Project Report

MIDSHIP SECTION CALCULATIONS
Group C

Ship Details given :

Type of vessel	RO-RO Cargo ship
LBP	195 m
Breadth	32.5 m
Depth	26.1 m
Draft	9.7 m
Cb	0.73
Speed (kn)	12.75 knots
CLASS	ClassNK

Group Members:
Vaidehi na19b014
Joshy na1b015
Hari prasad na19b016
Rahul Teja na19b017
Sri vathsa na19b018
Vineeth na19b019

AIM-

To calculate :

- ➢ Still water Bending moment from given data
- ➢ Wave Bending moment from ClassNK rules
- ➢ Scantling calculations from ClassNK rules
  - ○ Plate thickness from ClassNK rules
  - ○ Stiffener thickness from ClassNK rules
- ➢ Midship Section Modulus from calculated data
- ➢ Midship Section Modulus required by the ClassNK rules
- ➢ Midship section arrangement diagram

Introduction :

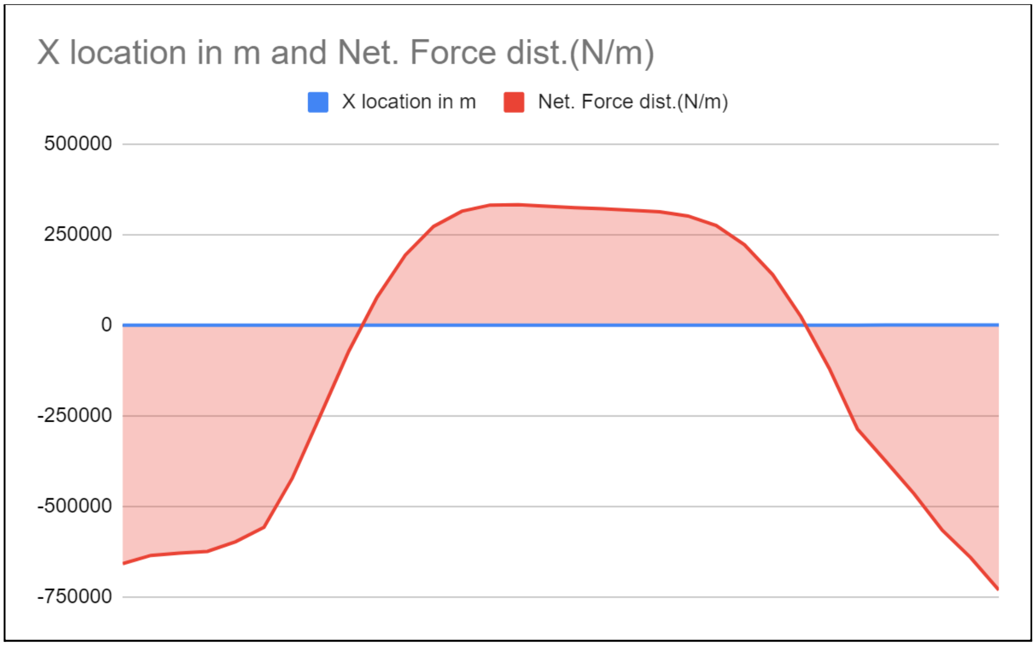
Roll-on/roll-off (RORO or ro-ro) ships are cargo ships designed to carry wheeled cargo, such as cars, trucks, semi-trailer trucks, buses, trailers, and railroad cars, that are driven on and off the ship on their own wheels or using a platform vehicle, such as a self-propelled modular transporter. This is in contrast to lift-on/lift-off (LoLo) vessels, which use a crane to load and unload cargo. These ships do not require any hatch openings as the cargo(vehicles) are driven over ramps and placed in the ship. These ships have multiple decks over which the vehicles are placed.

