Declaration

No portion of the work contained in this project has been submitted in support of an application for another degree or qualification of this or any other university or institute of learning.

Dr. Md. Mashiur Rahaman

Noshin Tarannum

Rafid Imam

Forwarding Letter

To,

Dr. Md. Mashiur Rahaman

Professor

Department of Naval Architecture and Marine Engineering Bangladesh University of Engineering and Technology.

Subject: Regarding completion of our project on designing of 3000 DWT IR class general cargo for operation in the inland waterways of Bangladesh.

Sir,

We are pleased to submit our project paper which was done as part of our course NAME 338. This project was aimed towards designing IR class general cargo for operating in inland waterways of Bangladesh. The project was completed over two semesters, and presented to the faculty through four consecutive presentations. This project paper serves as the complete documentation of the entire design process entailed throughout the past two semesters.

All throughout the duration of this project, we have received numerous suggestions as to how to correct, iterate or better our design. This final paper contains the final corrected and completed design-work with all the suggested edits incorporated within it.

This letter has our completed NAME 338 project paper attached and forwarded with it, provided to you for your inspection and approval. Therefore, we hope and pray that you will accept our project paper, and oblige thereby.

Sincerely,

Noshin Tarannum Student ID- 1712002

Rafid Imam Student ID- 1712043

Contents

Owner’s Requirement

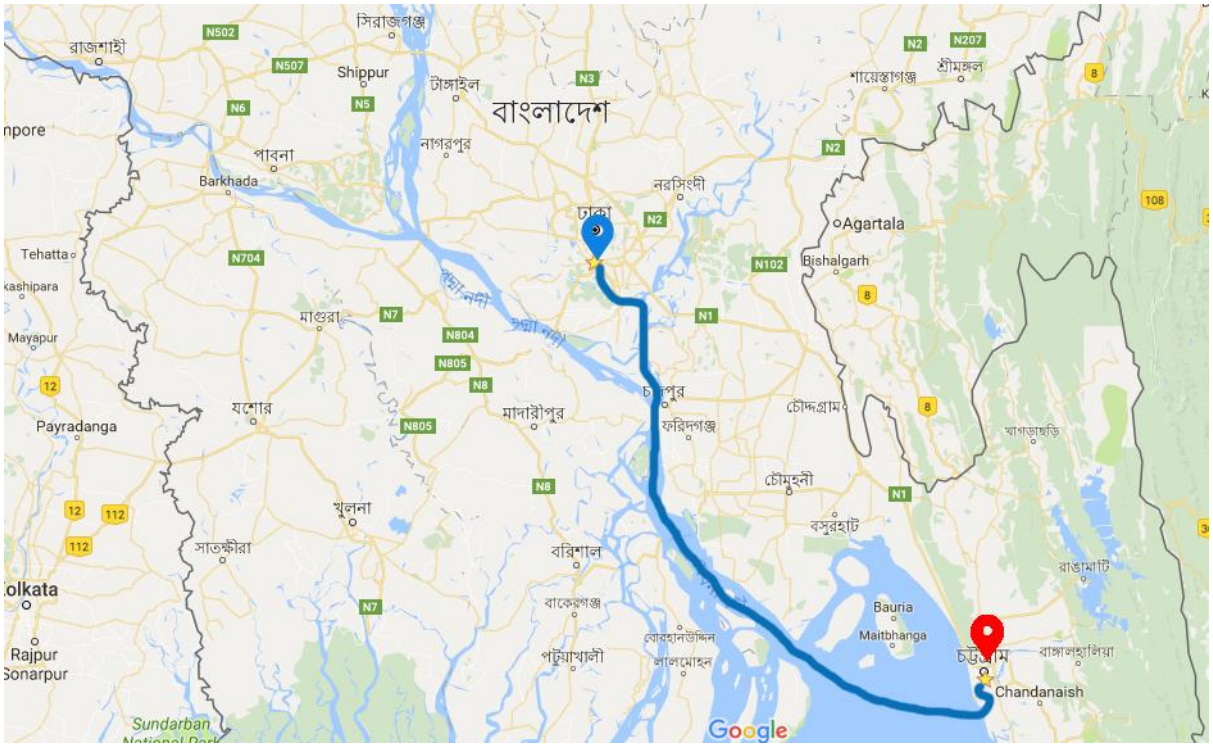
Vessel Type**: General Cargo**

Route**: Dhaka to Chittagong**

Service Speed**: 10 knot**

Deadweight**: 3000 tones**

Route Specification



Route: Dhaka to Chittagong
(Shadar Ghat to Chittagong Port)
Route Length: 304 km
(164 Nautical Miles)

Basis Ship Selection

M.V. ROKNOOR 32

Length overall,L_{OA}	82.56 m
Length between Perpendicular,L_{BP}	79.29 m
Breadth, B	16.00 m
Depth, D	5.50 m
Draft, H	4.10m
C_B	0.859
Deadweight	3200 tonnes
Speed	10 knot
Displacement	4526.83 tonnes
Class	IRS

Source: https://www.omeltd.com/projects/15

Principal Particulars

Principal Particulars of Design Ship

DETERMINATION OF PRINCIPAL PARTICULARS OF DESIGN SHIP

From the Ratio of Basis Ship:

L/B = 4.956

B/H = 3.902

B/D = 2.909

H/B = 0.256

Applying Cubic Root Formula Length, $\boldsymbol{L} = \left[\frac{DWT\times(L/B)^2\times(B/H)}{C_D\times C_B\times\rho}\right]^{1/3}$ = 77.942m

Now from the ratio of basis ship we get,

Breadth, B 15.728 m

Depth, D 5.500 m

Draft, H 4.100 m

Displacement 4317.350 tones

Using Empirical Method,

For general cargo ship Length,

$\mathbf{L = 5.54\left(\frac{V}{V+2}\right)DWT^{\frac{1}{3}} + 12.041}$ = 78.620m

Breadth, B = 15.865 m
Depth, D = 5.453m
Draft, H = 4.065 m

Displacement= 4355.60 tones

Using Munro-Smith,

For a general Cargo Ship,

$$\frac{\boldsymbol{DWT}}{\Delta} = \frac{\boldsymbol{.750 \times DWT}}{\boldsymbol{DWT + 300}}$$

Displacement = 4400.000 tones

Again, $\Delta = \boldsymbol{L/_B \times H/_B \times B^3 \times C_b}$

(page 18, method 3 ,ex-2.3)
Length, L = 78.886 m
Breadth, B = 15.918 m
Depth, D = 5.472 m
Draft, H = 4.079 m

The comparison of the values among different methods for determining preliminary particulars:

	Using Basis Ship Ratio	Using Empirical Formula	Using formula from Munro Smith
Length, L	77.942	78.620	78.886
Breadth, B	15.728	15.865	15.918
Depth, D	5.500	5.453	5.472
Draft, H	4.100	4.065	4.079

Principal particulars comparison between basis ship and design ship

Parameters	Basis Ship	Design Ship
Length Overall, L_{OA}	82.56 m	81.16 m
Length Between Perpendicular, L_{pp}	79.29 m	77.94 m
Breadth, B	16.00 m	15.72 m
Depth, D	5.50 m	5.41 m
Draft, H	4.10 m	3.59 m
Deadweight	3200 tonnes	3000 tonnes
Displacement	4526.83 tonnes	3776.00 tonnes
C_B	0.859	.859
C_D	0.707	.700

The Principal Particulars Comparison between Preliminary and Final Design Ship

Parameters	Final Design Ship	Preliminary Design Ship
Length Overall, L_{OA}	81.16 m	81.16 m
Length Between Perpendicular, L_{pp}	77.94 m	77.94 m
Breadth, B	15.72 m	15.72 m
Depth, D	5.41 m	5.41 m
Draft, H	3.59 m	4.03 m
Deadweight	3000 tonnes	3000 tonnes
Displacement	3776.00 tonnes	4243.90 tones
C_B	0.859	0.859
C_D	0.70	0.70

POWER ESTIMATION

&

MANNING

We know,

Admiralty Coefficient, Ac $=\left(\frac{\Delta^{2/3}\times V^3}{P}\right)_D$

For Basis ship and design Ship $\left(\frac{\Delta^{2/3}\times V^3}{P}\right)_B = \left(\frac{\Delta^{2/3}\times V^3}{P}\right)_D$

Power of Basis Ship 1125 KW

So using the formula we can estimate the power of Design Ship = 1096 KW

1096 KW for two Engines. Thus 548 KW for each of them

Fuel Used : Diesel

PRELIMINARY WEIGHT CALCULATION AND POWER ESTIMATION

Service Speed , V = 10 knot

= 18.5 km/h

Voyage distance , s = 164 nautical miles

Voyage time, $t = 2 \cdot s / v$ =32.800 Hours

= 1.3667 Days

Endurance time = 4Days

= 96 Hours

Cargo Capacity (tones) = 2950 tones

Power of Basis Ship = 1125 KW

Admiralty Coefficient of Basis Ship : 243.2150866

Crew Member: 16

Engine Information

Model M26

BHP 548 KW each

SFC $\leq$ 213 gKW/h

SLOC $\leq$ 1.0 gKW/h

Source : Weichai Marine Engines

Iteration 1

BHP (Single Engine)548 kW

BHP = (2 · 1 engine's BHP) 1096 kW

SFC (Single Engine) = 213 g/kW·hr

SLOC (Single Engine) = 0.8 g/kW·hr

Constant Addition of Fuel= 1.5 (1.14-1.5)

WHFO = SFC · BHP · Voyage time · Constant Addition =11485.64 kg

WDO = 20% of WHFO =2297.128kg

WLO = SLOC · BHP · Voyage time · Constant Addition = 43.13856 kg

Fresh water consumption for

Crew = 20 kg per person per day=1280 kg

Bath & Laundry needs = 200 kg per person per day =12800 kg

Cooking = 4 kg per person per day =256 kg

Machinery (Main Engine) (10 g/kW·hr) =1052.16 kg

Auxiliary needs = 20% of Main Engine= 210.432 kg

Reserve= 5000 kg

Net Crew Weight = 75 kg · Crew Member=1200 kg

Store & Provision = 10 kg per person per day= 640kg

Net weight =36264.50048 kg= 36.2645 tonnes

Deadweight = Cargo capacity + Net Weight= 2986.2645tonnes

Displacement , Δ = Deadweight / C_D=4340.5007 tonnes

PB = $\frac{\Delta^{\frac{2}{3}} \times V^3}{A_c}$ = 1094.0472 kW

PB per engine = 547.0236 kW

Iteration 2

BHP (Single Engine) = 547.02 kW

BHP = (2 · 1 engine's BHP) = 1094.047 kW

SFC (Single Engine) = 211g/kW·hr

SLOC (Single Engine)= 0.8 g/kW·hr

Constant Addition of Fuel= 1.5 (1.14-1.5)

WHFO = SFC · BHP · Voyage time · Constant Addition =12557.16kg

WDO = 20% of WHFO= 2511.43 kg

WLO = SLOC · BHP · Voyage time · Constant Addition = 47.61 kg

Fresh water consumption for Crew = 20 kg per person per day = 1280kg

Bath & Laundry needs = 200 kg per person per day =12800 kg

Cooking = 4 kg per person per day = 256 kg

Machinery (Main Engine) (10 g/kW·hr)= 1050.28 kg

Auxiliary needs = 20% of Main Engine = 210.05 kg

Reserve = 5000 kg

Net Crew Weight = 75 kg · Crew Member = 1200 kg

Store & Provision = 10 kg per person per day= 640 kg

Net weight = 37552.54 kg

= 37.55 tonnes

Deadweight = Cargo capacity + Net Weight = 2987.55 tonnes

Displacement , Δ = Deadweight / C_D =4342.37 tonnes

PB = $\frac{\Delta^{\frac{2}{3}} \times V^3}{A_c}$ = 1094.384622 kW

PB per engine 547.1923109 kW

Following the same path as before we got,

Iteration 3	**546.969 KW**
Iteration 4	**546.968 KW**
Iteration 5	**546.968 KW**

Source: Ship Design Methodologies of Preliminary Design by Apostolos Papanikolaou

Preliminary Engine Power 547 KW each

Total of 1094 KW

Determination of Number of Bulkheads

Distance between two bulkheads = **0.15L + 6.5 = 18.27 m**

So the Number of Bulkhead Stands = 4

Determination of Frame Spacing

Frame spacing = 450 + 2L $\approx 600\ mm$

Framing System : Transverse Framing

Source: Inland Shipping Ordinance

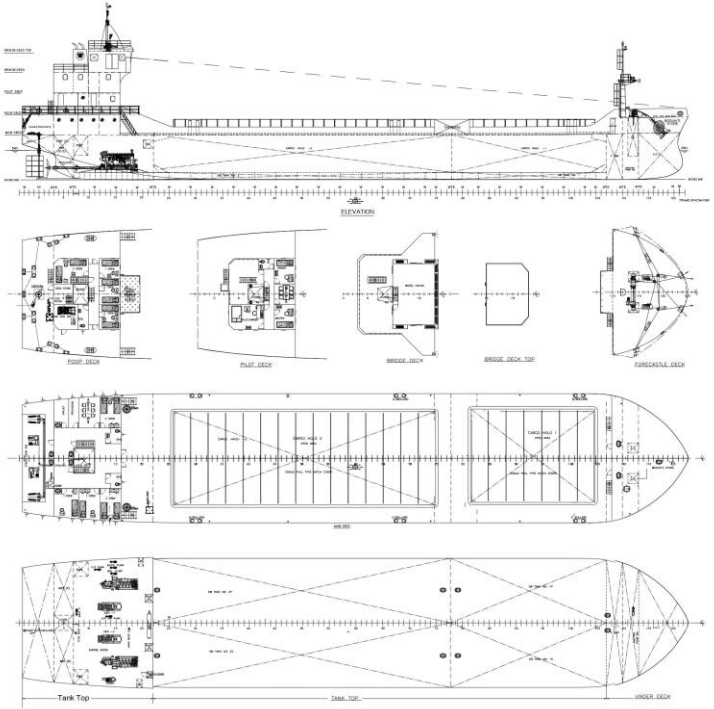
MANNING

Owner	**1**
1st Class Master	**1**
2nd Class Master	**1**
Sailor	**7**
Inland Marine Engineer	**2**
1st Class Driver	**1**
Greaser	**3**
Total	**16**

Source: Inland Shipping Ordinance

General Arrangement Plan

MAIN PARTICULARS	
Length(0A)	81.161 m
Length(WL)	79.038 m
Length(BP)	77.942 m
Breadth(Moulded)	15.728 m
Depth(Moulded)	5.406 m
Draft(Design)	3.588 m
Frame Spacing	650 mm
Service Speed	10 knot
Deadweight	3000 T

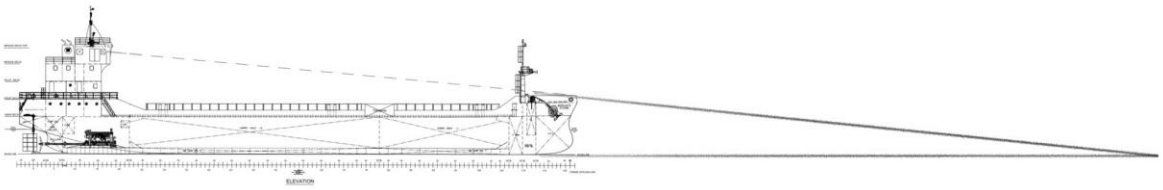


General Arrangement Plan

1712002- Noshin Tarannum

1712043-Rafid Imam

Visibility Test:

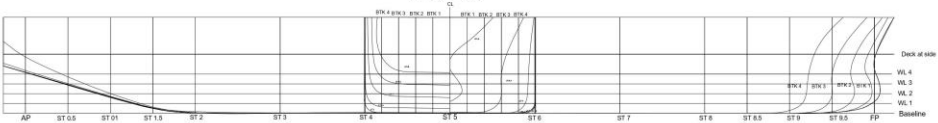


Note: (2×L) distance is taken to check if the ship passes the visibility test and it is evident that the ship meets the criteria successfully; where L= Ship's length.

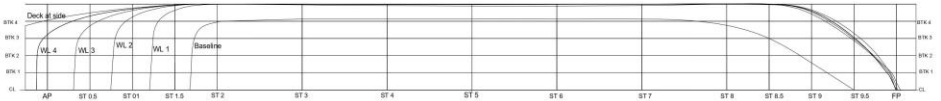
Lines Plan

MAIN PARTICULARS	
Length(0A)	81.161 m
Length(WL)	78.955 m
Length(BP)	77.942 m
Breadth(Moulded)	15.728 m
Depth(Moulded)	5.406 m
Draft(Design)	3.588 m
Frame Spacing	650 mm
Service Speed	10 knot
Deadweight	3000 T

Body Plan



Profile Plan



Half Breadth Plan

Lines Plan

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Table of Offset

OFFSET TABLE													
Station	**Half Breadth**						**Height Above Base Line**						**Station**
	Baseline	**WL - 1**	**WL - 2**	**WL - 3**	**WL - 4**	**Deck at Side**	**Keel**	**BTK - 1**	**BTK - 2**	**BTK - 3**	**Deck**	**Poop Deck**	
0	0	0.0000	0.0000	0.0000	2.5579	6.4200	3.793	3.806	3.826	3.987	5.181	0.000	**0**
0.5	0	0.0000	0.0000	5.2949	6.6263	7.0855	2.619	2.649	2.680	2.765	3.395	0.000	**0.5**
1	0	0.0000	6.4510	7.2146	7.4036	7.5062	1.462	1.495	1.529	1.572	1.831	0.000	**1**
1.5	0	7.2174	7.6930	7.7634	7.7783	7.8011	0.435	0.454	0.473	0.493	0.568	0.000	**1.5**
2	6.209	7.7965	7.8460	7.8480	7.8480	7.8640	0.03	0.031	0.032	0.032	0.038	0	**2**
3	6.5	7.8514	7.8640	7.8640	7.8640	7.8640	0	0.000	0.000	0.000	0.001	0	**3**
4	6.5	7.8514	7.8640	7.8640	7.8640	7.8640	0	0.000	0.000	0.000	0.001	0	**4**
5	6.5	7.8514	7.8640	7.8640	7.8640	7.8640	0	0.000	0.000	0.000	0.001	0	**5**
6	6.5	7.8514	7.8640	7.8640	7.8640	7.8640	0	0.000	0.000	0.000	0.001	0	**6**
7	6.5	7.8514	7.8640	7.8640	7.8640	7.8640	0	0.000	0.000	0.000	0.001	0	**7**
8	5.92	7.8512	7.8640	7.8640	7.8640	7.8640	0	0.000	0.000	0.000	0.001	0	**8**
8.5	4.72	7.817	7.849	7.851	7.852	7.854	0	0.000	0.000	0.000	0.001	0	**8.5**
9	2.5	6.9241	7.1250	7.1757	7.2217	7.3322	0	0.000	0.000	0.001	0.251	F Castle	**9**
9.5	2.48	4.4697	4.7387	4.6910	4.7495	5.2060	0.062	0.065	0.132	2.604	7.913	0.000	**9.5**
10	0	0.0000	1.0677	0.8461	0.1637	0.5180	4.095	6.534	7.989	0	0.000	0.000	**10**

Hydrostatic Calculation

Waterplane area, Displacement, LCB VCB calculation for WL - 1												
Water planes		**0**		**1**		**2**		**Station Distance**	7.7942	**WP Distance**		1.0075
	SM	**5**		**8**		**-1**		**Area products for sectional area**	**Sectional area below waterline**	**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	0	0	0	0	0	0	0	-5	0
0.5	2	0	0	0	0	0	0	0	0	0	-4.5	0
1	1	0	0	0	0	6.68	6.68	-6.68	-1.12	-1.12	-4	4.49
1.5	2	0	0	7.32	14.63	7.73	15.45	50.81	8.53	17.06	-3.5	-59.72
2	1.5	6.21	9.31	7.84	11.77	7.86	11.79	85.93	14.43	21.64	-3	-64.93
3	4	6.5	26	7.86	31.42	7.86	31.46	87.49	14.69	58.76	-2	-117.52
4	2	6.5	13	7.86	15.71	7.86	15.73	87.49	14.69	29.38	-1	-29.38
5	4	6.5	26	7.86	31.42	7.86	31.46	87.49	14.69	58.76	0	0
6	2	6.5	13	7.86	15.71	7.86	15.73	87.49	14.69	29.38	1	29.38
7	4	6.5	26	7.86	31.42	7.86	31.46	87.49	14.69	58.76	2	117.52
8	1.5	5.92	8.88	7.85	11.78	7.86	11.80	84.55	14.20	21.30	3.00	63.89
8.5	2	4.72	9.44	7.82	15.63	7.85	15.70	78.29	13.15	26.29	3.50	92.02

9	1	2.5	2.50	6.96	6.96	7.14	7.14	61.03	10.25	10.25	4.00	40.99
9.5	2	2.48	4.96	4.52	9.05	4.75	9.51	43.85	7.36	14.72	4.50	66.26
10	0.5	0	0.00	0.00	0.00	1.38	0.69	-1.38	-0.23	-0.12	5.00	-0.58
Different totals		**Sum of the area products of WP 0**	139.09	**Sum of the area products of WP 1**	195.52	**Sum of the area products of WP 2**	204.59	**Summation of volume functions**		345.07	**Summation of moments**	142.42
Waterplane area		722.75		1015.93		1063.05						
SM		5		8		-1		**VOLUME**		**896.5168694**	**LCB**	**3.22**
Volume products		3613.74		8127.43		-1063.05		**Summation of volume products**	10678.12	**VOLUME**		**896.52**
Levers		0.00		1.00		2.00						
Moment about the keel		0.00		8127.43		-2126.11		**Summation of moments**	6001.32	**VCB**		**0.57**

Waterplane area, Displacement, LCB VCB calculation for WL - 2												
Water planes		**0**		**1**		**2**		**Station Distance**	7.7942	**WP Distance**		1.0075
	SM	**1**		**4**		**1**		**Area products for sectional area**	**Sectional area below waterline**	**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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-5.00	0.00
1	2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-4.50	0.00
1	1.0	0.00	0.00	0.00	0.00	6.68	6.68	6.68	4.49	4.49	-4.00	-17.96
2	2.0	0.00	0.00	7.32	14.63	7.73	15.45	36.99	24.85	49.69	-3.50	-173.93
2	1.5	6.21	9.31	7.84	11.77	7.86	11.79	45.45	30.52	45.79	-3.00	-137.36
3	4.0	6.50	26.00	7.86	31.42	7.86	31.46	45.79	30.75	123.02	-2.00	-246.04
4	2.0	6.50	13.00	7.86	15.71	7.86	15.73	45.79	30.75	61.51	-1.00	-61.51
5	4.0	6.50	26.00	7.86	31.42	7.86	31.46	45.79	30.75	123.02	0.00	0.00
6	2.0	6.50	13.00	7.86	15.71	7.86	15.73	45.79	30.75	61.51	1.00	61.51
7	4.0	6.50	26.00	7.86	31.42	7.86	31.46	45.79	30.75	123.02	2.00	246.04
8	1.5	5.92	8.88	7.85	11.78	7.86	11.80	45.19	30.35	45.53	3.00	136.60
9	2.0	4.72	9.44	7.82	15.63	7.85	15.70	43.84	29.44	58.89	3.50	206.10
9	1.0	2.50	2.50	6.96	6.96	7.14	7.14	37.47	25.17	25.17	4.00	100.68

10	2.0	2.48	4.96	4.52	9.05	4.75	9.51	25.33	17.01	34.03	4.50	153.13
10	0.5	0.00	0.00	0.00	0.00	1.38	0.69	1.38	0.93	0.46	5.00	2.32
Different totals		**Sum of the area products of WP 0**	139.09	**Sum of the area products of WP 1**	195.52	**Sum of the area products of WP 2**	204.59	**Summation of volume functions**		756.12	**Summation of moments**	269.59
Waterplane area		722.75		1015.93		1063.05						
SM		1		4		1		**VOLUME**		**1964.46**	**LCB**	**2.78**
Volume products		722.75		4063.71		1063.05		**Summation of volume products**	5849.52	**VOLUME**		**1964.46**
Levers		0		1		2						
Moment about the keel		0		4063.71		2126.11		**Summation of moments**	6189.82	**VCB**		**1.07**

Waterplane area, Displacement, LCB VCB calculation for WL - 3														
Water planes		**0**		**1**		**2**		**3**		**ST Distance**	7.7942	**WP Distance**		1.0075
	SM	**1**		**3**		**3**		**1**		**Area products for sectional area**	**Sectional area below waterline**	**Volume Function**	**Levers**	**Moments about amidship**
Section	**SM**	**y_0**	**y x SM**	**y_1**	**y x SM**	**y_2**	**y x SM**	**y_3**	**y x SM**					
0	0.5	0	0	0	0.000	0	0.00	0.00	0.00	0.00	0.00	0.00	-5	0.00
0.5	2	0	0	0	0.000	0	0.00	5.85	11.71	5.85	4.42	8.85	-4.5	-39.82
1	1	0	0	0	0.000	6.68	6.68	7.29	7.29	27.34	20.66	20.66	-4	-82.64
1.5	2	0	0	7.32	14.63	7.73	15.45	7.77	15.55	52.90	39.97	79.95	-3.5	-279.82
2	1.5	6.21	9.31	7.84	11.77	7.86	11.79	7.86	11.80	61.19	46.24	69.36	-3	-208.07
3	4	6.50	26.00	7.86	31.42	7.86	31.46	7.86	31.46	61.52	46.49	185.96	-2	-371.92
4	2	6.50	13.00	7.86	15.71	7.86	15.73	7.86	15.73	61.52	46.49	92.98	-1	-92.98
5	4	6.50	26.00	7.86	31.42	7.86	31.46	7.86	31.46	61.52	46.49	185.96	0	0.00
6	2	6.50	13.00	7.86	15.71	7.86	15.73	7.86	15.73	61.52	46.49	92.98	1	92.98
7	4	6.50	26.00	7.86	31.42	7.86	31.46	7.86	31.46	61.52	46.49	185.96	2	371.92
8	1.5	5.92	8.88	7.85	11.78	7.86	11.80	7.86	11.80	60.93	46.04	69.06	3	207.19
8.5	2	4.72	9.44	7.82	15.63	7.85	15.70	7.85	15.70	59.57	45.01	90.02	3.5	315.09
9	1	2.50	2.50	6.96	6.96	7.14	7.14	7.19	7.19	51.98	39.27	39.27	4	157.10

9.5	2	2.48	4.96	4.52	9.05	4.75	9.51	4.70	9.39	35.01	26.45	52.91	4.5	238.08
10	0.5	0.00	0.00	0	0.00	1.38	0.69	1.02	0.51	5.17	3.91	1.95	5	9.77
Different totals		**Sum of the area products of WP 0**	139.09	**Sum of the area products of WP 1**	195.52	**Sum of the area products of WP 2**	204.59	**Sum of the area products of WP 3**	216.75	**Summation of volume functions**		1175.87	**Summation of moments**	316.88
Waterplane area		722.75		1015.93		1063.05		1126.26						
SM		1.00		3.00		3.00		1.00		**VOLUME**		**3054.98**	**LCB**	**2.10**
Volume products		722.75		3047.79		3189.16		1126.26		**Summation of volume products**	8085.96	**VOLUME**		**3054.98**
Levers		0		1		2		3						
Moment about the keel		0.00		3047.79		6378.32		3378.79		**Summation of moments**	12804.90	**VCB**		**1.60**

Waterplane area, Displacement, LCB VCB calculation for WL - 4																
Water planes		**0**		**1**		**2**		**3**		**4**		**Distance**	7.79	**WP Distance**		1.01
	SM	**1**		**4**		**2**		**4**		**1**		**Area products for sectional area**		**Sectional area below waterline**	**Volume Function**	**Levers**	**Moments about amidship**
Section	**SM**	**y_0**	**y x SM**	**y_1**	**y x SM**	**y_2**	**y x SM**	**y_3**	**y x SM**	**y_4**	**y x SM**						
0	0.5	0	0	0	0.0	0.0	0.0	0.00	0.00	5.05	2.52	5.05	3.39	1.69		-5	-8.47
0.5	2	0	0	0	0.0	0.0	0.0	5.85	11.71	6.78	13.56	30.20	20.28	40.57		-4.5	-182.56
1	1	0	0	0	0.0	6.68	6.68	7.29	7.29	7.43	7.43	49.95	33.55	33.55		-4	-134.19
1.5	2	0	0	7.32	14.63	7.73	15.45	7.77	15.55	7.79	15.58	83.60	56.15	112.31		-3.5	-393.07
2	1.50	6.21	9.31	7.84	11.77	7.86	11.79	7.86	11.80	7.86	11.80	92.63	62.22	93.32		-3	-279.97
3	4	6.5	26	7.86	31.42	7.86	31.46	7.86	31.46	7.86	31.46	92.97	62.45	249.79		-2	-499.57

4	2	6.5	13	7.86	15.71	7.86	15.73	7.86	15.73	7.86	15.73	92.97	62.45	124.89	-1	-124.89
5	4	6.5	26	7.86	31.42	7.86	31.46	7.86	31.46	7.86	31.46	92.97	62.45	249.79	0	0.00
6	2	6.5	13	7.86	15.71	7.86	15.73	7.86	15.73	7.86	15.73	92.97	62.45	124.89	1	124.89
7	4	6.5	26	7.86	31.42	7.86	31.46	7.86	31.46	7.86	31.46	92.97	62.45	249.79	2	499.57
8	1.5	5.92	8.88	7.85	11.78	7.86	11.80	7.86	11.80	7.86	11.80	92.38	62.05	93.07	3	279.21
8.5	2	4.72	9.44	7.82	15.63	7.85	15.70	7.85	15.70	7.85	15.70	90.94	61.08	122.17	3.5	427.58
9	1	2.5	2.5	6.96	6.96	7.14	7.14	7.19	7.19	7.24	7.24	80.60	54.14	54.14	4	216.54
9.5	2	2.48	4.96	4.52	9.05	4.75	9.51	4.70	9.39	4.81	9.62	53.68	36.05	72.11	4.5	324.49
10	0.5	0	0	0.00	0.00	1.38	0.69	1.02	0.51	0.00	0.00	6.84	4.60	2.30	5	11.49
Different totals		**Sum of the area products of WP 0**	139.09	**Sum of the area products of WP 1**	195.52	**Sum of the area products of WP 2**	204.59	**Sum of the area products of WP 3**	216.75	**Sum of the area products of WP 4**	221.08	**Summation of volume functions**		1624.37	**Summation of moments**	261.04

Waterplane area	722.75	1015.93	1063.05	1126.26	1148.76					
SM	1	4	2	4	1	**VOLUME**		**4220.21**	**LCB**	**1.25**
Volume products	722.75	4063.71	2126.11	4505.06	1148.76	**Summation of volume products**	12566.39	**VOLUME**		**4220.21**
Levers	0.00	1.00	2.00	3.00	4.00					
Moment about the keel	0.00	4063.71	4252.21	13515.18	4595.04	**Summation of moments**	26426.14	**VCB**		**2.12**

Transverse Metacentric Height:

BM_T calculation													
Section	**SM**	**Section Distance**			7.7942			**Density of fresh water (t/m^3)**			1		
		1			**2**			**3**			**4**		
		y_1	**y^3**	**$y^3 \cdot SM$**	**y_2**	**y^3**	**$y^3 \cdot SM$**	**y_3**	**y^3**	**$y^3 \cdot SM$**	**y_4**	**y^3**	**$y^3 \cdot SM$**
0	0.5	0	0	0	0	0	0	0	0	0	5.05	128.54	64.27
0.5	2	0	0	0	0	0	0	5.85	200.69	401.38	6.78	311.90	623.81
1	1	0.00	0.00	0.00	6.68	298.67	298.67	7.29	386.94	386.94	7.43	410.42	410.42
1.5	2	7.32	391.66	783.31	7.73	461.24	922.48	7.77	469.74	939.49	7.79	472.78	945.56
2	1.5	7.84	482.51	723.76	7.86	486.15	729.22	7.86	486.33	729.49	7.86	486.33	729.49
3	4	7.86	484.87	1939.49	7.86	486.33	1945.32	7.86	486.33	1945.32	7.86	486.33	1945.32
4	2	7.86	484.87	969.74	7.86	486.33	972.66	7.86	486.33	972.66	7.86	486.33	972.66
5	4	7.86	484.87	1939.49	7.86	486.33	1945.32	7.86	486.33	1945.32	7.86	486.33	1945.32
6	2	7.86	484.87	969.74	7.86	486.33	972.66	7.86	486.33	972.66	7.86	486.33	972.66
7	4	7.86	484.87	1939.49	7.86	486.33	1945.32	7.86	486.33	1945.32	7.86	486.33	1945.32
8	1.5	7.85	484.14	726.22	7.86	486.33	729.49	7.86	486.33	729.49	7.86	486.33	729.49
8.5	2	7.82	477.63	955.26	7.85	483.60	967.20	7.85	483.96	967.92	7.85	484.14	968.29

9	1	6.96	336.96	336.96	7.14	363.62	363.62	7.19	371.34	371.34	7.24	379.32	379.32
9.5	2	4.52	92.64	185.27	4.75	107.36	214.72	4.70	103.54	207.09	4.81	111.34	222.68
10	0.5	0.00	0.00	0.00	1.38	2.65	1.33	1.02	1.06	0.53	0.00	0.00	0.00
TOTALS				11468.73			12008.00			12514.94			12854.59

Waterplane	**1**	**2**	**3**	**4**
Volume	896.52	1964.46	3054.98	4220.21
Δ	896.52	1964.46	3054.98	4220.21
Moment of Inertia, I	19864.35	**20798.40**	21676.44	22264.73
Transverse metacentric height, BM_T	22.16	10.59	7.10	5.28

