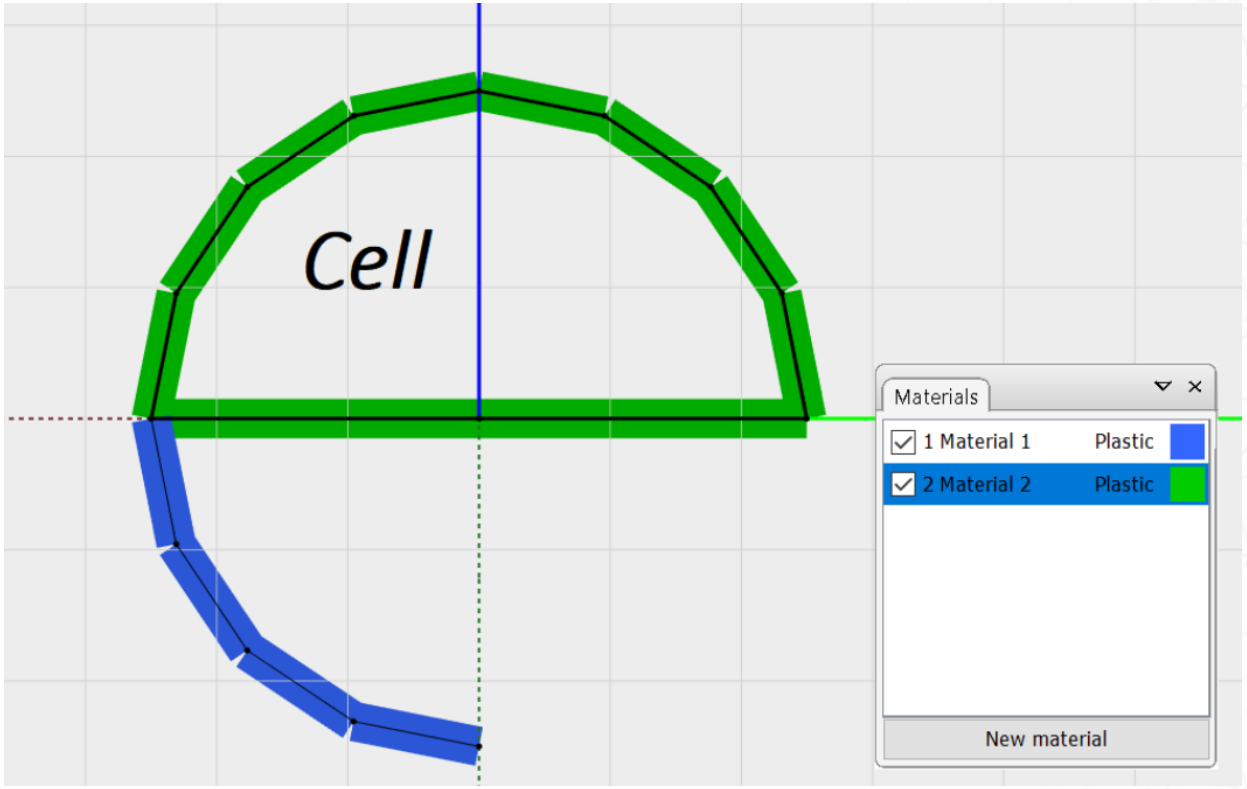
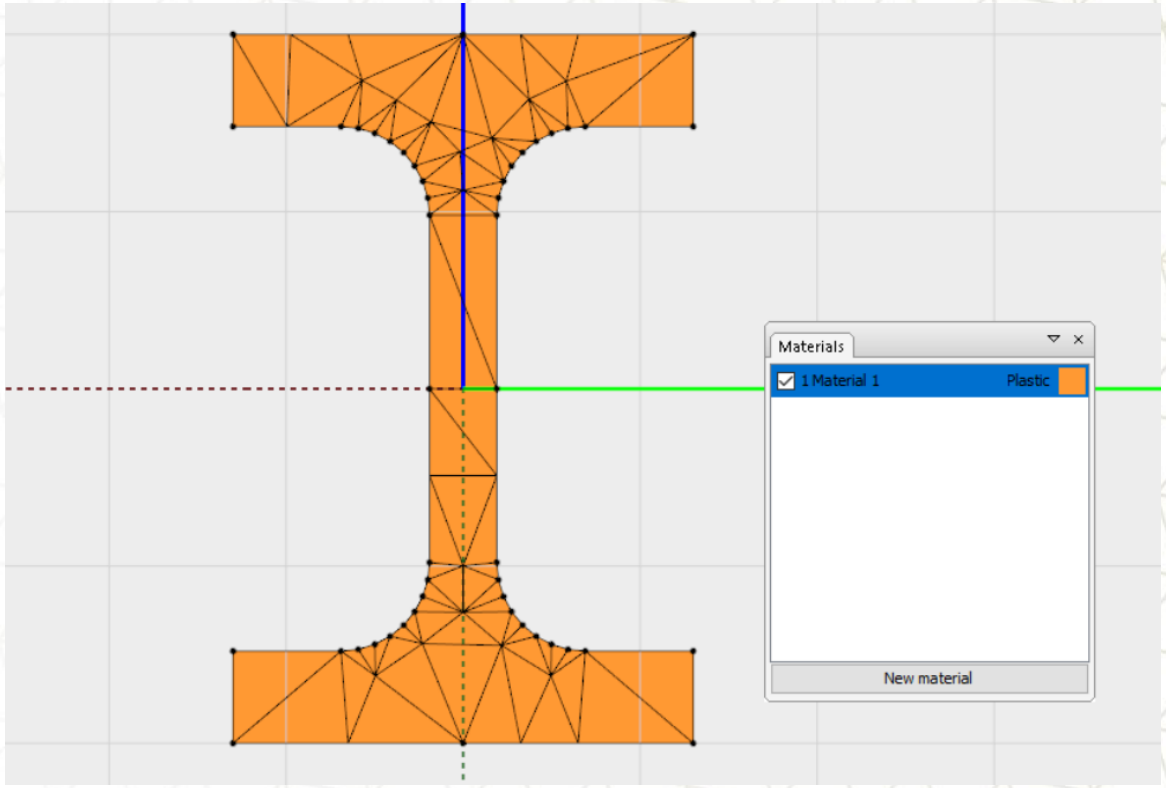
AquaCross - Tynnvegget tverrsnitt



- Består av diskretiserte linjer med angitt tykkelse
- Deles opp i lukkede og åpne “celler”
- Tverrsnittet ekstruderes i bjelkens lengderetning

AquaCross - Massive tverrsnitt



- Tverrsnittet er geometrisk avgrenset
- Diskretiseres opp i triangulære størrelser, “mesh”
- Tverrsnittet ekstruderes i bjelkens lengderetning

