# Arbitrary Section Property Calculation and Use

For LUSAS version:	20.0
For software product(s):	All (except LT versions)
With product option(s):	None.

## **Description**

The section properties of an arbitrary shaped box section are to be computed prior to the section being used on a model. Section geometry is supplied as a DXF file.

Units of N, mm, t, s, C are used.

#### **Objectives**

The required output from the analysis consists of:

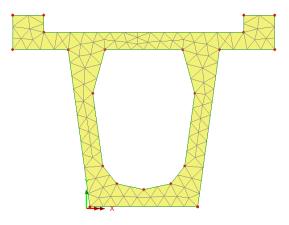
Section properties of a box section

#### Keywords

2D, Inplane, Section Properties, Arbitrary Section, Box Section, Holes, Fibre locations.

#### **Associated Files**

Associated files can be downloaded from the user area of the LUSAS website.



 $\hfill\square$  **box\_section.dxf** DXF file providing the section geometry.

## Modelling

### **Running LUSAS Modeller**

For details of how to run LUSAS Modeller, see the heading *Running LUSAS Modeller* in the *Introduction to LUSAS Worked Examples* document.



**Note.** This example is written assuming a new LUSAS Modeller session has been started. If continuing from an existing Modeller session select the menu command **File> New** to start a new model file. Modeller will prompt for any unsaved data and display the New Model dialog.

### **Creating a new model**

- Enter a File name of **box\_section**
- Use the default **User-defined** working folder.
- Ensure an Analysis type of **Structural** is set.
- Select an Analysis Category of **2D Inplane**
- Set Model units of **N,mm,t,s,C**
- Leave the Timescale units as Seconds
- Select a Startup template of None.
- Ensure the Layout grid is set as None
- Enter a Title of **Box Section**
- Click the **OK** button.

### Discussion

The arbitrary section property calculator within LUSAS Modeller allows a user-defined section to be drawn (or imported) and properties for that section to be calculated during the creation of any model. In doing so, a section utility is created in the Utilities Treeview and the ability to create a corresponding geometric line attribute in the Attributes Treeview is provided. This attribute can be assigned directly to selected lines in a model.

The calculator itself computes the section properties of any open or closed section. Cross-sections are created either as a single regular or irregular surface, or as a group of

surfaces (including holes). Fibre definitions (positions on the cross-section at which stresses or values can be plotted when viewing results) are also created for each drawn section at the time of section property calculation.

#### Arbitrary Section × Utilities Geometry Attributes Standard Shapes Section Property 🗅 📽 🏚 〓 | X 요요| ㅇ - / - 🗖 - | m 는 스| 🏠 💠 🖡 🐱 💖 🚧 🗖 A Calculator -1.0E3 -800.0 -600.0 -400.0 -200.0 Attributes (0) > Arbitrary section... None Specify... Name Sct1 ~ 🕂 (new) OK Cancel Apply Help

Accessing the Arbitrary Section View Window

The arbitrary section view window contains a reduced set of menu items and toolbar buttons from the main Modeller window that are suitable for creating and manipulating user-defined sections.



**Caution.** 2D cross-sections for section property calculation <u>must</u> be defined in the XY plane.



**Note.** All menu commands that follow are for selection inside the Arbitrary Section window, and not the main User Interface.

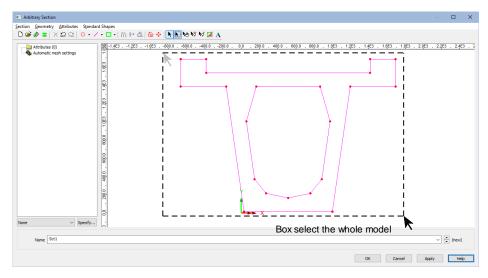
### **Feature Geometry**

- Set the **Files of type** drop-down menu to **DXF Files** (\*.dxf)
  - Locate the **box\_section.dxf** file that was downloaded and placed in a folder of your choosing and click the **Import** button to read in the DXF file and create the cross-section geometry as shown below.