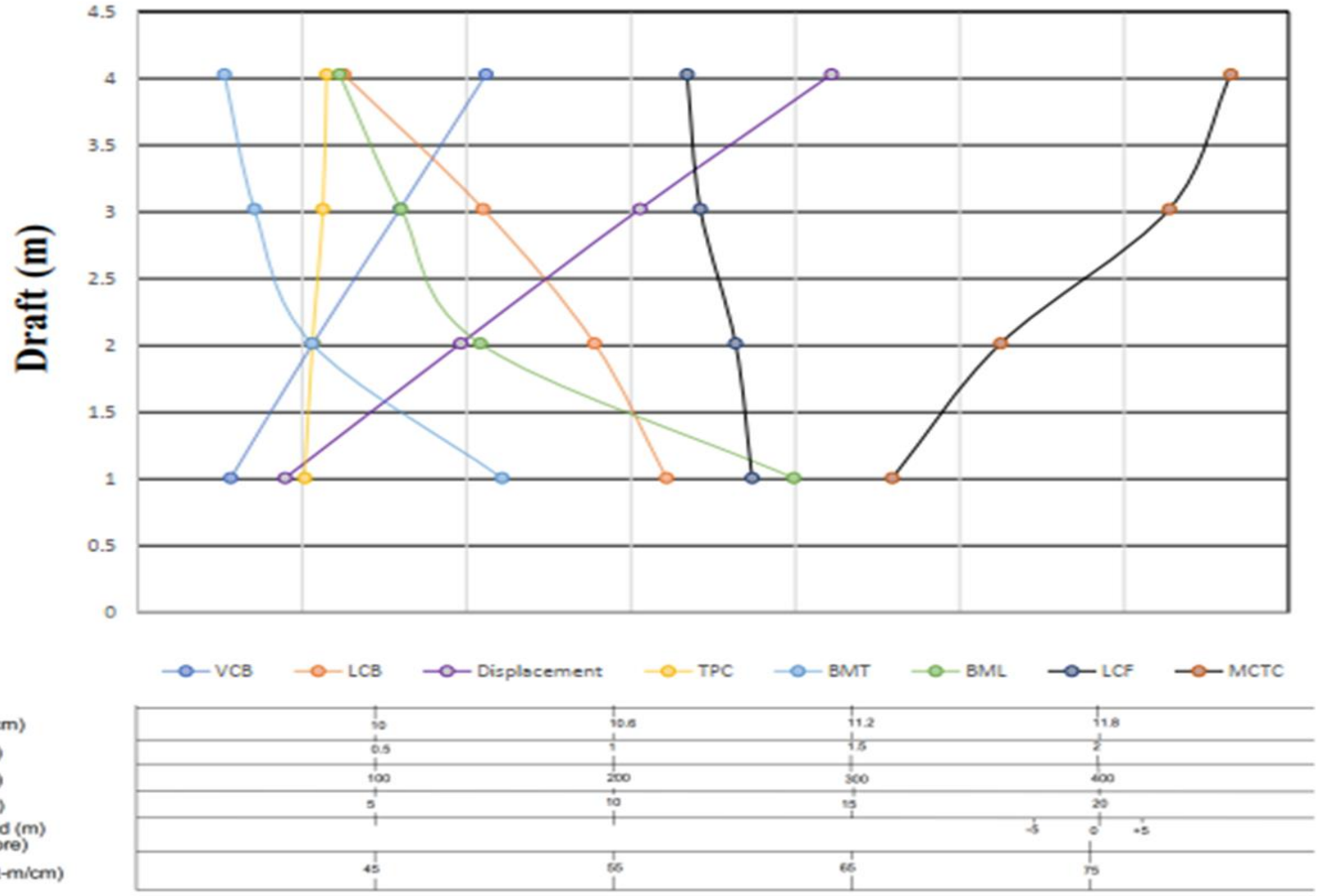
Longitudinal Metacentric Height:

LCF and BM_L calculation																		
Section	SM	Section Distance			7.7942		Length		77.942			Density of fresh water (t/m^3)		1				
		Levers from amidships (x)	1				2				3				4			
			y_1	y · SM	(y · SM) x	(y · SM) x^2	y_2	y · SM	(y · SM) x	(y · SM) x^2	y_3	y · SM	(y · SM) x	(y · SM) x^2	y_4	y · SM	(y · SM) x	(y · SM · SM) x^2
0	0.5	-5	0	0	0	0	0	0	0	0	0	0	0	0	5.05	2.52	-12.62	63.08
0.5	2	-4.5	0	0	0	0	0	0	0	0	5.85	11.71	-52.69	237.12	6.78	13.56	-61.04	274.66
1	1	-4	0.00	0.00	0.00	0.00	6.68	6.68	-26.74	106.95	7.29	7.29	-29.15	116.59	7.43	7.43	-29.73	118.90
1.5	2	-3.5	7.32	14.63	-51.22	179.25	7.73	15.45	-54.08	189.30	7.77	15.55	-54.41	190.45	7.79	15.58	-54.53	190.86
2	1.5	-3	7.84	11.77	-35.30	105.89	7.86	11.79	-35.38	106.15	7.86	11.80	-35.39	106.16	7.86	11.80	-35.39	106.16
3	4	-2	7.86	31.42	-62.85	125.70	7.86	31.46	-62.91	125.82	7.86	31.46	-62.91	125.82	7.86	31.46	-62.91	125.82
4	2	-1	7.86	15.71	-15.71	15.71	7.86	15.73	-15.73	15.73	7.86	15.73	-15.73	15.73	7.86	15.73	-15.73	15.73

5	4	0	7.86	31.42	0.00	0.00	7.86	31.46	0.00	0.00	7.86	31.46	0.00	0.00	7.86	31.46	0.00	0.00
6	2	1	7.86	15.71	15.71	15.71	7.86	15.73	15.73	15.73	7.86	15.73	15.73	15.73	7.86	15.73	15.73	15.73
7	4	2	7.86	31.42	62.85	125.70	7.86	31.46	62.91	125.82	7.86	31.46	62.91	125.82	7.86	31.46	62.91	125.82
8	1.5	3	7.85	11.78	35.33	106.00	7.86	11.80	35.39	106.16	7.86	11.80	35.39	106.16	7.86	11.80	35.39	106.16
8.5	2	3.5	7.82	15.63	54.72	191.51	7.85	15.70	54.94	192.31	7.85	15.70	54.96	192.35	7.85	15.70	54.97	192.38
9	1	4	6.96	6.96	27.83	111.34	7.14	7.14	28.55	114.20	7.19	7.19	28.75	115.00	7.24	7.24	28.96	115.82
9.5	2	4.5	4.52	9.05	40.72	183.25	4.75	9.51	42.78	192.49	4.70	9.39	42.26	190.18	4.81	9.62	43.30	194.84
10	0.5	5	0	0	0	0	1.38	0.69	3.46	17.30	1.02	0.51	2.55	12.73	0	0	0	0
TOTALS				195.52	72.10	1160.07		204.59	48.91	1307.96		216.75	-7.74	1549.86		221.08	-30.69	1645.98
			1				**2**				**3**				**4**			
Volume			**896.52**				**1964.46**				**3054.98**				**4220.21**			
Water plane Area			**1015.93**				**1063.05**				**1126.26**				**1148.76**			
TPC			**10.16**				**10.63**				**11.26**				**11.49**			

LCF from Amidship	**2.87**	**1.86**	**-0.28**	**-1.08**
LCF from Aft	**37.37**	**36.36**	**34.22**	**33.42**
Moment of inertia about the amidship	**366190.07**	**412875.11**	**489233.34**	**519574.14**
Moment of inertia about the LCF	**357797.28**	**409183.72**	**489146.14**	**518229.11**
Longitudinal Metacenter BM_L	**399.10**	**208.29**	**160.11**	**122.80**
Δ	**896.52**	**1964.46**	**3054.98**	**4220.21**
MCT 1 cm	**45.91**	**52.50**	**62.76**	**66.49**

Hydrostatic Curve



Scantling Calculation

(IRS Inland Rules 2021)

Scantling Calculation: Thickness of Plates

Deadweight	3000	tonnes
Speed	10	knots
L	77.942	m
B	15.728	m
D	5.406	m
T	4.030	m
Displacement	4243.9031	tonnes
C_b	0.859	

IRS inland rules: Section 1.2; Chapter 2

Material Factor, K = 1

Minimum Yield stress = 235 N/mm^2

Range for Tensile Strength = 400-490 N/mm^2

Taken, Tensile Strength = 450 N/mm^2

IRS inland rules: Section 1.4; Chapter 2

Plate thickness, ts = 20 mm

Frame Spacing = 650 mm

IRS inland rules: Section 2.1; Chapter 3

Corrosion Addition

Tc = 2 mm

IRS inland rules: Section 3.1 ; Chapter 6

Design Load

At Bottom Shell

T1 = T+1 [L > 60m]

= 4.030+1

= 5.030 m

Load, P = 10 T_1

= 10 * 5.030

= 50.303 KN/m^2

At inner bottom

H = height [m], to deck or top of hatchway coaming

= 5.406 m

Load, P =12.5 * ρ * H

= 12.5*0.7* 5.406

= 47.306 t/m^2

IRS inland rules: Section 2.1; Chapter 5

Bar Keel

Depth = 75 + 0.75 L

= 75 + (0.75 *77.942)

= 133.46 mm

Thickness = 10 + 0.4 L

= 10 + (0.4 *77.942)

= 41.18 mm

IRS inland rules: Section 3.1; Chapter 5

Stem

Cross Sectional Area = 0.6L

= 0.6 *77.942

= 46.77 cm^2

Thickness = (0.08 L + 5.0)

= (0.08 * 77.942) + 5.0

= 11.24 mm

IRS inland rules: Section 4.1; Chapter 6

Bottom Structure

Double Bottom calculations

Bottom Plate Thickness = (4 +0.04L) + tc

= (4+0.04*77.942) + 2

= 9.118 mm

Width of Keel Plate = 400+10*L

=400 + (10*77.942)

= 1179.421 mm

Keel Plate Thickness = Bottom Plate Thickness +1

= 9.118 +1

= 10.118 mm

Inner Bottom Thickness = (4+0.03*L)+2

= (4+0.03*77.942)+2

= 8.338 mm

IRS inland rules: Section 6.1 ; Chapter 6

Depth of the center Girder, d = 250 + 20B + 50T

= 250 +(20*15.728) + (50*4.030)

= 766.069 mm

Minimum thickness of bottom girder, t = (0.007d + 3)

= (0.007*766.069) + 3

= 8.362 mm

Minimum thickness of floors t = (0.007d + 3)

= (0.007*766.069) + 3

= 8.362 mm

IRS inland rules: Section 4.1; Chapter 7

Side Shell Plating and Stiffeners

Minimum Side shell plating, t = (4 + 0.04L) + tc

= (4+0.04*77.942) + 2

= 9.118 mm

Minimum Breadth of sheer strake = 100 D

= 100 * 5.406

= 540.643 mm

IRS inland rules: Section 3.1; Chapter 8
Deck Structure

$h_o = D - T$

$= 5.406 - 4.030$

$= 1.376$

$H_1 = 15$

Pressure on exposed decks, = H1 - 10 ho

$= 15 – (10 * 1.376)$

$= 1.238\ kN/mm^2$

For strength and forecastle deck,

to = 5

Minimum Thickness of Deck Plating $t = (to+0.02L)\sqrt{k} + t_c$

$= (5+0.02*77.942) + 2$

$= 8.559$ mm

For other decks,

to = 4

Minimum Thickness of Deck Plating $t = (to+0.02L)\sqrt{k} + t_c$

$= (4+0.02*77.942) + 2$

$=7.559$ mm

IRS inland rules: Section 5.1.2; Chapter 9

Bulkheads

Minimum bulkhead thickness = t = (4.0 + 0.01L) + tc

= (4+0.01*77.942)+2

= 6.779 mm

Design Pressure , p = 10 h

= 10*(D/2)

=10*(5.406/2)

= 27.032 KN/m^2

Bulkhead Thickness (watertight bulkhead) ,t = $15.8s\sqrt{p/\sigma} \times 0.001 + tc$

= 15.8*650*((27.032 /220)^0.5)*0.001 + 2

= 5.600 mm or 7 mm

= 7mm, is taken

Bulkhead thickness (tank and collision bulkhead) , t = $15.8s\sqrt{p/\sigma} \times 0.001 + tc$

= 15.8*650*(27.032 /160)^(1/2)*0.001 + 2

= 6.221 mm or 7 mm

= 7mm, is taken

IRS inland rules: Section 4.3.1 & 2.1.1; Chapter 10

Superstructures, Deckhouses and Bulwarks

Bulwark Thickness = 6 mm

Lower tier Thickness , t = (0.004 s + 2.5) √k

=(0.004*650)+2.5

=5.1 mm

Upper tier thickness ,t = (0.004 s + 1.5) √k

= (0.004*650)+1.5

= 4.1 mm

IRS inland rules: Section 2.3.1& 3.3.1; Chapter 11

Hatch

Hatch coaming thickness

At strength and forecastle deck = Minimum Thickness of Deck Plating at strength and forecastle deck

= (to+0.02L) √k + tc

= (5+0.02*77.942) + 2

= 8.559 mm

Others = Minimum Thickness of Deck Plating at other decks t

= (to+0.02L) √k + tc

= (4+0.02*77.942) + 2

=7.559 mm

Hatch Cover thickness = $15.8s\sqrt{p/\sigma} \times 0.001 + tc$

= 15.8*M17*((D99/G5)^(1/2))*0.001+D12

= 8.124 mm

Design pressure = 160/k

= 160/1

=160 N/mm^2

IRS inland rules: Section 2.2 ; Chapter 10

Machinery Thickness

Minimum Machinery casing thickness = $(0.003\ s + 1.5)\ \sqrt{k}$

$= (0.003*650)+1.5$

$= 3.45mm$

Minimum Exposed Machinery casing = 20% of Minimum Machinery casing thickness

$= 3.45+3.45*20\%$

$= 4.14$ mm

IRS rules for bulk cargo carriers

Part 1 Chapter 6 Section 3.1.1

Machinery Thickness

Double bottom centreline girder = Machinery space

$= 1.55(L_2)^{1/3} + 3.5$

$= 1.55*(77.946\ ^{(1/3))+3.5}$

$= 10.121$ mm

Other bottom Girder = Machinery space = $1.7\ (L_2)^{1/3} + 1.0$

$= 1.7*(77.946\ ^{(1/3))+1}$

$= 8.262$ mm

Bottom Floor = Machinery space = $1.7\ (L_2)^{1/3} + 1.0$

$= 1.7*(77.946\ ^{(1/3))+1}$

$= 8.262$ mm

Scantling Calculation: Section Modulus Of Structural Members

Deadweight	3000	tonnes
Speed	10	knots
L	77.94209643	m
B	15.72780697	m
D	5.406433647	m
T	4.030250537	m
Displacement	4243.903125	tonnes
Cb	0.859	

Bottom Structures

Bottom Frames and Reverse Frames **[Pt -3, CH -6,Sec-6,6.3.4]**

$$Z = \frac{splk^2}{1.6} \times 10^{-3} + Z_c \text{ cm}^3$$

Design Pressure p=10T1=50.30250537 kN/m^2

T1=T+1=5.030250537 m

Spacing of Stiffeners s= 650 mm

Span of Stiffeners l= 1.75 m

Material Factor k= 1

Section Modulus Z= 62.58339047 cm^3

T-300×150×10

Side Structures:

Design Pressure , pi=10 (hs +1) [kN/m2] $\mathbf{10h0 + \left(15 - 5\frac{h0}{T}\right)\ for\ L \geq 60}$

vertical distance [m], from the maximum load waterline to the loadpoint. h_0=1.6 m

External Pressure , p= 29.01501174 kN/m^2

Internal Tank Pressure

The vertical distance [m] from the load point to the top of tank ,h_s = 0.4 m

Internal Tank Pressure,P= 14 kN/m^2

Main Frames [Pt 3, CH 7, Sec-4 ,4.3.1]

Spacing of Stiffeners s= 650 mm

Span Of stiffeners l= 2.6 m

Material factork= 1

$$Z = \frac{splk^2}{2400} \times 10^{-3} + Z_c \text{ cm}^3$$

Section Modulus, Z= 48.55665162 cm^3

L-130×130×12

Main Frame Brackets	**Upper Bracket**	**70 l**	**182**	**mm**
	Lower Bracket	**120 l**	**312**	**mm**

Side Stringers **[Pt 3, CH 7, Sec-5 ,5.1.5]**

h0=1.6

Design Pressure p= 29.01501174 kN/m^2

Spacing of Girders b= 2.6 m

Span of Girders S= 2.6 m

Material Factor k= 1

Allowable stress σ= 160 N/mm^2

Constant m= 12

$$Z = \frac{bpS^2}{m\sigma} \times 10^3 + Z_c \text{ cm}^3$$

Section Modulus ,Z= 265.6082533 cm^3

T-350×175×13

Side Web Frames **[Pt 3, CH 7, Sec-5 ,5.1.5]**

h0 =1.6 m

Design Pressure p= 29.01501174 kN/m^2

Spacing of Girders b= 2.6 m

Span of Girders S= 2.6 m

Material Factor k= 1

Allowable stress σ= 160 N/mm^2

Constant m= 12

$$Z = \frac{bpS^2}{m\sigma} \times 10^3 + Z_c \text{ cm}^3$$

Section Modulus, Z=265.6082533 cm^3

T-350×175×13

Deck Structure

Design Load

Vertical distance [m], from the maximum load waterline to the deck, h_0=1.37618311 m

H1= 15

Weather Deck Design Load p= H_1-10h_0=5 kN/m^2

Accomodation Decks Design Load p=4.5 kN/m2

Transverse Deck Beams [Pt 3, CH-8, Sec 4, 4.2.2]

Weather Deck

Spacing Of stiffeners s= 650 mm

Span of stiffeners l= 1.75 m

$$Z = \frac{spl^2}{1600} \times 10^3 + Z_c \text{ cm3}$$

Section Modulus Z= 6.220703125 cm^3

T-62.5×6.5 and 125×9

Accommodation Deck

Section Modulus ,Z= 5.598632813 cm^3

T-62.5×6.5 and 125×9

Deck Girders [Pt 3 , CH 8 , Sec 5 , 5.1.3]

Spacing of Girders	b=	2.6	m
Span of Girders	S=	2.6	m
Constant	m=	12	
Material Factor	k=	1	
Allowable stress	σ=	160	N/mm^2

$$Z = \frac{bpS^2}{m\sigma} \times 10^3 + Z_c \ cm^3$$

Z= 45.77083333 cm^3

T-150×8 and 200×12

Bulkheads

The vertical distance [m] from the loadpoint

to the uppermost continuous deck. h= 2.305 m

Ordinary Water Tight Bulkhead Loads p= 23.05 kN/m^2

Stiffener Spacing s= 650 mm

Span of Stiffeners	l=	1.75	m
Constant	m=	10	
Allowable Stress	σ=	160	N/mm^2
Material Factor	k=	1	

Bulkhead Stiffener [Pt -3, CH-9, Sec-5, 5.3.1]

$$Z = \frac{spl^2}{m\sigma} \times 10^3 + Z_c \text{ cm}^3$$

Section Modulus Z= 28.67744141 cm^3

L-100×100×12

Bulkhead Girder [Pt -3, CH-9, Sec-6, 6.1.2]

Spacing of Girders	b=	2.6	m
Span of Girders	S=	2.6	m
Constant	m=	12	
Material Factor	k=	1	
Allowable stress	σ=	210	N/mm^2

$$Z = \frac{bpS^2}{m\sigma} \times 10^3 + Z_c \text{ cm}^3$$

Section Modulus Z= 160.7646032 cm^3

L-200×200×14

Superstructure [PT-3, CH-10, SEC-2 ,2.1.2]

The section modulus Z of stiffeners on fronts, sides and aft ends of deck houses and the front and aft ends of superstructures is not to be less than:

$z = 3.6sl^2 \times 10^{-3}.k\ cm3$

Spacing of Stiffeners s= 650 mm

Span of stiffeners l= 2 m

Material Factor k= 1

Section Modulus Z= 9.36 cm^3

L-80×80×8

Hatch Cover

Stiffeners and Girders [Pt 3, Ch-11, Sec 3,3.4.1]

Design Load p= 3 kN/m^2

Member spacing s=2.14 m

Member Span l=2.14 m

Constant m=12

$$Z = \frac{6.25spl^2}{m}\ cm3$$

Section Modulus Z= 15.3130375 cm^3

T-150×9 , 100×6

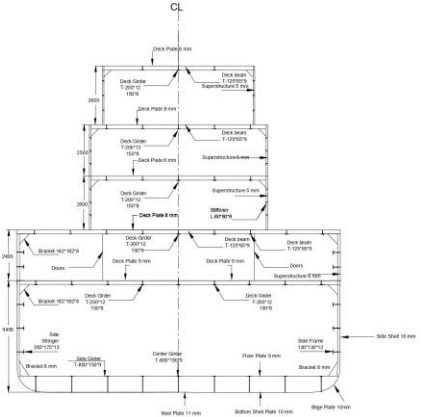
Scantling Calculation Summary

PLATE	THICKNESS
Bottom Plate Thickness	**10 mm**
Keel Plate Thickness	**11 mm**
Inner Bottom Thickness	**9 mm**
Floor Thickness	**9 mm**
Side Shell Plating	**10 mm**
Deck Plating (Strength and Forecastle Deck)	**9 mm**
Deck plating (Other Deck)	**8 mm**
Bulkhead Thickness (Watertight Bulkhead)	**6 mm**
Bulkhead Thickness (Tank and Collision Bulkhead)	**7 mm**
Bulwark Thickness	**6 mm**
Superstructure Thickness (Upper tier)	**5 mm**
Superstructure Thickness Lower Tier)	**6 mm**
Hatch Coaming Thickness (Strength and Forecastle deck)	**9 mm**
Hatch Coaming Thickness (Others)	**8 mm**
Hatch Cover Thickness	**9 mm**
Machinery Casing Thickness	**4 mm**
Machinery Casing (Bottom floor)	**9 mm**
Sheerstrake Thickness	**11 mm**
Bilge Plate Thickness	**10 mm**

STRUCTURAL MEMBERS	
Center Girder	**T-800×150×9**
Side Girder	**T-800×150×9**
Floor	**T-800×150×9**
Side Web Frame	**T-350×175×13**
Side Frame	**L-130×130×12**
Side Stringers	**T-350×175×13**
Deck Girders	**T-200×12, 150×8**
Deck Web beam	**T-125×65×9**
Bulkhead Stiffeners	**L-100×100×12**
Bulkhead Girders	**L-200×200×14**
Superstructure Stiffeners	**L-80×80×8**
Girder(Machinery Space)	**T-800×150×9**
Web Frame(Machinery Space)	**T-350×175×13**
Hatch Cover Stiffeners and Girders	**T-150×9, 100×6**

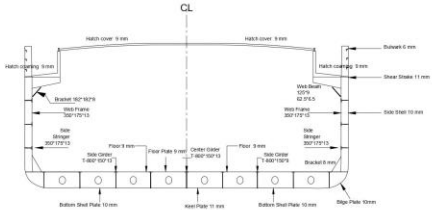
Midship Section

MAIN PARTICULARS	
Length(0A)	81.161 m
Length(WL)	78.955 m
Length(BP)	77.942 m
Breadth(Moulded)	15.728 m
Depth(Moulded)	5.406 m
Draft(Design)	3.588 m
Frame Spacing	650 mm
Service Speed	10 knot
Deadweight	3000 T



FRAME NO- 16

MIDSHIP SECTION



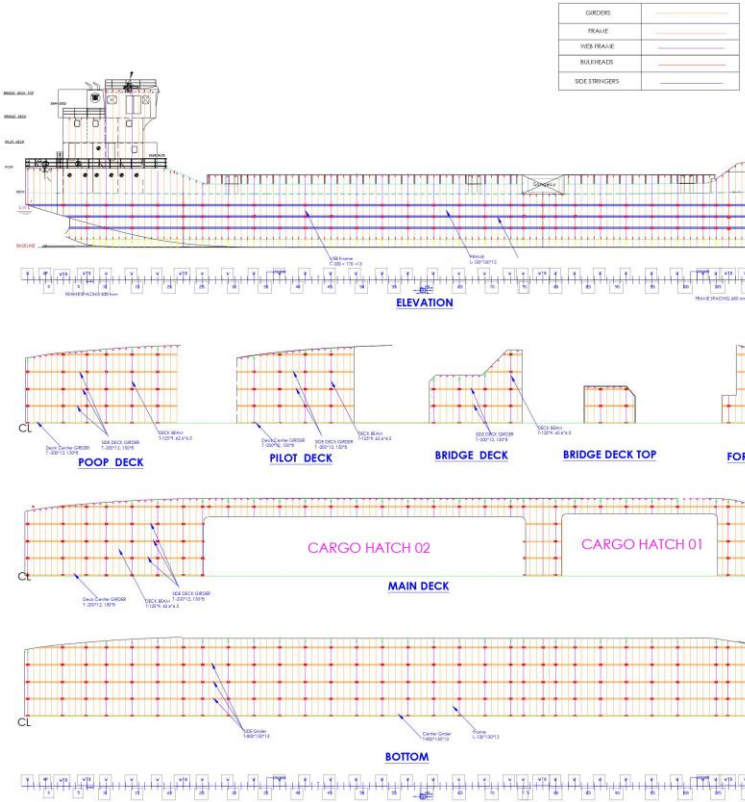
FRAME NO- 45 (Web)

MIDSHIP SECTION

MIDSHIP SECTION	
Student ID	**Name**
1712002	Noshin Tarannum
1712043	Rafid Imam

Longitudinal Construction

MAIN PARTICULARS	
Length(0A)	81.161 m
Length(WL)	78.955 m
Length(BP)	77.942 m
Breadth(Moulded)	15.728 m
Depth(Moulded)	5.406 m
Draft(Design)	4.030 m
Frame Spacing	650 mm
Service Speed	10 knot
Deadweight	3000 T



LONGITUDINAL CONSTRUCTION	
Student ID	Name
1712002	Noshin Tarannum
1712043	Rafid Imam

Shell Expansion

MAIN PARTICULARS	
Length(0A)	81.161 m
Length(WL)	78.955 m
Length(BP)	77.942 m
Breadth(Moulded)	15.728 m
Depth(Moulded)	5.406 m
Draft(Design)	3.588 m
Frame Spacing	650 mm
Service Speed	10 knot
Deadweight	3000 T

SYMBOLS

- Web frame
- Strake lines
- Welding lines
- BHD

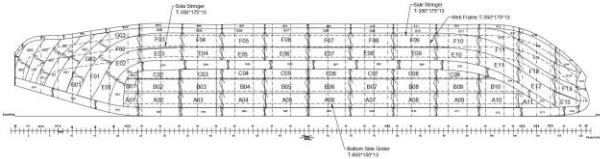


PLATE SIZE TABLE

K STRAKE		A STRAKE		B STRAKE		C STRAKE		D STRAKE		E STRAKE		F STRAKE		G STRAKE		H STRAKE		I STRAKE		J STRAKE		I STRAKE		M STRAKE		N STRAKE		S STRAKE	
PLT. NO	SIZE	PLT. NO	SIZE	PLT. NO	SIZE	PLT. NO	SIZE	PLT. NO	SIZE	PLT. NO	SIZE	PLT. NO	SIZE	PLT. NO	SIZE	PLT. NO	SIZE	PLT. NO	SIZE	PLT. NO	SIZE	PLT. NO	SIZE	PLT. NO	SIZE	PLT. NO	SIZE	PLT. NO	SIZE
K1	8000X12800X16mm	A1	2500X2800X10mm	B1	2000X2800X10mm	C1	7550X1000X10mm	D1	3800X1500X10mm	E1	4000X2800X16mm	F1	8000X2800X16mm	G1	8000X2800X16mm	H1	8000X2800X16mm	I1	6000X3000X10mm	J1	2000X2000X10mm	L1	3750X2800X16mm	M1	2500X2800X10mm	N1	15000X800X16mm	S1	7150X8000X11mm
K2	8000X12800X16mm	A2	6000X2800X16mm	B2	5000X2800X16mm	C2	8000X14000X16mm	D2	8000X12500X10mm	E2	5000X2800X16mm	F2	8000X2800X16mm	G2	6000X2800X16mm	H2	8000X2800X16mm	I2	6000X1500X10mm	J2	3500X2800X16mm	L2	3750X2800X16mm	M2	4000X2800X16mm			S2	8000X8000X11mm
K3	8000X12800X16mm	A3	8000X2800X16mm	B3	8000X2800X16mm	C3	8000X14000X16mm	D3	8000X12500X10mm	E3	8000X2800X16mm	F3	8000X2800X16mm	G3	8000X1500X16mm	H3	8000X1200X16mm			J3	3750X2800X16mm							S3	8000X8000X11mm
K4	8000X12800X16mm	A4	8000X2800X16mm	B4	8000X2800X16mm	C4	8000X14000X16mm	D4	8000X12500X10mm	E4	8000X2800X16mm	F4	8000X2800X16mm	G4	8000X8000X16mm	H4	8000X2800X16mm											S4	8000X8000X11mm
K5	8000X12800X16mm	A5	8000X2800X16mm	B5	8000X2800X16mm	C5	8000X14000X16mm	D5	8000X12500X10mm	E5	8000X2800X16mm	F5	8000X2800X16mm	G5	6000X7000X10mm	H5	3750X1700X16mm											S5	8000X8000X11mm
K6	8000X12800X16mm	A6	8000X2800X16mm	B6	8000X2800X16mm	C6	8000X14000X16mm	D6	8000X12500X10mm	E6	8000X2800X16mm	F6	8000X2800X16mm	G6	6000X7000X10mm													S6	8000X8000X11mm
K7	8000X12800X16mm	A7	6000X2800X16mm	B7	5000X2800X16mm	C7	8000X14000X16mm	D7	8000X12500X10mm	E7	8000X2800X16mm	F7	8000X2800X16mm	G7	6000X7000X10mm													S7	8000X8000X11mm
K8	8000X12800X16mm	A8	8000X2800X16mm	B8	8000X2800X16mm	C8	8000X14000X16mm	D8	8000X12500X10mm	E8	8000X2800X16mm	F8	8000X2800X16mm	G8	6000X7000X10mm													S8	8000X8000X11mm
K9	8000X12800X16mm	A9	8000X2800X16mm	B9	8000X2800X16mm	C9	8000X14000X16mm	D9	8000X12500X10mm	E9	8000X2800X16mm	F9	8000X2800X16mm	G9	6000X7000X10mm													S9	8000X8000X11mm
K10	8000X12800X16mm	A10	8000X2800X16mm	B10	8000X2800X16mm	C10	3500X7900X16mm	D10	8000X12500X10mm	E10	8000X2800X16mm	F10	8000X2800X16mm	G10	6000X7000X10mm													S10	8000X8000X11mm
K11	8000X12800X16mm	A11	1600X4800X16mm					D11	8000X12500X10mm	E11	4000X2800X16mm	F11	8000X2800X16mm	G11	6000X10000X10mm													S11	8000X8000X11mm
K12	8000X12800X16mm							D12	3500X12500X10mm	E12	6000X2800X16mm	F12	8000X2800X16mm	G12	8000X2800X16mm													S12	8000X8000X11mm
K13	8000X12800X16mm									E13	4000X2800X16mm	F13	3500X2800X16mm	G13	6000X2800X16mm													S13	8000X8000X11mm
K14	8000X12800X16mm													G14	4000X2800X16mm													S14	8000X8000X11mm
K15	8000X12800X16mm																											S15	5000X8000X11mm
K16	8000X12800X16mm																												

SHELL EXPANSION	
Student ID	**Name**
1712002	**Noshin Tarannum**
1712043	**Rafid Imam**

Preliminary
Weight Calculation

Preliminary

Lightweight and Deadweight Calculation

Total Weight of plates	417.98
Total weight of structural and stiffening members	185.72
Total Steel weight (considering 10% scrap)	**664.07**

Machinery weight	44.28

Wood and Outfit Weight	12.60

Lightweight	**720.97**

Capacity of the Cargo Holds	2886.86
Capacity of Fresh Water Tank	11.25
Capacity of Fuel Oil Reserve Tank	26.4
Capacity of Lubricating Oil Reserve Tank	0.66
Capacity of Forward Ballast Water Tank	160.19
Crew weight	1.12
Provision	0.80
Deadweight	**3089.21**

Lightweight	720.97
Deadweight	3089.21
Displacement	**3810.18**

Preliminary calculated deadweight was **3000** tones.