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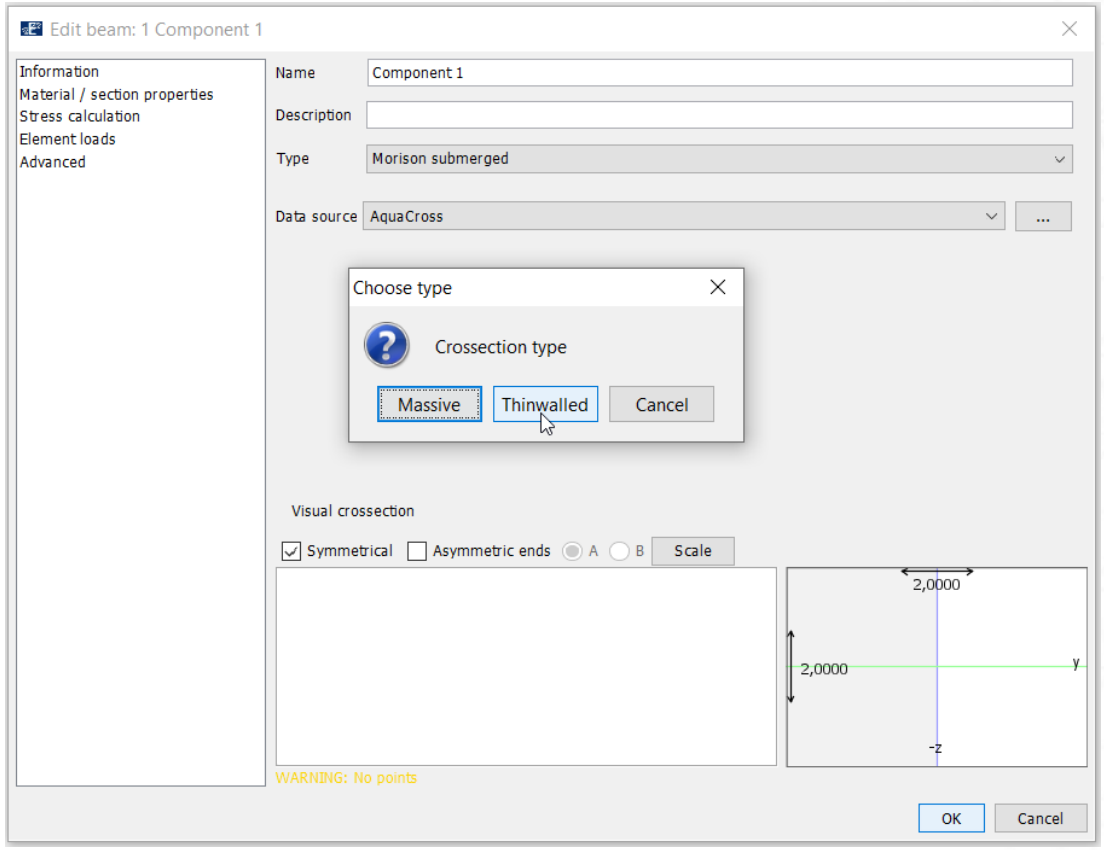
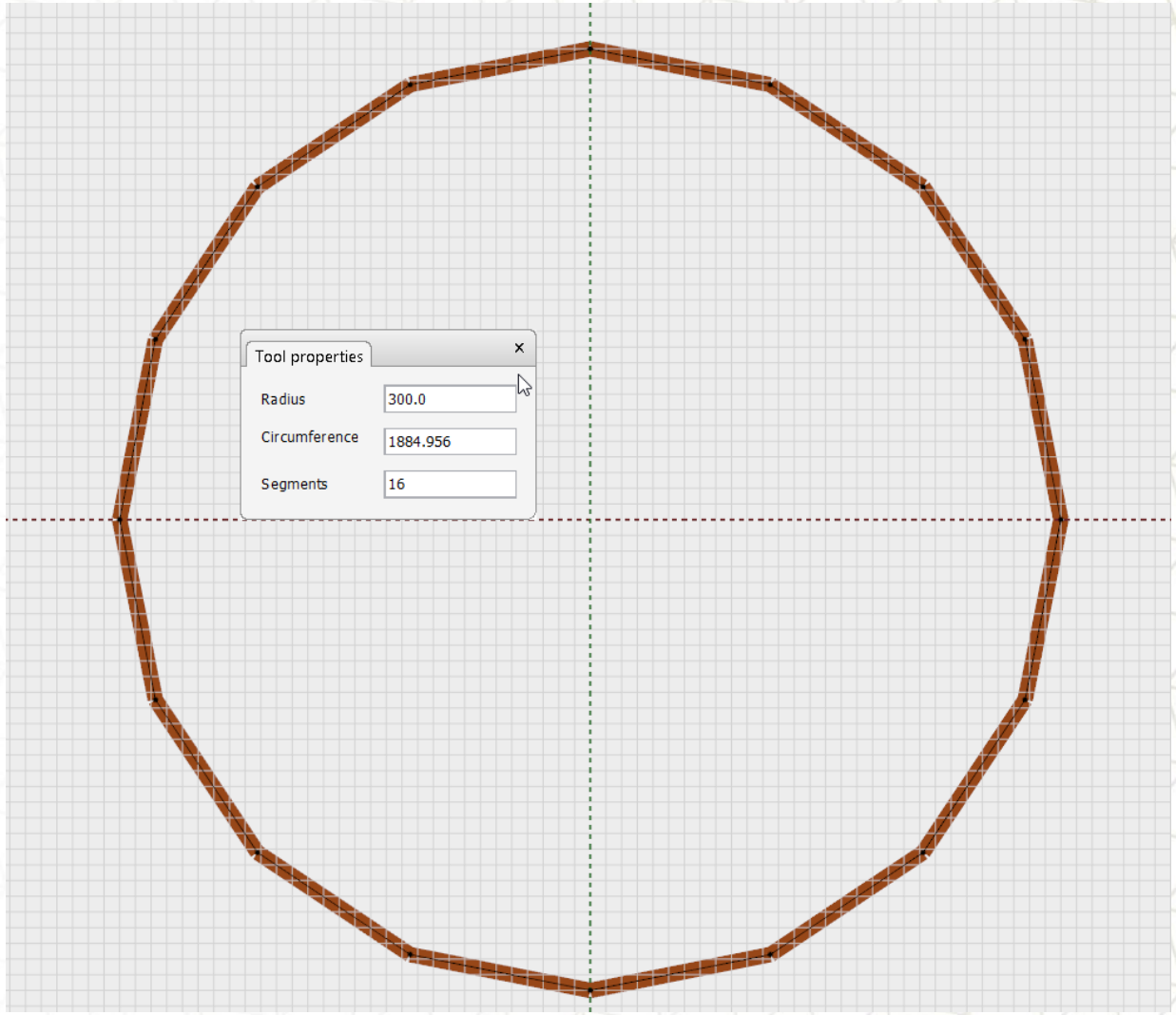
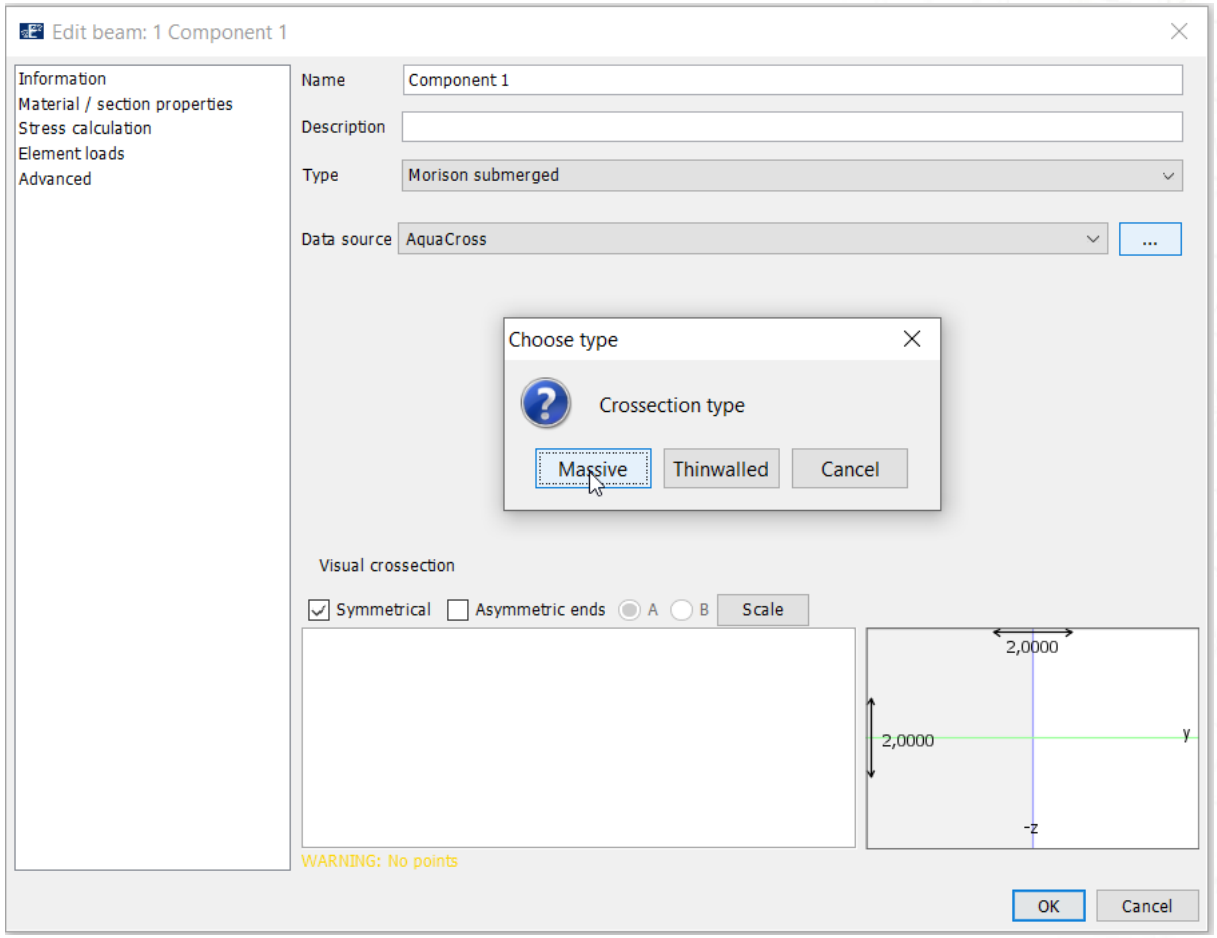
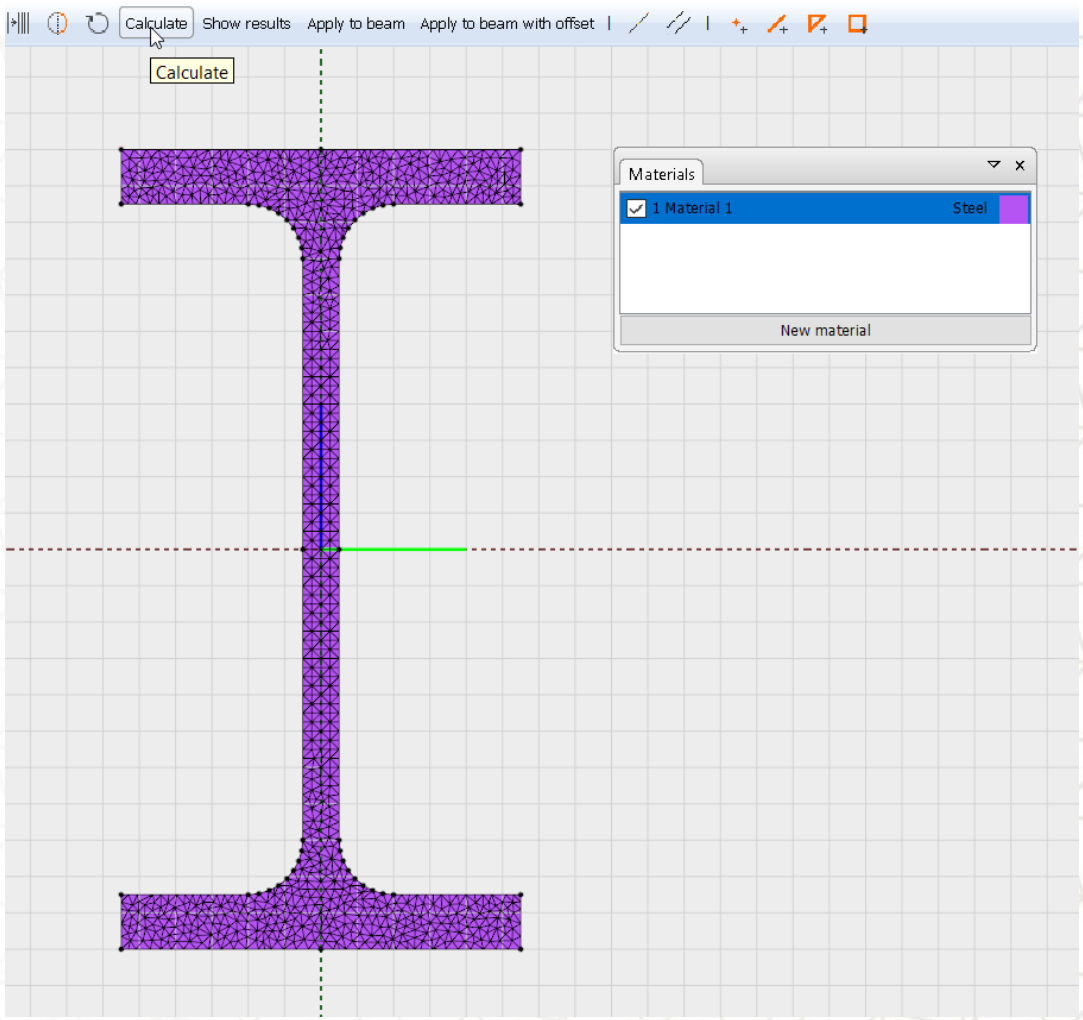
Generering av tynnveggede tverrsnitt i AquaCross