Excel sheet for calculations:

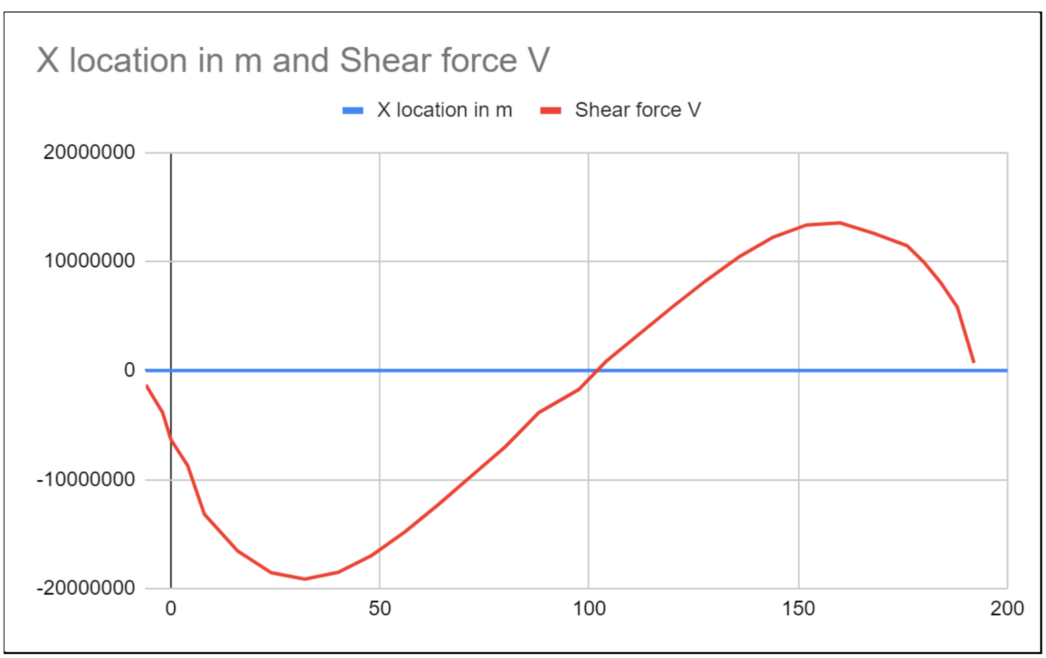
- In sheet 1, we have calculated the shear forces, still water bending moments and plotted the graphs between them and the position from aft.
- In sheet 2, we have calculated the wave vertical bending moments for hogging, sagging conditions in fatigue and strength assessment scenarios.
- In sheet 3, scantlings and minimum thickness for the elements were derived.
- In sheet 4, section modulus from the structural elements is calculated and cross checked with the minimum sectional modulus which is derived empirically.

1) Calculations of Still water bending moment :

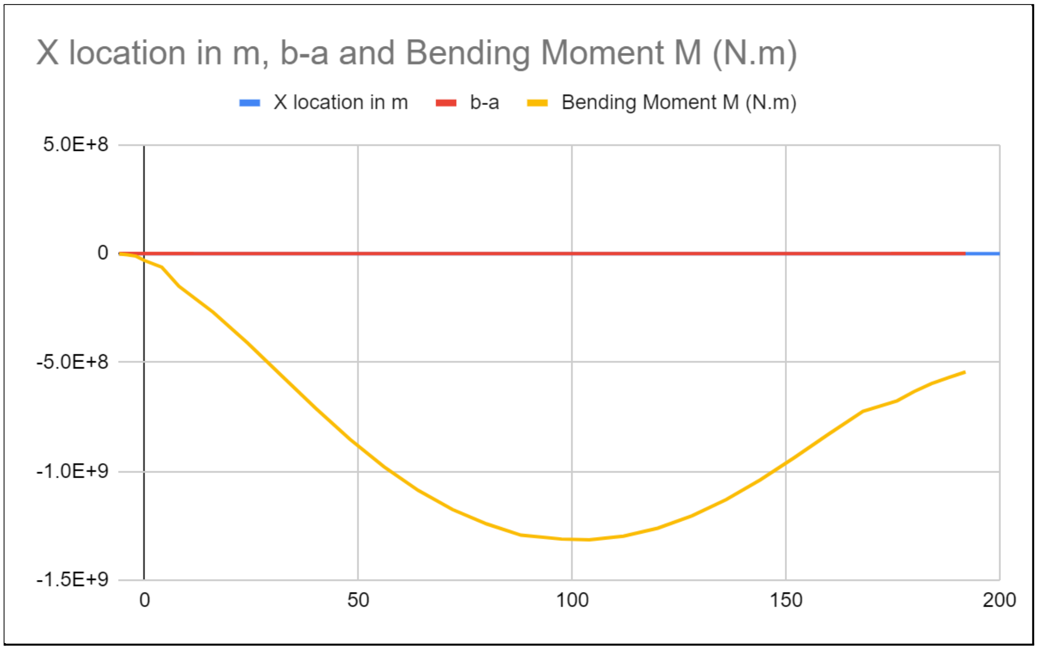
From the given data of Buoyancy and Weight distributions at different stations, Net Force Distribution is obtained as the difference between weight and buoyancy.