Preliminary calculated displacement was **4243.90** tones

Resistance and Power Calculation

Resistance Calculation by Holtrop and Mennen's Method

Frictional Resistance, R_F	35.6 kN
Wave-Making Resistance, R_W	10.5 kN
Appendage Resistance , R_{APP}	1.64 kN
Model Ship Correlation Resistance , R_A	11.7 kN
Air Resistance , R_{AA}	12.1 kN
Total Resistance, R_T	**90 kN**
Total Resistance Co-efficient, C_T	4.32×10^{-3}

Power Calculation

Efficiencies and QPC Calculation

Taylor Wake Fraction , w_T = 0.26

Thrust Deduction Factor , t = 0.22

Hull Efficiency , n_H = 1.057

Relative Rotative Efficiency, n_R = 1.028

QPC, Open Water Efficiency and Propeller RPM

	Method 1 (B_P- Delta Chart)	**Method 2 (K_T and K_Q)**
QPC	0.475	0.478
Propeller Open Water Efficiency, n_O	0.44	0.446
Propeller RPM	325	329

Note: Detailed Calculation is provided in Appendix 1

Power Calculation Summary

Total resistance	R_T	$R_F + R_{APP} + R_w + R_A + R_{AA}$	90	kN
Effective Power	P_E	R_T*V	460.52	kW
QPC			0.47	
Delivered Power	P_D		969.66	kW
Shaft Efficiency	n_S		0.95	
Shaft Power	P_S		1020.69	kW
		Transmission line loss 5% for transmission via gear box		
Engine power			1074.41	kW
Brake Power	P_b	(85% MCR),Considering 15% sea margin	1200.81	kW
Total installed power	P_I	(100% MCR)	1412.72	kW
			710*2	kW

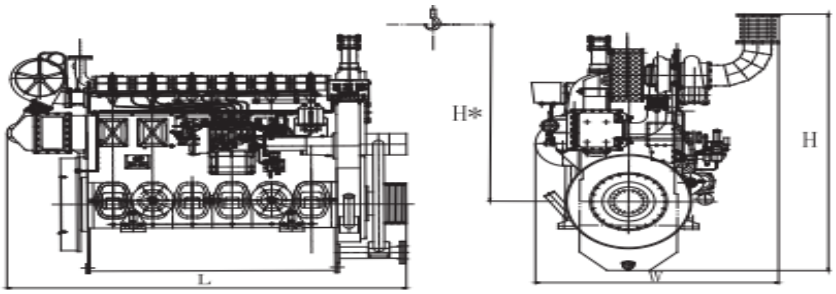
Note: Detailed Calculation is provided in Appendix 1

Engine Selection

We finally considered **Two Engines** of 710 kW or 950 HP

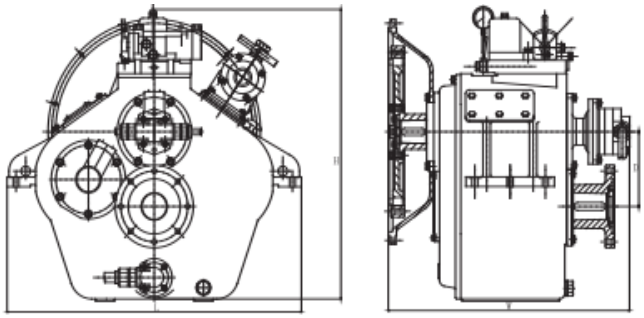
Engine Specifications
Model No: XCW6200ZC-1 (Ref. Marine Propulsion Engine, Weichai Catalogue)
Engine Power: 720 kW or 969 HP
Engine RPM: 1000
Net Weight: 6300 kg
Mechanical Pump Bore and stroke: 200×270 mm
Displacement: 50.89 L
Min Fuel Consumption: 200 g /kW-h
Dimension: L-2828 mm, W-1726 mm, H-2412mm, H*-2000 mm

Note: Detailed Calculation is provided in Appendix 1



Gear Box Selection

Marine Gear Box Specifications
Model: WHG120 (Ref. Marine Propulsion Engine, Weichai Catalogue)
Input Speed: 750-2000 RPM
Gear Rati: 3.03
Net Weight: 120 kg
Dimension: 792 mm× 609 mm× 736 mm



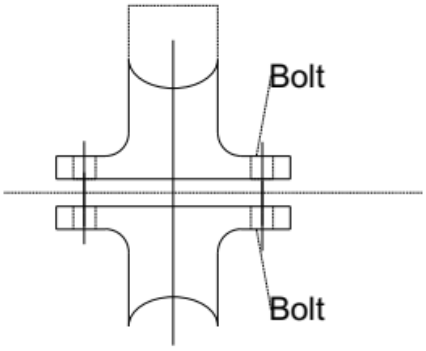
Note: Detailed Calculation is provided in Appendix 1

Rudder Calculation Summary

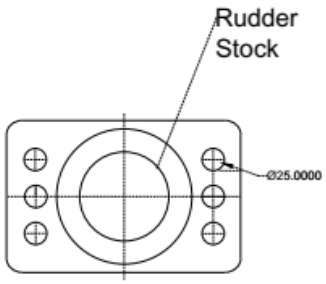
ITEM	VALUES
Area of a Single Rudder	2.98 m^2
Rudder Force	60.40 kN
Rudder Torque	21.20 kN-m
Rudder Stock Diameter	100 mm
Rudder Coupling Bolt Diameter	25 mm
Rudder Coupling Flange Thickness	25 mm
Rudder Pintle Thickness	8 mm
Rudder Pintle Diameter	55 mm
Rudder Plate Thickness	8 mm
Rudder Web Plate Thickness	7 mm
Rudder Horizontal Frame Spacing	560 mm
Rudder Vertical Frame Spacing	830 mm
Rudder Profile	NACA -0020

Note: Detailed Calculation is provided in Appendix 2

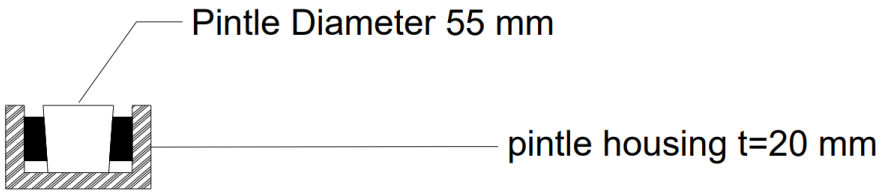
Details of Rudder Drawing:



Coupling Details

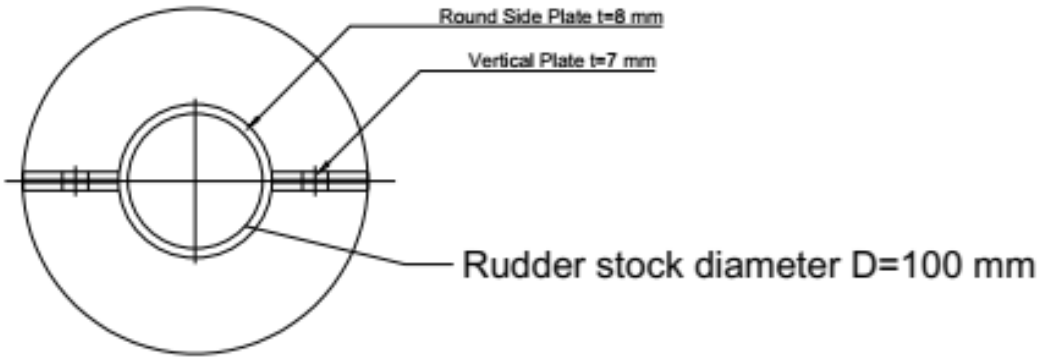


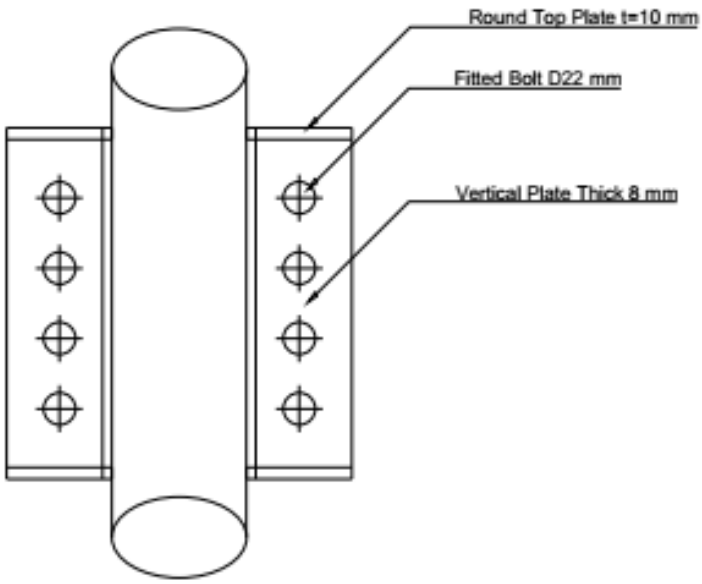
Coupling Flange



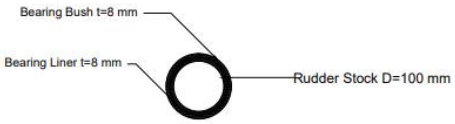
Pintle

Details of Rudder Drawing (Contd….)

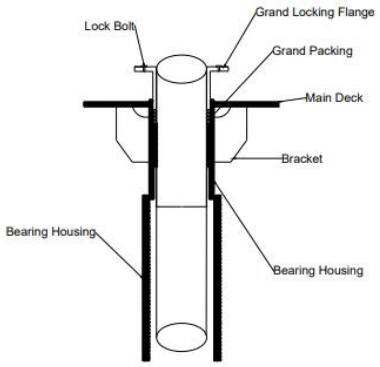




Jumping Clamp



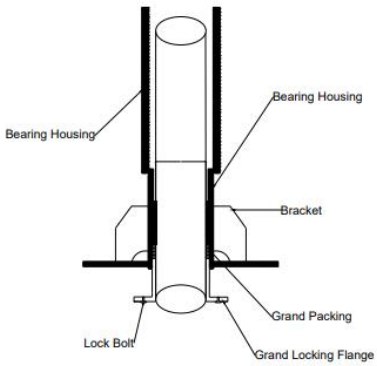
Top View



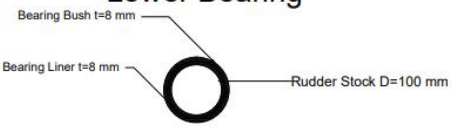
Upper Bearing

Bottom View

Top View

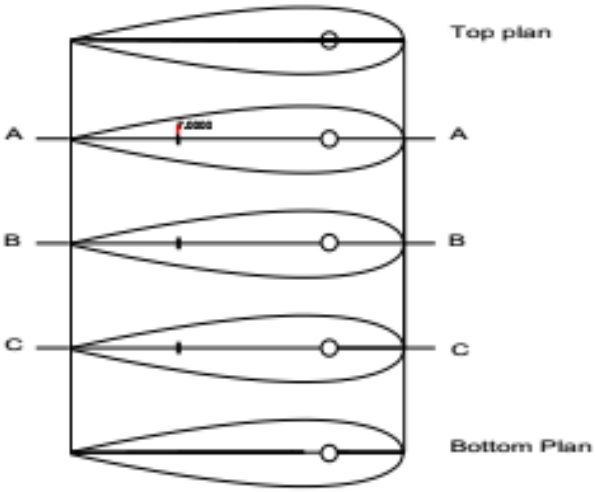


Lower Bearing

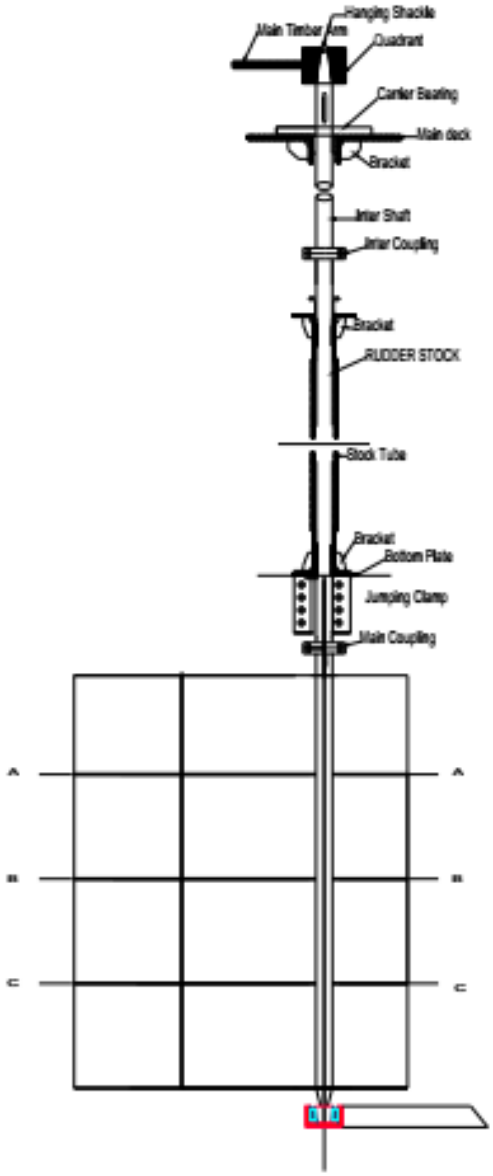


Bottom View

Details of Rudder Drawing (Contd….)

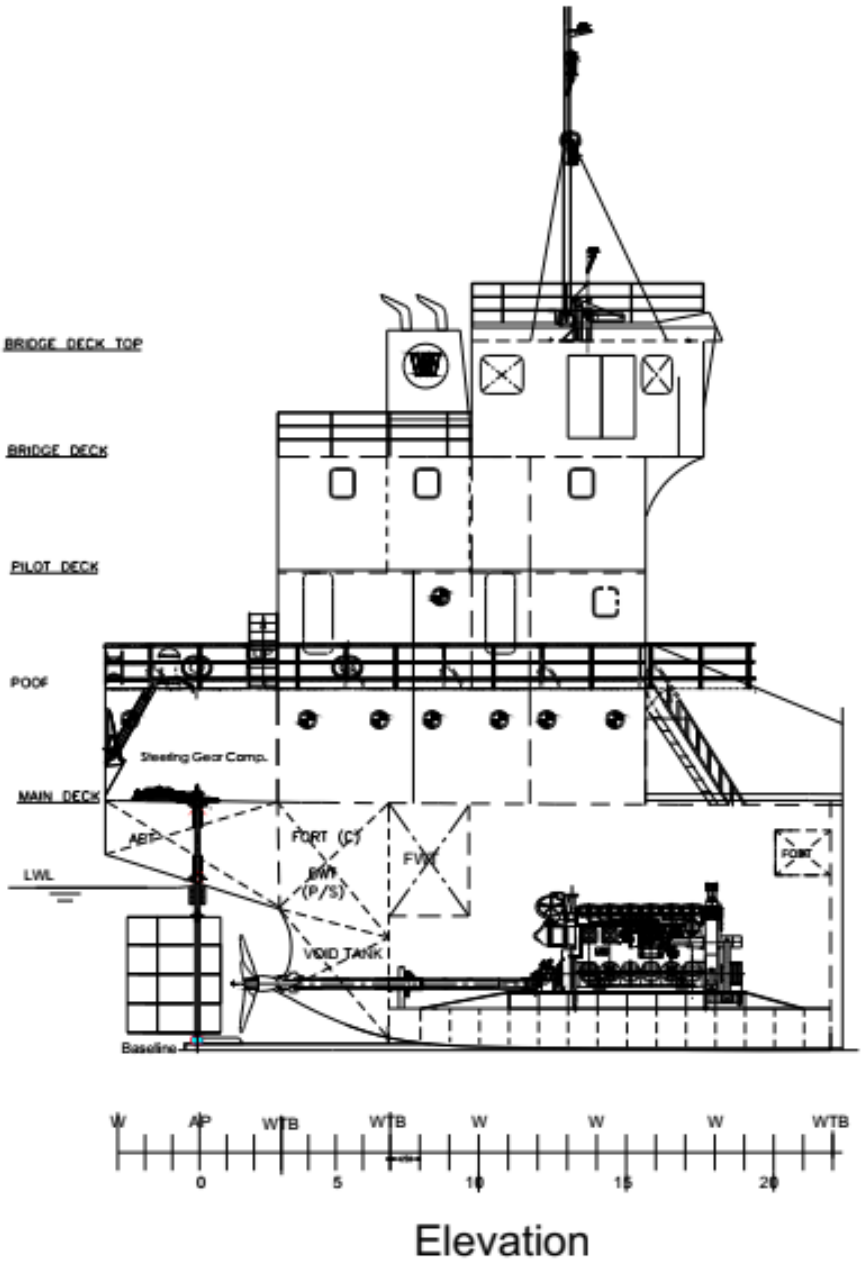


NACA PROFILE-0020



RUDDER PROFILE

Rudder Arrangement in Ship Profile



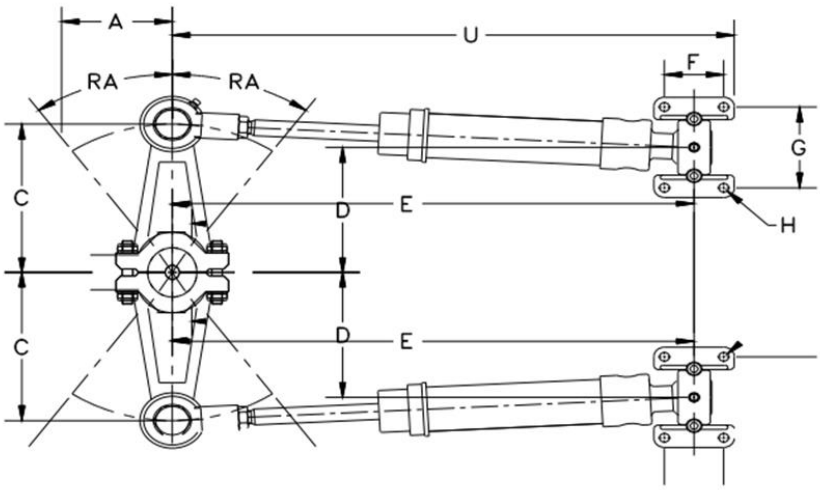
Elevation

STEERING GEAR ARRANGEMENT

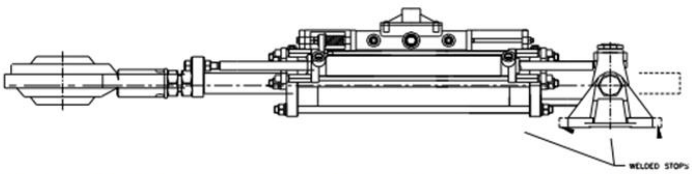
Working Torque for Steering Gear 25.5 kN-m

Steering Gear Model -7093- B20 (Ref. Kobelt Electro-Hydraulic Steering Gear Catalogue)

Note: Detailed Calculation is provided in Appendix 3



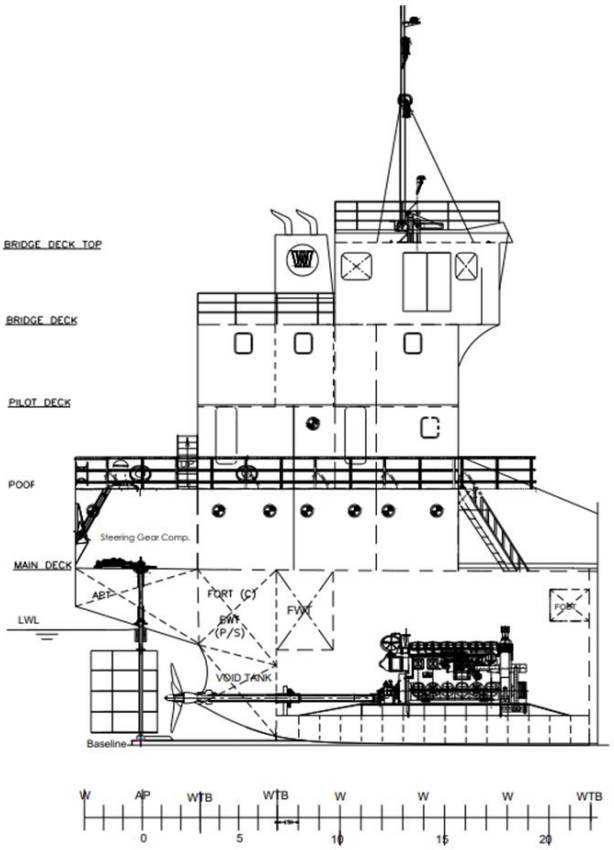
STEERING GEAR (TOP VIEW)



STEERING GEAR (SIDE VIEW)

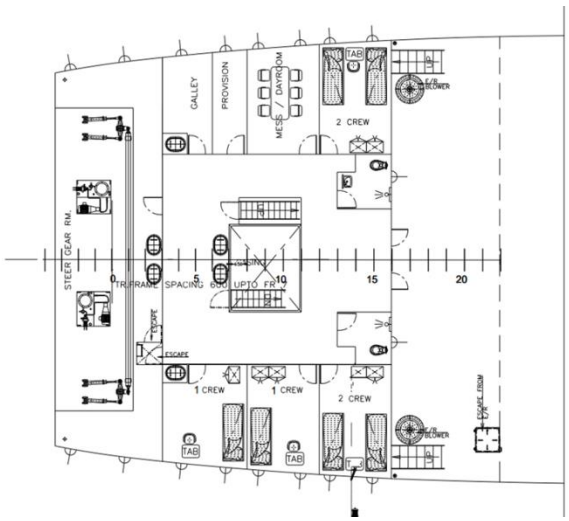
Model No-7093-B20

Steering Gear Arrangement Drawing:



Elevation

Profile View



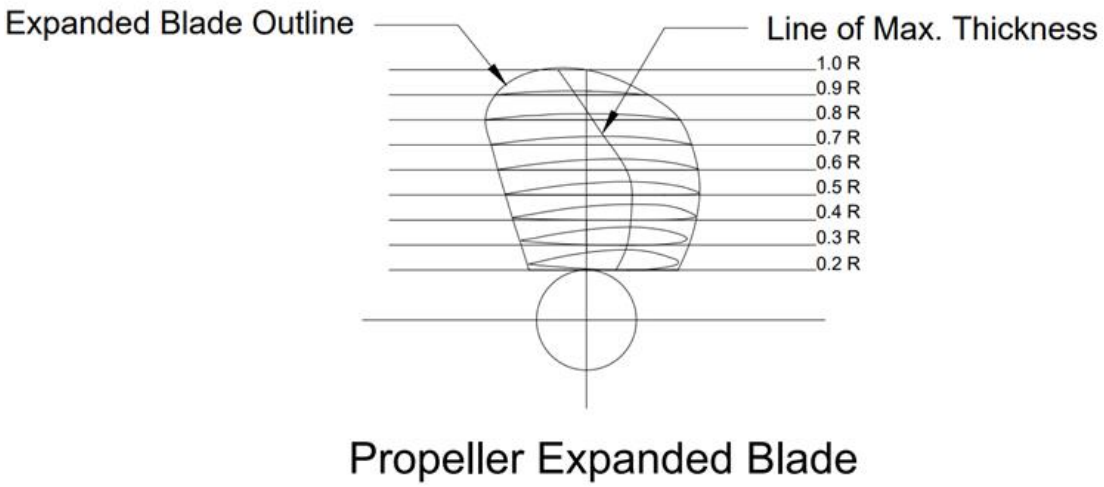
Plan View

Summary of Propeller Calculation

Particulars	**Value**	**Unit**
Propeller diameter	2.15	meter
Taylor wake fraction	0.26	--
Thrust deduction co-efficient	0.22	--
Expanded blade area ratio, $\frac{A_E}{A_0}$	0.46	--
Pitch-dia Ratio	0.64	--
Projected blade area, A_P	3.63	m^2
Burrill co-efficient, τ_c	0.16	--
Shaft efficiency, η_S	0.95	--

Note: Detailed Calculation is provided in Appendix 2

Propeller Expanded Blade Section Drawing:



Propeller Expanded Blade

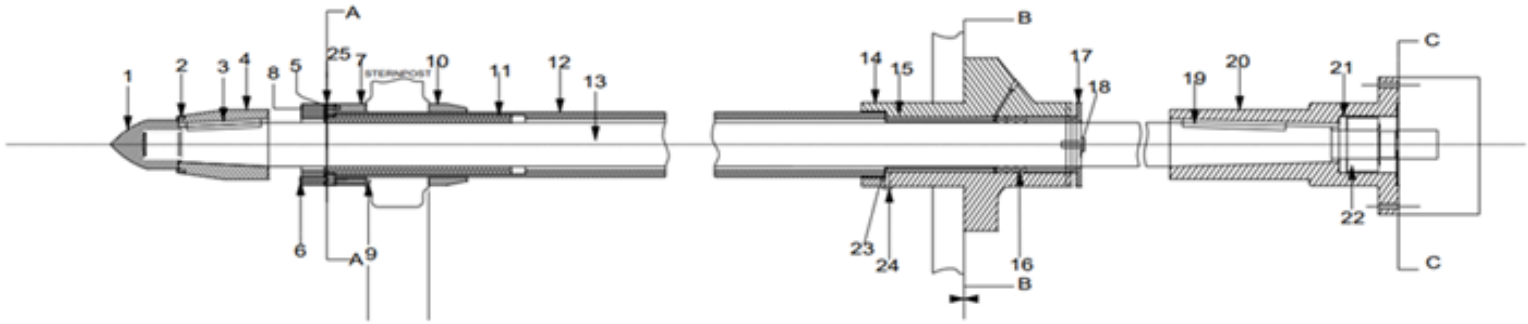
Note: 1) The vessel is twin-screw vessel and the propeller is of 3 blades.

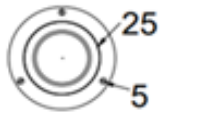
2) The geometry of the propeller is drawn from Wageningen B-screw propeller.

Note: Detailed Calculation is provided in Appendix 2

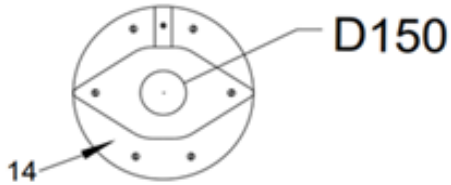
Propeller Shaft Arrangement

Diameter of Propeller Shaft 150 mm

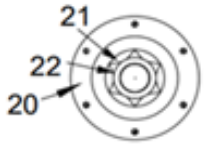




Section : A-A



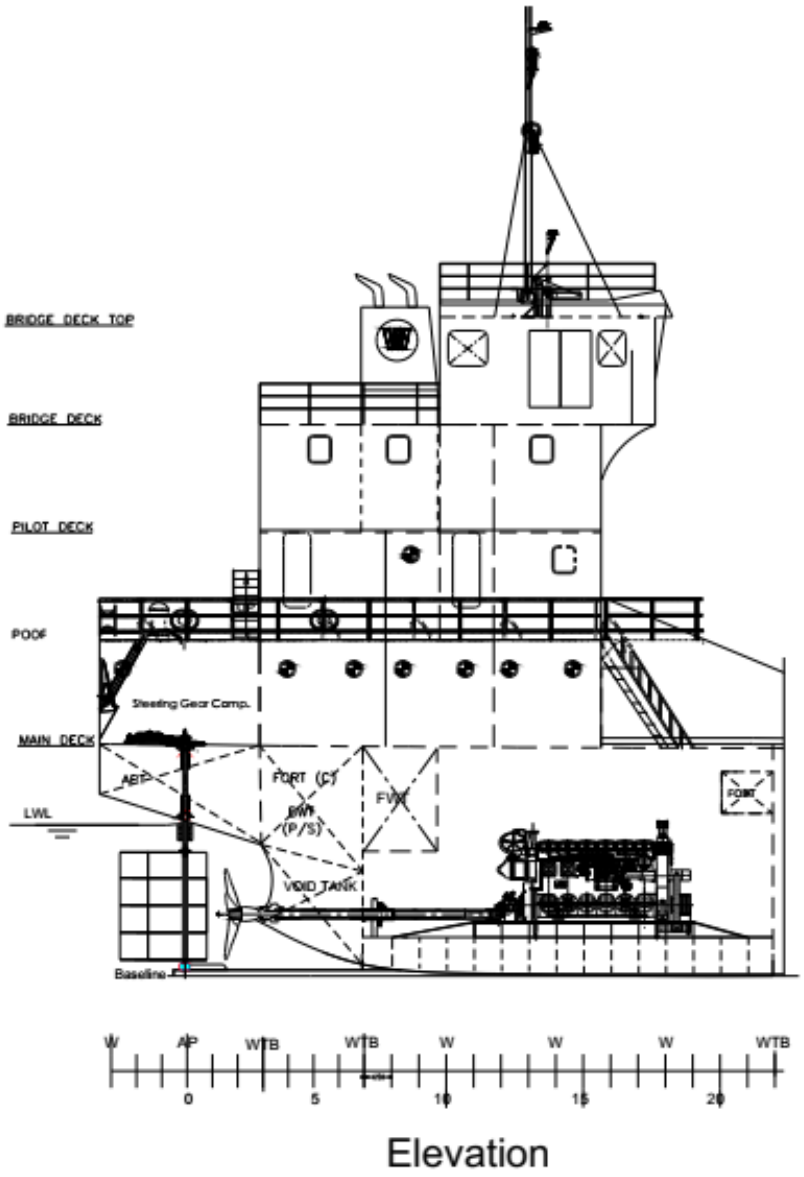
Section : B-B



Section :
C-C

Propeller shaft arrangement

Propeller Shaft Arrangement on Ship Profile:


BRIDGE DECK TOP
BRIDGE DECK
PILOT DECK
POOP
Steering Gear Comp.
MAIN DECK
LWL
FORT (C)
FVT
VOID TANK
Baseline
W
AP
WTB
WTB
W
W
W
WTB
0
5
10
15
20

Elevation

Engine Foundation And Engine Room Arrangement

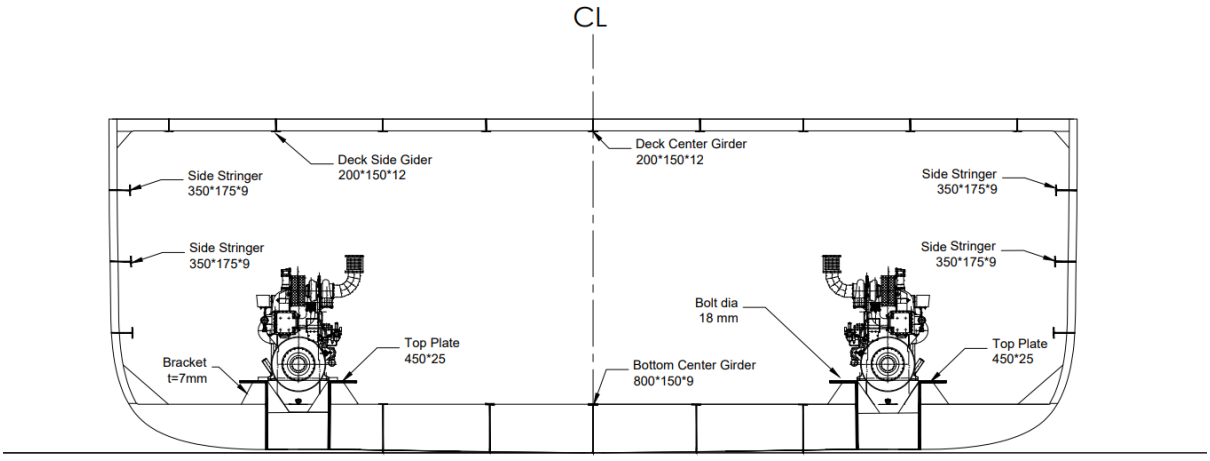
Summary of Engine Foundation Scantling:

Item	Dimension
Top Plate Area	10520 mm^2
Top Plate Width	450 mm
Top Plate Thickness	25 mm
Girder Web Thickness	12 mm
Floor Web Thickness	9 mm
Floor Depth	800 mm
Bracket Thickness	7 mm
Foundation Bolt Diameter	30 mm

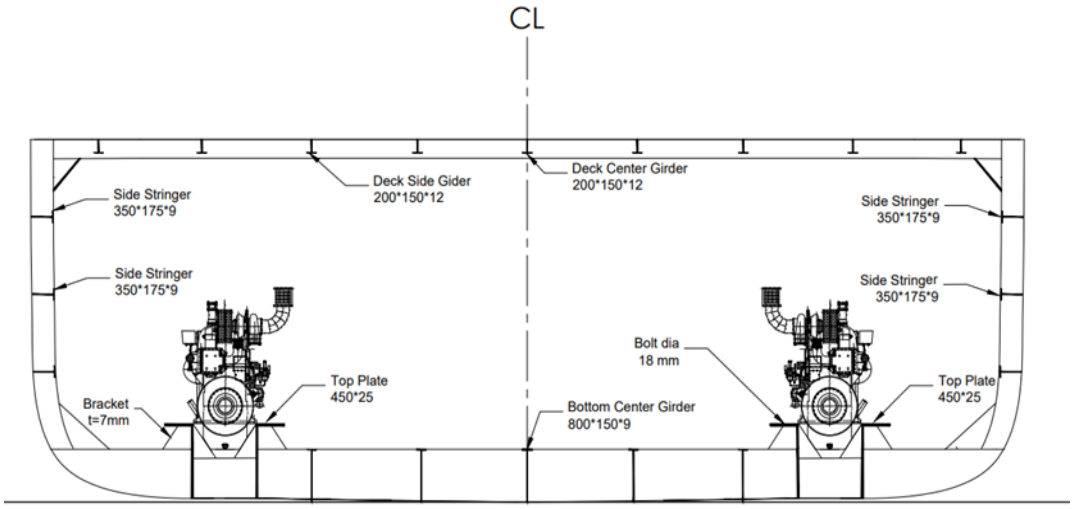
Note: Detailed Calculation is provided in Appendix 4

Ref.IRS, Ch-6, Sec-7,7.2

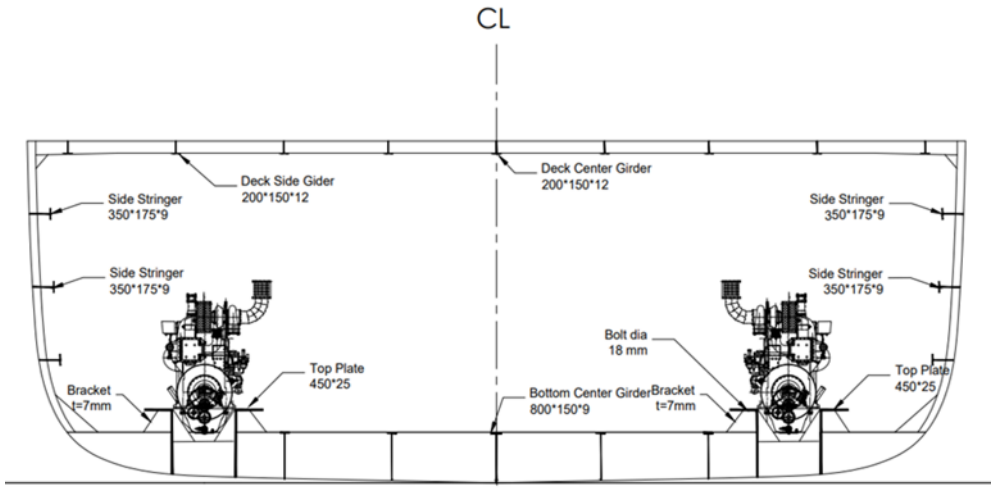
Engine Foundation Drawing



Frame no 17

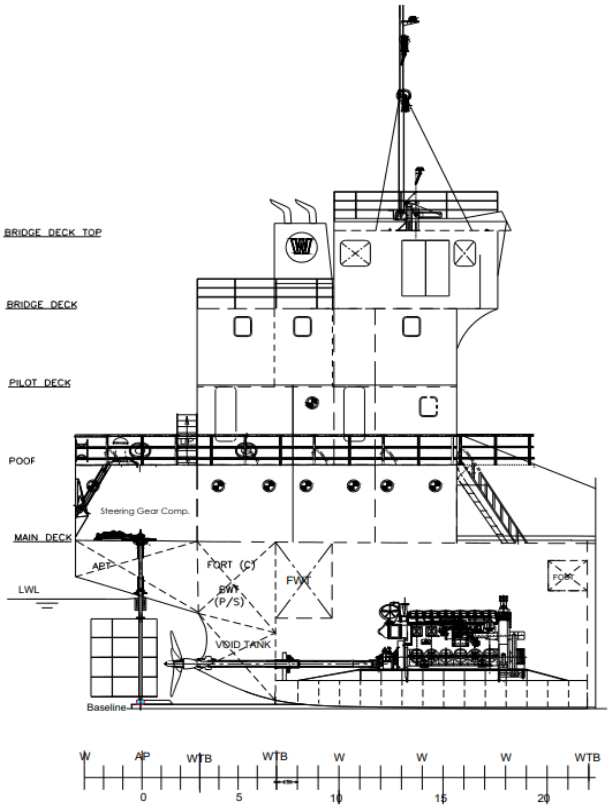


Frame no 14(Web)

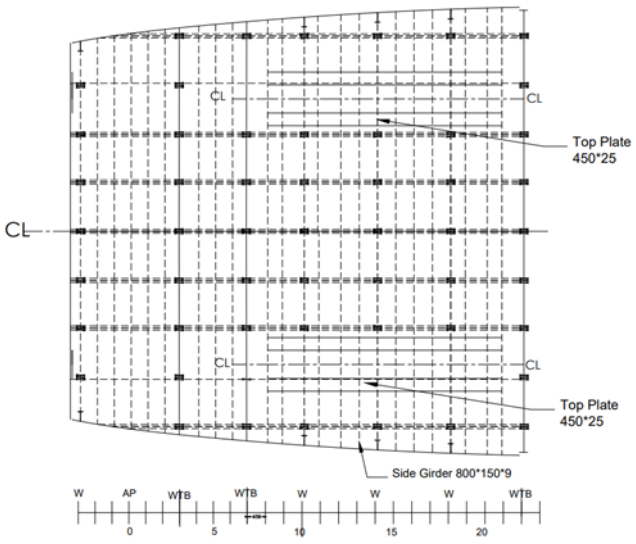


Frame no 12 (Engine with Gear Box)

Engine Foundation And Engine Room Arrangement In Ship:



Elevation



Engine Room

Detailed
Weight Calculation

Detailed

Lightweight and Deadweight Calculation

Total Weight of plates	418.98 tonnes
Total weight of structural and stiffening members	154.04 tonnes
Total Steel weight (considering 10% scrap)	**630.20 tonnes**

Machinery weight	45.61 tonnes

Wood and Outfit Weight	12.60 tonnes

Lightweight	**688.41 tonnes**

Capacity of the Cargo Holds	2898.86
Capacity of Fresh Water Tank	15.00
Capacity of Fuel Oil Reserve Tank	9.77
Capacity of Lubricating Oil Reserve Tank	0.06
Capacity of Forward Ballast Water Tank	160.19
Crew weight	1.12
Provision	0.80
Deadweight	**3087.21**

Lightweight	688.41 tonnes
Deadweight	3087.21 tonnes
Displacement	**3776.00 tonnes**

Preliminary calculated deadweight was **3000** tones.

