Design Of a General Cargo Ship Of 2500 Tonnes Cargo Capacity
In The Route Of
Dhaka-Chittagong-Dhaka

Prepared by

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DEPARTMENT OF NAVAL ARCHITECTURE & MARINE ENGINEERING
BANGLADESH UNIVERSITY OF ENGINEERING & TECHNOLOGY

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The project is submitted to the Department of Naval Architecture & Marine Engineering in partial fulfillment of the requirement for the course of Ship Design Project and Presentation.

February 2021

Preface

Knowledge of ship design is difficult to attain and requires extensive experience and research work to reach a high degree of proficiency. Realizing the fact, "Department of Naval Architecture & Marine Engineering" of "Bangladesh University of Engineering & Technology" introduced NAME 338 course known as "Ship Design Project and Presentation" which provides us with valuable opportunity of getting involved in whole ship designing process. We got the firsthand experience to implement our achieved theoretical knowledge in our project work to attain proficiency.

We have completed our project under the supervision of "Dr. Nayeb Md. Golam Zakaria". We wish to express our sincerest gratitude to Sir for his heartiest co-operation and wisdom throughout the preparation of the project. From the very beginning to the end of our project work Sir supported us with his constructive suggestions and ideas. At every step of our designing process, Sir helped us a lot to correct our mistake as well as provided endless encouragement to fulfill our work.

We are also grateful to all the teachers of "Department of Naval Architecture & Marine Engineering" for their valuable suggestions and necessary information during the preparation and presentation of the project.

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OWNER'S REQUIREMENT

Route : **Dhaka – Chittagong**

Deadweight : **2500 Ton**

Service Speed : **10 knot**

Cargo To be Carried : **Grain**

Route Specification

- Route :

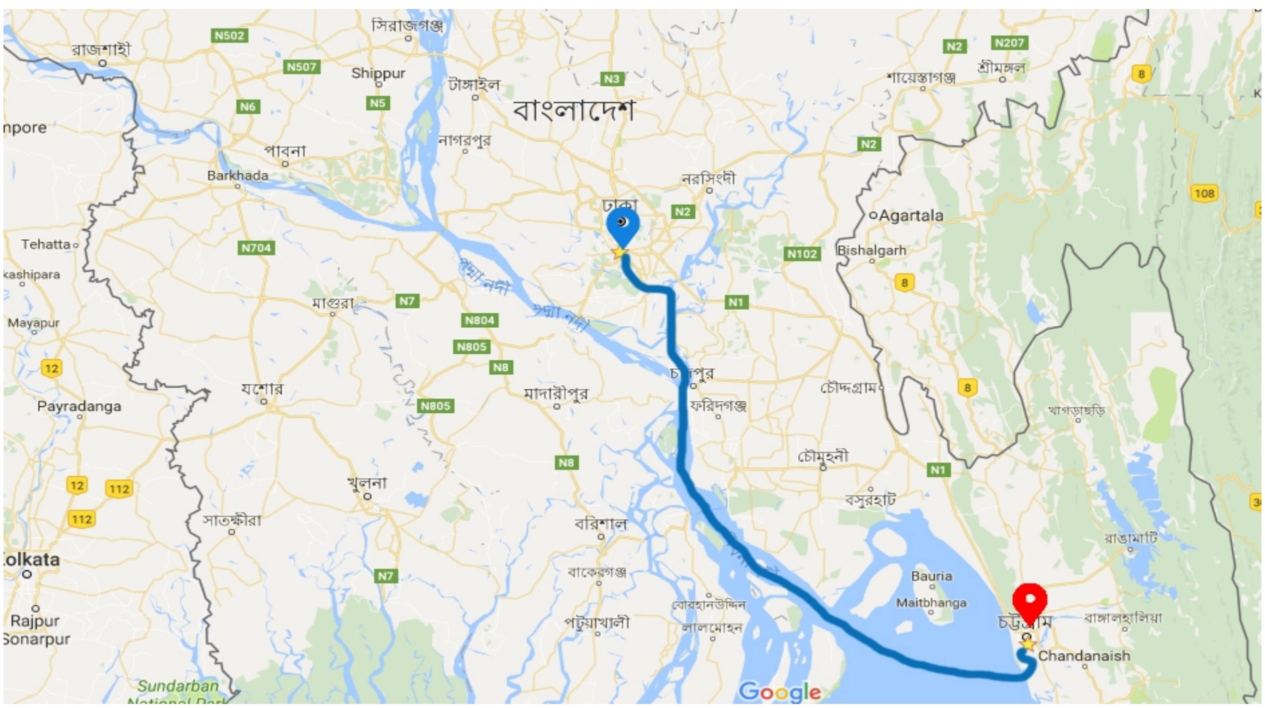
Dhaka – Chittagong

(Sadar Ghat Terminal to Chittagong Port)

- Route Length :

304 km

(164 nautical mile)



Selection of Basis Ship

M.V HAJI MOYNUL- 3

Principal particulars of basis ship

Length Overall : 74.50m

Length between Perpendiculars : 70.8 m

Breadth Moulded : 13 m

Depth Moulded : 5 m

Draft : 4 m

Service Speed : 10 knot

C_B : 0.78

C_D : 0.75

Determination of principal particulars of design ship

$$\frac{L}{B}=\frac{73.8}{13.7}=5.38$$

$$\frac{B}{T}=\frac{13.7}{4.2}=3.26$$

$$\frac{D}{T}=\frac{5.25}{4.2}=1.25$$

Using Empirical Formula

Considering, C_D = 0.75 (For General Cargo, C_D = 0.65-0.75)

C_D= $\frac{DWT}{W}$ $\therefore W=DWT/C_D=2500/0.75=3334\,ton$

Using Cubic Root Formula:

L = $Cubic\,root\,of\,\frac{DWT\times\left(\frac{L}{B}\right)^2\times\left(\frac{B}{T}\right)}{C_D\times C_B\times\rho}$

= Cubic root of $\frac{2500\times(5.38)^2\times(3.26)}{0.75\times0.78\times1}=73.8\,m$

B = $\frac{L}{\left(\frac{L}{B}\right)}=\frac{73.8}{5.38}=13.7\,m$

T = $\frac{B}{\left(\frac{B}{T}\right)}=\frac{13.7}{3.26}=4.2\,m$

D $=T * \left(\frac{D}{T}\right)=4.2 * 1.25=5.25\,m$

Posdunine Approach:

$$L = C\left(\frac{V}{V+2}\right)^2 W^{1/3}\ ;C = 1.7\frac{V}{L0.5} + 4.4$$

L= 73.8 m

B= 13.7 m

T= 4.2 m

Benford Approach:

$$L = 6.31\left(\frac{V}{V+2}\right)^2 W^{1/3}$$

= 73.8 m

B= 13.7 m

T = 4.2 m

Principal Particulars

Length Overall : 77.5 m

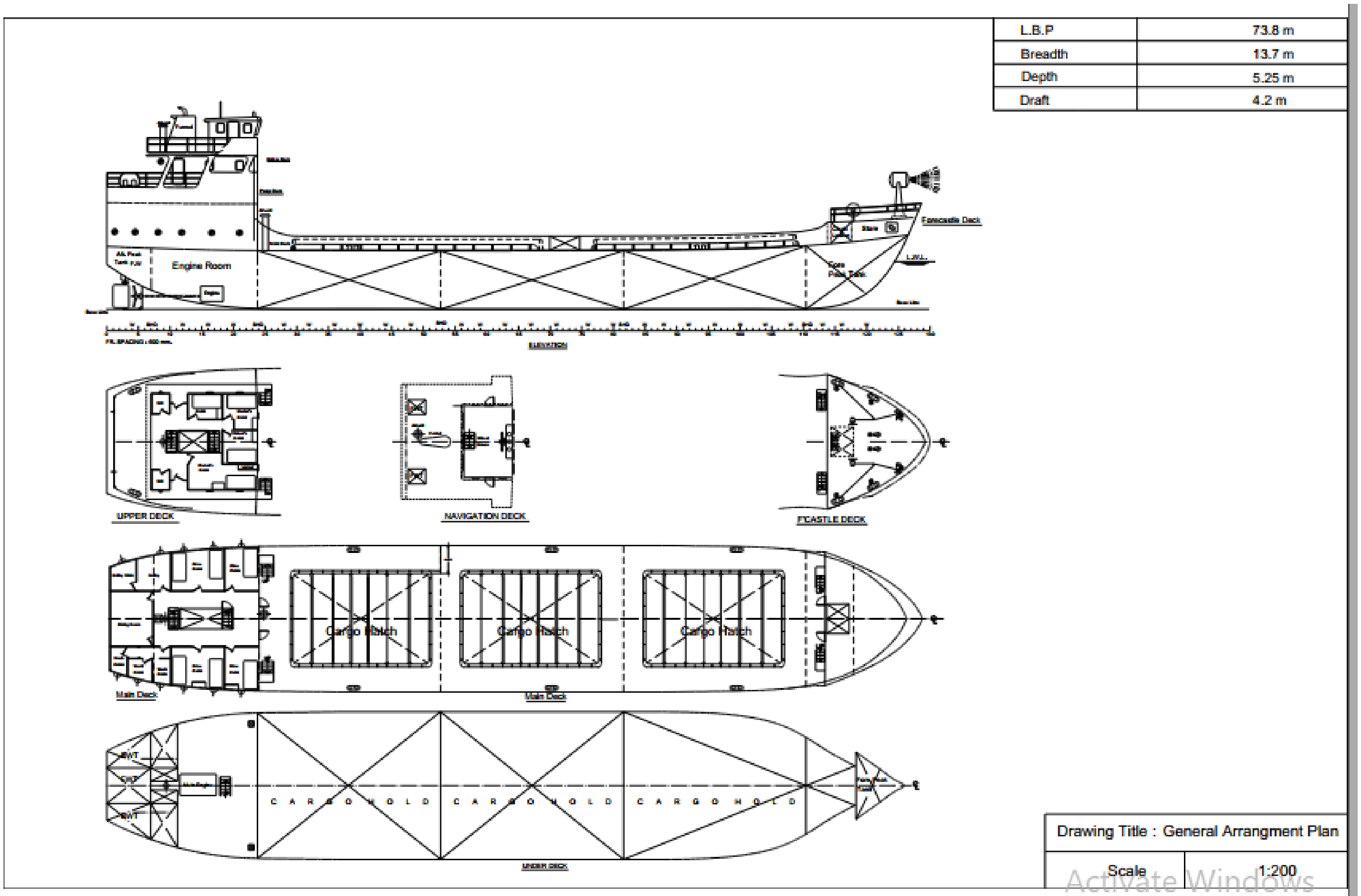
Length between Perpendiculars : 73.8 m

Breadth Moulded : 13.7 m

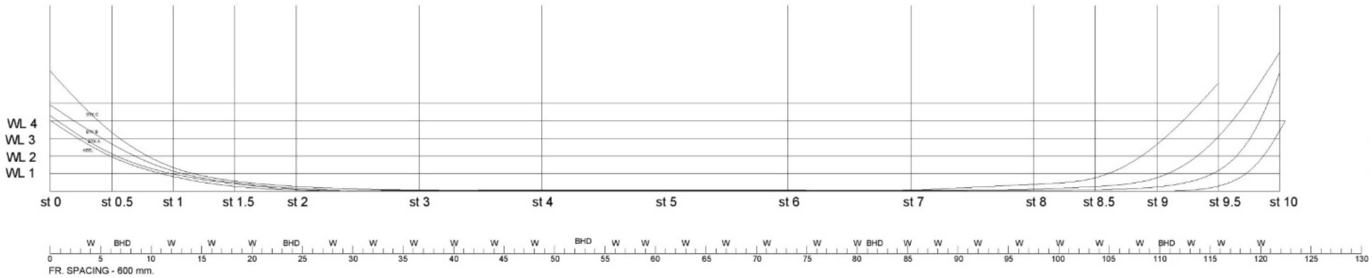
Depth Moulded : 5.25 m

Draft : 4.2 m

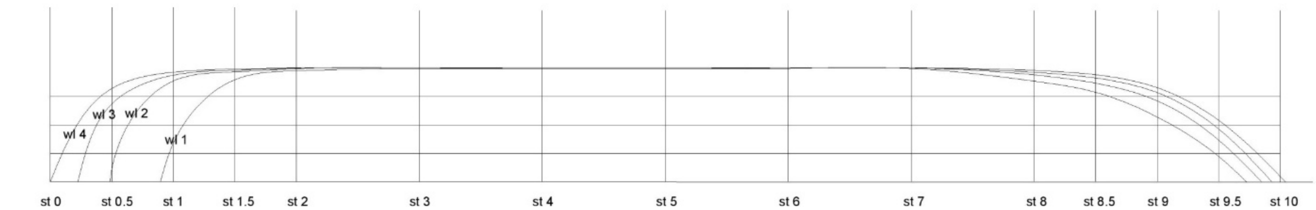
GENERAL ARRANGEMENT PLAN


L.B.P
73.8 m
Breadth
13.7 m
Depth
5.25 m
Draft
4.2 m
Engine Room
Forecastle Deck
ELEVATION
UPPER DECK
NAVIGATION DECK
F'CASTLE DECK
Cargo Hatch
Cargo Hatch
Cargo Hatch
Main Deck
Main Deck
C A R G O H O L D
C A R G O H O L D
C A R G O H O L D
UNDER DECK
Drawing Title : General Arrangment Plan
Scale
1:200

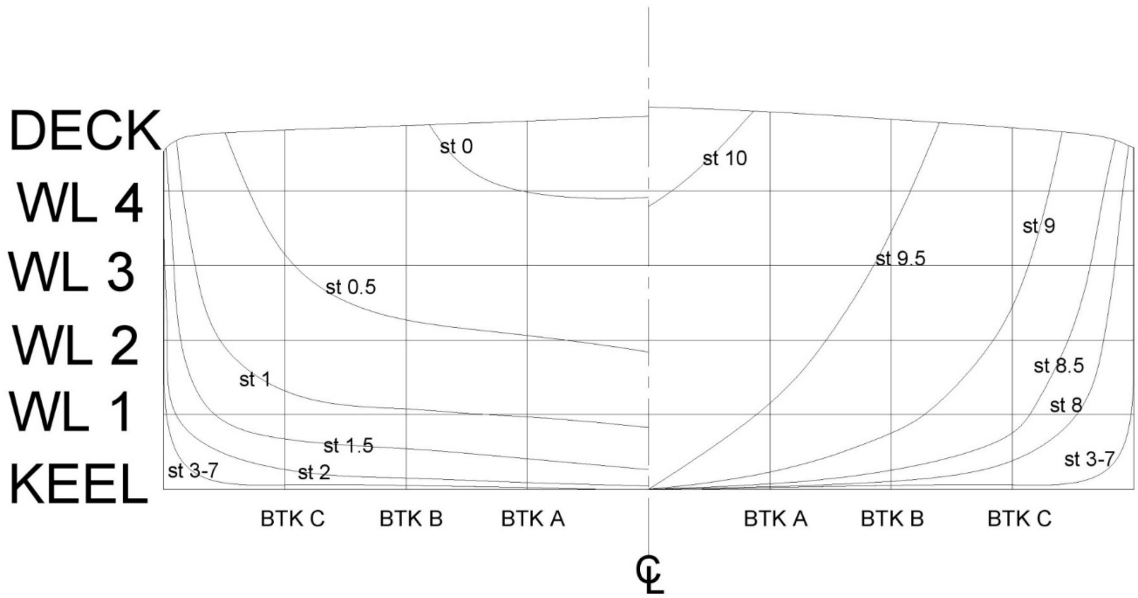
Lines plan



PROFILE PLAN



HALF BREADTH PLAN


DECK
WL 4
WL 3
WL 2
WL 1
KEEL
st 0
st 10
st 9
st 9.5
st 0.5
st 8.5
st 1
st 8
st 1.5
st 3-7
st 2
st 3-7
BTK C
BTK B
BTK A
BTK A
BTK B
BTK C
CL

BODY PLAN

Hydrostatic calculation

Offset table

Station	HALF BREADTH						
	wl 0	WL 1	WL 2	WL 3	WL 4	DECK SIDE	POOP/ F'CASTLE DECK
0	0	0	0	0	1803.7	3298.38902	4999.157
0.5	0	0	1200	5000	5610	6076.24549	6514.753
1	0	2310	6050	6410	6590	6668.62275	6803.474
1.5	0	6130	6610	6710	6780	6826.57569	6849.785
2	0	6680	6800	6830	6850	6849.89255	8304.134
3	750	6850	6850	6850	6850	6850	-
4	750	6850	6850	6850	6850	6850	-
5	750	6850	6850	6850	6850	6850	-
6	750	6850	6850	6850	6850	6850	-
7	750	6850	6850	6850	6850	6850	-
8	0	6220	6420	6580	6690	6776.18118	-
8.5	0	5380	5920	6230	6430	6592.44	6175.745
9	0	3890	4870	5404	5650	5842.1098	8151.339
9.5	0	1520	2500	3179	3690	4109.7851	5207.504
10	0	0	0	0	326	398.96549	2365.426

Station	HEIGHT ABOVE BASELINE				
	KEEL	BTK A	BTK B	BTK C	DECK
0	4244.543	4414.359	5166.31	7199.131	5129.859
0.5	2060.618	2181.978	2514.363	3549.269	5020.722
1	871.1469	1017.708	1192.5	1645.271	4932.786
1.5	276.898	353.802	477.9735	707.3878	4860.1
2	46	92.26327	155.6469	275.7082	4805.478
3	-	26.28367	52.56735	78.85102	4775.192
4	0	26.28367	52.56735	78.85102	4775.192
5	0	26.28367	52.56735	78.85102	4775.192
6	0	26.28367	52.56735	78.85102	4775.192
7	0	26.28367	52.56735	78.85102	4775.192
8	0	26.28367	86.96327	259.7	4831.761
8.5	0	49.53878	205.1857	866.0633	4935.814
9	0	143.5327	765.0388	2934.794	5064.204
9.5	0	1152.155	3834.28	6458.969	5185.455
10	4244.543	7078.42	8310.292	-	5363.276

Calculation table

Waterplane area, Displacement, LCB VCB calculation for WL-01												
Water planes		wl 0		wl 01		wl 02						
	SM	5		8		-1						
section	SM	y_0	y x SM	y_1	y x SM	y_2	y x SM	Area products for	Sectional area below waterline	Volume function	levers	moments about amidship
0	0.5	0.00	0.000	0.00	0.000	0.00	0.000	0.000	0.000	0.000	-5	0.000
0.5	2	0.00	0.000	0.00	0.000	1.20	2.400	-1.200	-0.210	-0.420	-4.5	1.890
1	1	0.00	0.000	2.31	2.310	6.05	6.050	12.430	2.175	2.175	-4	-8.701
1.5	2	0.00	0.000	6.13	12.260	6.61	13.220	42.430	7.425	14.851	-3.5	-51.977
2	1.5	0.00	0.000	6.68	10.020	6.80	10.200	46.640	8.162	12.243	-3	-36.729
3	4	0.75	3.000	6.85	27.400	6.85	27.400	51.700	9.048	36.190	-2	-72.380
4	1	0.75	0.750	6.85	6.850	6.85	6.850	51.700	9.048	9.048	-1	-9.048
5	4	0.75	3.000	6.85	27.400	6.85	27.400	51.700	9.048	36.190	0	0.000
6	2	0.75	1.500	6.85	13.700	6.85	13.700	51.700	9.048	18.095	1	18.095
7	4	0.75	3.000	6.85	27.400	6.85	27.400	51.700	9.048	36.190	2	72.380
8	1.5	0.00	0.000	6.22	9.330	6.42	9.630	43.340	7.585	11.377	3	34.130
8.5	2	0.00	0.000	5.38	10.760	5.92	11.840	37.120	6.496	12.992	3.5	45.472
9	1	0.00	0.000	3.89	3.890	4.87	4.870	26.250	4.594	4.594	4	18.375
9.5	2	0.00	0.000	1.52	3.040	2.50	5.000	9.660	1.691	3.381	4.5	15.215
10	0.5	0.00	0.000	0.00	0.000	0.00	0.000	0.000	0.000	0.000	5	0.000
Different totals		**sum of the area products of water plane 0**	11.250	**sum of the area products of water plane 0.5**	154.360	**sum of the area products of water plane 1**	165.960	**Summation of volume functions**		196.905	**Summation of moments**	26.723
Waterplane area		**55.350**		**759.451**		**816.523**						

Different totals	**sum of the area products of water plane 0**	11.250	**sum of the area products of water plane 0.5**	154.360	**sum of the area products of water plane 1**	165.960	**Summation of volume functions**		196.905	**Summation of moments**	26.723
Waterplane area	**55.350**		**759.451**		**816.523**						
SM	5.000		8.000		-1.000		***VOLUME***		**484.386**	***LCB***	1.002
Volume products	276.750		6075.610		-816.523		**Summation of volume products**	5535.836	***VOLUME***		**484.386**
levers	0.000		0.500		1.000						
Monent about the keel	0.000		3037.805		-816.523		**Summation of moments**	2221.282	***VCB***		0.421
Distance between two consecutive sections				7.38	**Distance between two consecutive waterlines**						1.05

	SM	1		4		1		Area products for	Sectional area below	Volume function	levers	moments about amidship
Section	SM	y_0	y x SM	y_1	y x SM	y_2	y x SM					
0	0.5	0	0.000	0	0.000	0.00	0.000	0.000	0.000	0.000	-5.000	0.000
0.5	2	0	0.000	0	0.000	1.20	2.400	1.200	0.843	1.686	-4.500	-7.589
1	1	0	0.000	2.3055	2.305	6.05	6.050	15.272	10.731	10.731	-4.000	-42.924
1.5	2	0	0.000	6.1226	12.245	6.61	13.220	31.100	21.853	43.706	-3.500	-152.972
2	1.5	0	0.000	6.6795	10.019	6.80	10.200	33.518	23.552	35.328	-3.000	-105.984
3	4	0.75	3.000	6.8499	27.400	6.85	27.400	35.000	24.593	98.372	-2.000	-196.744
4	1	0.75	0.750	6.8499	6.850	6.85	6.850	35.000	24.593	24.593	-1.000	-24.593
5	4	0.75	3.000	6.8499	27.400	6.85	27.400	35.000	24.593	98.372	0.000	0.000
6	2	0.75	1.500	6.8499	13.700	6.85	13.700	35.000	24.593	49.186	1.000	49.186
7	4	0.75	3.000	6.8499	27.400	6.85	27.400	35.000	24.593	98.372	2.000	196.744
8	1.5	0	0.000	6.2247	9.337	6.42	9.630	31.319	22.007	33.010	3.000	99.031
8.5	2	0	0.000	5.5166	11.033	5.92	11.840	27.987	19.665	39.330	3.500	137.657
9	1	0	0.000	3.9832	3.983	4.87	4.870	20.803	14.617	14.617	4.000	58.470
9.5	2	0	0.000	1.6955	3.391	2.50	5.000	9.282	6.522	13.044	4.500	58.699
10	0.5	0	0.000	0	0.000	0.00	0.000	0.000	0.000	0.000	5.000	0.000
Different totals		**sum of the area products of water plane 0**	11.250	**sum of the area products of water plane**	155.063	**sum of the area products of water plane 1**	165.960	**Summation of volume functions**		560.349	**Summation of moments**	68.980
Water plane		**55.350**		**762.909**		**816.523**						
SM		1.000		4.000		1.000		*VOLUME*		**1378.459**	LCB	0.908
Volume products		55.350		3051.634		816.523		**Summation of volume product**	3923.508	*VOLUME*		**1378.459**
levers		0.000		1.000		2.000						
Monent about the keel		0.000		3051.634		1633.046		**Summation of momen**	4684.681	VCB		1.258
Distance between two consecutive sections					7.380	**Distance between two consecutive waterlines**						1.054

Section	SM	y_0	y x SM	y_1	y x SM	y_2	y2 x SM	y_3	y3 x SM	products for	area below waterline	function	levers	about amidship
0	0.5	0	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.000	0.000	0.000	-5	0.000
0.5	2	0	0.000	0.00	0.000	1.20	2.400	5.00	10.000	8.600	6.798	13.597	-4.5	-61.185
1	1	0	0.000	2.31	2.305	6.05	6.050	6.41	6.410	31.476	24.882	24.882	-4	-99.528
1.5	2	0	0.000	6.12	12.245	6.61	13.220	6.71	13.420	44.908	35.500	70.999	-3.5	-248.497
2	1.5	0	0.000	6.68	10.019	6.80	10.200	6.83	10.245	47.268	37.366	56.049	-3	-168.146
3	4	0.75	3.000	6.85	27.400	6.85	27.400	6.85	27.400	48.700	38.497	153.988	-2	-307.977
4	1	0.75	0.750	6.85	6.850	6.85	6.850	6.85	6.850	48.700	38.497	38.497	-1	-38.497
5	4	0.75	3.000	6.85	27.400	6.85	27.400	6.85	27.400	48.700	38.497	153.988	0	0.000
6	2	0.75	1.500	6.85	13.700	6.85	13.700	6.85	13.700	48.700	38.497	76.994	1	76.994
7	4	0.75	3.000	6.85	27.400	6.85	27.400	6.85	27.400	48.700	38.497	153.988	2	307.977
8	1.5	0	0.000	6.22	9.337	6.42	9.630	6.58	9.870	44.514	35.188	52.783	3	158.348
8.5	2	0	0.000	5.52	11.033	5.92	11.840	6.23	12.460	40.540	32.047	64.094	3.5	224.328
9	1	0	0.000	3.98	3.983	4.87	4.870	5.40	5.404	31.964	25.267	25.267	4	101.069
9.5	2	0	0.000	1.70	3.391	2.50	5.000	3.18	6.358	15.765	12.463	24.925	4.5	112.163
10	0.5	0	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.000	0.000	0.000	5	0.000
Different totals		**sum of the area products of water plane 0**	11.250	**sum of the area products of water plane**	155.063	**sum of the area products of water plane**	165.960	**sum of the area products of water plane 1**	176.917	**Summation of volume functions**		910.051	**Summation of moments**	57.050
Water plane		**55.350**		**762.909**		**816.523**		**870.432**						
SM		1.000		3.000		3.000		1.000		*VOLUME*		**2238.726**	LCB	0.463
Volume products		55.350		2288.726		2449.570		870.432		**Summation of volume products**	5664.077	*VOLUME*		**2238.726**
levers		0.000		1.000		2.000		3.000						
Moment about the keel		0.000		2288.726		4899.139		2611.295		**Summation of moments**	9799.160	VCB		1.823
Distance between two consecutive sections					7.380			**Distance between two consecutive waterlines**						1.054

