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

Design of 2000 DWT GL class Oil-tanker for operation in the inland waterways of Bangladesh

Supervised by:
Dr. Md. Mashiur Rahaman
Professor
Naval Architecture & Marine Engineering, BUET

Submitted by:

Sakibul Hasan Nahid: 1612046

Md. Riasat Morshed Khan: 1612047

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 2000 DWT GL class oil Tanker 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 GL class oil Tanker 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,

Md. Sakibul Hasan Nahid Student ID- 1612046
Md. Riasat Morshed Khan Student ID- 1612047

Contents

Introduction:

The report is divided into 26 chapters. In the second chapter it contains the calculations of the principle particulars considering the owners requirements. The chapter 3-19 contains all the calculations and drawings required for the design of this ship. And from chapter 20-26 this is the appendix section which comprises all the detailed calculations and tables. This is GL-Class vessel. GL-2013 rulebook has been used to determine all the structural members of the ship. The ship design process is iterative, and is subdivided into several phases during which the design is developed in increasing degrees of detail. So the design cycle was performed once the designing process. Then we faced problem while accommodating rudder and propeller in the aft section of the ship. Because there wasn't enough space for rudder and propeller. So we had to change the hull section and we had to change the lines plan and had to perform the whole process again. In addition to unique mission requirements and constraints, every ship must satisfy certain physical principles. The fundamental principles are that (1) the ship hull and superstructure must have adequate storage space, and (2) the ship must float at an acceptable waterline (draft neither too great nor too small) when it is fully loaded. Another principle is that the ship must be statically stable; that is, when it is displaced from its equilibrium condition, it must tend to return to that condition. For example, when the ship is heeled to one side by a disturbing force such as a wind gust, it must tend to return to the vertical rather than continuing to roll and capsizing. The ship's hull must have sufficient strength to withstand the forces that will act upon it over a range of loading and sea conditions. The ship must possess sufficient propulsive power to achieve the desired speed even with a fouled bottom and in adverse sea conditions. In addition, it must generate sufficient electric power to satisfy the requirements of mission systems; ship machinery; heating, ventilation, and air conditioning systems; hotel; and other ship services. Last of all it must be remembered that ship designing is a not just a process of calculating various particulars and meeting the rules and regulations but it is also a work of art. We hope that this design will satisfy the mission requirements as well as be regarded as an artwork.

Owner's requirements:

i. Type of ship : Oil Tanker

ii. Capacity : 2000 tones

iii. Service speed : 10 knots

iv. Route : Inland waterways of Bangladesh

Principle particulars:

By means of empirical formula:

1. According to Kafali's Formula:

For Oil Tanker: $\frac{DWT}{\Delta} = \frac{0.775\,DWT}{DWT+250}$

$\frac{2000}{\Delta} = \frac{.775\times2000}{2000+250}$

$\Delta = 2660\ tons$

2. According to Posdunine Formula:

$L = C(\frac{V}{V+2})^2\Delta^{\frac{1}{3}}$

C=7.15 (According to Watson for single screw ship)

L = 70.8 m

3. According to Watson's Formula:

For Tankers, $B = \left(\frac{L}{7.5} + 1.98\right) m$

= 11.42 m

And,

Depth,D = $(\frac{L}{12.5})$

= 5.7 m

4. C_B determination:

Frude No, $F_N = \frac{70.8}{\sqrt{9.8\times70.8}}$

= 0.2

As $0.15 \leq F_N \leq 0.32$, using Scheekluth & Bertram formula for C_B

$C_B = -4.22 + 27.8\sqrt{F_N} - 39.1F_N + 46.6{F_N}^3$

= 0.75

5. Draft Calculation:

$C_B = \frac{\nabla}{L\times B\times T}$

T = 4.4m

By means of basis ship:

Principle particulars obtained from a basis ship is as follows:

Particulars	Values	Unit
Displacement	2904.4	tonne
Lightweight	904.4	tonne
Length between perpendiculars, L_{BP}	73.76	m
Breadth, B	12	m
Depth, D	5.5	m
Draft, T	4.75	m
Block coefficient, Cb	0.7	-

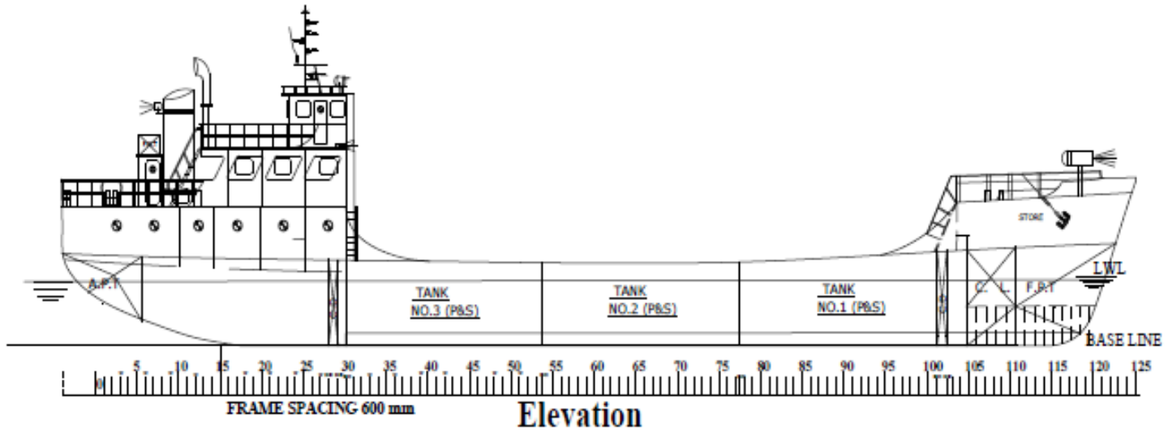
Deviations of particulars from different methods:

Form ratio	Standard value	Values from basis ship	Values from empirical formula
L/D	11.03	13.4	12.4
B/D	1.81	2.2	2
B/T	2.83	2.5	2.6
L/B	6.20	6.14	6.2

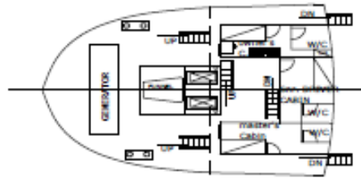
Note: Now, among these two methods, particulars obtained from empirical formula are taken because those values mostly conform to the standard form ratio. Finally, the principle particulars are as follows:

Principle particulars	**Value**	**Unit**
Length overall, L_{OA}	73.75	meter
Length between perpendiculars, L_{BP}	70.80	meter
Breadth, B	11.42	meter
Depth, D	5.70	meter
Draft, T	4.40	meter
Block co-efficient, C_B	0.75	--
Speed, V	10	knot

General arrangement drawing:

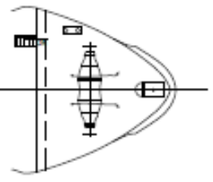


Elevation

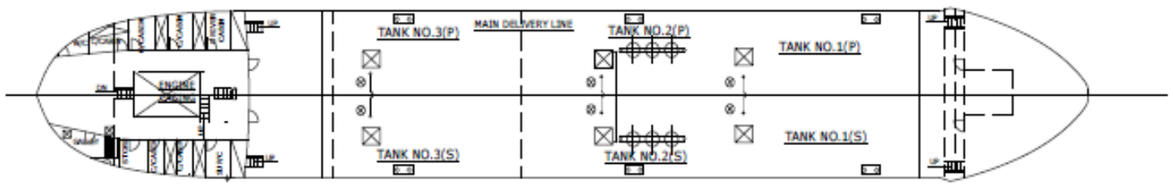


Poop deck

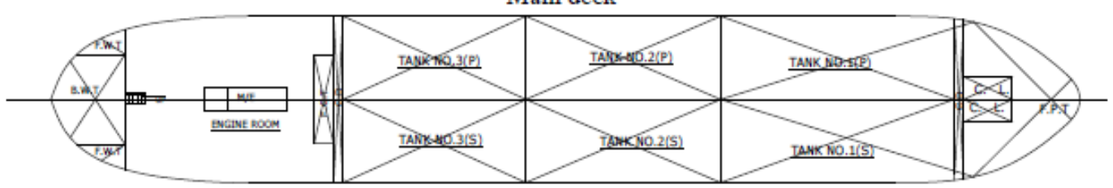
Bridge deck



Fore castle deck



Main deck



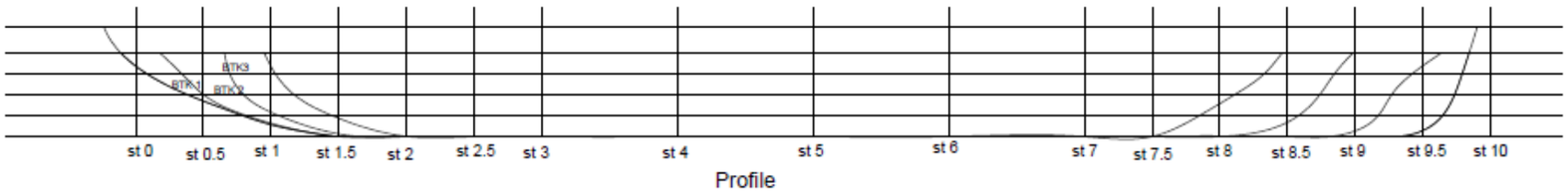
Under deck

Principle Particulars		
Length	70.80	meter
Breadth	11.42	meter
Depth	5.70	meter
Draft	4.40	meter
C_B	0.75	
Displacement	2660	tonnes
Service Speed	10	knots
Scale	1:386	

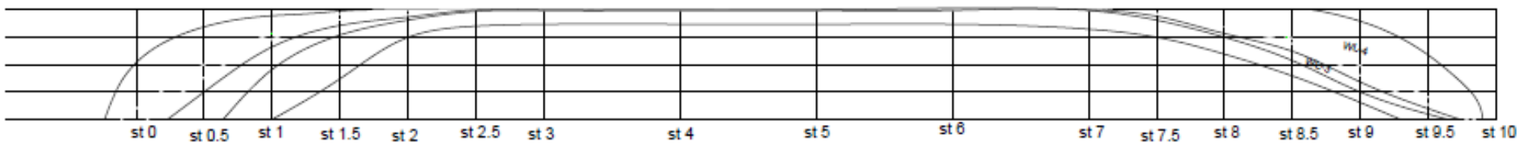
NAME-338
General Arrangement Drawing
Sakibul Hasan
Student ID : 1612046
Riasat Morshed
Student ID : 1612047
Date of submission: 15/11/20

Lines Plan:

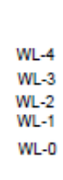
Principle Particulars		
Length	70.80	meter
Breadth	11.42	meter
Depth	5.70	meter
Draft	4.40	meter
C_B	0.75	
Displacement	2660	tonnes
Service Speed	10	knots
Scale	1:332	

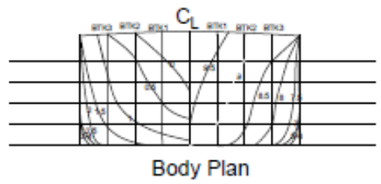


Profile



Half Breadth Plan



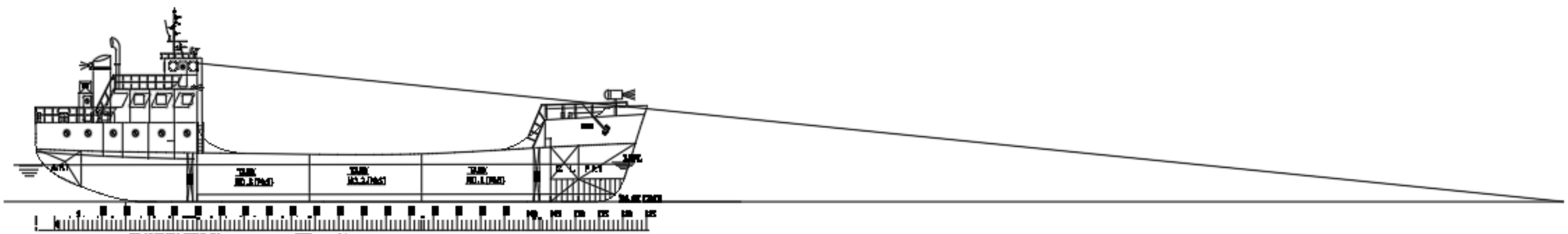


Body Plan

NAME-338
Lines Plan Drawing
Sakibul Hasan
Student ID : 1612046
Riasat Morshed
Student ID : 1612047
Date of submission: 15/11/20

Visibility Test:

Note: (1.5×L) distance is taken to check if the ship passes the visibility test and from the picture above it is evident that the ship meets the criteria successfully; where L= Ship's length



Elevation

Hydrostatics Calculation:

Waterline 1:

No. of ord.	SM	Water Lines						Waterline Spacing	Station Spacing	F. of Area	Area	F. of Volume	Lever	F. of Moment of Volume
		WL-0		WL-1		WL-2								
		SM												
		5		8		-1								
		Col 1		Col 2		Col 3		Col 7	Col 8	Col 9		Col 10	Col 11	Col 12
0	0.5	0.00	0.00	0.00	0.00	0.08	0.04	1.10	7.08					
		0.00		0.00		-0.08				-0.08	-0.09	-0.04	0	0
0.5	2	0.00	0.00	0.74	1.47	1.40	2.80							
		0.00		5.89		0.00				5.88	6.47	11.77	0.5	5.88
1	1	0.00	0.00	2.63	2.63	3.80	3.80							
		0.00		21.07		-3.80				17.27	18.99	17.27	1	17.27
1.5	2	2.20	4.40	4.40	8.80	4.90	9.80							
		11.00		35.20		-4.90				41.30	45.43	82.60	1.5	123.90
2	1	4.50	4.50	5.00	5.00	5.20	5.20							
		22.50		40.00		-5.20				57.30	63.03	57.30	2	114.60
		5.00	10.00	5.45	10.90	5.71	11.42							
		25.00		43.60		-5.71				62.89	69.17	125.78	2.5	314.45
3	1.5	5.12	7.68	5.68	8.51	5.71	8.57							
		25.60		45.40		-5.71				65.29	71.81	97.93	3	293.80
4	4	5.12	20.48	5.68	22.70	5.71	22.84							
		25.60		45.40		-5.71				65.29	71.81	261.16	4	1044.64
5	2	5.12	10.24	5.68	11.35	5.71	11.42							
		25.60		45.40		-5.71				65.29	71.81	130.58	5	652.90
6	4	5.12	20.48	5.68	22.70	5.71	22.84							
		25.60		45.40		-5.71				65.29	71.81	261.16	6	1566.96
7	1.5	4.82	7.23	5.40	8.10	5.62	8.44							
		24.10		43.20		-5.62				61.67	67.84	92.51	7	647.59
7.5	2	4.55	9.09	5.40	10.80	5.63	11.26							
		22.73		43.20		-5.63				60.30	66.33	120.60	7.5	904.50
8	1	3.80	3.80	4.78	4.78	5.04	5.04							
		19.00		38.24		-5.04				52.19	57.41	52.19	8	417.59
8.5	2	2.66	5.32	3.57	7.14	4.01	8.02							
		13.30		28.58		-4.01				37.86	41.65	75.73	8.5	643.72
9	1	1.05	1.05	2.46	2.46	2.88	2.88							
		5.23		19.66		-2.88				22.00	24.20	22.00	9	198.08
9.5	2	0.00	0.00	1.31	2.62	2.20	4.40							
		0.00		10.48		-2.20				8.28	9.10	16.56	9.5	157.32
10	0.5	0.00	0.00	0.00	0.00	0.00	0.00							
		0.00		0.00		0.00				0	0	0	10	0
Col 13				104.27		129.97		138.76		688.05		1425.13		7103.22
Col 14				5.00		8.00		-1.00						
Col 15				521.34		1039.76		-138.76				1422.33	LCB	35.29
Col 16				0.00		1.00		2.00	Displacement	616.60				
Col 17				0.00		1039.76		-277.53				762.23	VCB	0.59

Waterline 2:

No. of ord.	SM	Water Lines						Waterline Spacing	Station Spacing	F. of Area	Area	F. of Volume	Lever	F. of Moment of Volume
		WL-0		WL-1		WL-2								
		SM												
		1		4		1								
		Col 1		Col 2		Col 3		Col 7	Col 8	Col 9		Col 10	Col 11	Col 12
0	0.5	0.00	0.00	0.00	0.00	0.08	0.04	1.100	7.08					
		0.00		0.00		0.08				0.08	0.09	0.04	0.00	0.00
0.5	2	0.00	0.00	0.74	1.47	1.40	2.80							
		0.00		2.94		0.00				2.94	3.24	5.89	2.94	2.94
1	1	0.00	0.00	2.63	2.63	3.80	3.80							
		0.00		10.54		3.80				14.34	15.77	14.34	14.34	14.34
1.5	2	2.20	4.40	4.40	8.80	4.90	9.80							
		2.20		17.60		4.90				24.70	27.17	49.40	74.10	74.10
2	1	4.50	4.50	5.00	5.00	5.20	5.20							
		4.50		20.00		5.20				29.70	32.67	29.70	59.40	59.40
2.5	2	5.00	10.00	5.45	10.90	5.71	11.42							
		5.00		21.80		5.71				32.51	35.76	65.02	162.55	162.55
3	1.5	5.12	7.68	5.68	8.51	5.71	8.57							
		5.12		22.70		5.71				33.53	36.88	50.30	150.89	150.89
4	4	5.12	20.48	5.68	22.70	5.71	22.84							
		5.12		22.70		5.71				33.53	36.88	134.12	536.48	536.48
5	2	5.12	10.24	5.68	11.35	5.71	11.42							
		5.12		22.70		5.71				33.53	36.88	67.06	335.30	335.30
6	4	5.12	20.48	5.68	22.70	5.71	22.84							
		5.12		22.70		5.71				33.53	36.88	134.12	804.72	804.72
7	1.5	4.82	7.23	5.40	8.10	5.62	8.44							
		4.82		21.60		5.62				32.04	35.25	48.07	336.46	336.46
7.5	2	4.55	9.09	5.40	10.80	5.63	11.26							
		4.55		21.60		5.63				31.78	34.95	63.55	476.64	476.64
8	1	3.80	3.80	4.78	4.78	5.04	5.04							
		3.80		19.12		5.04				27.96	30.76	27.96	223.69	223.69
8.5	2	2.66	5.32	3.57	7.14	4.01	8.02							
		2.66		14.29		4.01				20.96	23.05	41.92	356.29	356.29
9	1	1.05	1.05	2.46	2.46	2.88	2.88							
		1.05		9.83		2.88				13.76	15.13	13.76	123.81	123.81
9.5	2	0.00	0.00	1.31	2.62	2.20	4.40							
		0.00		5.24		2.20				7.44	8.18	14.88	141.36	141.36
10	0.5	0.00	0.00	0.00	0.00	0.00	0.00							
		0.00		0.00		0.00				0.00	0.00	0.00	0.00	0.00
Col 13			104.26		129.97		138.76			372.328	372.33		760.11	3798.96
Col 14			1		4		1							
Col 15			104.26		519.88		138.76					762.91	LCB	35.38
Col 16			0		1		2		Displacement	1315.501				
Col 17			0		519.88		277.52					797.41	VCB	1.15

Waterline 3:

No. of ord.	SM	Water Lines								Waterline Spacing	Station Spacing	F. of Area	Area	F. of Volume	Lever	F. of Moment of Volume
		WL-0		WL-1		WL-2		WL-3								
		SM														
		1		3		3		1								
		Col 1		Col 2		Col 3		Col 4		Col 7	Col 8	Col 9		Col 10	Col 11	Col 12
0.00	0.50	0.00	0.00	0.00	0.00	0.08	0.04	0.31	0.16	1.10	7.08					
		0.00		0.00		0.25		0.31				0.56	0.61	0.28	0.00	0.00
0.50	2.00	0.00	0.00	0.74	1.47	1.40	2.80	2.85	5.70							
		0.00		2.21		0.00		2.85				5.06	5.56	10.12	0.50	5.06
1.00	1.00	0.00	0.00	2.63	2.63	3.80	3.80	4.80	4.80							
		0.00		7.90		11.40		4.80				24.10	26.51	24.10	1.00	24.10
1.50	2.00	2.20	4.40	4.40	8.80	4.90	9.80	5.20	10.40							
		2.20		13.20		14.70		5.20				35.30	38.83	70.60	1.50	105.90
2.00	1.00	4.50	4.50	5.00	5.00	5.20	5.20	5.40	5.40							
		4.50		15.00		15.60		5.40				40.50	44.55	40.50	2.00	81.00
2.50	2.00	5.00	10.00	5.45	10.90	5.71	11.42	5.71	11.42							
		5.00		16.35		17.13		5.71				44.19	48.61	88.38	2.50	220.95
3.00	1.50	5.12	7.68	5.68	8.51	5.71	8.57	5.71	8.57							
		5.12		17.03		17.13		5.71				44.99	49.48	67.48	3.00	202.43
4.00	4.00	5.12	20.48	5.68	22.70	5.71	22.84	5.71	22.84							
		5.12		17.03		17.13		5.71				44.99	49.48	179.94	4.00	719.76
5.00	2.00	5.12	10.24	5.68	11.35	5.71	11.42	5.71	11.42							
		5.12		17.03		17.13		5.71				44.99	49.48	89.97	5.00	449.85
6.00	4.00	5.12	20.48	5.68	22.70	5.71	22.84	5.71	22.84							
		5.12		17.03		17.13		5.71				44.99	49.48	179.94	6.00	1079.64
7.00	1.50	4.82	7.23	5.40	8.10	5.62	8.44	5.71	8.57							
		4.82		16.20		16.87		5.71				43.60	47.96	65.40	7.00	457.82
7.50	2.00	4.56	9.13	5.40	10.80	5.63	11.26	5.71	11.42							
		4.56		16.20		16.89		5.71				43.36	47.70	86.73	7.50	650.46
8.00	1.00	3.80	3.80	4.78	4.78	5.04	5.04	5.22	5.22							
		3.80		14.34		15.12		5.22				38.49	42.33	38.49	8.00	307.89
8.50	2.00	2.66	5.32	3.57	7.14	4.01	8.02	4.31	8.61							
		2.66		10.72		12.03		4.31				29.71	32.68	59.43	8.50	505.12
9.00	1.00	1.05	1.05	2.46	2.46	2.88	2.88	3.22	3.22							
		1.05		7.37		8.64		3.22				20.28	22.31	20.28	9.00	182.51
9.50	2.00	0.00	0.00	1.31	2.62	2.20	4.40	2.20	4.40							
		0.00		3.93		6.60		2.20				12.73	14.00	25.46	9.50	241.87
10.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.04							
		0.00		0.00		0.00		0.09				0.09	0.09	0.30	10.00	3.01
Col 13			104.30		129.97		138.76		145.03			517.91		1047.39		5237.37
Col 14			1.00		3.00		3.00		1.00							
Col 15			104.30		389.91		416.29		145.03					1055.53	LCB	35.40
Col 16			0.00		1.00		2.00		3.00		Displacement	2055.11				
Col 17			0.00		389.91		832.58		435.08					1657.57	VCB	1.73

Waterline 4:

No. of ord.	SM	Water Lines										Waterline Spacing	Station Spacing	F. of Area	Area	F. of Volume	Lever	F. of Moment of Volume
		WL-0		WL-1		WL-2		WL-3		WL-4								
		SM																
		1		4		2		4		1								
		Col 1		Col 2		Col 3		Col 4		Col 5		Col 7	Col 8	Col 9		Col 10	Col 11	Col 12
0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.12	0.57	0.29	1.10	7.08					
		0.00		0.00		0.00		0.97		0.57				1.54	1.69	0.77	0.00	0.00
0.50	2.00	0.00	0.00	0.00	0.00	1.40	2.80	1.90	3.80	2.10	4.20							
		0.00		0.00		0.00		7.60		2.10				9.70	10.67	19.40	0.50	9.70
1.00	1.00	0.00	0.00	2.60	2.60	3.77	3.77	4.18	4.18	3.05	3.05							
		0.00		10.40		7.54		16.72		3.05				37.71	41.48	37.71	1.00	37.71
1.50	2.00	2.20	4.40	4.40	8.80	4.90	9.80	5.20	10.40	5.50	11.00							
		2.20		17.60		9.80		20.80		5.50				55.90	61.49	111.80	1.50	167.70
2.00	1.00	4.50	4.50	5.00	5.00	5.20	5.20	5.40	5.40	5.71	5.71							
		4.50		20.00		10.40		21.60		5.71				62.21	68.43	62.21	2.00	124.42
2.50	2.00	5.00	10.00	5.45	10.90	5.71	11.42	5.71	11.42	5.71	11.42							
		5.00		21.80		11.42		22.84		5.71				66.77	73.45	133.54	2.50	333.85
3.00	1.50	5.12	7.68	5.68	8.51	5.71	8.57	5.71	8.57	5.71	8.57							
		5.12		22.70		11.42		22.84		5.71				67.79	74.57	101.69	3.00	305.06
4.00	4.00	5.12	20.48	5.68	22.70	5.71	22.84	5.71	22.84	5.71	22.84							
		5.12		22.70		11.42		22.84		5.71				67.79	74.57	271.16	4.00	1084.64
5.00	2.00	5.12	10.24	5.68	11.35	5.71	11.42	5.71	11.42	5.71	11.42							
		5.12		22.70		11.42		22.84		5.71				67.79	74.57	135.58	5.00	677.90
6.00	4.00	5.12	20.48	5.68	22.70	5.71	22.84	5.71	22.84	5.71	22.84							
		5.12		22.70		11.42		22.84		5.71				67.79	74.57	271.16	6.00	1626.96
7.00	1.50	4.82	7.23	5.40	8.10	5.62	8.44	5.71	8.57	5.71	8.57							
		4.82		21.60		11.25		22.84		5.71				66.22	72.84	99.33	7.00	695.29
7.50	2.00	4.28	8.56	5.10	10.20	5.37	10.74	5.47	10.94	5.51	11.02							
		4.28		20.40		10.74		21.88		5.51				62.81	69.09	125.62	7.50	942.15
8.00	1.00	2.75	2.75	3.90	3.90	4.40	4.40	4.70	4.70	4.90	4.90							
		2.75		15.60		8.80		18.80		4.90				50.85	55.94	50.85	8.00	406.80
8.50	2.00	1.88	3.76	3.06	6.12	3.50	7.00	3.90	7.80	4.20	8.40							
		1.88		12.24		7.00		15.60		4.20				40.92	45.01	81.84	8.50	695.64
9.00	1.00	0.00	0.00	1.43	1.43	1.95	1.95	2.28	2.28	2.80	2.80							
		0.00		5.71		3.90		9.12		2.80				21.53	23.68	21.53	9.00	193.75
9.50	2.00	0.00	0.00	0.00	0.00	0.27	0.54	0.49	0.98	0.83	1.65							
		0.00		0.00		0.54		1.97		0.83				3.34	3.67	6.68	9.50	63.42
10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00							
		0.00		0.00		0.00		0.00		0.00				0.00	0.00	0.00	10.00	0.00
Col 13			100.08		122.31		131.73		136.26		138.67			750.65		1530.86		7364.99
Col 14			1.00		4.00		2.00		4.00		1.00							
Col 15			100.08		489.24		263.45		545.02		138.67					1536.46	LCB	34.06
Col 16			0.00		1.00		2.00		3.00		4.00		Δ	2659.09				
Col 17			0.00		489.24		526.90		1635.06		554.67					3205.87	VCB	2.30

Transverse Metacentric Height:

Waterline 1 & Waterline 2:

BM_T Calculation

Station	SM	WL- 1			WL- 2		
		Half Ordinate	(Half Ordinate)^3	Function	Half Ordinate	(Half Ordinate)^3	Function
0.00	0.50	0.00	0.00	0.00	0.08	0.00	0.00
0.50	2.00	0.74	0.40	0.80	1.40	2.74	5.49
1.00	1.00	2.63	18.27	18.27	3.80	54.87	54.87
1.50	2.00	4.40	85.18	170.37	4.90	117.65	235.30
2.00	1.00	5.00	125.00	125.00	5.20	140.61	140.61
2.50	2.00	5.45	161.88	323.76	5.71	186.17	372.34
3.00	1.50	5.68	182.77	274.15	5.71	186.17	279.25
4.00	4.00	5.68	182.77	731.07	5.71	186.17	744.68
5.00	2.00	5.68	182.77	365.53	5.71	186.17	372.34
6.00	4.00	5.68	182.77	731.07	5.71	186.17	744.68
7.00	1.50	5.40	157.46	236.20	5.62	177.88	266.83
7.50	2.00	5.40	157.46	314.93	5.63	178.45	356.91
8.00	1.00	4.78	109.22	109.22	5.04	128.10	128.10
8.50	2.00	3.57	45.58	91.15	4.01	64.48	128.96
9.00	1.00	2.46	14.85	14.85	2.88	23.89	23.89
9.50	2.00	1.31	2.25	4.50	2.20	10.65	21.30
10.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
Sum Of Function		3510.85			3875.53		
I_{CL}		5523.74			6097.50		
Displacement		616.61			1315.50		
BM_T		8.96			4.64		

Waterline 3 & Waterline 4:

BM_T Calculation

Station	SM	WL- 3			WL- 4		
		Half Ordinate	(Half Ordinate)^3	Function	Half Ordinate	(Half Ordinate)^3	Function
0.00	0.50	0.31	0.03	0.02	0.63	0.25	0.13
0.50	2.00	2.85	23.15	46.30	3.84	56.62	113.25
1.00	1.00	4.80	110.59	110.59	5.30	148.88	148.88
1.50	2.00	5.20	140.61	281.22	5.50	166.38	332.75
2.00	1.00	5.40	157.46	157.46	5.71	186.17	186.17
2.50	2.00	5.71	186.17	372.34	5.71	186.17	372.34
3.00	1.50	5.71	186.17	279.25	5.71	186.17	279.25
4.00	4.00	5.71	186.17	744.68	5.71	186.17	744.68
5.00	2.00	5.71	186.17	372.34	5.71	186.17	372.34
6.00	4.00	5.71	186.17	744.68	5.71	186.17	744.68
7.00	1.50	5.71	186.17	279.25	5.71	186.17	279.25
7.50	2.00	5.71	186.17	372.34	5.71	186.17	372.34
8.00	1.00	5.22	142.48	142.48	5.40	157.46	157.46
8.50	2.00	4.31	79.90	159.79	4.58	96.20	192.40
9.00	1.00	3.22	33.39	33.39	3.70	50.65	50.65
9.50	2.00	2.20	10.65	21.30	2.40	13.82	27.65
10.00	0.50	0.09	0.00	0.00	0.06	0.00	0.00
Sum Of Function		4117.42			4374.21		
I_{CL}		6478.08			6882.09		
Displacement		2055.11			2824.36		
BM_T		3.15			2.44		

Longitudinal Metacentric Height:

Waterline 1 & Waterline 2:

Calculation of BM_L

Station	SM	Lever	WL 1				WL 2			
			Half Ordinate	Function of A.	Function of M.	Function of I.	Half Ordinate	Function of A.	Function of M.	Function Of I.
0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.08	0.04	0.00	0.00
0.50	2.00	0.50	0.74	1.47	0.74	1.47	1.40	2.80	1.40	2.80
1.00	1.00	1.00	2.63	2.63	2.63	2.63	3.80	3.80	3.80	3.80
1.50	2.00	1.50	4.40	8.80	13.20	26.40	4.90	9.80	14.70	29.40
2.00	1.00	2.00	5.00	5.00	10.00	10.00	5.20	5.20	10.40	10.40
2.50	2.00	2.50	5.45	10.90	27.25	54.50	5.71	11.42	28.55	57.10
3.00	1.50	3.00	5.68	8.51	25.54	38.31	5.71	8.57	25.70	38.54
4.00	4.00	4.00	5.68	22.70	90.80	363.20	5.71	22.84	91.36	365.44
5.00	2.00	5.00	5.68	11.35	56.75	113.50	5.71	11.42	57.10	114.20
6.00	4.00	6.00	5.68	22.70	136.20	544.80	5.71	22.84	137.04	548.16
7.00	1.50	7.00	5.40	8.10	56.70	85.05	5.62	8.44	59.05	88.58
7.50	2.00	7.50	5.40	10.80	81.00	162.00	5.63	11.26	84.45	168.90
8.00	1.00	8.00	4.78	4.78	38.24	38.24	5.04	5.04	40.33	40.33
8.50	2.00	8.50	3.57	7.14	60.72	121.45	4.01	8.02	68.17	136.34
9.00	1.00	9.00	2.46	2.46	22.12	22.12	2.88	2.88	25.92	25.92
9.50	2.00	9.50	1.31	2.62	24.89	49.78	2.20	4.40	41.80	83.60
10.00	0.50	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				129.97	646.78	1633.45		138.76	689.77	1713.51
				Area	CF from aft	I_M Abt aft		Area	CF from aft	I_M Abt aft
				613.46	35.23	386469.26		654.96	35.19	405410.30
				I_{CF}	-375051.22			I_{CF}	-405806.88	
Displacement			616.61				1315.50			
BMI			-608.25				-308.48			

Waterline 3 & Waterline 4:

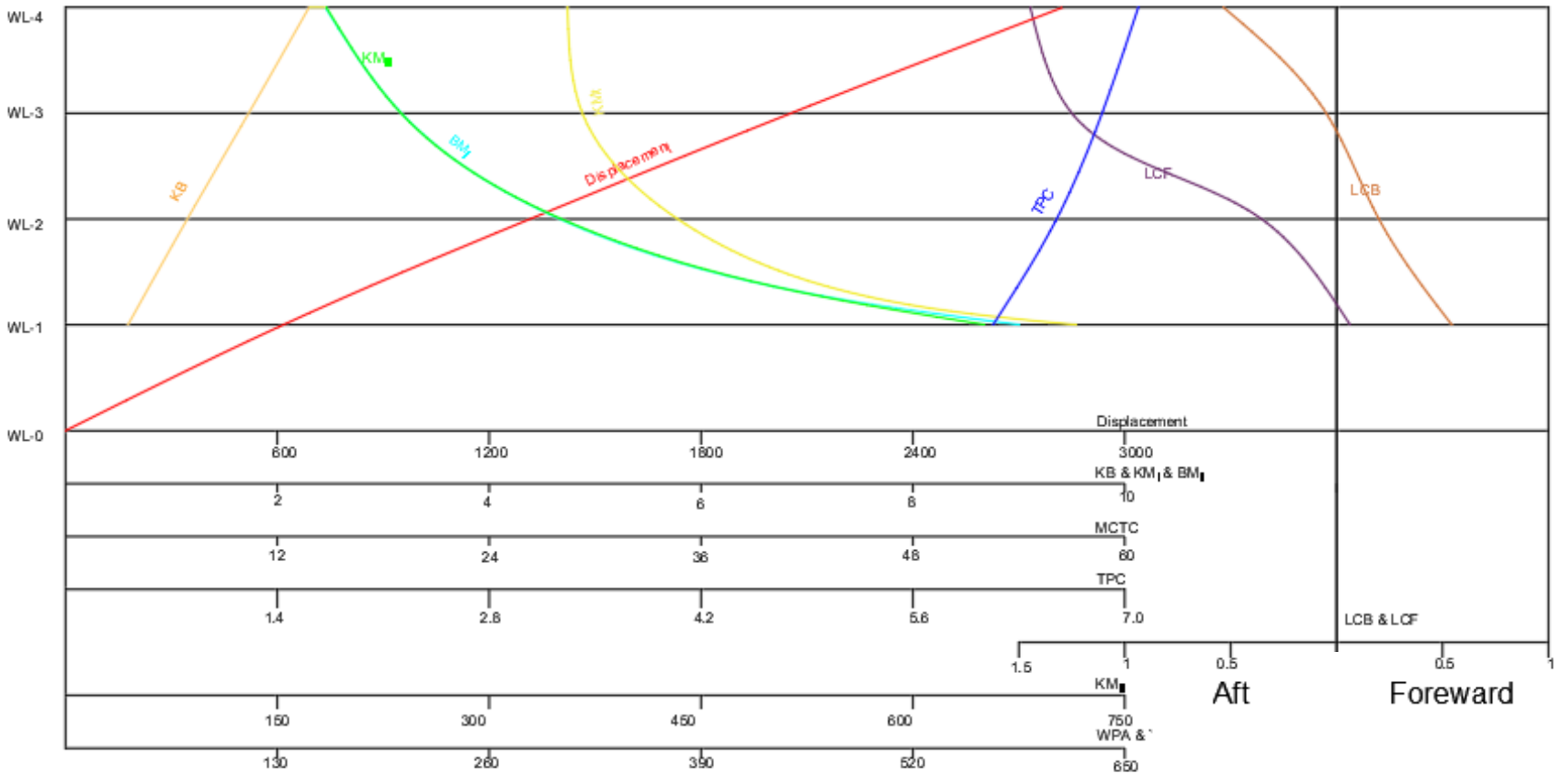
Calculation of BM_L

Station	SM	Lever	WL 3				WL 4			
			Half Ordinate	Function of A.	Function of M.	Function of I.	Half Ordinate	Function of A.	Function of M.	Function Of I.
0.00	0.50	0.00	0.31	0.16	0.00	0.00	0.63	0.32	0.00	0.00
0.50	2.00	0.50	2.85	5.70	2.85	5.70	3.84	7.68	3.84	7.68
1.00	1.00	1.00	4.80	4.80	4.80	4.80	5.30	5.30	5.30	5.30
1.50	2.00	1.50	5.20	10.40	15.60	31.20	5.50	11.00	16.50	33.00
2.00	1.00	2.00	5.40	5.40	10.80	10.80	5.71	5.71	11.42	11.42
2.50	2.00	2.50	5.71	11.42	28.55	57.10	5.71	11.42	28.55	57.10
3.00	1.50	3.00	5.71	8.57	25.70	38.54	5.71	8.57	25.70	38.54
4.00	4.00	4.00	5.71	22.84	91.36	365.44	5.71	22.84	91.36	365.44
5.00	2.00	5.00	5.71	11.42	57.10	114.20	5.71	11.42	57.10	114.20
6.00	4.00	6.00	5.71	22.84	137.04	548.16	5.71	22.84	137.04	548.16
7.00	1.50	7.00	5.71	8.57	59.96	89.93	5.71	8.57	59.96	89.93
7.50	2.00	7.50	5.71	11.42	85.65	171.30	5.71	11.42	85.65	171.30
8.00	1.00	8.00	5.22	5.22	41.78	41.78	5.40	5.40	43.20	43.20
8.50	2.00	8.50	4.31	8.61	73.22	146.44	4.58	9.16	77.89	155.79
9.00	1.00	9.00	3.22	3.22	28.98	28.98	3.70	3.70	33.30	33.30
9.50	2.00	9.50	2.20	4.40	41.80	83.60	2.40	4.80	45.60	91.20
10.00	0.50	10.00	0.09	0.04	0.43	0.21	0.06	0.03	0.32	0.16
				145.03	705.61	1738.19		150.17	722.72	1765.72
				Area	CF from aft	I_M Abt aft		Area	CF from aft	I_M Abt aft
				684.52	34.45	411249.74		708.81	34.07	417764.07
				I_{CF}	-401002.91			I_{CF}	-405174.45	
Displacement			2055.11				2824.36			
BMl			-195.12				-143.46			

Hydrostatics Summary:

Draft	TPC	LCB	KB	Displacement	BM_L	BM_T	MCTC	KM_L	KM_T	LCF abt aft
1.10	6.13	35.29	0.59	616.61	608.25	8.96	52.97	643.54	9.55	35.23
2.20	6.55	35.39	1.15	1315.50	308.48	4.64	57.32	343.87	5.78	35.19
3.30	6.85	35.40	1.73	2055.11	195.12	3.15	56.64	230.53	4.88	34.45
4.40	7.09	34.97	2.30	2824.36	143.46	2.44	57.23	178.43	4.74	34.07

Hydrostatics Curves:



Scantling calculation:

Particulars:

Length: 70.8 m

Breadth: 11.4 m

Depth: 5.7 m

Draft: 4.4 m

Deadweight-Displacement Co-efficient: 0.7

Deadweight: 2000 tons

Displacement: 2660 tons

Material Factor, k: taking steel yield stress as 235MPa

k = 1

Web Frame Spacing: 1.8 m

Frame Spacing: 0.6 m = 600mm[1] Ship Construction by DJ Eyer

Bottom shell plating:

C_0= Wave Co-efficient = $\frac{L}{25} + 4.1 \times CR_W = 6.93$

CR_W=1, for unlimited service range

C_L= Length Co-efficient = $\sqrt{\frac{L}{90}} = .887$

f = Probability Factor = 0.6

p_0 = Basic external dynamic load = $2.1(C_B+0.7)\times C_0 \times C_L \times f$ = 11.62 kN/m^2

p_B =Load on ship bottom = $2.6(C_B+0.7)\times c_0 \times C_L$ = 24 kN/m^2

n_f = transverse framing=1

a= frame spacing =m0.6

t_{B1}=1,9×n_f×a$\sqrt{p_B \times k \times t_k}$ = 7.58 mm

The obtained value of minimum thickness, $t_{min} = (4.5+0.005.L_{200}).\sqrt{k}$ =8.41 mm

Bottom Plate Thickness = 10 mm

Side plate thickness:

z = .5×(Depth – double bottom depth) + double bottom depth = 3.23 m

p_s = Load on sides = 10(T – z) + $p_0 \times c_f (1+\frac{z}{T})$ = 31.85 kN/m^2

t_{s1} = Thickness within .4L amidship = $1.9 \times n_f \times a \times \sqrt{p_s \times k} + t_k$ = 8.43 mm

Minimum Thickness = $T + \frac{C_0}{2}$ = 7.9 mm

Side Plate Thickness = 10 mm

Bilge plate thickness:

Bilge plate thickness is same as the bottom plate thickness, t_B

i.e, Bilge Plate Thickness = 10 mm

Flat keel plate thickness:

Width of the flat keel, b = 800+50×L = 4340mm = 4.34 m

t_{FK} = Thickness of the flat keel plate = t_B + 2 = 10+2 =12 mm

Deck plate thickness:

Table 4.1 Distribution factors for sea loads on ship's shell and weather decks

Range		c_D	c_F [1]
A	$0 \le \frac{x}{L} < 0.2$	$1.2 - \frac{x}{L}$	$1.0 + \frac{5}{C_B}\cdot\left(0.2 - \frac{x}{L}\right)$
M	$0.2 \le \frac{x}{L} < 0.7$	1.0	1.0
F	$0.7 \le \frac{x}{L} < 1.0$	$1.0 + \frac{c}{3}\cdot\left(\frac{x}{L} - 0.7\right)$ $c = 0.15\cdot L - 10$ $100\ m \le L \le 250\ m$	$1.0 + \frac{20}{C_B}\cdot\left(\frac{x}{L} - 0.7\right)^2$
1	Within the range **A** the ratio x / **L** need not to be taken less than 0.1 and within the range **F** the ratio x / **L** need not to be taken greater than 0.93.		

P_D = Load on Weather Decks = $\frac{20 \times T}{(10+z-T)H} \times c_D$ =

1.75 kN/m^2 (For aft)

1.75 kN/m^2 (For amidship)

3.61 kN/m^2 (For forward)

F = $.11 \times .11 \times \frac{V_0}{\sqrt{L}} = 0.11$

m_0 = 1.5 + 1.1 = 1.61

a_v = F× m

$m = m_0 - 5\, m_0 \times x/L$ For $0 < x/L < 0.2 = 1$

so $a_v = 0.11$

$P_L = 16.65$ kN/m^2

$t_E = 5.5$ mm

$T_{E,}$ min $= 5.5 + .02 \times L = 6.92$mm

So, the deck plate thickness = 7 mm

Sheerstreak:

Width is not to be taken less than = $800 + 5 \times L = 4.34$ m

Thickness of the sheerstrake = $.5 \times (t_D + t_S) = 8.5$ mm

So, thickness of the sheerstrake = 9mm

Bulkheads:

Minimum Plate thickness = $6 \times \sqrt{f}$

$= 6 \times \sqrt{1}$

= 6 mm

Center girder:

The depth of center girder, $h = 350 + 45 \times l$; where l=B

= 863.9 mm

Thickness = $t_m = \frac{h}{h_a}\left(\frac{h}{100} + 1.0\right)\sqrt{k}$

= 9.8 mm = 10 mm

Sectional area of center girder, $A_f = 0.7 \times L + 12$ cm^2

Therefore the width of the girder = 840 mm

Web frame & side stringer:

$P_S = 31.85$ kN/m^2

No cross ties would be used, that is why, $n_c = 1$.

Section modulus = $0.55 \times e \times l^2 \times P_s \times n_c \times k$

Unsupported span,l= 1.8

Frame spacing, a = 0.6 m

Section modulus = 102.2 cm^3

So the dimension is = 180mm × 25mm × 5mm

Deck web & deck girder:

P_D = 3.61 kN/m^2

Section modulus = $c \times e \times l^2 \times P_D \times k$ = 15.8 cm^3 ; c =0.75 (for girders and beams)

So, the dimension is = 100mm × 100 mm × 5 mm

Bottom longitudinals:

C_1 = 0.11

L_K = 55.4 mm

m_k = 0.94

m= 0.814

Here, $\sigma_{Pr} = \frac{230}{k} = \frac{230}{1} = 230$

Section Modulus = $\frac{83.3}{\sigma_{Pr}} \times m \times l^2 \times P_B = 6.65$ cm^3

So, the dimension of bottom longitudinals = 75mm × 75 mm × 5mm

Side longitudinals:

P_S = 31.85 kN/m^2

Section Modulus, W = $\frac{83.3}{\sigma_{Pr}} \times m \times l^2 \times P_S$ = 2.21 cm^3

So, the dimension is = 45mm × 45 mm × 5mm

Deck beam:

P_D = 31.85 kN/m^2

Section Modulus, W = $c \times a \times l^2 \times k \times P_D$ = 5.3 cm^3

So, the dimension is = 50mm × 50mm × 10mm

Bracket:

$t = c \times \sqrt[3]{\frac{W}{k_1}} + t_k$

c = 1.2 for non-flanged bracket

$k_1 = 1$

$t_k = 2$

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

$p = p_B = 24kN/m^2$

c= 0.6

n= 0.7

l=1.8

a=.6

$W=19.59\ cm^3$

$t = 1\times \sqrt{\frac{19.59}{1}} + 2$

= 4.695 mm

= 5mm

The arm length of bracket, $l = 46.2\times \sqrt[3]{\frac{W}{k_1} \times \sqrt{k_2}} \times \sqrt{\frac{4.695}{5}}$

= 120.68 mm

= 121 mm

Floor plate:

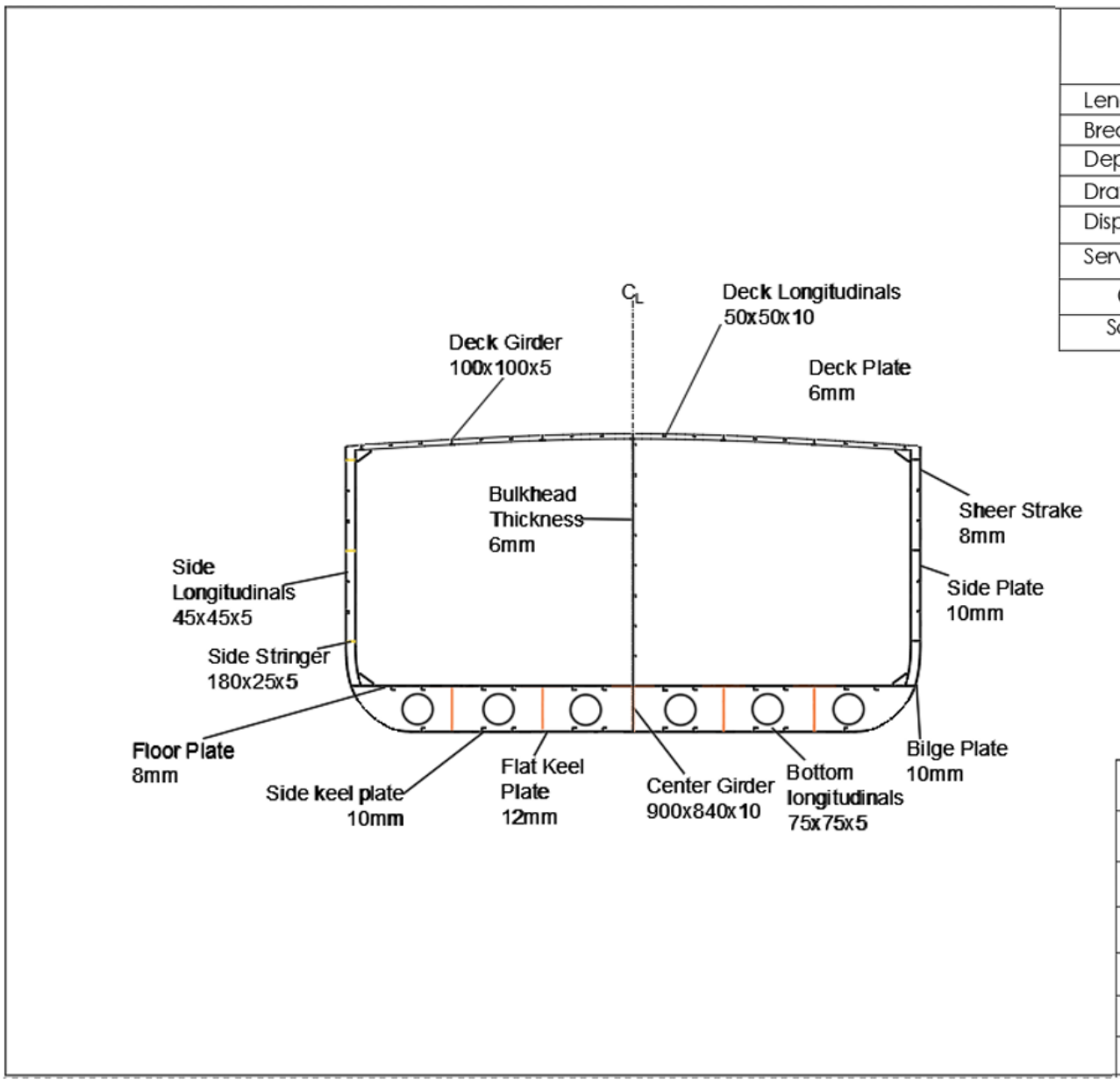
The thickness of plate floor = $t_k - 2 \times \sqrt{k}$

= 8 mm

Summary of scantling calculation:

Particulars	Dimensions	Unit
Material factor (k)	1	--
Web frame spacing	1.8	m
Yield strength	235	N/mm^2
Bottom shell plating	10	m
Sheer strake	8	mm
Floor plate	8	mm
Side plate thickness	10	mm
Bilge thickness	10	mm
Flat keel plate	12	mm
Deck plate	6	mm
Bulkhead thickness	6	mm
Center girder(width x height x length)	840× 900× 1000	mm × mm × mm
Web-frame and side stringers	T-180 x 25 x 5	mm × mm × mm
Deck web and deck girder	T-100 x 100 x 5	mm × mm × mm
Bottom longitudinal	L- 75 x 75 x 5	mm × mm × mm
Side longitudinal	L- 45 x 45 x 5	mm × mm × mm
Deck beam	L- 50 x 50 x 10	mm × mm × mm

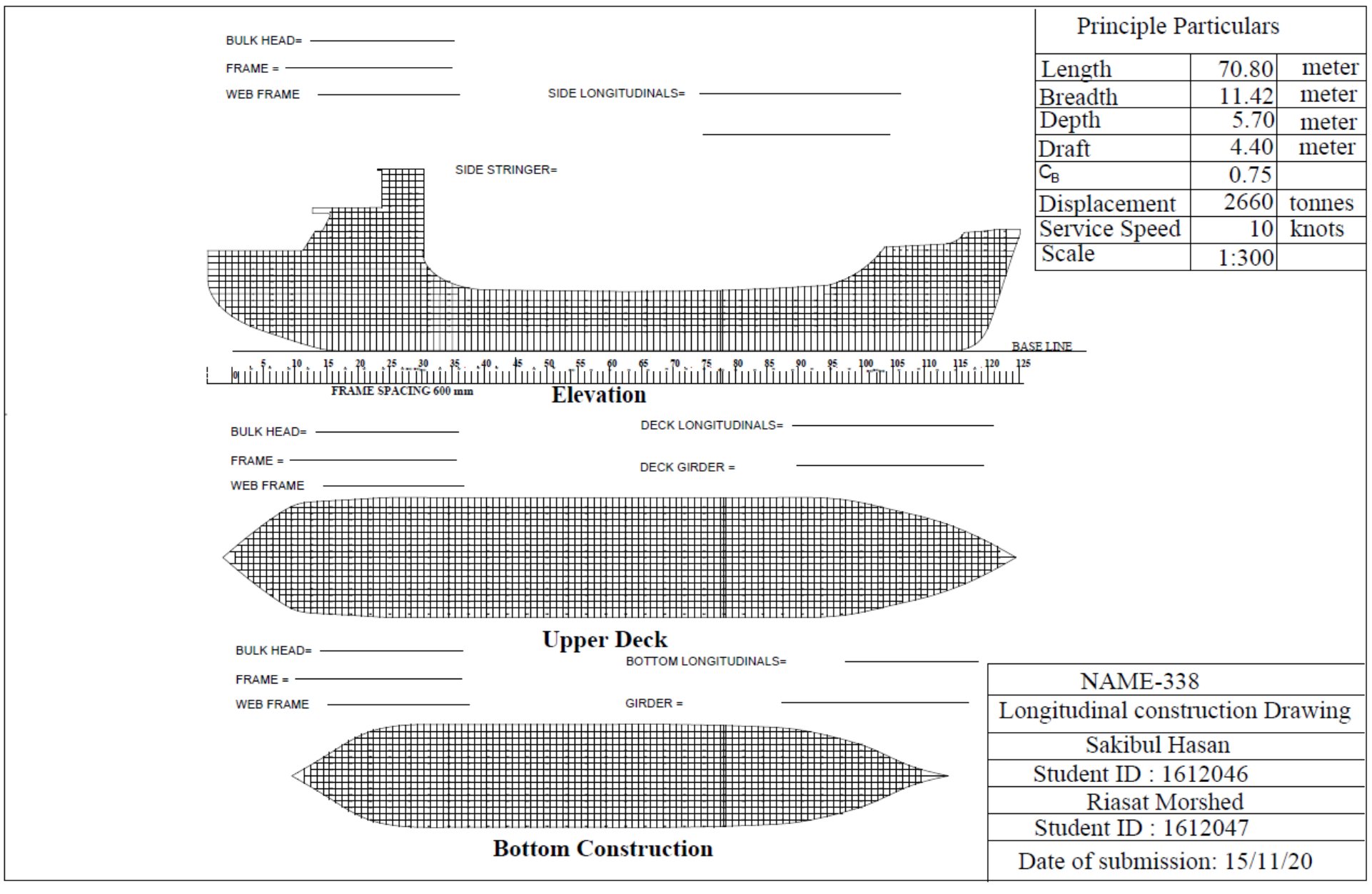
Midship section:



Principle Particulars		
Length	70.8	meter
Breadth	11.42	meter
Depth	5.7	meter
Draft	4.4	meter
Displacement	2660	tonnes
Service speed	10	knots
C_B	0.75	
Scale	1:75	

NAME-338	
Midship Section Drawing	
Sakibul Hasan	
Student ID	S2016 12046
Riasat Morshed	
Student ID	S2016 12047
Date of Submission	29/07/2019

Longitudinal construction:

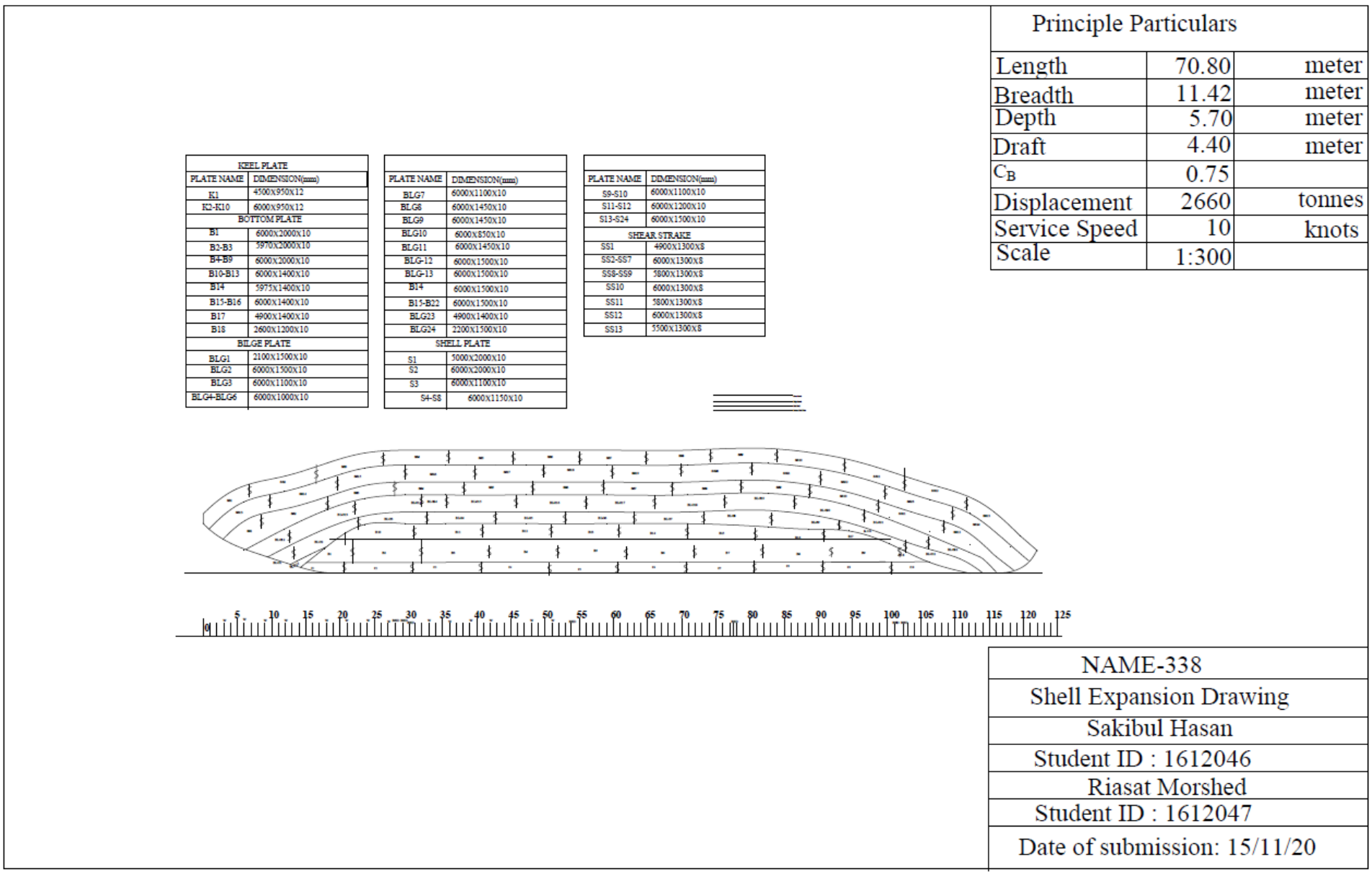


Principle Particulars		
Length	70.80	meter
Breadth	11.42	meter
Depth	5.70	meter
Draft	4.40	meter
C_B	0.75	
Displacement	2660	tonnes
Service Speed	10	knots
Scale	1:300	

NAME-338
Longitudinal construction Drawing
Sakibul Hasan
Student ID : 1612046
Riasat Morshed
Student ID : 1612047
Date of submission: 15/11/20

<u>Correction made at longitudinal Construction:</u> On fourth presentation, Professor Dr. Mir Tareque Ali sir pointed on the fact that some of the spaces are not accessible to perform welding. The previous drawing includes welding symbols on such spaces. Hence, those spaces were cleared of welding symbols as well as structural members.

Shell expansion drawing:



KEEL PLATE	
PLATE NAME	DIMENSION(mm)
K1	4500X950X12
K2-K10	6000X950X12
BOTTOM PLATE	
B1	6000X2000X10
B2-B3	5970X2000X10
B4-B9	6000X2000X10
B10-B13	6000X1400X10
B14	5975X1400X10
B15-B16	6000X1400X10
B17	4900X1400X10
B18	2600X1200X10
BILGE PLATE	
BLG1	2100X1500X10
BLG2	6000X1500X10
BLG3	6000X1100X10
BLG4-BLG6	6000X1000X10

PLATE NAME	DIMENSION(mm)
BLG7	6000X1100X10
BLG8	6000X1450X10
BLG9	6000X1450X10
BLG10	6000X850X10
BLG11	6000X1450X10
BLG-12	6000X1500X10
BLG-13	6000X1500X10
B14	6000X1500X10
B15-B22	6000X1500X10
BLG23	4900X1400X10
BLG24	2200X1500X10
SHELL PLATE	
S1	5000X2000X10
S2	6000X2000X10
S3	6000X1100X10
S4-S8	6000X1150X10

PLATE NAME	DIMENSION(mm)
S9-S10	6000X1100X10
S11-S12	6000X1200X10
S13-S24	6000X1500X10
SHEAR STRAKE	
SS1	4900X1300X8
SS2-SS7	6000X1300X8
SS8-SS9	5800X1300X8
SS10	6000X1300X8
SS11	5800X1300X8
SS12	6000X1300X8
SS13	5500X1300X8

Principle Particulars		
Length	70.80	meter
Breadth	11.42	meter
Depth	5.70	meter
Draft	4.40	meter
C_B	0.75	
Displacement	2660	tonnes
Service Speed	10	knots
Scale	1:300	

NAME-338
Shell Expansion Drawing
Sakibul Hasan
Student ID : 1612046
Riasat Morshed
Student ID : 1612047
Date of submission: 15/11/20

Weight calculation:

Summary of steelweight:

Steelweight summary					
Item	**Weight (tonne)**	**LCG from Midship (m)**	**Moment for LCG (t-m)**	**VCG from keel (m)**	**Moment for VCG (t-m)**
Center girder	8.43	0.24	2.02	0.40	3.37
Side girder	53.96	0.25	13.41	0.58	31.24
Bottom longitudinals	24.48	0.50	12.22	0.48	11.84
Deck center girder	3.10	2.10	6.51	6.34	19.65
Deck girder	15.00	0.62	9.25	5.92	88.84
Deck longitudinals	16.00	0.98	15.74	6.08	97.21
Side stringer	33.20	-0.24	-7.99	2.85	94.62
Side longitudinals	19.00	-0.33	-6.27	2.87	54.53
Keel plate	10.40	2.33	24.23	0.01	0.06
Bottom plate	30.20	0.13	3.93	0.01	0.15
Bilge plate	30.40	1.50	45.60	0.75	22.80
Shell plate	34.40	-0.53	-18.23	2.85	98.04
Shear strake	14.00	1.25	17.50	5.50	77.00
Web frame	24.00	-0.30	-7.12	2.94	70.47
Ordinary frame	12.20	0.82	10.01	2.93	35.80
Transverse bulkhead	17.40	1.57	27.33	2.72	47.40
Centerline bulkhead	10.80	4.50	48.60	2.72	29.42
Bracket	5.00	-1.50	-7.50	3.50	17.50
Floor plate	41.00	0.59	24.12	0.92	37.56
Deck beam	16.30	1.20	19.56	5.70	92.91
Bulkhead longitudinals	12.00	4.50	54.00	3.36	40.32
Superstructure plate	26.25	-17.40	-456.75	10.20	267.75
Side stringer	8.01	-6.94	-55.59	9.40	75.29
Side longitudinals	6.00	-4.48	-26.88	10.00	60.00
Web frame	6.17	-8.30	-51.21	9.50	58.62
Ordinary frame	3.10	-8.04	-24.92	9.58	29.70
Engine Room foundation	10.65	-21.00	-223.65	1.40	14.91
Deck plate	40.40	1.14	46.04	5.70	230.27
Bulwark and stairs	6.00	1.40	8.40	12.10	72.60
Piping	12.00	0.00	0.00	5.70	68.40
Mast 1	3.00	-28.20	-84.60	24.20	72.60
Mast 2	1.00	36.50	36.50	9.40	9.40
Scrap	55.00				
Funnel	2.00	-26.75	-53.50	17.50	35.00
Total	**610.85**	**-61.89**	**-506.04**	**115.21**	**1707.27**
LCG=	**-0.83**				
VCG=	**2.79**				

Summary of lightweight:

Lightweight Summary					
Item	**Weight (tonne)**	**LCG from Midship (m)**	**Moment for LCG (t-m)**	**VCG from keel (m)**	**Moment for VCG (t-m)**
Steelweight	610.85	-0.91	-555.87	3.07	1876.22
Machinery weight	20.6	-48.01	-1056.22	3.84	84.48
Wood & Oufit	3.88	-19.98	-109.89	6.64	36.52
Total	**635.33**	**-2.70**	**-1721.98**	**3.13**	**1997.22**

Total weight summary:

Total weight calculation					
Item	Weight (tonne)	LCG from Midship (m)	Moment for LCG (t-m)	VCG from keel (m)	Moment for VCG (t-m)
Lightship weight	635.33	-2.70	-1723.54	3.13	1997.27
Fore Peak Tank	1.00	31.80	31.80	4.50	4.50
Aft Peak Tank	2.00	-32.99	-65.98	4.40	8.80
Tank 1	334.00	17.01	5681.34	2.80	935.20
Tank 2	333.00	3.03	1008.99	2.80	932.40
Tank 3	333.00	-10.28	-3423.24	2.80	932.40
Tank 4	333.00	17.01	5664.33	2.80	932.40
Tank 5	333.00	3.03	1008.99	2.80	932.40
Tank 6	333.00	-10.28	-3423.24	2.80	932.40
Fuel Oil Tank	3.00	-30.30	-90.90	3.00	9.00
Crew Effect	0.98	-26.20	-25.55	7.50	7.31
Total	**2641.30**	**1.76**	**4643.00**	**2.88**	**7624.08**

Note: Detail calculations are provided in appendix 1

Resistance calculation:

Resistance component	Value	Unit
Frictional resistance	54.40	kN
Appendage resistance	0.77	kN
Wave resistance	38.47	kN
Additional pressure resistance due to bulbous bow	0	kN
Additional pressure resistance of immersed transom stern	0	kN
Model-ship co-relation resistance	9.30	kN
Wind resistance	9.00	kN
Total resistance	102.64	kN

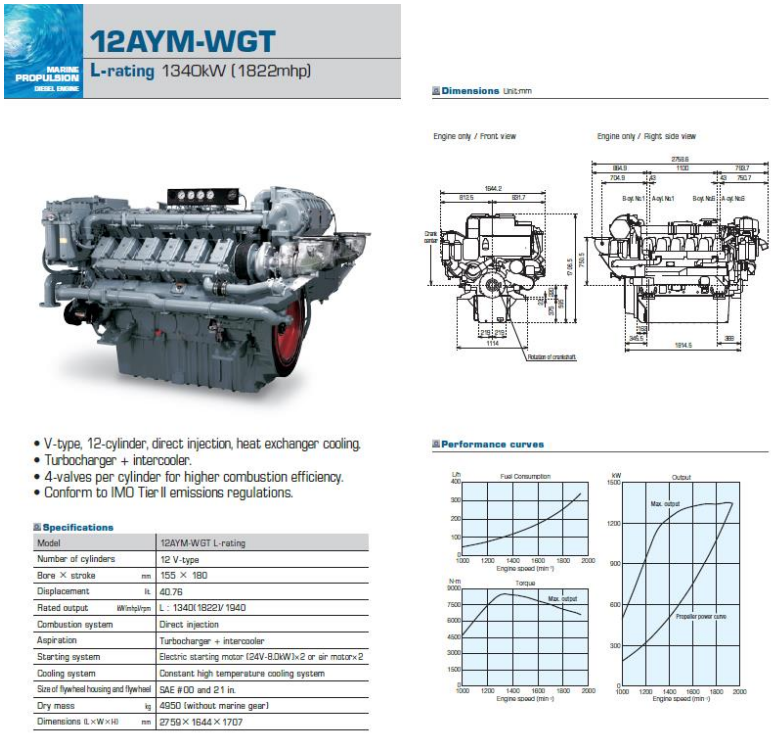
Summary of power calculation:

Power Component	Value	Unit
Effective Power, P_E	579.24	kW
Developed Power, P_D	1053.16	kW
Break Power, P_B	1074.65	kW
Installed Power	1265	kW

Note: Detailed calculation is provided in Appendix 2

Engine selection:

From “Yanmar Catalogue for Marine Diesel Engine”, the engine chosen is: 12AYM-WGT (L-Rating: 1340 kW)



12AYM-WGT

L-rating 1340kW (1822mhp)

- V-type, 12-cylinder, direct injection, heat exchanger cooling.
- Turbocharger + intercooler.
- 4-valves per cylinder for higher combustion efficiency.
- Conform to IMO Tier II emissions regulations.