Preliminary calculated displacement was **4243.90** tones.

Trim
Calculation

T	3.59	m
LBP	77.94	m
half length	38.97	m
LCG	0.40	fwd from mid
LCB	1.46	fwd of mid
WF	38.42	m
FL	39.52	m
LCF	-0.55	fwd(+)
MCTC	63.53	
Displacement	3775.00	tonnes

Change in trim = $x = \frac{(LCG-LCB)\Delta}{MCT\ 1\ Cm} = \frac{(0.40-1.46)3775}{63.53}$

= **-62.75 cm**

Change in draught at aft perpendicular =$WW' = \frac{WF}{L} \times Change\ of\ trim$

$= \frac{38.42}{77.94} \times (-62.75)$

= - 30.93 cm

= - 0.31 m

Change in draught at fore perpendicular = $LL' = \frac{FL}{L} \times Change\ of\ trim$

$= \frac{39.52}{77.94} \times (-62.75)$

= - 31.82 cm

= -0.32 m

Final draft fwd.	**3.27 m**
Final draft aft	**3.89 m**

Trim by Stern

Principal Particulars Comparison between Preliminary and Final Design Ship

Parameters	Final Design Ship	Preliminary Design Ship
Length Overall, L_{OA}	**81.16 m**	**81.16 m**
Length Between Perpendicular, L_{pp}	**77.94 m**	**77.94 m**
Breadth, B	**15.72 m**	**15.72 m**
Depth, D	**5.41 m**	**5.41 m**
Draft, H	**3.59 m**	**4.03 m**

Deadweight	**3000 tonnes**	**3000 tonnes**
Displacement	**3776.00 tonnes**	**4243.90 tones**
C_B	**0.859**	**0.859**
C_D	**0.70**	**0.70**

Capacity Calculation

Cargo Hold Name	Volume	Capacity	LCG (from stern)	VCG(from keel)	LCG moment	VCG moment
Cargo hold 1	768	937.6	62.2	3.09	58318.72	2897.184
Cargo Hold 2	1637.72	1965.264	33.63	3.09	66091.82832	6072.66576

Total capacity 2902.864 tonnes

	Length	Breadth	Depth	Volume	Weight	LCG	VCG	moment LCG	moment VCG
FWT(both)	1.50	1.50	2.50	11.25	11.25	11.17	4.10	125.66	46.13
FORT	2.39	7.37	1.50	26.40	9.77	5.01	3.90	48.97	38.12
LORT	0.65	1.02	0.99	0.66	0.07	14.43	3.90	0.95	0.26
FOST*2	0.99	0.98	0.99	1.93	1.93	15.44	3.90	29.76	7.52
B.BWT	1.93	14.82	5.60	160.19	160.19	2.69	2.80	430.92	448.54
crew					1.12				
provision					0.80				540.55

Total Weight 185.13

Dhaka Chittagong route distance	212.43	KM
Engine fuel consuption rate	0.079	KG/s
Speed of vessel	5.144	m/s
Time required in voyage	41296.66	s
Fuel amount needed	3257.85	KG
	9.77	tonne

Lightship Condition			
	Capacity (tonnes)	vcg(from keel) (m)	Vcg moment (tonnes-m)
Cargo Hold1	0.00	3.09	0.00
Cargo Hold2	0.00	3.09	0.00
Lightweight	688.97	3.66	2518.75
FWT(both)	0.00	4.10	0.00
FORT	0.00	3.90	0.00
LORT	0.00	3.90	0.00
FOST*2	0.00	3.90	0.00
B.BWT	0.00	2.80	0.00
Total Capacity	688.97	VCG	3.66 m

Fully Loaded Departure Condition			
	Capacity (tonnes)	vcg(from keel) (m)	Vcg moment (tonnes-m)
Cargo Hold1	937.60	3.09	2897.18
Cargo Hold2	1965.26	3.09	6072.67
Lightweight	688.55	3.72	2562.93
FWT(both)	11.25	4.10	46.13
FORT	9.77	3.90	38.12
LORT	0.07	3.90	2.56
FOST*2	1.93	3.90	7.52
B.BWT	160.19	2.80	448.54
Total Capacity	3774.62	VCG	3.20 m

In Ballast in Departure Condition			
	Capacity (tonnes)	vcg(from keel) (m)	Vcg moment (tonnes-m)
Cargo Hold1	0.00	3.09	0.00
Cargo Hold2	0.00	3.09	0.00
Lightweight	688.97	3.66	2518.75
FWT(both)	15.00	4.10	46.13
FORT	9.77	3.90	38.12
LORT	0.07	3.90	2.56
FOST*2	1.93	3.90	7.52
B.BWT	135.19	2.80	448.54
FPT	191.44	3.28	627.91
FBWT	190.74	2.75	524.54
BBWT	81.35	4.23	344.11
DBT1	285.62	0.44	125.67
DBT2	563.36	0.44	247.88
APT	130.06	4.76	619.09
Total Capacity	2293.50	VCG	2.42 m

Stability Calculation

STABILITY IN LIGHTSHIP CONDITION

Lightship Condition			
	Capacity (tonnes)	vcg(from keel) (m)	Vcg moment (tonnes-m)
Cargo Hold1	0.00	3.09	0.00
Cargo Hold2	0.00	3.09	0.00
Lightweight	688.97	3.66	2518.75
FWT(both)	0.00	4.10	0.00
FORT	0.00	3.90	0.00
LORT	0.00	3.90	0.00
FOST*2	0.00	3.90	0.00
B.BWT	0.00	2.80	0.00
Total Capacity	688.97	VCG	3.66 m

Properties	IMO value	Lightship Condition	
Area up to 30 degree (m-rad)	≥ 0.055	1.41	PASS
Area up to 40˚ (m-rad)	≥ 0.09	2.16	PASS
Area up to 30˚ - 40˚ (m-rad)	≥ 0.03	0.75	PASS
GZ at 30 degree (m)	≥ 0.2	4.901	PASS
Max. GZ at (degree)	≥ 30 (preferable) but not ≤ 25	47.00	PASS
Initial Metacentric Height (m)	Should not be ≤ 0.15	10.80	PASS

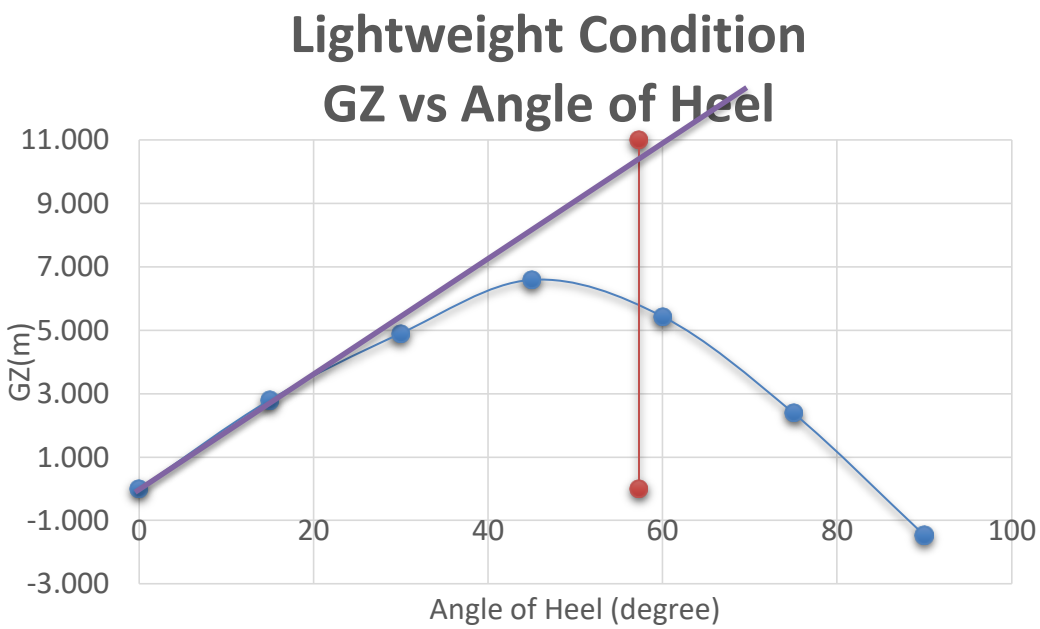


Fig :GZ vs Angle of Heel

STABILITY IN FULLY LOADED DEPARTURE CONDITION

Fully Loaded Departure Condition			
	Capacity (tonnes)	vcg(from keel) (m)	Vcg moment (tonnes-m)
Cargo Hold1	937.60	3.09	2897.18
Cargo Hold2	1965.26	3.09	6072.67
Lightweight	688.55	3.72	2562.93
FWT(both)	11.25	4.10	46.13
FORT	9.77	3.90	38.12
LORT	0.07	3.90	2.56
FOST*2	1.93	3.90	7.52
B.BWT	160.19	2.80	448.54
Total Capacity	3774.62	VCG	3.20 m

Properties	IMO value	Loaded Condition	
Area up to 30 degree (m-rad)	≥ 0.055	0.609	PASS
Area up to 40˚ (m-rad)	≥ 0.09	0.925	PASS
Area up to 30˚ - 40˚ (m-rad)	≥ 0.03	0.316	PASS
GZ at 30 degree (m)	≥ 0.2	2.179	PASS
Max. GZ at (degree)	≥ 30 (preferable) but not ≤ 25	42.000	PASS
Initial Metacentric Height (m)	Should not be ≤ 0.15	4.500	PASS

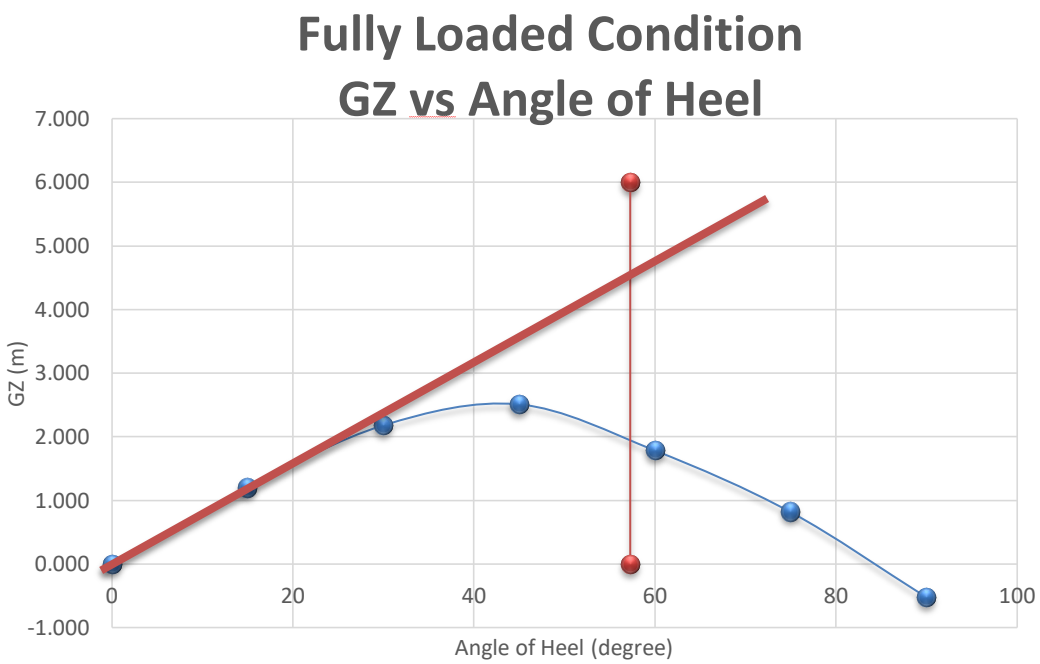


Fig :GZ vs Angle of Heel

STABILITY IN BALLAST IN

DEPARTURE CONDITION

In Ballast in Departure Condition			
	Capacity (tonnes)	vcg(from keel) (m)	Vcg moment (tonnes-m)
Cargo Hold1	0.00	3.09	0.00
Cargo Hold2	0.00	3.09	0.00
Lightweight	688.97	3.66	2518.75
FWT(both)	15.00	4.10	46.13
FORT	9.77	3.90	38.12
LORT	0.07	3.90	2.56
FOST*2	1.93	3.90	7.52
B.BWT	135.19	2.80	448.54
FPT	191.44	3.28	627.91

FBWT	190.74	2.75	524.54
BBWT	81.35	4.23	344.11
DBT1	285.62	0.44	125.67
DBT2	563.36	0.44	247.88
APT	130.06	4.76	619.09
Total Capacity	2293.50	VCG	2.42 m

Properties	IMO value	Ballast in Departure Condition	
Area up to 30 degree (m-rad)	≥ 0.055	1.1958	PASS
Area up to 40˚ (m-rad)	≥ 0.09	5.3890	PASS
Area up to 30˚ - 40˚ (m-rad)	≥ 0.03	4.1932	PASS
GZ at 30 degree (m)	≥ 0.2	3.9968	PASS
Max. GZ at (degree)	≥ 30 (preferable) but not ≤ 25	44	PASS
Initial Metacentric Height (m)	Should not be ≤ 0.15	9.2	PASS

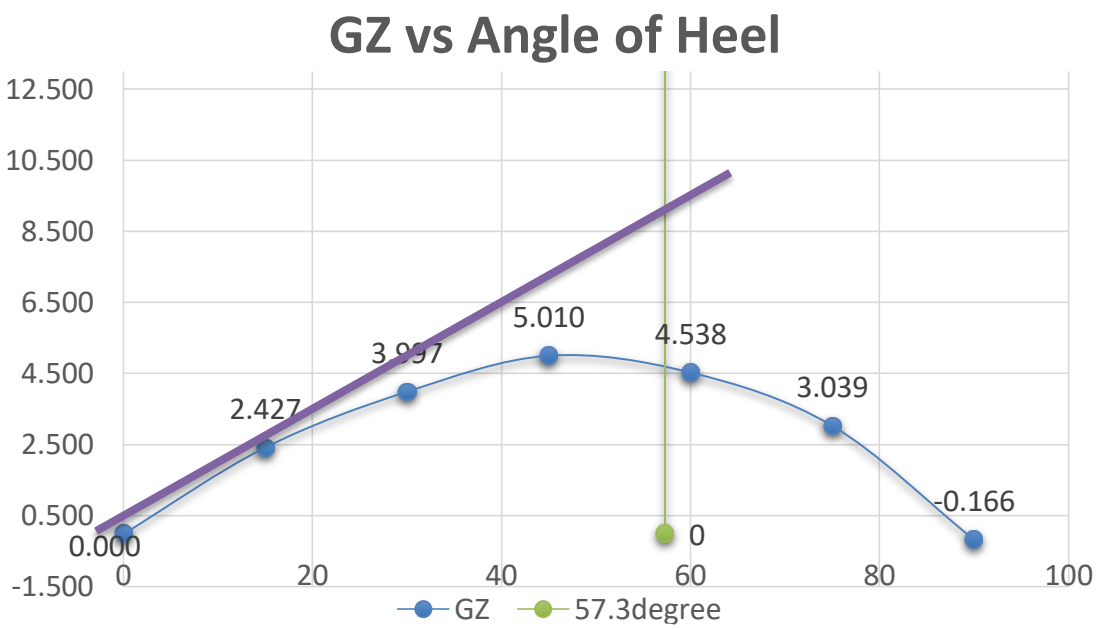


Fig : GZ vs Angle of Heel

Appendix 1

Power and Engine Selection:

Total resistance, R=90 kN

Effective power, P_E = 90X10X.5144= 460.52 kW

Ship Length, $L_{Bp=}$ 77.942 m

Breadth, B= 15.728 m

Draft, T= 3.585 m

Speed, V=10 knots

Volume displacement, = 3775.123 m3

Propeller diameter, D= 0.6T= 2.151 m

Taylor wake fraction,

ω_t= 0.26

Thrust Deduction factor, t = 0.22

We know,

T(1-t) = R

T = 115.059 kN

$\eta_H = \frac{(1-t)}{1-\omega_t}$ = 1.049

η_R = 1.028

V_A = V(1-ω_t)=7.416 knot

Shaft immersion, h= D/2+0.2 = 1.276 m

H= T(Draft)- h

= 2.309 m

$P_0 = P_{atm} + \rho gH$

=123956.195 N/m^2

P_V = 1646N/m^2

K=0.1(for twin screw)

Z=3

Do= 2.26 m

Here, $\frac{A_E}{A_0} = \frac{(1.3+0.3Z)T}{(P_0-P_v)D^2} + K$

= 0.547

We know, $K_T/j^2 = \frac{T}{\rho.D^2{V_a}^2}$

= 1.3

From chart,

here, $j=\frac{V_a}{nD}$

so, n = 330 rpm

assume, $\eta_D = 0.46$

$P_D = \frac{P_E}{\eta_D}$ = 460.52/0.46 = 1001.13 kw

Va = 7.416 knots

Bp = $1.158(\frac{n\times {P_D}^{.5}}{Va^{2.5}})$

= 81.294

$\delta = 3.28\frac{nD}{Va}$

= 332.474

And, P/D = .0.64

So , From Bp -δ chart we get,

η_o = .44

P/D=.64

Here,

$\eta_{D\ Calculated} = \eta_H \times \eta_R \times \eta_o$

= 0.47

$€ = \eta_{DCalculated} - \eta_{D\ assumed}$

= -0.0149 < 0.005

So, η_D = 0.47

Now, P_D = 460.52/ 0.47=969.66 kW

And $P_s = P_D/\eta_s$ = 1020.692 kW

So, Break Power(85% MCR) = 1200.815 kW

And Installed Power (100% MCR) = 1412.724 kW

As ours a twin screw power of each engine= 1412.724/2 =706.362 kW

=946.865 HP

We finally selected **two engines** of 950 HP .

Appendix 2

Propeller Cavitation Check:

$p_0 - p_v = = 122310.195kPa$

$q_{0.7R} = \frac{1}{2} \times \rho \times {V_R}^2$

$= \frac{1}{2} \times 1.000 \times ({V_A}^2 + (0.7 \times \pi \times n \times D)^2$

$= \frac{1}{2} \times 1.000 \times (3.815^2 + (0.7 \times \pi \times 3.00 \times 2.15)^2$

=33.552 kPa

$\sigma_{0.7R} = \frac{p_0 - p_v}{q_{0.7R}} = \frac{83.85}{250.33}$=0.406

$$\frac{A_E}{A_{0_{necessary}}} = \frac{T}{\frac{\pi}{4} \times D^2 \left(1.067 - 0.229 \frac{P}{D}\right) (0.3{\sigma_{0.7R}}^{0.5} - 0.03) q_{0.7R}}$$

$$= \frac{115.059}{\frac{\pi}{4} \times 2.151^2 (1.067 - 0.229 \times 0.67)(0.3 \times 0.406^{0.5} - 0.03) 0.406}$$

=1.989

$A_D = \frac{\pi}{4} \times D^2$=3.634 m2

Therefore, A_E =7.229 m2

Assuming$A_E = A_D$,

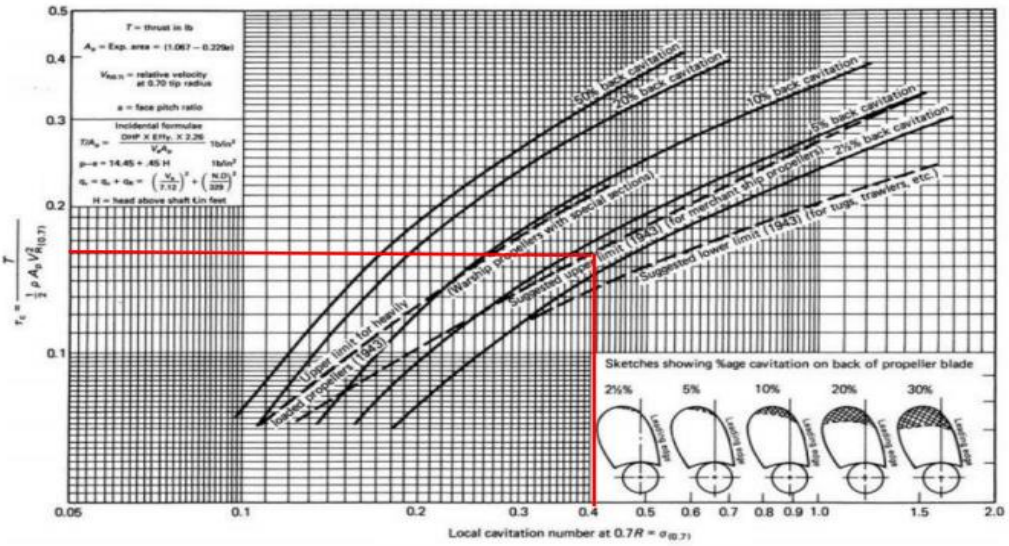
$$A_E \approx \frac{A_P}{1.067 - 0.229 \times \frac{P}{D}}$$

$A_P = 1.831\ m^2$

$\tau_c = \frac{\frac{T}{A_P}}{q_{0.7R}}$=0.187

From Burrill Cavitation Diagram ($\tau_c \; vs \; \sigma_{0.7R}$), the value obtained is just below the upper limit for merchant ship propeller.

Figure 1. Burril Diagram



Propeller profile generation:

BAR= A_E/A_O =0.550 D=2.151 m

r/R	(c/D)*(Z/BAR)	a/c	b/c	Ar	Br	c	a	b	T (max)	c-a
0.200	1.633	0.616	0.350	0.053	0.004	0.644	0.397	0.225	0.087	0.247
0.300	1.832	0.611	0.350	0.046	0.004	0.722	0.441	0.253	0.077	0.281
0.400	2.000	0.599	0.351	0.040	0.003	0.789	0.472	0.277	0.067	0.316
0.500	2.120	0.583	0.355	0.034	0.003	0.836	0.487	0.297	0.057	0.349
0.600	2.186	0.558	0.389	0.028	0.002	0.862	0.481	0.335	0.047	0.381
0.700	2.168	0.526	0.442	0.022	0.002	0.855	0.450	0.378	0.037	0.405
0.800	2.127	0.481	0.478	0.015	0.001	0.839	0.403	0.401	0.027	0.435
0.850	1.892	0.441	0.489	0.012	0.001	0.746	0.329	0.365	0.022	0.417
0.900	1.657	0.400	0.500	0.009	0.001	0.653	0.261	0.327	0.017	0.392
1.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.006	0.000

				Table of V1			
r/R	T_{max}	T_{LE}	T_{TE}	P (-)	V1	P (+)	V1
0.2	0.0873	0.0009	0.0017	-1.00	0.2826	1.00	0.3560
	0.0873	0.0009	0.0017	-0.95	0.2630	0.95	0.2821
	0.0873	0.0009	0.0017	-0.90	0.2400	0.90	0.2353
	0.0873	0.0009	0.0017	-0.80	0.1967	0.80	0.1685
	0.0873	0.0009	0.0017	-0.70	0.1570	0.70	0.1180
	0.0873	0.0009	0.0017	-0.60	0.1207	0.60	0.0804
	0.0873	0.0009	0.0017	-0.50	0.0880	0.50	0.0520
	0.0873	0.0009	0.0017	-0.40	0.0592	0.40	0.0304
	0.0873	0.0009	0.0017	-0.20	0.0172	0.20	0.0049
	0.0873	0.0009	0.0017	0.00	0.0000	0.00	0.0000

Table of V2				for P<0		for P>0	
P (-)	V2	P (+)	V2	Y_{face}	Y_{back}	Y_{face}	Y_{back}
-1.00	0.0000	1.00	0.0000	0.0242	0.0259	0.0308	0.0322
-0.95	0.0640	0.95	0.1560	0.0225	0.0297	0.0244	0.0392
-0.90	0.1455	0.90	0.2840	0.0205	0.0347	0.0203	0.0462
-0.80	0.3060	0.80	0.4777	0.0168	0.0448	0.0146	0.0571
-0.70	0.4535	0.70	0.6190	0.0134	0.0540	0.0102	0.0648
-0.60	0.5842	0.60	0.7277	0.0103	0.0621	0.0070	0.0709
-0.50	0.6995	0.50	0.8170	0.0075	0.0691	0.0045	0.0761
-0.40	0.7984	0.40	0.8875	0.0051	0.0751	0.0026	0.0803
-0.20	0.9446	0.20	0.9750	0.0015	0.0841	0.0004	0.0856
0.00	1.0000	0.00	1.0000	0.0000	0.0873	0.0000	0.0873

				Table of V1			
r/R	T_{max}	T_{LE}	T_{TE}	P (-)	V1	P (+)	V1
0.3	0.0772	0.0008	0.0015	-1.00	0.2306	1.00	0.2923
	0.0772	0.0008	0.0015	-0.95	0.2040	0.95	0.2186
	0.0772	0.0008	0.0015	-0.90	0.1790	0.90	0.1760
	0.0772	0.0008	0.0015	-0.80	0.1333	0.80	0.1191
	0.0772	0.0008	0.0015	-0.70	0.0943	0.70	0.0790
	0.0772	0.0008	0.0015	-0.60	0.0623	0.60	0.0503
	0.0772	0.0008	0.0015	-0.50	0.0376	0.50	0.0300
	0.0772	0.0008	0.0015	-0.40	0.0202	0.40	0.0148
	0.0772	0.0008	0.0015	-0.20	0.0033	0.20	0.0027
	0.0772	0.0008	0.0015	0.00	0.0000	0.00	0.0000

Table of V2				for P<0		for P>0	
P (-)	V2	P (+)	V2	Y_{face}	Y_{back}	Y_{face}	Y_{back}
-1.00	0.0000	1.00	0.0000	0.0175	0.0190	0.0223	0.0237
-0.95	0.0800	0.95	0.1890	0.0154	0.0230	0.0167	0.0324
-0.90	0.1670	0.90	0.3197	0.0135	0.0277	0.0135	0.0391
-0.80	0.3360	0.80	0.5130	0.0101	0.0371	0.0091	0.0494
-0.70	0.4885	0.70	0.6505	0.0071	0.0456	0.0060	0.0568
-0.60	0.6195	0.60	0.7520	0.0047	0.0531	0.0038	0.0623
-0.50	0.7335	0.50	0.8315	0.0028	0.0599	0.0023	0.0667
-0.40	0.8265	0.40	0.8020	0.0015	0.0656	0.0011	0.0634
-0.20	0.9583	0.20	0.9750	0.0002	0.0743	0.0002	0.0755
0.00	1.0000	0.00	1.0000	0.0000	0.0772	0.0000	0.0772

				Table of V1			
r/R	T_{max}	T_{LE}	T_{TE}	P (-)	V1	P (+)	V1
0.4	0.0671	0.0007	0.0013	-1.00	0.1467	1.00	0.2181
	0.0671	0.0007	0.0013	-0.95	0.1200	0.95	0.1467
	0.0671	0.0007	0.0013	-0.90	0.0972	0.90	0.1088
	0.0671	0.0007	0.0013	-0.80	0.0630	0.80	0.0637
	0.0671	0.0007	0.0013	-0.70	0.0395	0.70	0.0357
	0.0671	0.0007	0.0013	-0.60	0.0214	0.60	0.0189
	0.0671	0.0007	0.0013	-0.50	0.0116	0.50	0.0090
	0.0671	0.0007	0.0013	-0.40	0.0044	0.40	0.0033
	0.0671	0.0007	0.0013	-0.20	0.0000	0.20	0.0000
	0.0671	0.0007	0.0013	0.00	0.0000	0.00	0.0000

Table of V2				for P<0		for P>0	
P (-)	V2	P (+)	V2	Y_{face}	Y_{back}	Y_{face}	Y_{back}
-1.00	0.0000	1.00	0.0000	0.0096	0.0110	0.0145	0.0157
-0.95	0.0905	0.95	0.1935	0.0079	0.0152	0.0097	0.0237
-0.90	0.1810	0.90	0.3235	0.0064	0.0196	0.0072	0.0298
-0.80	0.3500	0.80	0.5220	0.0041	0.0285	0.0042	0.0399
-0.70	0.0504	0.70	0.6590	0.0026	0.0073	0.0024	0.0470
-0.60	0.6353	0.60	0.7593	0.0014	0.0445	0.0013	0.0525
-0.50	0.7525	0.50	0.8345	0.0008	0.0516	0.0006	0.0568
-0.40	0.8415	0.40	0.8933	0.0003	0.0570	0.0002	0.0603
-0.20	0.9645	0.20	0.9725	0.0000	0.0648	0.0000	0.0653
0.00	1.0000	0.00	1.0000	0.0000	0.0671	0.0000	0.0671

				Table of V1			
r/R	T_{max}	T_{LE}	T_{TE}	P (-)	V1	P (+)	V1
0.5	0.0570	0.0006	0.0011	-1.00	0.0522	1.00	0.1278
	0.0570	0.0006	0.0011	-0.95	0.0420	0.95	0.0778
	0.0570	0.0006	0.0011	-0.90	0.0330	0.90	0.0500
	0.0570	0.0006	0.0011	-0.80	0.0190	0.80	0.0211
	0.0570	0.0006	0.0011	-0.70	0.0100	0.70	0.0085
	0.0570	0.0006	0.0011	-0.60	0.0040	0.60	0.0034
	0.0570	0.0006	0.0011	-0.50	0.0012	0.50	0.0008
	0.0570	0.0006	0.0011	-0.40	0.0000	0.40	0.0000
	0.0570	0.0006	0.0011	-0.20	0.0000	0.20	0.0000
	0.0570	0.0006	0.0011	0.00	0.0000	0.00	0.0000