Waterplane area, Displacement, LCB VCB calculation for WL-04

Water planes		wl 0		wl 01		wl 02		wl 03		wl 04						
	SM	1		4		2		4		1		Area products for	Sectional area below	Volume function	levers	moments about amidship
Section	SM	y	y x SM	y	y x SM	y	y x SM	y	y x SM	y	y x SM					
0	0.5	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	1.80	0.902	1.804	1.268	0.634	-5	-3.169
0.5	2	0.00	0.000	0.00	0.000	1.20	2.400	5.00	10.000	5.65	11.306	28.053	19.712	39.424	-4.5	-177.407
1	1	0.00	0.000	2.31	2.310	6.05	6.050	6.41	6.410	6.59	6.590	53.570	37.642	37.642	-4	-150.567
1.5	2	0.00	0.000	6.13	12.260	6.61	13.220	6.71	13.420	6.78	13.560	71.360	50.142	100.285	-3.5	-350.996
2	1.5	0.00	0.000	6.68	10.020	6.80	10.200	6.83	10.245	6.85	10.275	74.490	52.342	78.512	-3	-235.537
3	4	0.75	3.000	6.85	27.400	6.85	27.400	6.85	27.400	6.85	27.400	76.100	53.473	213.892	-2	-427.783
4	2	0.75	1.500	6.85	13.700	6.85	13.700	6.85	13.700	6.85	13.700	76.100	53.473	106.946	-1	-106.946
5	4	0.75	3.000	6.85	27.400	6.85	27.400	6.85	27.400	6.85	27.400	76.100	53.473	213.892	0	0.000
6	2	0.75	1.500	6.85	13.700	6.85	13.700	6.85	13.700	6.85	13.700	76.100	53.473	106.946	1	106.946
7	4	0.75	3.000	6.85	27.400	6.85	27.400	6.85	27.400	6.85	27.400	76.100	53.473	213.892	2	427.783
8	1.5	0.00	0.000	6.22	9.330	6.42	9.630	6.58	9.870	6.69	10.035	70.730	49.700	74.549	3	223.648
8.5	2	0.00	0.000	5.38	10.760	5.92	11.840	6.23	12.460	6.43	12.860	64.710	45.470	90.939	3.5	318.287
9	1	0.00	0.000	3.89	3.890	4.87	4.870	5.40	5.404	5.65	5.650	52.566	36.936	36.936	4	147.746
9.5	2	0.00	0.000	1.52	3.040	2.50	5.000	3.18	6.358	3.69	7.380	27.486	19.313	38.627	4.5	173.821
10	0.5	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.33	0.163	0.326	0.229	0.115	5	0.573
Different totals		**sum of the area products of water plane 0**	12.000	**sum of the area products of water plane 0.5**	161.210	**sum of the area products of water plane 1**	**172.810**	**sum of the area products of water plane 2**	**183.767**	**sum of the area products of water plane 3**	188.321	**Summation of volume functions**		1353.230	**Summation of moments**	-53.602

Different totals	**sum of the area products of water plane 0**	12.000	**sum of the area products of water plane 0.5**	161.210	**sum of the area products of water plane 1**	**172.810**	**sum of the area products of water plane 2**	**183.767**	**sum of the area products of water plane 3**	188.321	**Summation of volume functions**	1353.230	**Summation of moments**	-53.602

Water plane area	**59.040**	**793.153**	**850.225**	**904.134**	**926.539**				
SM	1.000	4.000	2.000	4.000	1.000	***VOLUME***	**3328.95**	***LCB***	-0.292
Volume products	59.040	3172.613	1700.450	3616.535	926.539	**Summation of volume products**	9475.1771	***VOLUME***	**3328.95**
levers	0.000	1.000	2.000	3.000	4.000				
Monent about the keel	0.000	3172.613	3400.901	10849.604	3706.157	**Summation of moments**	21129.275	***VCB***	2.350
Distance between two consecutive sections	7.38	**Distance between two consecutive waterlines**							1.054

LCF and BM_L calculation for WL 1 TO 4

Sections	SM	Levers from amidsips (x)	wl 1				wl 2				wl 3				wl 4			
			y	y´sm	(y´sm) x	(y´sm) x^2	y	y´sm	(y´sm) x	(y´sm) x^2	y	y´sm	(y´sm) x	(y´sm) x^2	y	y´sm	(y´sm) x	(y´sm) x^2
0	0.5	-5	0.00	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.00	0.000	0.000	0.000	1.80	0.902	-4.509	22.546
0.5	2	-4.5	0.00	0.000	0.000	0.000	1.20	2.400	-10.800	48.600	5.00	10.000	-45.000	202.500	5.61	11.220	-50.490	227.205
1	1	-4	2.31	2.310	-9.240	36.960	6.05	6.050	-24.200	96.800	6.41	6.410	-25.640	102.560	6.59	6.590	-26.360	105.440
1.5	2	-3.5	6.13	12.260	-42.910	150.185	6.61	13.220	-46.270	161.945	6.71	13.420	-46.970	164.395	6.78	13.560	-47.460	166.110
2	1.5	-3	6.68	10.020	-30.060	90.180	6.80	10.200	-30.600	91.800	6.83	10.245	-30.735	92.205	6.85	10.275	-30.825	92.475
3	4	-2	6.85	27.400	-54.800	109.600	6.85	27.400	-54.800	109.600	6.85	27.400	-54.800	109.600	6.85	27.400	-54.800	109.600
4	1	-1	6.85	6.850	-6.850	6.850	6.85	6.850	-6.850	6.850	6.85	6.850	-6.850	6.850	6.85	6.850	-6.850	6.850
5	4	0	6.85	27.400	0.000	0.000	6.85	27.400	0.000	0.000	6.85	27.400	0.000	0.000	6.85	27.400	0.000	0.000
6	2	1	6.85	13.700	13.700	13.700	6.85	13.700	13.700	13.700	6.85	13.700	13.700	13.700	6.85	13.700	13.700	13.700
7	4	2	6.85	27.400	54.800	109.600	6.85	27.400	54.800	109.600	6.85	27.400	54.800	109.600	6.85	27.400	54.800	109.600
8	1.5	3	6.22	9.330	27.990	83.970	6.42	9.630	28.890	86.670	6.58	9.870	29.610	88.830	6.69	10.035	30.105	90.315
8.5	2	3.5	5.38	10.760	37.660	131.810	5.92	11.840	41.440	145.040	6.23	12.460	43.610	152.635	6.43	12.860	45.010	157.535
9	1	4	3.89	3.890	15.560	62.240	4.87	4.870	19.480	77.920	5.40	5.404	21.616	86.464	5.65	5.650	22.600	90.400
9.5	2	4.5	1.52	3.040	13.680	61.560	2.50	5.000	22.500	101.250	3.18	6.358	28.611	128.750	3.69	7.380	33.210	149.445
10	0.5	5	0.00	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.33	0.163	0.815	4.075
TOTALS				**154.360**	**19.530**	**856.655**		**165.960**	**7.290**	**1049.775**		**176.917**	**-18.048**	**1258.089**		**181.385**	**-21.054**	**1345.296**
Distance between two sections						7.38				7.38				7.38				7.78
Displacement						484.386				1378.459				2238.726				3328.946
Water plane Area						759.451				816.523				870.432				940.783
TPC						**7.595**				**8.165**				**8.704**				**9.408**

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TPC				**7.595**				**8.165**				**8.704**				**9.408**
LCF from Amidship				**0.934**				**0.324**				**-0.753**				**-0.903**
Moment of inertia about the amidship				229553.427				2.81E+05				3.37E+05				4.22E+05
Moment of inertia about the LCF				228891.290				2.81E+05				3.37E+05				4.22E+05
Longitudinal Metacenter				**472.539**				**204.008**				**150.367**				**126.639**
Length				77.880				77.880				77.880				77.880
Density of fresh water (t/m^3)				1.000				1.000				1.000				1.000
Δ				484.386				1378.459				2238.726				3328.946
MCT 1 cm				**29.390**				**36.109**				**43.224**				**54.131**

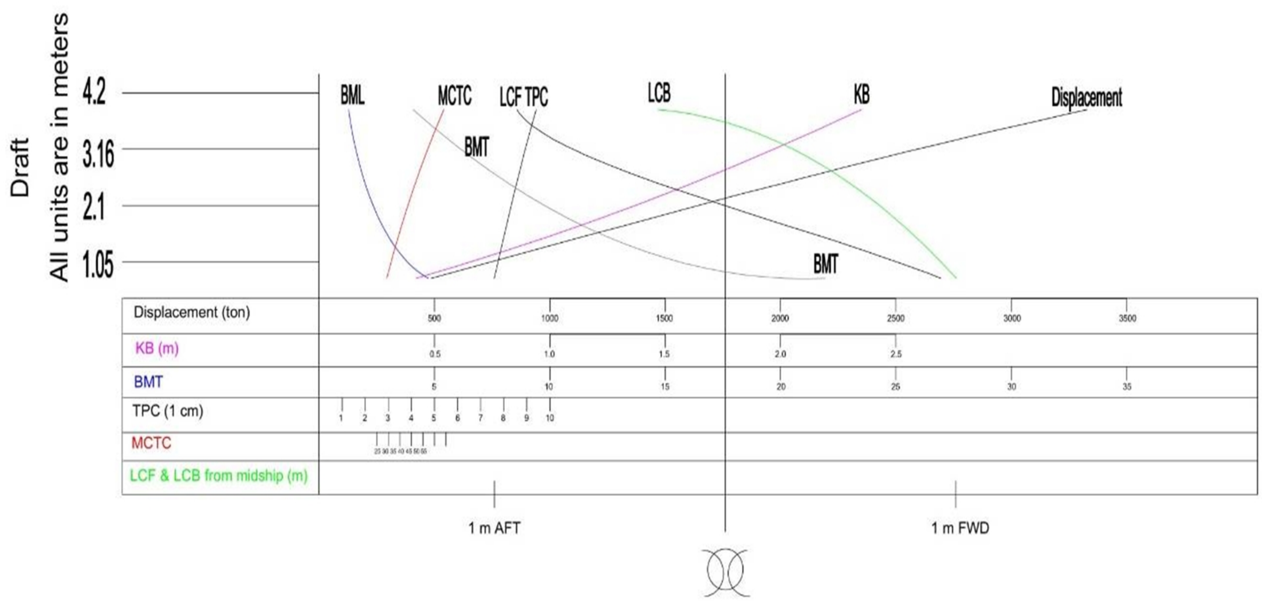
Transverse metacentric height BM_T calculation

		Water lines above base line			Water lines above base line			Water lines above base line			Water lines above base line		
		1			2			3			4		
Sections	SM	y	y^3	y^3 X SM	y	y^3	y^3 X SM	y	y^3	y^3 X SM	y	y^3	y^3 X SM
0	0.5	0.00	0.000	0.000	0.00	0.000	0.000	0.00	0.000	0.000	1.80	5.868	2.934
0.5	2	0.00	0.000	0.000	1.20	1.728	3.456	5.00	125.000	250.000	5.61	176.558	353.117
1	1	2.31	12.326	12.326	6.05	221.445	221.445	6.41	263.375	263.375	6.59	286.191	286.191
1.5	2	6.13	230.346	460.693	6.61	288.805	577.610	6.71	302.112	604.223	6.78	311.666	623.332
2	1.5	6.68	298.078	447.116	6.80	314.432	471.648	6.83	318.612	477.918	6.85	321.419	482.129
3	4	6.85	321.419	1285.677	6.85	321.419	1285.677	6.85	321.419	1285.677	6.85	321.419	1285.677
4	1	6.85	321.419	321.419	6.85	321.419	321.419	6.85	321.419	321.419	6.85	321.419	321.419
5	4	6.85	321.419	1285.677	6.85	321.419	1285.677	6.85	321.419	1285.677	6.85	321.419	1285.677
6	2	6.85	321.419	642.838	6.85	321.419	642.838	6.85	321.419	642.838	6.85	321.419	642.838
7	4	6.85	321.419	1285.677	6.85	321.419	1285.677	6.85	321.419	1285.677	6.85	321.419	1285.677
8	1.5	6.22	240.642	360.963	6.42	264.609	396.914	6.58	284.890	427.335	6.69	299.418	449.127
8.5	2	5.38	155.721	311.442	5.92	207.475	414.949	6.23	241.804	483.609	6.43	265.848	531.695
9	1	3.89	58.864	58.864	4.87	115.501	115.501	5.40	157.814	157.814	5.65	180.362	180.362
9.5	2	1.52	3.512	7.024	2.50	15.625	31.250	3.18	32.127	64.254	3.69	50.243	100.487
10	0.5	0.00	0.000	0.000	0.00	0.000	0.000	0.00	0.000	0.000	0.33	0.035	0.017
ummation of y3 x SM				6479.715			7054.060			7549.816			7830.678
Distance between two stations		H		7.380	H		7.380	H		7.380	H		7.800
displacement of ship		For waterplane 01		484.386	For waterplane 2		1378.459	for waterplane 3		2238.726	For waterplane 4		3328.946
Moment of inertia		I		10626.732	I		11568.659	I		12381.698	I		13573.176
Transverse metacentric height		**BM_T**		**21.939**	**BM_T**		**8.392**	**BM_T**		**5.531**	**BM_T**		**4.077**

Hydrostatic calculation (summary)

WL	Position of WL (m)	Displacement (tons)	VCB (m)	LCB (m from amidship)	TPC (ton)	BM_T (m)	BM_L (m)	LCF (m from amidship)	MCTC (t-m/cm)	Cb	Cm	Cw	Cp
1	1.05	486.231	0.421	1.002	7.595	21.94	472.5	0.934	29.39	0.458012	0.628954	0.007511	0.728212
2	2.1	1378.5	1.26	0.910	8.16	8.39	204.01	0.324	36.1	0.649248	0.854815	0.008076	0.759518
3	3.16	2238.7	1.820	0.460	8.7	5.530	150.37	-0.753	43.22	0.7007	0.889243	0.008609	0.787973
4	4.2	3328.95	2.35	-0.292	9.41	4.08	126.64	-0.903	54.13	0.783937	0.929318	0.009305	0.843562

Hydrostatic curve



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SCANTLING CALCULATIONS

Particulars:

Length of ship, $L = 73.8\,m$

Breadth of ship, $B = 13.7\,m$

Draft, $T = 4.2\,m$

Height, $H = 5.25\,m$

Block coefficient, $C_B = 0.78$

Frame spacing, **a** = 0.6 m [Ref: GL 2013 Sec-9- B.1.1]

Web frame spacing, $e = 2.4\,m$

Material factor, $K = 1$

Bottom Structure

Floor

For single bottom

Section modulus : W = c T e l^2 [cm^3]

c : coefficient, defined as:

c = 7.5 = for spaces which may be empty at full draught, e.g. machinery spaces, store-rooms, etc.

c = 4.5 = elsewhere

e: spacing [m]of plate floors

l : unsupported span [m], generally measured on upper edge of floor from side shell to side

shell, with:

Depth: [Ref: GL 2013, Sec-8, B.1.2]

$h = 55\ B - 45$ [mm]

$= 708.5$ mm $= 710$ mm

Depth is taken as 750 mm

Web thickness:

$t = (h/100)+3 = 10.08 = 11$ mm

section modulus – $c \times T \times e \times l^2$

$= 4.5 \times 4.2 \times .6 \times 13.7^2$

Flange area is 19.7 cm^2

So flange width is 180 mm

Dimension- T- 750 x 180 x 11 mm

Floor plates in the peaks : [Ref: GL 2013, Sec-8, B.1.2.2]

$t = 0.035L + 5.0$ [mm]

$= 7.583 = 8$ mm

$h = 0.06H + 0.7[m] \quad = .952m$

Centre girder:

[Ref: GL 2013, Sec-8, B.2.2.1]

The web thickness :

$t_w = 0.07L + 5.5[mm]$

$= 10.66 = 11$ mm

Thickness is taken as 12 mm

$A_f = 0.7L + 12$ [cm]

$=65\ cm^2$

So , flange width is 540 mm

Dimension – T-750 x 540 x 12 mm

Side girder:

[Ref: GL 2013, Sec-8, B.2.2.2]

Web thickness ::

$t_w = 0.04L + 5$ [mm]
$= 7.952 = 8$ mm

sectional area –
$A_f = 0.2L + 6\ [cm^2]$

$= 20.76 = 21\ [cm^2]$

So , flange width is taken as 270 mm

Dimension –T- 750 x 270 x 8 mm

Bottom Shell plating

C_{rw} = Service Range Co-efficient = 1 [Ref: GL 2013, Sec-4 .A.3]

C_0 = Wave Co-efficient

$= \left[\frac{L}{25}+4.1\right] \times C_{rw}$ [Ref: GL 2013, Sec-4 .A.3]

= 7.05

C_L = Length Co-efficient = $\sqrt{\frac{L}{90}}$ = 0.9 [Ref: GL 2013, Sec-4 .A.3]

n_f = 1 for transverse framing [Ref : GL 2013 , Sec-6 .A.2]

Probability factor, f = 1; for plate panels of outer hull

Po = Basic external dynamic load [Ref : GL 2013 Sec-4.A.2]

$= 2.1\ (C_B+0.7) \times C_0 \times C_L \times f$ KN/m^2

$= 2.1\ (0.78+0.7) \times 7.04 \times 0.9 \times 1$ KN/m^2

=19.72 mm^2

P = P_B = Load at bottom

= 10**T** + $P_0.C_F$ KN/m^2 [Ref: GL 2013, Sec-4, B, 5]

= 10×4.2 + 19.72×1 KN/m^2

= 61.72 mm^2

σ_{perm} =Permissible design stress [N/mm^2] defined as

$= [0.8+\frac{L}{450}]\frac{230}{K}$ [Ref: GL 2013, Sec-6, A, 1]

= 241 mm^2

σ_{lp}=12.6 x$\sqrt{L}$ = 108.24

t_{B1}= 1.9x n_f × a × $\sqrt{pbxk}$ + t_k = 1.9 x1 x .6x .6 x × $\sqrt{61.72}$+ 1.5 = 10.45=11 mm

t_{B2} =1.21 x a x $\sqrt{(P_B¿.K)¿}$+ t_K = 7.2 mm [Ref: GL 2013, Sec-6, B.1]

Again, Minimum bottom plate thickness = c$\sqrt{(L.K)}$+ t_k = 9.8 mm ≈ 10 mm

[Ref: GL 2013, Sec-6, B, 2]

So, Thickness of Bottom Plate: 12 mm

Side shell plate thickness

[Ref: GL 2013, Sec-6, C, 2]

ps = 10 x (T-Z) + p_0 . c_f (1+z/T) = 10 +(4.2-2.63)+19.72x1x(1+$\frac{2.63}{4.2}$)

=47.76 N/mm^2

t_{B1}= 1.9x n_f × a × $\sqrt{ps}\,xk$ + t_k = 9.37 mm

So, 10 mm is taken

Sheer strake width = 800 + 5 L = 1170 mm

Thickness = .5 (t_D + t_S) = 10 mm

Keel plate [Ref: GL 2013, Sec-6, B.4.1]

$t = t_B + 2 = 14$ mm

$B = 800 + 5L = 1170$ mm

So, it is taken as 14 mm

Bilge plate

Thickness of bilge plate is taken as 14 mm

Scantling of side structure

Main frame [Ref: GL 2013, Sec-9, B.2]

$M_c = 1 - s/l = 1$ $s = 0$ [Ref: GL 2013, Sec-3, B3.4]

$Mk_3 = 1 - (l_{ku}/l + .4\ (l_{k0}/l)) = .77$

$W = n x\ m_{k3} x\ (1 - m_a^2)\ m_c\ .a\ .l^2\ .\ k$

$= .64 \times .77 \times (1 - .142^2) \times 1 \times .6 \times 2.4^2 \times 47.76 \times 1$

$= 79.69 \sim 80\ cm^3$

Dimension – L – 100 x 75 x 9 mm (Ref. Zulfikar.M.M. (2008). *The Inland Shipping Laws & Rules,* P-166)

Web frame and side stringer [Ref: GL 2013, Sec-9, B.5.3]

Z= 2.63 m

e=web frame spacing = 2.4m

l= length of unsupported span =2.4 mm

W=.55 x e x l^2 x p x k x n_c

=.55 x 2.4 x 2.4^2x 47.76 x 1x 1

=363.13 cm^3

Dimension –T- 270x130x8 mm (Ref. Zulfikar.M.M. (2008). *The Inland Shipping Laws & Rules,* P-170)

Bracket [Ref: GL 2013, Sec-3, B3.5.2]

$$W_B = n \times c \times a \times l^2 \times p \times k$$

$$288\, cm^3$$

The thickness of the bracket should not be less than

$$t = c \times \sqrt[3]{\frac{W}{K}} + t_K$$

$$0.95 \times \sqrt[3]{\frac{288}{1}} + 1.5$$

$$8\,mm$$

Arm length

The arm length of brackets should not be less than

$$l_B = 46.2 \times \sqrt[3]{\frac{W}{k}} \times c_t$$

$$46.2 \times \sqrt[3]{\frac{288}{1}} \times 0.96$$

= 292 mm

We take as 300 mm

Scantling of deck structure

Deck girder

$P = P_D$ [Ref: GL 2013, Sec-4, B.1]

$= P_0 \times \frac{20\,T}{(10 + z - T)\,H} \times C_D$

$= 19.72 \times \frac{20\,x\,4.2}{(10 + 2.63 - 4.2)\,5.25}$

= 37.42 kN /mm^2

Section modulus – W = c x e x l^2 x P x k

= 202.34 cm^3

[Ref: GL 2013, Sec-10, B.2]

Dimension T- 200 x 150 x 6 mm

Deck Beam

l=length of unsupported span = 2.65 m

c=.55

w_d= cx (mk_1^2- ma^2) x axl^2x px k [Ref: GL 2013, Sec-10, B.1]

= 62.38 cm^3

Dimension L-100 x 65 x 7 mm (Ref. Zulfikar.M.M. (2008). *The Inland Shipping Laws & Rules,* P-165)

Deck plate

t= c x a x $\sqrt{p}.k$ + t_k

t_{min} = (5.5 + .02 L) x $\sqrt{k}$

we take as 10 mm

Scantling of Superstructure

Thickness of side plating

[Ref: GL 2013, Sec-16,D .2]

$t = 1.21 \times a \times \sqrt{p.k} + t_k$

$= 7$ mm

Deck plating

$T_{min} = (5.5 + .02\ L) \times \sqrt{k}$

$= 6.976$

We take as 7 mm

Deck beam

[Ref: GL 2013, Sec-10, B.1]

$w_d = c x (m k_1^2 - m a^2) \times a x l^2 x\ p x\ k$

$= .55 \times (.86^2 - .142^2) \times .6 \times 1.8^2 \times 37.42$

$= 62.38\ cm^3$

Dimension L-100 x 65 x 7 (Ref. Zulfikar.M.M. (2008). *The Inland Shipping Laws & Rules,* P-165)

Superstructure frame

[Ref: GL 2013, Sec-9, B.3]

$w_d = c x (m k_1^2 - m a^2) \times m_c\ x a x l^2 x\ p x\ k$

$= .55 \times (.86^2 - .142^2)\ x1x\ .6 \times 1.8^2 \times 47.76$

$= 36.76\ cm^3$

Dimension L -75 x55 x 7 mm (Ref. Zulfikar.M.M. (2008). *The Inland Shipping Laws & Rules,* P-165)

Hatch cover

[Ref: GL 2013, Sec-17, B.5]

T_k =2 in general

Minimum thickness

$T_{min} = 6 + t_k$

= 8 mm

So 9 mm is taken

Hatch coaming thickness

8.5 ≈ 9 mm is taken

Bulkhead

Maximum spacing between bulkhead= .15L + 6.5

= 17.57 m

We take 17.6 m

Bulkhead plating [Ref: GL 2013, Sec-10, B.1]

$T_{min} = 6 \times \sqrt{f}$

= 6 mm

We take as 7 mm

Collision bulkhead plating

t= 1.1 x f xa $\sqrt{p}$+ t_k

= 5.4 mm

P= 9.81 xh

= 9.81 x 3.5

= 34.33 KN/mm^2

$T_{min=}$ 6 x $\sqrt{f}$

=6 mm

So we take as 7 mm

Bulkhead stiffeners

[Ref: GL 2013, Sec-11, C.1]

Section modulus of bulkhead stiffeners

W= C_s x(mk_1^2- ma^2) x axl^2x p

=.33 x ($.86^2$- $.142^2$) x .6 x 1.8^2 x 51.50

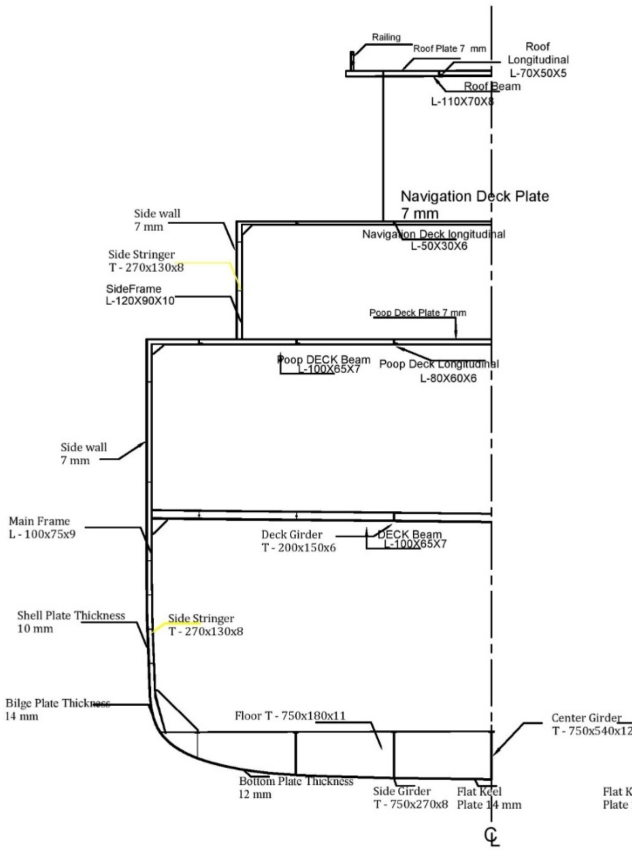
= 42.24 cm^3

Dimension L – 75 x 50 x9 mm (Ref. Zulfikar.M.M. (2008). *The Inland Shipping Laws & Rules,* P-165)

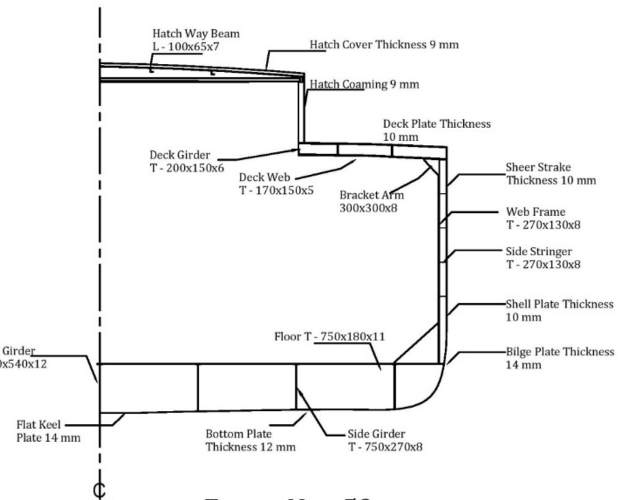
Name of Component	Dimensions
Bottom Plate	Thickness:12 mm

Keel Plate	Thickness:14 mm; Width 1170mm
Bilge Plate	Thickness:14 mm
Side shell Plate	Thickness: 10 mm
Sheer strake	Thickness: 10 mm Width 1170mm
Deck plate	Thickness:10 mm;
Bulkhead plate	Thickness: 7 mm
Center Girder	T – 750 ×540×12 mm
Side Girder	T – 750 x 270 x 8 mm
Deck beam	L- 100 x 65 x 7 mm
Deck girder	T- 200 x 150 x 6 mm
Superstructure frame	L – 75 x 55 x 7 mm
Super structure deck plate	7 mm
Superstructure side plate	7 mm
Hatch cover plate	9 mm
Hatch coaming	9 mm
Floor	T – 750 x 180 x 11 mm
Ordinary frame	L- 100 x 75 x 9 mm
Web Frame and side stringers	T-270 x 130 x 8 mm
Bulkhead Stiffener	L- 75 x 50 x 9 mm
Brackets	Thickness: 8 mm; Arm length: 300 mm