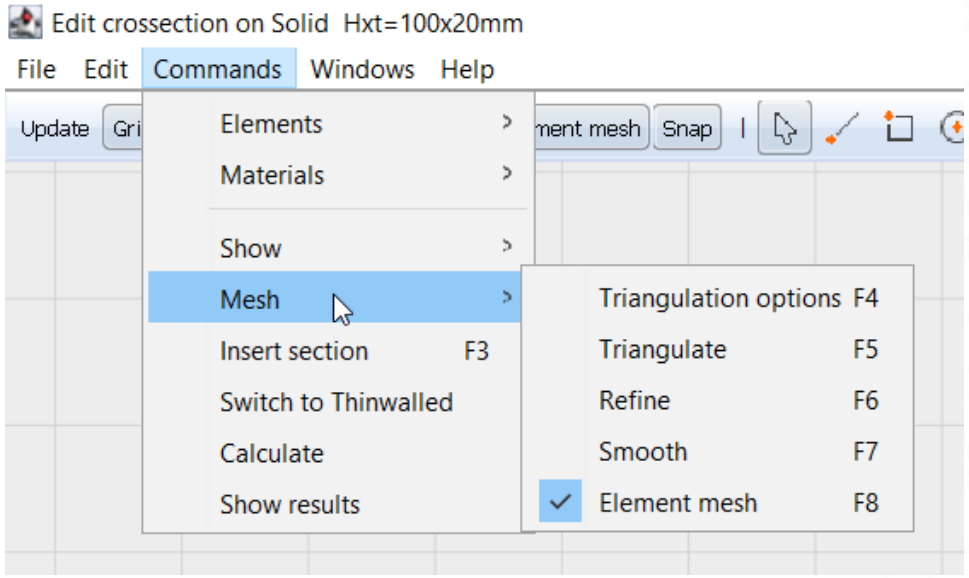


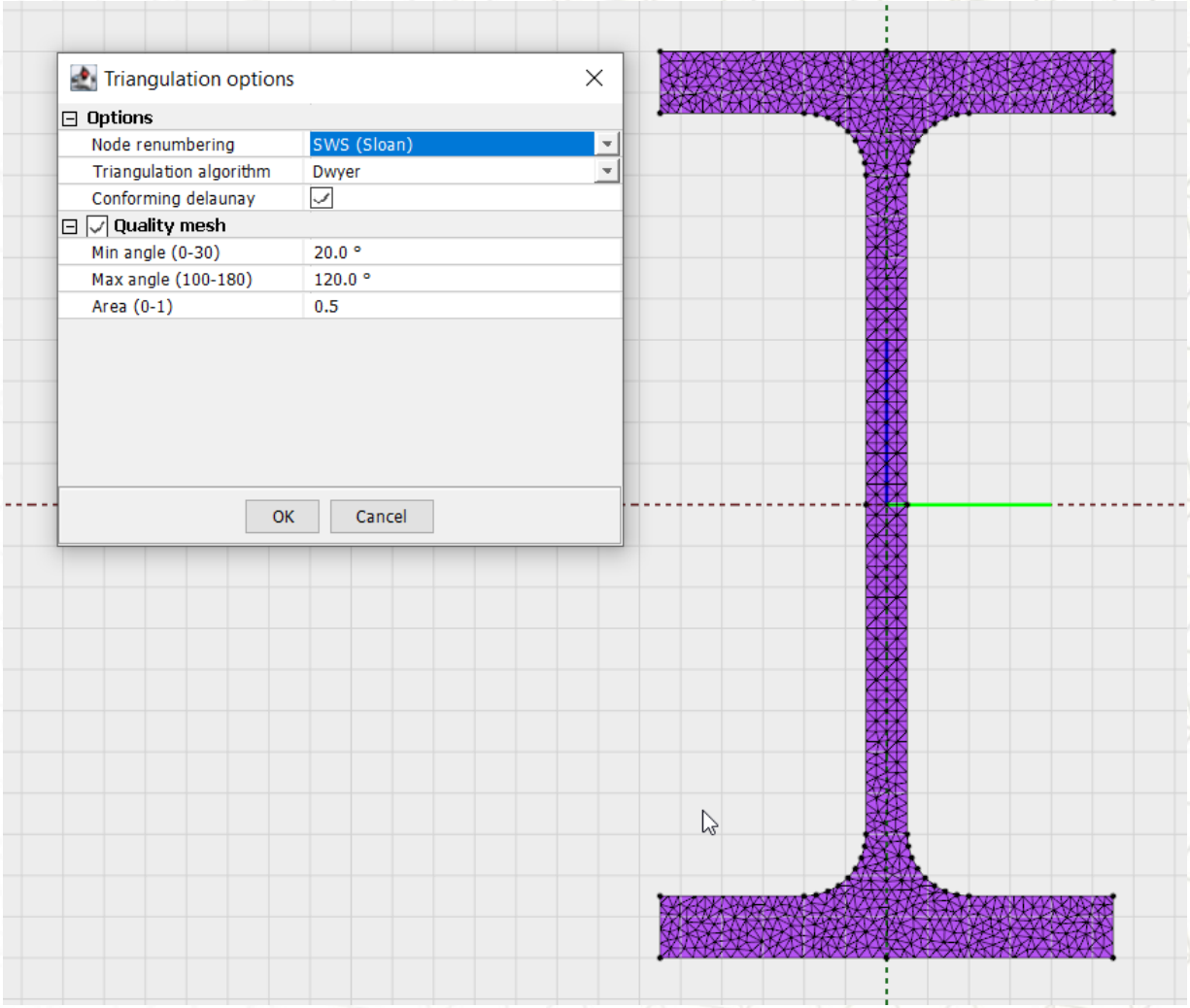
Generering av massive tverrsnitt i AquaCross



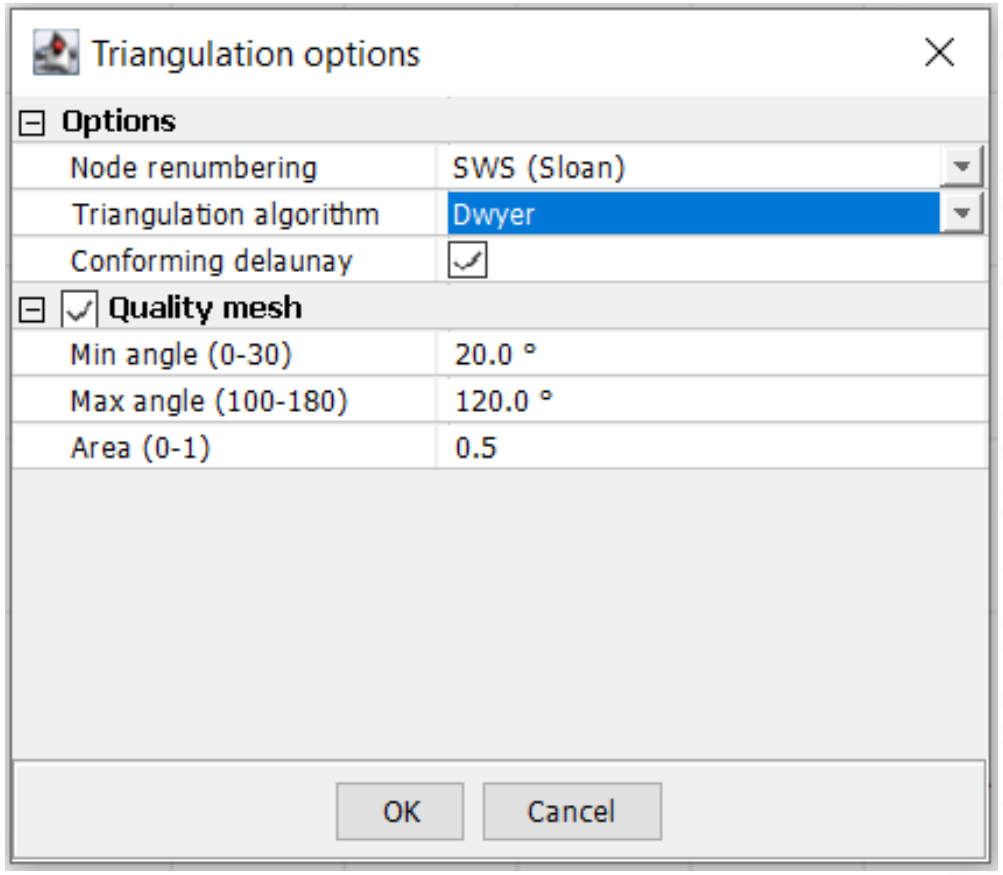


Generering av Mesh i AquaCross





Triangulering av Mesh i AquaCross



Option	Description
Node renumbering	Nodes in a massive section are automatically numbered. This option allows the user to change the numbering system. Changing the numbering system will influence the computational efficiency. Renumbering reduces the bandwidth of the calculation matrices, so that the calculations go faster. Choose between: SWS (Sloan), PFM (Profile Front Minimization) And ELW (Wilson).
Triangulation algorithm	Allow the user to change the algorithm conducting the triangulation. Dwyer: a divide-and-conquer algorithm for construction of Delaunay triangulations. By Dwyer. SweepLine: an algorithm that 'sweeps' across a plane for constructing of Delaunay triangulations. Incremental: algorithm that repeatedly add one vertex at a time for construction of Delaunay triangulations.
Conforming delaunay	Delaunay triangle is such that if one draws a circle around each triangle that passes through the three triangle points, no other points lies inside that circle. When toggle Conforming Delaunay ensures that extra points are inserted so that all the triangles created are a Delaunay triangle.
Min angle (0-30)	Restrictions for minimum allowed angle in the mesh triangles. The minimum angle may be set between 0° and 30°. By default, this is set to 20.0°.
Max angle (100-180)	Restrictions for maximum allowed angle in the mesh triangles. The maximum angle may be set between 100° and 180°.
Area (0-1)	Restrictions for allowed area of the triangle mesh. This is a coefficient, and the value is set between 0-1. If one chooses to use the Refine option after triangulation, the area of the smallest triangle is taken in the mesh and multiplied with this. Then the new area becomes a target for all the triangles that are made when pressing Refine. If the value in Area is set low, the number of triangles increase quickly upon pressing Refine multiple times.