Table of V2				for P<0		for P>0	
P (-)	V2	P (+)	V2	Y_{face}	Y_{back}	Y_{face}	Y_{back}
-1.00	0.0000	1.00	0.0000	0.0029	0.0041	0.0072	0.0083
-0.95	0.0950	0.95	0.1750	0.0023	0.0088	0.0044	0.0153
-0.90	0.1865	0.90	0.3056	0.0018	0.0134	0.0028	0.0210
-0.80	0.3569	0.80	0.5039	0.0011	0.0221	0.0012	0.0305
-0.70	0.5140	0.70	0.6430	0.0006	0.0304	0.0005	0.0375
-0.60	0.6439	0.60	0.7478	0.0002	0.0373	0.0002	0.0431
-0.50	0.7580	0.50	0.8275	0.0001	0.0436	0.0000	0.0474
-0.40	0.8456	0.40	0.8880	0.0000	0.0484	0.0000	0.0507
-0.20	0.9639	0.20	0.9710	0.0000	0.0550	0.0000	0.0554
0.00	1.0000	0.00	1.0000	0.0000	0.0570	0.0000	0.0570

				Table of V1			
r/R	T_{max}	T_{LE}	T_{TE}	P (-)	V1	P (+)	V1
0.6	0.0469	0.0005	0.0009	-1.00	0.0000	1.00	0.0382
	0.0469	0.0005	0.0009	-0.95	0.0000	0.95	0.0169
	0.0469	0.0005	0.0009	-0.90	0.0000	0.90	0.0067
	0.0469	0.0005	0.0009	-0.80	0.0000	0.80	0.0006
	0.0469	0.0005	0.0009	-0.70	0.0000	0.70	0.0000
	0.0469	0.0005	0.0009	-0.60	0.0000	0.60	0.0000
	0.0469	0.0005	0.0009	-0.50	0.0000	0.50	0.0000
	0.0469	0.0005	0.0009	-0.40	0.0000	0.40	0.0000
	0.0469	0.0005	0.0009	-0.20	0.0000	0.20	0.0000
	0.0469	0.0005	0.0009	0.00	0.0000	0.00	0.0000

Table of V2				for P<0		for P>0	
P (-)	V2	P (+)	V2	Y_{face}	Y_{back}	Y_{face}	Y_{back}
-1.00	0.0000	1.00	0.0000	0.0000	0.0009	0.0018	0.0027
-0.95	0.0965	0.95	0.1485	0.0000	0.0054	0.0008	0.0085
-0.90	0.1885	0.90	0.2720	0.0000	0.0096	0.0003	0.0137
-0.80	0.3585	0.80	0.4620	0.0000	0.0174	0.0000	0.0222
-0.70	0.5110	0.70	0.6060	0.0000	0.0244	0.0000	0.0288
-0.60	0.6415	0.60	0.7200	0.0000	0.0304	0.0000	0.0340
-0.50	0.7530	0.50	0.8090	0.0000	0.0355	0.0000	0.0381
-0.40	0.8426	0.40	0.8790	0.0000	0.0397	0.0000	0.0413
-0.20	0.9613	0.20	0.9690	0.0000	0.0451	0.0000	0.0455
0.00	1.0000	0.00	1.0000	0.0000	0.0469	0.0000	0.0469

				Table of V1			
r/R	T_{max}	T_{LE}	T_{TE}	P (-)	V1	P (+)	V1
0.7	0.0368	0.0004	0.0007	-1.00	0.0000	1.00	0.0000
	0.0368	0.0004	0.0007	-0.95	0.0000	0.95	0.0000
	0.0368	0.0004	0.0007	-0.90	0.0000	0.90	0.0000
	0.0368	0.0004	0.0007	-0.80	0.0000	0.80	0.0000
	0.0368	0.0004	0.0007	-0.70	0.0000	0.70	0.0000
	0.0368	0.0004	0.0007	-0.60	0.0000	0.60	0.0000
	0.0368	0.0004	0.0007	-0.50	0.0000	0.50	0.0000
	0.0368	0.0004	0.0007	-0.40	0.0000	0.40	0.0000
	0.0368	0.0004	0.0007	-0.20	0.0000	0.20	0.0000
	0.0368	0.0004	0.0007	0.00	0.0000	0.00	0.0000

Table of V2				for P<0		for P>0	
P (-)	V2	P (+)	V2	Y_{face}	Y_{back}	Y_{face}	Y_{back}
-1.00	0.0000	1.00	0.0000	0.0000	0.0007	0.0000	0.0007
-0.95	0.0975	0.95	0.1240	0.0000	0.0043	0.0000	0.0052
-0.90	0.1900	0.90	0.2337	0.0000	0.0076	0.0000	0.0092
-0.80	0.3600	0.80	0.4140	0.0000	0.0137	0.0000	0.0157
-0.70	0.5100	0.70	0.5615	0.0000	0.0191	0.0000	0.0210
-0.60	0.6400	0.60	0.6840	0.0000	0.0238	0.0000	0.0254
-0.50	0.7500	0.50	0.7850	0.0000	0.0278	0.0000	0.0290
-0.40	0.8400	0.40	0.8660	0.0000	0.0310	0.0000	0.0320
-0.20	0.9600	0.20	0.9675	0.0000	0.0353	0.0000	0.0356
0.00	1.0000	0.00	1.0000	0.0000	0.0368	0.0000	0.0368

				Table of V1			
r/R	T_{max}	T_{LE}	T_{TE}	P (-)	V1	P (+)	V1
0.8	0.0267	0.0003	0.0005	-1.00	0.0000	1.00	0.0000
	0.0267	0.0003	0.0005	-0.95	0.0000	0.95	0.0000
	0.0267	0.0003	0.0005	-0.90	0.0000	0.90	0.0000
	0.0267	0.0003	0.0005	-0.80	0.0000	0.80	0.0000
	0.0267	0.0003	0.0005	-0.70	0.0000	0.70	0.0000
	0.0267	0.0003	0.0005	-0.60	0.0000	0.60	0.0000
	0.0267	0.0003	0.0005	-0.50	0.0000	0.50	0.0000
	0.0267	0.0003	0.0005	-0.40	0.0000	0.40	0.0000
	0.0267	0.0003	0.0005	-0.20	0.0000	0.20	0.0000
	0.0267	0.0003	0.0005	0.00	0.0000	0.00	0.0000

Table of V2				for P<0		for P>0	
P (-)	V2	P (+)	V2	Y_{face}	Y_{back}	Y_{face}	Y_{back}
-1.00	0.0000	1.00	0.0000	0.0000	0.0005	0.0000	0.0005
-0.95	0.0975	0.95	0.1050	0.0000	0.0031	0.0000	0.0033
-0.90	0.1900	0.90	0.2028	0.0000	0.0055	0.0000	0.0058
-0.80	0.3600	0.80	0.3765	0.0000	0.0099	0.0000	0.0104
-0.70	0.5100	0.70	0.5265	0.0000	0.0139	0.0000	0.0143
-0.60	0.6400	0.60	0.6545	0.0000	0.0173	0.0000	0.0176
-0.50	0.7500	0.50	0.7635	0.0000	0.0201	0.0000	0.0205
-0.40	0.8400	0.40	0.8520	0.0000	0.0225	0.0000	0.0228
-0.20	0.9600	0.20	0.9635	0.0000	0.0256	0.0000	0.0257
0.00	1.0000	0.00	1.0000	0.0000	0.0267	0.0000	0.0267

				Table of V1			
r/R	T_{max}	T_{LE}	T_{TE}	P (-)	V1	P (+)	V1
0.9	0.0166	0.0002	0.0003	-1.00	0.0000	1.00	0.0000
	0.0166	0.0002	0.0003	-0.95	0.0000	0.95	0.0000
	0.0166	0.0002	0.0003	-0.90	0.0000	0.90	0.0000
	0.0166	0.0002	0.0003	-0.80	0.0000	0.80	0.0000
	0.0166	0.0002	0.0003	-0.70	0.0000	0.70	0.0000
	0.0166	0.0002	0.0003	-0.60	0.0000	0.60	0.0000
	0.0166	0.0002	0.0003	-0.50	0.0000	0.50	0.0000
	0.0166	0.0002	0.0003	-0.40	0.0000	0.40	0.0000
	0.0166	0.0002	0.0003	-0.20	0.0000	0.20	0.0000
	0.0166	0.0002	0.0003	0.00	0.0000	0.00	0.0000

Table of V2				for P<0		for P>0	
P (-)	V2	P (+)	V2	Y_{face}	Y_{back}	Y_{face}	Y_{back}
-1.00	0.0000	1.00	0.0000	0.0000	0.0003	0.0000	0.0003
-0.95	0.0975	0.95	0.1000	0.0000	0.0019	0.0000	0.0020
-0.90	0.1900	0.90	0.1950	0.0000	0.0034	0.0000	0.0035
-0.80	0.3600	0.80	0.3660	0.0000	0.0062	0.0000	0.0063
-0.70	0.5100	0.70	0.5160	0.0000	0.0086	0.0000	0.0087
-0.60	0.6400	0.60	0.6455	0.0000	0.0107	0.0000	0.0108
-0.50	0.7500	0.50	0.7550	0.0000	0.0125	0.0000	0.0126
-0.40	0.8400	0.40	0.8450	0.0000	0.0140	0.0000	0.0140
-0.20	0.9600	0.20	0.9615	0.0000	0.0159	0.0000	0.0159
0.00	1.0000	0.00	1.0000	0.0000	0.0166	0.0000	0.0166

				Table of V1			
r/R	T_{max}	T_{LE}	T_{TE}	P (-)	V1	P (+)	V1
1	0.0065	0.0001	0.0001	-1.00	0.0000	1.00	0.0000
	0.0065	0.0001	0.0001	-0.95	0.0000	0.95	0.0000
	0.0065	0.0001	0.0001	-0.90	0.0000	0.90	0.0000
	0.0065	0.0001	0.0001	-0.80	0.0000	0.80	0.0000
	0.0065	0.0001	0.0001	-0.70	0.0000	0.70	0.0000
	0.0065	0.0001	0.0001	-0.60	0.0000	0.60	0.0000
	0.0065	0.0001	0.0001	-0.50	0.0000	0.50	0.0000
	0.0065	0.0001	0.0001	-0.40	0.0000	0.40	0.0000
	0.0065	0.0001	0.0001	-0.20	0.0000	0.20	0.0000
	0.0065	0.0001	0.0001	0.00	0.0000	0.00	0.0000

Table of V2				for P<0		for P>0	
P (-)	V2	P (+)	V2	Y_{face}	Y_{back}	Y_{face}	Y_{back}
-1.00	0.0000	1.00	0.0000	0.0000	0.0001	0.0000	0.0001
-0.95	0.0975	0.95	0.0975	0.0000	0.0007	0.0000	0.0007
-0.90	0.1900	0.90	0.1900	0.0000	0.0013	0.0000	0.0013
-0.80	0.3600	0.80	0.3600	0.0000	0.0024	0.0000	0.0024
-0.70	0.5100	0.70	0.5100	0.0000	0.0034	0.0000	0.0034
-0.60	0.6400	0.60	0.6400	0.0000	0.0042	0.0000	0.0042
-0.50	0.7500	0.50	0.7500	0.0000	0.0049	0.0000	0.0049
-0.40	0.8400	0.40	0.8400	0.0000	0.0054	0.0000	0.0054
-0.20	0.9600	0.20	0.9600	0.0000	0.0062	0.0000	0.0062
0.00	1.0000	0.00	1.0000	0.0000	0.0065	0.0000	0.0065

Calculation of Propeller Shaft:

Parameters	Values	Units
Waterline Length, LWL	79.0376	m
Length Between Perpendicular, LBP	77.942	m
Breadth moulded, B	15.728	m
Draft moulded, T	3.588	m
Block Coefficient, Cb	0.859	
Ship Speed, V	10	knots
Engine Power,P=	710	kW
Shaft Length,L		m
RPM	1000	
Gear Ratio	3.03	
Shaft RPM	330.0330033	rpm
Angular velocity,ω	34.56	rad/sec
Torque,T	20.54	kN-m

Calculation of shaft diameter using theoretical formula:

We obtain of the tensile strength of steel (AISI 1018) 450 MPa

Allowable stress=450MPa

By taking the Factor of Safety 3we obtain

the Working Stress,τ =150 MPa

So,

T = 20543.40174 N-m

τ = 150000000 Pa

J = $\pi d^4/32$

C = d/2

Shaft Dia,d= 0.0886 m

=88.685mm

Calculation using GL rule book (Part-1, Chapter-2, Section-4)

PW (considering 2% gear loss and 3% shaft loss)=532.500KW

Tensile strength of shaft material (Forged Steel)=450N/mm2

Material factor, C_W =0.918

k (for propeller shafts with flange mounted and propeller is keyed to the tapered propeller shaft) =1.26

F=100

$1-(di/da)^4=1$

Diameter of the shaft, d=143.630 mm

Diameter taken=150 mm

Twisting Angle Calculation:

Here, length of the shaft is, L=3.5 m

Polar moment of inertia, $J=\pi d^4/32$=4.9701E-05m4

Shearing modulus of elasticity, G=83 GPa

=83000000000 Pa

Torque,T=20543.40174 N-m

Twisting angle, θ=TL/GJ=0.01743 radian

=0.998 degree

The twisting angle is .998˚ which is less than 1˚

Minimum wall thickness:

Minimum wall thickness=0.03d+7.5mm= 11.809 mm

Thickness taken= 12 mm

Coupling:

Thickness of the coupling =0.2d= 28.726 mm

Thickness taken 30 mm

Distance between bearings:

K2=8400

The maximum bearing spacing=$k2 * \sqrt{\frac{d}{n}}$ = 5541.44 mm

Spacing taken 5550 mm

Stern tube bearing:

Length of after stern tube bearing=2d=287 mm

Length of forward stern tube bearing =0.8*d=115 mm

List Of Materials For Propeller Shaft:

Sl. No	Description	Materials	Number of component	Dimensions (mm)
1	Cone nut	M.B. BS	1	208 (Length)
2	Cone nut securing screw	M.B. BS	2	12.5 (dia), 23 (Length)
3	Propeller key	M.B. BS	1	25(depth), 22.5(Length)
4	Propeller dia	M.B. BS	1	1960(dia) X 1570(pitch)
5	Aft. BRG . securing screw	M.B. BS	3	16 (dia), 46.5(Length)
6	Cover plate securing screw	STEEL BS	3	15.5(dia), 84.5 (Length)
7	Aft locking ring	STEEL BS	1	260 (o/d), 206 (i/d)
8	Cover plate	STEEL BS	1	260 (o/d), 165 (i/d), 70.5 (Length)
9	Lock ring securing screw	STEEL BS	3	15.5 (dia), 108 (Length)
10	Forward locking ring	STEEL BS	1	260 (o/d), 206 (i/d), 117.5 (Length)
11	Rubber bearing	RUBBER		187 (o/d), 140 (i/d)
12	Stern tube	STEEL BS	1	206 (o/d), 166 (i/d)
13	Tail shaft	FORGED STEEL	1	140 (dia)
14	Forward gland housing	G.M. BS	1	270 (o/d), 206 (i/d)
15	Forward bearing	G.M. BS	1	176 (o/d), 146.5 (i/d)
16	Greasy packing	GRAPHITED ASBESTOS	3 turns	29.4X19.4
17	Gland ring	G.M. BS	1	268 (o/d), 140 (i/d)
18	Gland studs and nuts	M.B. BS	2	44.5 (dia), 70 (Length)
19	Coupling key	STEEL BS	1	28 (depth), 315.5 (Length)
20	Half coupling	STEEL BS	1	222.5 (o/d), 140 (i/d)
21	Backing washer	STEEL BS	1	180 (o/d), 91 (i/d), 24 (thickness)
22	Locking nut	STEEL En7 BS	1	171.5 (o/d), 91 (i/d)
23	Sealing ring	BS	1	175 (o/d), 2.5 (thickness)
24	Fwd.BRG. securing screw	M.B. BS	1	53.5 (length), 28 (dia)
25	Bearing lock ring	STEEL BS	1	260 (o/d), 32.5 (Length)

Appendix 3

Rudder Calculation:

Lbp=77.942 m

B=15.728 m

T=3.583 m

B/Lbp =0.201

H/Lbp=0.051

LWL =79.0376 m

Block Coefficient, CB=0.847

Prismatic Coefficient, CPR=0.852

CX=0.994

CS=0.923

L/Lbp=1.014

Speed=10 knots

Calculation of Rudder Area: **(GL-13, rules I part -1 chapter-1 Section 14 A.3)**

$$A = c1 \times c2 \times c3 \times c4 \frac{1.75 \times L_{WL} \times T}{100}$$

$$= 1x1x1x1 \times \frac{1.75 \times 79.0376 \times 3.585}{100}$$

$$= 5.26 \ m^2$$

From 'Applied Naval Architecture' Munro & Smith

A=Lx T/60 = 5.006 m2

From DNV rulebook,

A=(TL/100)*(1+25(B/L)2)

=5.977 m2

Maximum Area = 5.977 m2

Area of a single rudder =2.988 m2

Yield Str Material used -High strength steel "GL F-36" (**DNV GL Pt. 3 Chapter 14, 1.6)**

Yield strength =355 MPa

Material Factor,kr =(235/Reh)0.75 =0.734

Assuming clearence for rudder =1.000m (Ref.**GL-13, rules I part -1 chapter-1 Section 14 A.4)**

Allowable height =3.550m

Mean height of rudder,b=2.550m

Mean Breadth,c=A/b=2.061m

Calculation of Rudder Force: (GL-13, Rules-I, Part-1, Chapter-1 Section 14 D.1.1)

Rudder Force, $CR = 132 \times A \times V2 \times k1 \times k2 \times k3 \times kt$

k1=($Aspect\ ratio$+2)/3 = 1.392

k2 = 1.1 (Naca-00 series ahead and astern)

k3= 1

kt= 1

CR = 132*2.988*10*1.392*1.1*1*1*1

=60400N(Ahead)

CR=15800 N(Astern)

Total Ahead Force=1.21E+05 N

Total Astern Force=3.16E+04 N

Calculation of Rudder Torque: (GL-13, Rules-I, Part-1, Chapter-1 Section 14 D.1.2)

$Q_r = C_R r$

$r = c(\alpha - k_b)$,

$K_b=A_f/A$,

A_f=25% of A

Balance Factor, Kb=0.25

α=0.33 (ahead)

=0.9 (astern)

Lever, r=0.16 (ahead)
=1.34 (astern)

Qr=1.24E+04 Nm,Ahead
=2.12E+04 Nm,Astern

Calculation of Rudder Stock Diameter: GL-13, Rules-I, Part-1, Chapter-1 Section 14 E.1.1

Material Factor Kr= 0.734
Rudder Torque , Qr=2.12E+04 Nm,Astern

$D_t=4.2(Q_r*K_r)^{1/3}$
$=4.2\times(2.12E+04\times0.734)^{1/3}$
=100 mm

Calculation Of Rudder Coupling: (GL-13, Rules-I, Part-1, Chapter-1 Section 14 F.1)

Rudder stock diameter, D=1 00.000 mm
Material Facrtor, Kb =0.734
kr=0.733887739
No of Bolts, n=6
Mean distances of bolts, e=115 mm

Bolt dia,db=0.62*(D3*Kb/Kr*n*e)0.5
=25 mm

Flange thickness ,Tf =25 mm

Filler radius minimum 45 mm & angle 30 degree .

The minimum thickness After the bolt holes=0.65* Tf= 16.466 mm
The minimum width of the materials outside of the bolt holes =0.67* db=16.973 mm

Calculation Of Pintle :GL-13, Rules-I, Part-1, Chapter-1 Section 14 G.5.1

b1=Cr*0.5=30199.703

Diameter=$0.35*(B1*Kr)^{0.5}$
=52.106 mm

T=$0.01*(B1)^{0.5}$ =1.738 mm

0r, T= 8mm, Whichever Is Maximum
So, T=8.000 mm

Bearing Clearance = (Db/1000)+1
=1.052 mm

Calculation of Rudder Plates and Web: (GL-2008, Section 14, Article-2.1)

The thickness of the Rudder Plating,t= 1.74×a×√(Pr× Kr) +2.5 mm

Smaller supported width of plate panel ,a =0.5 m

Pr= $10T + \frac{CR}{1000 \times a}$ = 58.212 kN/m2

Rudder Plate thickness tp=1.74 ×0.5×√(58.212×0.734) +2.5 = 8.186 mm

Thickness considered, tp= 8 mm

Thickness of Web =0.7×tp= 5.6 mm

Minimum thickness= 8√k = 6.853 mm

Thickness of the web considered = 7 mm

Calculation of Rudder bearing: GL-13, Rules-I, Part-1, Chapter-1 Section 14 G.5.1

T_{min}=8.000 mm
$B_1=C_R*0.5$=30199.703
$A_b=C_R/q$= 10981.710 (5.5 For Synthetic Material)

Calculation of Rudder Framing:

Spacing of Horizontal rudder frame a_h= (0.2*L/100)+0.40 =.558m =558.075 mm

Spacing of Vertical rudder frame a_v =1.5 × a_h= 0.837m= 837.113 mm

Approximate vertical frame spacing 840 mm and horizontal frame spacing 560 mm

Airfoil Generator:

Chord Length,c= 2.15 m

x/c	x	x (mm)	y/c	y	y(mm)
0.000	0.000	0.000	0.044	0.095	95.030
0.013	0.027	26.875	0.032	0.068	67.854
0.025	0.054	53.750	0.044	0.094	93.654
0.050	0.108	107.500	0.059	0.127	127.366
0.100	0.215	215.000	0.078	0.168	167.786
0.150	0.323	322.500	0.089	0.192	191.565
0.200	0.430	430.000	0.096	0.206	205.583
0.250	0.538	537.500	0.099	0.213	212.893
0.300	0.645	645.000	0.100	0.215	215.000
0.400	0.860	860.000	0.097	0.208	207.948
0.450	0.968	967.500	N/A	N/A	N/A
0.500	1.075	1075.000	0.088	0.190	189.716
0.600	1.290	1290.000	0.076	0.164	163.529
0.700	1.505	1505.000	0.061	0.131	131.279
0.800	1.720	1720.000	0.044	0.094	93.998
0.900	1.935	1935.000	0.024	0.052	51.901
1.000	2.150	2150.000	0.002	0.005	4.515

Appendix 4

Calculation of Steering Gear Arrangement :

Rudder Torque=12.449 kN-m,ahead
=21.186 kN-m ,astern

Working Torque=1.2×21.186 =25.423 kN-m
=18751.707 lbs-ft

Steering Gear MODEL:7093-B20 (REF.Kobelt Catalogue hydraulic Steering Gear)
Net Weight=51.4 kg
Total Weight=120 kg

Appendix 5

Engine Foundation Scantling (IRS, CH-6, Sec-7, 7.2)

Maximum Power of a Engine P=710 kW
Maximum RPM ,R=1000

Top Plate Area =A=$20 + 120 \times \frac{P}{R}$ = 105.2 cm2

Top Plate Width=$\frac{A}{tp} \times 10$ =42.903 cm
Width taken= 45 cm

Thickness of Top Plate=tp= 0.1A+14 mm = 24.52 mm

Thickness taken= 25 mm

Girder Web Thickness=tg=0.043A+7 mm= 11.5236 mm

Thickness taken= 12 mm

Floor Web Thickness tf= 0.02A+6 mm = 8.104 mm

Thickness taken =9 mm

Floor Depth =800 mm

Thickness of Bracket =7 mm

Bracket arm a=340 mm , b=340 mm

Appendix 6

Detailed Weight Calculation

WEIGHT OF SHELL PLATES

				Dimensions		***Area***	***Thickness***	***Thickness***	***Volume***	***Weight***	***VCG from keel***	***Moment from Base***	***LCG from aft***	***Moment from aft***
				m	***m***	***m^2***	***mm***	***m***	***m^3***	***tonnes***				
			k01	6	1.2	7.2	11	0.011	0.0792	0.622	4.07	2.53	2.8	1.74
			k02	6	1.2	7.2	11	0.011	0.0792	0.622	2.46	1.53	8.28	5.15
			k03	6	1.2	7.2	11	0.011	0.0792	0.622	0.91	0.57	14.28	8.88
			k04	6	1.2	7.2	11	0.011	0.0792	0.622	0.6	0.37	20.28	12.61
			k05	6	1.2	7.2	11	0.011	0.0792	0.622	0.6	0.37	26.28	16.34
			k06	6	1.2	7.2	11	0.011	0.0792	0.622	0.6	0.37	32.28	20.07
KEEL Strake			k07	6	1.2	7.2	11	0.011	0.0792	0.622	0.6	0.37	38.28	23.80
			k08	6	1.2	7.2	11	0.011	0.0792	0.622	0.6	0.37	44.28	27.53

			k09	6	1.2	7.2	11	0.011	0.0792	0.622	0.6	0.37	50.28	31.26
			k10	6	1.2	7.2	11	0.011	0.0792	0.622	0.6	0.37	56.28	34.99
			k11	6	1.2	7.2	11	0.011	0.0792	0.622	0.6	0.37	62.28	38.72
			k12	6	1.2	7.2	11	0.011	0.0792	0.622	0.6	0.37	68.28	42.45
			k13	6	1.2	7.2	11	0.011	0.0792	0.622	0.6	0.37	74.28	46.18
			k14	6	1.2	7.2	11	0.011	0.0792	0.622	0.75	0.47	78	48.49
			k15	4	1.2	4.8	11	0.011	0.0528	0.414	2.2	0.91	79.75	33.05
			k16	6	1.2	7.2	11	0.011	0.0792	0.622	4.83	3.00	79.38	49.35

				Dimensions		***Area***	***Thickness***	***Thickness***	***Volume***	***Weight***	***VCG from keel***	***Moment from Base***	***LCG from aft***	***Moment from aft***
				m	***m***	***m^2***	***mm***	***m***	***m^3***	***tonnes***				
Garboard Strake			A01	2	2	4	10	0.01	0.04	0.314	2.22	0.70	16.25	5.10
			A02	6	2	12	10	0.01	0.12	0.942	2.2	2.07	20.18	19.01
			A03	6	2	12	10	0.01	0.12	0.942	2.2	2.07	26.18	24.66
			A04	6	2	12	10	0.01	0.12	0.942	2.2	2.07	32.18	30.31
			A05	6	2	12	10	0.01	0.12	0.942	2.2	2.07	38.18	35.97
			A06	6	2	12	10	0.01	0.12	0.942	2.2	2.07	44.18	41.62
			A07	6	2	12	10	0.01	0.12	0.942	2.2	2.07	50.18	47.27
			A08	6	2	12	10	0.01	0.12	0.942	2.2	2.07	56.18	52.92
			A09	6	2	12	10	0.01	0.12	0.942	2.2	2.07	62.18	58.57
A Strake			A10	6	2	12	10	0.01	0.12	0.942	2.2	2.07	68.18	64.23
			A11	1	4	4.57	10	0.01	0.0457	0.3587	2.07	0.74	71.4	25.61

				Dimensions		Area	Thickness	Thickness	Volume	Weight	VCG from keel	Moment from Base	LCG from aft	Moment from aft
				m	m	m^2	mm	m	m^3	tonnes				
Garboard Strake			B01	2	2	4	10	0.01	0.04	0.314	4.18	1.313	16.34	5.13
			B02	6	2	12	10	0.01	0.12	0.942	4.2	3.956	20.22	19.05
			B03	6	2	12	10	0.01	0.12	0.942	4.2	3.956	26.22	24.70
			B04	6	2	12	10	0.01	0.12	0.942	4.2	3.956	32.22	30.35
			B05	6	2	12	10	0.01	0.12	0.942	4.2	3.956	38.22	36.00
			B06	6	2	12	10	0.01	0.12	0.942	4.2	3.956	44.22	41.66
B Strake			B07	6	2	12	10	0.01	0.12	0.942	4.2	3.956	50.22	47.31
			B08	6	2	12	10	0.01	0.12	0.942	4.2	3.956	56.22	52.96
			B09	6	2	12	10	0.01	0.12	0.942	4.2	3.956	62.22	58.61
			B10	6	2.3	8.34	10	0.01	0.083	0.655	4.05	2.651	67	43.86

				Dimensions	Area	Thickness	Thickness	Volume	Weight	VCG from	Moment from Base	LCG from	Moment from aft

											keel		aft	
				m	***m***	***m^2***	***mm***	***m***	***m^3***	***tonnes***				
Garboard Strake			C01	1.55	1	1.55	10	0.01	0.016	0.122	5.5	0.669	16.7	2.032
			C02	6	1.4	8.4	10	0.01	0.084	0.659	5.75	3.792	20.52	13.531
			C03	6	1.4	8.4	10	0.01	0.084	0.659	5.76	3.798	26.52	17.487
			C04	6	1.4	8.4	10	0.01	0.084	0.659	5.76	3.798	32.52	21.444
			C05	6	1.4	8.4	10	0.01	0.084	0.659	5.76	3.798	38.52	25.400
			C06	6	1.4	8.4	10	0.01	0.084	0.659	5.76	3.798	44.52	29.356
C Strake			C07	6	1.4	8.4	10	0.01	0.084	0.659	5.76	3.798	50.52	33.313
			C08	6	1.4	8.4	10	0.01	0.084	0.659	5.76	3.798	56.52	37.269
			C09	6	1.4	8.1	10	0.01	0.081	0.636	5.74	3.650	62.52	39.753
			C10	2.5	0.7	0.8225	10	0.01	0.008	0.065	5.4	0.349	65.52	4.230

				Dimensions		***Area***	***Thickness***	***Thickness***	***Volume***	***Weight***	***VCG from keel***	***Moment from Base***	***LCG from aft***	***Moment from aft***
				m	***m***	***m^2***	***mm***	***m***	***m^3***	***tonnes***				
Bilge Strake			D01	3	1.5	4.5	10	0.01	0.045	0.353	3	1.060	14.46	5.108
			D02	5	1.25	6.25	10	0.01	0.0625	0.491	6.6	3.238	16.14	7.919
			D03	6	1.25	7.5	10	0.01	0.075	0.589	7.01	4.127	20.86	12.281
			D04	6	1.25	7.5	10	0.01	0.075	0.589	7.2	4.239	26.86	15.814
			D05	6	1.25	7.5	10	0.01	0.075	0.589	7.2	4.239	32.86	19.346
			D06	6	1.25	7.5	10	0.01	0.075	0.589	7.2	4.239	38.86	22.879
D Strake			D07	6	1.25	7.5	10	0.01	0.075	0.589	7.2	4.239	44.86	26.411
			D08	6	1.25	7.5	10	0.01	0.075	0.589	7.2	4.239	50.86	29.944
			D09	6	1.25	7.5	10	0.01	0.075	0.589	7.2	4.239	56.86	33.476
			D10	6	1.25	7.5	10	0.01	0.075	0.589	6.74	3.968	62.86	37.009
			D11	6	1.25	7.5	10	0.01	0.075	0.589	4.86	2.861	68.86	40.541
			D12	3.5	1.25	4.54	10	0.01	0.0454	0.356	2.3	0.820	73.75	26.284

				Dimensions		***Area***	***Thickness***	***Thickness***	***Volume***	***Weight***	***VCG from keel***	***Moment from Base***	***LCG from aft***	***Moment from aft***
				m	***m***	***m^2***	***mm***	***m***	***m^3***	***tonnes***				
Side Shell			E01	4	2	7.87	10	0.01	0.079	0.618	3.83	2.366	12.8	7.908
			E02	5	2	9.89	10	0.01	0.099	0.776	7.4	5.745	15.2	11.801
			E03	6	2	12	10	0.01	0.12	0.942	8.6	8.101	20.5	19.311
			E04	6	2	12	10	0.01	0.12	0.942	8.7	8.195	26.5	24.963
			E05	6	2	12	10	0.01	0.12	0.942	8.7	8.195	32.5	30.615
			E06	6	2	12	10	0.01	0.12	0.942	8.7	8.195	38.5	36.267
			E07	6	2	12	10	0.01	0.12	0.942	8.7	8.195	44.5	41.919
			E08	6	2	12	10	0.01	0.12	0.942	8.7	8.195	50.5	47.571
E Strake			E09	6	2	12	10	0.01	0.12	0.942	8.7	8.195	56.5	53.223
			E10	6	2	12	10	0.01	0.12	0.942	8.5	8.007	62.5	58.875
			E11	6	2	12	10	0.01	0.12	0.942	7.03	6.622	68.2	64.244
			E12	6	2	12	10	0.01	0.12	0.942	3.92	3.693	73.16	68.917

	E13	4	2	4.5	10	0.01	0.045	0.353	2.05	0.724	77	27.200

				Dimensions		***Area***	***Thickness***	***Thickness***	***Volume***	***Weight***	***VCG from keel***	***Moment from Base***	***LCG from aft***	***Moment from aft***
				m	***m***	***m2***	***mm***	***m***	***m3***	***tonnes***				
F Strake			F01	6	2	12	10	0.01	0.12	0.942	5.5	5.181	11.32	10.663
			F02	6	2	12	10	0.01	0.12	0.942	9.46	8.911	15	14.130
			F03	6	2	12	10	0.01	0.12	0.942	10.61	9.995	20.6	19.405
			F04	6	2	12	10	0.01	0.12	0.942	10.61	9.995	26.6	25.057
			F05	6	2	12	10	0.01	0.12	0.942	10.61	9.995	32.6	30.709
			F06	6	2	12	10	0.01	0.12	0.942	10.61	9.995	38.6	36.361
			F07	6	2	12	10	0.01	0.12	0.942	10.61	9.995	44.6	42.013
			F08	6	2	12	10	0.01	0.12	0.942	10.61	9.995	50.6	47.665
			F09	6	2	12	10	0.01	0.12	0.942	10.61	9.995	56.6	53.317
			F10	6	2	12	10	0.01	0.12	0.942	10.45	9.844	62.6	58.969

	F11	6	2	12	10	0.01	0.12	0.942	9	8.478	68	64.056
	F12	6	2	12	10	0.01	0.12	0.942	5.86	5.520	73.2	68.954
	F13	3.5	2	7.15	10	0.01	0.0715	0.561	3.6	2.021	77.5	43.499