Midship section

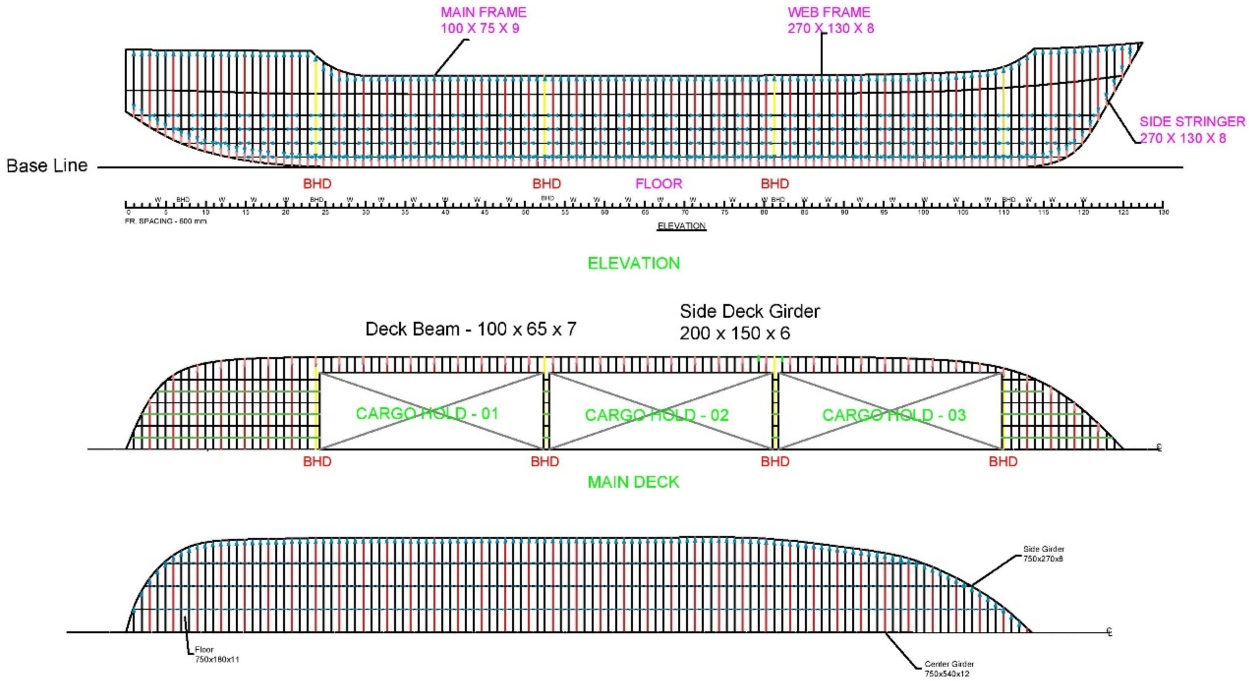


Frame No - 22



Frame No - 59

Longitudinal Construction



Shell expansion

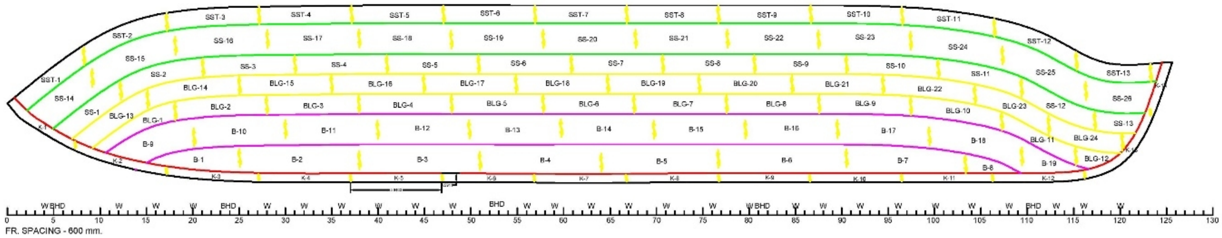


Fig : Shell Expansion

PLATE DESCRIPTION		
PLATE	DIMESION (mm)	NO. OF PLATES
1. KEEL PLATE	6000X1200X14	14
2. BOTTOM PLATE	6000X2000X12	19
3. BILGE PLATE	6000X1600X14	24
4. SHEAR STRAKE	6000X1200X10	13
5. SIDE SHELL	6000X2000X10	26

SYMBOLS

FRAMES

WEB FRAMES

WELDING LINES

BHD

RUDDER CALCULATION

Principal Particulars:

Length of ship, L=73.8 m

Breadth of ship, B=13.7 m

Draft =4.2 m (Where B/T = 3.26)

Ship Speed, $V=10$ Knots

C_b = .78

Rudder Area:

The classification society DNV calls for rudder area to be at least the size of (Rules , 1975):

$$A=\frac{TL}{100}\left\{1+25\left(\frac{B}{L}\right)^2\right\}$$

Where,

A=Area of rudder
T=Draft
L=Length of the ship
B=Breadth of the ship

So, we have $A=\frac{TL}{100}\left\{1+25\left(\frac{B}{L}\right)^2\right\}$

= (4.2*73.8/100){1+25*(13.7/73.8)} m^2

= 5.76m^2

From the reference book 'Applied Naval Architecture' by Munro Smith, the rudder area can be determined by,

$$A=\frac{\square}{60}$$

So, we have

$$A=\frac{\square}{60}$$

= 5.12m^2

The size of the movable rudder area is recommended not to be less than obtained from the following formula (according to GL Rule book):

A= $C_1. C_2.C_3. C_4 \frac{1.75xLxT}{100}$ m^2

C_1 = factor for the ship types=1.0 (in general)

C_2 = factor for the rudder types=1.0 (in general)

C_3 = factor for the rudder profiles=1.0 (for NACA –profiles and plate rudder)

C_4 = factor for the rudder arrangement= 1.0 (for rudders in the propeller jet)

So, we have

$$\mathbf{A} = C_1. C_2.C_3. C_4 \frac{1.75xLxT}{100} m^2$$

$$=1x1x1x1x(1.75*73.8*4.2/100)\ m^2$$

$$\mathbf{=5.42\ m^2}$$

So, we have taken rudder area, **A = 5.42m^2**

Material:

In general materials having yield strength ReH of less than 200 N /mm^2 and a tensile strength of less than 400 N /mm^2 or more than 900 N /mm^2 are not to be used for rudder stocks, pintles, keys and bolts. The requirements of this Section are based on a material's yield strength ReH of 235 N/mm^2. If material is used having a ReH differing from 235 N /mm^2, the material factor k_r is to be determined by the following formula:

$k_r=\left(\frac{235}{ReH}\right)^{0.75}$;for R_{eH}>235 (N/mm^2)

$=\frac{235}{R_{eH}}$; for $R_{eH} \leq 235$ [N/mm^2] [GL 2008 section 14 article-4]

Yield strength of forged steel $R_{eH}=450\ N/mm^2$

Material factor, $k_r=\left(\frac{235}{R_{eH}}\right)^{0.75}$ in case of $R_{eH} \geq 235\ N/mm^2$

$$\left(\frac{235}{450}\right)^{0.75}$$

0.614

Aspect ratio:

Aspect ratio, $a = \frac{b}{c}$ [GL 2008 section 14 article A-5]

Let's assume, Aspect ratio, a = b^2/A = 1.7

A=total moveable area of rudder

Where,

Rudder area, A =5.42 m^2

Mean height of rudder, b =3.03 m

Mean Breadth of rudder, c =1.78 m

Rudder force:

From the GL, the rudder force is to be determined form the following formula,

$$C_R = 132 \times A \times v^2 \times \kappa_1 \times \kappa_2 \times \kappa_3 \times \kappa_t$$

Where, [GL 2008 section 14 article B-1.1]

$C_R =$ ¿ Normal force acting on rudder

$\kappa_1 =$ ¿ Coefficient depending on the aspect ratio

=3.7/3=1.23

$\kappa_2 =$ ¿ Coefficient depending on the type of the rudder and rudder profile

1.1*(For NACA-00 series Gottingen profile and ahead condition)*

$\kappa_3 =$ ¿ Coefficient depending on the location of the rudder

= 1.0 (For rudders within the propeller jet)

$\kappa_t =$ ¿ Coefficient depending on the thrust coefficient

1.0 (Normally)

$v =$ ¿ Ship speed for ahead condition

=10 knots

$A = ¿$ Movable rudder area

= **5.42 m^2**

So, we have

$$C_R = 132 \times A \times v^2 \times \kappa_1 \times \kappa_2 \times \kappa_3 \times \kappa_t$$

$=132 \times 5.42 \times (10)^2 \times 1.23 \times 1.1 \times 1.0 \times 1.0$

=96800 N

=96.8KN

For astern condition taking Va 6 knot. Cr is 34820 N

Rudder torque:

The distance of center of pressure from the turning axis is given by,

$r = c\left(\alpha - k_b\right)$ [GL 2008 section 14 article B-1.2]

Where,

$\alpha = .33$ (For ahead condition)

$k_b = ¿$ Balance factor = 0.25 (for unbalanced rudders)

$b = ¿$ Mean height of rudder = 3.14 m

$c = \frac{A_1}{b}$ = (5.42/3.03) = 1.78m

So, we have

$$r = c\left(\alpha - k_b\right)$$

= 1.78(0.33- 0.25)

$= 0.14\text{m}$

The torque on rudder is to be determined by using this formula,

$$Q_R = C_r \times r$$

$$= 13552 \text{ Nm}$$

For astern cond. k=.55 r=1.78(.66-.55)

=.2

Torque=Cr X r =6970 Nm

Rudder stock:

According to GL the diameter of rudder stock for transmitting the rudder torque is not to be less than,

$$D_t = 4.2 \times \sqrt[3]{Q_R \times k_r}$$

Where,

Material factor for rudder, k_r = 0.614

So, we have

$$D_t = 4.2 \times \sqrt[3]{Q_R \times k_r}$$

$$4.2 \times \sqrt[3]{14040.96 \times 0.614}$$

$$=85$$

So, we take diameter of the rudder stock as **85 mm**

Related torsional stress, r_t = (68 /k_r) = 110.75 N/mm^2

Quadrangle for auxiliary tiller, = 0.77D_t

=0.77×85 mm

=65.45~ 66mm

Height of the tiller, = 0.80D_t

= 0.80×85mm

= 68 mm

Rudder frames:

According to GL rules for construction of ships, the standard spacing of horizontal rudder frames is to be obtained from the following formula:

$$a_h = 0.2 \times \frac{L}{100} + 0.4$$

=.5476

=547 mm

So, we take the spacing of horizontal rudder frames

=550 mm

The standard distance from the vertical rudder frame forming the rudder main piece to the adjacent vertical frame is to be obtained by,

$$a_v = 1.5 \times a_h = 1.5 * 550$$

=825 mm

So we take the spacing of vertical rudder frames = 825 mm

Rudder plates & web:

According to GL, the thickness of rudder plating is to determined from the following formula,

$t_p = 1.74 \times a \times \sqrt{p_R \times k_r} + 2.5$ [GL 2008 section 14 article E-2.1]

Where,

Smaller unsupported width of a plate panel, a $0.63\,m$

And $p_R = 10\,T + \dfrac{C_R}{10^3 \times A}$

=59.85 KN/m²

Material factor, k_r = 0.614

So, we have

$$t_p = 1.74 \times a \times \sqrt{p_R \times k_r} + 2.5$$

$$1.74 \times 0.63 \times \sqrt{98.44 \times 0.614} + 2.5$$

=9.87~10 mm

Hence, we take the thickness of rudder plating as

10 mm

The thickness of the webs is not to be less than,

$$t_w = 0.7 \times t_p$$

=7 mm

So, we take thickness of webs as t= 7 mm

Pintle:

The diameter of pintle is not to be less than,

$d_p = 0.35 \times \sqrt{B_1 \times k_R}$ [GL 2008 section 14 article E-5]

Where,

$B_1 = ¿$ Support reaction at the pintle

$= C_R \times b/c$

$= 96800 \text{ X } 1.7$

$= 164560$

$= 164.56 \text{ KN}$

Material factor, $k_r = 0.614$

So, we have

$$d_p = 0.35 \times \sqrt{B_1 \times k_R}$$

$$= 111.25$$

Hence, we take pintle diameter as =112 mm

Bearing:

In way of bearings liners and bushes are to be fitted. Their minimum thickness is given as,

$$t_{min} = 22\,mm$$

For metallic materials. [GL 2008 section 14 article E-4]

So, we take thickness of liner $t_l = 22\,mm$

Thickness of bush not be less than,

$d = 0.01\sqrt{B_1}$

$Where,$

Support reaction at the pintle, $B_1 = 164560$ N

The thickness of the bush,
d=.01*√164560

=4.05 mm

Hence, we take thickness of bush, d = 5 mm

The projected bearing surface at the neck bearing

$$A_{bn}=\frac{B_2}{q}$$

Where,

Support reaction at neck bearing and carrier bearing, B_2

B_1-C_R

=164560-96800

=67760 N

Permissible surface pressure, q

$2.5\,N/mm^2$ (For lignum vitae)

So, we have

$$A_{bn}=\frac{B_2}{q}$$

=27104 m^2

Again,

$$A_{bn}=bearing\,height\times external\,diameter\ of\ liner$$

External diameter of liner, d_b

=(84+44)mm= 128 mm

So, we have Bearing height,

=27104/128

=211.8 mm

So, we take bearing height as, 212 mm

Bearing clearance

=d_b /1000 +1

Where, Inner diameter of bush, d_b

=128/1000+1

=1.128 mm

Rudder couplings:

The diameter of horizontal coupling bolts is not to be less than,

$d_b = 0.62 \times \sqrt{\frac{D_t^3 \times k_b}{k_R \times n \times e}}$ [GL 2008 section 14 article D-2.1]

Where,

$D_t = ¿$ Rudder stock diameter

$n = ¿$ Total number of bolts 8

$k_r = ¿$ Material factor for rudder 0.614

$k_b = ¿$ Material factor for bolt =0.614

$e = ¿$ Mean distance of the bolt axis form the center of bolt system

Rudder stock radius + distance of bolt axis from outer surface of rudder stock

=42 +100

=142 mm

So, we have

$$d_b = 0.62 \times \sqrt{\frac{D_t^3 \times k_b}{k_r \times n \times e}}$$

=16.35 mm

So, we take the diameter of horizontal coupling bolts as 17 mm

The thickness of coupling flanges is not to be less than,

$$t_f = 0.62 \times \sqrt{\frac{D_t^3 \times k_f}{k_r \times n \times e}}$$

Where,

$D_t = ¿$ Rudder stock diameter

$n = ¿$ Total number of bolts =6

$k_R = ¿$ Material factor for rudder 0.614

$k_f = ¿$ Material factor for flanges $k_r = 0.614$

$e = ¿$ Mean distance of the bolt axis form the centre of bolt system

Rudder stock radius + distance of bolt axis from outer surface of rudder stock

=42+100

=142mm

So, we have

=16.35 mm

So we take the thickness of coupling flanges as 17 mm

Thickness of coupling flange clear of bolt hole=0.65 t_f

= 0.65× 17mm

= 11.05mm~11.1 mm

Width of material outside bolt hole = 0.67× t_f

=0.67× 17mm

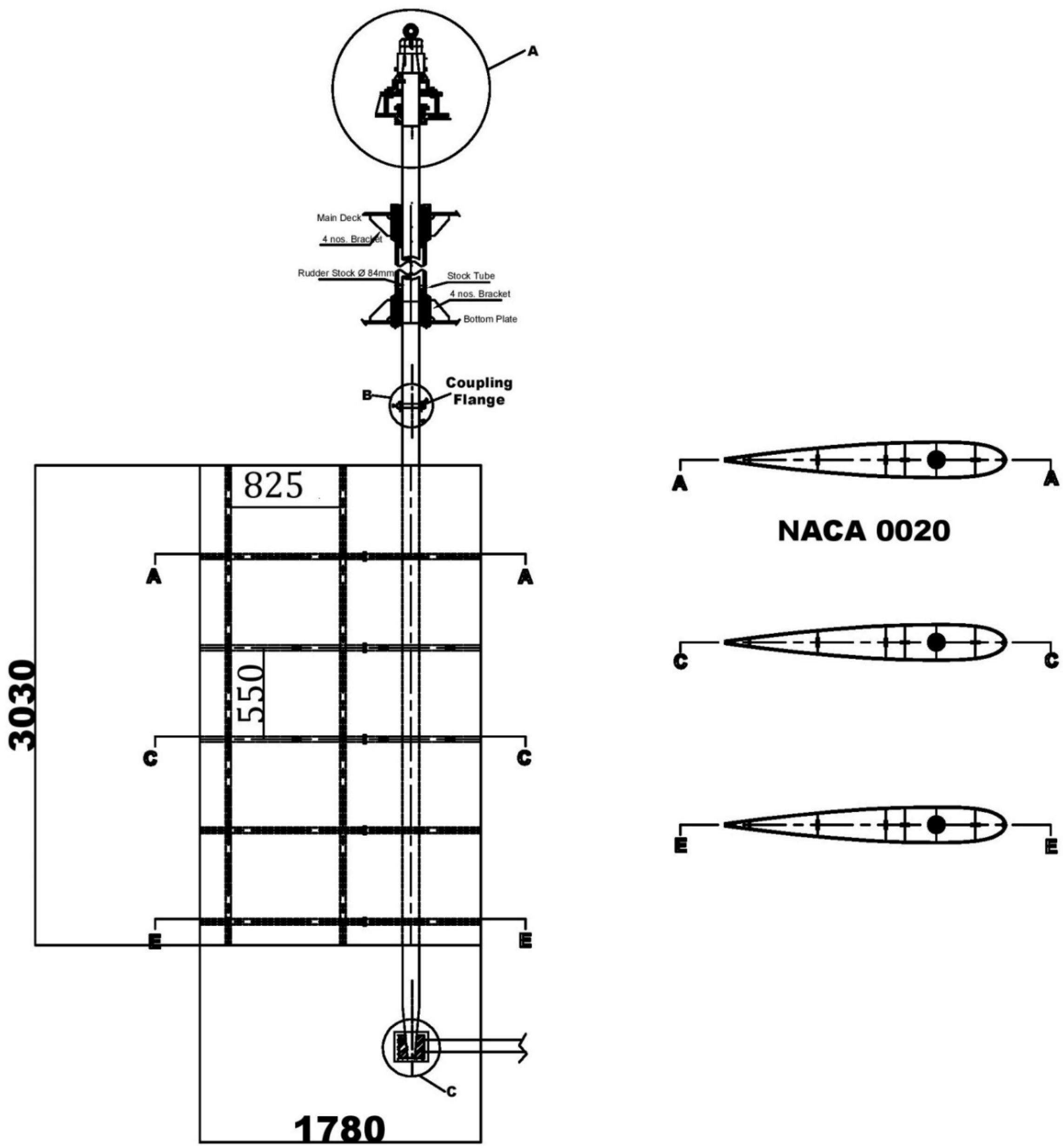
= 11.4mm

Summary

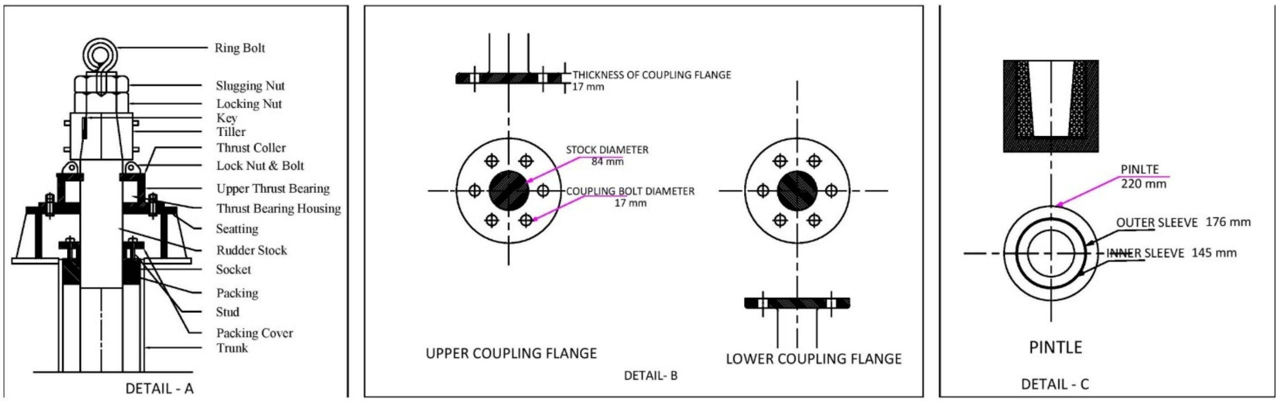
Items	Dimensions	Material
Rudder area	5.42 m^2	
Rudder stock	Diameter 84mm	Forged steel
Coupling bolts	Diameter 17mm	Forged steel
Coupling flanges	Thickness 17mm	Forged steel
Horizontal web	Spacing 550 mm	Forged steel
Vertical web	Spacing 825mm	Forged steel
Web plate	Thickness 7mm	Forged steel
Rudder plate	Thickness 10mm	Forged steel
Pintle	Diameter 112 mm	Forged steel

Liner	Thickness 22 mm	Forged steel
Tiller	Diameter 33 mm	Forged steel
Steering rod	Diameter 52.5 mm	Forged steel
Bush	Thickness 5 mm	Lignum vitae
Height of Bearing	212 mm	Forged steel

Rudder Drawings



A
Main Deck
4 nos. Bracket
Rudder Stock Ø 84mm
Stock Tube
4 nos. Bracket
Bottom Plate
B
Coupling Flange
825
3030
550
1780
C
NACA 0020



Steering Arrangement

Principal Particulars of Ship	
Length (L)	79.15 m
Breadth (B)	12.86m
Draft (T)	3.95 m
Speed (V)	10 knot (ahead) 5 knot (astern)
Block Coefficient (C_B)	0.733

Rudder force:

From the GL, the rudder force is to be determined form the following formula,

$$C_R = 132 \times A \times v^2 \times \kappa_1 \times \kappa_2 \times \kappa_3 \times \kappa_t$$

Where, [GL 2008 section 14 article B-1.1]

$C_R =¿$ Normal force acting on rudder

$\kappa_1 =¿$ Coefficient depending on the aspect ratio

$$\frac{a+2}{3} = \frac{1.80+2}{3} = 1.27$$

$\kappa_2 =¿$ Coefficient depending on the type of the rudder and rudder profile

1.1*(For NACA-00 series Gottingen profile and ahead condition)*

$\kappa_3 =¿$ Coefficient depending on the location of the rudder

= 1.0 (For rudders within the propeller jet)

$\kappa_t =¿$ Coefficient depending on the thrust coefficient

1.0 (Normally)

$v=¿$ Ship speed for ahead condition

=10 knots

$A=¿$ Movable rudder area

= **5.47 m²**

So, we have

$$C_R=132\times A\times v^2\times \kappa_1\times \kappa_2\times \kappa_3\times \kappa_t$$

$$=132\times5.47\times (10)^2\times1.27\times1.1\times1.0\times1.0$$

$$=100868.988 \text{ N}$$

$$=100.87\text{KN}$$

Rudder Torque:

The distance of center of pressure from the turning axis is given by,

$r=c\left(\alpha-k_b\right)$ [GL 2008 section 14 article B-1.2]

Where,

$\alpha=.33$ (For ahead condition)

$k_b=¿$ Balance factor = 0.25 (for unbalanced rudders)

$b=¿$ Mean height of rudder = 3.14 m

$c=\frac{A_1}{b}$= (5.47/3.14) = 1.74m

So, we have

$$r=c\left(\alpha-k_b\right)$$

$$= 1.74(0.33- 0.25)$$

$= 0.1392$ m

The torque on rudder is to be determined by using this formula,

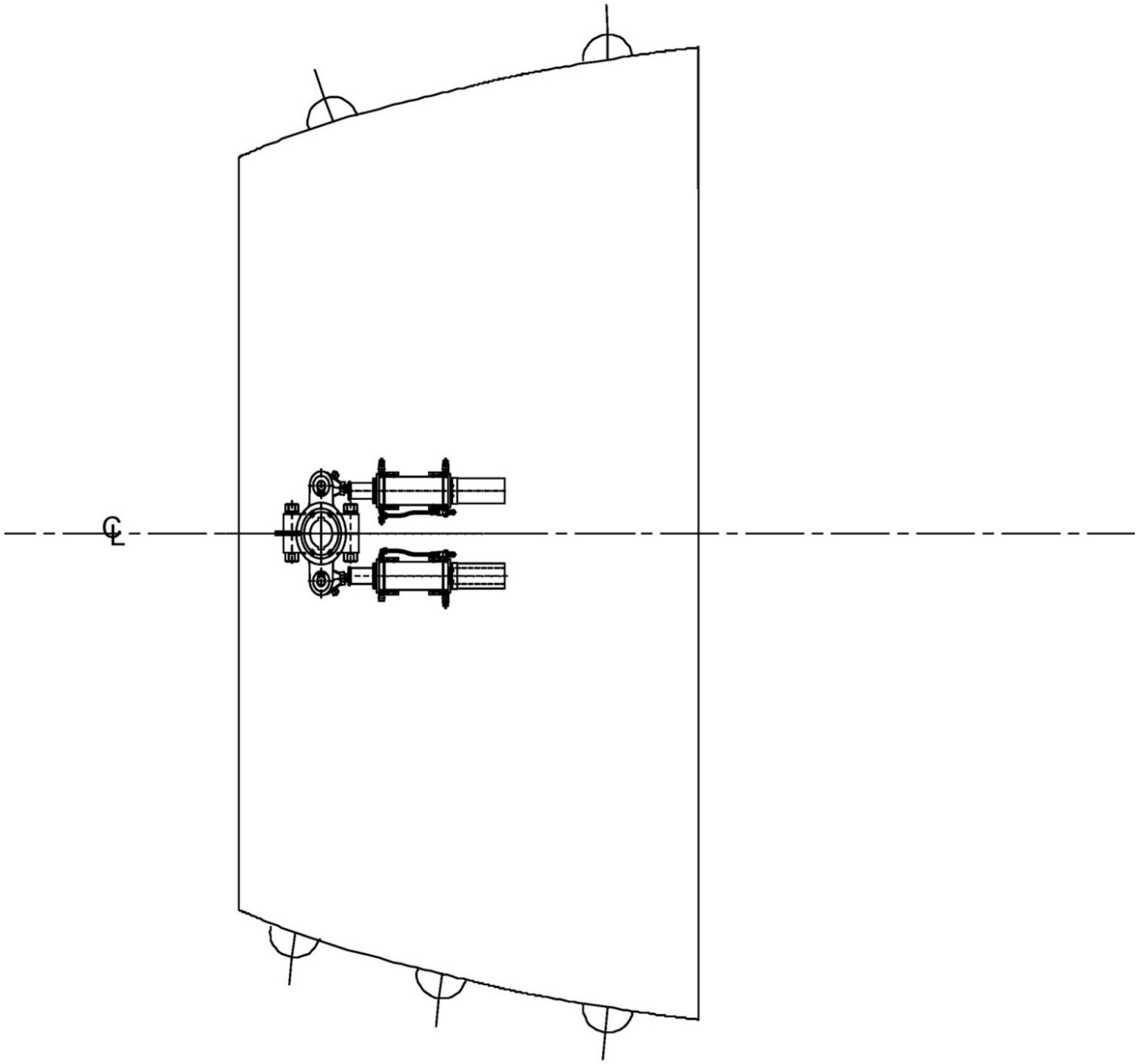
$$Q_R = C_r \times r$$

$$= 100868.988 \text{ N} \times 0.1392 \text{ m}$$

$$= 14040.96 \text{ N-m}$$

Steering particulars summary

Tiller	Diameter 33 mm	Forged steel
Steering rod	Diameter 52.5 mm	Forged steel
Bush	Thickness 5 mm	Lignum vitae



Steering Arrangment

Propeller calculation

Here, D_B =2.52

We have to calculate, BAR = $\frac{A_E}{A_O}$

According to Keller Criteria for avoiding Cavitation, $\frac{A_E}{A_O}$ $=\frac{(1.3+.3Z)T}{(Po-Pv)D^2}+0.2$

w= 0.25, t= 0.2, R_T = 82.80 KN

We know, T=$\frac{R}{1-t}$

Putting the values of R and t

T=$\frac{82.80}{1-.2}$ = 103.50 KN

V_A =V_S (1-w) =10X .75 = 7.5 knots = 3.86 ms^{-2}

Now, h= D/2 + .2

= 1.46

H = 4.2-1.46 = 2.74

P_O =101325 + Hρg

=101325 + 2.59× 1000 × 9.8 =126707 Pa

P_V = 3169 Pa

Now,P_0 - P_V =126707-3169 =123538 Pa

Hence $\frac{A_E}{A_O} = \frac{(1.3+0.3\times3)\times56.608\times1000}{123538\times2^2} + 0.2 = 0.452$

We have, $\frac{K_T}{J^2} = \frac{T}{\rho D^2 V_a{}^2} = \frac{103.5}{1.0\times 2.5^2 \times 3.86^2} = 1.1$

For BAR = .65,

from $\frac{K_T}{J^2}$ chart, η =0.51, J= 0.44, $\frac{P}{D}$ =0.86

P/D = 0.86

P = 0.86 x 2.52 = 2.17 m.