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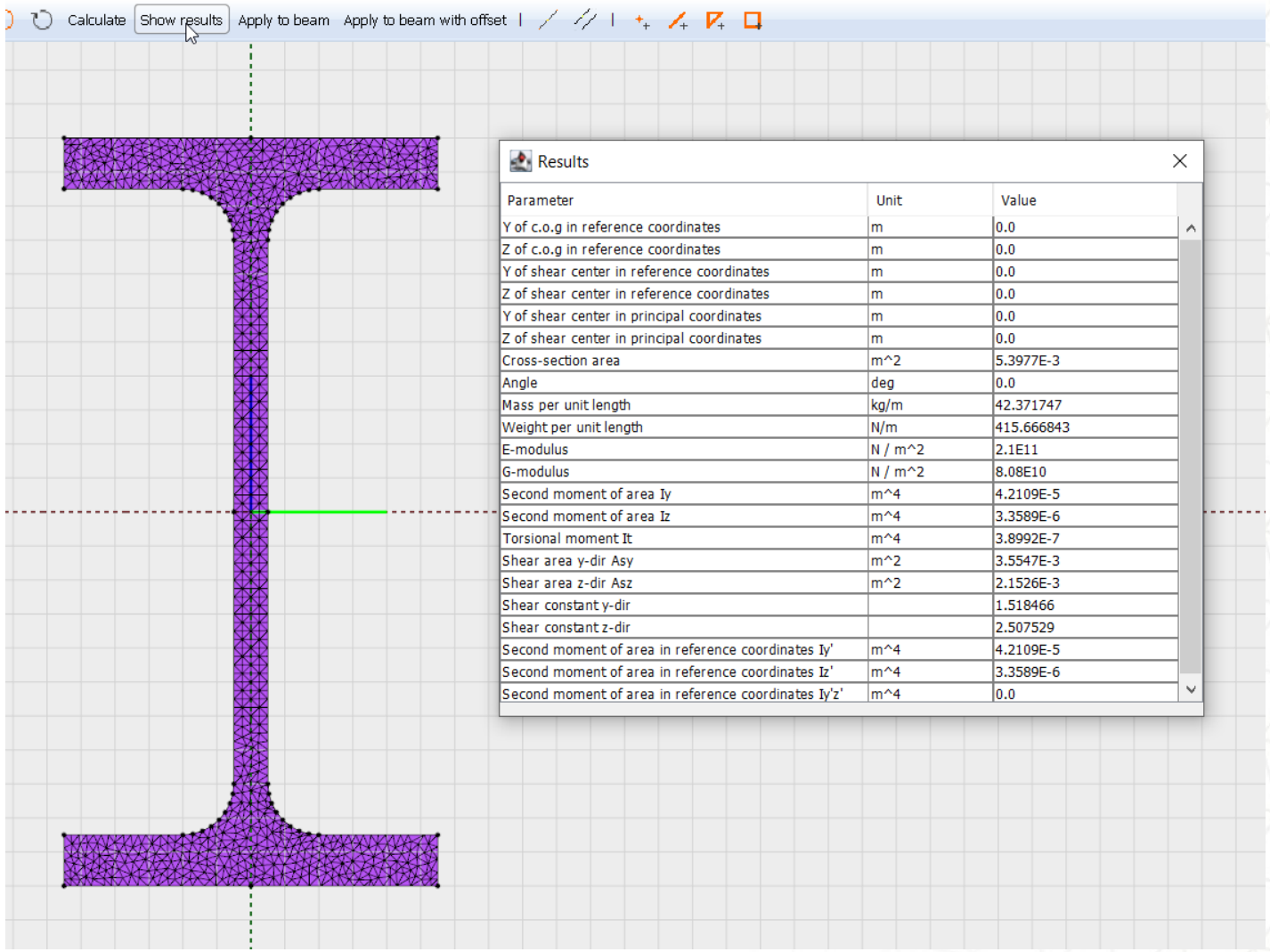
Calculate and Show Results



Results

Parameter	Unit	Value
Y of c.o.g in reference coordinates	m	0.0
Z of c.o.g in reference coordinates	m	0.0
Y of shear center in reference coordinates	m	0.0
Z of shear center in reference coordinates	m	0.0
Y of shear center in principal coordinates	m	0.0
Z of shear center in principal coordinates	m	0.0
Cross-section area	m^2	5.3977E-3
Angle	deg	0.0
Mass per unit length	kg/m	42.371747
Weight per unit length	N/m	415.666843
E-modulus	N / m^2	2.1E11
G-modulus	N / m^2	8.08E10
Second moment of area Iy	m^4	4.2109E-5
Second moment of area Iz	m^4	3.3589E-6
Torsional moment It	m^4	3.8992E-7
Shear area y-dir Asy	m^2	3.5547E-3
Shear area z-dir Asz	m^2	2.1526E-3
Shear constant y-dir		1.518466
Shear constant z-dir		2.507529
Second moment of area in reference coordinates Iy'	m^4	4.2109E-5
Second moment of area in reference coordinates Iz'	m^4	3.3589E-6
Second moment of area in reference coordinates Iy'z'	m^4	0.0

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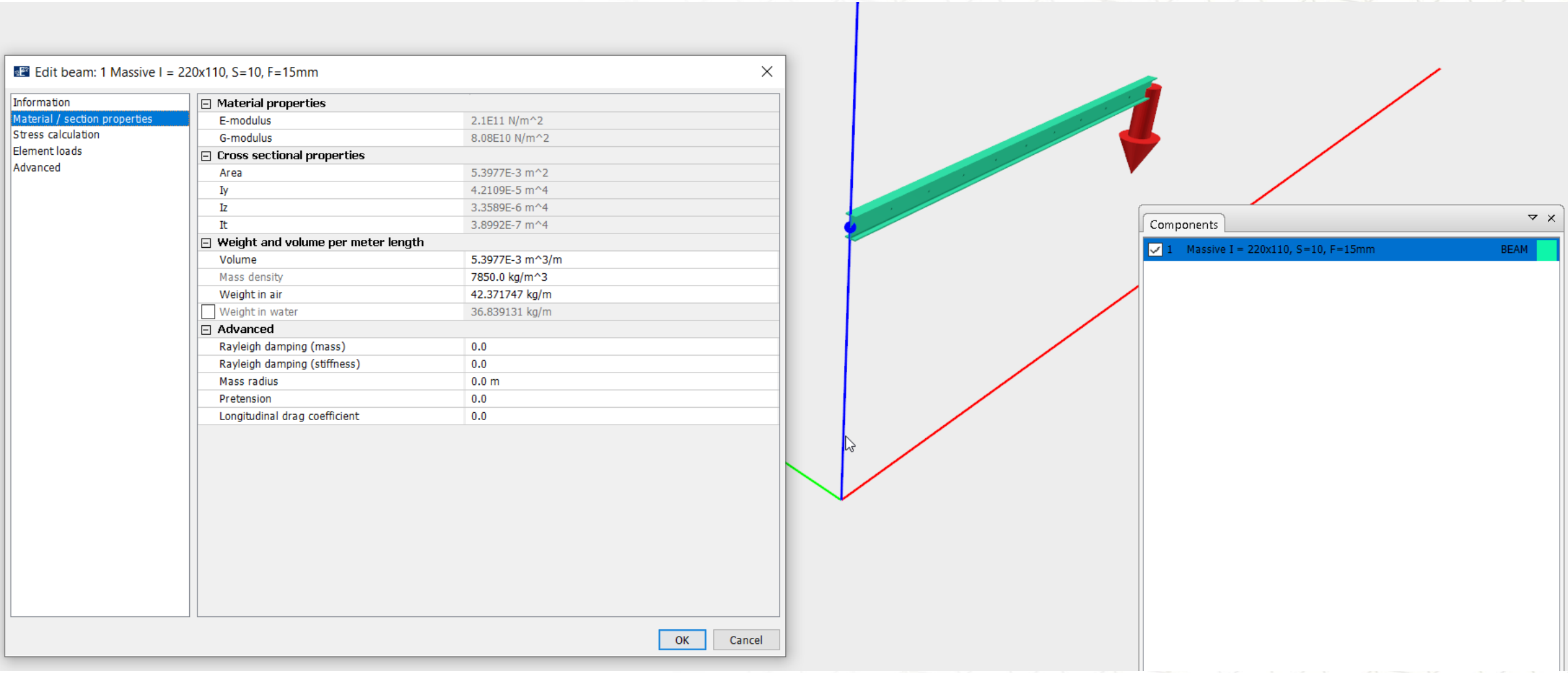
Apply to Beam



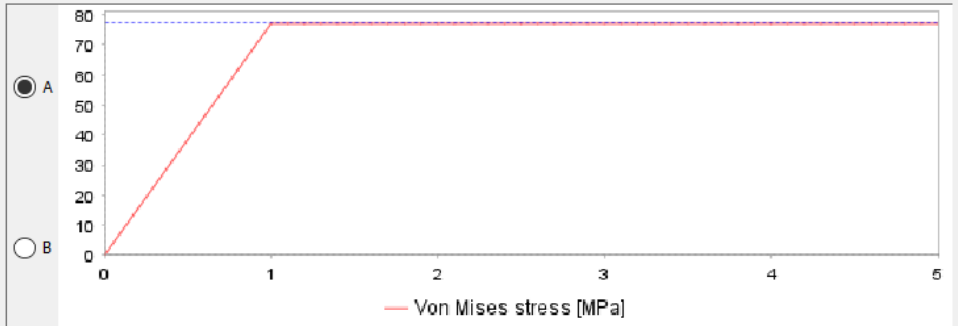
Von Mises stress [MPa]

77.11
62.50
47.90
33.30
18.70
4.10

Von Mises stress [MPa]

Step	Von Mises stress [MPa]
0	0
1	77.107
2	77.107
3	77.107
4	77.107
5	77.107

Copy all to clipboard | View local section forces | Add series | Remove series | Set labels



Component (1): Massive I = 220x110, S=10, F=15mm
Element number: 1
Position of node A (1): 0, 0, 3
Position of node B (2): 0,5, 0, 3
X: 5, Y: 77,107

Show cross-section | Close

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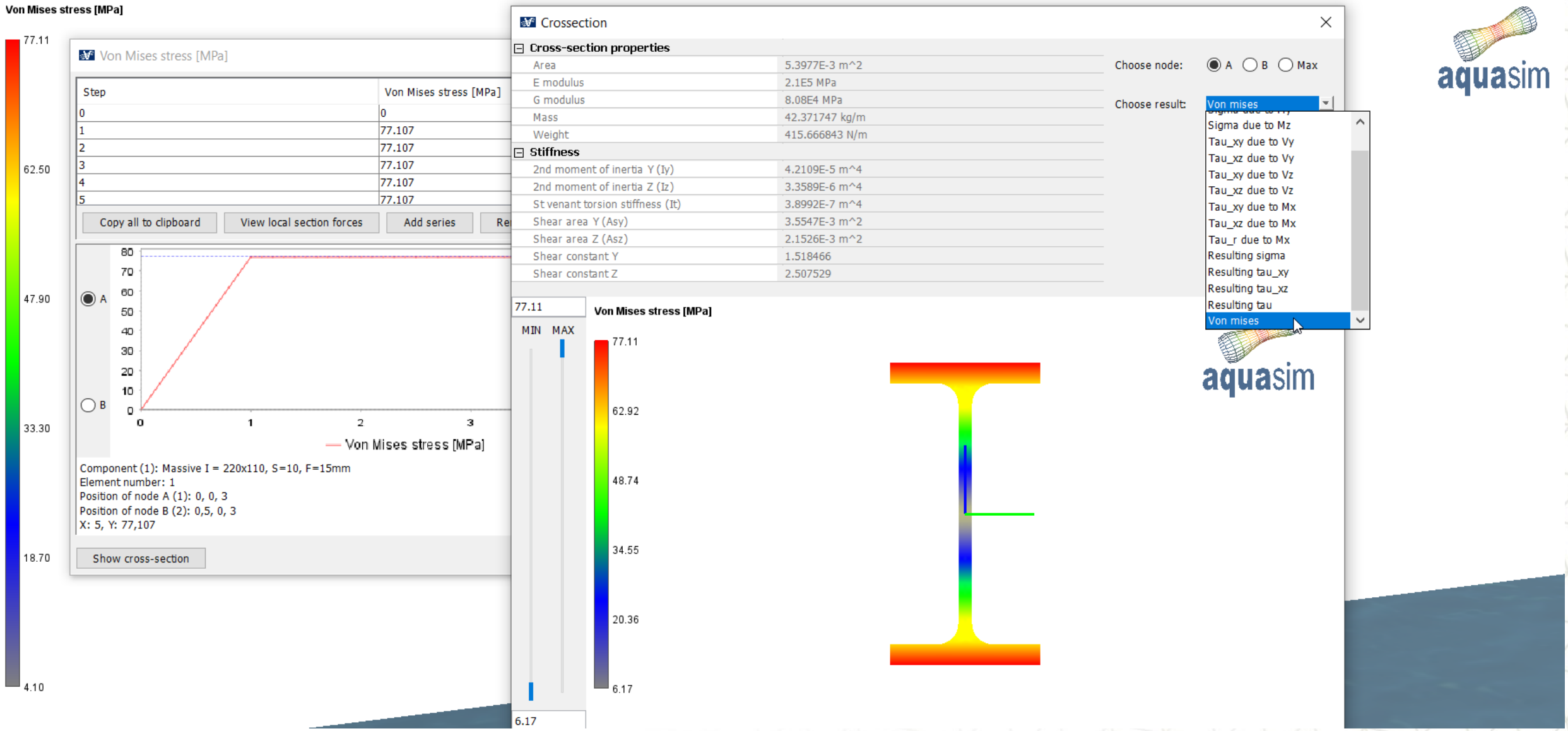