From loading, shear force at different stations can be obtained using the trapezoidal rule of integration and cumulatively adding up those areas up to the required station.



Similarly, the bending moment is obtained by integrating the shear force and cumulatively adding them.



Result: **Maximum Still Water Bending Moment = 1314965.937 kNm**

2) Calculation of Wave bending moment from ClassNK rules:

The formula for wave bending moment amidship is given by:

$$M_{wv-hog} = f_{prob} 0.19 f_{wv-v} C_{wv} L_{CSR-T}{}^2 B C_b \qquad (kNm)$$

$$M_{wv-sag} = -f_{prob} 0.11 f_{wv-v} C_{wv} L_{CSR-T}{}^2 B (C_b + 0.7)$$

Where:

f_{wv-v} : distribution factor for vertical wave bending moment along the vessel length, see **3.4.1.2** or **3.4.1.3** as appropriate

C_{wv} : wave coefficient to be taken as

$$= 10.75 - \left(\frac{300 - L_{CSR-T}}{100}\right)^{\frac{3}{2}} \qquad \text{for } 150 \le L_{CSR-T} \le 300$$

$$= 10.75 \qquad \text{for } 300 < L_{CSR-T} \le 350$$

$$= 10.75 - \left(\frac{L_{CSR-T} - 350}{150}\right)^{\frac{3}{2}} \qquad \text{for } 350 < L_{CSR-T} \le 500$$

L_{CSR-T} : rule length, in *m*, as defined in **Section 4/1.1.1.1**

B : moulded breadth, in *m*, as defined in **Section 4/1.1.3.1**

C_b : block coefficient, as defined in **Section 4/1.1.9.1**

From the rules above, the values are obtained as:

F_prob for strength assessment	1	
F_prob for fatigue	0.5	
Fwv_v (for both fatigue and strength assessment)	1	
Cwv	9.582912154	
Lcsr_b	189.15	m
B	32.5	m
Cb	0.73	

On substituting the above values:

For Hogging Condition	
Mwv for strength assessment	1545503.598 kNm
Mwv for fatigue	772751.7988 kNm

For Sagging Condition	
Mwv for strength assessment	-1752759.307 kNm
Mwv for fatigue	-876379.6536 kNm

The maximum among hogging and sagging is taken.

Result: **Maximum Vertical Wave Bending Moment = 1752759.307 kNm**

3) Scantling calculations from ClassNK rules:

The scantlings required for a Ro-Ro cargo ship are:

- Deck plating
  - ❏ Strength deck
  - ❏ Multiple Tween decks
- Side Shell plating
- Bottom and Inner bottom plating
  - ❏ Keel plate
  - ❏ Bottom
  - ❏ Inner bottom
  - ❏ Center Girder
  - ❏ Side Girder
- Longitudinal Stiffeners

The formula for minimum net thickness of plating is given by the following table:
(Ch 2 Sec 1 2.2.1)