J=$\frac{V_a}{nD}$

$\Rightarrow$ n = $\frac{V_a}{JD} = \frac{3.86}{0.44 \times 2.52} = 3.48$

V_R^2 = $(0.7 \times 3.1416 \times n \times D)^2$

=(0.7 x 3.1416 x 3.48 x 2.52)^2

= 371.9

$\sigma_{0.7R}$ =$\frac{123538}{.5\times1000\times(5.211^2+352.706)} = 0.646$

τ_C =0.21[Burril Cavitation Chart]

τ_C =$\frac{\frac{T}{A_P}}{.5 \times\rho\times V_R{}^2}$

Now,

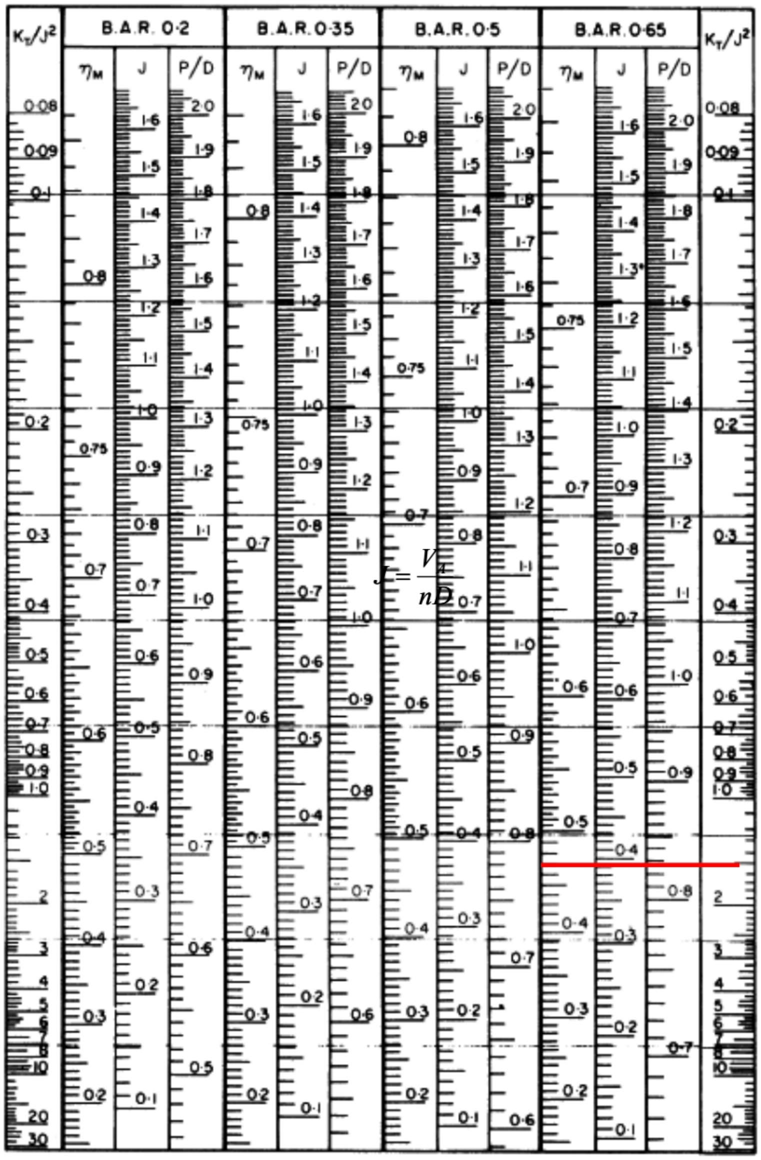
A_P =$\frac{T}{\tau C\times.5*p\times Vr^2} = \frac{56.608}{0.197\times0.5\times352.706}$=1.63

Again, A_E =$\frac{Ap}{1.067-.229\frac{P}{D}} = 1.93$

So, $\frac{A_E}{A_O} = \frac{1.93}{\frac{3.1416}{4}\times2^2} = 0.614 \approx .6$ (close value)

Now, we reconsider the problem with BAR=0.65

ht



For BAR .65,

from $\frac{K_T}{J^2}$ chart, η_H =0.48, J= 0.63, $\frac{P}{D}$ =1.1

$J=\frac{V_a}{nD}$

$\Rightarrow n=\frac{V_a}{JD} = \frac{5.211}{0.62\times 2} = 4.202$

$V_R^2 = (0.7 \times 3.1416 \times n \times D)^2$

=341.56

$\sigma_{0.7R} = \frac{128177}{.5\times 1000\times (3.86^2+371.9)} = 0.646$

τ_C = 0.21 [Burril Cavitation Chart]

$\tau_C = \frac{\frac{T}{A_P}}{.5\times\rho\times {V_R}^2}$

Now,

$A_P = \frac{T}{Tc\times p\times Vr^2} = \frac{103.5}{0.21\times 0.5\times 371.9}$= 2.65 m^2

Again, $A_E = \frac{Ap}{1.067-.229\frac{P}{D}\times 0.86} = 3.045$

So, $\frac{A_E}{A_O} = \frac{3.045}{\frac{3.1416}{4} \times 2.52^2} = 0.62 \approx .65$ [The value is converged]

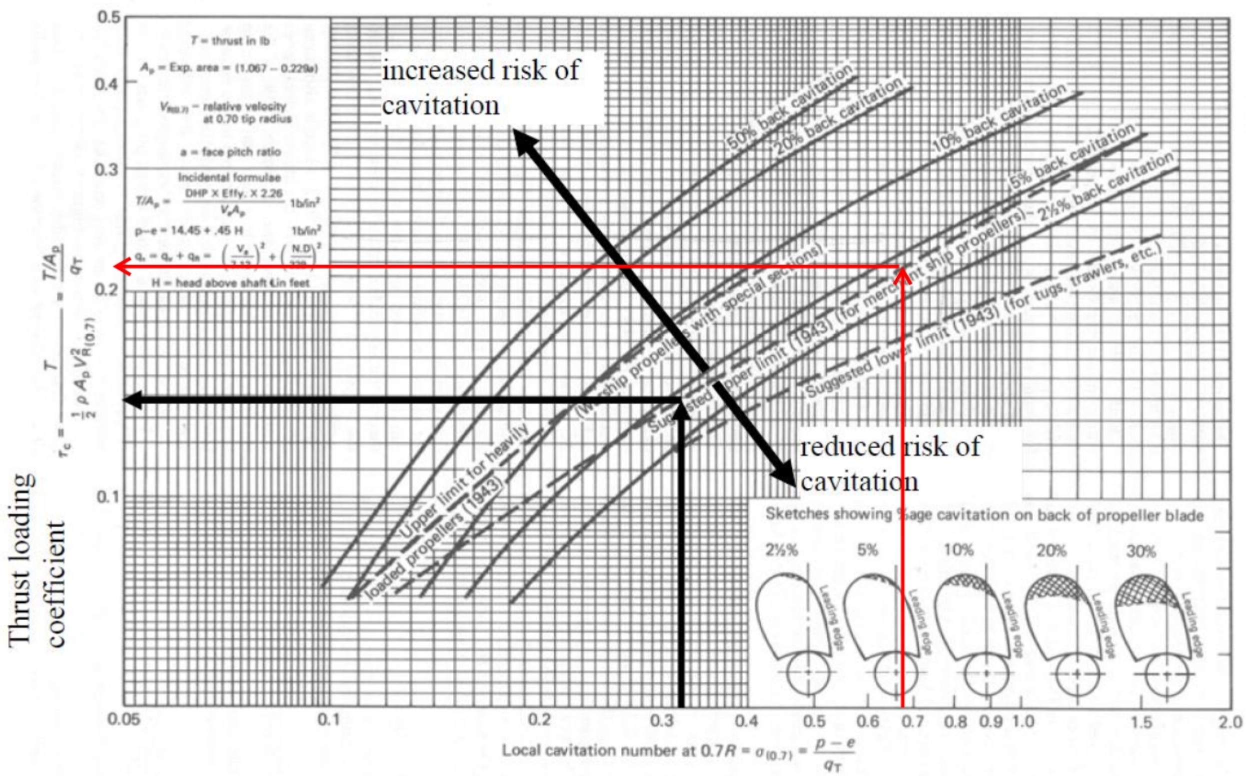
So we take B.A.R = 0.65

Finally at 210 rpm and Bp is 44.45 , delta 219.5 open water efficiency we take .49 from Bp delta diagram

Taking diameter 2.2 Kt/J^2 is 1.43 and efficiency is .48

Taking dia 1.6 Kt/J^2 is 2.71 efficiency is .32

So we take dia 2.52 m

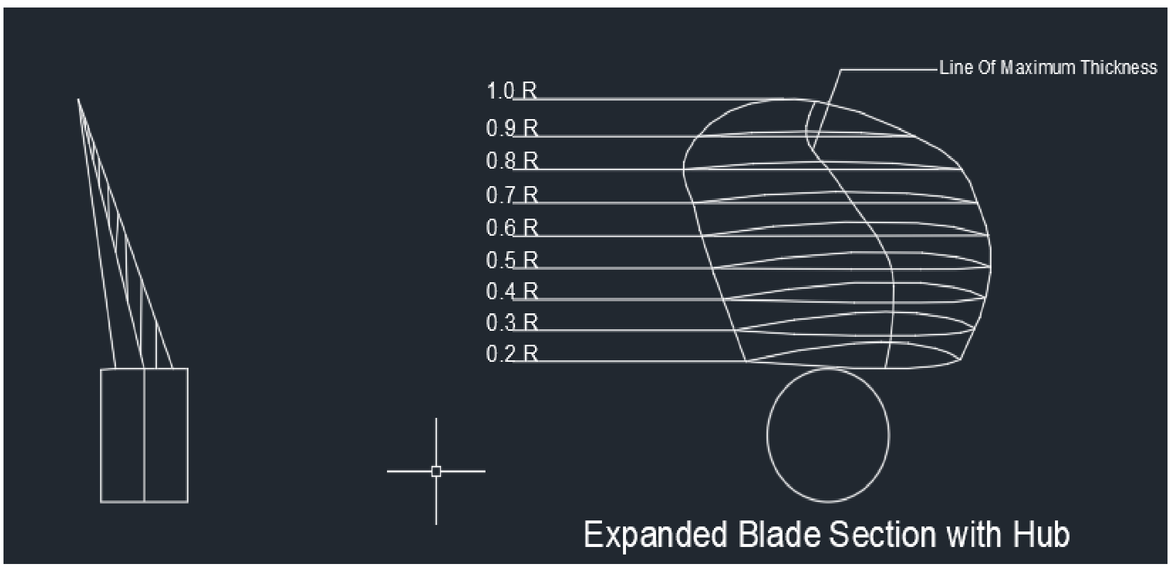


Propeller Specification

Propeller Particulars:

Number of Propeller	1 (Single Screw)
Number of Blades, Z	3
BAR	0.65
Diameter, D	2.52 m
P/D	.86
Efficiency, η	0.49
Propeller RPM	210 rpm

Propeller Drawings



Propeller shaft calculation

Propeller Shaft Arrangement Calculation

Engine power, P =880.82 kw

From propeller calculation we get,

Shaft speed, f= 210 rpm

We know,

Shaft speed, f = $\frac{Engine\,speed}{Gear\,ratio\,(Z)}$

Engine Speed=900 rpm

So,

Gear Ratio=900/210=4.28

Calculation for Shaft Diameter (Theoretical Formula)

[Strength of Materials, by Ferdinand L.Singer et. al]

Torque at shaft, T = P × $\frac{60}{2\pi f}$

=(880.82x1000x60)/2π x210=40053.4 Nm

Stress, τ =$\frac{16\,T}{\pi\,d^3}$

Here, τ = 60N/mm^2

= 60×10^6 N/m^2

T =40053.4N-m

Then, 60×10^6 = $\frac{16\,x\,55184.22}{\pi\,d^3}$

d= $^3\surd$ ($\frac{55184.22 \times 16}{\pi \times 60000000}$

=0.15 m

=150 mm

<u>Calculation for Shaft Diameter</u> **[**Chapter 2, Page 4–2, GL 2013]

(Using GL Rule Book-2013)

<u>Shaft Diameter:</u>

According to GL rule,

Minimum shaft diameter, $d = F \times K \times \sqrt[3]{\frac{P_W}{n \times \left[1 - \left\{\frac{d_i}{d_a}\right\}^4\right]}} \times C_W$

Where,

d = Required outside diameter of shaft

$d_i =$ ¿Actual diameter of shaft bore, where present.

$d_a =$ ¿Actual shaft diameter

The expression $1 - \left\{\frac{d_i}{d_a}\right\}^4$ can be taken as equal to1

$P_w =$ ¿Power transmitted by shaft

0.97 x 880.82 kW

= 836.8 kW

$f =$ ¿Shaft speed= 210 rpm

Here,

$R_m =$ ¿Tensile strength of shaft material (Forged steel)

$600\, N/mm$

$C_w =$ ¿Material factor

$= \frac{560}{R_m + 160}$

$\frac{560}{600+160}$ = 0.736

$F=¿$Factor for type of propulsion installation = 100

$k=¿$Factor for shaft type

1.40(Intermediate propeller shaft)

So we have,' $d=F\times k\times\sqrt[3]{\frac{P_W}{f\times\left[1-\left\{\frac{d_i}{d_a}\right\}^4\right]}}\times$ C_w

$$100\times1.4\times\sqrt[3]{\frac{1648.02}{294\times1}}\times0.736=¿163.4 \text{ mm}$$

From two methods we take the shaft diameter =**165 mm**

Angle of Twist:

$$\theta=\frac{TL}{GJ}$$

Here length of the shaft, L=8 m

Angular moment of inertia, J = $\frac{\pi d^4}{32}$ =7.27 x $10^{-5}m^4$

Modulus of rigidity, G = 83 GPa= 8.3x10^{10} Nm^{-2}

So, angle of twist, $\theta=\frac{55184.22\times4.72}{\left(8.3\times10^{10}\right)\times\left(1.10\,x\,10-4\right)}$rad.

= 0.053 rad.

=3.04^0

Minimum Liner Thickness [Chapter 2, Page 4–4]

s =0.03×165+7.5 mm

= **12.45~13mm**

Coupling: [Chapter 2, Page 4–4]

The thickness of coupling flanges must be equal to at least 20 % of the calculated diameter of the shaft.

Thickness of coupling flange =0.20×165= **33mm**

Shaft Bearings [Chapter 2, Page 4–6]

$l_{max} = K_1 \cdot \sqrt{d}$(< 350 rpm)

Where,

l_{max} = Maximum permissible distance between bearings

d = Diameter of shaft between bearings (mm) = 165mm

k_1 = 280-350 (for water lubricated rubber bearing in stern tubes and shaft bracket)

So,$l_{max} = K_2 . \sqrt{(d)} = 350 * \sqrt{165} = 4495.8$mm = 4.5m

Shaft Bearings

For water lubricated aft and forward rubber bearings inside stern tube,

Length of after stern tube bearing = 4d

Length of forward stern tube bearing= 1.5d

So we have,

Length of after stern tube bearing = 4 x 165= 660 mm

Length of forward stern tube bearing = 1.5 x 165 = 247.5~ 250mm

Shaft details:

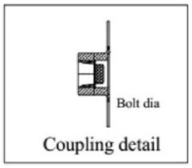
Details of the elements are given in the following table according to their serial number in CAD drawing

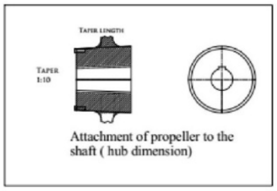
SL. NO	DESCRIPTION	MATERIALS	NUMBER OF COMPONENT
1	CONE NUT	M.B. BS	1
2	CONE NUT SECURING SCREW	M.B. BS	2
3	PROPELLER KEY	M.B. BS	1
4	PROPELLER DIA X PITCH	M.B. BS	1
5	AFT BRG SECURING SCREW	M.B. BS	3
6	COVER PLATE SECURING SCREW	STEEL BS	3
7	AFT LOCKING RING	STEEL BS	1
8	COVER PLATE	STEEL BS	1
9	LOCK RING SECURING SCREW	STEEL BS	3
10	FWD LOCKING RING	STEEL BS	1
11	RUBBER BEARING		
12	STERNTUBE	STEEL BS	1
13	TAILSHAFT		1
14	GLAND HOUSING	G.M. BS	1
15	FWD BEARING	G.M. BS	1
16	GREASY PACKING	GRAPHITED ASBESTOS	3 turns
17	GLAND RING	G.M. BS	1
18	GLAND STUDS AND NUTS	M.B. BS	2
19	COUPLING KEY	STEEL BS	1
20	HALF COUPLING	STEEL BS	1
21	BACKING WASHER	STEEL BS	1
22	LOCKING NUT	STEEL En7 BS	1

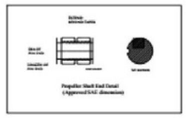
23	SEALING RING	BS	1
24	FWD BRG SECURING SCREW	M.B. BS	1
25	BEARING LOCK RING	STEEL BS	1

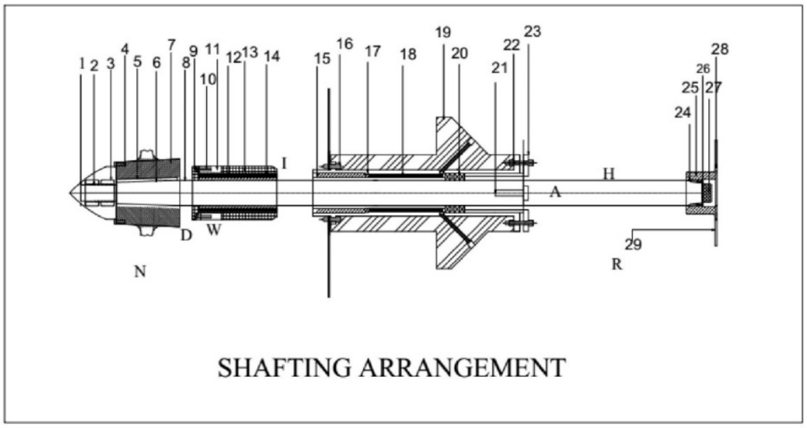
Summary :

Item	Dimensions
Shaft speed	210rpm
Torque	40.05 KN
Stress	$60x\ 10^6$ N/mm^2
Shaft Diameter	165mm
Twisting angle	3.04^0
Shaft liners	13mm
Coupling	33mm
Shaft bearing	4.5m
Stern Tube Bearing	250mm(frwd),660mm(aft)









LIST OF ITEMS

Sl. No.	Description	15	Stem Tube-fwd
1	PIN END	16	Jack Bolt
2	THREAD	17	Neck bearing Holder
3	PROPELLER LOCK NUT	18	Neck bearing
4	SECURING SCREW	19	Gland housing
5	PROPELLER KEY	20	Packing Gland
6	Taper	21	Gland nut
7	Propeller hub	22	Lock nut
8	SHAFT	23	Gland Locking Flange
9	Check ring	24	Propeller Shaft Coupling key
10	BOLT	25	Propeller Shaft Coupling
11	LOCKING RING	26	Backing washer
12	Shaft bearing	27	Coupling Nut
13	Bearing holder	28	Coupling bolt
14	Stem Tube-aft	29	Coupling Flange

Resistance Calculation

Approximate Calculation of Ship's Resistance

Holtrop & Mennen's method

Parameters	Value	Unit
Waterline Length, L_{WL}	74.53	m
Length Between Perpendicular, L_{BP}	73.8	m
Breadth moulded, B	13.7	m
Draft moulded, T	4.20	m
Block Coefficient, C_b	0.78	
Ship Speed, V	10	knots
Prismatic Coefficient, C_p	0.848	
Midship Coefficient, C_m	0.92	
Density of water, ρ	1	$tons/m^3$
Displacement, Δ	3334.000	tons
Water plane Co-efficient, C_{wp}	0.893	
Longitudinal Center of Buoyancy, L.C.B.	0.292	m (aft,mid)
L.C.B as a % of L_{WL}	0.3917885	% of L_{WL}
Transverse sectional area of BULB, A_{BT}	0	m^2
Immersed Transom area, A_T	0	m^2
Dynamic Viscosity , μ	1.22E-03	m^2/s
Propeller Dia, D	2.520	m

		Propeller Dia, D	2.520	m		
		Pitch ratio, P/D	1.35			
Parameter	**Symbol**		**Values**	**Unit**	**Note**	**Values**
1. Frictional resistance	R_F	$0.5\ \rho\ V^2\ S\ C_F$	31.69147	KN		
Frictional resist. coef.	C_F	$0.075 / (Log_{10}R_e - 2)^2$	0.001776			
Reynold's No.	R_E	$\rho VL / \mu$	3.15E+08			
Form factor of the hull	$1+k_1$	$c_{13}\{0.93 + c_{12}\ (B/L_R)^{0.92497}\ (0.95-C_P)^{-0.521448}$ $(1-CP+0.0225lcb)^{0.6906}\}$	1.383821			
Length of the run	L_R	$L\ \{1 - C_P + 0.06\ C_P\ lcb\ (4C_P-1)\}$	14.89354			
	C_{12}	$(T/L)^{0.2228446}$, if $T/L > 0.05$; $48.20\ (T/L-0.02)^{2.078} + 0.479948$, if $0.02<T/L<0.05$; 0.479948, if $T/L<0.02$	0.526804		T/L=	0.05635
	C_{13}	1+0.003 Cstern	1		Cstern=	0
Wetted area of the hull	S	$L\ (2T+B)\ \sqrt{C_M}(0.453 + 0.4425C_B - 0.2862\ C_M - 0.003467\ B/T + 0.3696\ C_{WP}) + 2.38\ A_{BT}/C_B$	1348.548		A_{BT}	0
2. Appendage Resistance	R_{APP}	$0.5\ \rho\ V^2\ S_{APP}\ (1+k_2)_{eq}\ C_F$	0.950744	KN	S_{APP}	26.971
Appendage resist. factor	$1+k_2$		1.5			
3. Wave Resistance	R_W	$c_1c_2c_5\ \nabla\ \rho\ g\ \exp\{m_1F_n^{\ d} + m_2\cos(\lambda F_n^{-2})\}$	10.6987	KN	F_n	0.19024

3. Wave Resistance	R_W	$c_1 c_2 c_5 \nabla \rho g \exp\{m_1 F_n^d + m_2 \cos(\lambda F_n^{-2}\}$	10.6987	KN	F_n	0.19024
	c_1	$2223105\ c_7^{3.78613} (T/B)^{1.07961} (90-i_E)^{-1.37656}$	3.990326		T/B	0.30657
	c_7	$0.229577(B/L)^{0.33333}$, if B/L<0.11; B/L , if 0.11<B/L<0.25; 0.5-0.0625 L/B, if B/L>0.25	0.183819		B/L	0.18382
	c_2	$\exp(-1.89\sqrt{c_3})$	1			
	c_5	$1-0.8\ A_T/(BTC_M)$	1			
	λ	$1.446C_p-0.03$ L/B, if L/B < 12; $1.446C_p-0.36$, if L/B>12	1.062752		L/B	5.44015
	m_1	$0.0140407\ L/T - 1.75254\ \nabla^{1/3}/L - 4.79323B/L - c_{16}$	-2.121059		L/T	17.7452
	c_{16}	$8.07981C_p-13.8673C_p^2+6.984388C_p^3$, if Cp<0.8; $1.73014-0.7067C_p$, if CP > 0.8	1.138794		C_p	0.848
	m_2	$c_{15}C_p^2 \exp(-0.1Fn^{-2})$	-0.076822			
	c_{15}	-1.69385 for $L^3/\nabla<512$; 0 for $L^3/\nabla>1727$; $-1.69385+(L^3/\nabla-8.0)/2.36$ if $512<L^3/\nabla<1727$	-1.69385		L^3/∇	124.173
	d		-0.9			
Half angle of entrance	i_E		34			
	c_3	$0.56\ A_{BT}^{1.5} / \{B\ T\ (0.31\sqrt{A_{BT}}+T_F-h_B)\ \}$	0		h_B	7

4. Additional pressure resistance due to bulbous bow	R_B	$0.11 \exp(-3P_B^{-2}) F_{ni}^3 A_{BT} 1.5 \rho g/(1+F_{ni}^2)$	0	KN	A_{BT}	0
	P_B	$0.56 \sqrt{A_{BT}} / (T_F - 1.5h_B)$	0			
5. Additional pressure resistance of immersed transom stern	R_{TR}	$.5 \rho V^2 A_T c_6$	0	KN	A_T	0
	c_6	$0.2 (1-0.2F_{nT})$, if $F_{nT}<5$; 0, if $F_{nT}\geq 5$	0			
	F_{nT}	$V / \sqrt{\{2g A_T/ (B+BC_{WP})\}}$	0			
6. Model-ship correlation resistance	R_A	$0.5 \rho V^2 S C_A$	10.55119	KN		
	C_A	$0.006 (L+100)^{-0.16} - 0.00205 + 0.003 \sqrt{(L/7.5)} C_B^4 c_2 (0.04-c_4)$	0.000577			
	c_4	T_F/L, when $T_F/L \leq 0.04$; 0.04, when $T_F/L>0.04$	0.04		T_F/L	0.05635
7. Wind Resitance			16.399	KN		
Total resistance	$R_T =$	$R_F(l + k_i) + R_{APP} + R_w + R_B + R_{TR} + R_A$	82.45495	KN		

6. Model-ship correlation resistance	R_A	$0.5\ \rho\ V^2\ S\ C_A$	10.55119	KN		
	C_A	$0.006\ (L+100)^{-0.16} - 0.00205 + 0.003\ \sqrt{(L/7.5)}\ C_B^{\ 4} c_2\ (0.04-c_4)$	0.000577			
	c_4	T_F/L, when $T_F/L \le 0.04$; 0.04,when $T_F/L>0.04$	0.04		T_F/L	0.05635
7. Wind Resitance			16.399	KN		
Total resistance	R_T =	$R_F(l + k_l) + R_{APP} + R_w + R_B + R_{TR} + R_A$	82.45495	KN		
Effective Power	P_E	$R_T \cdot V$	424.1483	KW		
			568.5634	HP		
Wake fraction	w	$0.395\ C_B + 10\ C_V C_B - 0.23\ D/\sqrt{(BT)}$	0.255364		C_V	0.00303
Thrust deduction factor	t	$0.325\ C_B - 0.1885\ D/\sqrt{(BT)}$	0.190878			
Relative rotative effic.	η_R	$0.9737 + 0.111(C_P - 0.0225\ lcb) - 0.06325P/D$	0.981443			
Shaft efficiency	η_s		0.97		1-w	0.74464
Open water efficiency	η_o		0.49		1- t	0.80912
Shaft Power	P_S		836.7872	KW		
			1121.699	HP	hull eff	1.0866
Gear efficiency	η_g		0.95			
Break Power	P_B		880.8286	KW		
			1180.735	HP		
Delivered Power	Pd		854.4038	KW		
			1145.313	HP		
		QPC	0.506877			

Adding 15 % to the brake power we get power equal to 1012 KW . so , we chose engine of 1030 KW.