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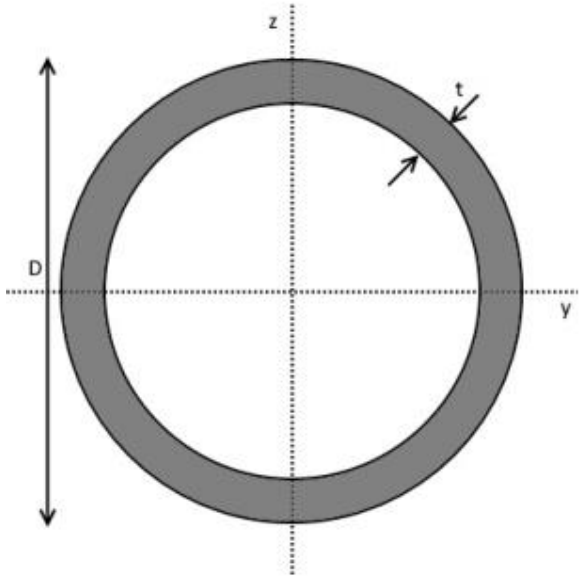
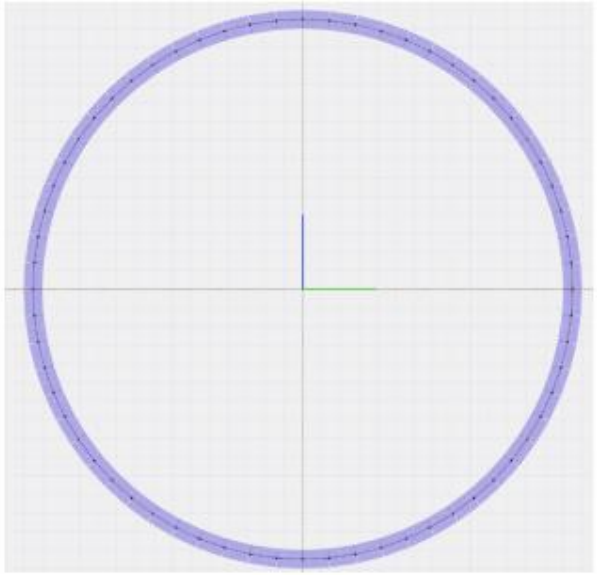
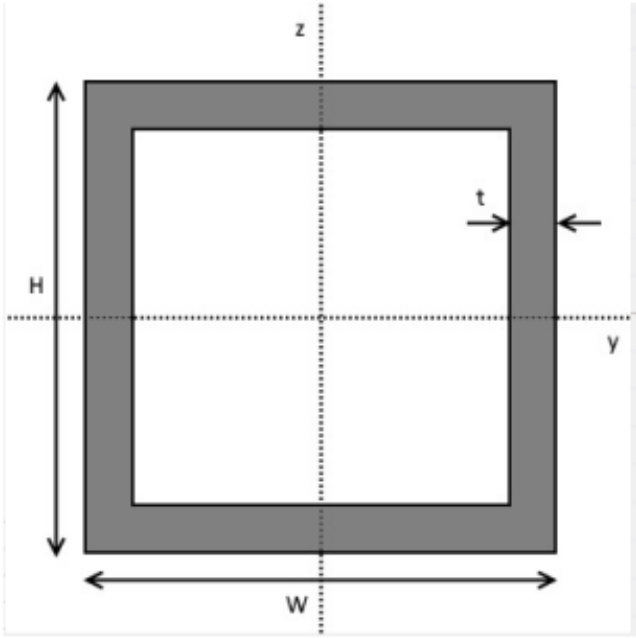
Gitt et sirkulært tverrsnitt med diameter D=300mm og tykkelse t = 10mm

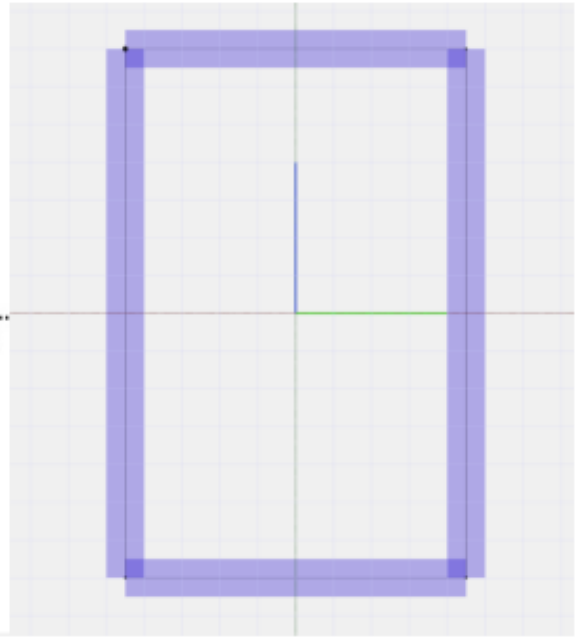




Parameters	AquaEdit	AquaCross, number of elements						
		32	64	128	256	512	1024	2048
Area	9,111E-03	9,096E-03	9,107E-03	9,110E-03	9,110E-03	9,111E-03	9,111E-03	9,111E-03
Iz	9,589E-05	9,505E-05	9,562E-05	9,577E-05	9,580E-05	9,581E-05	9,581E-05	9,581E-05
Iy	9,589E-05	9,505E-05	9,562E-05	9,577E-05	9,580E-05	9,581E-05	9,581E-05	9,581E-05
It	1,918E-04	1,894E-04	1,910E-04	1,914E-04	1,915E-04	1,915E-04	1,915E-04	1,916E-04
Kappa Y	1,500E+00	1,500E+00	1,499E+00	1,499E+00	1,499E+00	1,499E+00	1,499E+00	1,499E+00
Kappa Z	1,500E+00	1,500E+00	1,499E+00	1,499E+00	1,499E+00	1,499E+00	1,499E+00	1,499E+00

Hult rektangulært tverrsnitt, H = 150mm, W = 100mm, t = 5mm





Parameters	AquaEdit	AquaCross, number of elements	
		5	25
Area	2,400E-03	2,400E-03	2,400E-03
Iz	3,995E-06	3,989E-06	3,989E-06
Iy	7,545E-06	7,536E-06	7,536E-06
It	7,906E-06	7,906E-06	7,906E-06
Kappa Y	2,400E+00	2,539E+00	2,539E+00
Kappa Z	1,600E+00	1,692E+00	1,692E+00

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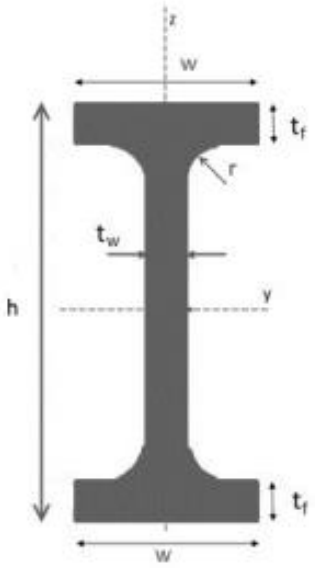
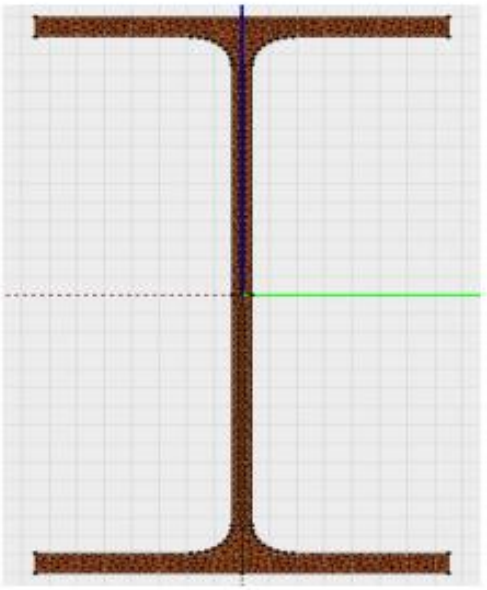
Standard IPE 300-bjelke, Flens = 150 x 10.7mm, Steg = 278.6 x 7.1mm





Parameters	AquaEdit	AquaCross	Official numbers
Area	5,188E-03	5,386E-03	5,380E-03
Iz	6,027E-06	6,382E-06	6,040E-06
Iy	7,999E-05	8,364E-06	8,365E-05
It	1,951E-07	1,985E-07	2,010E-07
Kappa Y	1,616E+00	1,570E+00	1,571E+00
Kappa Z	2,623E+00	2,569E+00	2,569E+00

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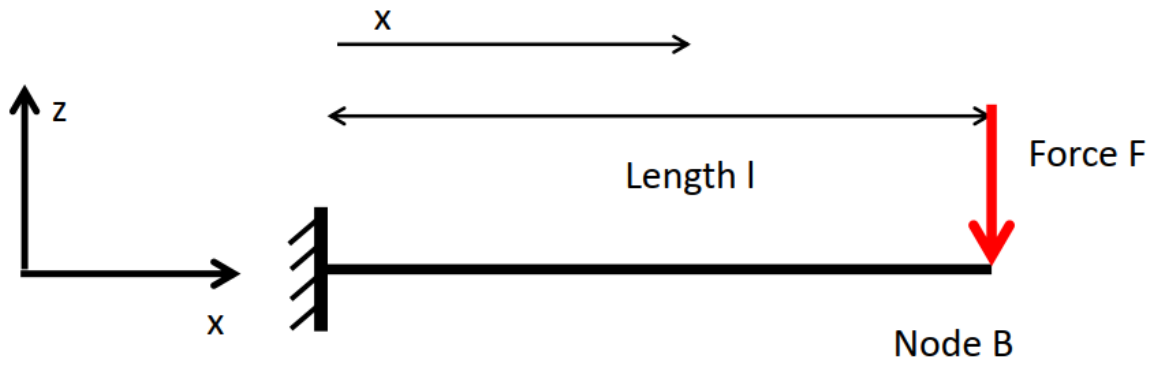
Safety through technology