#### **Defining holes within a section**

This is done by first defining a surface that represents the total extent of the boxsection, then defining a surface that represents the void or hole, and then selecting both the surrounding and inner surface to create the hole in the bounding surface.

Section Import... • Drag a box around the whole model



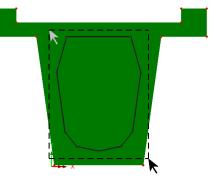
G	ieometry	
_	Surface	>
	By Lines	

Click the **OK** button to create a **General Surface** (for the outer surface) from the selected Lines.

• Now, drag a box around the only the lines defining the void.

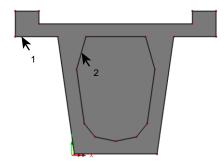
G	eometry	
	Surface	>
	By Lines	

Click the **OK** button to create a **General Surface** (for the inner surface) from the selected Lines.



Box select the lines defining the void

• Select the outer Surface of the boxsection, then hold the **Shift** key down, and select the inner Surface representing the void.

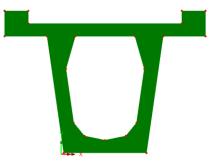


Select the two surfaces

Geometry	
Surface	>
Holes	>
Create	

• On the Create Holes dialog, ensure the option **Delete geometry defining holes** is selected, and click **OK**.

A new singular Surface will be created, containing a void. This can be seen by clicking in an empty region of the view window to deselect all features, and then clicking inside the outer perimeter of the box section and seeing that all lines are selected.



#### Name the section

Sections are saved with the model in which they are defined, and with the section name stated.

• At the bottom of the Arbitrary Section window, enter a name of dxf\_box\_section.

#### **Calculate section properties**

Section	
Compute	
properties	

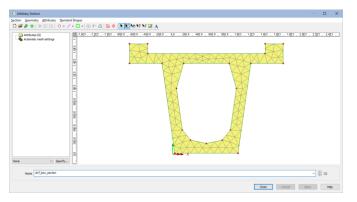
The section properties will then be calculated and shown on the Section Details dialog. Centroid, Shear Centre and Plastic Neutral Axis symbols and locations are also shown.

			_		
		Value	<u>        0</u>	Centroid	100
Cross sectional area	A	1.09398E6		Shear centre	
Second moment of area about x axis	box	328.705E9	· •	Plastic neutral axis	
Second moment of area about y axis	by I	390.837E9	•	Origin	
Product moment of area	bxy	-140.403E6			
Torsional constant	J	309.979E9	1.063	A2 A1	
Effective shear area in x direction	Asx	469.376E3			
Effective shear area in y direction	Asy	496.459E3		The second se	
Radius of gyration about x axis	kx	548.149			
Radius of gyration about y axis	ky	597.713			
Warping torsional constant about shear centre	Cw	7.86679E15	0		
Shear centre x distance from centroid	xo	0.355327	-   <b>-</b>   -	V V X	
Shear centre y distance from centroid	yo	-49.6374			
Monosymmetry constant about x	betax	172.508			
Monosymmetry constant about y	betay	-1.16398			
Wagner constant 1st moment of square radius about x	bor	24.0722E12			
Wagner constant 1st moment of square radius about y	lyr	-177.423E9		<b>€</b> _ ⊘	
Wagner constant 4th moment of area about origin	lπ	644.502E15	- T	A3 A4	
Wagner constant 2nd moment of warping about origin	lwr	-62.3584E12			
Plastic section modulus about x axis	Zpx	519.019E6			
Plastic section modulus about y axis	Zpy	578.144E6			
Plastic torsional section modulus	Zpt	578.263E6	1		
Plastic neutral axis, distance from centroid along x axis	хр	-0.050769	2.0E3.	I	
Plastic neutral axis, distance from centroid along y axis	ур	221.17	¥/	-1.0E3	
Centroid X from geometry origin	Xc	-515.275	x		
Centroid Y from geometry origin	Yc	-976.138			
Principal axes angle	theta	0.0			



**Note.** There is no need to compute the section properties in the units they are to be used in the analysis model because conversion of units is carried out when the section properties are extracted from the section library if it is found to be required.

• After viewing the properties, click the **Close** button. The mesh used to calculate the section properties is now shown on the model in the Arbitrary Section window.



**Note.** By default, an element size is selected which will assign 15 elements to the longest side and a minimum of 2 elements is applied to the shorter sides. This mesh may be adjusted by selecting 'Automatic mesh settings' in the Arbitrary Section treeview prior to computing section properties.

As with all finite element models the more elements used the more accurate the results but the slower the calculation. A good compromise of 2 elements across all thin sections has been found to provide reasonable results without using excessive computation time.

• On the Arbitrary Section property window click **OK**.

A dxf\_box\_section utility has now been added to the Utilities 🖑 Treeview.

### Notes on defining and using arbitrary sections

When accessing the arbitrary section property calculator from the **Utilites > Section Property Calculator** menu item (as done here), on completion using this method of accessing the tool, only a utility is created in the Utilities  $\checkmark$  Treeview, and this will need to be selected in order to define a geometric line attribute for subsequent assignment to selected lines in a model.

The Arbitrary Section Property Calculator can also be accessed from the Attributes > Geometric > Section Calculators menu item, or from the Attributes > Geometric > Section Library Item. On completion, using these methods of accessing the tool, a section utility is created in the Utilities  $\checkmark$  Treeview and the ability to create a corresponding geometric line attribute in the Attributes  $\checkmark$  Treeview is provided. This attribute can be assigned directly to selected lines in a model.

#### How to access arbitrary sections from the section library



**Note.** All menu commands that follow are for selection inside the main User Interface, and not the Arbitrary Section window.

When defining sections for use within a current model (as in this case):

- Select Arbitrary Sections from the top-right drop-list on the dialog.
  - In the lower drop-list, browse for and select the **dxf\_box\_section** name. The section shape will be visualised, showing defined fibre locations.

Fibre locations are used to calculate beam stress results for plotting force and moment diagrams. LUSAS automatically creates one for every extreme point on a section.

Note that eccentricity values can be defined here for sections, when appropriate

eometric Line	>
Analysis category 2D Inplane Definition © From library / calculator	Arbitrary Sections V
Rotation about centroid 0 v ° Mirrored about axis None v Center properties Usage 20 Thick Beam (Any beam) v	1:dxf_box_section ~
ung ( ini ini ini ini ini ini ini ini ini i	
ey origin Centraid v  Tross sectional area (A)  Second moment of area adout z aris (Izz)  Effective shear area in y direction (Aey)  Eccentricity in y direction (ey)	Volue 10336E6 328.75E9 496.45E3 0.0
Visualise Tapering >>	Section details

Attributes Geometric > Section library...

- On the Geometric Line dialog, press the **Section details** button.
- On the Section Details dialog, select the **Fibre locations** tab. The calculated extreme fibre locations can be seen.

Note that additional fibre locations can be added manually to the library item by clicking in the Fibre locations area and pressing the **TAB** key until a new line is created, and then entering the coordinate of the fibre location required.



**Tip.** If additional fibre locations are required on the section use Modeller to obtain the properties of any additional points on the saved model and enter the point coordinates in the manner described above. Note that if invalid coordinates are used the fibre

		y z 3 4		100%
Properties	Fibre locations Cross sec	Distance from centroid, z	Distance from centroid, y	
1	A1	1.17963E3	709.205	
1 2	A1 A2	1.17963E3 -1.18037E3	709.205 709.205	
2	A1 A2 A3	1.17963E3 -1.18037E3 -484.75	709.205 709.205 -960.795	
1 2 3 4 5	A1 A2	1.17963E3 -1.18037E3	709.205 709.205	

location will be added to the nearest point on the outer perimeter of the section.

- Press **OK** to save changes and return to the Geometric Line dialog.
- Finally, to add the arbitrary section to the Attributes here assignment to selected lines representing beams in the model) press the **OK** button.

This completes the example.



**Note.** A Box Section Property Calculator is provided in Bridge and Civil & Structural software products and allows for generating solid or voided sections of a type typically used in precast and segmentally constructed bridges.