Selection Of Engine

Engine Model:

YANMAR 6EY22AW (1030)

Marine propulsion diesel engine [Bore:165-330mm]

6EY22AW

| Power | 885~1370kW

Main Data

- Type : 4-stroke, Diesel
- No. of Cylinders : In-line 6
- Cylinder Bore : 220 mm
- Piston Stroke : 320 mm
- Mean Effective Pressure : 1.62 - 2.50 MPa
- Piston Speed : 9.60 m/s

Rated Power

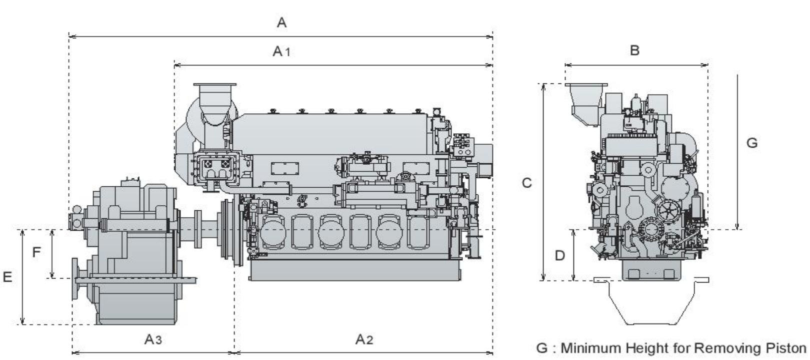
Engine Model	6EY22AW				
Continuous Rated Power kW (PS)	885 (1203)	1030 (1400)	1180 (1604)	1330 (1808)	1370 (1863)
Rated Engine Speed min^{-1}	900				
Engine Dry Weight kg	10000				

Standard Marine Gear

Propeller Type		for F.P.P.	
Marine Gear Model	Offset	YX-1000	YXH-2000
	Co-Axial	YX-1000C	YXH-2000C
Reduction Gear Ratio (Ahead)	Offset	2.03, 2.36, 2.78, 3.32	2.23, 2.58, 2.79, 3.03
	Co-Axial	2.03, 2.36, 2.78, 3.32	2.23, 2.58, 2.79, 3.03
Marine Gear Dry Weight kg	Offset	2400	4750
	Co-Axial	2565	5050

Dimensions [mm] / Weights [kg]

Engine Model	Marine Gear	A	A1	A2	A3	B	C	D	E	F	G	Total Dry Weight with Marine Gear
6EY22AW (885kW)	YX-1000	4574	3647	2965	1488	1618	2416	666	885	435	1922	12505
	YX-1000C	4687	3647	2965	1601	1618	2416	666	450	-	1922	12670
6EY22AW (1030kW)	YX-1000	4603	3647	2965	1517	1618	2416	666	885	435	1922	12556
	YX-1000C	4636	3647	2965	1550	1618	2416	666	450	-	1922	12721
6EY22AW (1180kW) (1330kW) (1370kW)	YXH-2000	4810	3647	2965	1807	1618	2416	666	1145	590	1922	14861
	YXH-2000C	4960	3647	2965	1957	1618	2416	666	555	-	1922	15161



G : Minimum Height for Removing Piston

12

The engine dry weight and outline may differ depending upon the specifications and attached accessories.

Engine foundation calculation

Bottom Structure in Machinery Spaces in Way of the Main Propulsion Plant

General

Openings in way of the engine foundation are to be kept as small as possible with due regard,

however, to accessibility. Where necessary, the edges of openings are to be strengthened by means of

face bars or the plate panels are to be stiffened.

Local strengthenings are to be provided beside the following minimum requirements, according to the construction, the local conditions and the main engine maker requirements.

Single bottom

The scantlings of floors are to be determined for the greatest unsupported

span measured in the engine room.

The web depth of the plate floors in way of the engine foundation is to be as large as possible.

The depth of plate floors connected to web frames is to be similar to the depth of the longitudinal foundation girders. In way of the crank case, the depth is not to be less than $0.5 \cdot h$.

The web thickness t is not to be less than determined by the following formula

$t=(h/100)+4$

$=11$ mm

h : depth of the floor plate

h=55 x B - 45

=708.5. ~ 710 mm

Longitudinal girders

The thickness t of the longitudinal girders above the inner bottom is not to be less than determined by the following formula:

$t=\sqrt{(p/15)} +6$ (mm)

$=\sqrt{(1030/15)} +6$

=14.2 ~ 15 in mm

P : single engine output [kW)

TOP PLATE:

The sizes of the top plate (width and thickness) are to be sufficient to attain efficient attachment and seating of the engine and - depending on seating height and type of engine - adequate transverse rigidity.

The thickness of the top plate is approximately to be equal to the diameter of the fitted-in bolts. The cross

sectional area A of the top plate is not to be less than determined by the following formula:

$A =(p/75) +70$

$=(1030/75)+70$ for $p>750$ kw

$=83.7\ cm^2$

A= cross sectional area

The thickness of the top plate should approximately be equal to the diameter of fitted in bolt . So thickness is taken as 32 mm

So, the width of top plate will be ,

B= (A X 100)/ t

= 261. 6

So it is taken as 260 mm

Web frames in machinery spaces

Arrangement

In the engine room, web frames are to be fitted. Generally, they should extend up to the uppermost continuous deck. They are to be spaced not more than 5 times the frame spacing in the engine

room.

For combustion engines, web frames are generally to be fitted at the forward and aft ends of

the engine. The web frames are to be evenly distributed along the length of the engine.

Where combustion engines are fitted aft, stringers spaced 2.6 m apart are to be fitted in the

engine room, in alignment with the stringers in the after peak, if any. Otherwise the main frames are to be

adequately strengthened. The scantlings of the stringers are to be similar to those of the web frames. At least one stringer is required where the depth up to the lowest deck is less than 4 m.

Scantlings

The section modulus W and moment of inertia I of web frames are not to be less than determined by the following formulae:

$W = 0.8 \cdot e \cdot l^2 \cdot P_s \cdot k$ (cm^3)

Crw = Service Range Co-efficient = 1 [Ref: GL 2013, Sec-4 .A.3]

C0 = Wave Co-efficient

= × Crw [Ref: GL 2013, Sec-4 .A.3]

= 7.04

CL = Length Co-efficient = = 0.9 [Ref: GL 2013, Sec-4 .A.3]

Po = Basic external dynamic load [Ref : GL 2013 Sec-4.A.2]

= 2.1 (CB+0.7) × C0 × CL ×f KN/m2

= 2.1 (0.78+0.7) × 7.04 × 0.9× 1 KN/m2

= 19.7 KN/m2

P = PB = Load at bottom

= 10T + P0.CF KN/m2 [Ref: GL 2013, Sec-4, B, 5]

= 10×3 + 18.26×1 KN/m2

= 56.7 KN/m2

$Ps = 47.76\ KN/m^2$

$W = 0.8 \cdot e \cdot l^2 \cdot Ps \cdot k\ (cm^3)$

$= 528.1\ cm^3$

Dimension: T-330X 120 X10 (Ref. Zulfikar.M.M. (2008).The Inland Shipping Laws & Rules, P-166)

Foundation Bolt

Spacing of bolts should be at least 3xd .

D=dia of foundation bolt. Found from engine drawing

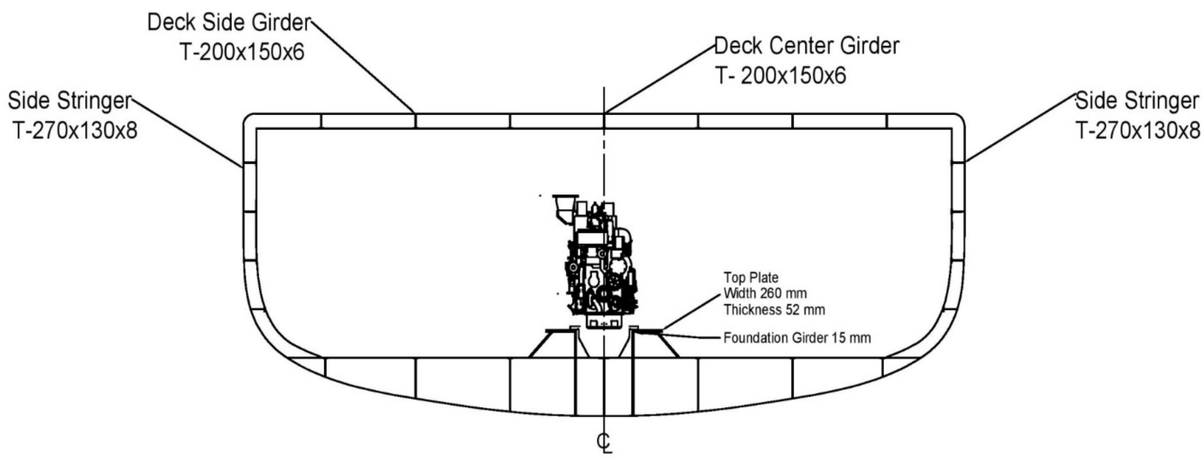
50 mm

So spacing 150 mm

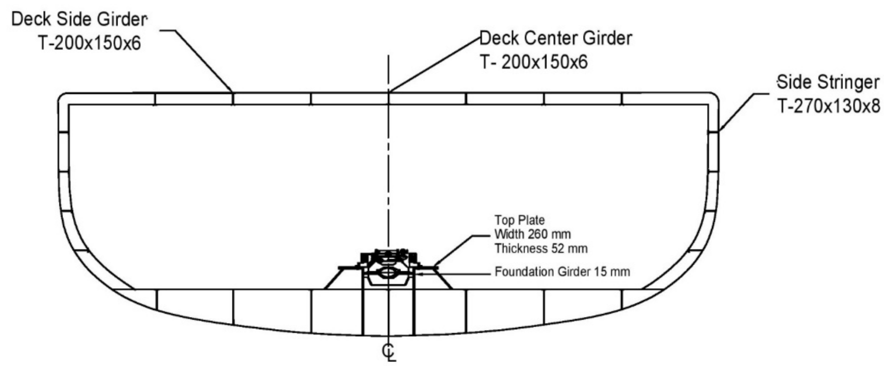
SUMMARY OF ENGINE FOUNDATION:

Plate floor	Thickness 11 mm
Foundation girder	Thickness 15 mm
Foundation bolt dia	50 mm
Top plate	Width 260 mm, thickness 52 mm
Web frame	T- 330 X 120X 10 mm
Bolt spacing	150 mm

Engine Foundation Drawings

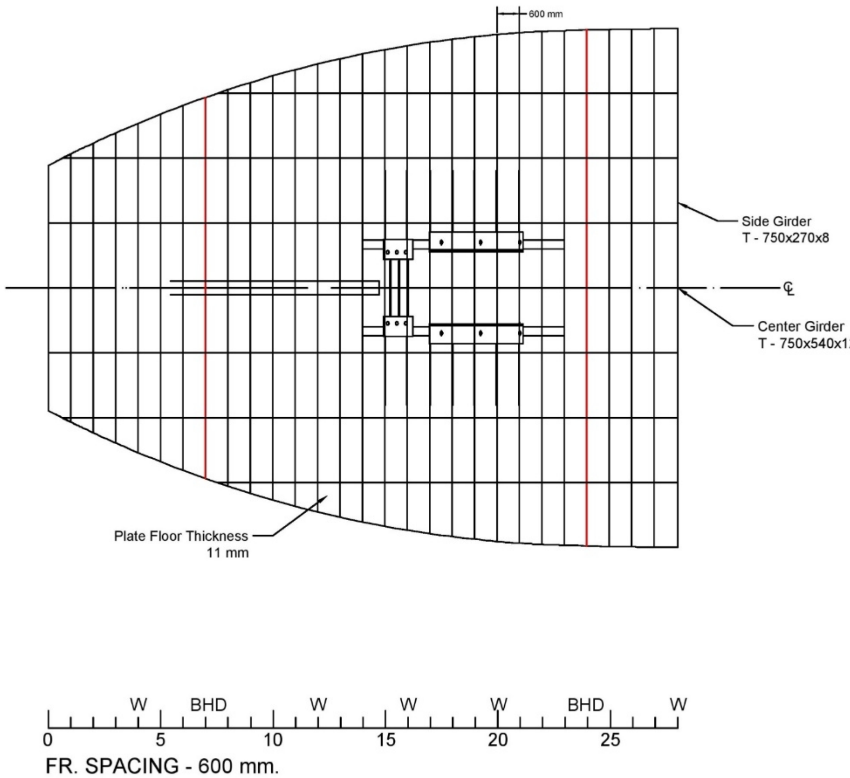


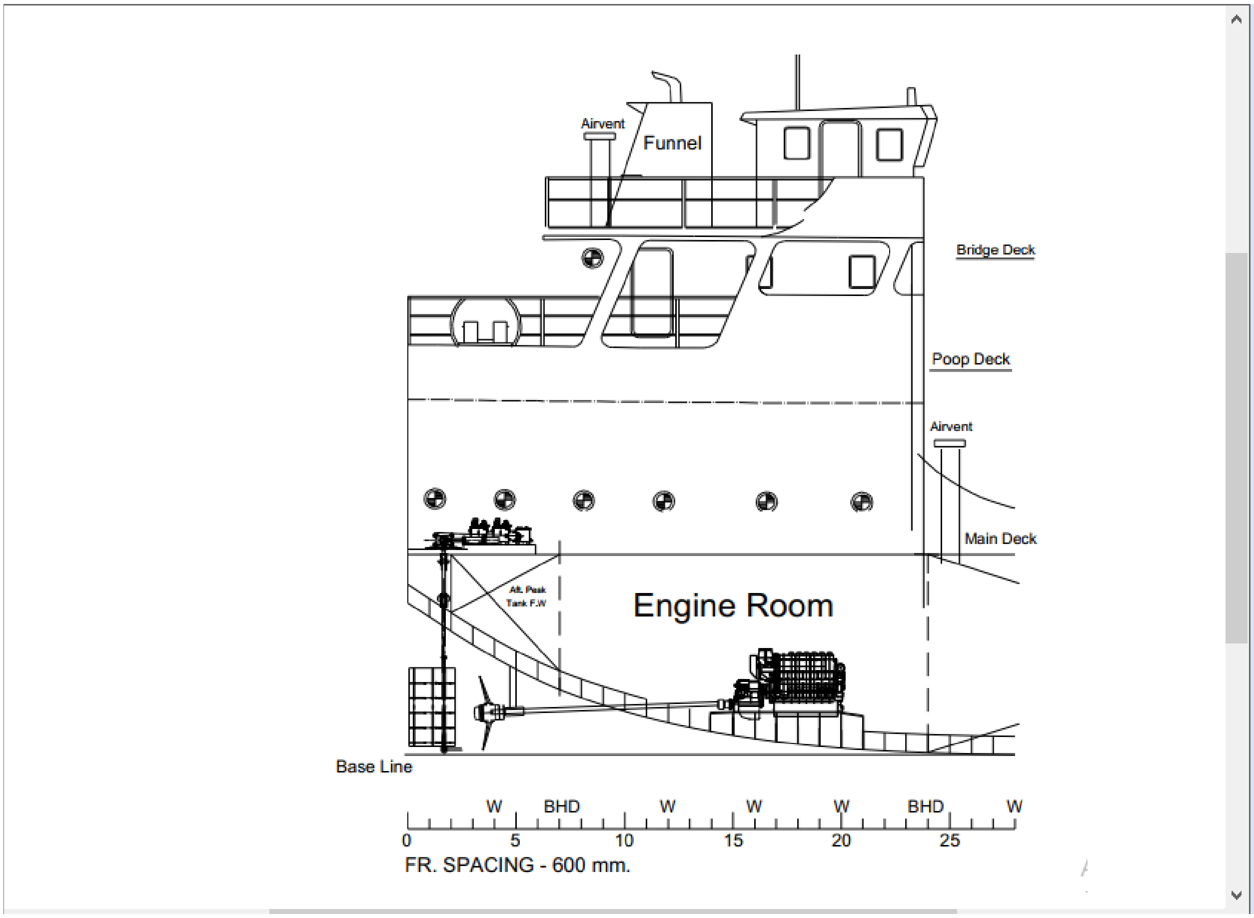
Main Engine Foundation (Sectional View) at frame 18



Gear Box (Sectional View) at frame 16

Top view


600 mm
Side Girder
T - 750x270x8
Center Girder
T - 750x540x12
Plate Floor Thickness
11 mm
W
BHD
W
W
W
BHD
W
0
5
10
15
20
25
FR. SPACING - 600 mm.



Manning of ship

Designation	No. of Personnel
1st Class Master	1
2nd Class Master	2
Sailor	8
1st Class Driver	1
Greaser	3
Total	15

Reference: Zulfiqur M.M . The Inland shipping laws and rules

Equipment Number calculation

Equipment number calculation

B Equipment numeral

B.1 The equipment numeral Z_1 for anchors and chain cables is to be determined by the following formula:

$$Z_1 = D^{2/3} + 2 \cdot h \cdot \mathbf{B} + \frac{A}{10}$$

h : effective height [m] from the summer load waterline to the top of the uppermost house, defined as:

$h = a + \sum h_i$

a : distance [m] from the summer load waterline, amidships, to the upper deck at side

$\sum h_i$: sum of height [m] of superstructures and deckhouses on the upper deck, measured on the centreline of each tier having a breadth greater than $\mathbf{B}$ / 4. Deck sheer, if any, is to be ignored. For the lowest tier, h is to be measured at centreline from the upper deck or from a notional deck line where there is local discontinuity in the upper deck.

Where a = 5.25 – 4.2 = 1.05

and $\sum h_i$ = 11.38

So That, h = a + $\sum h_i$

= 1.05 + 11.38
= 12.4

Again Area **A =** area [m2], in profile view of the hull, superstructures and deckhouses, having a breadth
greater than **B** / 4, above the summer load waterline within the length **L** and up to the height
h.

So That, A = 46 + 17 + 7 + 10
= 80 m^2

$Z = (3150)^{2/3} + 2 \times 12.4 \times 13.7 + \frac{80}{10}$

$= 562.64$

Table 18.2 Anchor, Chain Cables and Ropes

No. for Reg.	Equipment numeral Z_1 or Z_2	Stockless anchor			Stud link chain cables						Recommended ropes				
		Bower anchor		Stream anchor	Bower anchors				Stream wire or chain for stream anchor		Towline		Mooring ropes		
		Number [1]	Mass per anchor		Total length	Diameter			Length	Br. Load [2]	Length	Br. Load [2]	Number	Length	Br. Load [2]
						d_1	d_2	d_3							
			[kg]		[m]	[mm]			[m]	[kN]	[m]	[kN]		[m]	[kN]
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
101	up to 50	2	120	40	165	12,5	12,5	12,5	80	65	180	100	3	80	35
102	50 – 70	2	180	60	220	14	12,5	12,5	80	65	180	100	3	80	35
103	70 – 90	2	240	80	220	16	14	14	85	75	180	100	3	100	40
104	90 – 110	2	300	100	247.5	17.5	16	16	85	80	180	100	3	110	40
105	110 – 130	2	360	120	247.5	19	17.5	17.5	90	90	180	100	3	110	45
106	130 – 150	2	420	140	275	20.5	17.5	17.5	90	100	180	100	3	120	50
107	150 – 175	2	480	165	275	22	19	19	90	110	180	100	3	120	55
108	175 – 205	2	570	190	302.5	24	20.5	20.5	90	120	180	110	3	120	60
109	205 – 240	3	660		302.5	26	22	20.5			180	130	4	120	65
110	240 – 280	3	780		330	28	24	22			180	150	4	120	70
111	280 – 320	3	900		357.5	30	26	24			180	175	4	140	80
112	320 – 360	3	1020		357.5	32	28	24			180	200	4	140	85
113	360 – 400	3	1140		385	34	30	26			180	225	4	140	95
114	400 – 450	3	1290		385	36	32	28			180	250	4	140	100
115	450 – 500	3	1440		412.5	38	34	30			180	275	4	140	110
116	500 – 550	3	1590		412.5	40	34	30			190	305	4	160	120
117	550 – 600	3	1740		440	42	36	32			190	340	4	160	130
118	600 – 660	3	1920		440	44	38	34			190	370	4	160	145
119	660 – 720	3	2100		440	46	40	36			190	405	4	160	160

Detailed Lightweight calculation

	Area	Length	Weight	LCG	Moment	VCG	Moment
Floor							
Floor 1	1.30E-02	3.04	0.6220448	39	24.2597472	4.4	2.73699712
Floor 2	1.30E-02	3.28	0.6711536	37.8	25.36960608	4	2.6846144
Floor 3	1.30E-02	3.52	0.7202624	37.2	26.79376128	3.75	2.700984
Floor 4	1.30E-02	3.76	0.7693712	36.6	28.15898592	3.2	2.46198784
Floor 5	1.30E-02	4	0.81848	36	29.46528	2.75	2.25082
Floor 6	1.30E-02	4.24	0.8675888	35.4	30.71264352	2.6	2.25573088
Floor 7	1.30E-02	4.76	0.9739912	34.8	33.89489376	2.4	2.33757888
Floor 8	1.30E-02	4.945	1.0118459	34.2	34.60512978	2.3	2.32724557
Floor 9	1.30E-02	5.13	1.0497006	33.6	35.26994016	2.2	2.30934132
Floor 10	1.30E-02	5.315	1.0875553	33	35.8893249	1.9	2.06635507
Floor 11	1.30E-02	5.5	1.12541	32.4	36.463284	1.6	1.800656
Floor 12	1.30E-02	5.685	1.1632647	31.8	36.99181746	1.5	1.74489705
Floor 13	1.30E-02	5.87	1.2011194	31.2	37.47492528	1.4	1.68156716
Floor 14	1.30E-02	5.985	1.2246507	30.6	37.47431142	1.25	1.53081338
Floor 15	1.30E-02	6.1	1.248182	30	37.44546	1.1	1.3730002
Floor 16	1.30E-02	6.215	1.2717133	29.4	37.38837102	0.95	1.20812764
Floor 17	1.30E-02	6.33	1.2952446	28.8	37.30304448	0.85	1.10095791
Floor 18	1.30E-02	6.445	1.3187759	28.2	37.18948038	0.75	0.98908193
Floor	1.30E-	6.56	1.342307	27.6	37.04767	0.7	0.93961

19	02		2		872		504
Floor 20	1.30E-02	6.75	1.381185	27	37.291995	0.68	0.9392058
Floor 21	1.30E-02	6.75	1.381185	26.4	36.463284	0.67	0.92539395
Floor 22	1.30E-02	6.75	1.381185	25.8	35.634573	0.66	0.9115821
Floor 23	1.30E-02	6.75	1.381185	25.2	34.805862	0.62	0.8563347
Floor 24	1.30E-02	6.75	1.381185	24.6	33.977151	0.6	0.828711
Floor 25	1.00E-02	6.68	1.051432	24	25.234368	0.5	0.525716
Floor 26	1.00E-02	6.85	1.07819	23.4	25.229646	0.48	0.5175312
Floor 27	1.00E-02	6.85	1.07819	22.8	24.582732	0.44	0.4744036
Floor 28	1.00E-02	6.85	1.07819	22.2	23.935818	0.44	0.4744036
Floor 29	1.00E-02	6.85	1.07819	21.6	23.288904	0.44	0.4744036
Floor 30	1.00E-02	6.85	1.07819	21	22.64199	0.44	0.4744036
Floor 31	1.00E-02	6.85	1.07819	20.4	21.995076	0.44	0.4744036
Floor 32	1.00E-02	6.85	1.07819	19.8	21.348162	0.44	0.4744036
Floor 33	1.00E-02	6.85	1.07819	19.2	20.701248	0.44	0.4744036
Floor 34	1.00E-02	6.85	1.07819	18.6	20.054334	0.44	0.4744036
Floor 35	1.00E-02	6.85	1.07819	18	19.40742	0.44	0.4744036
Floor 36	1.00E-02	6.85	1.07819	17.4	18.760506	0.44	0.4744036
Floor 37	1.00E-02	6.85	1.07819	16.8	18.113592	0.44	0.4744036
Floor 38	1.00E-02	6.85	1.07819	16.2	17.466678	0.44	0.4744036
Floor 39	1.00E-02	6.85	1.07819	15.6	16.819764	0.44	0.4744036
Floor 40	1.00E-02	6.85	1.07819	15	16.17285	0.44	0.4744036
Floor 41	1.00E-02	6.85	1.07819	14.4	15.525936	0.44	0.4744036
Floor 42	1.00E-02	6.85	1.07819	13.8	14.879022	0.44	0.4744036
Floor 43	1.00E-02	6.85	1.07819	13.2	14.232108	0.44	0.4744036

Floor 44	1.00E-02	6.85	1.07819	12.6	13.585194	0.44	0.4744036
Floor 45	1.00E-02	6.85	1.07819	12	12.93828	0.44	0.4744036
Floor 46	1.00E-02	6.85	1.07819	11.4	12.291366	0.44	0.4744036
Floor 47	1.00E-02	6.85	1.07819	10.8	11.644452	0.44	0.4744036
Floor 48	1.00E-02	6.85	1.07819	10.2	10.997538	0.44	0.4744036
Floor 49	1.00E-02	6.85	1.07819	9.6	10.350624	0.44	0.4744036
Floor 50	1.00E-02	6.85	1.07819	9	9.70371	0.44	0.4744036
Floor 51	1.00E-02	6.85	1.07819	8.4	9.056796	0.44	0.4744036
Floor 52	1.00E-02	6.85	1.07819	7.8	8.409882	0.44	0.4744036
Floor 53	1.00E-02	6.85	1.07819	7.2	7.762968	0.44	0.4744036
Floor 54	1.00E-02	6.85	1.07819	6.6	7.116054	0.44	0.4744036
Floor 55	1.00E-02	6.85	1.07819	6	6.46914	0.44	0.4744036
Floor 56	1.00E-02	6.85	1.07819	5.4	5.822226	0.44	0.4744036
Floor 57	1.00E-02	6.85	1.07819	4.8	5.175312	0.44	0.4744036
Floor 58	1.00E-02	6.85	1.07819	4.2	4.528398	0.44	0.4744036
Floor 59	1.00E-02	6.85	1.07819	3.6	3.881484	0.44	0.4744036
Floor 60	1.00E-02	6.85	1.07819	3	3.23457	0.44	0.4744036
Floor 61	1.00E-02	6.85	1.07819	2.4	2.587656	0.44	0.4744036
Floor 62	1.00E-02	6.85	1.07819	1.8	1.940742	0.44	0.4744036
Floor 63	1.00E-02	6.85	1.07819	1.2	1.293828	0.44	0.4744036
Floor 64	1.00E-02	6.85	1.07819	0.6	0.646914	0.44	0.4744036
Floor 65	1.00E-02	6.85	1.07819	0	0	0.44	0.4744036
Floor 66	1.00E-02	6.85	1.07819	-0.6	-0.646914	0.44	0.4744036
Floor 67	1.00E-02	6.85	1.07819	-1.2	-1.293828	0.44	0.4744036
Floor	1.00E-	6.85	1.07819	-1.8	-1.940742	0.44	0.47440

68	02						36
Floor 69	1.00E-02	6.85	1.07819	-2.4	-2.587656	0.44	0.4744036
Floor 70	1.00E-02	6.85	1.07819	-3	-3.23457	0.44	0.4744036
Floor 71	1.00E-02	6.85	1.07819	-3.6	-3.881484	0.44	0.4744036
Floor 72	1.00E-02	6.85	1.07819	-4.2	-4.528398	0.44	0.4744036
Floor 73	1.00E-02	6.85	1.07819	-4.8	-5.175312	0.44	0.4744036
Floor 74	1.00E-02	6.85	1.07819	-5.4	-5.822226	0.44	0.4744036
Floor 75	1.00E-02	6.85	1.07819	-6	-6.46914	0.44	0.4744036
Floor 76	1.00E-02	6.85	1.07819	-6.6	-7.116054	0.44	0.4744036
Floor 77	1.00E-02	6.85	1.07819	-7.2	-7.762968	0.44	0.4744036
Floor 78	1.00E-02	6.85	1.07819	-7.8	-8.409882	0.44	0.4744036
Floor 79	1.00E-02	6.85	1.07819	-8.4	-9.056796	0.44	0.4744036
Floor 80	1.00E-02	6.85	1.07819	-9	-9.70371	0.44	0.4744036
Floor 81	1.00E-02	6.85	1.07819	-9.6	-10.350624	0.44	0.4744036
Floor 82	1.00E-02	6.85	1.07819	-10.2	-10.997538	0.44	0.4744036
Floor 83	1.00E-02	6.85	1.07819	-10.8	-11.644452	0.44	0.4744036
Floor 84	1.00E-02	6.85	1.07819	-11.4	-12.291366	0.44	0.4744036
Floor 85	1.00E-02	6.85	1.07819	-12	-12.93828	0.48	0.5175312
Floor 86	1.00E-02	6	0.9444	-12.6	-11.89944	0.5	0.4722
Floor 87	1.00E-02	5.89	0.927086	-13.2	-12.2375352	0.5	0.463543
Floor 88	1.00E-02	5.78	0.909772	-13.8	-12.5548536	0.5	0.454886
Floor 89	1.00E-02	5.66	0.890884	-14.4	-12.82872	0.5	0.445442