Testing og validering

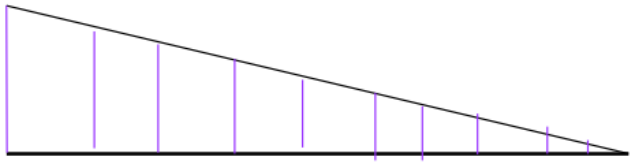


Moment = F*l

Node A

Moment i node A er F*l (kraft ganger momentarm). Definer en hjelpestørrelse x, og vi ser at i et hvert snitt bortover er moment F*(l-x) noe som gir følgende momentdiagram (tegnes på strekkside):

Moment M
F*l



- Nedbøyning i tuppen (x=l):

$$Z(l) = \frac{F}{EI}\left(\frac{1}{2}l^3 - \frac{1}{6}l^3\right) = \frac{Fl^3}{3EI}$$

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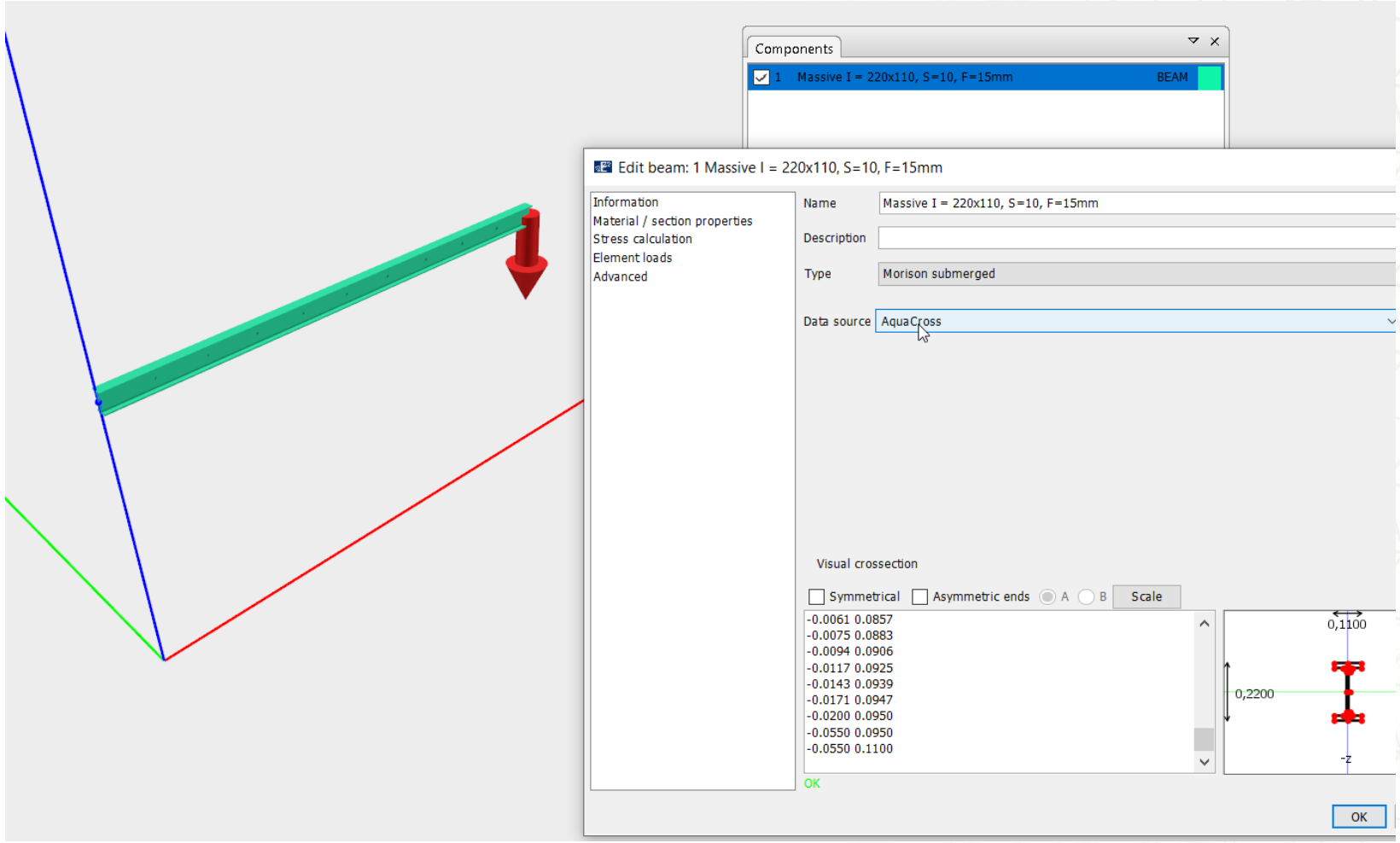
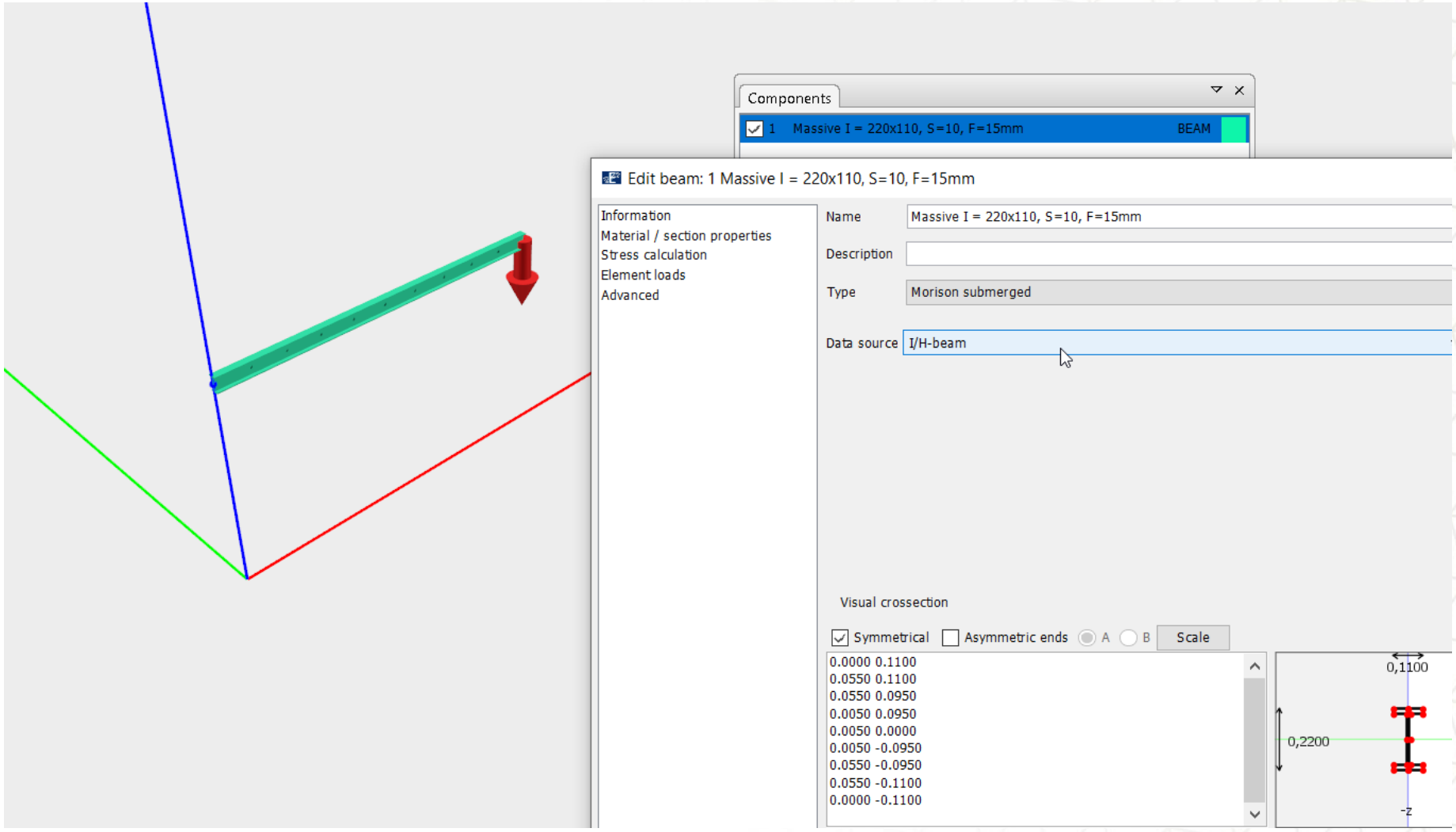
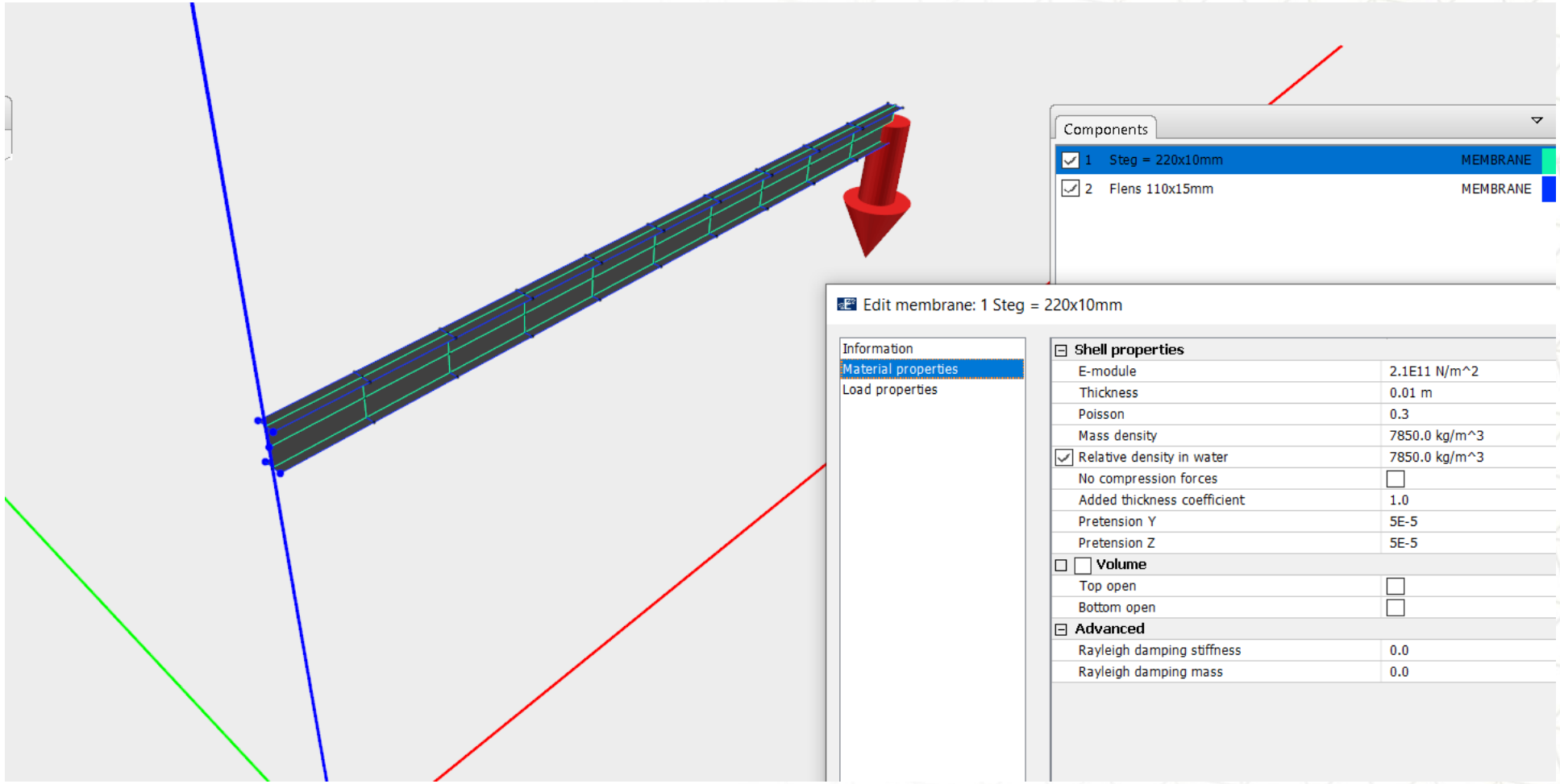
Massiv I-bjelke, 220x110mm, Steg=10mm, Flens =15mm