Specifications

Model	12AYM-WGT L-rating
Number of cylinders	12 V-type
Bore × stroke mm	155 × 180
Displacement lit.	40.76
Rated output kW/min^{-1}(rpm)	L : 1340(1822)/ 1940
Combustion system	Direct injection
Aspiration	Turbocharger + intercooler
Starting system	Electric starting motor (24V-8.0kW)×2 or air motor×2
Cooling system	Constant high temperature cooling system
Size of flywheel housing and flywheel	SAE #00 and 21 in.
Dry mass kg	4950 (without marine gear)
Dimensions (L×W×H) mm	2759 × 1644 × 1707

Dimensions Unit:mm

Engine only / Front view

Engine only / Right side view

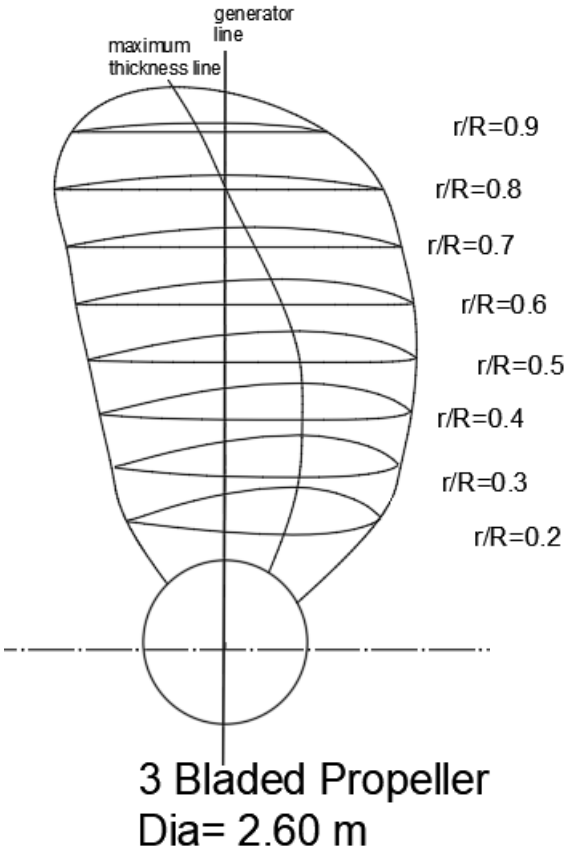
Performance curves

Summary of propeller calculation:

Particulars	**Value**	**Unit**
Propeller diameter	2.60	meter
Taylor wake fraction	0.22	--
Thrust deduction co-efficient	0.204	--
Shaft immersion	1.50	meter
Expanded blade area ratio, $\frac{A_E}{A_0}$	0.50	--
Pitch-dia Ratio	0.67	--
Projected blade area, A_P	3.97	m^2
Burrill co-efficient, τ_c	0.14	--
Shaft efficiency, η_S	0.98	--

Note: Detail Calculations are provided in Appendix 3

Propeller Profile:



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

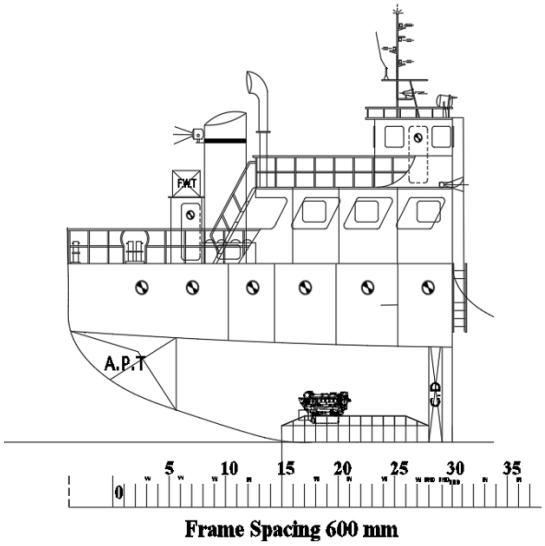
2) The geometry of the propeller is drawn from Wageningen B-screw propeller.

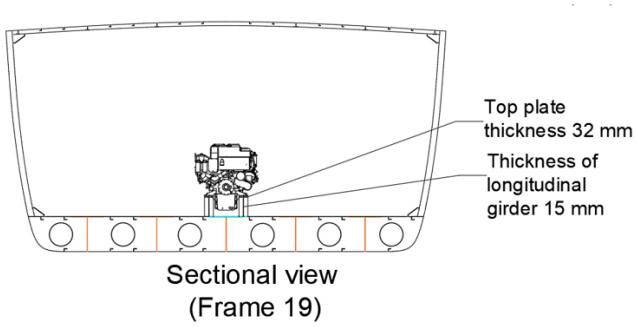
3) Detail Calculations are provided in Appendix 4

Summary of engine room foundation calculation:

Items	Dimension	Unit
Thickness of floor plate	8	mm
Center girder thickness	10	mm
Center girder height	870	mm
Thickness of longitudinal girder	15	mm
Top plate area	81.68	cm^2
Thickness of center girder	10	mm
Inner bottom plate	8	mm
Web frame	T-180 x 25 x 5	mm x mm x mm
Top plate thickness	32	mm
Bolt diameter	32	mm

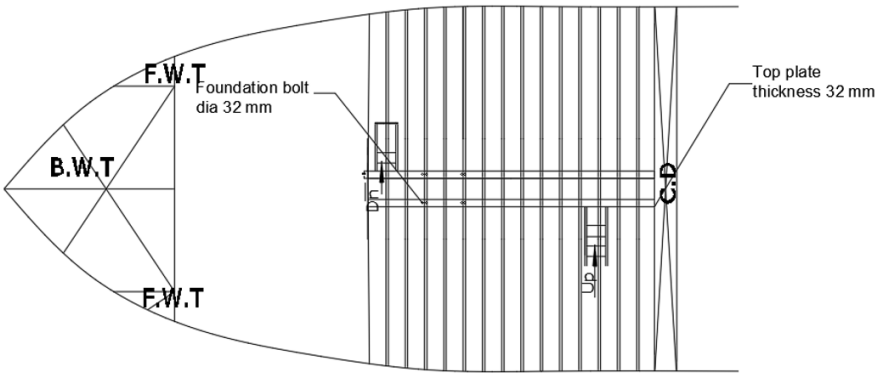
Engine room foundation drawing:





Sectional view
(Frame 19)

Top view for engine room foundation:

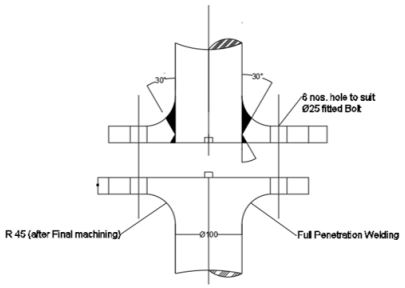


Summary of Rudder Calculation:

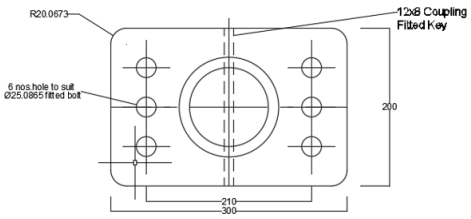
Item	Dimension	Unit
Rudder area	8.52	m^2
Aspect ratio	1.2	--
Stock dia	100	mm
Distance of the bolt axis from the center of the bolt system	105	mm
No. Of bolts	6	--
Coupling dia	25	mm
Thickness of coupling flanges	22.5	mm
Thickness of coupling flange clear of bolt hole	16.25	mm
Thickness of rudder plating	10	mm
Thickness of the webs	7	mm
Diameter of pintle	113	mm

Note: Detail calculation is provided at Appendix 5

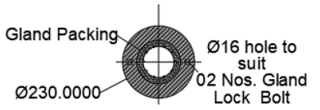
Details of Rudder Drawing:



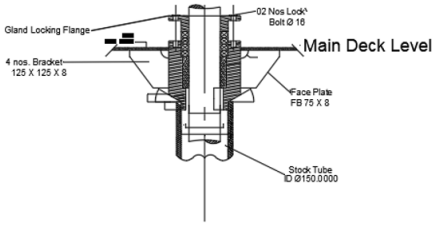
Coupling Details



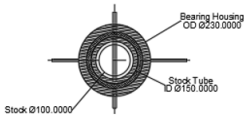
Coupling Flange



Upper Bearing (Top View)

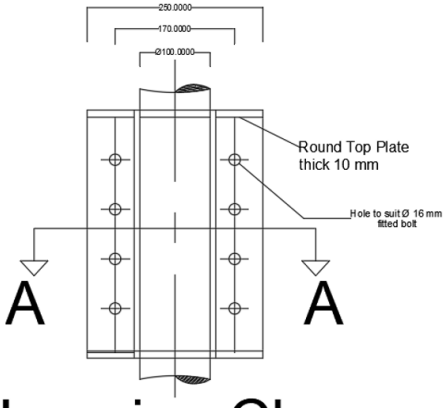


Upper Bearing

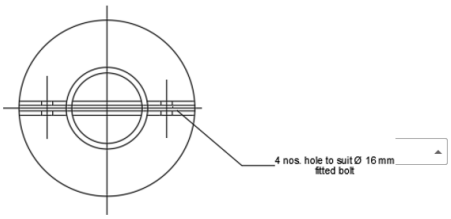


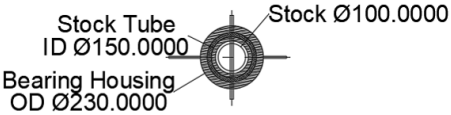
Upper Bearing (Bottom View)

Details of Rudder Drawing (contd…):

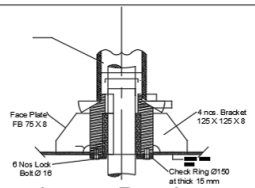


Jumping Clamp

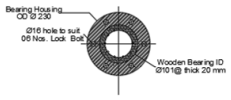




Lower Bearing (Top View)

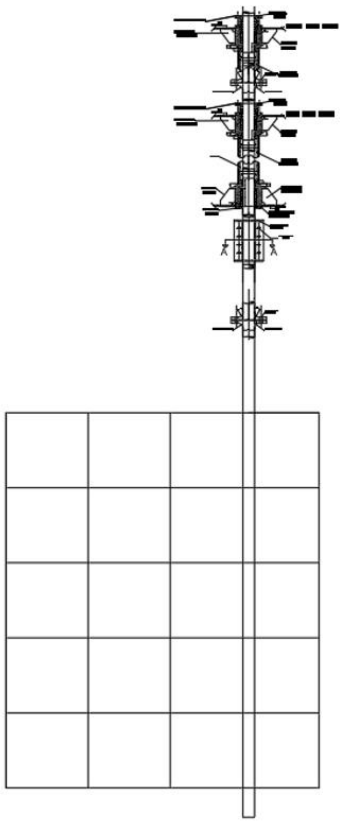


Lower Bearing

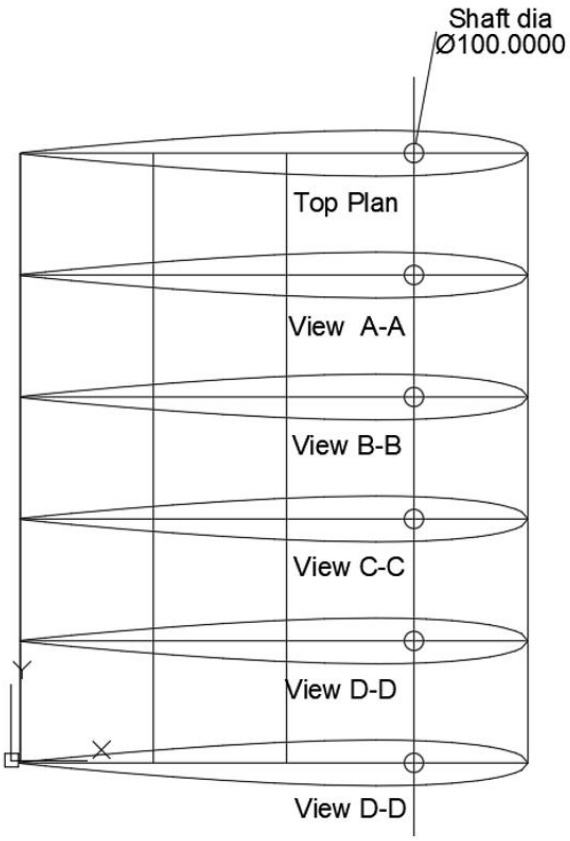


Lower Bearing (Bottom View)

Details of Rudder Drawing (contd…):



Profile View



NACA 0018 Sections

Steering gear arrangement drawing:

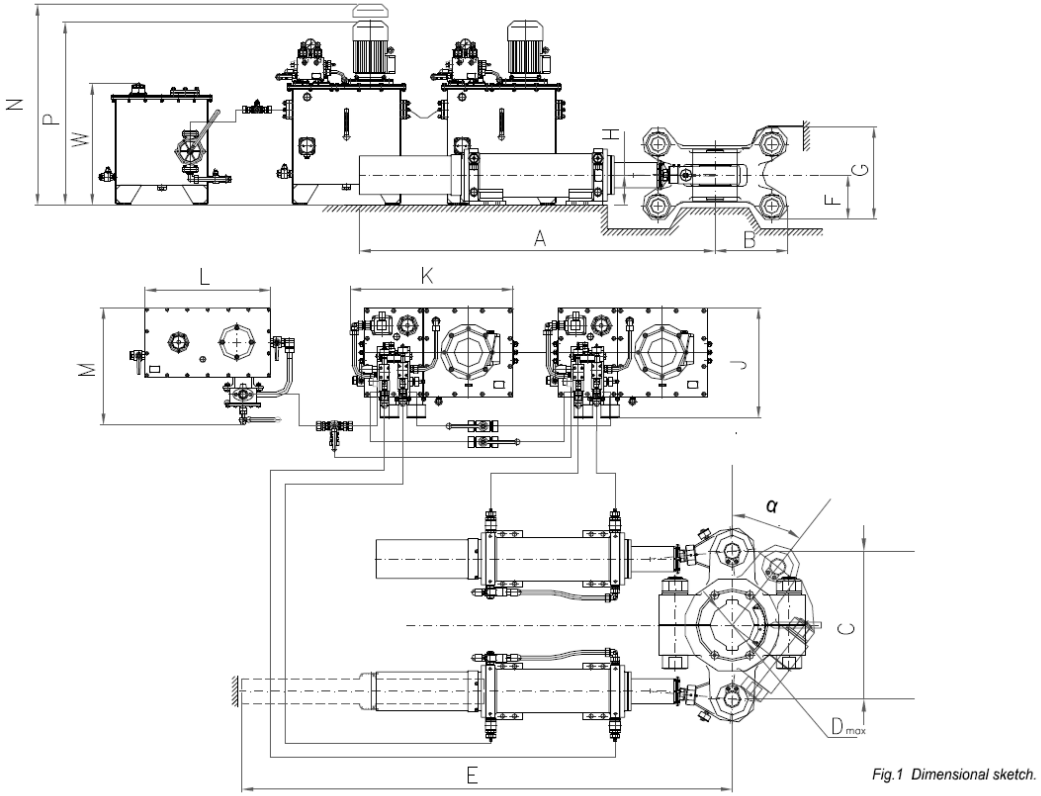
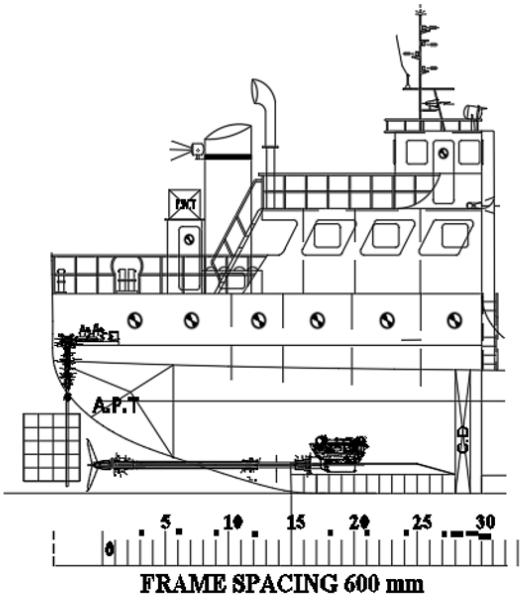


Fig.1 Dimensional sketch.