					96		
Floor 90	1.00E-02	5.55	0.87357	-15	-13.10355	0.5	0.436785
Floor 91	1.00E-02	6.75	1.06245	-15.6	-16.57422	0.5	0.531225
Floor 92	1.00E-02	6.75	1.06245	-16.2	-17.21169	0.5	0.531225
Floor 93	1.00E-02	6.75	1.06245	-16.8	-17.84916	0.5	0.531225
Floor 94	1.00E-02	5.35	0.84209	-17.4	-14.652366	0.5	0.421045
Floor 95	1.00E-02	6.75	1.06245	-18	-19.1241	0.5	0.531225
Floor 96	1.00E-02	6.75	1.06245	-18.6	-19.76157	0.5	0.531225
Floor 97	1.00E-02	6.75	1.06245	-19.2	-20.39904	0.5	0.531225
Floor 98	1.00E-02	6.75	1.06245	-19.8	-21.03651	0.5	0.531225
Floor 99	1.00E-02	6.75	1.06245	-20.4	-21.67398	0.5	0.531225
Floor 100	1.00E-02	6.75	1.06245	-21	-22.31145	0.5	0.531225
Floor 101	1.00E-02	3.83	0.602842	-21.6	-13.0213872	0.5	0.301421
Floor 102	1.00E-02	6.75	1.06245	-22.2	-23.58639	0.5	0.531225
Floor 103	1.00E-02	6.75	1.06245	-22.8	-24.22386	0.5	0.531225
Floor 104	1.00E-02	6.75	1.06245	-23.4	-24.86133	0.5	0.531225
Floor 105	1.00E-02	6.75	1.06245	-24	-25.4988	0.5	0.531225
Floor 106	1.00E-02	6.75	1.06245	-24.6	-26.13627	0.5	0.531225
Floor 107	1.00E-02	6.75	1.06245	-25.2	-26.77374	0.5	0.531225
Floor 108	1.00E-02	6.75	1.06245	-25.8	-27.41121	0.5	0.531225
Floor 109	1.00E-02	6.75	1.06245	-26.4	-28.04868	0.5	0.531225
Floor 110	1.00E-02	1.46	0.229804	-27	-6.204708	0.5	0.114902
Floor 111	1.30E-02	6.01	1.2297662	-27.6	-33.9415471	0.5	0.6148831
Floor	1.30E-	6.301	1.289310	-28.2	-	0.5	0.64465

112	02		62		36.3585595		531
Floor 113	1.30E-02	6.158	1.26004996	-28.8	-36.2894388	0.5	0.63002498
Floor 114	1.30E-02	5.99	1.2256738	-29.4	-36.0348097	0.5	0.6128369
Floor 115	1.30E-02	5.82	1.1908884	-30	-35.726652	0.5	0.5954442
Floor 116	1.30E-02	5.625	1.1509875	-30.6	-35.2202175	0.5	0.57549375
Floor 117	1.30E-02	1.67	0.3417154	-31.2	-10.6615205	0.5	0.1708577
Floor 118	1.30E-02	5	1.0231	-31.8	-32.53458	0.5	0.51155
Floor 119	1.30E-02	4.5	0.92079	-32.4	-29.833596	0.6	0.552474
Floor 120	1.30E-02	3.473	0.71064526	-33	-23.4512936	1	0.71064526
Floor 121	1.30E-02	3.049	0.62388638	-33.6	-20.9625824	1.7	1.06060685
Floor 122	1.30E-02	2.89	0.5913518	-34.2	-20.2242316	2.2	1.30097396
Floor 123	1.30E-02	1.763	0.36074506	-34.8	-12.5539281	3.7	1.33475672
Floor 124	1.30E-02	3.83	0.7836946	-35.4	-27.7427888	4.2	3.29151732
Floor 125	1.30E-02	0.8	0.163696	-36	-5.893056	5	0.81848
			129.579818		334.9325272	0.73780035	95.6040352
			LCG	2.58475844	aft		

Web Frame								
WF 1	0.0032	7.2	0.3626496	36.6	13.27297536	5.07	1.83863347
WF 2	0.0032	9.96	0.50166528	31.8	15.95295 59	2	1.00333056
WF 3	0.0032	10.9	0.5490112	29.4	16.14092928	1.8	0.98822016
WF 4	0.0032	10.95	0.5515296	27	14.8912992	1.6	0.88244736
WF 5	0.0032	11.5	0.579232	22.2	12.8589504	1.5	0.868848
WF 6	0.0032	11.5	0.579232	19.8	11.4687936	1.4	0.8109248
WF 7	0.0032	11.5	0.579232	17.4	10.0786368	1.4	0.8109248
WF 8	0.0032	11.5	0.579232	15	8.68848	1.4	0.8109248
WF 9	0.0032	11.5	0.579232	12.6	7.2983232	1.4	0.8109248
WF 10	0.0032	11.5	0.579232	10.2	5.9081664	1.4	0.8109248
WF 11	0.0032	11.5	0.579232	5.4	3.1278528	1.4	0.8109248
WF 12	0.0032	11.5	0.579232	3.6	2.0852352	1.4	0.8109248
WF 13	0.0032	11.5	0.579232	1.2	0.6950784	1.4	0.8109248
WF 14	0.0032	11.5	0.579232	-1.2	-0.6950784	1.4	0.8109248
WF 16	0.0032	11.5	0.579232	-6.6	-3.8229312	1.4	0.8109248
WF 17	0.0032	11.5	0.579232	-9	-5.213088	1.4	0.8109248
WF 18	0.0032	11.5	0.579232	-12	-6.950784	1.4	0.8109248
WF 19	0.0032	11.5	0.579232	-13.8	-7.9934016	1.4	0.8109248
WF 20	0.0032	11.08	0.55807744	-16.2	-9.04085453	1.4	0.78130842
WF 21	0.0032	10.5	0.528864	-18.6	-9.8368704	1.45	0.7668528
WF 22	0.0032	9.4	0.473459	-21	-	1.75	0.82855

			2		9.942643 2		36
WF 23	0.0032	7.6	0.382796 8	-23.4	- 8.957445 12	2	0.76559 36
WF 24	0.0032	6.25	0.3148	-25.8	-8.12184	2.2	0.69256
WF 25	0.0032	4.29	0.216078 72	-28.8	- 6.223067 14	2.5	0.54019 68
WF 26	0.0032	4.344	0.218798 59	-30.6	- 6.695236 92	2.7	0.59075 62
WF 27	0.0032	3.044	0.153320 19	-33	- 5.059566 34	2.8	0.42929 654
			13.4995 306		**31.82963 451**		**22.329 5447**
			LCG	**2.35783 268**	**VCG**	**1.65409 786**	
Main Frame							
Frame 1	1.60E- 03	3.6	9.07E-02	39	3.54E+00	7.231	6.56E- 01
Frame 2	1.60E- 03	3.9	9.82E-02	38.4	3.77E+00	6.915	6.79E- 01
Frame 3	1.60E- 03	4.3	1.08E-01	37.8	4.09E+00	6.4	6.93E- 01
Frame 4	1.60E- 03	5.2	1.31E-01	37.2	4.87E+00	6.251	8.19E- 01
Frame 5	1.60E- 03	6	1.51E-01	36	5.44E+00	5.892	8.90E- 01
Frame 6	1.60E- 03	7.82	1.97E-01	35.4	6.97E+00	5.743	1.13E+0 0

Frame 7	1.60E-03	4.5	1.13E-01	34.2	3.88E+00	5.525	6.26E-01
Frame 8	1.60E-03	6.02	1.52E-01	33.6	5.09E+00	5.405	8.19E-01
Frame 9	1.60E-03	6.02	1.52E-01	33	5.00E+00	5.405	8.19E-01
Frame 10	1.60E-03	7.79	1.96E-01	32.4	6.36E+00	4.767	9.35E-01
Frame 11	1.60E-03	8.005	2.02E-01	31.2	6.29E+00	4.619	9.31E-01
Frame 12	1.60E-03	8.052	2.03E-01	30.6	6.21E+00	4.514	9.15E-01
Frame 13	1.60E-03	8.279	2.08E-01	30	6.25E+00	4.541	9.47E-01
Frame 14	1.60E-03	8.116	2.04E-01	28.8	5.89E+00	4.507	9.21E-01
Frame 15	1.60E-03	8.283	2.09E-01	28.2	5.88E+00	4.414	9.21E-01
Frame 16	1.60E-03	8.352	2.10E-01	27.6	5.81E+00	4.414	9.28E-01
Frame 17	1.60E-03	8.462	2.13E-01	26.4	5.63E+00	4.414	9.41E-01
Frame 18	1.60E-03	8.503	2.14E-01	25.8	5.52E+00	4.414	9.45E-01
Frame 19	1.60E-03	9.134	2.30E-01	25.2	5.80E+00	4.414	1.02E+00
Frame 20	1.60E-03	9.197	2.32E-01	24	5.56E+00	4.414	1.02E+00
Frame 21	1.60E-03	11.5	2.90E-01	23.4	6.78E+00	4.414	1.28E+00
Frame 22	1.60E-03	11.5	2.90E-01	22.8	6.60E+00	4.116	1.19E+00
Frame 23	1.60E-03	11.5	2.90E-01	21.6	6.26E+00	3.831	1.11E+00
Frame 24	1.60E-03	11.5	2.90E-01	21	6.08E+00	3.327	9.64E-01
Frame 25	1.60E-03	11.5	2.90E-01	20.4	5.91E+00	1.3	3.77E-01
Frame 26	1.60E-03	11.5	2.90E-01	19.2	5.56E+00	1.3	3.77E-01
Frame 27	1.60E-03	11.5	2.90E-01	18.6	5.39E+00	1.3	3.77E-01
Frame 28	1.60E-03	11.5	2.90E-01	18	5.21E+00	1.3	3.77E-01
Frame 29	1.60E-03	11.5	2.90E-01	16.8	4.87E+00	1.3	3.77E-01
Frame 30	1.60E-03	11.5	2.90E-01	16.2	4.69E+00	1.3	3.77E-01
Frame	1.60E-	11.5	2.90E-01	15.6	4.52E+00	1.3	3.77E-

31	03						01
Frame 32	1.60E-03	11.5	2.90E-01	14.4	4.17E+00	1.3	3.77E-01
Frame 33	1.60E-03	11.5	2.90E-01	13.8	4.00E+00	1.3	3.77E-01
Frame 34	1.60E-03	11.5	2.90E-01	13.2	3.82E+00	1.3	3.77E-01
Frame 35	1.60E-03	11.5	2.90E-01	12	3.48E+00	1.3	3.77E-01
Frame 36	1.60E-03	11.5	2.90E-01	11.4	3.30E+00	1.3	3.77E-01
Frame 37	1.60E-03	11.5	2.90E-01	10.8	3.13E+00	1.3	3.77E-01
Frame 38	1.60E-03	11.5	2.90E-01	9.6	2.78E+00	1.3	3.77E-01
Frame 39	1.60E-03	11.5	2.90E-01	9.3	2.69E+00	1.3	3.77E-01
Frame 40	1.60E-03	11.5	2.90E-01	8.1	2.35E+00	1.3	3.77E-01
Frame 41	1.60E-03	11.5	2.90E-01	7.5	2.17E+00	1.3	3.77E-01
Frame 42	1.60E-03	11.5	2.90E-01	6.9	2.00E+00	1.3	3.77E-01
Frame 43	1.60E-03	11.5	2.90E-01	5.7	1.65E+00	1.3	3.77E-01
Frame 44	1.60E-03	11.5	2.90E-01	4.5	1.30E+00	1.3	3.77E-01
Frame 45	1.60E-03	11.5	2.90E-01	3.9	1.13E+00	1.3	3.77E-01
Frame 46	1.60E-03	11.5	2.90E-01	2.7	7.82E-01	1.3	3.77E-01
Frame 47	1.60E-03	11.5	2.90E-01	2.1	6.08E-01	1.3	3.77E-01
Frame 48	1.60E-03	11.5	2.90E-01	1.5	4.34E-01	1.3	3.77E-01
Frame 49	1.60E-03	11.5	2.90E-01	1.2	3.48E-01	1.3	3.77E-01
Frame 50	1.60E-03	11.5	2.90E-01	0.6	1.74E-01	1.3	3.77E-01
Frame 51	1.60E-03	11.5	2.90E-01	0	0.00E+00	1.3	3.77E-01
Frame 52	1.60E-03	11.5	2.90E-01	-0.6	-1.74E-01	1.3	3.77E-01
Frame 53	1.60E-03	11.5	2.90E-01	-1.8	-5.21E-01	1.3	3.77E-01
Frame 54	1.60E-03	11.5	2.90E-01	-2.4	-6.95E-01	1.3	3.77E-01
Frame 55	1.60E-03	11.5	2.90E-01	-3	-8.69E-01	1.3	3.77E-01

Frame 56	1.60E-03	11.5	2.90E-01	-4.2	-1.22E+00	1.3	3.77E-01
Frame 57	1.60E-03	11.5	2.90E-01	-4.8	-1.39E+00	1.3	3.77E-01
Frame 58	1.60E-03	11.5	2.90E-01	-5.4	-1.56E+00	1.3	3.77E-01
Frame 59	1.60E-03	11.5	2.90E-01	-6.6	-1.91E+00	1.3	3.77E-01
Frame 60	1.60E-03	11.5	2.90E-01	-7.4	-2.1431584	1.3	3.77E-01
Frame 61	1.60E-03	11.5	2.90E-01	-8	-2.316928	1.3	3.77E-01
Frame 62	1.60E-03	11.5	2.90E-01	-9.2	-2.6644672	1.3	3.77E-01
Frame 63	1.60E-03	11.5	2.90E-01	-9.8	-2.8382368	1.3	3.77E-01
Frame 64	1.60E-03	11.5	2.90E-01	-11	-3.185776	1.3	3.77E-01
Frame 65	1.60E-03	11.5	2.90E-01	-11.6	-3.3595456	1.3	3.77E-01
Frame 66	1.60E-03	11.5	2.90E-01	-12.2	-3.5333152	1.3	3.77E-01
Frame 67	1.60E-03	11.5	2.90E-01	-13.4	-3.8808544	1.3	3.77E-01
Frame 68	1.60E-03	11.5	2.90E-01	-14	-4.054624	1.3	3.77E-01
frame 69	1.60E-03	11.5	2.90E-01	-14.6	-4.2283936	1.3	3.77E-01
frame 70	1.60E-03	11.5	2.90E-01	-15.8	-4.5759328	1.3	3.77E-01
frame 71	1.60E-03	11.5	2.90E-01	-17	-4.923472	1.3	3.77E-01
frame72	1.60E-03	11.5	2.90E-01	-17.6	-5.0972416	1.3	3.77E-01
Frame 73	1.60E-03	11.5	2.90E-01	-18.2	-5.2710112	1.3	3.77E-01
frame 74	1.60E-03	11.5	2.90E-01	-19.4	-5.6185504	1.3	3.77E-01

frame 75	1.60E-03	11.1	2.80E-01	-20.6	-5.75857344	1.3	3.63E-01
frame 76	1.60E-03	11.1	2.80E-01	-21.2	-5.92629888	1.3	3.63E-01
frame 77	1.60E-03	11	2.77E-01	-21.8	-6.0391232	1.3	3.60E-01
frame 78	1.60E-03	10.95	2.76E-01	-23	-6.3425904	1.3	3.58E-01
frame 79	1.60E-03	10.8	2.72E-01	-23.6	-6.41889792	1.3	3.54E-01
frame 80	1.60E-03	10.85	2.73E-01	-24.2	-6.61256288	1.3	3.55E-01
frame 81	1.60E-03	10.82	2.72E-01	-25.4	-6.92126835	1.3	3.54E-01
frame 82	1.60E-03	10.81	2.72E-01	-26	-7.07821504	1.3	3.54E-01
frame 83	1.60E-03	10.8	2.72E-01	-26.6	-7.23485952	1.35	3.67E-01
frame 84	1.60E-03	10.7	2.69E-01	-27.8	-7.49123264	1.4	3.77E-01
frame 85	1.60E-03	10.6	2.67E-01	-28.4	-7.58139136	1.45	3.87E-01
frame 86	1.60E-03	9.95	2.51E-01	-29	-7.2668432	1.47	3.68E-01
frame 87	1.60E-03	9.8	2.47E-01	-29.6	-7.30537472	1.8	4.44E-01
frame 88	1.60E-03	9.6	2.42E-01	-30.8	-7.44640512	1.85	4.47E-01
frame 89	1.60E-03	9.46	2.38E-01	-31.4	-7.4807561	1.95	4.65E-01
frame 90	1.60E-03	8.6	2.17E-01	-32	-6.9306368	2.02	4.37E-01
frame	1.60E-	8.3	2.09E-01	-33.2	-	2.4	5.02E-

91	03				6.939703 04		01
frame 92	1.60E-03	8	2.01E-01	-33.8	-6.809753 6	2.5	5.04E-01
frame 93	1.60E-03	7.65	1.93E-01	-34.4	-6.627421 44	2.6	5.01E-01
frame 94	1.60E-03	4.2	1.06E-01	-35.6	-3.765511 68	2.74	2.90E-01
frame 95	1.60E-03	3.5	8.81E-02	**-36.20**	-3.190812 8	4.20	3.70E-01
frame 96	1.60E-03	2.2	5.54E-02	**-36.80**	-2.038896 64	5.00	2.77E-01
frame 97	1.60E-03	2	5.04E-02	-37.4	-1.883763 2	5.57	2.81E-01
		total weight	24.26032 64		2.90		49.80
			LCG	.1194	VCG	2.05	

Steel weight

ITEM		Dimension	Area (m^2)	Thickness (m) or Total Length (m)	Volume (m^3)	Density (t/m^3)	Weight (ton)	Total Weight (ton)	LCG (m)	Moment (t-m) (about midship)	VCG (m)	Moment (t-m) (about keel)
Keel			100	0.0140	1.4000	7.87	11.0180	11.0180	-1.5	-16.5270	0.95	10.4671
Bottom			465	0.0120	5.5800	7.87	43.9146	43.9146	-2.5	-109.7865	1.08	47.4278
Bilge			380	0.0140	5.3200	7.87	41.8684	41.8684	-3.2	-133.9789	2.89	120.9997
Side Shell			520	0.0100	5.2000	7.87	40.9240	40.9240	-1.1	-45.0164	3.3	135.0492
Sheer Strake			185	0.0100	1.8500	7.87	14.5595	14.5595	-1.2	-17.4714	4.65	67.7017
Deck Plate (Strength Deck)			992.0000	0.0100	9.9200	7.87	78.0704	78.0704	-3.2	-249.8253	8.64	674.5283
Poop Deck Plate			118.7250	0.0070	0.8311	7.87	6.5406	6.5406	-32.5	-212.5682	9.3	60.8272
F'Castle Deck Plate			98.4000	0.0070	0.6888	7.87	5.4209	5.4209	32.4	175.6357	7.354	39.8650
Main Frame		L-100×50×7					24.3000	24.3000	-0.2	-4.8600	2.05	49.8150
Side Web Frame		T-270x130x8					13.5000	13.5000	-2.36	-31.8600	2.65	35.7750
Side Stringer		T-270x130x8	0.0256	73.8000	1.8893	7.87	14.8686	14.8686	-2.2	-32.7110	3.3	49.0665
Center Girder		T-750x540x12	0.0155	73.8000	1.1439	7.87	9.0025	9.0025	-0.5	-4.5012	0.88	7.9222
Side Girder		T-750x180x11	0.0490	73.8000	3.6162	7.87	28.4595	28.4595	-1.5	-42.6892	0.83	23.6214
Deck Center Girder		T-200x150x6	0.0020	73.8000	0.1476	7.87	1.1616	1.1616	-1.2	-1.3939	5.15	5.9823
Deck Side Girder		T-200x150x6	0.0120	73.8000	0.8856	7.87	6.9697	6.9697	-1.2	-8.3636	5.15	35.8938
Floors		T-750×180×11				7.87	129.5600	129.5600	-2.59	-335.5604	0.74	95.8744
Deck Web		T-270x130x8	0.0864	13.7000	1.1837	7.87	9.3156	9.3156	-2.36	-21.9847	5.25	48.9067
deck beam		L-100x65x7	0.1200	13.7000	1.6440	7.87	12.9383	12.9383	-0.2	-2.5877	5.25	67.9260
Machinery Space												0.0000
												0.0000
Deck Plate			42.0000	0.0080	0.3360	7.87	2.6443	2.6443	-17.947	-47.4576	5.516	14.5861
Deck Center Girder		T-200x150x6	0.0058	47.1500	0.2743	7.87	2.1587	2.1587	-20.257	-43.7288	5.516	11.9074
Deck Side Girder		T-200x150x6	0.0058	14.3000	0.0832	7.87	0.6547	0.6547	-20.257	-13.2624	5.516	3.6114
Deck Web		T-270x130x8	0.0864	13.7000	1.1837	7.87	9.3156	9.3156	-22.5	-209.6001	5.516	51.3846

	ITEM	Dimension	Area (m^2)	Thickness (m) or Total Length (m)	Volume (m^3)	Density (t/m^3)	Weight (ton)	Total Weight (ton)	LCG (m)	Moment (t-m) (about midship)	VCG (m)
	Machinery Space										
26	Deck Plate		42.0000	0.0080	0.3360	7.87	2.6443	2.6443	-17.947	-47.4576	5.516
28	Deck Center Girder	T-200x150x6	0.0058	47.1500	0.2743	7.87	2.1587	2.1587	-20.257	-43.7288	5.516
29	Deck Side Girder	T-200x150x6	0.0058	14.3000	0.0832	7.87	0.6547	0.6547	-20.257	-13.2624	5.516
30	Deck Web	T-270x130x8	0.0864	13.7000	1.1837	7.87	9.3156	9.3156	-22.5	-209.6001	5.516
31	Deck Beam	L-100x65x7	0.1200	13.7000	1.6440	7.87	12.9383	12.9383	-21.98	-284.3834	5.516
32	Foundation girder						4.5000	4.5000	-28.2	-126.9000	1.138
33	Side web	T-330x120x10	0.0180	10.0000	0.1800	7.87	1.4166	1.4166	-27.3	-38.6732	1.9
34											
35											
	superstructure										
	superstructure side plate		250.0000	0.0070	1.7500	7.87	13.7725	13.7725	-30.1	-414.5523	11.8
	Poop side Plate		126.6000	0.0070	0.8862	7.87	6.9744	6.9744	-32.5	-226.6678	7.32
	F'Castle side Plate		57.8199	0.0070	0.4047	7.87	3.1853	3.1853	33.04	105.2423	9.34
	Navigation deck plate		132.2830	0.0070	0.9260	7.87	7.2875	7.2875	-32.8	-239.0290	12.13
	Navigation Side plate		0.0007	15.4895	0.0101	7.87	0.0794	2.6982	-31.8	-85.8023	16.3
	Frame	L-75x55x7	0.0010				2.3800	2.3800	-27.8900	-66.3782	11.6700
	railing and staires		155.6000	0.0045	0.7002	7.87	5.5106	5.5106	-2.2	-12.1233	5.3

ITEM		Dimension	Area (m^2)	Thickness (m) or Total Length (m)	Volume (m^3)	Density (t/m^3)	Weight (ton)	Total Weight (ton)	LCG (m)	Moment (t-m) (about midship)	VCG (m)	Moment (t-m) (about keel)
Bulkhead												0.0000
												0.0000
BHD 1												0.0000
Plate			106.8600	0.0070	0.7480	7.87	5.8869	5.8869	-35.13	-206.8074	5.94	34.9683
Vertical Stiffener		L-90x60x6	0.0011	5.0240	0.7600	7.87	5.9812	5.9812	-35.13	-210.1196	5.9	35.2891
Transverse Stiffener		L-75x50x9	0.0028	16.5000	0.6200	7.87	4.8794	4.8794	-35.13	-171.4133	5.95	29.0324
												0.0000
												0.0000
BHD 2												0.0000
Plate			159.0000	0.0070	1.1130	7.87	8.7593	8.7593	-24.6	-215.4790	2.63	23.0370
Vertical Stiffener		L-90x60x6	0.0011	8.1320	0.1480	7.87	1.1644	1.1644	-24.6	-28.6454	2.6	3.0276
Transverse Stiffener		L-75x50x9	0.0028	18.5000	0.1220	7.87	0.9601	0.9601	-24.6	-23.6194	2.65	2.5444
								0.0000	-17.224	0.0000	3.144	0.0000
						7.87						0.0000
BHD 3						7.87						0.0000
Plate			159.0000	0.0070	1.1130	7.87	8.7593	8.7593	-7.2	-63.0670	2.63	23.0370
Vertical Stiffener		L-90x60x6	0.0011	8.1320	0.1480	7.87	1.1644	1.1644	-7.2	-8.3840	2.6	3.0276
Transverse Stiffener		L-75x50x9	0.0028	18.5000	0.1220	7.87	0.9601	0.9601	-7.2	-6.9130	2.65	2.5444
									-2.934	0.0000	3.248	0.0000
												0.0000
												0.0000
												0.0000
BHD 4												0.0000
Plate			159.0000	0.0070	1.1130	7.87	8.7593	8.7593	10.2	89.3450	2.63	23.0370

ITEM		Dimension	Area (m^2)	Thickness (m) or Total Length (m)	Volume (m^3)	Density (t/m^3)	Weight (ton)	Total Weight (ton)	LCG (m)	Moment (t-m) (about midship)	VCG (m)
BHD 4											
Plate			159.0000	0.0070	1.1130	7.87	8.7593	8.7593	10.2	89.3450	2.63
Vertical Stiffener		L-90x60x6	0.0011	8.1320	0.1480	7.87	1.1644	1.1644	10.2	11.8773	2.65
Transverse Stiffener		L-75x50x9	0.0028	18.5000	0.1220	7.87	0.9601	0.9601	10.2	9.7934	2.65
BHD 5											
Plate			159.0000	0.0070	1.1130	7.87	8.7593	8.7593	33.6	294.3128	2.7
Vertical Stiffener		L-90x60x6	0.0011	8.1320	0.1480	7.87	1.1644	1.1644	33.6	39.1254	2.7
Transverse Stiffener		L-75x50x9	0.0028	18.5000	0.1220	7.87	0.9601	0.9601	33.6	32.2607	2.75
										-2658.6671	
				Steel Weight			600.4002				
				LCG (about amidship)			-4.4282				
				VCG (about Keel)			3.7188				

Machinery weight

	Items	Quantity	Unit weight (tonne)	Total weight (tonnes)	LCG (m)	Moment (about amidship)	VCG (m)	Moment (abou keel)
1	Main Engine	1.0	10.0	10.0	-27.6	-276.0	1.9	18
2	Gear Box	1.0	2.4	2.4	-28.6	-68.6	1.9	4
11	Rudder & Steering Arrangement		5.3	5.3	-36.6	-194.0	6.0	31
12	Anchor, Chain, Bollard, Capstan and other fittings		9.2	9.2	30.6	281.5	7.9	72
13	Propeller, Propeller Shaft		2.1	2.1	-36.0	-75.6	1.2	2
				31.4		**-402.9**		**134**

Total Machinery Weight	31.4
LCG (about amidship)	-12.82240611
VCG (about Keel)	4.276034373