Standard I-bjelke, 220x110mm, Steg=10mm, Flens =15mm



Shell-element I-bjelke, 220x110mm, Steg=10mm, Flens =15mm



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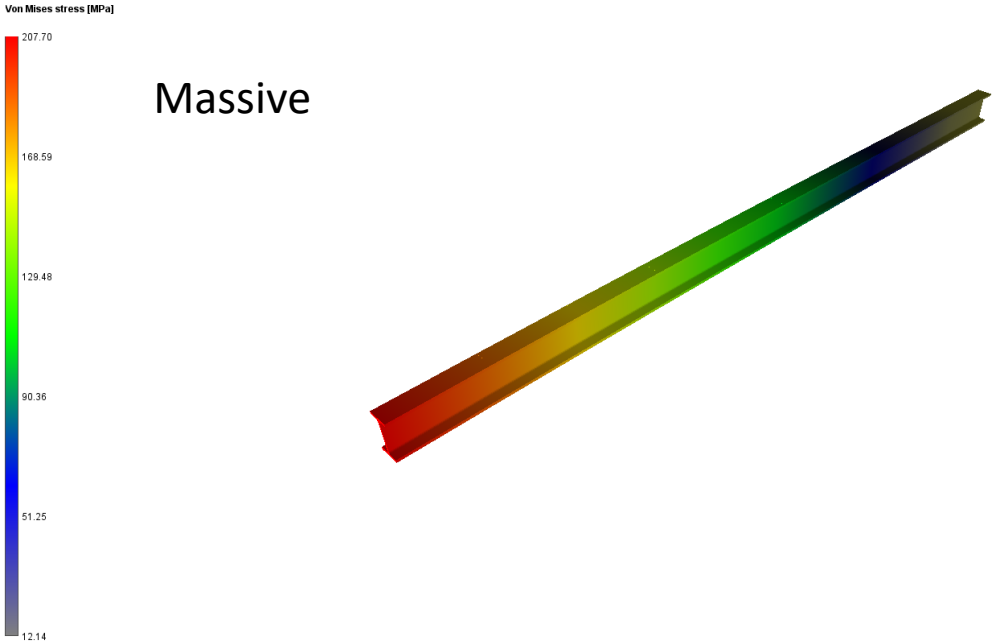
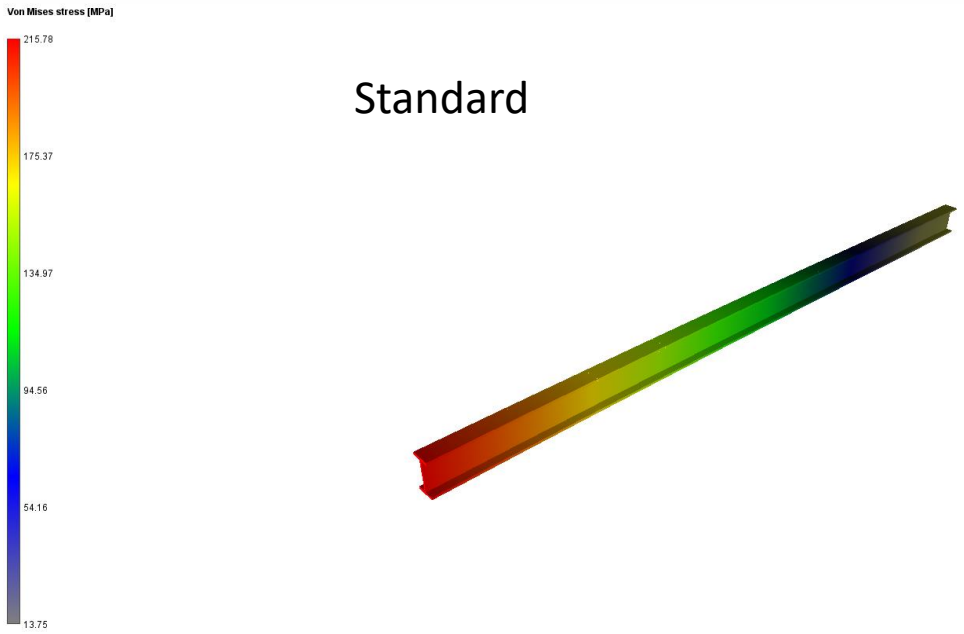
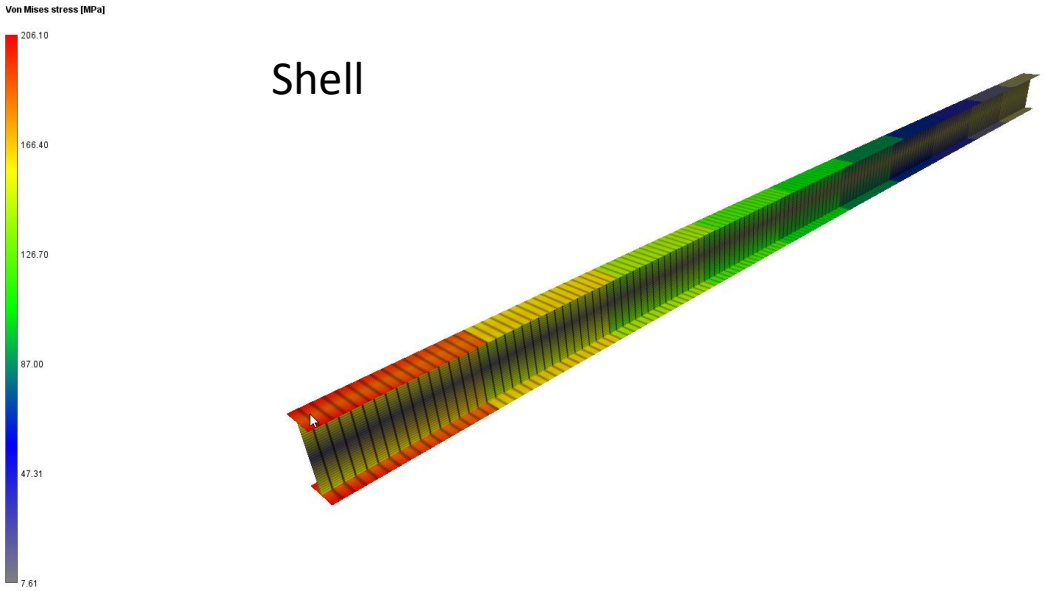
Massive



Standard



Shell



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Massive

Material properties	
E-modulus	2.1E11 N/m^2
G-modulus	8.08E10 N/m^2
Cross sectional properties	
Area	5.3977E-3 m^2
Iy	4.2109E-5 m^4
Iz	3.3589E-6 m^4
It	3.8992E-7 m^4
Weight and volume per meter length	
Volume	5.3977E-3 m^3/m
Mass density	7850.0 kg/m^3
Weight in air	42.371747 kg/m
Weight in water	36.839131 kg/m

	Forces (N)			
Massive I = 220x110mm	**0**	**5000**	**10000**	**15000**
Von Mises (Mpa)	11.801	77.107	142.41	207.7
Axial Force (N)	0.2054	5.3923	17.411	36.258
Shear Force Y (N)	0	0	0	
Shear Force Z (N)	-1716.6	-6716.6	-11717	-16717
Moment Y (N)	4517.4	29517	54514	79507
Moment Z (N)	0	0	0	0
Max Deflexion (mm)	-0.0032	-0.0268	-0.0503	-0.0739

Standard

Material properties	
E-modulus	2.1E11 N/m^2
G-modulus	8.08E10 N/m^2
Cross sectional properties	
Area	5.2E-3 m^2
Iy	4.0448E-5 m^4
Iz	3.3433E-6 m^4
It	6.6561E-7 m^4
Weight and volume per meter length	
Volume	5.2E-3 m^3/m
Mass density	7850.0 kg/m^3
Weight in air	40.82 kg/m
Weight in water	35.49 kg/m

	Forces (N)			
Standard I = 220x110mm	**0**	**5000**	**10000**	**15000**
Von Mises (Mpa)	11.835	79.824	147.81	215.78
Axial Force (N)	0.1984	5.5309	17.975	37.529
Shear Force Y (N)				0
Shear Force Z (N)	-1653.7	-6653.7	-11654	-16654
Moment Y (N)	4352	29351	54349	79341
Moment Z (N)				0
Max Deflexion (mm)	-0.0032	-0.0277	-0.0523	-0.0768