				Dimensions		***Area***	***Thickness***	***Thickness***	***Volume***	***Weight***	***VCG from keel***	***Moment from Base***	***LCG from aft***	***Moment from aft***
				m	***m***	***m2***	***mm***	***m***	***m3***	***tonnes***				
G Strake			G01	3	2	6	10	0.01	0.06	0.471	4.45	2.096	8.42	3.966
			G02	6	2	12	10	0.01	0.12	0.942	7.91	7.451	10.6	9.985
			G03	6	1.5	11	10	0.01	0.11	0.864	11.07	9.559	14.5	12.521
			G04	6	0.8	5.16	10	0.01	0.05	0.405	11.9	4.820	20.34	8.239
			G05	6	0.7	4.2	10	0.01	0.04	0.330	11.95	3.940	26.34	8.684
			G06	6	0.7	4.2	10	0.01	0.04	0.330	11.95	3.940	32.34	10.662
			G07	6	0.7	4.2	10	0.01	0.04	0.330	11.95	3.940	38.34	12.641
			G08	6	0.7	4.2	10	0.01	0.04	0.330	11.95	3.940	44.34	14.619
			G09	6	0.7	4.2	10	0.01	0.04	0.330	11.95	3.940	50.34	16.597
			G10	6	0.7	4.2	10	0.01	0.04	0.330	11.95	3.940	56.34	18.575
			G11	6	1	6.3	10	0.01	0.06	0.495	11.8	5.836	62.34	30.830
			G12	6	2	12	10	0.01	0.12	0.942	10.7	10.079	68.4	64.433

	G13	6	2	12	10	0.01	0.12	0.942	7.85	7.395	73.15	68.907
	G14	4	2	8	10	0.01	0.12	0.628	5.73	3.598	77.31	48.551

				Dimensions		***Area***	***Thickness***	***Thickness***	***Volume***	***Weight***	***VCG from keel***	***Moment from Base***	***LCG from aft***	***Moment from aft***
				m	***m***	***m2***	***mm***	***m***	***m3***	***tonnes***				
H Strake			H01	6	2	12	10	0.01	0.12	0.94	5.88	5.54	7.25	6.83
			H02	6	2	12	10	0.01	0.12	0.94	9.57	9.01	10.4	9.80
			H03	5	1.2	3	10	0.01	0.03	0.24	11.53	2.72	69.82	16.44
			H04	6	2	12	10	0.01	0.12	0.94	9.54	8.99	73.5	69.24
			H05	3.75	1.7	3.2	10	0.01	0.032	0.25	7.77	1.95	77.5	19.47

				Dimensions		***Area***	***Thickness***	***Thickness***	***Volume***	***Weight***	***VCG from keel***	***Moment from Base***	***LCG from aft***	***Moment from aft***
				m	***m***	***m2***	***mm***	***m***	***m3***	***tonnes***				
I Strake			I01	6	2	12	10	0.01	0.12	0.94	6.47	6.09	5.8	5.46
			I02	6	1.5	9	10	0.01	0.09	0.71	9.98	7.05	8.84	6.25

				Dimensions		***Area***	***Thickness***	***Thickness***	***Volume***	***Weight***	***VCG from keel***	***Moment from Base***	***LCG from aft***	***Moment from aft***
				m	***m***	***m2***	***mm***	***m***	***m3***	***tonnes***				
J Strake			J01	2	2	4	10	0.01	0.04	0.314	5.32	1.670	3.84	1.206
			J02	3.5	2	7	10	0.01	0.07	0.550	7.82	4.297	5.05	2.775
			J03	3.75	2	7.5	10	0.01	0.075	0.589	10.02	5.899	7.15	4.210

				Dimensions		***Area***	***Thickness***	***Thickness***	***Volume***	***Weight***	***VCG from keel***	***Moment from Base***	***LCG from aft***	***Moment from aft***
				m	***m***	***m2***	***mm***	***m***	***m3***	***tonnes***				
L Strake			L01	3.75	2	7.5	10	0.01	0.075	0.589	6.52	3.84	2.85	1.68
			L02	3.75	2	7.5	10	0.01	0.075	0.589	9.26	5.45	4.24	2.50

				Dimensions		***Area***	***Thickness***	***Thickness***	***Volume***	***Weight***	***VCG from keel***	***Moment from Base***	***LCG from aft***	***Moment from aft***
				m	***m***	***m2***	***mm***	***m***	***m3***	***tonnes***				
M Strake			M01	2	2	4	10	0.01	0.04	0.314	6.36	1.997	1.01	0.317
			M02	4.5	2	9	10	0.01	0.09	0.707	8.8	6.217	2.01	1.420

				Dimensions		Area	Thickness	Thickness	Volume	Weight	VCG from keel	Moment from Base	LCG from aft	Moment from aft
				m	m	m2	mm	m	m3	tonnes				
N Strake			N01	3.5	0.5	0.875	10	0.01	0.00875	0.069	8.22	0.565	0.35	0.024

				Dimensions		Area	Thickness	Thickness	Volume	Weight	VCG from keel	Moment from Base	LCG from aft	Moment from aft
				m	m	m2	mm	m	m3	tonnes				
Sheer Strake			S01	1.75	0.5	0.875	11	0.011	0.0096	0.076	9.28	0.701	0.582	0.044
			S02	6	0.5	3	11	0.011	0.0330	0.259	11	2.850	3.870	1.003
			S03	6	0.5	3	11	0.011	0.0330	0.259	11.54	2.989	9.820	2.544
			S04	6	0.5	3	11	0.011	0.0330	0.259	12.3	3.186	15.820	4.098

	S05	6	0.5	3	11	0.011	0.0330	0.259	12.64	3.274	21.820	5.652
	S06	6	0.5	3	11	0.011	0.0330	0.259	12.64	3.274	27.820	7.207
	S07	6	0.5	3	11	0.011	0.0330	0.259	12.64	3.274	33.820	8.761
	S08	6	0.5	3	11	0.011	0.0330	0.259	12.64	3.274	39.820	10.315
	S09	6	0.5	3	11	0.011	0.0330	0.259	12.64	3.274	45.820	11.870
	S10	6	0.5	3	11	0.011	0.0330	0.259	12.64	3.274	51.820	13.424
	S11	6	0.5	3	11	0.011	0.0330	0.259	12.64	3.274	57.820	14.978
	S12	6	0.5	3	11	0.011	0.0330	0.259	12.64	3.274	63.820	16.533
	S13	6	0.5	3	11	0.011	0.0330	0.259	12.38	3.207	68.453	17.733
	S14	6	0.5	3	11	0.011	0.0330	0.259	10.8	2.798	73.440	19.025
	S15	5	0.5	2.5	11	0.011	0.0275	0.216	8.01	1.729	77.600	16.752

The sum of total weight= 164.74 tonnes

WEIGHT OF Other Plates

		Area	Thickness	Thickness	Volume	Weight	VCG from keel	Moment from Base	LCG from aft	Moment from aft
		m2	mm	m	m3	tonnes				
Inner bottom		818.55	9	0.009	7.37	57.83	0.87	50.31	47.7	2758.52
Hatch cover 1		368	9	0.009	3.31	29.81	7.02	209.25	34.4	1025.40
Hatch cover 2		178.25	9	0.009	1.60	14.44	7.02	101.36	62.24	898.64
Main deck Parallel middle body(without hatch cover)		272.3	9	0.008	2.18	19.61	7.02	137.63		
Main deck aft		230	9	0.008	1.84	16.56	7.02	116.25	8.18	135.46
Main deck fwd		76.97	9	0.008	0.62	5.54	7.02	38.90	74.53	413.03
Hatch Coaming Plate		50.71	9	0.009	0.46	4.11	6.115	25.12	42.96	176.46
Shell plate behind		15.64	10	0.01	0.16	1.56	6	9.39	0	0.00
Superstructure										
Poop deck	deck	170	8	0.008	1.36	10.68	9.35	99.82	6.08	64.91

	side plate1	51.22	5	0.005	0.26	2.01	7.35	14.78	0	0.00
	side plate2	94.56	5	0.005	0.47	3.71	7.35	27.28	5.92	21.97
	side plate3	61.07	5	0.005	0.31	2.40	7.35	17.62	11.83	28.36
Pilot deck	deck	70.17	8	0.008	0.56	4.41	12	52.88	7.87	34.68
	side plate 1	22.60	5	0.005	0.11	0.89	10.64	9.44	3.79	3.36
	side plate 2	42.54	5	0.005	0.21	1.67	10.64	17.77	7.87	13.14
	side plate 3	22.60	5	0.005	0.11	0.89	10.64	9.44	11.84	10.50
Bridge deck	deck	109.54	8	0.008	0.88	6.88	14.45	99.40	4.9	33.71
	side 1	24.23	4	0.004	0.10	0.76	13.2	10.04	3.79	2.88
	side 2	45	4	0.004	0.18	1.41	13.2	18.65	7.87	11.12
	side 3	43.85	4	0.004	0.18	1.38	13.2	18.17	11.84	16.30
Bridge deck top	deck	38.18	8	0.008	0.31	2.40	17.2	41.24	10.46	25.08

	side1	21.36	4	0.004	0.09	0.67	15	10.06	7.86	5.27
	side2	24.5	4	0.004	0.10	0.77	15	11.54	10.46	8.05
	side3	18.4	4	0.004	0.07	0.58	15	8.67	13.07	7.55
Forecastle	deck	71.9	9	0.009	0.65	5.08	8.62	43.79	74.5	378.44
	side plate	55	6	0.006	0.33	2.59	6.9	17.87	74.5	192.99
Bulwark	side plate	144.5	6	0.006	0.87	6.81	6.42	43.69	42.04	286.12
Void tank		82	11	0.011	0.90	7.08	1.1263	7.97	7.6644	54.27
Machinery space floor plate		149.62	9	0.009	1.35	10.57	0.87	9.20	11.14	102.45

Total Weight of Steel Plates = 418.98 tonnes

Weight of Structural Members

Bottom Strengthening Member

ITEM	Amount	Length(m)	area (m^2)	volume (m^3)	weight (ton)	LCG(m)	LCG moment from aft	VCG	VCG moment from baseline
Bottom Center Girder	1	74.891	0.00855	0.640	5.026	37.446	188.220	0.405	2.033
Bottom Side Girder (Port)	4	74.891	0.00855	0.640	20.106	37.446	752.879	0.405	8.133
Bottom Side Girder (Starboard)	4	74.891	0.00855	0.640	20.106	37.446	752.879	0.405	8.133
Floors(Aft)	1	13.490	0.00855	0.115	0.905	0.233	0.211	4.203	3.805
	1	15.218	0.00855	0.130	1.021	8.308	8.486	0.405	0.413
	1	15.542	0.00855	0.133	1.043	10.908	11.379	0.405	0.422
	1	15.700	0.00855	0.134	1.054	13.508	14.234	0.405	0.426
Floors(Parallel Middle body)	1	15.724	0.00855	0.134	1.055	18.058	19.058	0.405	0.427
	1	15.724	0.00855	0.134	1.055	20.658	21.802	0.405	0.427
	1	15.724	0.00855	0.134	1.055	23.258	24.545	0.405	0.427

	1	15.724	0.00855	0.134	1.055	25.858	27.289	0.405	0.427
	1	15.724	0.00855	0.134	1.055	28.458	30.033	0.405	0.427
	1	15.724	0.00855	0.134	1.055	31.058	32.777	0.405	0.427
	1	15.724	0.00855	0.134	1.055	33.658	35.521	0.405	0.427
	1	15.724	0.00855	0.134	1.055	36.258	38.265	0.405	0.427
	1	15.724	0.00855	0.134	1.055	38.858	41.009	0.405	0.427
	1	15.724	0.00855	0.134	1.055	41.458	43.753	0.405	0.427
	1	15.724	0.00855	0.134	1.055	44.058	46.497	0.405	0.427
	1	15.724	0.00855	0.134	1.055	46.658	49.241	0.405	0.427
	1	15.724	0.00855	0.134	1.055	49.258	51.985	0.405	0.427
	1	15.724	0.00855	0.134	1.055	51.858	54.729	0.405	0.427
	1	15.724	0.00855	0.134	1.055	54.458	57.473	0.405	0.427
	1	15.724	0.00855	0.134	1.055	57.058	60.216	0.405	0.427
	1	15.724	0.00855	0.134	1.055	59.658	62.960	0.405	0.427
	1	15.724	0.00855	0.134	1.055	62.258	65.704	0.405	0.427

	1	15.724	0.00855	0.134	1.055	64.858	68.448	0.405	0.427
	1	15.724	0.00855	0.134	1.055	67.458	71.192	0.405	0.427
Floors(Forward)	1	15.604	0.00855	0.133	1.047	70.058	73.372	0.405	0.424
	1	11.296	0.00855	0.097	0.758	76.458	57.967	0.405	0.307
	1	7.316	0.00855	0.063	0.491	78.858	38.722	0.405	0.199

Side Strengthening Member

ITEM	Amount	Length(m)	area (m^2)	volume (m^3)	weight (ton)	LCG(m)	LCG moment from aft	VCG	VCG moment from baseline
Side Stringer 1	1	76.0245	0.006656	0.506	3.972	38.01225	150.994	2.314	9.191
Side Stringer 2	1	78.5394	0.006656	0.523	4.104	39.2697	161.149	3.849	15.794
Web Frames(AFT)	1	1.25	0.006656	0.008	0.065	0.233	0.015	5.971	0.390
	1	4.653	0.006656	0.031	0.243	8.308	2.020	2.327	0.566
	1	4.632	0.006656	0.031	0.242	10.908	2.640	2.327	0.563
	1	4.632	0.006656	0.031	0.242	13.508	3.269	2.327	0.563
Web Frames(parallel Middle body)	1	4.618	0.006656	0.031	0.241	18.058	4.357	2.327	0.561
	1	4.618	0.006656	0.031	0.241	20.658	4.985	2.327	0.561
	1	4.618	0.006656	0.031	0.241	23.258	5.612	2.327	0.561
	1	4.618	0.006656	0.031	0.241	25.858	6.239	2.327	0.561
	1	4.618	0.006656	0.031	0.241	28.458	6.867	2.327	0.561
	1	4.618	0.006656	0.031	0.241	31.058	7.494	2.327	0.561

	1	4.618	0.006656	0.031	0.241	33.658	8.121	2.327	0.561
	1	4.618	0.006656	0.031	0.241	36.258	8.749	2.327	0.561
	1	4.618	0.006656	0.031	0.241	38.858	9.376	2.327	0.561
	1	4.618	0.006656	0.031	0.241	41.458	10.003	2.327	0.561
	1	4.618	0.006656	0.031	0.241	44.058	10.631	2.327	0.561
	1	4.618	0.006656	0.031	0.241	46.658	11.258	2.327	0.561
	1	4.618	0.006656	0.031	0.241	49.258	11.885	2.327	0.561
	1	4.618	0.006656	0.031	0.241	51.858	12.513	2.327	0.561
	1	4.618	0.006656	0.031	0.241	54.458	13.140	2.327	0.561
	1	4.618	0.006656	0.031	0.241	57.058	13.767	2.327	0.561
	1	4.618	0.006656	0.031	0.241	59.658	14.395	2.327	0.561
	1	4.618	0.006656	0.031	0.241	62.258	15.022	2.327	0.561
	1	4.618	0.006656	0.031	0.241	64.858	15.649	2.327	0.561
	1	4.618	0.006656	0.031	0.241	67.458	16.277	2.327	0.561
Web Frames Forward	1	4.618	0.006656	0.031	0.241	70.058	16.904	2.327	0.561

	1	4.618	0.006656	0.031	0.241	76.458	18.448	2.327	0.561
	1	4.618	0.006656	0.031	0.241	78.858	19.028	2.327	0.561
Ordinary Frames(AFT)	1	1.95	0.002832	0.006	0.043	0.827	0.036	4.449	0.193
	1	1.95	0.002832	0.006	0.043	1.477	0.064	4.449	0.193
	1	1.95	0.002832	0.006	0.043	2.127	0.092	4.449	0.193
	1	1.95	0.002832	0.006	0.043	2.777	0.120	4.449	0.193
	1	1.95	0.002832	0.006	0.043	3.427	0.149	4.449	0.193
	14	4.632	0.002832	0.013	1.442	2.316	3.339	2.327	3.354
Ordinary Frames(Parallel Middle Body)	1	4.632	0.002832	0.013	0.103	16.63	1.712	2.327	0.240
	1	4.632	0.002832	0.013	0.103	17.28	1.779	2.327	0.240
	1	4.632	0.002832	0.013	0.103	18.58	1.913	2.327	0.240
	1	4.632	0.002832	0.013	0.103	19.23	1.980	2.327	0.240
	1	4.632	0.002832	0.013	0.103	19.88	2.047	2.327	0.240
	1	4.632	0.002832	0.013	0.103	20.53	2.114	2.327	0.240
	1	4.632	0.002832	0.013	0.103	21.83	2.248	2.327	0.240

	1	4.632	0.002832	0.013	0.103	22.48	2.315	2.327	0.240
	1	4.632	0.002832	0.013	0.103	23.13	2.382	2.327	0.240
	1	4.632	0.002832	0.013	0.103	23.78	2.449	2.327	0.240
	1	4.632	0.002832	0.013	0.103	25.08	2.583	2.327	0.240
	1	4.632	0.002832	0.013	0.103	25.73	2.650	2.327	0.240
	1	4.632	0.002832	0.013	0.103	26.38	2.716	2.327	0.240
	1	4.632	0.002832	0.013	0.103	27.03	2.783	2.327	0.240
	1	4.632	0.002832	0.013	0.103	28.33	2.917	2.327	0.240
	1	4.632	0.002832	0.013	0.103	28.98	2.984	2.327	0.240
	1	4.632	0.002832	0.013	0.103	29.63	3.051	2.327	0.240
	1	4.632	0.002832	0.013	0.103	30.28	3.118	2.327	0.240
	1	4.632	0.002832	0.013	0.103	31.58	3.252	2.327	0.240
	1	4.632	0.002832	0.013	0.103	32.23	3.319	2.327	0.240
	1	4.632	0.002832	0.013	0.103	32.88	3.386	2.327	0.240
	1	4.632	0.002832	0.013	0.103	33.53	3.453	2.327	0.240

	1	4.632	0.002832	0.013	0.103	34.83	3.587	2.327	0.240
	1	4.632	0.002832	0.013	0.103	35.48	3.654	2.327	0.240
	1	4.632	0.002832	0.013	0.103	36.13	3.720	2.327	0.240
	1	4.632	0.002832	0.013	0.103	36.78	3.787	2.327	0.240
	1	4.632	0.002832	0.013	0.103	38.08	3.921	2.327	0.240
	1	4.632	0.002832	0.013	0.103	38.73	3.988	2.327	0.240
	1	4.632	0.002832	0.013	0.103	39.38	4.055	2.327	0.240
	1	4.632	0.002832	0.013	0.103	40.03	4.122	2.327	0.240
	1	4.632	0.002832	0.013	0.103	41.33	4.256	2.327	0.240
	1	4.632	0.002832	0.013	0.103	41.98	4.323	2.327	0.240
	1	4.632	0.002832	0.013	0.103	42.63	4.390	2.327	0.240
	1	4.632	0.002832	0.013	0.103	43.28	4.457	2.327	0.240
	1	4.632	0.002832	0.013	0.103	44.58	4.591	2.327	0.240
	1	4.632	0.002832	0.013	0.103	45.23	4.658	2.327	0.240
	1	4.632	0.002832	0.013	0.103	45.88	4.724	2.327	0.240

	1	4.632	0.002832	0.013	0.103	46.53	4.791	2.327	0.240
	1	4.632	0.002832	0.013	0.103	47.83	4.925	2.327	0.240
	1	4.632	0.002832	0.013	0.103	48.48	4.992	2.327	0.240
	1	4.632	0.002832	0.013	0.103	49.13	5.059	2.327	0.240
	1	4.632	0.002832	0.013	0.103	49.78	5.126	2.327	0.240
	1	4.632	0.002832	0.013	0.103	51.08	5.260	2.327	0.240
	1	4.632	0.002832	0.013	0.103	51.73	5.327	2.327	0.240
	1	4.632	0.002832	0.013	0.103	52.38	5.394	2.327	0.240
	1	4.632	0.002832	0.013	0.103	53.03	5.461	2.327	0.240
	1	4.632	0.002832	0.013	0.103	54.33	5.595	2.327	0.240
	1	4.632	0.002832	0.013	0.103	54.98	5.662	2.327	0.240
	1	4.632	0.002832	0.013	0.103	55.63	5.728	2.327	0.240
	1	4.632	0.002832	0.013	0.103	56.28	5.795	2.327	0.240
	1	4.632	0.002832	0.013	0.103	57.58	5.929	2.327	0.240
	1	4.632	0.002832	0.013	0.103	58.23	5.996	2.327	0.240

	1	4.632	0.002832	0.013	0.103	58.88	6.063	2.327	0.240
	1	4.632	0.002832	0.013	0.103	59.53	6.130	2.327	0.240
	1	4.632	0.002832	0.013	0.103	60.83	6.264	2.327	0.240
	1	4.632	0.002832	0.013	0.103	61.48	6.331	2.327	0.240
	1	4.632	0.002832	0.013	0.103	62.13	6.398	2.327	0.240
	1	4.632	0.002832	0.013	0.103	62.78	6.465	2.327	0.240
	1	4.632	0.002832	0.013	0.103	64.08	6.599	2.327	0.240
	1	4.632	0.002832	0.013	0.103	64.73	6.666	2.327	0.240
	1	4.632	0.002832	0.013	0.103	65.38	6.733	2.327	0.240
	1	4.632	0.002832	0.013	0.103	66.03	6.799	2.327	0.240
	1	4.632	0.002832	0.013	0.103	67.33	6.933	2.327	0.240
Ordinary Frames Forward	1	4.632	0.002832	0.013	0.103	71.87	7.401	2.327	0.240
	1	4.632	0.002832	0.013	0.103	72.52	7.468	2.327	0.240
	1	4.632	0.002832	0.013	0.103	73.82	7.602	2.327	0.240
	1	4.632	0.002832	0.013	0.103	74.47	7.669	2.327	0.240

	1	4.632	0.002832	0.013	0.103	75.77	7.802	2.327	0.240
	1	4.632	0.002832	0.013	0.103	76.42	7.869	2.327	0.240
	1	4.632	0.002832	0.013	0.103	77.72	8.003	2.327	0.240
	1	4.632	0.002832	0.013	0.103	78.37	8.070	2.327	0.240
	1	4.632	0.002832	0.013	0.103	79.02	8.137	2.327	0.240
	1	4.632	0.002832	0.013	0.103	80.32	8.271	2.327	0.240
	1	4.632	0.002832	0.013	0.103	80.97	8.338	2.327	0.240

Deck Strengthening Member

ITEM	Amount	Length(m)	area (m^2)	volume (m^3)	weight (ton)	LCG(m)	LCG moment from aft	VCG	VCG moment from baseline
Main Deck									
Deck Center Girder	1	81.16	0.0036	0.292	2.294	40.58	93.074	5.2	11.927
Deeck Side Girder 1	2	31.8986	0.0036	0.115	1.803	40.58	73.162	5.2	9.375
Deck Side Girder 2	2	30.6103	0.0036	0.110	1.730	40.58	70.207	5.2	8.996
Deck Side Girder 3	2	28.6056	0.0036	0.103	1.617	40.58	65.609	5.2	8.407
Deck Side Girder 4	2	70.646	0.0036	0.254	3.993	40.58	162.032	5.2	20.763
Deck Web Beam	1	13.49	0.00153125	0.021	0.162	0.233	0.038	5.2	0.843
	1	15.218	0.00153125	0.023	0.183	8.308	1.520	5.2	0.951
	1	15.542	0.00153125	0.024	0.187	10.908	2.038	5.2	0.971

	1	15.7	0.0015312 5	0.024	0.189	13.508	2.549	5.2	0.981
	1	15.724	0.0015312 5	0.024	0.189	18.058	3.413	5.2	0.983
	1	15.724	0.0015312 5	0.024	0.189	20.658	3.905	5.2	0.983
	1	15.724	0.0015312 5	0.024	0.189	23.258	4.396	5.2	0.983
	1	15.724	0.0015312 5	0.024	0.189	25.858	4.887	5.2	0.983
	1	15.724	0.0015312 5	0.024	0.189	28.458	5.379	5.2	0.983
	1	15.724	0.0015312 5	0.024	0.189	31.058	5.870	5.2	0.983
	1	15.724	0.0015312 5	0.024	0.189	33.658	6.362	5.2	0.983
	1	15.724	0.0015312 5	0.024	0.189	36.258	6.853	5.2	0.983
	1	15.724	0.0015312 5	0.024	0.189	38.858	7.344	5.2	0.983

	1	15.724	0.0015312 5	0.024	0.189	41.458	7.836	5.2	0.983
	1	15.724	0.0015312 5	0.024	0.189	44.058	8.327	5.2	0.983
	1	15.724	0.0015312 5	0.024	0.189	46.658	8.819	5.2	0.983
	1	15.724	0.0015312 5	0.024	0.189	49.258	9.310	5.2	0.983
	1	15.724	0.0015312 5	0.024	0.189	51.858	9.802	5.2	0.983
	1	15.724	0.0015312 5	0.024	0.189	54.458	10.293	5.2	0.983
	1	15.724	0.0015312 5	0.024	0.189	57.058	10.784	5.2	0.983
	1	15.724	0.0015312 5	0.024	0.189	59.658	11.276	5.2	0.983
	1	15.724	0.0015312 5	0.024	0.189	62.258	11.767	5.2	0.983
	1	15.724	0.0015312 5	0.024	0.189	64.858	12.259	5.2	0.983

	1	15.724	0.0015312 5	0.024	0.189	67.458	12.750	5.2	0.983
	1	15.604	0.0015312 5	0.024	0.188	70.058	13.140	5.2	0.975
	1	11.296	0.0015312 5	0.017	0.136	76.458	10.382	5.2	0.706
	1	7.316	0.0015312 5	0.011	0.088	78.858	6.935	5.2	0.457

Superstructure

ITEM	Amount	Length(m)	area (m^2)	volume (m^3)	weight (ton)	LCG(m)	LCG moment from aft	VCG	VCG moment from baseline
Poop Deck									
Deck Center girder	1	16.326	0.0036	0.059	0.461	8.163	3.766	9.16	4.226
Deeck Side Girder 1	2	16.326	0.0036	0.059	0.923	8.163	7.532	9.16	8.452
Deck Side Girder 2	2	16.326	0.0036	0.059	0.923	8.163	7.532	9.16	8.452
Deck Side Girder 3	2	16.326	0.0036	0.059	0.923	8.163	7.532	9.16	8.452
Deck Side Girder 4	2	13.206	0.0036	0.048	0.746	6.603	4.928	9.16	6.837
Deck Beam	1	13.2	0.00153125	0.020	0.159	0.204	0.032	9.16	1.453
	1	14.94	0.00153125	0.023	0.180	8.17	1.467	9.16	1.645
	1	15.3564	0.00153125	0.024	0.185	10.77	1.988	9.16	1.691
	1	15.58	0.00153125	0.024	0.187	13.67	2.560	9.16	1.715
Stiffener	2	16.326	0.002832	0.046	0.726	8.163	5.925	6.7	4.863
	2	16.326	0.002832	0.046	0.726	8.163	5.925	8.04	5.836

ITEM	Amount	Length(m)	area (m^2)	volume (m^3)	weight (ton)	LCG(m)	LCG moment from aft	VCG	VCG moment from baseline
Pilot Deck									
Deck Center girder	1	11.9	0.0036	0.0428	0.3363	9.75	3.279	11.8	3.968
Deeck Side Girder 1	2	11.9	0.0036	0.0428	0.6726	9.75	6.558	11.8	7.937
Deck Side Girder 2	2	11.9	0.0036	0.0428	0.6726	9.75	6.558	11.8	7.937
Deck Side Girder 3	2	11.9	0.0036	0.0428	0.6726	9.75	6.558	11.8	7.937
Deck Side Girder 4	2	9.73	0.0036	0.0350	0.5499	10	5.499	11.8	6.489
Deck Beam	1	6.9	0.00153125	0.0106	0.0829	5.56	0.461	11.8	0.979
	1	7.2	0.00153125	0.0110	0.0865	8.16	0.706	11.8	1.021
	1	7.4	0.00153125	0.0113	0.0890	10.76	0.957	11.8	1.050
	1	7.7	0.00153125	0.0118	0.0926	13.36	1.237	11.8	1.092
Stiffener	2	11.9	0.001152	0.0137	0.2152	9.75	2.098	10.51	2.262

	2	11.9	0.001152	0.0137	0.2152	9.75	2.098	11.135	2.397
	2	11.9	0.001152	0.0137	0.2152	9.75	2.098	11.76	2.531

ITEM	Amount	Length(m)	area (m^2)	volume (m^3)	weight (ton)	LCG(m)	LCG moment from aft	VCG	VCG moment from baseline
Bridge Deck									
Deck Center girder	1	9.4	0.0036	0.034	0.266	8.5	2.258	14.3	3.799
Deeck Side Girder 1	2	9.4	0.0036	0.034	0.531	8.5	4.516	14.3	7.597
Deck Side Girder 2	2	9.4	0.0036	0.034	0.531	8.5	4.516	14.3	7.597
Deck Side Girder 3	2	9.4	0.0036	0.034	0.531	8.5	4.516	14.3	7.597
Deck Side Girder 4	2	1.95	0.0036	0.007	0.110	9	0.992	14.3	1.576
Deck Beam	1	9.28	0.00153125	0.014	0.112	6.83	0.762	14.3	1.595
	1	9.28	0.00153125	0.014	0.112	9.43	1.052	14.3	1.595
	1	9.28	0.00153125	0.014	0.112	12.03	1.342	14.3	1.595

stiffener	2	9.4	0.001152	0.011	0.170	8.5	1.445	12.55	2.134
	2	9.4	0.001152	0.011	0.170	8.5	1.445	13.175	2.240
	2	9.4	0.001152	0.011	0.170	8.5	1.445	13.8	2.346

ITEM	Amount	Length(m)	area (m^2)	volume (m^3)	weight (ton)	LCG(m)	LCG moment from aft	VCG	VCG moment from baseline
Bridge Deck Top									
Deck Center Girder	1	5.207	0.0036	0.019	0.147	10.7	1.575	17.2	2.531
Deck Side Girder 1	2	5.207	0.0036	0.019	0.294	10.7	3.149	17.2	5.062
Deck Side Girder 2	2	4.6	0.0036	0.017	0.260	10.4	2.704	17.2	4.472
Deck Beam 1	1	7.52	0.00153125	0.012	0.090	9.72	0.879	17.2	1.555
	1	7.52	0.00153125	0.012	0.090	12.32	1.114	17.2	1.555
stiffener	2	5.207	0.001152	0.006	0.094	10.7	1.008	15.12	1.424
	2	5.207	0.001152	0.006	0.094	10.7	1.008	15.75	1.483
	2	5.207	0.001152	0.006	0.094	10.7	1.008	16.4	1.544

ITEM	Amount	Length(m)	area (m^2)	volume (m^3)	weight (ton)	LCG(m)	LCG moment from aft	VCG	VCG moment from baseline
Forcastle Deck									
Deck Center Girder	1	10.66	0.0036	0.038	0.301	75.83	22.844	8.4	2.531
Deeck Side Girder 1	2	10.32	0.0036	0.037	0.583	75.66	44.131	8.4	4.900
Deck Side Girder 2	2	7.78	0.0036	0.028	0.440	74.39	32.711	8.4	3.694
Deck Side Girder 3	2	6.1	0.0036	0.022	0.345	73.55	25.358	8.4	2.896
Deck Side Girder 4	2	3.16	0.0036	0.011	0.179	72.08	12.874	8.4	1.500
Deck Beam 1	1	12.72	0.00153125	0.019	0.153	76.328	11.670	8.4	1.284
Deck Beam 2	1	9.2	0.00153125	0.014	0.111	78.928	8.728	8.4	0.929

Bulkheads

ITEM	Amount	Length(m)	Height(m)	area (m^2)	volume (m^3)	weight (ton)	LCG(m)	LCG moment from aft	VCG	VCG moment from baseline
Collision BHD	1	12.9293	7.505	97.03956822	0.679	5.332	76.162	406.120	3.753	20.011
vertical stiffeners	3		7.505	0.002112	0.016	0.373	76.162	28.431	3.753	1.401
BHD 1	1	14.6377	7.478	109.4577931	0.766	6.015	73.178	440.144	3.739	22.488
vertical stiffeners	3		7.478	0.002112	0.016	0.050	73.178	3.640	3.739	0.186
BHD 2	1	15.2637	5.525	84.32888976	0.590	4.634	71.229	330.066	2.762	12.801
vertical stiffeners	3		5.525	0.002112	0.012	0.275	71.229	19.573	2.762	0.759
BHD 3	1	15.728	5.525	86.8940544	0.608	4.775	52.378	250.096	2.762	13.190
vertical stiffeners	3		5.525	0.002112	0.012	0.275	52.378	14.393	2.762	0.759
BHD 4 (machinery space)	1	15.728	5.656	88.9638592	0.623	4.889	15.978	78.109	2.828	13.826
vertical stiffeners	3		5.656	0.002112	0.012	0.281	15.978	4.495	2.828	0.796
BHD 5 (machinery Space)	1	15.8957	5.176	82.28250148	0.576	4.521	6.246	28.241	2.726	12.326
vertical stiffeners	3		5.176	0.002112	0.011	0.257	6.246	1.608	2.726	0.702

ITEM	Amount	Length(m)	area (m^2)	volume (m^3)	weight (ton)	LCG(m)	LCG moment from aft	VCG	VCG moment from baseline
Main Hull Brackets(upper)	192	0.182	0.002832	0.000515424	0.777	40.5805	31.525	2.703	2.0998
Main Hull Brackets lower	192	0.312	0.002832	0.000883584	1.332	40.5805	54.043	2.703	3.5997
Super Structure Brackets upper and lower	72	0.182	0.001511	0.000275002	0.155	5.95145	0.925	8.5	1.3212