Table 2 Minimum net thickness of plating

Plating	Minimum net thickness, in *mm*
Keel	$7.5 + 0.03L_{CSR\text{-}B}$
Bottom, inner bottom	$5.5 + 0.03\ L_{CSR\text{-}B}$
Weather strength deck and trunk deck, if any	$4.5 + 0.02\ L_{CSR\text{-}B}$
Side shell, bilge	$0.85\ L_{CSR\text{-}B}{}^{1/2}$
Inner side, hopper sloping plate and topside sloping plate	$0.7\ L_{CSR\text{-}B}{}^{1/2}$
Transverse and longitudinal watertight bulkheads	$0.6\ L_{CSR\text{-}B}{}^{1/2}$
Wash bulkheads	6.5
Accommodation deck	5.0

Substituting the value of $L_{csr\text{-}b}$=189.5 m in the formulas, we get the values as:

Keel	13.1745	mm
Bottom, inner bottom	11.1745	mm
Weather strength deck	8.283	mm
Side shell, bilge	11.69020423	mm
Inner side, hopper sloping plate and topside sloping plate	9.627227015	mm mm
Transverse and longitudinal watertight bulkheads	8.25190887	mm
Wash bulkheads	6.5	mm
Accomodation deck	5	mm

The ship is to be built at least with the gross scantlings obtained by adding the corrosion addition specified in Ch 3, Sec 3, to the net scantlings. The thickness for voluntary additions may be added as an extra.

Corrosion Addition:

Symbols:
t_C: Total corrosion addition, in mm.
t_{C1}, t_{C2} : Corrosion addition, in mm, on one side of the considered structural member.
$t_{reserve}$: Reserve thickness, in mm, taken equal to: $t_{reserve} = 0.5$

The values of the corrosion additions are to be applied in relation with the relevant protective coatings required by Sec 5. The formulas are given as follows:

Table 1 Corrosion addition on one side of structural members

Compartment Type	Structural member		Corrosion addition, t_{C1} or t_{C2}, in *mm*	
			BC-A or *BC-B* ships with $L_{CSR\text{-}B} \geq 150$ *m*	Other
Ballast water tank[2]	Face plate of primary members	Within 3 *m* below the top of tank[3]	2.0	
		Elsewhere	1.5	
	Other members	Within 3 *m* below the top of tank[3]	1.7	
		Elsewhere	1.2	
Dry bulk cargo hold[1]	Transverse bulkhead	Upper part[4]	2.4	1.0
		Lower stool : sloping plate, vertical plate and top plate	5.2	2.6
		Other parts	3.0	1.5
	Other members	Upper part[4]	1.8	1.0
		Webs and flanges of the upper end brackets of side frames of single side bulk carriers		
		Webs and flanges of lower brackets of side frames of single side bulk carriers	2.2	1.2
		Other parts	2.0	1.2
	Sloped plating of hopper tank, inner bottom plating	Continuous wooden ceiling	2.0	1.2
		No continuous wooden ceiling	3.7	2.4
Exposed to atmosphere	Horizontal member and weather deck[5]		1.7	
	Non horizontal member		1.0	
Exposed to sea water[7]			1.0	
Fuel oil tanks and lubricating oil tanks[2]			0.7	
Fresh water tanks			0.7	
Void spaces[6]	Spaces not normally accessed, e.g. access only through bolted manholes openings, pipe tunnels, etc.		0.7	
Dry spaces	Internal of deck houses, machinery spaces, stores spaces, pump rooms, steering spaces, etc.		0.5	
Other compartments than above			0.5	

Corrosion addition determination:

The corrosion addition for each of the two sides of a structural member, t_{C1} or t_{C2} , is specified in Table 1.

The total corrosion addition t_C, in mm, for both sides of the structural member is obtained by the following formula:

$\mathbf{t_C = Roundup_{0.5}\,(t_{C1} + t_{C2}) + t_{reserve}}$

For an internal member within a given compartment, the total corrosion addition tC is obtained from the following formula:

$t_C = \mathrm{Roundup}_{0.5}\,(2t_{C1}) + t_{reserve}$

where $t_{C1}$is the value specified in Table 1 for one side exposure to that compartment.

