MEC-E1004 Principles of Naval Architecture

Section modulus and bending moment calculations

Aalto University
School of Engineering

Determining main dimensions

Tips before going to calculations

- Make sure you have the scantlings and the dimensions of the ship section ready
- Be careful of the units used in defining scantlings and during calculations
- For simplicity, we do not consider any stiffeners

Define Scantlings

- ❑ **Define the dimensions of the plating**
  - ✓ *b is the horizontal dimension parallel to the NA*
  - ✓ *d is the vertical dimension perpendicular to the NA*
- ❑ **Then define the number of each component**

Item [-]	Number of parts n [-]	Horizontal b [m]	Vertical d [m]	Height h_i [m]	Area $a=n*b*d$ [m^2]	1st Moment $S=a*h_j$ [m^3]	2nd Moment @ centroid $i=n*b*d^3/12$ [m^4]	2nd moment @BL $I_S=a*h_j^2$ [m^4]
Bottom plating	1	10.000	0.020	0.000	0.200	0.000	0.000	0.000
Inner bottom plating	1	10.000	0.018	1.500	0.180	0.270	0.000	0.405
Strength deck plating	1	6.000	0.022	13.000	0.132	1.716	0.000	22.308
2nd deck plating	1	6.000	0.016	10.000	0.096	0.960	0.000	9.600
Side plating	1	0.014	11.500	7.250	0.161	1.167	1.774	8.463
Bilge	1	0.016	1.500	0.750	0.024	0.018	0.005	0.014
Center girder (1/2)	1	0.012	1.500	0.750	0.018	0.014	0.003	0.010
Upper hatch side girder	1	-	-	13.000	0.008	0.104	0.000	1.352
Lower hatch side girder	1	-	-	10.000	0.003	0.030	0.000	0.300
Insert other items					0.000	0.000	0.00E+00	0.00E+00
Insert other items					0.000	0.000	0.00E+00	0.00E+00
Insert other items					0.000	0.000	0.00E+00	0.00E+00
Insert other items					0.000	0.000	0.00E+00	0.00E+00
Insert other items					0.000	0.000	0.00E+00	0.00E+00
				∑	0.822	4.279	1.782	42.451

Height (hj)

- Define the height of each component's centroid above the baseline.
- For instance, the side shell in the figure has (h) above BL equal to its *half length + thickness* of the bottom plate.
- You can add more structural items in the empty cells.

Item	Number of parts	Horizontal	Vertical	Height	Area	1st Moment	2nd Moment @ centroid	2nd moment
	n	b	d	h_i	a=n*b*d	S=a*h_j	i=n*b*d^3/12	I_s=a*h_j
[-]	[-]	[m]	[m]	[m]	[m^2]	[m^3]	[m^4]	[m^4]
plating	1	10.000	0.020	0.000	0.200	0.000	0.000	0.000
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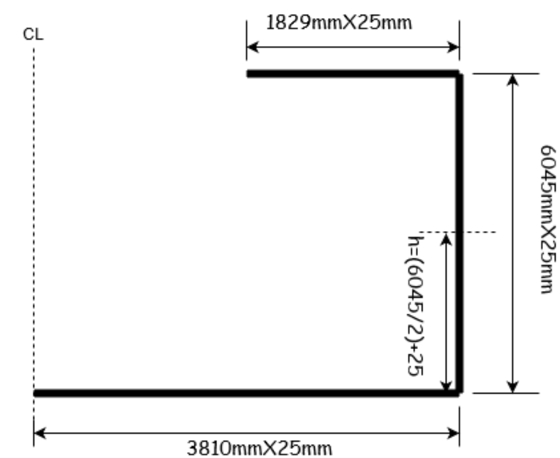
her items					0.000	0.000	0.00E+00	0.00E+0
her items					0.000	0.000	0.00E+00	0.00E+0
her items					0.000	0.000	0.00E+00	0.00E+0
her items					0.000	0.000	0.00E+00	0.00E+0
her items					0.000	0.000	0.00E+00	0.00E+0
				Σ	0.822	4.279	1.782	42.451



2nd moment of area @centroid (i)

- Calculate the area moment of inertia of each component about its centroid.
- For rectangular cross-sections (e.g. plates) i = breadth x depth^3/12

Item	Number of parts	Horizontal	Vertical	Height	Area	1st Moment	2nd Moment @ centroid	2nd moment @BL
	n	b	d	h_i	a=n*b*d	$S=a*h_j$	$i=n*b*d^3/12$	$I_S=a*h_j^2$
[-]	[-]	[m]	[m]	[m]	[m^2]	[m^3]	[m^4]	[m^4]
Bottom plating	1	10.000	0.020	0.000	0.200	0.000	0.000	0.000
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Insert other items					0.000	0.000	0.00E+00	0.00E+00
Insert other items					0.000	0.000	0.00E+00	0.00E+00
				Σ	0.822	4.279	1.782	42.451

Ship main particulars

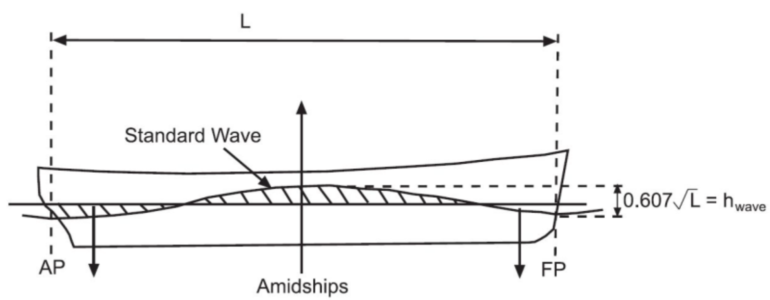
- Insert the ship main particulars, length, breadth, block coefficient C_b and height of the deck above the baseline (the ship's depth) and material yield stress.