Total weight of Structural members = 154.048 tonnes

Total moment of LCG = 6379.963

Machinery Weight

Items	**Quantity**	**Unit weight (tonne)**	**Total weight (tonnes)**	**LCG (m)**	**Moment** (about aft)	**VCG (m)**	**Moment** (about keel)
Main Engine	2	6.5	13	10.52	136.760	2	26
Generator	2	0.2	0.4	10.52	4.208	2	0.8
Pump	2	0.102	0.204	10.52	2.146	2	0.408
	2	0.102	0.204	10.52	2.146	2	0.408
	1	0.102	0.102	10.52	1.073	2	0.204
	1	0.102	0.102	10.52	1.073	2	0.204
Rudder & Steering Arrangement	2	0.8	1.6	2.02	3.232	2.9586	4.734
Anchor forward	2	3.5	7	77.94	5.820		0
anchor aft1	1	3.5	3.5	0.1735	0.607	6.535	22.873
Stud Link Chain Cable	1	3	3	0.8817	2.645	7.8951	23.685
Stud Link Chain Cable	2	3	6	75.8152	454.891	7.8951	47.371
Towline	1	0.25	0.25	40.58	10.145	8.13	2.033

Mooring Ropes	3		0.5	40.58	20.290	8.13	4.065
Windlass	3	1	3	40.58	121.740	8.13	24.39
Bollard	12	0.05	0.6	40.58	24.348	8.13	4.878
Propeller, Propeller Shaft	2	2	4	3.7	14.800	1.0812	4.325
Complete Piping		0.5	0.5	40.58	20.290	3	1.5
Gear box	2	0.36	0.72	10.52	7.574	2	1.44

Total machinery weight = 45.61tonnes

WOOD AND OUTFIT Weight

Item	No. of Items	Weight (kg)	Total Weight (ton)	LCG (m)	Moment about aft	VCG (m)	Moment about keel
Control Panel	1	450.00	0.45	47.92	21.56	14.40	6.48
Wing Control Panel (Starboard)	1	20.00	0.02	47.92	0.96	14.40	0.29
Wing Control Panel (Port side)	1	20.00	0.02	47.92	0.96	14.40	0.29
Cabinet	2	50.00	0.05	32.10	1.61	10.40	0.52
Chart Table	1	15.00	0.015	45.00	0.68	14.00	0.21
Chart Table-Chair	1	12.00	0.012	45.00	0.54	14.00	0.17
Map Table	1	18.00	0.018	45.00	0.81	14.00	0.25
Map Table- Chair	1	15.00	0.015	45.00	0.68	14.00	0.21
Control Panel- Chair	2	15.00	0.015	45.00	0.68	14.00	0.21
Radio Instrument Table	1	50.00	0.05	32.10	1.61	14.00	0.70
Radio Operator's Chair	1	20.00	0.02	21.10	0.42	10.40	0.21
Sofa	1	40.00	0.04	32.10	1.28	10.40	0.42

Shower	1	20.00	0.02	13.50	0.27	6.25	0.13
Shower	1	20.00	0.02	11.05	0.22	9.25	0.19
Shower	1	20.00	0.02	15.2	0.30	9.25	0.19
Washing Machine	2	150	0.15	5.85	0.88	8.18	1.23
Single bed	1	50.00	0.05	32.74	1.64	10.40	0.52
Locker	1	25.00	0.025	32.74	0.82	10.40	0.26
Table	1	15.00	0.015	32.74	0.49	10.40	0.16
chair	1	6.00	0.006	32.74	0.20	10.40	0.06
Single bed	1	50.00	0.05	10.70	0.54	6.54	0.33
Table	1	15.00	0.015	10.70	0.16	6.54	0.10
chair	1	6.00	0.006	10.70	0.06	6.54	0.04
Locker	1	25.00	0.025	10.70	0.27	6.54	0.16

Single bed	1	50.00	0.05	32.74	1.64	10.40	0.52
Cabinet	1	25.00	0.025	32.74	0.82	10.40	0.26
Table	1	15.00	0.015	32.74	0.49	10.40	0.16
Chair	1	6.00	0.006	32.74	0.20	10.40	0.06
Single Bed	2	100.00	0.1	10.70	1.07	6.54	0.65
locker	0	0.00	0	10.70	0.00	6.54	0.00
Table	1	15.00	0.015	10.70	0.16	6.54	0.10
Chair	1	6.00	0.006	10.70	0.06	6.54	0.04
Double bed	1	80.00	0.08	32.74	2.62	10.40	0.83
Cabinet	1	25.00	0.025	32.74	0.82	10.40	0.26
Table	1	20.00	0.02	32.74	0.65	10.40	0.21
Chair	1	6.00	0.006	32.74	0.20	10.40	0.06

TV	1	25.00	0.025	32.74	0.82	10.40	0.26
Mini Refrigerator	1	50.00	0.05	32.74	1.64	10.40	0.52
Single bed	2	100.00	0.1	10.70	1.07	6.54	0.65
Table	1	15.00	0.015	10.70	0.16	6.54	0.10
Chair	1	6.00	0.006	10.70	0.06	6.54	0.04
Locker	2	50.00	0.05	10.70	0.54	6.54	0.33
Single bed	2	100.00	0.1	10.70	1.07	6.25	0.63
Table	1	15.00	0.015	10.70	0.16	6.25	0.09
Chair	1	6.00	0.006	10.70	0.06	6.25	0.04
Locker	1	25.00	0.025	10.70	0.27	6.25	0.16
						6.25	
Single bed	2	100.00	0.1	10.70	1.07	6.25	0.63
Table	1	15.00	0.015	10.70	0.16	6.25	0.09

Chair	1	6.00	0.006	10.70	0.06	6.25	0.04
Locker	2	50.00	0.05	10.70	0.54	6.25	0.31
				10.70	0.00	6.25	0.00
Single bed	2	100.00	0.1	10.70	1.07	6.25	0.63
Table	1	15.00	0.015	10.70	0.16	6.25	0.09
Chair	1	6.00	0.006	10.70	0.06	6.25	0.04
Cabinet	1	25.00	0.025	10.70	0.27	6.25	0.16
				10.70	0.00	6.25	0.00
Single bed	2	100.00	0.1	10.70	1.07	6.25	0.63
Table	1	15.00	0.015	10.70	0.16	6.25	0.09
Chair	1	6.00	0.006	10.70	0.06	6.25	0.04
Cabinet	2	50.00	0.05	10.70	0.54	6.25	0.31
				10.70	0.00	6.25	0.00

Single bed	1	50.00	0.05	8.40	0.42	6.25	0.31
Locker	1	25.00	0.025	8.40	0.21	6.25	0.16
Table	1	15.00	0.015				
Chair	1	6.00	0.006				
Cooker Gas	1	45.00	0.045	11.20	0.50	6.25	0.28
Dish washer	1	50.00	0.05	11.20	0.56	6.25	0.31
Cabinet	1	25.00	0.025	8.40	0.21	6.25	0.16
Table	1	80.00	0.08	8.40	0.67	6.25	0.50
Chair	6	36.00	0.216	8.40	1.81	6.25	1.35
Vegetable Storage		100.00	0.1	13.50	1.35	6.25	0.63

Frogen Food Storage		400.00	0.4	13.50	5.40	6.25	2.50
Cabinet		50.00	0.05	13.50	0.68	6.25	0.31
Table	1	100.00	0.1	13.50	1.35	6.25	0.63
chair	6	36.00	0.036	13.50	0.49	6.25	0.23
aft	9	630.00	0.63	12.00	7.56	7.75	4.88
Fwd	4	280.00	0.28	62.50	17.50	6.25	1.75
		300.00	3	45.30	135.90	5.50	16.50
	1	200.00	2	8.90	17.80	12.25	24.50
			2	0.00	0.00	0.00	0.00

Total wood and outfit weight = 12.60 tonnes

Weight Calculation Summary

Steel Weight = 630.20 tonnes

Machinery Weight = 45.61 tonnes

Wood and Outfit Weight = 12.60 tonnes

Total Lightweight = 688.41 tonnes

Appendix 7

Stability Calculation:

Lightship condition ordinates

0 degree		
	immerse	**emmersed**
st o	0	0
st 0.5	0	0
st 1	0	0
st 1.5	6642	6642
st 2	7710	7710
st 3	7799	7799
st 4	7799	7799
st 5	7799	7799
st 6	7799	7799
st 7	7799	7799
st 8	7786	7786
st 8.5	7709	7709
st 9	6756	6756
st 9.5	4220	4220

st 10	0	0

15 degree		
	immerse	**emmersed**
st o	0	0
st 0.5	0	0
st 1	7375	0
st 1.5	7924	765
st 2	8130	2493
st 3	8149	2493
st 4	8149	2493
st 5	8149	2493
st 6	8149	2493
st 7	8149	2493
st 8	8147	2493

st 8.5	8129	2493
st 9	7425	2493
st 9.5	4913	2493
st 10	0	0

30 degree		
	immerse	**emmersed**
st o	0	0
st 0.5	8070	0
st 1	8672	0
st 1.5	9016	409
st 2	9086	1297
st 3	9107	1297
st 4	9107	1297
st 5	9107	1297
st 6	9107	1297
st 7	9107	1297
st 8	9099	1297
st 8,5	9091	1297
st 9	8442	1297

st 9.5	5443	1297
st 10	0	0

45 degree		
	immerse	**emmersed**
st o	9624	0
st 0.5	10230	0
st 1	10785	0
st 1.5	11130	291
st 2	11167	917
st 3	11177	917
st 4	11177	917
st 5	11177	917

st 6	11177	917
st 7	11177	917
st 8	11205	917
st 8,5	11201.2	917
st 9	10931	917
st 9.5	7943	917
st 10	0	0

60 degree		
	immerse	**emmersed**
st o	9419	0
st 0.5	9419	0
st 1	9419	0
st 1.5	9419	241
st 2	9419	757
st 3	9419	757
st 4	9419	757
st 5	9419	757
st 6	9419	757
st 7	9419	757
st 8	9419	757
st 8,5	9419	757
st 9	9419	757
st 9.5	9419	757
st 10	2060	0

75 degree		
	immerse	**emmersed**
st o	8412	0
st 0.5	8412	0
st 1	8412	0
st 1.5	8412	216
st 2	8412	676
st 3	8412	676
st 4	8412	676
st 5	8412	676
st 6	8412	676
st 7	8412	676
st 8	8412	676
st 8,5	8412	676
st 9	8412	676

st 9.5	8412	676
st 10	8412	0

90 degree		
	immerse	**emmersed**
st o	8115	0
st 0.5	8115	0
st 1	8115	0
st 1.5	8115	209
st 2	8115	653
st 3	8115	653
st 4	8115	653
st 5	8115	653
st 6	8115	653
st 7	8115	653
st 8	8115	653

st 8,5	8115	653
st 9	8115	653
st 9.5	8115	653
st 10	8115	0

Loaded condition ordinates

0 degree		
	immerse	**emmersed**
st o	0	0
st 0.5	6515	6515
st 1	7386	7386
st 1.5	7775	7775
st 2	7849	7849
st 3	7864	7864
st 4	7864	7864
st 5	7864	7864
st 6	7864	7864
st 7	7864	7864
st 8	7862	7862
st 8.5	7849	7849
st 9	7212	7212
st 9.5	4725	4725
st 10	279	279

15 degree		
	immerse	**emmersed**
st o	6569	0
st 0.5	7326	3608
st 1	7782	6631
st 1.5	8070	7875
st 2	8136	8135
st 3	8149	8149
st 4	8149	8149
st 5	8149	8149
st 6	8149	8149
st 7	8149	8149
st 8	8147	8148
st 8,5	8135	8134
st 9	7611	7362
st 9.5	5224	4190
st 10	241	362

30 degree		
	immerse	**emmersed**
st o	7819	0
st 0.5	8308	1948
st 1	8753	4119
st 1.5	9039	6139
st 2	9101	7128
st 3	9107	7128
st 4	9107	7128
st 5	9107	7128
st 6	9107	7128
st 7	9107	7128
st 8	9.105	7128
st 8,5	9100	7128
st 9	8815	7128
st 9.5	6850	7128
st 10	230	582

45 degree		
	immerse	**emmersed**
st o	7303	0
st 0.5	7303	1395
st 1	7730	2953
st 1.5	7730	4363
st 2	7730	5036
st 3	7730	5036
st 4	7730	5036
st 5	7730	5036
st 6	7730	5036
st 7	7730	5036
st 8	7730	5036
st 8,5	7730	5036
st 9	7730	5036
st 9.5	7730	5036
st 10	232	1369

60 degree		
	immerse	**emmersed**
st o	6016	0
st 0.5	6016	1160
st 1	6016	2458
st 1.5	6016	3621
st 2	6016	4159
st 3	6016	4159
st 4	6016	4159
st 5	6016	4159
st 6	6016	4159
st 7	6016	4159
st 8	6016	4159
st 8,5	6016	4159
st 9	6016	4159
st 9.5	6016	4159
st 10	6016	2053

75 degree		
	immerse	**emmersed**
st o	5373	0
st 0.5	5373	1042
st 1	5373	2210
st 1.5	5373	3245
st 2	5373	3712
st 3	5373	3712
st 4	5373	3712
st 5	5373	3712
st 6	5373	3712
st 7	5373	3712
st 8	5373	3712
st 8,5	5373	3712
st 9	5373	3712
st 9.5	5373	3712
st 10	5373	2272

90 degree		
	immerse	**emmersed**
st o	5189	0
st 0.5	5189	1011
st 1	5189	2146
st 1.5	5189	3144
st 2	5189	3588
st 3	5189	3588
st 4	5189	3588
st 5	5189	3588
st 6	5189	3588
st 7	5189	3588
st 8	5189	3588
st 8,5	5189	3588
st 9	5189	3588
st 9.5	5189	3588
st 10	5189	2519

L(ship length)	77.942	m
INTERVAL(radians)	0.262	
DEPTH	5.406	m
VOLUME	6.87E+11	mm^3
KB	326	mm

TABLE FOR STABILITY

WATER SECTION INCLINED AT 0 degree

STATION	SM MULTIPLIERS	IMMERSED WEDGE				EMERGED WEDGE			
		ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES	ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES
		y_i	y_i x SM	y_i^2 x SM	y_i^3x SM	y_e	y_e x SM	y_e^2 x SM	y_e^3 x SM
0	0.25	0	0	0	0	0	0	0	0
0.5	1	0	0	0	0	0	0	0	0

1	0.5	0	0	0	0	0	0	0	0
1.5	1	6642	6642	44116164	2.93E+11	6642	6642	44116164	2.93E+11
2	0.75	7710	5782.5	44583075	3.44E+11	7710	5782.5	44583075	3.44E+11
3	2	7799	15598	121648802	9.49E+11	7799	15598	121648802	9.49E+11
4	1	7799	7799	60824401	4.74E+11	7799	7799	60824401	4.74E+11
5	2	7799	15598	121648802	9.49E+11	7799	15598	121648802	9.49E+11
6	1	7799	7799	60824401	4.74E+11	7799	7799	60824401	4.74E+11
7	2	7799	15598	121648802	9.49E+11	7799	15598	121648802	9.49E+11
8	0.75	7786	5839.5	45466347	3.54E+11	7786	5839.5	45466347	3.54E+11
8.5	1	7709	7709	59428681	4.58E+11	7709	7709	59428681	4.58E+11
9	0.5	6756	3378	22821768	1.54E+11	6756	3378	22821768	1.54E+11
9.5	1	4220	4220	17808400	75151448000	4220	4220	17808400	75151448000
10	0.25	0	0	0	0	0	0	0	0
∑			95963	720819643	5.47E+12		95963	720819643	5.47E+12
(EW+ IW) of $\sum(y^3 \times SM)$ =									1.09E+13

TABLE FOR STABILITY									
WATER SECTION INCLINED AT 15 degree									
STATION	SM MULTIPLIERS	IMMERSED WEDGE				EMERGED WEDGE			
		ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES	ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES
		y_i	y_i x SM	y_i^2 x SM	y_i^3 x SM	y_e	y_e x SM	y_e^2 x SM	y_e^3 x SM
0	0.25	0	0	0	0	0	0	0	0
0.5	1	0	0	0	0	0	0	0	0
1	0.5	7375	3687.5	27195312.5	2.01E+11	0	0	0	0
1.5	1	7924	7924	62789776	4.98E+11	765	765	585225	447697125
2	0.75	8130	6097.5	49572675	4.03E+11	2493	1869.75	4661286.75	11620587868
3	2	8149	16298	132812402	1.08E+12	2493	4986	12430098	30988234314
4	1	8149	8149	66406201	5.41E+11	2493	2493	6215049	15494117157
5	2	8149	16298	132812402	1.08E+12	2493	4986	12430098	30988234314
6	1	8149	8149	66406201	5.41E+11	2493	2493	6215049	15494117157

7	2	8149	16298	132812402	1.08E+12	2493	4986	12430098	30988234314
8	0.75	8147	6110.25	49780206.75	4.06E+11	2493	1869.75	4661286.75	11620587868
8.5	1	8129	8129	66080641	5.37E+11	2493	2493	6215049	15494117157
9	0.5	7425	3712.5	27565312.5	2.05E+11	2493	1246.5	3107524.5	7747058579
9.5	1	4913	4913	24137569	1.19E+11	2493	2493	6215049	15494117157
10	0.25	0	0	0	0	0	0	0	0
∑			105765.75	838371100.8	6.70E+12		30681	75165813	1.86E+11
(EW+ IW) of $\sum(y^3 \times SM)$ =									6.88E+12

TABLE FOR STABILITY									
WATER SECTION INCLINED AT 30 degree									
STATION	SM MULTIPLIERS	IMMERSED WEDGE				EMERGED WEDGE			
		ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES	ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES
		y_i	y_i x SM	y_i^2 x SM	y_i^3 x SM	y_e	y_e x SM	y_e^2 x SM	y_e^3 x SM
0	0.25	0	0	0	0	0	0	0	0
0.5	1	8070	8070	65124900	5.26E+11	0	0	0	0
1	0.5	8672	4336	37601792	3.26E+11	0	0	0	0
1.5	1	9016	9016	81288256	7.33E+11	409	409	167281	68417929
2	0.75	9086	6814.5	61916547	5.63E+11	1297	972.75	1261656.75	1636368805
3	2	9107	18214	165874898	1.51E+12	1297	2594	3364418	4363650146
4	1	9107	9107	82937449	7.55E+11	1297	1297	1682209	2181825073
5	2	9107	18214	165874898	1.51E+12	1297	2594	3364418	4363650146
6	1	9107	9107	82937449	7.55E+11	1297	1297	1682209	2181825073

7	2	9107	18214	165874898	1.51E+12	1297	2594	3364418	4363650146
8	0.75	9099	6824.25	62093850.75	5.65E+11	1297	972.75	1261656.75	1636368805
8.5	1	9091	9091	82646281	7.51E+11	1297	1297	1682209	2181825073
9	0.5	8442	4221	35633682	3.01E+11	1297	648.5	841104.5	1090912537
9.5	1	5443	5443	29626249	1.61E+11	1297	1297	1682209	2181825073
10	0.25	0	0	0	0	0	0	0	0
∑			126671.75	1119431150	9.97E+12		15973	20353789	26250318805
(EW+ IW) of $\sum(y^3 \times SM)$ =									9.99E+12

TABLE FOR STABILITY									
WATER SECTION INCLINED AT 45 degree									
STATION	SM MULTIPLIERS	IMMERSED WEDGE				EMERGED WEDGE			
		ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES	ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES
		y_i	y_i x SM	y_i^2 x SM	y_i^3 x SM	y_e	y_e x SM	y_e^2 x SM	y_e^3 x SM
0	0.25	9624	2406	23155344	2.23E+11	0	0	0	0
0.5	1	10230	10230	104652900	1.07E+12	0	0	0	0
1	0.5	10785	5392.5	58158112.5	6.27E+11	0	0	0	0
1.5	1	11130	11130	123876900	1.38E+12	291	291	84681	24642171
2	0.75	11167	8375.25	93526416.75	1.04E+12	917	687.75	630666.75	578321409.8
3	2	11177	22354	249850658	2.79E+12	917	1834	1681778	1542190426
4	1	11177	11177	124925329	1.40E+12	917	917	840889	771095213
5	2	11177	22354	249850658	2.79E+12	917	1834	1681778	1542190426
6	1	11177	11177	124925329	1.40E+12	917	917	840889	771095213

7	2	11177	22354	249850658	2.79E+12	917	1834	1681778	1542190426
8	0.75	11205	8403.75	94164018.75	1.06E+12	917	687.75	630666.75	578321409.8
8.5	1	11201.2	11201.2	125466881.4	1.41E+12	917	917	840889	771095213
9	0.5	10931	5465.5	59743380.5	6.53E+11	917	458.5	420444.5	385547606.5
9.5	1	7943	7943	63091249	5.01E+11	917	917	840889	771095213
10	0.25	0	0	0	0	0	0	0	0
∑			159963.2	1745237835	1.91E+13		11295	10175349	9277784727
(EW+ IW) of $\sum(y^3 \times SM)$ =									1.91E+13

TABLE FOR STABILITY									
WATER SECTION INCLINED AT 60 degree									
STATION	SM MULTIPLIERS	IMMERSED WEDGE				EMERGED WEDGE			
		ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES	ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES
		y_i	y_i x SM	y_i^2 x SM	y_i^3 x SM	y_e	y_e x SM	y_e^2 x SM	y_e^3 x SM
0	0.25	9419	2354.75	22179390.25	2.09E+11	0	0	0	0
0.5	1	9419	9419	88717561	8.36E+11	0	0	0	0
1	0.5	9419	4709.5	44358780.5	4.18E+11	0	0	0	0
1.5	1	9419	9419	88717561	8.36E+11	241	241	58081	13997521
2	0.75	9419	7064.25	66538170.75	6.27E+11	757	567.75	429786.75	325348569.8
3	2	9419	18838	177435122	1.67E+12	757	1514	1146098	867596186
4	1	9419	9419	88717561	8.36E+11	757	757	573049	433798093
5	2	9419	18838	177435122	1.67E+12	757	1514	1146098	867596186
6	1	9419	9419	88717561	8.36E+11	757	757	573049	433798093

7	2	9419	18838	177435122	1.67E+12	757	1514	1146098	867596186
8	0.75	9419	7064.25	66538170.75	6.27E+11	757	567.75	429786.75	325348569.8
8.5	1	9419	9419	88717561	8.36E+11	757	757	573049	433798093
9	0.5	9419	4709.5	44358780.5	4.18E+11	757	378.5	286524.5	216899046.5
9.5	1	9419	9419	88717561	8.36E+11	757	757	573049	433798093
10	0.25	2060	515	1060900	2185454000	0	0	0	0
$\sum$			139445.25	1309644925	1.23E+13		9325	6934669	5219574637
(EW+ IW) of $\sum(y^3 \times SM)$ =									1.23E+13

TABLE FOR STABILITY									
WATER SECTION INCLINED AT 75 degree									
STATION	SM MULTIPLIERS	IMMERSED WEDGE				EMERGED WEDGE			
		ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES	ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES
		y_i	y_i x SM	y_i^2 x SM	y_i^3 x SM	y_e	y_e x SM	y_e^2 x SM	y_e^3 x SM
0	0.25	8412	2103	17690436	1.49E+11	0	0	0	0
0.5	1	8412	8412	70761744	5.95E+11	0	0	0	0
1	0.5	8412	4206	35380872	2.98E+11	0	0	0	0
1.5	1	8412	8412	70761744	5.95E+11	216	216	46656	10077696
2	0.75	8412	6309	53071308	4.46E+11	676	507	342732	231686832
3	2	8412	16824	141523488	1.19E+12	676	1352	913952	617831552
4	1	8412	8412	70761744	5.95E+11	676	676	456976	308915776
5	2	8412	16824	141523488	1.19E+12	676	1352	913952	617831552
6	1	8412	8412	70761744	5.95E+11	676	676	456976	308915776

7	2	8412	16824	141523488	1.19E+12	676	1352	913952	617831552
8	0.75	8412	6309	53071308	4.46E+11	676	507	342732	231686832
8.5	1	8412	8412	70761744	5.95E+11	676	676	456976	308915776
9	0.5	8412	4206	35380872	2.98E+11	676	338	228488	154457888
9.5	1	8412	8412	70761744	5.95E+11	676	676	456976	308915776
10	0.25	8412	2103	17690436	1.49E+11	0	0	0	0
∑			126180	1061426160	8.93E+12		8328	5530368	3717067008
(EW+ IW) of $\sum(y^3 \times SM)$ =									8.93E+12

TABLE FOR STABILITY									
WATER SECTION INCLINED AT 90 degree									
STATION	SM MULTIPLIERS	IMMERSED WEDGE				EMERGED WEDGE			
		ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES	ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES
		y_i	y_i x SM	y_i^2 x SM	y_i^3 x SM	y_e	y_e x SM	y_e^2 x SM	y_e^3 x SM
0	0.25	8115	2028.75	16463306.25	1.34E+11	0	0	0	0
0.5	1	8115	8115	65853225	5.34E+11	0	0	0	0
1	0.5	8115	4057.5	32926612.5	2.67E+11	0	0	0	0
1.5	1	8115	8115	65853225	5.34E+11	209	209	43681	9129329
2	0.75	8115	6086.25	49389918.75	4.01E+11	653	489.75	319806.75	208833807.8
3	2	8115	16230	131706450	1.07E+12	653	1306	852818	556890154
4	1	8115	8115	65853225	5.34E+11	653	653	426409	278445077
5	2	8115	16230	131706450	1.07E+12	653	1306	852818	556890154
6	1	8115	8115	65853225	5.34E+11	653	653	426409	278445077

7	2	8115	16230	131706450	1.07E+12	653	1306	852818	556890154
8	0.75	8115	6086.25	49389918.75	4.01E+11	653	489.75	319806.75	208833807.8
8.5	1	8115	8115	65853225	5.34E+11	653	653	426409	278445077
9	0.5	8115	4057.5	32926612.5	2.67E+11	653	326.5	213204.5	139222538.5
9.5	1	8115	8115	65853225	5.34E+11	653	653	426409	278445077
10	0.25	8115	2028.75	16463306.25	1.34E+11	0	0	0	0
$\sum$			121725	987798375	8.02E+12		8045	5160589	3350470253
(EW+ IW) of $\sum(y^3 \times SM)$ =									8.02E+12

COMBINATION TABLE FOR STABILITY														
CALCULATION OF GZ AT 15°														
IMMERSED WEDGE					*EMERGED WEDGE*					SUMS OF FUNCTIONS OF CUBES OF ORDINATES FOR BOTH SIDES	MULTIPLIERS	PRODUCTS OF SUMS OF FUNCTIONS OF CUBES FOR BOTH SIDES	COSINES OF INCLINTIONS OF RADIAL PLANES	FUNCTIONS OF CUBES FOR MOMENTS OF WEDGES
INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES	INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES					
0°	95963	720819643	5	3604098215	0°	95963	720819643	5	3604098215	1.09E+13	5	5.47E+13	0.866025404	4.74E+13
15°	105765	838371	8	670696	15°	30681	751658	8	601326	6.88E+	8	5.51E+	0.96592	5.32E+

	.75	100.8		8806			13		504	12		13	5826	13
30°	126671.75	111943 1150	-1	-111943 1150	30°	15973	203537 89	-1	-203537 89	9.99E+12	-1	-9.99E+12	1	-9.99E+12
			∑=	919163 5871				∑=	418507 0930				∑=	9.06E+13
IMMERSED WEDGE					9191635 871						UNCORRECTED MOMENT			3.42E+15
EMERGED WEDGE					4185070 930						CORRECTION OF LAYER			7.94E+14
DIFFERENCE					5006564 941						DIFFERENCE			2.63E+15
VOLUME OF LAYER					2.84E+11						VOLUME OF DISPLACEMENT			6.87E+11
AREA AND POSITION OF C.G. OF RADIAL PLANE											BR			3829.916
Area			2*(1/3)*(L*1000/10)*A.F								KG			3604
			708995505.9								BG			KG-KB
C.G. OF RADIAL PLANE			(1/2)*(M.F/A.F											3982

ON IMMERESED SIDE =	)										
	2796.714791								GZ		BR-BG*SIN(15)
THICKNESS OF LAYER =	VOLUME OF LAYER/AREA										2799.299
	400.25										

COMBINATION TABLE FOR STABILITY														
CALCULATION OF GZ AT 30°														
IMMERSED WEDGE					*EMERGED WEDGE*					SUMS OF FUNCTIONS OF CUBES OF ORDINATES FOR BOTH SIDES	MULTIPLIERS	PRODUCTS OF SUMS OF FUNCTIONS OF CUBES FOR BOTH SIDES	COSINES OF INCLINTIONS OF RADIAL PLANES	FUNCTIONS OF CUBES FOR MOMENTS OF WEDGES
INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES	INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES					
0°	95963	720819643	1	720819643	0°	95963	720819643	1	720819643	1.09E+13	1	1.09E+13	0.866	9.48E+12
15°	105765	838371	4	335348	15°	30681	751658	4	300663	6.88E+	4	2.75E+	0.966	2.66E+

	.75	100.8		4403			13		252	12		13		13
30°	126671.75	111943 1150	1	111943 1150	30°	15973	203537 89	1	203537 89	9.99E+12	1	9.99E+12	1	9.99E+12
			∑=	519373 5196				∑=	104183 6684				∑=	4.61E+13
IMMERSED WEDGE					5193735 196					degree	UNCORRECTED MOMENT			6.96E+15
EMERGED WEDGE					1041836 684					30	CORRECTION OF LAYER			3.63E+15
DIFFERENCE					4151898 512					15	DIFFERENCE			3.34E+15
VOLUME OF LAYER					9.41E+11					0	VOLUME OF DISPLACEMENT			6.87E+11
AREA AND POSITION OF C.G. OF RADIAL PLANE											BR			6.54E+03
Area			2*(1/3)*(L*1000/10)*A.F								KG			3604
			741201140.3								BG			KG-KB
C.G. OF RADIAL PLANE			(1/2)*(M.F/A.F)											3278

ON IMMERESED SIDE =	3852.498						GZ			BR-BG*SIN(30)
THICKNESS OF LAYER =	VOLUME OF LAYER/AREA									4900.580768
	1270.013									

COMBINATION TABLE FOR STABILITY													
CALCULATION OF GZ AT 45°													
IMMERSED WEDGE					*EMERGED WEDGE*					SUMS OF FUNCTIONS OF CUBES OF ORDINATES FOR BOTH SIDES	MULTIPLIERS	PRODUCTS OF SUMS OF FUNCTIONS OF CUBES FOR BOTH SIDES	COSINES OF INCLINTIONS OF RADIAL PLANES	FUNCTIONS OF CUBES FOR MOMENTS OF WEDGES
INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES	INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES					

0°	95963	72081 9643	1	72081 9643	0°	95963	72081 9643	1	72081 9643	1.09E +13	1	1.09E +13	0.866	9.48E +12
15°	10576 5.75	83837 1100.8	4	33534 84403	15°	30681	75165 813	4	30066 3252	6.88E +12	4	2.75E +13	0.966	2.66E +13
30°	12667 1.75	11194 31150	1	11194 31150	30°	15973	20353 789	1	20353 789	9.99E +12	1	9.99E +12	1	9.99E +12
			∑=	51937 35196				∑=	10418 36684				∑=	4.61E +13
45°	15996 3.2	17452 37835	5	87261 89175	45°	11295	10175 349	5	50876 745	1.91E +13	5	9.57E +13	0.966	9.24E +13
30°	12667 1.75	11194 31150	8	89554 49198	30°	15973	20353 789	8	16283 0312	9.99E +12	8	8.00E +13	0.866	6.92E +13
15°	10576 5.75	83837 1100.8	-1	- 83837 1100.8	15°	30681	75165 813	-1	- 75165 813	6.88E +12	-1	- 6.88E +12	0.707	- 4.87E +12
			∑=	16843 26727 2				∑=	13854 1244				∑=	1.57E +14
IMMERSED WEDGE					9.55E+11	1.18E +12					UNCORRECTED MOMENT			5.93E +15
EMERGED WEDGE					7852659285	2.36E +11					CORRECTION OF LAYER			9.56E +15

DIFFERENCE		1.89E+12						DIFFERENCE			3.32E+15
VOLUME OF LAYER		1.89E+12						VOLUME OF DISPLACEMENT			6.87E+11
AREA AND POSITION OF C.G. OF RADIAL PLANE								BR			8906.646774
Area	2*(1/3)*(L*1000/10)*A.F							KG			3604
	889880441.6							BG			KG-KB
C.G. OF RADIAL PLANE ON IMMERESED SIDE =	(1/2)*(M.F/A.F)										3278
	5065.633							GZ			BR-BG*SIN(45)
THICKNESS OF LAYER =	VOLUME OF LAYER/AREA										6588.750745
	2121.831										

COMBINATION TABLE FOR STABILITY														
CALCULATION OF GZ AT 60°														
IMMERSED WEDGE					*EMERGED WEDGE*					SUMS OF FUNCTIONS OF CUBES OF ORDINATES FOR BOTH SIDES	MULTIPLIERS	PRODUCTS OF SUMS OF FUNCTIONS OF CUBES FOR BOTH SIDES	COSINES OF INCLINTIONS OF RADIAL PLANES	FUNCTIONS OF CUBES FOR MOMENTS OF WEDGES
INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES	INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES					
0°	95963	720819643	1	720819643	0°	95963	720819643	1	720819643	1.09E+13	1	1.09E+13	0.5	5.47E+12
15°	105765.75	838371100.8	4	3353484403	15°	30681	75165813	4	300663252	6.88E+12	4	2.75E+13	0.707106781	1.95E+13
30°	126671.75	1119431150	2	2238862300	30°	15973	20353789	2	40707578	9.99E+12	2	2.00E+13	0.866025404	1.73E+13
45°	159963	174523	4	698095	45°	11295	101753	4	407013	1.91E+	4	7.66E+	0.96592	7.39E+