Wood and outfit weight

A	B	C	D	E	F	G	H	I	J
		No. of items	unit weight(kg)	total weight(kg)	total weight (tons)	L.C.G	Moment	V.C.G.	Moment
	chair	8	15	120	0.12	-25.2	-3.024	5.3	0.636
sailor(8)	locker	8	30	240	0.24	-25.1	-6.024	5.4	1.296
	single bed	8	35	280	0.28	-25.2	-7.056	5.3	1.484
					0		0		0
	chair	3	15	45	0.045	-26.1	-1.1745	5.35	0.24075
Greaser(3)	locker	3	30	90	0.09	-26.1	-2.349	5.5	0.495
	single bed	3	35	105	0.105	-26.1	-2.7405	5.32	0.5586
					0		0		0
					0		0		0
	chair	1	15	15	0.015	-19.20	-0.288	8.00	0.12
	table	1	25	25	0.025	-19.30	-0.4825	8.10	0.2025
1st class master	bed	1	35	35	0.035	-19.30	-0.6755	8.00	0.28
	sofa	1	30	30	0.03	-19.30	-0.579	8.00	0.24
	wash room items			40	0.04	-19.40	-0.776	8.00	0.32
	wardrobe	1	35	35	0.035	-19.40	-0.679	8.10	0.2835
					0		0		0
					0		0		0
	chair	1	15	15	0.015	-20.20	-0.303	8.00	0.12
	table	1	25	25	0.025	-20.30	-0.5075	8.10	0.2025
	bed	1	30	30	0.03	-20.40	-0.612	8.00	0.24
2nd class master	sofa	1	30	30	0.03	-20.40	-0.612	8.00	0.24
	wash room		[illegible]	[illegible]	[illegible]		[illegible]		[illegible]

37						0		0		0
38		chair	1		15	0.015	-25.2	-0.378	8.3	0.1245
39		locker	1		35	0.035	-25.1	-0.8785	8.9	0.3115
40	2nd class driver	single bed	1		30	0.03	-25.3	-0.759	8.4	0.252
41		wash room items	1		25	0.025	-25.4	-0.635	8.4	0.21
42		table	1		20	0.02	-26.2	-0.524	8.5	0.17
43						0		0		0
44						0		0		0
45		chair	11	15	165	0.165	-21.30	-3.5145	5.3	0.8745
46	crew mess	table	1	50	50	0.05	-21.4	-1.07	5.4	0.27
47		other items			30	0.03	-21.5	-0.645	5.28	0.1584
48						0		0		0
49						0		0		0
50						0		0		0
51		chair	5	15	75	0.075	-22.4	-1.68	8.45	0.63375
52	officer's mess	table	1		40	0.04	-22.6	-0.904	8.5	0.34
53		other items			30	0.03	-22.3	-0.669	8.6	0.258
54						0		0		0
55						0		0		0
56	Store - 1	Cabinet	1	50.00	50.00	0.05	-27.00	-1.35	8.10	0.405
57	Deck Store	Cabinet	2	50.00	50.00	0.05	-27.00	-1.35	8.20	0.41
58	Engine Office	Table	2	40.00	40.00	0.04	-20.34	-0.8136	8.50	0.34
59	Engine Controll Room	Controll Room Electronic	1	100.00	100.00	0.1	-20.50	-2.05	8.20	0.82

67		Map Table	1		18.00	0.018	-20.50	-0.369	9.05	0.1629
68		Map Table- Chair	1		15.00	0.015	-20.50	-0.3075	9.10	0.1365
69		Control Panel- Chair	2		15.00	0.015	-21.00	-0.315	9.10	0.1365
70		Radio Instrument Table	1		30.00	0.03	-21.00	-0.63	9.10	0.273
71		Radio Operator's Chair	1		20.00	0.02	-21.00	-0.42	9.40	0.188
72		Sofa	2		30.00	0.03	-22.00	-0.66	9.10	0.273
73		Wash cabin item	2		20.00	0.02	-23.00	-0.46	9.20	0.184
74										
75										
76										
77						2.345		-54.4284		16.3171
78										
79										
80										
81						**Total weight(tons)**	2.345			
82										
83										
84						**L.C.G(m)**	-23.2104			
85										
86										
87						**V.C.G.(m)**	6.958252			
88										
89										

	ITEM	WEIGHT (ton)	LCG (m)	**Moment** (about amidship)	VCG (m)	**Moment** (about keel)
1	Steel Weight	600.40	-4.43	-2658.67	3.72	2232.75
2	W&O Weight	2.35	-23.21	-54.43	6.96	16.32
3	Machinery Weight	31.42	-12.82	-402.88	4.28	134.35
Total Lightship Weight		**634.17**	**-4.91**	-3115.98	**3.76**	2383.42

CONDITION 1: LIGHTSHIP CONDITION

ITEM NO.	ITEM NAME	WEIGHT (ton)	LCG (m)	**Moment** (about amidship)	VCG (m)	**Moment** (about keel)
1	Light Ship	634.17	-4.91	-3115.98	3.76	2383.42
Total Weight		**634.17**	**-4.91**	-3115.98	**3.76**	2383.42

CONDITION 2: FULLY LOADED (DEPARTURE CONDITION)

ITEM NO.	ITEM NAME	WEIGHT (ton)	LCG (m)	**Moment** (about amidship)	VCG (m)	**Moment** (about keel)
1	Light Ship	634.17	-4.91	-3115.98	3.76	2383.42
2	Crew Effect (15 persons)	1.12	-21.00	-23.52	5.25	5.88
3	Reserved Fuel Oil	2.5	-22.50	-56.25	3.50	8.75

CONDITION 2: FULLY LOADED (DEPARTURE CONDITION)						
ITEM NO.	ITEM NAME	**WEIGHT (ton)**	**LCG (m)**	**Moment** (about amidship)	**VCG (m)**	**Moment** (about keel)
1	Light Ship	634.17	-4.91	-3115.98	3.76	2383.42
2	Crew Effect (15 persons)	1.12	-21.00	-23.52	5.25	5.88
3	Reserved Fuel Oil	2.5	-22.50	-56.25	3.50	8.75
4	Service Fuel Oil (Engine)	6	-22.50	-135.00	3.50	21.00
5	Service Fuel Oil (Generator)	2	-22.50	-45.00	3.60	7.20
7	Reserved Fresh Water	2	21.00	42.00	3.60	7.20
8	Service Fresh Water	4	21.00	84.00	3.90	15.60
9	Cargo Hold 1	872	-16.20	-14126.40	2.81	2450.32
10	Cargo Hold 2	890	1.12	996.80	2.81	2500.90
11	Cargo Hold 3	732	18.00	13176.00	2.81	2056.92
Total Weight		**3145.79**	**-1.02**	-3203.35	**3.01**	9457.19

CONDITION 2: FULLY LOADED (ARRIVAL CONDITION)						
ITEM NO.	ITEM NAME	**WEIGHT (ton)**	**LCG (m)**	**Moment** (about amidship)	**VCG (m)**	**Moment** (about keel)
1	Light Ship	634.17	-4.91	-3115.98	3.76	2383.42
2	Crew Effect (15 persons)	1.12	-28.57	-32.00	5.25	5.88
3	Reserved Fuel Oil	0.25	-35.75	-8.94	3.50	0.88
4	Service Fuel Oil (Engine)	6	-25.75	-154.50	3.50	21.00
5	Service Fuel Oil (Generator)	2	-25.75	-51.50	3.60	7.20
7	Reserved Fresh Water	0.2	21.00	4.20	3.60	0.72
8	Service Fresh Water	4	21.00	84.00	3.90	15.60
9	Cargo Hold 1	872	-16.20	-14126.40	2.81	2450.32
10	Cargo Hold 2	890	1.12	996.80	2.81	2500.90
11	Cargo Hold 3	732	18.00	13176.00	2.81	2056.92
Total Weight		**3141.74**	**-1.03**	-3228.31	**3.01**	9442.83

CONDITION 2: BALLAST CONDITION (DEPARTURE CONDITION)						
ITEM NO.	ITEM NAME	**WEIGHT (ton)**	**LCG (m)**	**Moment** (about amidship)	**VCG (m)**	**Moment** (about keel)
1	Light Ship	634.17	-4.91	-3115.98	3.76	2383.42
2	Crew Effect (15 persons)	1.12	-21.00	-23.52	5.25	5.88
3	Reserved Fuel Oil	2.5	-22.50	-56.25	3.50	8.75
4	Service Fuel Oil (Engine)	6	-22.50	-135.00	3.50	21.00
5	Service Fuel Oil (Generator)	2	-22.50	-45.00	3.60	7.20
7	Reserved Fresh Water	2	21.00	42.00	3.60	7.20
8	ballast water	90	-35.20	-3168.00	3.23	290.70
8	Service Fresh Water	4	21.00	84.00	4.00	16.00
Total Weight		**741.79**	**-8.65**	-6417.75	**3.69**	2740.15

CONDITION 2: BALLAST CONDITION (ARRIVAL CONDITION)						
ITEM NO.	ITEM NAME	**WEIGHT (ton)**	**LCG (m)**	**Moment** (about amidship)	**VCG (m)**	**Moment** (about keel)
1	Light Ship	634.17	-4.91	-3115.98	3.76	2383.42
2	Crew Effect (15 persons)	1.12	-21.00	-23.52	4.50	5.04
3	Reserved Fuel Oil	0.25	-22.50	-5.63	3.50	0.88
4	Service Fuel Oil (Engine)	6	-22.50	-135.00	3.50	21.00
5	Service Fuel Oil (Generator)	2	-22.50	-45.00	3.60	7.20
7	Reserved Fresh Water	0.15	21.00	3.15	3.60	0.54
8	Service Fresh Water	4	21.00	84.00	4.00	16.00
9	ballast water	90	-35.20	-3168.00	3.23	290.70
Total Weight		**737.69**	**-8.68**	-6405.97	**3.69**	2724.77

Stability calculation

WATER SECTION INCLINED AT 0°

Immersed Wedge

No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	0.00	1	0.00	0.00	0.00	0.00	0.00
1	0.00	4	0.00	0.00	0.00	0.00	0.00
2	2.78	2	5.56	7.72	15.45	21.47	42.93
3	4.05	4	16.21	16.43	65.71	66.58	266.31
4	4.63	2	9.26	21.46	42.91	99.38	198.76
5	5.33	4	21.31	28.37	113.50	151.15	604.59
6	5.44	2	10.89	29.62	59.24	161.22	322.44
7	5.44	4	21.77	29.62	118.49	161.22	644.88
8	5.44	2	10.89	29.62	59.24	161.22	322.44
9	5.44	4	21.77	29.62	118.49	161.22	644.88
10	5.44	2	10.89	29.62	59.24	161.22	322.44
11	5.44	4	21.77	29.62	118.49	161.22	644.88
12	5.44	2	10.89	29.62	59.24	161.22	322.44
13	5.44	4	21.77	29.62	118.49	161.22	644.88
14	5.44	2	10.89	29.62	59.24	161.22	322.44
15	5.10	4	20.38	25.96	103.84	132.28	529.11
16	4.86	2	9.73	23.65	47.31	115.05	230.09
17	3.82	4	15.29	14.60	58.41	55.80	223.22
18	2.90	2	5.79	8.38	16.76	24.26	48.53
19	1.74	4	6.95	3.02	12.07	5.24	20.96
20	0.46	1	0.46	0.21	0.21	0.10	0.10
		$\Sigma_1=$	252.44	$\Sigma_3=$	1246.35	$\Sigma_5=$	6356.32

WATER SECTION INCLINED AT 10°

Immersed Wedge

No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	0	1	0	0	0	0	0
0.5	0	4	0	0	0	0	0
1	3.5898	2	7.1796	12.886664	25.7733281	46.2605466	92.5210931
1.5	4.9794	4	19.9176	24.7944244	99.1776974	123.461357	493.845427
2	5.4426	2	10.8852	29.6218948	59.2437895	161.220124	322.440249
3	5.4426	4	21.7704	29.6218948	118.487579	161.220124	644.880498
4	5.5584	2	11.1168	30.8958106	61.7916211	171.731273	343.462547
5	5.5584	4	22.2336	30.8958106	123.583242	171.731273	686.925094
6	5.5584	2	11.1168	30.8958106	61.7916211	171.731273	343.462547
7	5.5584	4	22.2336	30.8958106	123.583242	171.731273	686.925094
8	5.5584	2	11.1168	30.8958106	61.7916211	171.731273	343.462547
8.5	5.5584	4	22.2336	30.8958106	123.583242	171.731273	686.925094
9	5.5584	2	11.1168	30.8958106	61.7916211	171.731273	343.462547
9.5	5.5584	4	22.2336	30.8958106	123.583242	171.731273	686.925094
10	5.5584	2	11.1168	30.8958106	61.7916211	171.731273	343.462547
		$\Sigma_1=$	204.2712	$\Sigma_3=$	1105.97347	$\Sigma_5=$	6018.70038

WATER SECTION INCLINED AT 20°

Immersed Wedge

No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	0	1	0	0	0	0	0
0.5	2.316	4	9.264	5.363856	21.455424	12.4226905	49.690762
1	4.9794	2	9.9588	24.7944244	49.5888487	123.461357	246.922713
1.5	5.6742	4	22.6968	32.1965456	128.786183	182.689639	730.758557
2	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
3	5.5584	4	22.2336	30.8958106	123.583242	171.731273	686.925094
4	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
5	5.6742	4	22.6968	32.1965456	128.786183	182.689639	730.758557
6	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
7	5.6742	4	22.6968	32.1965456	128.786183	182.689639	730.758557
8	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
8.5	5.6742	4	22.6968	32.1965456	128.786183	182.689639	730.758557
9	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
9.5	5.6742	4	22.6968	32.1965456	128.786183	182.689639	730.758557
10	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
		$\Sigma_1=$	223.0308	$\Sigma_3=$	1224.91698	$\Sigma_5=$	6829.60703

WATER SECTION INCLINED AT 30°

Immersed Wedge

No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	0	1	0	0	0	0	0
0.5	4.8636	4	19.4544	23.654605	94.6184198	115.046537	460.186147
1	6.1374	2	12.2748	37.6676788	75.3353575	231.181612	462.363223
1.5	6.2532	4	25.0128	39.1025102	156.410041	244.515817	978.063268
2	6.2532	2	12.5064	39.1025102	78.2050205	244.515817	489.031634
3	6.1374	4	24.5496	37.6676788	150.670715	231.181612	924.726446
4	6.2532	2	12.5064	39.1025102	78.2050205	244.515817	489.031634
5	6.2532	4	25.0128	39.1025102	156.410041	244.515817	978.063268
6	6.2532	2	12.5064	39.1025102	78.2050205	244.515817	489.031634
7	6.2532	4	25.0128	39.1025102	156.410041	244.515817	978.063268
8	6.2532	2	12.5064	39.1025102	78.2050205	244.515817	489.031634
8.5	6.2532	4	25.0128	39.1025102	156.410041	244.515817	978.063268
9	6.2532	2	12.5064	39.1025102	78.2050205	244.515817	489.031634
9.5	6.2532	4	25.0128	39.1025102	156.410041	244.515817	978.063268
10	6.2532	2	12.5064	39.1025102	78.2050205	244.515817	489.031634
		$\Sigma_1=$	256.3812	$\Sigma_3=$	1571.90482	$\Sigma_5=$	9671.78196

WATER SECTION INCLINED AT 40°

Immersed Wedge

No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	0	1	0	0	0	0	0
0.5	6.6006	4	26.4024	43.5679204	174.271681	287.574415	1150.29766
1	7.0638	2	14.1276	49.8972704	99.7945409	352.464339	704.928678
1.5	6.948	4	27.792	48.274704	193.098816	335.412643	1341.65057
2	6.948	2	13.896	48.274704	96.549408	335.412643	670.825287
3	6.948	4	27.792	48.274704	193.098816	335.412643	1341.65057
4	7.0638	2	14.1276	49.8972704	99.7945409	352.464339	704.928678
5	7.0638	4	28.2552	49.8972704	199.589082	352.464339	1409.85736
6	7.0638	2	14.1276	49.8972704	99.7945409	352.464339	704.928678
7	7.0638	4	28.2552	49.8972704	199.589082	352.464339	1409.85736
8	7.0638	2	14.1276	49.8972704	99.7945409	352.464339	704.928678
8.5	7.0638	4	28.2552	49.8972704	199.589082	352.464339	1409.85736
9	7.0638	2	14.1276	49.8972704	99.7945409	352.464339	704.928678
9.5	7.0638	4	28.2552	49.8972704	199.589082	352.464339	1409.85736
10	7.0638	2	14.1276	49.8972704	99.7945409	352.464339	704.928678
		$\Sigma_1=$	293.6688	$\Sigma_3=$	2054.14229	$\Sigma_5=$	14373.4256

WATER SECTION INCLINED AT 50°

Immersed Wedge

No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	4.4004	1	4.4004	19.3635202	19.3635202	85.2072341	85.2072341
0.5	7.2954	4	29.1816	53.2228612	212.891445	388.282061	1553.12825
1	7.2954	2	14.5908	53.2228612	106.445722	388.282061	776.564123
1.5	7.1796	4	28.7184	51.5466562	206.186625	370.084373	1480.33749
2	7.4112	2	14.8224	54.9258854	109.851771	407.066722	814.133444
3	7.2954	4	29.1816	53.2228612	212.891445	388.282061	1553.12825
4	7.4112	2	14.8224	54.9258854	109.851771	407.066722	814.133444
5	7.4112	4	29.6448	54.9258854	219.703542	407.066722	1628.26689
6	7.4112	2	14.8224	54.9258854	109.851771	407.066722	814.133444
7	7.4112	4	29.6448	54.9258854	219.703542	407.066722	1628.26689
8	7.4112	2	14.8224	54.9258854	109.851771	407.066722	814.133444
8.5	7.4112	4	29.6448	54.9258854	219.703542	407.066722	1628.26689
9	7.4112	2	14.8224	54.9258854	109.851771	407.066722	814.133444
9.5	7.4112	4	29.6448	54.9258854	219.703542	407.066722	1628.26689
10	7.4112	2	14.8224	54.9258854	109.851771	407.066722	814.133444
		$\Sigma_1=$	313.5864	$\Sigma_3=$	2295.70355	$\Sigma_5=$	16846.2336

WATER SECTION INCLINED AT 60°

Immersed Wedge

No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	4.4004	1	4.4004	19.3635202	19.3635202	85.2072341	85.2072341
0.5	6.369	4	25.476	40.564161	162.256644	258.353141	1033.41257
1	6.4848	2	12.9696	42.052631	84.1052621	272.702902	545.405804
1.5	6.369	4	25.476	40.564161	162.256644	258.353141	1033.41257
2	6.6006	2	13.2012	43.5679204	87.1358407	287.574415	575.14883
3	6.6006	4	26.4024	43.5679204	174.271681	287.574415	1150.29766
4	6.6006	2	13.2012	43.5679204	87.1358407	287.574415	575.14883
5	6.6006	4	26.4024	43.5679204	174.271681	287.574415	1150.29766
6	6.6006	2	13.2012	43.5679204	87.1358407	287.574415	575.14883
7	6.6006	4	26.4024	43.5679204	174.271681	287.574415	1150.29766
8	6.6006	2	13.2012	43.5679204	87.1358407	287.574415	575.14883
8.5	6.6006	4	26.4024	43.5679204	174.271681	287.574415	1150.29766
9	6.6006	2	13.2012	43.5679204	87.1358407	287.574415	575.14883
9.5	6.6006	4	26.4024	43.5679204	174.271681	287.574415	1150.29766
10	6.6006	2	13.2012	43.5679204	87.1358407	287.574415	575.14883
		$\Sigma_1=$	279.5412	$\Sigma_3=$	1822.15552	$\Sigma_5=$	11899.8195

WATER SECTION INCLINED AT 70°

Immersed Wedge

No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	5.9058	1	5.9058	34.8784736	34.8784736	205.98529	205.98529
0.5	6.0216	4	24.0864	36.2596666	145.038666	218.341208	873.364833
1	5.9058	2	11.8116	34.8784736	69.7569473	205.98529	411.970579
1.5	6.0216	4	24.0864	36.2596666	145.038666	218.341208	873.364833
2	6.1374	2	12.2748	37.6676788	75.3353575	231.181612	462.363223
3	6.1374	4	24.5496	37.6676788	150.670715	231.181612	924.726446
4	6.1374	2	12.2748	37.6676788	75.3353575	231.181612	462.363223
5	6.1374	4	24.5496	37.6676788	150.670715	231.181612	924.726446
6	6.1374	2	12.2748	37.6676788	75.3353575	231.181612	462.363223
7	6.1374	4	24.5496	37.6676788	150.670715	231.181612	924.726446
8	6.1374	2	12.2748	37.6676788	75.3353575	231.181612	462.363223
8.5	6.1374	4	24.5496	37.6676788	150.670715	231.181612	924.726446
9	6.1374	2	12.2748	37.6676788	75.3353575	231.181612	462.363223
9.5	6.1374	4	24.5496	37.6676788	150.670715	231.181612	924.726446
10	6.1374	2	12.2748	37.6676788	75.3353575	231.181612	462.363223
		$\Sigma_1=$	262.287	$\Sigma_3=$	1600.07847	$\Sigma_5=$	9762.49711

WATER SECTION INCLINED AT 80°

Immersed Wedge

No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	4.053	1	4.053	16.426809	16.426809	66.5778569	66.5778569
0.5	5.6742	4	22.6968	32.1965456	128.786183	182.689639	730.758557
1	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
1.5	5.6742	4	22.6968	32.1965456	128.786183	182.689639	730.758557
2	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
3	5.6742	4	22.6968	32.1965456	128.786183	182.689639	730.758557
4	5.79	2	11.58	33.5241	67.0482	194.104539	388.209078
5	5.79	4	23.16	33.5241	134.0964	194.104539	776.418156
6	5.79	2	11.58	33.5241	67.0482	194.104539	388.209078
7	5.79	4	23.16	33.5241	134.0964	194.104539	776.418156
8	5.79	2	11.58	33.5241	67.0482	194.104539	388.209078
8.5	5.79	4	23.16	33.5241	134.0964	194.104539	776.418156
9	5.79	2	11.58	33.5241	67.0482	194.104539	388.209078
9.5	5.79	4	23.16	33.5241	134.0964	194.104539	776.418156
10	5.79	2	11.58	33.5241	67.0482	194.104539	388.209078
		Σ_1=	245.3802	Σ_3=	1403.19814	Σ_5=	8036.3301

WATER SECTION INCLINED AT 90°

Immersed Wedge

No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	4.053	1	4.053	16.426809	16.426809	66.5778569	66.5778569
0.5	5.5584	4	22.2336	30.8958106	123.583242	171.731273	686.925094
1	5.5584	2	11.1168	30.8958106	61.7916211	171.731273	343.462547
1.5	5.5584	4	22.2336	30.8958106	123.583242	171.731273	686.925094
2	5.5584	2	11.1168	30.8958106	61.7916211	171.731273	343.462547
3	5.5584	4	22.2336	30.8958106	123.583242	171.731273	686.925094
4	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
5	5.6742	4	22.6968	32.1965456	128.786183	182.689639	730.758557
6	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
7	5.6742	4	22.6968	32.1965456	128.786183	182.689639	730.758557
8	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
8.5	5.6742	4	22.6968	32.1965456	128.786183	182.689639	730.758557
9	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
9.5	5.6742	4	22.6968	32.1965456	128.786183	182.689639	730.758557
10	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
		Σ_1=	240.5166	Σ_3=	1347.86996	Σ_5=	7564.20885

WATER SECTION INCLINED AT 0°

Emerged Wedge

No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	0	1	0	0	0	0	0
0.5	0	4	0	0	0	0	0
1	2.5476	2	5.0952	6.49026576	12.9805315	16.5346011	33.0692021
1.5	3.8214	4	15.2856	14.603098	58.4123918	55.8042785	223.217114
2	4.8636	2	9.7272	23.654605	47.3092099	115.046537	230.093073
3	5.3268	4	21.3072	28.3747982	113.499193	151.146875	604.587501
4	5.5584	2	11.1168	30.8958106	61.7916211	171.731273	343.462547
5	5.5584	4	22.2336	30.8958106	123.583242	171.731273	686.925094
6	5.5584	2	11.1168	30.8958106	61.7916211	171.731273	343.462547
7	5.5584	4	22.2336	30.8958106	123.583242	171.731273	686.925094
8	5.5584	2	11.1168	30.8958106	61.7916211	171.731273	343.462547
8.5	5.5584	4	22.2336	30.8958106	123.583242	171.731273	686.925094
9	5.5584	2	11.1168	30.8958106	61.7916211	171.731273	343.462547
9.5	5.5584	4	22.2336	30.8958106	123.583242	171.731273	686.925094
10	5.5584	2	11.1168	30.8958106	61.7916211	171.731273	343.462547
		Σ_2=	195.9336	Σ_4=	1035.4924	Σ_6=	5555.98

WATER SECTION INCLINED AT 10°

Emerged Wedge

No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	0	1	0	0	0	0	0
0.5	0	4	0	0	0	0	0
1	1.737	2	3.474	3.017169	6.034338	5.24082255	10.4816451
1.5	2.895	4	11.58	8.381025	33.5241	24.2630674	97.0522695
2	3.9372	2	7.8744	15.5015438	31.0030877	61.0326784	122.065357
3	4.7478	4	18.9912	22.5416048	90.1664194	107.023031	428.092126
4	5.69736	2	11.39472	32.459911	64.9198219	184.935798	369.871597
5	5.69736	4	22.78944	32.459911	129.839644	184.935798	739.743193
6	5.69736	2	11.39472	32.459911	64.9198219	184.935798	369.871597
7	5.69736	4	22.78944	32.459911	129.839644	184.935798	739.743193
8	5.69736	2	11.39472	32.459911	64.9198219	184.935798	369.871597
8.5	5.69736	4	22.78944	32.459911	129.839644	184.935798	739.743193
9	5.69736	2	11.39472	32.459911	64.9198219	184.935798	369.871597
9.5	5.69736	4	22.78944	32.459911	129.839644	184.935798	739.743193
10	5.69736	2	11.39472	32.459911	64.9198219	184.935798	369.871597
		Σ_2=	190.05096	Σ_4=	1004.68563	Σ_6=	5466.02215

WATER SECTION INCLINED AT 20°

Emerged Wedge

No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	0	1	0	0	0	0	0
0.5	2.316	4	9.264	5.363856	21.455424	12.4226905	49.690762
1	4.9794	2	9.9588	24.7944244	49.5888487	123.461357	246.922713
1.5	5.6742	4	22.6968	32.1965456	128.786183	182.689639	730.758557
2	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
3	5.5584	4	22.2336	30.8958106	123.583242	171.731273	686.925094
4	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
5	5.6742	4	22.6968	32.1965456	128.786183	182.689639	730.758557
6	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
7	5.6742	4	22.6968	32.1965456	128.786183	182.689639	730.758557
8	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
8.5	5.6742	4	22.6968	32.1965456	128.786183	182.689639	730.758557
9	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
9.5	5.6742	4	22.6968	32.1965456	128.786183	182.689639	730.758557
10	5.6742	2	11.3484	32.1965456	64.3930913	182.689639	365.379279
		$\Sigma_2=$	223.0308	$\Sigma_4=$	1224.91698	$\Sigma_6=$	6829.60703

WATER SECTION INCLINED AT 30°

Emerged Wedge

No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	0	1	0	0	0	0	0
0.5	0	4	0	0	0	0	0
1	0.9843	2	1.9686	0.96884649	1.93769298	0.9536356	1.9072712
1.5	1.6791	4	6.7164	2.81937681	11.2775072	4.7340156	18.9360624
2	2.0844	2	4.1688	4.34472336	8.68944672	9.05614137	18.1122827
3	1.9686	4	7.8744	3.87538596	15.5015438	7.6290848	30.5163392
4	2.0844	2	4.1688	4.34472336	8.68944672	9.05614137	18.1122827
5	2.0844	4	8.3376	4.34472336	17.3788934	9.05614137	36.2245655
6	2.0844	2	4.1688	4.34472336	8.68944672	9.05614137	18.1122827
7	2.0844	4	8.3376	4.34472336	17.3788934	9.05614137	36.2245655
8	2.0844	2	4.1688	4.34472336	8.68944672	9.05614137	18.1122827
8.5	2.0844	4	8.3376	4.34472336	17.3788934	9.05614137	36.2245655
9	2.0844	2	4.1688	4.34472336	8.68944672	9.05614137	18.1122827
9.5	2.0844	4	8.3376	4.34472336	17.3788934	9.05614137	36.2245655
10	2.0844	2	4.1688	4.34472336	8.68944672	9.05614137	18.1122827
		$\Sigma_2=$	74.9226	$\Sigma_4=$	150.368998	$\Sigma_6=$	304.931631