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Safety through technology

Massive

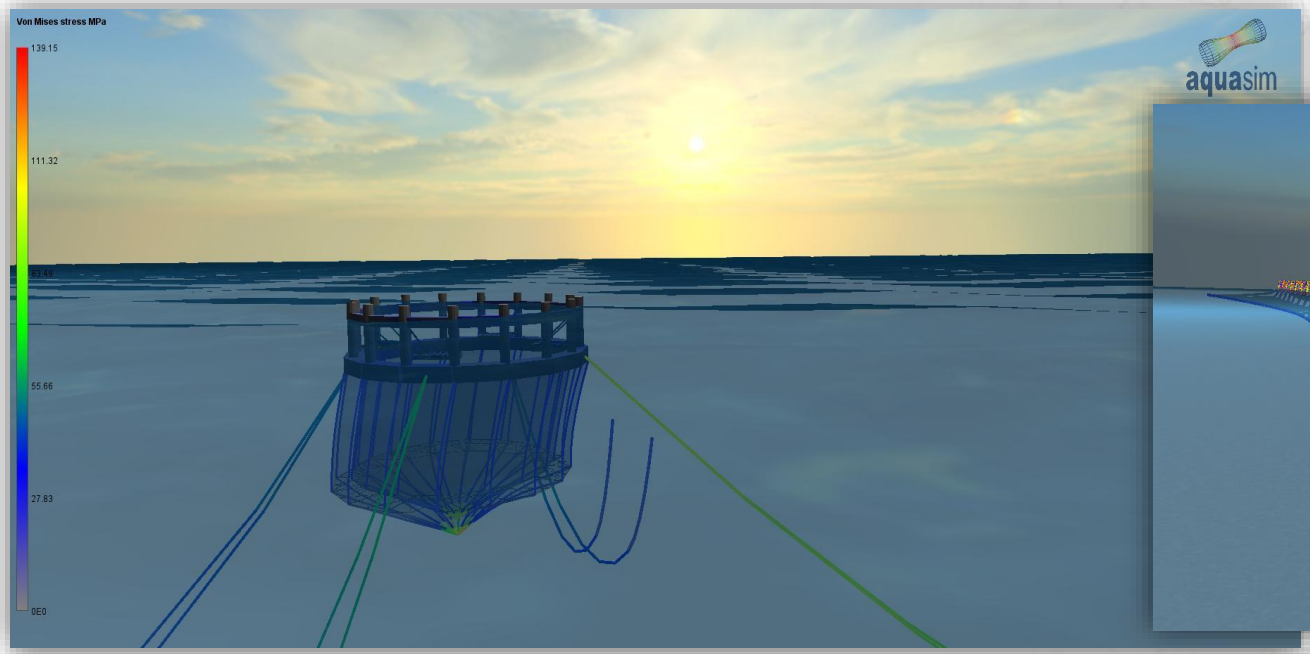
Material properties	
E-modulus	2.1E11 N/m^2
G-modulus	8.08E10 N/m^2
Cross sectional properties	
Area	5.3977E-3 m^2
Iy	4.2109E-5 m^4
Iz	3.3589E-6 m^4
It	3.8992E-7 m^4
Weight and volume per meter length	
Volume	5.3977E-3 m^3/m
Mass density	7850.0 kg/m^3
Weight in air	42.371747 kg/m
Weight in water	36.839131 kg/m

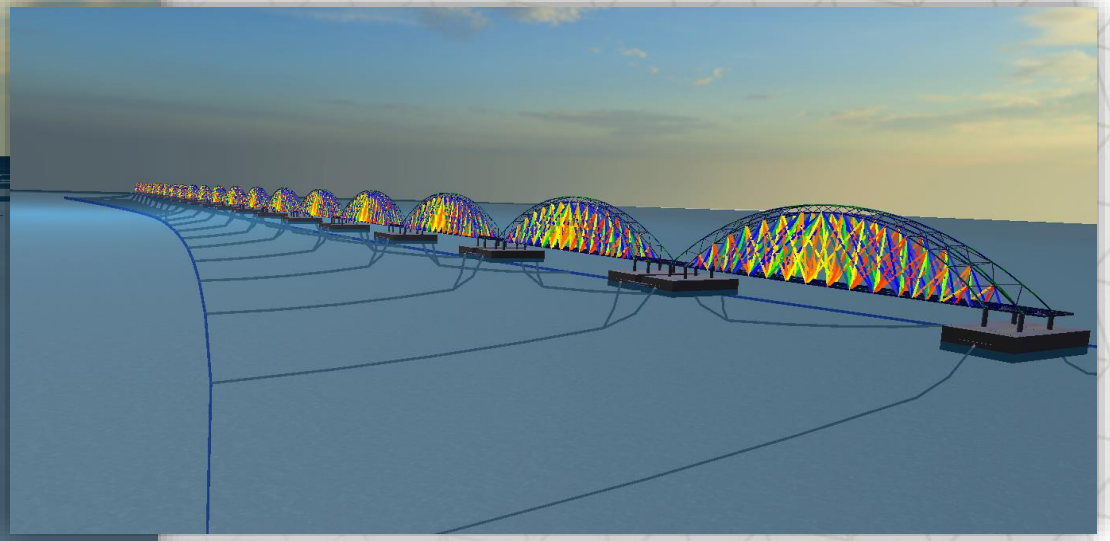
	Forces (N)			
Massive I = 220x110mm	**0**	**5000**	**10000**	**15000**
Von Mises (Mpa)	11.801	77.107	142.41	207.7
Axial Force (N)	0.2054	5.3923	17.411	36.258
Shear Force Y (N)	0	0	0	
Shear Force Z (N)	-1716.6	-6716.6	-11717	-16717
Moment Y (N)	4517.4	29517	54514	79507
Moment Z (N)	0	0	0	0
Max Deflexion (mm)	-0.0032	-0.0268	-0.0503	-0.0739

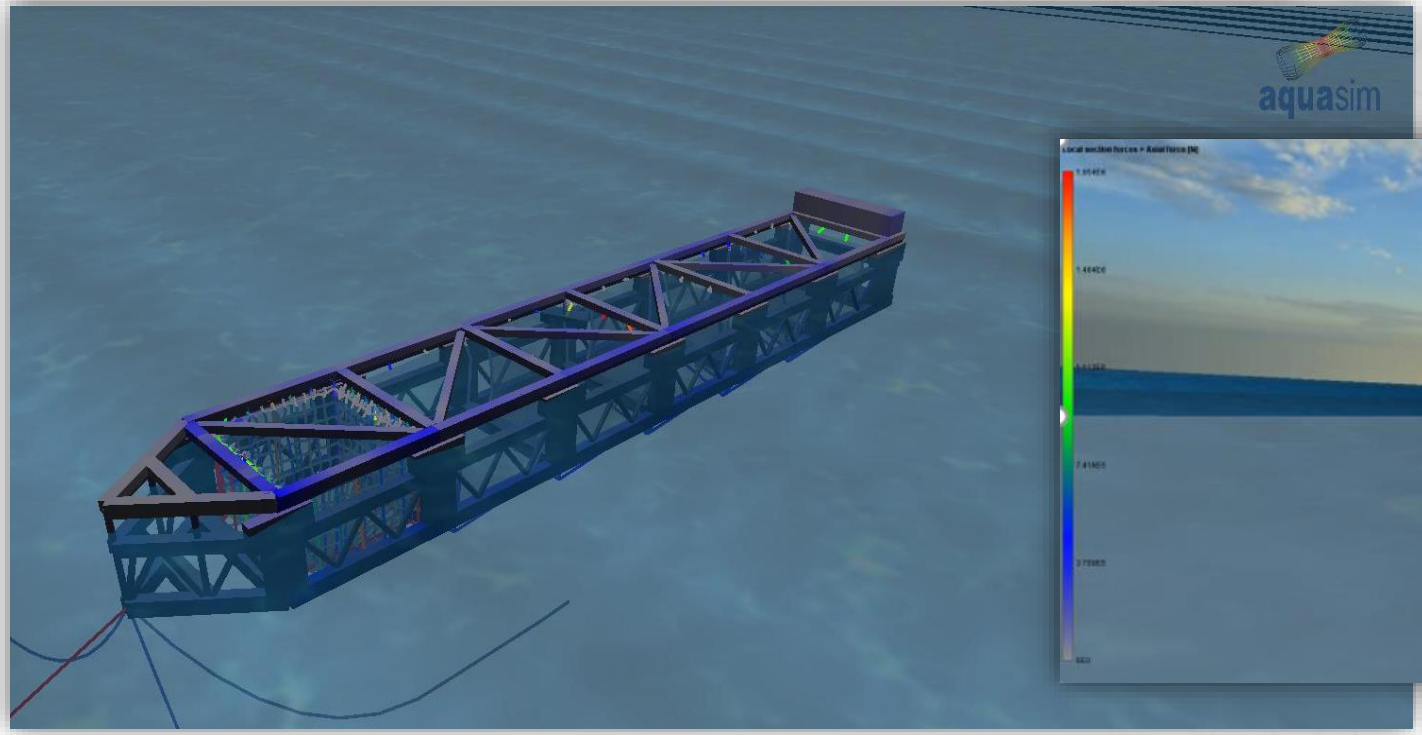
Skallelementer

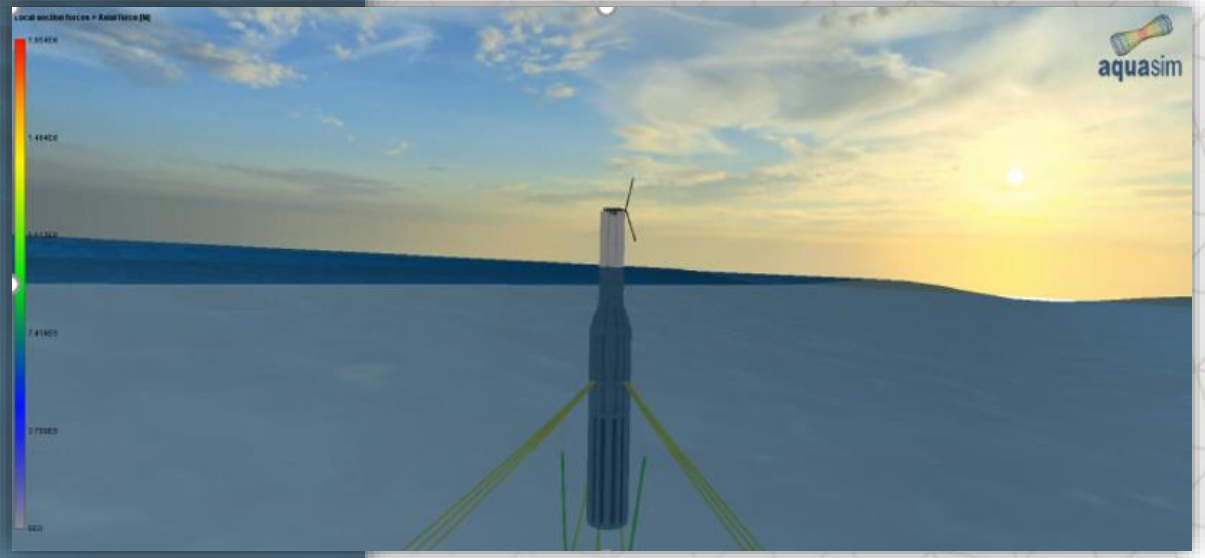
	Forces (N)			
Skall I = 220x110mm	**0**	**5000**	**10000**	**15000**
Von Mises (Mpa)	13.21	77.44	141.7	206.1
Max Deflexion (mm)	-0.0033	0.0237	-0.0441	-0.0645
Analytiske formler:				
Moment Y (N)	5195.85	30195.85	55195.85	80195.85
Max Deflexion (mm)	-1.22E-03	-0.0248	-0.0483	-0.0719

aquastructures
Safety through technology









aquastructures
Safety through technology