	.2	7835		1340			49		96	13		13	5826	13
60°	139445.25	1309644925	1	1309644925	60°	9325	6934669	1	6934669	1.23E+13	1	1.23E+13	1	1.23E+13
			∑=	14603762610				∑=	1109826538				∑=	1.29E+14
IMMERSED WEDGE					14603762610						UNCORRECTED MOMENT			1.94E+16
EMERGED WEDGE					1109826538						CORRECTION OF LAYER			1.34E+16
DIFFERENCE					13493936072						DIFFERENCE			6.03E+15
VOLUME OF LAYER					3.06E+12						VOLUME OF DISPLACEMENT			6.87E+11
AREA AND POSITION OF C.G. OF RADIAL PLANE											BR			8271.74532
Area			2*(1/3)*(L*1000/10)*A.F								KG			3604
			773030055								BG			KG-KB
C.G. OF RADIAL PLANE			(1/2)*(M.F/A.F)											3278

ON IMMERESED SIDE =	4378.26197						GZ			BR-BG*SIN(60)
THICKNESS OF LAYER =	VOLUME OF LAYER/AREA									5433.237888
	3957.67									

COMBINATION TABLE FOR STABILITY														
CALCULATION OF GZ AT 75°														
IMMERSED WEDGE					*EMERGED WEDGE*					SUMS OF FUNCTIONS OF CUBES OF ORDINATES FOR BOTH SIDES	MULTIPLIERS	PRODUCTS OF SUMS OF FUNCTIONS OF CUBES FOR BOTH SIDES	COSINES OF INCLINTIONS OF RADIAL PLANES	FUNCTIONS OF CUBES FOR MOMENTS OF WEDGES
INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES	INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES					
0°	95963	720819643	1	720819643	0°	95963	720819643	1	720819643	1.09E+13	1	1.09E+13	0.5	5.47E+12
15°	105765.75	838371100.8	4	3353484403	15°	30681	75165813	4	300663252	6.88E+12	4	2.75E+13	0.707106781	1.95E+13
30°	126671.75	1119431150	2	2238862300	30°	15973	20353789	2	40707578	9.99E+12	2	2.00E+13	0.866025404	1.73E+13
45°	159963	174523	4	698095	45°	11295	101753	4	407013	1.91E+	4	7.66E+	0.96592	7.39E+

	.2	7835		1340			49		96	13		13	5826	13
60°	139445.25	1309644925	1	1309644925	60°	9325	6934669	1	6934669	1.23E+13	1	1.23E+13	1	1.23E+13
			∑=	14603762610				∑=	1109826538				∑=	1.29E+14
75°	126180	1061426160	5	5307130800	75°	8328	5530368	5	27651840	8.93E+12	5	4.47E+13	0.707106781	3.16E+13
60°	139445.25	1309644925	8	10477159398	60°	9325	6934669	8	55477352	1.23E+13	8	9.87E+13	0.5	4.93E+13
45°	159963.2	1745237835	-1	-1745237835	45°	11295	10175349	-1	-10175349	1.91E+13	-1	-1.91E+13	0.258819045	-4.95E+12
			∑=	14039052363				∑=	72953843				∑=	7.60E+13
IMMERSED WEDGE					7.96E+11	3.31E+12					UNCORRECTED MOMENT			2.87E+15
EMERGED WEDGE					4135098373	2.52E+11					CORRECTION OF LAYER			1.51E+16
DIFFERENCE					3.85E+12						DIFFERENCE			7.18E+15
VOLUME OF LAYER					3.85E+1						VOLUME OF			6.87E+

	2						DISPLACEMENT	11
AREA AND POSITION OF C.G. OF RADIAL PLANE							BR	6054.474513
Area	2*(1/3)*(L*1000/10)*A.F						KG	3604
	874463514						BG	KG-KB
C.G. OF RADIAL PLANE ON IMMERESED SIDE =	(1/2)*(M.F/A.F)							3278
	3925.0297						GZ	2888.169655

COMBINATION TABLE FOR STABILITY														
CALCULATION OF GZ AT 90°for WL - 1														
IMMERSED WEDGE					*EMERGED WEDGE*					SUMS OF FUNCTIONS OF CUBES OF ORDINATES FOR BOTH SIDES	MULTIPLIERS	PRODUCTS OF SUMS OF FUNCTIONS OF CUBES FOR BOTH SIDES	COSINES OF INCLINTIONS OF RADIAL PLANES	FUNCTIONS OF CUBES FOR MOMENTS OF WEDGES
INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES	INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES					
0°	95963	720819643	1	720819643	0°	95963	720819643	1	720819643	1.09E+13	1	1.09E+13	6.13E-17	0.000670546
15°	105765.75	838371100.8	4	3353484403	15°	30681	75165813	4	300663252	6.88E+12	4	2.75E+13	0.258819045	7.13E+12
30°	126671.75	1119431150	2	2238862300	30°	15973	20353789	2	40707578	9.99E+12	2	2.00E+13	0.5	9.99E+12
45°	159963	174523	4	698095	45°	11295	101753	4	407013	1.91E+	4	7.66E+	0.70710	5.41E+

	.2	7835		1340			49		96	13		13	6781	13
60°	139445.25	1309644925	2	2619289850	60°	9325	6934669	2	13869338	1.23E+13	2	2.47E+13	0.866025404	2.14E+13
75°	126180	1061426160	4	4245704640	75°	8328	5530368	4	22121472	8.93E+12	4	3.57E+13	0.965925826	3.45E+13
90°	121725	987798375	1	987798375	90°	8045	5160589	1	5160589	8.02E+12	1	8.02E+12	1	8.02E+12
			∑=	21146910550				∑=	1144043268				∑=	1.35E+14
IMMERSED WEDGE					21146910550						UNCORRECTED MOMENT			2.04E+16
EMERGED WEDGE					1144043268						CORRECTION OF LAYER			1.72E+16
DIFFERENCE					20002867282						DIFFERENCE			3.26E+15
VOLUME OF LAYER					4.54E+12						VOLUME OF DISPLACEMENT			6.87E+11
AREA AND POSITION OF C.G. OF RADIAL PLANE											BR			4743.125377
Area			2*(1/3)*(L*1000/10)*A.F								KG			3604

	674302222.7						BG			KG-KB
C.G. OF RADIAL PLANE ON IMMERESED SIDE =	(1/2)*(M.F/A.F)									3278
	3786.0745						GZ			BR-BG*SIN(90)
THICKNESS OF LAYER =	VOLUME OF LAYER/AREA									-1465.125377
	6725.666									

Stability calculation for Fully loaded Condition

L(ship length)	77.942	m
INTERVAL(radians)	0.261799388	
DEPTH	5.406	m
VOLUME	3.78E+12	mm^3
KB	1.881	mm

WATER SECTION INCLINED AT 0 degree ABOUT WL - 4									
STATION	SM MULTIPLIERS	IMMERSED WEDGE				EMERGED WEDGE			
		ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES	ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES
		y_i	y_i x SM	y_i^2 x SM	y_i^3x SM	y_e	y_e x SM	y_e^2 x SM	y_e^3 x SM
0	0.25	0	0	0	0	0	0	0	0
0.5	1	6515	6515	42445225	2.77E+11	6515	6515	42445225	2.77E+11
1	0.5	7386	3693	27276498	2.01E+11	7386	3693	27276498	2.01E+11
1.5	1	7775	7775	60450625	4.70E+11	7775	7775	60450625	4.70E+11
2	0.75	7849	5886.75	46205100.75	3.63E+11	7849	5886.75	46205100.75	3.63E+11
3	2	7864	15728	123684992	9.73E+11	7864	15728	123684992	9.73E+11
4	1	7864	7864	61842496	4.86E+11	7864	7864	61842496	4.86E+11
5	2	7864	15728	123684992	9.73E+11	7864	15728	123684992	9.73E+11
6	1	7864	7864	61842496	4.86E+11	7864	7864	61842496	4.86E+11
7	2	7864	15728	123684992	9.73E+11	7864	15728	123684992	9.73E+11
8	0.75	7862	5896.5	46358283	3.64E+11	7862	5896.5	46358283	3.64E+11
8.5	1	7849	7849	61606801	4.84E+11	7849	7849	61606801	4.84E+11
9	0.5	7212	3606	26006472	1.88E+11	7212	3606	26006472	1.88E+11
9.5	1	4725	4725	22325625	1.05E+11	4725	4725	22325625	1.05E+11

10	0.25	279	69.75	19460.25	5429409.75	279	69.75	19460.25	5429409.75
∑			108928	827434058	6.34E+12		108928	827434058	6.34E+12
(EW+ IW) of $\sum(y^3 \times SM)$ =									1.27E+13

WATER SECTION INCLINED AT 30 degree ABOUT WL - 4									
STATION	SM MULTIPLIERS	IMMERSED WEDGE				EMERGED WEDGE			
		ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES	ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES
		y_i	y_i x SM	y_i^2 x SM	y_i^3 x SM	y_e	y_e x SM	y_e^2 x SM	y_e^3 x SM
0	0.25	7819	1954.75	15284190.25	1.20E+11	0	0	0	0
0.5	1	8308	8308	69022864	5.73E+11	1948	1948	3794704	7392083392
1	0.5	8753	4376.5	38307504.5	3.35E+11	4119	2059.5	8483080.5	34941808580
1.5	1	9039	9039	81703521	7.39E+11	6139	6139	37687321	2.31E+11
2	0.75	9101	6825.75	62121150.75	5.65E+11	7128	5346	38106288	2.72E+11
3	2	9107	18214	165874898	1.51E+12	7128	14256	101616768	7.24E+11
4	1	9107	9107	82937449	7.55E+11	7128	7128	50808384	3.62E+11
5	2	9107	18214	165874898	1.51E+12	7128	14256	101616768	7.24E+11
6	1	9107	9107	82937449	7.55E+11	7128	7128	50808384	3.62E+11
7	2	9107	18214	165874898	1.51E+12	7128	14256	101616768	7.24E+11
8	0.75	9.105	6.82875	62.17576875	566.1103745	7128	5346	38106288	2.72E+11
8.5	1	9100	9100	82810000	7.54E+11	7128	7128	50808384	3.62E+11
9	0.5	8815	4407.5	38852112.5	3.42E+11	7128	3564	25404192	1.81E+11
9.5	1	6850	6850	46922500	3.21E+11	7128	7128	50808384	3.62E+11

10	0.25	230	57.5	13225	3041750	582	145.5	84681	49284342
∑			123781.8288	1098536722	9.79E+12		95828	659750394.5	4.62E+12
(EW+ IW) of $\sum(y^3 \times SM)$ =									1.44E+13

WATER SECTION INCLINED AT 45 degree ABOUT WL - 4									
STATION	SM MULTIPLIERS	IMMERSED WEDGE				EMERGED WEDGE			
		ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES	ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES
		y_i	y_i x SM	y_i^2 x SM	y_i^3x SM	y_e	y_e x SM	y_e^2 x SM	y_e^3 x SM
0	0.25	7303	1825.75	13333452.25	97374201782	0	0	0	0
0.5	1	7303	7303	53333809	3.89E+11	1395	1395	1946025	2714704875
1	0.5	7730	3865	29876450	2.31E+11	2953	1476.5	4360104.5	12875388589
1.5	1	7730	7730	59752900	4.62E+11	4363	4363	19035769	830530601447
2	0.75	7730	5797.5	44814675	3.46E+11	5036	3777	19020972	957896149932
3	2	7730	15460	119505800	9.24E+11	5036	10072	50722592	2.55E+11
4	1	7730	7730	59752900	4.62E+11	5036	5036	25361296	1.28E+11
5	2	7730	15460	119505800	9.24E+11	5036	10072	50722592	2.55E+11
6	1	7730	7730	59752900	4.62E+11	5036	5036	25361296	1.28E+11
7	2	7730	15460	119505800	9.24E+11	5036	10072	50722592	2.55E+11
8	0.75	7730	5797.5	44814675	3.46E+11	5036	3777	19020972	957896149932

8.5	1	7730	7730	59752900	4.62E+11	5036	5036	25361296	1.28E+11
9	0.5	7730	3865	29876450	2.31E+11	5036	2518	12680648	63859743328
9.5	1	7730	7730	59752900	4.62E+11	5036	5036	25361296	1.28E+11
10	0.25	232	58	13456	3121792	1369	342.25	468540.25	641431602.3
∑			113541.75	873344867.3	6.72E+12		68008.75	330145990.8	1.63E+12
(EW+ IW) of $\sum(y^3 \times SM)$ =									8.35E+12

WATER SECTION INCLINED AT 60 degree ABOUT WL - 4									
STATION	SM MULTIPLIERS	IMMERSED WEDGE				EMERGED WEDGE			
		ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES	ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES
		y_i	y_i x SM	y_i^2 x SM	y_i^3 x SM	y_e	y_e x SM	y_e^2 x SM	y_e^3 x SM
0	0.25	6016	1504	9048064	54433153024	0	0	0	0
0.5	1	6016	6016	36192256	2.18E+11	1160	1160	1345600	1560896000
1	0.5	6016	3008	18096128	1.09E+11	2458	1229	3020882	7425327956
1.5	1	6016	6016	36192256	2.18E+11	3621	3621	13111641	47477252061
2	0.75	6016	4512	27144192	1.63E+11	4159	3119.25	12972960.75	53954543759
3	2	6016	12032	72384512	4.35E+11	4159	8318	34594562	1.44E+11
4	1	6016	6016	36192256	2.18E+11	4159	4159	17297281	71939391679
5	2	6016	12032	72384512	4.35E+11	4159	8318	34594562	1.44E+11
6	1	6016	6016	36192256	2.18E+11	4159	4159	17297281	71939391679
7	2	6016	12032	72384512	4.35E+11	4159	8318	34594562	1.44E+11
8	0.75	6016	4512	27144192	1.63E+11	4159	3119.25	12972960.75	53954543759
8.5	1	6016	6016	36192256	2.18E+11	4159	4159	17297281	71939391679
9	0.5	6016	3008	18096128	1.09E+11	4159	2079.5	8648640.5	35969695840
9.5	1	6016	6016	36192256	2.18E+11	4159	4159	17297281	71939391679

10	0.25	6016	1504	9048064	54433153024	2053	513.25	1053702.25	2163250719
∑			90240	542883840	3.27E+12		56431.25	226099197.3	9.22E+11
(EW+ IW) of $\sum(y^3 \times SM)$ =									4.19E+12

WATER SECTION INCLINED AT 75 degree ABOUT WL - 4									
STATION	SM MULTIPLIERS	IMMERSED WEDGE				EMERGED WEDGE			
		ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES	ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES
		y_i	y_i x SM	y_i^2 x SM	y_i^3 x SM	y_e	y_e x SM	y_e^2 x SM	y_e^3 x SM
0	0.25	5373	1343.25	7217282.25	38778457529	0	0	0	0
0.5	1	5373	5373	28869129	1.55E+11	1042	1042	1085764	1131366088
1	0.5	5373	2686.5	14434564.5	77556915059	2210	1105	2442050	5396930500
1.5	1	5373	5373	28869129	1.55E+11	3245	3245	10530025	34169931125
2	0.75	5373	4029.75	21651846.75	1.16E+11	3712	2784	10334208	38360580096
3	2	5373	10746	57738258	3.10E+11	3712	7424	27557888	1.02E+11
4	1	5373	5373	28869129	1.55E+11	3712	3712	13778944	51147440128
5	2	5373	10746	57738258	3.10E+11	3712	7424	27557888	1.02E+11
6	1	5373	5373	28869129	1.55E+11	3712	3712	13778944	51147440128
7	2	5373	10746	57738258	3.10E+11	3712	7424	27557888	1.02E+11

8	0.75	5373	4029.75	21651846.75	1.16E+11	3712	2784	10334208	38360580096
8.5	1	5373	5373	28869129	1.55E+11	3712	3712	13778944	51147440128
9	0.5	5373	2686.5	14434564.5	77556915059	3712	1856	6889472	25573720064
9.5	1	5373	5373	28869129	1.55E+11	3712	3712	13778944	51147440128
10	0.25	5373	1343.25	7217282.25	38778457529	2272	568	1290496	2932006912
∑			80595	433036935	2.33E+12		50504	180695663	6.57E+11
(EW+ IW) of $\sum(y^3 \times SM)$ =									2.98E+12

WATER SECTION INCLINED AT 90 degree ABOUT WL - 4									
STATION	SM MULTIPLIERS	IMMERSED WEDGE				EMERGED WEDGE			
		ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES	ORDINATES	FUNCTIONS OF ORDINATES	FUNCTIONS OF SQUARES	FUNCTIONS OF CUBES
		y_i	y_i x SM	y_i^2 x SM	y_i^3 x SM	y_e	y_e x SM	y_e^2 x SM	y_e^3 x SM
0	0.25	5189	1297.25	6731430.25	34929391567	0	0	0	0
0.5	1	5189	5189	26925721	1.40E+11	1011	1011	1022121	1033364331
1	0.5	5189	2594.5	13462860.5	69858783135	2146	1073	2302658	4941504068
1.5	1	5189	5189	26925721	1.40E+11	3144	3144	9884736	31077609984
2	0.75	5189	3891.75	20194290.75	1.05E+11	3588	2691	9655308	34643245104
3	2	5189	10378	53851442	2.79E+11	3588	7176	25747488	92381986944
4	1	5189	5189	26925721	1.40E+11	3588	3588	12873744	46190993472
5	2	5189	10378	53851442	2.79E+11	3588	7176	25747488	92381986944
6	1	5189	5189	26925721	1.40E+11	3588	3588	12873744	46190993472
7	2	5189	10378	53851442	2.79E+11	3588	7176	25747488	92381986944
8	0.75	5189	3891.75	20194290.75	1.05E+11	3588	2691	9655308	34643245104
8.5	1	5189	5189	26925721	1.40E+11	3588	3588	12873744	46190993472
9	0.5	5189	2594.5	13462860.5	69858783135	3588	1794	6436872	23095496736
9.5	1	5189	5189	26925721	1.40E+11	3588	3588	12873744	46190993472

10	0.25	5189	1297.25	6731430.25	34929391567	2519	629.75	1586340.25	3995991090
∑			77835	403885815	2.10E+12		48913.75	169280783.3	5.95E+11
(EW+ IW) of $\sum(y^3 \times SM)$ =									2.69E+12

CALCULATION OF GZ AT 15°for WL - 4

IMMERSED WEDGE					*EMERGED WEDGE*									
INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES	INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES	SUMS OF FUNCTIONS OF CUBES OF ORDINATES FOR BOTH SIDES	MULTIPLIERS	PRODUCTS OF SUMS OF FUNCTIONS OF CUBES FOR BOTH SIDES	COSINES OF INCLINTIONS OF RADIAL PLANES	FUNCTIONS OF CUBES FOR MOMENTS OF WEDGES
0°	108928	827434058	5	4137170290	0°	108928	827434058	5	4137170290	1.27E+13	5	6.34E+13	0.866	5.49E+13
15°	115558.25	912985146.8	8	7303881174	15°	108298.25	838544413.3	8	6708355306	1.39E+13	8	1.11E+14	0.966	1.07E+14
30°	123781.8288	1098536722	-1	-10985	30°	95828	659750394.5	-1	-65975	1.44E+13	-1	-1.44E	1	-1.44E

				36722					0394.5			+13		+13
			∑=	10342 51474 2				∑=	10185 77520 2				∑=	1.48E +14
IMMERSED WEDGE					103425 14742						UNCORRECTED MOMENT			5.59E +15
EMERGED WEDGE					101857 75202						CORRECTION OF LAYER			1.48E +12
DIFFERENCE					156739 540.3						DIFFERENCE			5.59E +15
VOLUME OF LAYER					888415 7318						VOLUME OF DISPLACEMENT			3.78E +12
AREA AND POSITION OF C.G. OF RADIAL PLANE											BR			2.02E +03
Area			2*(1/3)*(L*1000/10)*A.F								KG			3188.6
			1163188222								BG			KG-KB
C.G. OF RADIAL PLANE ON IMMERESED SIDE =			(1/2)*(M.F/A.F)											3186.719
			166.2689								GZ			BR-BG*SI

											N(15)
THICKNESS OF LAYER =	VOLUME OF LAYER/AREA										1199.982
	7.638										

CALCULATION OF GZ AT 30°for WL - 4

IMMERSED WEDGE					*EMERGED WEDGE*					SUMS OF FUNCTIONS OF CUBES OF ORDINATES FOR BOTH SIDES	MULTIPLIERS	PRODUCTS OF SUMS OF FUNCTIONS OF CUBES FOR BOTH SIDES	COSINES OF INCLINTIONS OF RADIAL PLANES	FUNCTIONS OF CUBES FOR MOMENTS OF WEDGES
INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES	INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES					
0°	108928	827434058	1	827434058	0°	108928	827434058	1	827434058	1.26847E+13	1	1.26847E+13	0.866	1.09853E+13
15°	115558.25	912985146.8	4	3651940587	15°	108298.25	838544413.3	4	3354177653	1.38962E+13	4	5.5585E+13	0.966	5.3691E+13
30°	123781.8288	1098536722	1	1098536722	30°	95828	659750394.5	1	659750394.5	1.44118E+13	1	1.44118E+13	1	1.44118E+13

			∑=	557791 1367				∑=	484136 2106				∑=	7.9088 1E+13
IMMERSED WEDGE					5577911 367						UNCORRECTED MOMENT			1.1954 1E+16
EMERGED WEDGE					4841362 106						CORRECTION OF LAYER			1.6682 9E+14
DIFFERENCE					7365492 61.7						DIFFERENCE			1.1787 3E+16
VOLUME OF LAYER					1.66993 E+11						VOLUME OF DISPLACEMENT			3.78E+ 12
AREA AND POSITION OF C.G. OF RADIAL PLANE											BR			3119.7 74165
Area			2*(1/3)*(L*1000/10)*A.F								KG			3188.6
			1141121951								BG			KG-KB
C.G. OF RADIAL PLANE ON IMMERESED SIDE =			(1/2)*(M.F/A.F)											3186.7 19
			999.013								GZ			BR-BG*SI N(30)

THICKNESS OF LAYER =	VOLUME OF LAYER/AREA									2179.034665
	146.3414661									

CALCULATION OF GZ AT 45° for WL - 4

IMMERSED WEDGE					*EMERGED WEDGE*					SUMS OF FUNCTIONS OF CUBES OF ORDINATES FOR BOTH SIDES	MULTIPLIERS	PRODUCTS OF SUMS OF FUNCTIONS OF CUBES FOR BOTH SIDES	COSINES OF INCLINATIONS OF RADIAL PLANES	FUNCTIONS OF CUBES FOR MOMENTS OF WEDGES
INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES	INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES					
0°	108928	827434058	1	827434058	0°	108928	827434058	1	827434058	1.26847E+13	1	1.26847E+13	0.866025404	1.09853E+13
15°	115558.25	912985146.8	4	3651940587	15°	108298.25	838544413.3	4	3354177653	1.38962E+13	4	5.5585E+13	0.965925826	5.3691E+13
30°	123781.8288	1098536722	1	1098536722	30°	95828	659750394.5	1	659750394.5	1.44118E+13	1	1.44118E+13	1	1.44118E+13

			∑=	5577911367				∑=	4841362106				∑=	7.90881E+13
45°	113541.75	873344867.3	5	4366724336	45°	68008.75	330145990.8	5	1650729954	8.35431E+12	5	4.17715E+13	0.965925826	4.03482E+13
30°	123781.8288	1098536722	8	8788293777	30°	95828	659750394.5	8	5278003156	1.44118E+13	8	1.15294E+14	0.866025404	9.98478E+13
15°	115558.25	912985146.8	-1	-912985146.8	15°	108298.25	838544413.3	-1	-838544413.3	1.38962E+13	-1	-1.38962E+13	0.707106781	-9.82613E+12
			∑=	12242032967				∑=	6090188697				∑=	1.3037E+14
IMMERSED WEDGE					6.93891E+11	1.26465E+12					UNCORRECTED MOMENT			4.92633E+15
EMERGED WEDGE					3.45198E+11	1.09765E+12					CORRECTION OF LAYER			7.71466E+14
DIFFERENCE					5.15686E+11						DIFFERENCE			1.6109E+16
VOLUME OF LAYER					5.15686E+11						VOLUME OF DISPLACEMENT			3.78E+12
AREA AND POSITION OF C.G. OF RADIAL PLANE											BR			4263.609543

Area	=2*(1/3)*(L*1000/10)*A.F						KG			3188.6
	943360604.7						BG			= KG-KB
C.G. OF RADIAL PLANE ON IMMERESED SIDE =	=(1/2)*(M.F/A.F)									3186.719
	1495.999395						GZ			=BR-BG*SIN(45)
THICKNESS OF LAYER =	=VOLUME OF LAYER/AREA									2510.258928
	546.6480968									

CALCULATION OF GZ AT 60° for WL - 4

IMMERSED WEDGE					*EMERGED WEDGE*					SUMS OF FUNCTIONS OF CUBES OF ORDINATES FOR BOTH SIDES	MULTIPLIERS	PRODUCTS OF SUMS OF FUNCTIONS OF CUBES FOR BOTH SIDES	COSINES OF INCLINTIONS OF RADIAL PLANES	FUNCTIONS OF CUBES FOR MOMENTS OF WEDGES
INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES	INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES					
0°	108928	827434058	1	827434058	0°	108928	827434058	1	827434058	1.26847E+13	1	1.26847E+13	0.5	6.34237E+12
15°	115558.25	912985146.8	4	3651940587	15°	108298.25	838544413.3	4	3354177653	1.38962E+13	4	5.5585E+13	0.707106781	3.93045E+13
30°	123781.8288	1098536722	2	2197073444	30°	95828	659750394.5	2	1319500789	1.44118E+13	2	2.88236E+13	0.866025404	2.4962E+13
45°	113541	873344	4	349337	45°	68008.	330145	4	132058	8.3543	4	3.3417	0.96592	3.2278

	.75	867.3		9469		75	990.8		3963	1E+12		2E+13	5826	6E+13
60°	90240	542883840	1	542883840	60°	56431.25	226099197.3	1	226099197.3	4.18789E+12	1	4.18789E+12	1	4.18789E+12
			∑=	10712711398				∑=	7047795660				∑=	1.07075E+14
IMMERSED WEDGE					10712711398						UNCORRECTED MOMENT			1.61844E+16
EMERGED WEDGE					7047795660						CORRECTION OF LAYER			8.97327E+14
DIFFERENCE					3664915738						DIFFERENCE			1.5287E+16
VOLUME OF LAYER					8.30925E+11						VOLUME OF DISPLACEMENT			3.78E+12
AREA AND POSITION OF C.G. OF RADIAL PLANE											BR			4046.063882
Area			=2*(1/3)*(L*1000/10)*A.F								KG			3188.6
			762123371.2								BG			=KG-KB

C.G. OF RADIAL PLANE ON IMMERESED SIDE =	=(1/2)*(M.F/A.F)										3186.719
	1079.913898								GZ		=BR-BG*SIN(60)
THICKNESS OF LAYER =	=VOLUME OF LAYER/AREA										1786.284273
	1090.275811										

CALCULATION OF GZ AT 75° for WL - 4

IMMERSED WEDGE					*EMERGED WEDGE*									
INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES	INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES	SUMS OF FUNCTIONS OF CUBES OF ORDINATES FOR BOTH SIDES	MULTIPLIERS	PRODUCTS OF SUMS OF FUNCTIONS OF CUBES FOR BOTH SIDES	COSINES OF INCLINTIONS OF RADIAL PLANES	FUNCTIONS OF CUBES FOR MOMENTS OF WEDGES
0°	108928	827434058	1	827434058	0°	108928	827434058	1	827434058	1.26847E+13	1	1.26847E+13	0.5	6.34237E+12
15°	115558.25	912985146.8	4	3651940587	15°	108298.25	838544413.3	4	3354177653	1.38962E+13	4	5.5585E+13	0.707106781	3.93045E+13
30°	123781.8288	1098536722	2	2197073444	30°	95828	659750394.5	2	1319500789	1.44118E+13	2	2.88236E+13	0.866025404	2.4962E+13
45°	113541.75	873344867.3	4	3493379469	45°	68008.75	330145990.8	4	1320583963	8.35431E+12	4	3.34172E+13	0.965925826	3.22786E+13

60°	90240	54288 3840	1	54288 3840	60°	56431. 25	22609 9197.3	1	22609 9197.3	4.1878 9E+12	1	4.1878 9E+12	1	4.18789 E+12
			∑=	10712 71139 8				∑=	70477 95660				∑=	1.07075 E+14
75°	80595	43303 6935	5	21651 84675	75°	50504	18069 5663	5	90347 8315	2.9841 1E+12	5	1.4920 5E+13	0.7071 06781	1.05504 E+13
60°	90240	54288 3840	8	43430 70720	60°	56431. 25	22609 9197.3	8	18087 93578	4.1878 9E+12	8	3.3503 1E+13	0.5	1.67516 E+13
45°	11354 1.75	87334 4867.3	-1	- 87334 4867.3	45°	68008. 75	33014 5990.8	-1	- 33014 5990.8	8.3543 1E+12	-1	- 8.3543 1E+12	0.2588 19045	- 2.16225 E+12
			∑=	56349 10528				∑=	23821 25902				∑=	2.51397 E+13
IMMERSED WEDGE					3.19392 E+11	2.4288 3E+12					UNCORRECTED MOMENT			9.49963 E+14
EMERGED WEDGE					1.35021 E+11	1.5979 1E+12					CORRECTION OF LAYER			9.77128 E+14

DIFFERENCE			1.0153 E+12					DIFFERENCE	1.61572 E+16
VOLUME OF LAYER			1.0153 E+12					VOLUME OF DISPLACEMENT	3.78E+12
AREA AND POSITION OF C.G. OF RADIAL PLANE								BR	3.90E+03
Area	=2*(1/3)*(L*1000/10)*A.F							KG	3188.6
	852403589.8							BG	=KG-KB
C.G. OF RADIAL PLANE ON IMMERESED SIDE =	=(1/2)*(M.F/A.F)								3186.719
	962.4073105								
THICKNESS OF LAYER =	=VOLUME OF LAYER/AREA								

			1191.097557								GZ	=BR-BG*SIN(75)
												818.2379421

CALCULATION OF GZ AT 90° for WL - 4

IMMERSED WEDGE					*EMERGED WEDGE*					SUMS OF FUNCTIONS OF CUBES OF ORDINATES FOR BOTH SIDES	MULTIPLIERS	PRODUCTS OF SUMS OF FUNCTIONS OF CUBES FOR BOTH SIDES	COSINES OF INCLINATIONS OF RADIAL PLANES	FUNCTIONS OF CUBES FOR MOMENTS OF WEDGES
INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES	INCLNATIONS OF RADIAL PLANES	FUNCTIONS OF ORDINATES OF RADIAL PLANES	FUNCTIONS OF SQUARES OF ORDINATES	MULTIPLIERS	FUNCTIONS OF SQUARES OF ORDINATES FOR VOLUME OF WEDGES					
0°	108928	827434058	1	827434058	0°	108928	827434058	1	827434058	1.26847E+13	1	1.26847E+13	6.12574E-17	0.000777035
15°	115558.25	912985146.8	4	3651940587	15°	108298.25	838544413.3	4	3354177653	1.38962E+13	4	5.5585E+13	0.258819045	1.43865E+13
30°	123781.8288	1098536722	2	2197073444	30°	95828	659750394.5	2	1319500789	1.44118E+13	2	2.88236E+13	0.5	1.44118E+13

45°	113541.75	873344867.3	4	3493379469	45°	68008.75	330145990.8	4	1320583963	8.35431E+12	4	3.34172E+13	0.707106781	2.36295E+13
60°	90240	542883840	2	1085767680	60°	56431.25	226099197.3	2	452198394.5	4.18789E+12	2	8.37578E+12	0.866025404	7.25364E+12
75°	80595	433036935	4	1732147740	75°	50504	180695663	4	722782652	2.98411E+12	4	1.19364E+13	0.965925826	1.15297E+13
90°	77835	403885815	1	403885815	90°	48913.75	169280783.3	1	169280783.3	2.6911E+12	1	2.6911E+12	1	2.6911E+12
			∑=	1339162 8793				∑=	8165958293				∑=	7.39022E+13
IMMERSED WEDGE					1339162 8793						UNCORRECTED MOMENT			1.11703E+16
EMERGED WEDGE					8165958 293						CORRECTION OF LAYER			1.09649E+15
DIFFERENCE					5225670 501						DIFFERENCE			1.00738E+16
VOLUME OF LAYER					1.18479 E+12						VOLUME OF DISPLACEMENT			3.78E+12

AREA AND POSITION OF C.G. OF RADIAL PLANE							BR			2666.258897
Area	=2*(1/3)*(L*1000/10)*A.F						KG			3188.6
	658603404.8						BG			=KG-KB
C.G. OF RADIAL PLANE ON IMMERESED SIDE =	=(1/2)*(M.F/A.F)									3186.719
	925.472763						GZ			=BR-BG*SIN(90)
THICKNESS OF LAYER =	=VOLUME OF LAYER/AREA									-520.4601032
	1798.936003									

Water plane	SM	SM	SM	SM	Area
	1	4	1		

	1	3	3	1	
WL-1	0	2.799298717	4.900580768	6.588750745	
Area up to 30	0	11.19719487	4.900580768		1.404795935
Area up to 45	0	8.39789615	14.7017423	6.588750745	2.914650794
Area up to 40					2.159723365
WL-4	0	1.199982283	2.179034665	2.510258928	
Area up to 30	0	4.799929133	2.179034665		0.609029483
Area up to 45	0	3.59994685	6.537103996	2.510258928	1.241646734
Area up to 40					0.925338108