Profile View for Steering Gear:



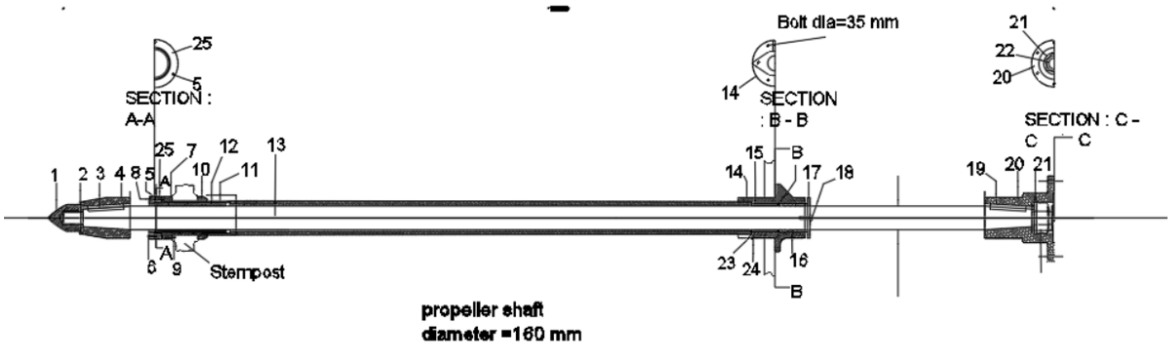
FRAME SPACING 600 mm

Elevation

Note: Detail calculation is provided in Appendix 6

Shaft arrangement:

Principle Particulars		
Length	70.8	meter
Breadth	11.42	meter
Depth	5.7	meter
Draft	4.4	meter
Displacement	2660	tonnes
Service speed	10	knots
C_B	0.75	
Scale	1:322	



NAME-338	
Shaft Drawing	
Sakibul Hasan	
Student ID	S2016 12046
Riasat Morshed	
Student ID	S2016 12047
Date of Submission	23/12/2020

Stability calculation:

GZ at fully loaded condition:

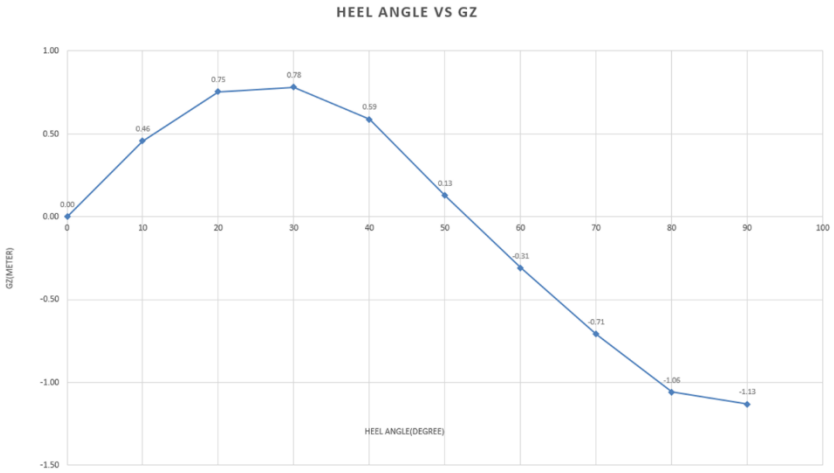
Heel angle(degree)	GZ	Unit
0	0.00	m
10	0.46	m
20	0.75	m
30	0.78	m
40	0.59	m
50	0.13	m
60	-0.31	m
70	-0.71	m
80	-1.06	m
90	-1.13	m

Note: Detail calculation is provided in Appendix 7

Comparison between IMO criteria & obtained values:

Criteria	IMO value	WL 4(Fully loaded condition)
		obtained value
Area up to 30 degree (m-rad)	≥ 0.055	0.281
Area up to 40 degree (m-rad)	≥ 0.09	0.397
GZ at 30 degree (m)	≥ 0.2	0.78
Max. GZ at (degree)	≥ 30 but not ≤ 25	30
Initial Metacentric Height (m)	Should not be ≤ 0.15	2.64

GZ curve at fully loaded condition:



Trim Calculation:

Full load condition	Value	Unit	No load condition	Values	Unit
Displacement	2659	tonne	Displacement	659	tonnes
Length overall, L_{OA}	73.75	m	Length overall, L_{OA}	73.75	m
Draft, T	4.4	m	Draft	1.1	m
LCG	1.77	m	LCG	-2.7	m
LCB	0.43	m	LCB	-0.11	m
MCT 1cm	57.23	tonne - m	MCT 1cm	52.97	tonne - m
C_F	-1.33	m	C_F	-0.17	m
Trim	0.62	m	Trim	0.31	m
Aft trim	0.30	m	Aft trim	0.16	m
Fore trim	0.32	m	Fore trim	0.16	m
Aft draft	4.70	m	Aft draft	1.26	m
Fore draft	4.08	m	Fore draft	0.94	m
The ship is trimmed by stern					

Note: Detail calculation is provided at appendix 5

Appendix 1:

Longitudinal member:

Center girder:

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.01	0.89	0.01	62.50	0.90	0.01	0.56	7.80	4.34
Flange	0.84	0.01	0.01	62.50	0.01	0.00	0.53	7.80	4.10
			0.02		VCG=	0.46			8.43
					LCG=	2.24	fore(positive)		

Side girder:

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.01	0.89	0.01	54.00	0.90	0.01	0.48	7.80	3.75
Flange	0.84	0.01	0.01	54.00	0.45	0.00	0.45	7.80	3.54
					VCG=	0.68			7.29
					LCG=	0.47	fore(positive)		7.29

Girder 2 (x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.01	0.89	0.01	46.00	0.90	0.01	0.41	7.80	3.19
Flange	0.84	0.01	0.01	46.00	0.01	0.00	0.39	7.80	3.01
					VCG=	0.46			6.21
					LCG=	0.00			

Bottom Longitudinals:

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.07	0.01	0.00	59.00	0.88	0.00	0.02	7.80	0.16
Flange	0.08	0.01	0.00	59.00	0.84	0.00	0.02	7.80	0.17
					VCG=	0.86			0.33
					LCG=	1.46	fore(positive)		

Longitudinals 1 (keel x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.07	0.01	0.00	59.00	0.05	0.00	0.02	7.80	0.16
Flange	0.08	0.01	0.00	59.00	0.09	0.00	0.02	7.80	0.17
					VCG=	0.07			0.33
					LCG=	1.46	fore(positive)		

Longitudinals 2 (floor x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.07	0.01	0.00	56.20	0.88	0.00	0.02	7.80	0.15
Flange	0.08	0.01	0.00	56.20	0.84	0.00	0.02	7.80	0.16
					VCG=	0.86			0.32
					LCG=	1.15	fore(positive)		

Longitudinals 2(keel x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.07	0.01	0.00	56.20	0.05	0.00	0.02	7.80	0.15
Flange	0.08	0.01	0.00	56.20	0.09	0.00	0.02	7.80	0.16
					VCG=	0.07			0.32
					LCG=	1.15	fore(positive)		

Longitudinals 3(floor x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.07	0.01	0.00	51.70	0.88	0.00	0.02	7.80	0.14
Flange	0.08	0.01	0.00	51.70	0.84	0.00	0.02	7.80	0.15
					VCG=	0.86			0.29
					LCG=	0.80	fore(positive)		

Longitudinals 3(keel x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.07	0.01	0.00	51.70	0.05	0.00	0.02	7.80	0.14
Flange	0.08	0.01	0.00	51.70	0.09	0.00	0.02	7.80	0.15
					VCG=	0.07			0.29
					LCG=	0.80	fore(positive)		

Longitudinals 4(floor x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.07	0.01	0.00	49.20	0.88	0.00	0.02	7.80	0.13
Flange	0.08	0.01	0.00	49.20	0.84	0.00	0.02	7.80	0.14
					VCG=	0.86			0.28
					LCG=	0.50			

Longitudinals 4(keel x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.07	0.01	0.00	49.20	0.05	0.00	0.02	7.80	0.13
Flange	0.08	0.01	0.00	49.20	0.09	0.00	0.02	7.80	0.14
					VCG=	0.07			0.28
					LCG=	0.50	fore(positive)		

Longitudinals 5(floor x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.07	0.01	0.00	42.04	0.88	0.00	0.01	7.80	0.11
Flange	0.08	0.01	0.00	42.04	0.84	0.00	0.02	7.80	0.12
					VCG=	0.86			0.24
					LCG=	-0.64	aft(negative)		

Longitudinals 5(keel x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.07	0.01	0.00	42.04	0.05	0.00	0.01	7.80	0.11
Flange	0.08	0.01	0.00	42.04	0.09	0.00	0.02	7.80	0.12
					VCG=	0.07			0.24
					LCG=	-0.64	aft(negative)		

Longitudinals 6(floor x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.07	0.01	0.00	31.00	0.88	0.00	0.01	7.80	0.08
Flange	0.08	0.01	0.00	31.00	0.84	0.00	0.01	7.80	0.09
					VCG=	0.86			0.18
					LCG=	-3.20	aft(negative)		

Deck center girder:

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.05	0.10	0.00	75.60	6.40	0.03	0.36	7.80	2.80
Flange	0.10	0.01	0.00	75.60	6.30	0.00	0.04	7.80	0.29
					VCG=	6.39			3.10
					LCG=	2.10	fore(positive)		

Deck girder 2(x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.05	0.10	0.00	70.10	6.17	0.03	0.33	7.80	2.60
Flange	0.10	0.01	0.00	70.10	6.12	0.00	0.04	7.80	0.27
					VCG=	6.16			2.87
					LCG=	1.58	fore(positive)		

Deck girder 3(x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.05	0.10	0.00	63.16	5.93	0.03	0.30	7.80	2.34
Flange	0.10	0.01	0.00	63.16	5.88	0.00	0.03	7.80	0.25
					VCG=	5.92			2.59
					LCG=	0.46	fore(positive)		

Deck girder 4(x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.05	0.10	0.00	49.70	5.70	0.03	0.24	7.80	1.84
Flange	0.10	0.01	0.00	49.70	5.60	0.00	0.02	7.80	0.19
					VCG=	5.69			2.04
					LCG=	-0.56	fore(positive)		

Deck longitudinals 1 (x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.05	0.05	0.00	73.80	6.35	0.01	0.17	7.80	1.30
Flange	0.05	0.01	0.00	73.80	6.32	0.00	0.02	7.80	0.14
					VCG=	6.35			1.44
					LCG=	1.99	fore(positive)		

Deck longitudinals 2 (x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.05	0.05	0.00	72.74	6.27	0.01	0.16	7.80	1.28
Flange	0.05	0.01	0.00	72.74	6.25	0.00	0.02	7.80	0.14
					VCG=	6.27			1.42
					LCG=	1.43	fore(positive)		

Deck longitudinals 3 (x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.05	0.05	0.00	68.07	6.11	0.01	0.15	7.80	1.19
Flange	0.05	0.01	0.00	68.07	6.09	0.00	0.02	7.80	0.13
					VCG=	6.11			1.33
					LCG=	1.30	fore(positive)		

Deck longitudinals 4 (x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.05	0.05	0.00	65.78	6.03	0.01	0.15	7.80	1.15
Flange	0.05	0.01	0.00	65.78	6.00	0.00	0.02	7.80	0.13
					VCG=	6.03			1.28
					LCG=	0.95	fore(positive)		

Deck longitudinals 5 (x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.05	0.05	0.00	58.88	5.87	0.01	0.13	7.80	1.03
Flange	0.05	0.01	0.00	58.88	5.85	0.00	0.01	7.80	0.11
					VCG=	5.87			1.15
					LCG=	0.24	fore(positive)		

Deck longitudinals 6 (x2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.05	0.05	0.00	56.30	5.80	0.01	0.13	7.80	0.99
Flange	0.05	0.01	0.00	56.30	5.77	0.00	0.01	7.80	0.11
					VCG=	5.80			1.10
					LCG=	-1.06	aft(negative)		

Side stringer 1(x 2)

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.05	0.18	0.01	68.66	1.81	0.02	0.60	7.80	4.69
Flange	0.25	0.01	0.00	68.66	1.81	0.00	0.09	7.80	0.67
					VCG=	1.81			5.36
					LCG=	-0.35	aft(negative)		

Side stringer 2(x 2)

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.05	0.18	0.01	71.17	3.61	0.03	0.62	7.80	4.86
Flange	0.25	0.01	0.00	71.17	3.61	0.00	0.09	7.80	0.69
					VCG=	3.61			5.55
					LCG=	-0.38	aft(negative)		

Side stringer 3(x 2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.05	0.18	0.01	73.00	5.41	0.05	0.64	7.80	4.98
Flange	0.25	0.01	0.00	73.00	5.41	0.01	0.09	7.80	0.71
					VCG=	5.41			5.69
					LCG=	0.00			

Side Longitudinals 1(x 2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.05	0.04	0.00	69.64	2.40	0.00	0.14	7.80	1.09
Flange	0.45	0.01	0.00	69.64	2.31	0.01	0.16	7.80	1.22
					VCG=	2.35			2.31
					LCG=	-0.46	aft(negative)		

Side Longitudinals 2(x 2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.05	0.04	0.00	70.46	3.00	0.01	0.14	7.80	1.10
Flange	0.45	0.01	0.00	70.46	2.98	0.01	0.16	7.80	1.24
					VCG=	2.99			2.34

Side Longitudinals 3(x 2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.05	0.04	0.00	71.80	4.28	0.01	0.14	7.80	1.12
Flange	0.45	0.01	0.00	71.80	4.19	0.01	0.16	7.80	1.26
					VCG=	4.23			2.38
					LCG=	-0.27	aft(negative)		

Side Longitudinals 4(x 2):

Dimension	Width	Height	Area	Length	Dist from keel	Moment about keel	Volume	Density	Weight(tons)
Web	0.05	0.04	0.00	72.40	4.80	0.01	0.14	7.80	1.13
Flange	0.45	0.01	0.00	72.40	4.79	0.01	0.16	7.80	1.27
					VCG=	4.79			2.40
					LCG=	-0.14	aft(negative)		

Keel plate:

Plate Name	Length	Width	Thickness	Volume	Density	Weight	Distance from Midship	Moment about midship	VCG
K1	4.5	0.95	0.01	0.05	7.80	0.40	-24.14	-9.66	0.01
K2	6	0.95	0.01	0.07	7.80	0.53	-19.53	-10.42	0.01
K3	6	0.95	0.01	0.07	7.80	0.53	-13.53	-7.22	0.01
K4	6	0.95	0.01	0.07	7.80	0.53	-7.70	-4.11	0.01
K5	6	0.95	0.01	0.07	7.80	0.53	-1.20	-0.64	0.01
K6	6	0.95	0.01	0.07	7.80	0.53	4.60	2.45	0.01
K7	6	0.95	0.01	0.07	7.80	0.53	10.50	5.60	0.01
K8	6	0.95	0.01	0.07	7.80	0.53	16.63	8.87	0.01
K9	6	0.95	0.01	0.07	7.80	0.53	22.20	11.84	0.01
K10	6	0.95	0.01	0.07	7.80	0.53	28.90	15.42	0.01
					Total	5.20		12.15	
LCG=2.33									

Bottom Plate:

Plate Name	Length	Width	Thickness	Volume	Density	Weight	Distance from Midship	Moment about Midship	VCG
B1	6.00	2.00	0.01	0.13	7.80	1.03	-23.50	-24.20	0.01
B2	5.90	2.00	0.01	0.13	7.80	1.01	-18.48	-18.71	0.01
B3	5.90	2.00	0.01	0.13	7.80	1.01	-12.72	-12.88	0.01
B4	6.00	2.00	0.01	0.13	7.80	1.03	-6.53	-6.72	0.01
B5	6.00	2.00	0.01	0.13	7.80	1.03	-8.14	-8.38	0.01
B6	6.00	2.00	0.01	0.13	7.80	1.03	5.52	5.68	0.01
B7	6.00	2.00	0.01	0.13	7.80	1.03	11.19	11.52	0.01
B8	6.00	2.00	0.01	0.13	7.80	1.03	17.46	17.98	0.01
B9	6.00	2.00	0.01	0.13	7.80	1.03	23.08	23.76	0.01
B10	6.00	1.40	0.01	0.09	7.80	0.72	-19.00	-13.69	0.01
B11	6.00	1.40	0.01	0.09	7.80	0.72	-12.67	-9.13	0.01
B12	6.00	1.40	0.01	0.09	7.80	0.72	-6.63	-4.78	0.01
B13	6.00	1.40	0.01	0.09	7.80	0.72	-1.50	-1.08	0.01
B14	5.90	1.40	0.01	0.09	7.80	0.71	4.70	3.33	0.01
B15	6.00	1.40	0.01	0.09	7.80	0.72	10.62	7.65	0.01
B16	6.00	1.40	0.01	0.09	7.80	0.72	16.24	11.70	0.01
B17	4.90	1.40	0.01	0.08	7.80	0.59	21.81	12.84	0.01
B18	2.60	1.20	0.01	0.03	7.80	0.27	26.61	7.12	0.01
					Total	15.12		2.02	
LCG=0.13									

Bilge plate:

Plate Name	Length	Width	Thickness	Volume	Density	Weight	Distance about Midship	Moment about Midship	VCG
BLG1	2.10	1.50	0.01	0.03	7.80	0.27	-28.19	-7.62	0.75
BLG2	6.00	1.50	0.01	0.10	7.80	0.77	-24.53	-18.94	0.75
BLG3	6.00	1.10	0.01	0.07	7.80	0.57	-17.81	-10.09	0.75
BLG4	6.00	1.00	0.01	0.07	7.80	0.51	-12.24	-6.30	0.75
BLG5	6.00	1.00	0.01	0.07	7.80	0.51	-6.06	-3.12	0.75
BLG6	6.00	1.00	0.01	0.07	7.80	0.51	0.00	0.00	0.75
BLG7	6.00	1.10	0.01	0.07	7.80	0.57	6.14	3.48	0.75
BLG8	6.00	1.45	0.01	0.10	7.80	0.75	12.91	9.64	0.75
BLG9	6.00	1.45	0.01	0.10	7.80	0.75	18.41	13.74	0.75
BLG10	6.00	0.85	0.01	0.06	7.80	0.44	23.82	10.42	0.75
BLG11	6.00	1.45	0.01	0.10	7.80	0.75	30.16	22.51	0.75
BLG12	6.00	1.50	0.01	0.10	7.80	0.77	-27.76	-21.44	0.75
BLG13	6.00	1.50	0.01	0.10	7.80	0.77	-22.14	-17.10	0.75
BLG14	6.00	1.50	0.01	0.10	7.80	0.77	-16.21	-12.52	0.75
BLG15	6.00	1.50	0.01	0.10	7.80	0.77	-10.45	-8.07	0.75
BLG16	6.00	1.50	0.01	0.10	7.80	0.77	-3.91	-3.02	0.75
BLG17	6.00	1.50	0.01	0.10	7.80	0.77	2.13	1.64	0.75
BLG18	6.00	1.50	0.01	0.10	7.80	0.77	8.00	6.18	0.75
BLG19	6.00	1.50	0.01	0.10	7.80	0.77	14.27	11.02	0.75
BLG20	6.00	1.50	0.01	0.10	7.80	0.77	20.16	15.57	0.75
BLG21	6.00	1.50	0.01	0.10	7.80	0.77	25.69	19.84	0.75
BLG22	6.00	1.50	0.01	0.10	7.80	0.77	31.80	24.56	0.75
BLG23	2.20	1.50	0.01	0.04	7.80	0.28	-26.44	-7.49	0.75
					Total	15.17		22.90	

LCG=	1.51

Shell plate:

Plate Name	Length	Width	Thickness	Volume	Density	Weight	Distance from Midship	Moment about Midship	VCG
S1	5.00	2.00	0.01	0.11	7.80	0.86	-30.28	-25.98	2.85
S2	6.00	2.00	0.01	0.13	7.80	1.03	-26.69	-27.48	2.85
S3	6.00	1.10	0.01	0.07	7.80	0.57	-21.16	-11.98	2.85
S4	6.00	1.15	0.01	0.08	7.80	0.59	-14.82	-8.77	2.85
S5	6.00	1.15	0.01	0.08	7.80	0.59	-8.88	-5.26	2.85
S6	6.00	1.15	0.01	0.08	7.80	0.59	-2.95	-1.75	2.85
S7	6.00	1.15	0.01	0.08	7.80	0.59	3.07	1.82	2.85
S8	6.00	1.15	0.01	0.08	7.80	0.59	9.03	5.35	2.85
S9	6.00	1.10	0.01	0.07	7.80	0.57	15.72	8.90	2.85
S10	6.00	1.10	0.01	0.07	7.80	0.57	21.37	12.10	2.85
S11	6.00	1.20	0.01	0.08	7.80	0.62	27.50	16.99	2.85
S12	6.00	1.50	0.01	0.10	7.80	0.77	31.69	24.47	2.85
S13	6.00	1.50	0.01	0.10	7.80	0.77	-31.47	-24.30	2.85
S14	6.00	1.50	0.01	0.10	7.80	0.77	-26.01	-20.08	2.85
S15	6.00	1.50	0.01	0.10	7.80	0.77	-20.13	-15.54	2.85
S16	6.00	1.50	0.01	0.10	7.80	0.77	-14.09	-10.88	2.85
S17	6.00	1.50	0.01	0.10	7.80	0.77	-7.99	-6.17	2.85
S18	6.00	1.50	0.01	0.10	7.80	0.77	-1.96	-1.51	2.85
S19	6.00	1.50	0.01	0.10	7.80	0.77	4.28	3.31	2.85
S20	6.00	1.50	0.01	0.10	7.80	0.77	10.21	7.88	2.85
S21	6.00	1.50	0.01	0.10	7.80	0.77	6.53	5.04	2.85
S22	6.00	1.50	0.01	0.10	7.80	0.77	21.84	16.86	2.85
S23	6.00	1.50	0.01	0.10	7.80	0.77	28.43	21.95	2.85
S24	6.00	1.50	0.01	0.10	7.80	0.77	33.51	25.88	2.85
					Total	17.20		-9.16	

LCG=	-0.53

Shearstreak:

Plate Name	Length	Width	Thickness	Volume	Density	Weight	Distance from Midship	Moment about Midship	VCG
SS1	4.90	1.30	0.01	0.06	7.80	0.45	-32.50	-14.53	5.50
SS2	6.00	1.30	0.01	0.07	7.80	0.55	-27.70	-15.17	5.50
SS3	6.00	1.30	0.01	0.07	7.80	0.55	-21.90	-11.99	5.50
SS4	6.00	1.30	0.01	0.07	7.80	0.55	-16.20	-8.87	5.50
SS5	6.00	1.30	0.01	0.07	7.80	0.55	-10.60	-5.80	5.50
SS6	6.00	1.30	0.01	0.07	7.80	0.55	-4.50	-2.46	5.50
SS7	6.00	1.30	0.01	0.07	7.80	0.55	1.50	0.82	5.50
SS8	5.80	1.30	0.01	0.07	7.80	0.53	6.90	3.65	5.50
SS9	5.80	1.30	0.01	0.07	7.80	0.53	12.90	6.83	5.50
SS10	6.00	1.30	0.01	0.07	7.80	0.55	18.60	10.18	5.50
SS11	5.80	1.30	0.01	0.07	7.80	0.53	24.00	12.70	5.50
SS12	6.00	1.30	0.01	0.07	7.80	0.55	29.40	16.10	5.50
SS13	5.50	1.30	0.01	0.06	7.80	0.50	34.30	17.22	5.50
					Total	6.92		8.67	

LCG=	1.25

Webframe (x35):

Frame no	Area	Length	Volume	Density	Weight	LCG	VCG	Moment about LCG	Moment about VCG
WF1	0.01	5.04	0.04	7.80	0.31	-33.00	3.40	-10.38	1.07
WF2	0.01	5.60	0.04	7.80	0.35	-31.20	3.17	-10.90	1.11
WF3	0.01	5.65	0.05	7.80	0.35	-29.40	3.60	-10.37	1.27
WF4	0.01	5.70	0.05	7.80	0.36	-27.60	2.85	-9.82	1.01
WF5	0.01	5.70	0.05	7.80	0.36	-25.80	2.85	-9.18	1.01
WF6	0.01	5.70	0.05	7.80	0.36	-24.00	2.85	-8.54	1.01
WF7	0.01	5.70	0.05	7.80	0.36	-22.20	2.85	-7.90	1.01
WF8	0.01	5.70	0.05	7.80	0.36	-20.40	2.85	-7.26	1.01
WF9	0.01	5.70	0.05	7.80	0.36	-18.60	2.85	-6.62	1.01
WF10	0.01	5.70	0.05	7.80	0.36	-15.00	2.85	-5.34	1.01
WF11	0.01	5.70	0.05	7.80	0.36	-13.20	2.85	-4.69	1.01
WF12	0.01	5.70	0.05	7.80	0.36	-11.40	2.85	-4.05	1.01
WF13	0.01	5.70	0.05	7.80	0.36	-9.60	2.85	-3.41	1.01
WF14	0.01	5.70	0.05	7.80	0.36	-7.80	2.85	-2.77	1.01
WF15	0.01	5.70	0.05	7.80	0.36	-6.00	2.85	-2.13	1.01
WF16	0.01	5.70	0.05	7.80	0.36	-4.20	2.85	-1.49	1.01
WF17	0.01	5.70	0.05	7.80	0.36	-0.60	2.85	-0.21	1.01
WF18	0.01	5.70	0.05	7.80	0.36	1.20	2.85	0.43	1.01
WF19	0.01	5.70	0.05	7.80	0.36	3.00	2.85	1.07	1.01
WF20	0.01	5.70	0.05	7.80	0.36	4.80	2.85	1.71	1.01
WF21	0.01	5.70	0.05	7.80	0.36	6.60	2.85	2.35	1.01
WF22	0.01	5.70	0.05	7.80	0.36	8.40	2.85	2.99	1.01
WF23	0.01	5.70	0.05	7.80	0.36	10.20	2.85	3.63	1.01
WF24	0.01	5.70	0.05	7.80	0.36	13.20	2.85	4.69	1.01
WF25	0.01	5.70	0.05	7.80	0.36	15.00	2.85	5.34	1.01
WF26	0.01	5.70	0.05	7.80	0.36	16.80	2.85	5.98	1.01
WF27	0.01	5.70	0.05	7.80	0.36	18.60	2.85	6.62	1.01
WF28	0.01	5.70	0.05	7.80	0.36	20.40	2.85	7.26	1.01
WF29	0.01	5.70	0.05	7.80	0.36	22.20	2.85	7.90	1.01
WF30	0.01	5.70	0.05	7.80	0.36	24.00	2.85	8.54	1.01
WF31	0.01	5.70	0.05	7.80	0.36	28.80	2.85	10.24	1.01
WF32	0.01	5.70	0.05	7.80	0.36	30.60	2.85	10.88	1.01
WF33	0.01	5.70	0.05	7.80	0.36	32.40	2.85	11.52	1.01
WF34	0.01	3.60	0.03	7.80	0.22	34.20	4.20	7.68	0.94
WF35	0.01	1.20	0.01	7.80	0.07	36.00	5.30	2.70	0.40
				Sum	11.99	26.40	105.17	-3.55	35.20

LCG=	**-0.30**
VCG=	**2.94**

Ordinary frame(x 77):

Frame Name	Area	Length	Volume	Density	Weight	LCG	VCG	Moment about LCG	Moment about VCG
NF1	0.00	4.19	0.01	7.80	0.06	-34.80	3.60	-2.05	0.21
NF2	0.00	4.60	0.01	7.80	0.06	-34.20	3.60	-2.21	0.23
NF3	0.00	4.86	0.01	7.80	0.07	-33.60	3.60	-2.29	0.25
NF4	0.00	5.13	0.01	7.80	0.07	-32.40	3.80	-2.33	0.27
NF5	0.00	5.30	0.01	7.80	0.07	-31.80	3.20	-2.37	0.24
NF6	0.00	5.40	0.01	7.80	0.08	-30.60	3.00	-2.32	0.23
NF7	0.00	5.50	0.01	7.80	0.08	-30.00	2.90	-2.32	0.22
NF8	0.00	5.55	0.01	7.80	0.08	-28.80	2.85	-2.24	0.22
NF9	0.00	5.70	0.01	7.80	0.08	-28.20	2.85	-2.26	0.23
NF10	0.00	5.70	0.01	7.80	0.08	-27.00	2.85	-2.16	0.23
NF11	0.00	5.70	0.01	7.80	0.08	-26.40	2.85	-2.11	0.23
NF12	0.00	5.70	0.01	7.80	0.08	-25.20	2.85	-2.02	0.23
NF13	0.00	5.70	0.01	7.80	0.08	-24.60	2.85	-1.97	0.23
NF14	0.00	5.70	0.01	7.80	0.08	-23.40	2.85	-1.87	0.23
NF15	0.00	5.70	0.01	7.80	0.08	-22.80	2.85	-1.82	0.23
NF16	0.00	5.70	0.01	7.80	0.08	-21.60	2.85	-1.73	0.23
NF17	0.00	5.70	0.01	7.80	0.08	-19.80	2.85	-1.58	0.23
NF18	0.00	5.70	0.01	7.80	0.08	-19.20	2.85	-1.54	0.23
NF19	0.00	5.70	0.01	7.80	0.08	-18.00	2.85	-1.44	0.23
NF20	0.00	5.70	0.01	7.80	0.08	-16.20	2.85	-1.30	0.23
NF21	0.00	5.70	0.01	7.80	0.08	-15.60	2.85	-1.25	0.23
NF22	0.00	5.70	0.01	7.80	0.08	-14.40	2.85	-1.15	0.23
NF23	0.00	5.70	0.01	7.80	0.08	-13.80	2.85	-1.10	0.23
NF24	0.00	5.70	0.01	7.80	0.08	-12.60	2.85	-1.01	0.23
NF25	0.00	5.70	0.01	7.80	0.08	-12.00	2.85	-0.96	0.23
NF26	0.00	5.70	0.01	7.80	0.08	-10.80	2.85	-0.86	0.23
NF27	0.00	5.70	0.01	7.80	0.08	-10.20	2.85	-0.82	0.23
NF28	0.00	5.70	0.01	7.80	0.08	-8.40	2.85	-0.67	0.23
NF29	0.00	5.70	0.01	7.80	0.08	-7.20	2.85	-0.58	0.23
NF30	0.00	5.70	0.01	7.80	0.08	-6.60	2.85	-0.53	0.23
NF31	0.00	5.70	0.01	7.80	0.08	-5.40	2.85	-0.43	0.23
NF32	0.00	5.70	0.01	7.80	0.08	-4.80	2.85	-0.38	0.23
NF33	0.00	5.70	0.01	7.80	0.08	-3.60	2.85	-0.29	0.23
NF34	0.00	5.70	0.01	7.80	0.08	-3.00	2.85	-0.24	0.23
NF35	0.00	5.70	0.01	7.80	0.08	-1.80	2.85	-0.14	0.23
NF36	0.00	5.70	0.01	7.80	0.08	-1.20	2.85	-0.10	0.23
NF37	0.00	5.70	0.01	7.80	0.08	0.00	2.85	0.00	0.23
NF38	0.00	5.70	0.01	7.80	0.08	0.60	2.85	0.05	0.23
NF39	0.00	5.70	0.01	7.80	0.08	1.80	2.85	0.14	0.23
NF40	0.00	5.70	0.01	7.80	0.08	2.40	2.85	0.19	0.23