Thus after the corrosion addition, the values for scantlings are obtained as:

Structural Member	Tc	Reserve thickness	Minimum thickness	Total Thickness	Rounded values
Keel	1	0.5	13.1745	14.6745	15
Bottom, inner bottom	1	0.5	11.1745	12.6745	13
Weather strength deck	1.7	0.5	8.283	10.483	11
Side shell, bilge	1	0.5	11.69020423	13.19020423	14
Inner side, hopper sloping plate and topside sloping plate	3.7	0.5	9.627227015	13.82722702	14
Transverse and longitudinal watertight bulkheads	5.2	0.5	8.25190887	13.95190887	14
Wash bulkheads	1.5	0.5	6.5	8.5	9
Accomodation deck	0.5	0.5	5	6	6
Side girders	0.5	0.5	17	18	18
Center girders	0.5	0.5	14	15	15

- **Height of Double Bottom= B/20**
- **Width of the keel = 0.8+(RuleLength/200)**
- **For sheer strake:** Minimum Breadth = (800+5*Rule Length) mm

Values Obtained:

Height of double bottom	1.625	
Width of the keel	1.74575	
Sheer Strake Minimum breadth	1745.75	mm

Spacing	Distance	Number of members
Stiffeners	0.9m apart	36

Structural elements and its position from the keel

Structural element	Thickness in mm	Length in m	Members	Distance from bottom in m
Keel plate	15	0.018	1	0
Bottom	13	29.25	1	0
Bilge	14	2.552544031	2	0.6896714201
Inner bottom	13	32.5	1	1.625
Center girders	15	1.625	1	0.8125
Side girders	18	1.625	8	0.8125
Side shell	14	24.475	2	13.05
Tween deck 1	11	32.5	1	7.765
Tween deck 2	11	32.5	1	13.905
Tween deck 3	11	32.5	1	20.045
Strength deck	11	32.5	1	26.1

4) Midship section modulus from calculated scantlings:

Midship section modulus calculation summary. We'll calculate the area occupied by the structural elements, number of members required and deduce the neutral axis, moments to land at the final moment of inertia about the neutral axis. Rest of the columns are in the sheet.

Structural element	Area in m2	First moment	Second moment about NA	Local Second moment
Keel plate	0.00027	0	0.02981476501	0.0000000050625
Bottom	0.38025	0	41.98912738	0.0000053551875
Bilge	0.07147123287	0.04929166667	6.890263453	0.03575098243
Inner bottom	0.4225	0.6865625	33.34099574	0.000005950208333
Center girders	0.024375	0.0198046875	2.291473549	0.005363769531
Side girders	0.234	0.190125	21.99814607	0.006436523438
Side shell	0.6853	8.943165	4.427087889	17.10467753
Tween deck 1	0.3575	2.7759875	2.690500012	0.000003604791667
Tween deck 2	0.3575	4.9710375	4.124602241	0.000003604791667
Tween deck 3	0.3575	7.1660875	32.51391847	0.000003604791667
Strength deck	0.3575	9.33075	86.90828218	0.000003604791667
Total	3.248166233	34.13281135	237.2042118	17.15225454

$I\_total = I\_local + Sum(A_i * y_{NA}^2)$

= Sum(Second moment about NA)+ Sum(Local Second moment)

= 254.3564663 m^4

Height of Neutral Axis = Total first Moment/Total Area

=10.50833267

Z = I_total/Height of NA

= 24.20521639

Important results from calculation:

Height of neutral axis	10.508m
Moment of Inertia about Neutral axis	254.356 m4
Section modulus from the calculations	24.2052 m3

5) Midship section modulus from ClassNK rules:

$$Z = kC_wL^2B(C_b + 0.7)(0.5 + R_s/2)\ \text{cm}^3$$

where,
k = 1
Cw is same as the one we calculated above = 9.5829
Rs = 1

From these calculations,

Zmin = 16935036.16 cm3
= 16.93503616 m3

6) Comparison of Section modulus from calculations and rules

The minimum midship section modulus obtained from calculations is **24.2052** m^3
Minimum midship section modulus as per rules = **16.9350** m^3

Thus, the Section modulus at midship from calculations is **greater than the minimum** required by rules. Thus, it is acceptable.

7) Midship section arrangement of RoRo ship: