The Sigma-X Challenge

Prepare to be shocked by the inaccuracies of other section property calculators.

Sigma-X have tested many section property calculators and found errors in both the basic load independent properties (area, inertias…) and load dependent properties (neutral axis, elastic and plastic moduli...). It goes without saying that if any of these properties are wrong the design values for your section will be wrong.

At Sigma-X we pay very particular and careful attention to getting all the numbers calculated absolutely correct. To do this we calculate the sections properties using two independent methods. The first method uses Integration by Parts (Green's Theorem)[1] to calculate the exact area, inertias and centroids of any shaped section – this method is not an approximation, it is exact. Therefore the answers are exact.

For properties which cannot be calculated using Green's Theorem such as the torsion and warping constants, the shear centre and shear areas, an approximate method has to be used. In this case we use the finite element method. We have taken great care in the development of our finite element (FE) processes to make them extremely accurate, easy to use and numerically transparent. We also use the finite element method to calculate the properties calculated using Green's Theorem since a comparison of the FE result to the exact result is an indicator of how accurate the finite element 'approximation' is.

We tested several other sections property calculators on the market, ranging from cheap to mid range to the 'top of the range' finite element systems, and all of them were found to be incorrect and outside the acceptable limits of accuracy. If Sigma-X can get the calculations right we see no reason why anything less is acceptable.

The common sources of error we have found are

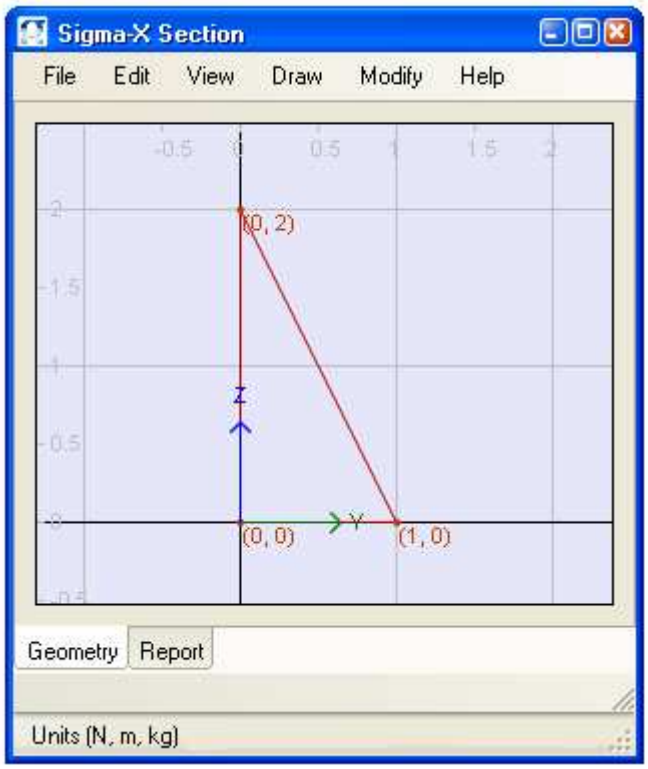
- Errors in the calculation of properties. The numbers were simply wrong.
- Wrong signs; i.e. positive when the sign should have been negative
- Not distinguishing between load independent and dependent properties. The neutral axis of a section is dependent on both the applied load and section geometry.
- Defining the section clockwise, then anticlockwise gives a different answer.

[1] Reference: The Finite Element Method, Its Basis and Fundamentals, Appendix G, Zeinkiewicz Taylor & Zhu, 6th Edition.

Try this for yourself. Print out and fill in the challenge sheets on the pages below to compare your software answers with theory. The challenges range from very simple to practical everyday sections. If necessary use the free trial to verify that Sigma-X Section is 100% correct, 100% of the time!

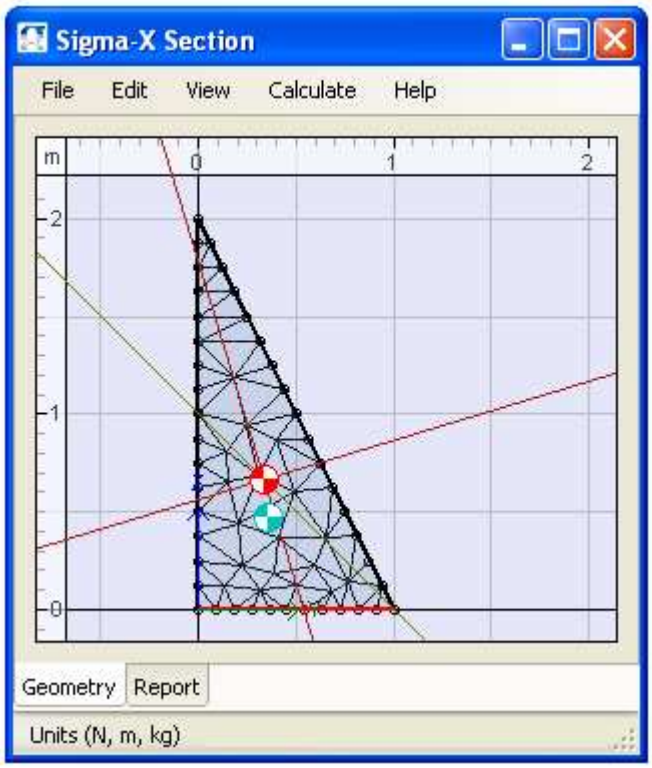
Challenge 1

Object: To compare the load independent properties of a right angled triangle.



Input Notes

- All numbers are correct to six places of decimal. This ensures that errors are not introduced if say the section properties are converted from meters to millimetres.
- To conform to the EuroCode notation, the cross section is described in the Y-Z plane as shown in the picture. The EuroCodes consider the X axis to be along the length of the section.
- The coordinates of the triangle are shown on the picture and are (0,0), (1,0) and (0,2).
- From the picture the breath, b, and height, h, of the triangle are 1m and 2m, respectively.



Output Notes

- Advanced properties are calculated using the finite element method.
- A quality finite element mesh is generated automatically.
- The user may easily adjust finite element mesh if required.
- A pdf or excel input and output report can be produced immediately.

Challenge 1 Results

Property Category	Property Description	Property Label	Theory Calculates	Sigma-X Section Calculates	Your current software Calculates
Standard Properties	Area	A	1.000000	1.000000	
	Centroid y Axis	Cy	0.333333	0.333333	
	Centroid z Axis	Cz	0.666667	0.666667	
	Inertia about y Axis	Iyy	0.222222	0.222222	
	Inertia about z Axis	Izz	0.055556	0.055556	
	Product of Inertia	Iyz	-0.055560	-0.055560	
Principal Properties	Maximum Principal Inertia	Ip max	0.055556	0.055556	
	Minimum Principal Inertia	Ip min	0.038735	0.038735	
	Major Principal Axis	Axis Angle	16.845030	16.845030	
Twist Properties	Torsion Constant	J	0.090017	0.090017	
	Warping Constant	Cw	0.001520	0.001520	
Shear Properties	Shear Area y Axis	Ay	0.635449	0.635449	
	Shear Area z Axis	Az	0.781582	0.781582	
	Shear Centre y Axis	Sy	0.360664	0.360664	
	Shear Centre z Axis	Sz	0.466160	0.466160	
Elastic Properties	Elastic Neutral Axis y	ENA y	0.333333	0.333333	
	Elastic Neutral Axis z	ENA z	0.666667	0.666667	
	Elastic Neutral Axis Angle	ENA Angle	-45.000000	-45.000000	
	Elastic Modulus Top y Axis	SyyT	0.314270	0.31427	
	Elastic Modulus Bottom y Axis	SyyB	0.314270	0.31427	
	Elastic Modulus Top z Axis	SzzT	0.058926	0.058926	
	Elastic Modulus Bottom z Axis	SzzB	0.047140	0.047140	
Plastic Properties	Plastic Neutral Axis y	PNA y	0.333333	0.333333	
	Plastic Neutral Axis z	PNA z	0.666667	0.666667	
	Plastic Neutral Axis Angle	PNA Angle	-45.000000	-45.000000	
	Plastic Modulus y Axis	Zyy	0.235702	0.235702	
	Plastic Modulus z Axis	Zzz	0.362030	0.362030	

Table 1: Some of the Challenge 1 Geometric Properties Calculated by Sigma-X Section.