WATER SECTION INCLINED AT 40°

Emerged Wedge							
No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	0	1	0	0	0	0	0
0.5	0	4	0	0	0	0	0
1	0.8685	2	1.737	0.75429225	1.5085845	0.65510282	1.31020564
1.5	1.3896	4	5.5584	1.93098816	7.72395264	2.68330115	10.7332046
2	1.5633	2	3.1266	2.44390689	4.88781378	3.82055964	7.64111928
3	1.5054	4	6.0216	2.26622916	9.06491664	3.41158138	13.6463255
4	1.6212	2	3.2424	2.62828944	5.25657888	4.26098284	8.52196568
5	1.6212	4	6.4848	2.62828944	10.5131578	4.26098284	17.0439314
6	1.6212	2	3.2424	2.62828944	5.25657888	4.26098284	8.52196568
7	1.6212	4	6.4848	2.62828944	10.5131578	4.26098284	17.0439314
8	1.6212	2	3.2424	2.62828944	5.25657888	4.26098284	8.52196568
8.5	1.6212	4	6.4848	2.62828944	10.5131578	4.26098284	17.0439314
9	1.6212	2	3.2424	2.62828944	5.25657888	4.26098284	8.52196568
9.5	1.6212	4	6.4848	2.62828944	10.5131578	4.26098284	17.0439314
10	1.6212	2	3.2424	2.62828944	5.25657888	4.26098284	8.52196568
		Σ_2=	58.5948	Σ_4=	91.520793	Σ_6=	144.116409

WATER SECTION INCLINED AT 50°

Emerged Wedge							
No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	0	1	0	0	0	0	0
0.5	0	4	0	0	0	0	0
1	0.8106	2	1.6212	0.65707236	1.31414472	0.53262286	1.06524571
1.5	1.158	4	4.632	1.340964	5.363856	1.55283631	6.21134525
2	1.4475	2	2.895	2.09525625	4.1905125	3.03288342	6.06576684
3	1.3317	4	5.3268	1.77342489	7.09369956	2.36166993	9.4466797
4	1.3896	2	2.7792	1.93098816	3.86197632	2.68330115	5.36660229
5	1.3896	4	5.5584	1.93098816	7.72395264	2.68330115	10.7332046
6	1.3896	2	2.7792	1.93098816	3.86197632	2.68330115	5.36660229
7	1.3896	4	5.5584	1.93098816	7.72395264	2.68330115	10.7332046
8	1.3896	2	2.7792	1.93098816	3.86197632	2.68330115	5.36660229
8.5	1.3896	4	5.5584	1.93098816	7.72395264	2.68330115	10.7332046
9	1.3896	2	2.7792	1.93098816	3.86197632	2.68330115	5.36660229
9.5	1.3896	4	5.5584	1.93098816	7.72395264	2.68330115	10.7332046
10	1.3896	2	2.7792	1.93098816	3.86197632	2.68330115	5.36660229
		Σ_2=	50.6046	Σ_4=	68.1679049	Σ_6=	92.5548673

WATER SECTION INCLINED AT 60°

Emerged Wedge							
No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	0	1	0	0	0	0	0
0.5	0	4	0	0	0	0	0
1	0.7527	2	1.5054	0.56655729	1.13311458	0.42644767	0.85289534
1.5	1.0422	4	4.1688	1.08618084	4.34472336	1.13201767	4.52807069
2	1.158	2	2.316	1.340964	2.681928	1.55283631	3.10567262
3	1.158	4	4.632	1.340964	5.363856	1.55283631	6.21134525
4	1.2738	2	2.5476	1.62256644	3.24513288	2.06682513	4.13365026
5	1.2738	4	5.0952	1.62256644	6.49026576	2.06682513	8.26730053
6	1.2738	2	2.5476	1.62256644	3.24513288	2.06682513	4.13365026
7	1.2738	4	5.0952	1.62256644	6.49026576	2.06682513	8.26730053
8	1.2738	2	2.5476	1.62256644	3.24513288	2.06682513	4.13365026
8.5	1.2738	4	5.0952	1.62256644	6.49026576	2.06682513	8.26730053
9	1.2738	2	2.5476	1.62256644	3.24513288	2.06682513	4.13365026
9.5	1.2738	4	5.0952	1.62256644	6.49026576	2.06682513	8.26730053
10	1.2738	2	2.5476	1.62256644	3.24513288	2.06682513	4.13365026
		Σ_2=	45.741	Σ_4=	55.7103494	Σ_6=	68.4354373

WATER SECTION INCLINED AT 70°

Emerged Wedge							
No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	0	1	0	0	0	0	0
0.5	0	4	0	0	0	0	0
1	0.6948	2	1.3896	0.48274704	0.96549408	0.33541264	0.67082529
1.5	0.9843	4	3.9372	0.96884649	3.87538596	0.9536356	3.8145424
2	1.1001	2	2.2002	1.21022001	2.42044002	1.33136303	2.66272607
3	1.0422	4	4.1688	1.08618084	4.34472336	1.13201767	4.52807069
4	1.1001	2	2.2002	1.21022001	2.42044002	1.33136303	2.66272607
5	1.1001	4	4.4004	1.21022001	4.84088004	1.33136303	5.32545213
6	1.1001	2	2.2002	1.21022001	2.42044002	1.33136303	2.66272607
7	1.1001	4	4.4004	1.21022001	4.84088004	1.33136303	5.32545213
8	1.1001	2	2.2002	1.21022001	2.42044002	1.33136303	2.66272607
8.5	1.1001	4	4.4004	1.21022001	4.84088004	1.33136303	5.32545213
9	1.1001	2	2.2002	1.21022001	2.42044002	1.33136303	2.66272607
9.5	1.1001	4	4.4004	1.21022001	4.84088004	1.33136303	5.32545213
10	1.1001	2	2.2002	1.21022001	2.42044002	1.33136303	2.66272607
		Σ_2=	40.2984	Σ_4=	43.0717637	Σ_6=	46.2916033

WATER SECTION INCLINED AT 80°

Emerged Wedge							
No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	0	1	0	0	0	0	0
0.5	0	4	0	0	0	0	0
1	0.6948	2	1.3896	0.48274704	0.96549408	0.33541264	0.67082529
1.5	0.9843	4	3.9372	0.96884649	3.87538596	0.9536356	3.8145424
2	1.0422	2	2.0844	1.08618084	2.17236168	1.13201767	2.26403534
3	1.0422	4	4.1688	1.08618084	4.34472336	1.13201767	4.52807069
4	1.0422	2	2.0844	1.08618084	2.17236168	1.13201767	2.26403534
5	1.0422	4	4.1688	1.08618084	4.34472336	1.13201767	4.52807069
6	1.0422	2	2.0844	1.08618084	2.17236168	1.13201767	2.26403534
7	1.0422	4	4.1688	1.08618084	4.34472336	1.13201767	4.52807069
8	1.0422	2	2.0844	1.08618084	2.17236168	1.13201767	2.26403534
8.5	1.0422	4	4.1688	1.08618084	4.34472336	1.13201767	4.52807069
9	1.0422	2	2.0844	1.08618084	2.17236168	1.13201767	2.26403534
9.5	1.0422	4	4.1688	1.08618084	4.34472336	1.13201767	4.52807069
10	1.0422	2	2.0844	1.08618084	2.17236168	1.13201767	2.26403534
		Σ_2=	38.6772	Σ_4=	39.5986669	Σ_6=	40.7099332

WATER SECTION INCLINED AT 90°

Emerged Wedge							
No of sec	Ordinates	SM	F of ord.	Sq of ord.	F of sq.	Cube of ord	F of cubes
0	0	1	0	0	0	0	0
0.5	0	4	0	0	0	0	0
1	0.6948	2	1.3896	0.48274704	0.96549408	0.33541264	0.67082529
1.5	0.9843	4	3.9372	0.96884649	3.87538596	0.9536356	3.8145424
2	1.0422	2	2.0844	1.08618084	2.17236168	1.13201767	2.26403534
3	0.9843	4	3.9372	0.96884649	3.87538596	0.9536356	3.8145424
4	1.0422	2	2.0844	1.08618084	2.17236168	1.13201767	2.26403534
5	1.0422	4	4.1688	1.08618084	4.34472336	1.13201767	4.52807069
6	1.0422	2	2.0844	1.08618084	2.17236168	1.13201767	2.26403534
7	1.0422	4	4.1688	1.08618084	4.34472336	1.13201767	4.52807069
8	1.0422	2	2.0844	1.08618084	2.17236168	1.13201767	2.26403534
8.5	1.0422	4	4.1688	1.08618084	4.34472336	1.13201767	4.52807069
9	1.0422	2	2.0844	1.08618084	2.17236168	1.13201767	2.26403534
9.5	1.0422	4	4.1688	1.08618084	4.34472336	1.13201767	4.52807069
10	1.0422	2	2.0844	1.08618084	2.17236168	1.13201767	2.26403534
		Σ_2=	38.4456	Σ_4=	39.1293295	Σ_6=	39.9964049

Combination Table

Angle of heel : 10

HEEL ANGLE (α)	Σ_3	SM	PRD.	Σ_4	SM	PRD.
0	1246.34558	5	6231.727901	1035.492	5	5177.462004
10	1105.973469	8	8847.787749	1004.686	8	8037.485042
20	1224.916975	-1	-1224.91698	1224.917	-1	-1224.91698
Σ_7=		13854.59867		∑8=	11990.03007	

HEEL ANGLE (α)	$\Sigma_5+\Sigma_6$	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0	11912.30426	5	59561.52128	10	0.98	58656.64794
10	11484.72253	8	91877.78024	0	1.00	91877.78024
20	13659.21405	-1	-13659.2141	-10	0.98	-13451.6999
		∑9=			137082.7283	

Volume of Immersed=	92.777	cu. m	
Volume of Emerged=	92.777	cu. m	
New Volume=	486.300	cu. m	
Moment=	707.151	m^4	
BR=	1.454	m	
BG=KG-KB=	2.513	m	
BGsinΘ =	0.436	m	
GZ=BR-BGsinΘ=	1.018	m	

Combination Table

Angle of heel : 20

HEEL ANGLE (α)	Σ_3	SM	PRD.	Σ_4	SM	PRD.
0	1246.34558	1	1246.346	1035.492	1	1035.492
10	1105.973469	4	4423.894	1004.686	4	4018.743
20	1224.916975	1	1224.917	1224.917	1	1224.917
Σ_7=		6895.15643		∑8=	6279.151897	

HEEL ANGLE (α)	$\Sigma_5+\Sigma_6$	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0	11912.30426	1	11912.3	20	0.94	11193.9
10	11484.72253	4	45938.89	10	0.98	45240.98
20	13659.21405	1	13659.21	0	1.00	13659.21
∑9=					70094.09361	

Volume of Immersed=	213.415	cu. m
Volume of Emerged=	194.349	cu. m
New Volume=	505.366	cu. m
Moment=	1446.341	m^4
BR=	2.862	m
BG=KG-KB=	2.513	m
BGsinθ =	0.859	m
GZ=BR-BGsinθ=	2.002	m

Combination Table

Angle of heel :						30
HEEL ANGLE (α)	Σ_3	SM	PRD.	Σ_4	SM	PRD.
0	1246.34558	1	1246.35	1035.49	1	1035.49
10	1105.973469	3	3317.92	1004.69	3	3014.06
20	1224.916975	3	3674.75	1224.92	3	3674.75
30	1571.90482	1	1571.9	150.369	1	150.369
Σ_7=		9810.921732		∑8=	7874.669216	

HEEL ANGLE (α)	$\Sigma_5+\Sigma_6$	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0	11912.30426	1	11912.3	30	0.87	10316.4
10	11484.72253	3	34454.2	20	0.94	32376.3
20	13659.21405	3	40977.6	10	0.98	40355.1
30	9976.713593	1	9976.71	0	1.00	9976.71
∑9=					93024.49843	

Volume of Immersed=	341.620	cu. m	
Volume of Emerged=	274.199	cu. m	
New Volume=	553.721	cu. m	
Moment=	2159.430	m^4	
BR=	3.900	m	
BG=KG-KB=	2.513	m	
BGsinΘ =	1.257	m	
GZ=BR-BGsinΘ=	2.643	m	

Combination Table

Angle of heel :						40
HEEL ANGLE (α)	Σ_3	SM	PRD.	Σ_4	SM	PRD.
0	1246.34558	1	1246.35	1035.49	1	1035.49
10	1105.973469	4	4423.89	1004.69	4	4018.74
20	1224.916975	2	2449.83	1224.92	2	2449.83
30	1571.90482	4	6287.62	150.369	4	601.476
40	2054.142294	1	2054.14	91.5208	1	91.5208
Σ_7=		**16461.83498**		∑8=	**8197.065658**	

HEEL ANGLE (α)	$\Sigma_5+\Sigma_6$	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0	11912.30426	1	11912.3	40	0.77	9125.35
10	11484.72253	4	45938.9	30	0.87	39784.2
20	13659.21405	2	27318.4	20	0.94	25670.9
30	9976.713593	4	39906.9	10	0.98	39300.6
40	14517.54199	1	14517.5	0	1.00	14517.5
			∑9=		**128398.6472**	

Volume of Immersed=	509.517	cu. m	
Volume of Emerged=	253.711	cu. m	
New Volume=	742.106	cu. m	
Moment=	2649.413	m^4	
BR=	3.570	m	
BG=KG-KB=	2.513	m	
BGsinΘ =	1.615	m	
GZ=BR-BGsinΘ=	1.955	m	

Combination Table						
Angle of heel :						50
HEEL ANGLE (α)	Σ_3	SM	PRD.	Σ_4	SM	PRD.
0	1246.34558	0.4	498.538	1035.49	0.4	414.197
10	1105.973469	1	1105.97	1004.69	1	1004.69
20	1224.916975	1	1224.92	1224.92	1	1224.92
30	1571.90482	1	1571.9	150.369	1	150.369
40	2054.142294	1	2054.14	91.5208	1	91.5208
50	2295.703549	0.4	918.281	68.1679	0.4	27.2672
Σ_7=		7373.757209		∑8=	2912.956519	

HEEL ANGLE (α)	$\Sigma_5+\Sigma_6$	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0	11912.30426	0.4	4764.92	50	0.64	3062.83
10	11484.72253	1	11484.7	40	0.77	8797.81
20	13659.21405	1	13659.2	30	0.87	11829.2
30	9976.713593	1	9976.71	20	0.94	9375.04
40	14517.54199	1	14517.5	10	0.98	14297
50	16938.78843	0.4	6775.52	0	1.00	6775.52
			∑9=		54137.41429	

Volume of Immersed=	713.213 cu. m
Volume of Emerged=	281.750 cu. m
New Volume=	917.763 cu. m
Moment=	3490.894 m^4
BR=	3.804 m
BG=KG-KB=	2.513 m
BGsinΘ =	1.925 m
GZ=BR-BGsinΘ=	1.879 m

Combination Table						
Angle of heel :						60
HEEL ANGLE (α)	**Σ_3**	**SM**	**PRD.**	**Σ_4**	**SM**	**PRD.**
0	1246.34558	1	1246.35	1035.5	1	1035.49
10	1105.973469	4	4423.89	1004.7	4	4018.74
20	1224.916975	2	2449.83	1224.9	2	2449.83
30	1571.90482	4	6287.62	150.37	4	601.476
40	2054.142294	2	4108.28	91.521	2	183.042
50	2295.703549	4	9182.81	68.168	4	272.672
60	1822.155522	1	1822.16	55.71	1	55.7103
Σ_7=		**29520.94699**		$\sum 8$=	**8616.96842**	

HEEL ANGLE (α)	$\Sigma_5+\Sigma_6$	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0	11912.30426	1	11912.3	60	0.50	5956.15
10	11484.72253	4	45938.9	50	0.64	29528.9
20	13659.21405	2	27318.4	40	0.77	20927.1
30	9976.713593	4	39906.9	30	0.87	34560.3
40	14517.54199	2	29035.1	20	0.94	27284.1
50	16938.78843	4	67755.2	10	0.98	66725.8
60	11968.25489	1	11968.3	0	1.00	11968.3
			$\sum_9=$		**196950.6909**	

Volume of Immersed=	913.715	cu. m
Volume of Emerged=	266.707	cu. m
New Volume=	1133.308	cu. m
Moment=	4063.934	m^4
BR=	3.586	m
BG=KG-KB=	2.513	m
BGsinθ =	2.176	m
GZ=BR-BGsinθ=	1.410	m

Combination Table						
Angle of heel :						70
HEEL ANGLE (α)	Σ_3	SM	PRD.	Σ_4	SM	PRD.
0	1246.34558	1	1246.35	1035.5	1	1035.49
10	1105.973469	4	4423.89	1004.7	4	4018.74
20	1224.916975	2	2449.83	1224.9	2	2449.83
30	1571.90482	4	6287.62	150.37	4	601.476
40	2054.142294	1	2054.14	91.521	1	91.5208
$\Sigma_{7,1}$=			**16461.83498**	∑8,1=	**8197.065658**	
40	2054.142294	1	2054.14	91.521	1	91.5208
50	2295.703549	3	6887.11	68.168	3	204.504
60	1822.155522	3	5466.47	55.71	3	167.131
70	1600.078474	1	1600.08	43.072	1	43.0718
$\Sigma_{7,2}$=			**16007.79798**	∑8,2=	**506.2273196**	

HEEL ANGLE (α)	$\Sigma_5+\Sigma_6$	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0	11912.30426	1	11912.3	70	0.34	4074.25
10	11484.72253	4	45938.9	60	0.50	22969.4
20	13659.21405	2	27318.4	50	0.64	17559.9
30	9976.713593	4	39906.9	40	0.77	30570.4
40	14517.54199	1	14517.5	30	0.87	12572.6
			∑9=		**87746.62437**	

40	14517.54199	1	14517.5	30	0.87	12572.6
50	16938.78843	3	50816.4	20	0.94	47751.8
60	11968.25489	3	35904.8	10	0.98	35359.3
70	9808.788709	1	9808.79	0	1.00	9808.79
			∑9=		**105492.403**	

Volume of Immersed=	1066.914	cu. m
Volume of Emerged=	271.338	cu. m
New Volume=	1281.876	cu. m
Moment=	4259.442	m^4
BR=	3.323	m
BG=KG-KB=	2.513	m
BGsinΘ =	2.361	m
GZ=BR-BGsinΘ=	0.961	m

Combination Table						
Angle of heel :						80
HEEL ANGLE (α)	Σ_3	SM	PRD.	Σ_4	SM	PRD.
0	1246.34558	1	1246.34558	1035.4924	1	1035.49
10	1105.973469	4	4423.893875	1004.6856	4	4018.74
20	1224.916975	2	2449.833951	1224.917	2	2449.83
30	1571.90482	4	6287.61928	150.369	4	601.476
40	2054.142294	2	4108.284588	91.520793	2	183.042
50	2295.703549	4	9182.814195	68.167905	4	272.672
60	1822.155522	2	3644.311044	55.710349	2	111.421
70	1600.078474	4	6400.313895	43.071764	4	172.287
80	1403.198139	1	1403.198139	39.598667	1	39.5987
Σ_7=		39146.61455		∑8=	8884.564491	

HEEL ANGLE (α)	$\Sigma_5+\Sigma_6$	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0	11912.30426	1	11912.30426	80	0.17	2068.55
10	11484.72253	4	45938.89012	70	0.34	15712
20	13659.21405	2	27318.4281	60	0.50	13659.2
30	9976.713593	4	39906.85437	50	0.64	25651.6
40	14517.54199	2	29035.08399	40	0.77	22242.2
50	16938.78843	4	67755.1537	30	0.87	58677.7
60	11968.25489	2	23936.50978	20	0.94	22493
70	9808.788709	4	39235.15484	10	0.98	38639.1
80	8077.040032	1	8077.040032	0	1.00	8077.04
$\Sigma_9=$					207220.3567	

Volume of Immersed=	1211.643	cu. m
Volume of Emerged=	274.990	cu. m
New Volume=	1422.953	cu. m
Moment=	4275.841	m^4
BR=	3.005	m
BG=KG-KB=	2.513	m
BGsinΘ =	2.475	m
GZ=BR-BGsinΘ=	0.530	m

Combination Table

Angle of heel : 90

HEEL ANGLE (α)	Σ_3	SM	PRD.	Σ_4	SM	PRD.
0	1246.34558	1	1246.35	1035.492401	1	1035.4924
10	1105.973469	3	3317.92	1004.68563	3	3014.05689
20	1224.916975	3	3674.75	1224.916975	3	3674.75093
30	1571.90482	2	3143.81	150.3689981	2	300.737996
40	2054.142294	3	6162.43	91.520793	3	274.562379
50	2295.703549	3	6887.11	68.16790494	3	204.503715
60	1822.155522	2	3644.31	55.71034938	2	111.420699
70	1600.078474	3	4800.24	43.07176368	3	129.215291
80	1403.198139	3	4209.59	39.59866692	3	118.796001
90	1347.869965	1	1347.87	39.12932952	1	39.1293295
Σ_7=		38434.37493		∑8=	8902.665628	

HEEL ANGLE (α)	$\Sigma_5+\Sigma_6$	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0	11912.30426	1	11912.3	90	0.00	0
10	11484.72253	3	34454.2	80	0.17	5982.90341
20	13659.21405	3	40977.6	70	0.34	14015.179
30	9976.713593	2	19953.4	60	0.50	9976.71359
40	14517.54199	3	43552.6	50	0.64	27995.0883
50	16938.78843	3	50816.4	40	0.77	38927.5942
60	11968.25489	2	23936.5	30	0.87	20729.6255
70	9808.788709	3	29426.4	20	0.94	27651.7391
80	8077.040032	3	24231.1	10	0.98	23862.9949
90	7604.205257	1	7604.21	0	1.00	7604.20526
			Σ_9=		**176746.0435**	

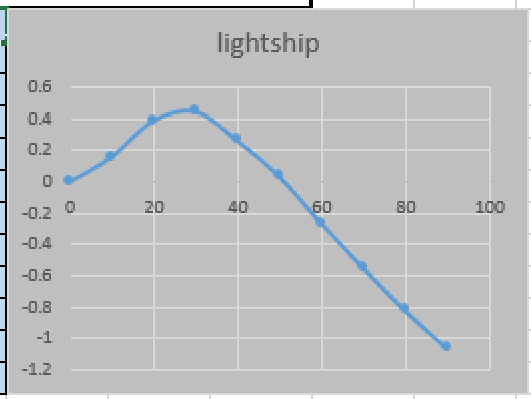
Volume of Immersed=	1338.298 cu. m
Volume of Emerged=	309.994 cu. m
New Volume=	1514.604 cu. m
Moment=	4102.904 m^4
BR=	2.709 m
BG=KG-KB=	2.513 m
BGsinΘ =	2.513 m
GZ=BR-BGsinΘ=	0.196 m

0	10	20	30	40	50	60	70	80	90
0	**0.15871**	**0.388335**	**0.447887**	**0.264113**	**0.035301**	**-0.26415**	**-0.55011**	**-0.82497**	**-1.06618**
0	**0.21523**	**0.399079**	**0.424419**	**0.306108**	**0.133655**	**-0.08**	**-0.29987**	**-0.51865**	**-0.72**
0	0.094773	0.197608	0.261845	0.322955	0.281661	0.217463	**0.116519**	**0.00079**	**-0.13151**

Stability curves

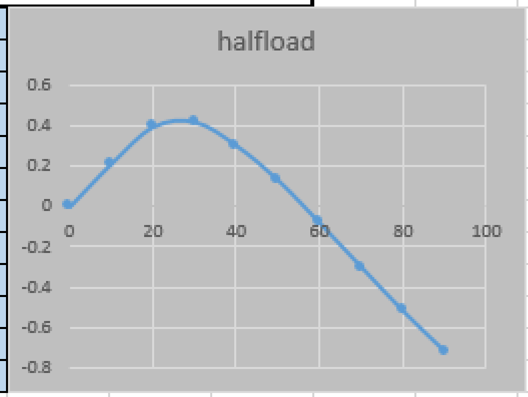
Lightship

lightship	
Angel	GZ
0	0
10	0.15871
20	0.38833
30	0.44789
40	0.26411
50	0.0353
60	-0.26415
70	-0.55011
80	-0.82497
90	-1.06618



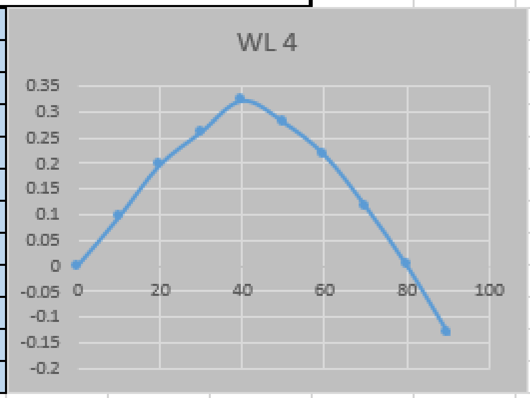
halfload

halfload	
Angel	GZ
0	0
10	0.21523
20	0.39908
30	0.42442
40	0.30611
50	0.13365
60	-0.08
70	-0.29987
80	-0.51865
90	-0.72



Loaded Waterline

WL 4	
Angel	GZ
0	0
10	0.09477
20	0.19761
30	0.26185
40	0.32295
50	0.28166
60	0.21746
70	0.11652
80	0.00079
90	-0.13151



	lightship			
	Criterias	Required Value	Actual Value	Remarks
Area under GZ curve	Up to 30 degree	>0.055	0.13	PASS
	From 30 to 40 degree	>0.03	0.06	PASS
	Up to 40 degree	>0.09	0.19	PASS
	Max GZ at an angel	>25 degree	30	PASS
	Initial GM	at least 0.15		

halfload				
	Criterias	Required Value	Actual Value	Remarks
Area under GZ curve	Up to 30 degree	>0.055	0.11	PASS
	righting lever 30^{0}	>0.2	0.40	PASS
	Up to 40 degree	>0.09	0.16	PASS
	Max GZ at an angel	>25 degree	30	PASS
	Initial GM	at least 0.15		pass

	Loaded Waterline			
	Criterias	Required Value	Actual Value	Remarks
Area under GZ curve	Up to 30 degree	>0.055	0.07	PASS
	righting lever 30⁰	>0.2	0.26	PASS
	Up to 40 degree	>0.09	0.11	PASS
	Max GZ at an angel	>25 degree	40	PASS
	Initial GM at least 0.15			pass

Trim Calculation

Length=73.8 m

L.   C.B=-.12 m
L.C.G.= -1.03 m

Loaded displacement= 3150 tons

MCTC=(WxGML)/100L

=53.35 tonm/cm

L.C.F.=-.9 m

V.C.G=3.01 m

BML=125

Draft at displacement= 4 m

Change of trim=Trimming moment/MCTC

=(1.03-.12)*3150/53.35

=53.7 cm

Change of draft aft=(l/L)change of trim

=((73.8/2-.9)/73.8)x53.7

=26.2 cm

So change in forward draft=(53.7-26.2)

=27.5 cm

Resulting draft =(4+.26)=4.26 m aft

Forward draft=(4-.275)=3.725 m forward

Hence trimmed by stern

Reference

- Elements of ship design by R.Munro & Smith
- Practical ship design by David G.M. Watson
- Resistance and propulsion of ships by SV. AA. Harvald
- Merchant ship design by R.Munro & Smith
- Rules and guidelines 2008 (GL)
- Rules and guidelines (ABS)
- Ship stability for Masters and Mates by D. R. Derret
- Introduction to Naval Architecture by Eric Tupper
- Naval Architectures for Marine Engineers by W. Muckle