Ship main particulars		
Ship Depth D	13.00	m
Ship length L	100.00	m
Ship Breadth B	13.00	m
Cb	0.7	
σ_{yield}	235	MPa

Bending moment calculation

Murray's method:

- **Murray's Method can be employed to estimate the longitudinal bending moment amidships which arises when the ship is stabilized on a 'Standard Wave'.**
- **Standard Wave means a wave with length equals to the length of the ship (L) and height equals** $0.607\sqrt{\mathrm{L(meter)}}$.



Bending moment calculation

Murray’s method:

- **The wave-induced bending moment is given as a function of ship breadth (B) and Length (L).**

$$M_w = b \cdot B \cdot L^{2.5} \times 10^{-3} \text{ tonnes metres}$$

where b is a constant based on the ship block coefficient C_b and whether the ship is sagging or hogging.

	Values of b	
C_b	Hogging	Sagging
0.80	10.555	11.821
0.78	10.238	11.505
0.76	9.943	11.188
0.74	9.647	10.850
0.72	9.329	10.513
0.70	9.014	10.175
0.68	8.716	9.858
0.66	8.402	9.541
0.64	8.106	9.204
0.62	7.790	8.887
0.60	7.494	8.571

Bending moment calculation

Murray's method:

- **Total bending moment equals the summation of the still water bending moment and wave-induced bending moment.**

- **The still water bending moment requires definition of load distribution; as it is still not available we can study only the wave induced bending moment and the corresponding maximum stress on deck and bottom plates.**

Bending moment calculation

Murray's method:

- **Enter the still water bending moment, if available. +ve for hogging and –ve for sagging.**
- **Excel sheet will calculate the wave induced bending moment based on Murray's method.**
- **Total bending moment(M) equals (wave sagging M + still water sagging M OR wave hogging M + still water hogging M)**

Bending moment			Notes
Still water bendign moment	0.00E+00	N.m	+ve hogging -ve sagging. If it is not availabe, enter 0.
wave induced hogging moment	1.15E+08	N.m	+ve hogging -ve sagging.
wave induced sagging moment	-1.30E+08	N.m	+ve hogging -ve sagging.
Total bending moment	-1.30E+08	N.m	+ve hogging -ve sagging.

Results

- **The results you get in the spreadsheet are:**
  - The location of the neutral axis.
  - The sectional modulus at the deck and the bottom.
  - Stresses at the deck and the bottom.
  - The area moment of inertia of the ship section considered.
  - Factor of safety (FOS) ratio between yeild stress and max bending stress

Total cross-section		
Neutral axis	5.205	m from BL
A_{tot}	1.644	m^2
Elements, $i_{,tot}$	3.56	m^4
Elements, $I_{S,tot}$	84.90	m^4
I_{BL}	88.47	m^4
I_{NA}	43.923	m^4
Z_{deck}	5.635	m^3
Z_{bottom}	8.438	m^3

Response			Notes
Moment Maximum	1.30E+08	N.m	
σ_{deck}	23.07	MPa	tention in hogging , compression in sagging
σ_{bottom}	15.40	MPa	compression in hogging , tention in sagging
Type of deformation	Sagging		
FOS	10.19		

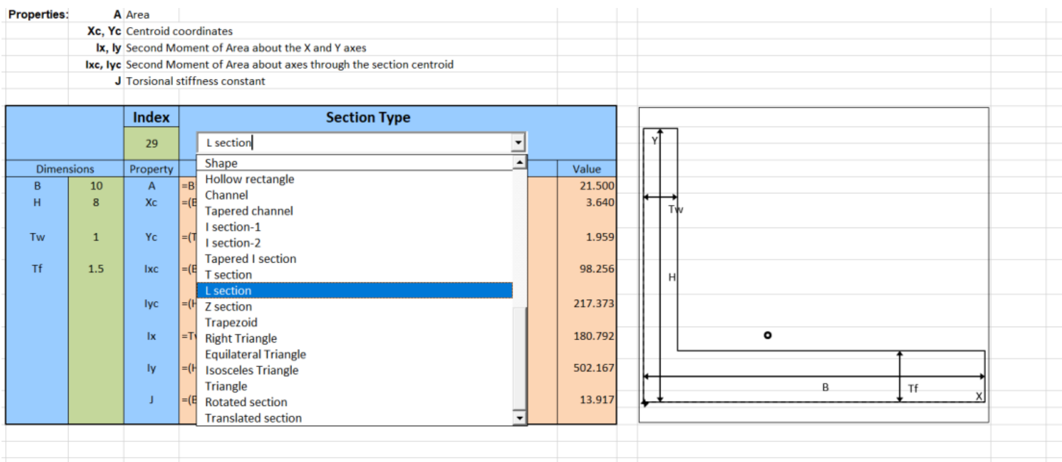
Results

- There are 5 sheet to calculate the second moment of area of several stiffeners shapes.

- You can use this calculator to define the second moment of inertia (i) of the different structural items in your design as L beams, T girders, circular pillars etc.

Results

- Go to defshapes sheet and select the appropriate shape of the stucutral member.
- Cross-section of the item will be plotted against the table
- Define the dimensions of the section and get the results from the value column



Thank you

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