NF41	0.00	5.70	0.01	7.80	0.08	3.60	2.85	0.29	0.23
NF42	0.00	5.70	0.01	7.80	0.08	4.20	2.85	0.34	0.23
NF43	0.00	5.70	0.01	7.80	0.08	5.40	2.85	0.43	0.23
NF44	0.00	5.70	0.01	7.80	0.08	6.00	2.85	0.48	0.23
NF45	0.00	5.70	0.01	7.80	0.08	7.20	2.85	0.58	0.23
NF46	0.00	5.70	0.01	7.80	0.08	7.80	2.85	0.62	0.23
NF47	0.00	5.70	0.01	7.80	0.08	9.00	2.85	0.72	0.23
NF48	0.00	5.70	0.01	7.80	0.08	9.60	2.85	0.77	0.23
NF49	0.00	5.70	0.01	7.80	0.08	10.80	2.85	0.86	0.23
NF50	0.00	5.70	0.01	7.80	0.08	11.40	2.85	0.91	0.23
NF51	0.00	5.70	0.01	7.80	0.08	12.00	2.85	0.96	0.23
NF52	0.00	5.70	0.01	7.80	0.08	12.60	2.85	1.01	0.23
NF53	0.00	5.70	0.01	7.80	0.08	13.80	2.85	1.10	0.23
NF54	0.00	5.70	0.01	7.80	0.08	14.40	2.85	1.15	0.23
NF55	0.00	5.70	0.01	7.80	0.08	15.60	2.85	1.25	0.23
NF56	0.00	5.70	0.01	7.80	0.08	16.20	2.85	1.30	0.23
NF57	0.00	5.70	0.01	7.80	0.08	17.40	2.85	1.39	0.23
NF58	0.00	5.70	0.01	7.80	0.08	18.00	2.85	1.44	0.23
NF59	0.00	5.70	0.01	7.80	0.08	19.20	2.85	1.54	0.23
NF60	0.00	5.70	0.01	7.80	0.08	19.80	2.85	1.58	0.23
NF61	0.00	5.70	0.01	7.80	0.08	21.00	2.85	1.68	0.23
NF62	0.00	5.70	0.01	7.80	0.08	21.60	2.85	1.73	0.23
NF63	0.00	5.70	0.01	7.80	0.08	22.80	2.85	1.82	0.23
NF64	0.00	5.70	0.01	7.80	0.08	23.40	2.85	1.87	0.23
NF65	0.00	5.70	0.01	7.80	0.08	24.60	2.85	1.97	0.23
NF66	0.00	5.70	0.01	7.80	0.08	25.20	2.85	2.02	0.23
NF67	0.00	5.70	0.01	7.80	0.08	27.00	2.85	2.16	0.23
NF68	0.00	5.70	0.01	7.80	0.08	27.60	2.85	2.21	0.23
NF69	0.00	5.70	0.01	7.80	0.08	28.20	2.85	2.26	0.23
NF70	0.00	5.70	0.01	7.80	0.08	29.40	2.85	2.35	0.23
NF71	0.00	5.70	0.01	7.80	0.08	30.00	2.85	2.40	0.23
NF72	0.00	5.70	0.01	7.80	0.08	30.60	2.85	2.45	0.23
NF73	0.00	5.70	0.01	7.80	0.08	31.80	2.85	2.54	0.23
NF74	0.00	5.70	0.01	7.80	0.08	33.00	2.85	2.64	0.23
NF75	0.00	5.70	0.01	7.80	0.08	33.60	3.60	2.69	0.29
NF76	0.00	4.80	0.01	7.80	0.07	34.80	4.80	2.35	0.32
NF77	0.00	2.30	0.00	7.80	0.03	35.40	4.90	1.14	0.16
				Sum	6.03	58.80	227.95	4.95	17.70

LCG=	**0.82**
VCG=	**2.93**

Transverse bulkhead:

Name	area	thickness	volume	Density	weight	LCG	VCG	Moment about LCG	Moment about VCG
BHD1	61.90	0.01	0.37	7.80	2.90	-17.40	2.72	-50.40	7.89
BHD2	61.90	0.01	0.37	7.80	2.90	-16.80	2.72	-48.67	7.89
BHD3	61.90	0.01	0.37	7.80	2.90	-2.40	2.72	-6.95	7.89
BHD4	61.90	0.01	0.37	7.80	2.90	11.70	2.72	33.89	7.89
BHD5	61.90	0.01	0.37	7.80	2.90	25.80	2.72	74.74	7.89
BHD6	61.90	0.01	0.37	7.80	2.90	26.40	2.72	76.47	7.89
				sum	17.38	27.30	16.34	79.08	47.34

LCG=	1.57
VCG=	2.72

Superstructure calculation:

Items	Thickness	Area	Volume	Density	Weight	LCG	Moment about Midship	VCG	Moment about Keel
Poop Deck Plate	0.006	159.17	0.95	7.80	7.45	-26.4	-196.65	9.58	71.36
Forecastle Deck Plate	0.006	66.86	0.40	7.80	3.13	33.41	104.54	10.69	33.45
Navigational Deck Plate	0.006	69.70	0.41	7.80	3.26	-20.4	-66.54	13.75	44.85
Side Plate	0.006	265.20	1.59	7.80	12.41	-24	-297.87	9.60	119.14
					26.25		-456.53		268.8134436

LCG	-17.39
VCG	10.24

Webframe:

Items	Area	Length	Volume	Density	Weight(tonne)	LCG	Moment about Midship	VCG	Moment about Keel
WF1	0.01	3.54	0.03	7.80	0.22	-34.20	-7.55	7.40	1.63
WF2	0.01	3.54	0.03	7.80	0.22	-32.40	-7.16	7.40	1.63
WF3	0.01	3.54	0.03	7.80	0.22	-30.60	-6.76	7.40	1.63
WF4	0.01	4.20	0.03	7.80	0.26	-28.80	-7.55	8.10	2.12
WF5	0.01	7.60	0.06	7.80	0.47	-27.00	-12.80	9.50	4.51
WF6	0.01	7.60	0.06	7.80	0.47	-25.20	-11.95	9.50	4.51
WF7	0.01	7.60	0.06	7.80	0.47	-23.40	-11.10	9.50	4.51
WF8	0.01	11.30	0.09	7.80	0.71	-21.60	-15.23	11.30	7.97
WF9	0.01	11.30	0.09	7.80	0.71	-19.80	-13.96	11.30	7.97
WF10	0.01	11.30	0.09	7.80	0.71	-18.00	-12.69	11.30	7.97
WF11	0.01	3.90	0.03	7.80	0.24	27.60	6.72	7.78	1.89
WF12	0.01	4.04	0.03	7.80	0.25	29.40	7.41	7.78	1.96
WF13	0.01	4.14	0.03	7.80	0.26	31.20	8.06	7.78	2.01
WF14	0.01	4.50	0.04	7.80	0.28	33.00	9.27	8.30	2.33
WF15	0.01	5.41	0.04	7.80	0.34	34.80	11.75	8.40	2.84
WF16	0.01	5.40	0.04	7.80	0.34	36.60	12.33	8.90	3.00
					6.17		-51.22		58.48

LCG	-8.30
VCG	9.47

Ordinary frame:

Items	Area	Length	Volume	Density	Weight	LCG	Moment about Midship	VCG	Moment about Keel
OF1	0.00	3.55	0.01	7.80	0.05	-34.80	-1.73	7.80	0.39
OF2	0.00	3.55	0.01	7.80	0.05	-34.20	-1.70	7.80	0.39
OF3	0.00	3.55	0.01	7.80	0.05	-33.60	-1.67	7.80	0.39
OF4	0.00	3.55	0.01	7.80	0.05	-33.00	-1.64	7.80	0.39
OF5	0.00	3.55	0.01	7.80	0.05	-32.40	-1.61	7.80	0.39
OF6	0.00	3.55	0.01	7.80	0.05	-31.80	-1.58	7.80	0.39
OF7	0.00	3.55	0.01	7.80	0.05	-31.20	-1.55	7.80	0.39
OF8	0.00	3.55	0.01	7.80	0.05	-30.60	-1.52	7.80	0.39
OF9	0.00	3.55	0.01	7.80	0.05	-30.00	-1.49	7.80	0.39
OF10	0.00	3.55	0.01	7.80	0.05	-29.40	-1.46	7.80	0.39
OF11	0.00	3.55	0.01	7.80	0.05	-28.80	-1.43	7.80	0.39
OF12	0.00	3.55	0.01	7.80	0.05	-28.20	-1.40	7.80	0.39
OF13	0.00	5.18	0.01	7.80	0.07	-27.60	-2.01	8.40	0.61
OF14	0.00	5.37	0.01	7.80	0.08	-27.00	-2.04	8.40	0.63
OF15	0.00	7.65	0.01	7.80	0.11	-26.40	-2.84	9.50	1.02
OF16	0.00	7.65	0.01	7.80	0.11	-25.80	-2.77	9.50	1.02
OF17	0.00	7.65	0.01	7.80	0.11	-25.20	-2.71	9.50	1.02
OF18	0.00	7.65	0.01	7.80	0.11	-24.60	-2.64	9.50	1.02
OF19	0.00	7.65	0.01	7.80	0.11	-24.00	-2.58	9.50	1.02
OF20	0.00	7.65	0.01	7.80	0.11	-22.80	-2.45	9.50	1.02
OF21	0.00	11.36	0.02	7.80	0.16	-22.20	-3.54	12.60	2.01
OF22	0.00	11.36	0.02	7.80	0.16	-21.00	-3.35	12.60	2.01

OF23	0.00	11.36	0.02	7.80	0.16	-20.40	-3.25	12.60	2.01
OF24	0.00	11.36	0.02	7.80	0.16	-19.10	-3.05	12.60	2.01
OF25	0.00	11.36	0.02	7.80	0.16	-18.50	-2.95	12.60	2.01
OF26	0.00	3.89	0.01	7.80	0.05	26.30	1.44	7.70	0.42
OF27	0.00	3.89	0.01	7.80	0.05	26.90	1.47	7.70	0.42
OF28	0.00	3.93	0.01	7.80	0.06	28.20	1.56	7.80	0.43
OF29	0.00	3.93	0.01	7.80	0.06	28.80	1.59	7.80	0.43
OF30	0.00	4.07	0.01	7.80	0.06	30.00	1.71	7.85	0.45
OF31	0.00	4.07	0.01	7.80	0.06	30.60	1.75	7.85	0.45
OF32	0.00	4.17	0.01	7.80	0.06	31.80	1.86	7.88	0.46
OF33	0.00	4.17	0.01	7.80	0.06	32.20	1.89	7.88	0.46
OF34	0.00	5.00	0.01	7.80	0.07	33.60	2.36	8.40	0.59
OF35	0.00	5.30	0.01	7.80	0.07	34.20	2.54	8.40	0.63
OF36	0.00	5.38	0.01	7.80	0.08	35.40	2.67	9.00	0.68
OF37	0.00	5.38	0.01	7.80	0.08	36.00	2.72	9.00	0.68
OF38	0.00	5.59	0.01	7.80	0.08	37.20	2.92	9.01	0.71
OF39	0.00	4.21	0.01	7.80	0.06	37.80	2.24	9.01	0.53
OF40	0.00	2.39	0.00	7.80	0.03	38.40	1.29	10.40	0.35
					3.11		-24.98		29.76

LCG	-8.05
VCG	9.58

Side longitudinals:

Items	Area	Length	Volume	Density	Weight	LCG	Moment abt Midship	VCG	Moment abt Keel
SL1	0.004	23.000	0.098	7.800	0.762	-26.800	-20.434	10.000	7.625
SL2	0.004	20.000	0.085	7.800	0.663	-27.700	-18.365	10.000	6.630
SL3	0.004	20.700	0.088	7.800	0.686	-27.900	-19.145	10.000	6.862
SL4	0.004	10.800	0.046	7.800	0.358	-23.200	-8.306	10.000	3.580
SL5	0.004	9.700	0.041	7.800	0.322	-22.600	-7.267	10.000	3.216
SL6	0.004	9.000	0.038	7.800	0.298	-22.400	-6.683	10.000	2.984
SL7	0.004	10.500	0.045	7.800	0.348	-22.700	-7.901	10.000	3.481
SL8	0.004	3.800	0.016	7.800	0.126	-19.700	-2.482	10.000	1.260
SL9	0.004	3.800	0.016	7.800	0.126	-19.700	-2.482	10.000	1.260
SL10	0.004	3.800	0.016	7.800	0.126	-19.700	-2.482	10.000	1.260
SL11	0.004	15.650	0.067	7.800	0.519	30.300	15.720	10.000	5.188
SL12	0.004	13.800	0.059	7.800	0.457	31.010	14.186	10.000	4.575
SL13	0.004	13.300	0.057	7.800	0.441	31.400	13.844	10.000	4.409
SL14	0.004	12.530	0.053	7.800	0.415	32.200	13.375	10.000	4.154
SL15	0.004	6.600	0.028	7.800	0.219	35.400	7.745	10.000	2.188
SL16	0.004	3.160	0.013	7.800	0.105	37.300	3.907	10.000	1.048
					5.972		-26.769		59.716

LCG	-4.48
VCG	10.00

Side stringer:

Items	Area	Length	Volume	Density	Weight	LCG	Moment about Midship	VCG	Moment about Keel
SS1	0.0	21.7	0.2	7.8	1.7	-27.3	-46.2	7.2	12.2
SS2	0.0	20.5	0.2	7.8	1.6	-28.0	-44.8	9.0	14.4
SS3	0.0	10.7	0.1	7.8	0.8	-23.0	-19.2	10.8	9.0
SS4	0.0	9.0	0.1	7.8	0.7	-22.0	-15.4	12.6	8.8
SS5	0.0	3.9	0.0	7.8	0.3	-19.7	-6.0	14.4	4.4
SS6	0.0	3.9	0.0	7.8	0.3	-19.7	-6.0	16.2	5.0
SS7	0.0	14.6	0.1	7.8	1.1	30.0	34.3	7.2	8.2
SS8	0.0	12.9	0.1	7.8	1.0	32.1	32.2	9.0	9.0
SS9	0.0	5.5	0.1	7.8	0.4	36.2	15.5	10.8	4.6
					8.0	-41.4	-55.7	97.2	75.7

LCG	-6.95
VCG	9.44

Wood & outfit weight:

Item	No. of Items	Weight (kg)	Total Weight (ton)	LCG (m)	Moment about amidship	VCG (m)	Moment about keel
Control Panel	1.00	500.00	0.50	-25.10	-12.55	16.00	8.00
Wing Control Panel (Starboard)	1.00	100.00	0.10	-25.10	-2.51	16.00	1.60
Wing Control Panel (Port side)	1.00	100.00	0.10	-25.10	-2.51	16.00	1.60
Cabinet	2.00	35.00	0.04	-22.80	-0.80	16.00	0.56
Chart Table-Chair	1.00	25.00	0.03	-22.80	-0.57	16.00	0.40
Map Table- Chair	1.00	25.00	0.03	-19.80	-0.50	16.00	0.40
Radio Instrument Table	1.00	15.00	0.02	-19.80	-0.30	16.00	0.24
Radio Operator's Chair	1.00	10.00	0.01	-19.80	-0.20	16.00	0.16
Wash Cabin	2.00	20.00	0.02	22.00	-0.44	6.80	0.14

Cabin 1:

Single bed	1.00	35.00	0.04	-31.00	-1.09	7.30	0.26
Locker	1.00	30.00	0.03	-31.00	-0.93	7.30	0.22
chair	1.00	10.00	0.01	-31.00	-0.31	7.30	0.07

Cabin 2:

Single bed	1.00	35.00	0.04	-29.16	-1.02	7.30	0.26
Locker	1.00	30.00	0.03	-29.16	-0.87	7.30	0.22
chair	1.00	10.00	0.01	-29.16	-0.29	7.30	0.07

Cabin 3:

Single bed	1.00	35.00	0.04	-26.60	-0.93	7.30	0.26
Table	1.00	15.00	0.02	-26.60	-0.40	7.30	0.11
Chair	1.00	10.00	0.01	-26.60	-0.27	7.30	0.07
Wardrobe	1.00	40.00	0.04	-26.60	-1.06	7.30	0.29

Cabin 4:

Single bed	1.00	35.00	0.04	-27.85	-0.97	7.30	0.26
Table	1.00	15.00	0.02	-27.85	-0.42	7.30	0.11
Chair	1.00	10.00	0.01	-27.85	-0.28	7.30	0.07
Wardrobe	1.00	40.00	0.04	-27.85	-1.11	7.30	0.29

Owner’s room:

Single bed	1.00	35.00	0.04	-25.80	-0.90	11.36	0.40
Table	1.00	15.00	0.02	-25.80	-0.39	11.36	0.17
Chair	1.00	10.00	0.01	-25.80	-0.26	11.36	0.11
Sofa	2.00	30.00	0.03	-25.80	-0.77	11.36	0.34
Wardrobe	1.00	40.00	0.04	-25.80	-1.03	11.36	0.45
Wash room items	3.00	10.00	0.01	-25.80	-0.26	11.36	0.11
TV	1.00	15.00	0.02	-25.80	-0.39	11.36	0.17
Refrigerator	1.00	80.00	0.08	-25.80	-2.06	11.36	0.91

Masters room:

Single bed	1.00	35.00	0.04	-25.80	-0.90	11.36	0.40
Locker	1.00	30.00	0.03	-25.80	-0.77	11.36	0.34
chair	1.00	10.00	0.01	-25.80	-0.26	11.36	0.11

Driver's room:

Single bed	1.00	35.00	0.04	-24.10	-0.84	6.50	0.23
Locker	1.00	20.00	0.02	-24.10	-0.48	6.50	0.13
chair	1.00	10.00	0.01	-24.10	-0.24	6.50	0.07

Cabin 5:

Single bed	1.00	35.00	0.04	-26.40	-0.92	7.30	0.26
Locker	1.00	30.00	0.03	-26.40	-0.79	7.30	0.22
chair	1.00	10.00	0.01	-26.40	-0.26	7.30	0.07

Senior driver's room:

Single bed	2.00	35.00	0.04	-22.58	-0.79	11.36	0.40
Locker	2.00	40.00	0.04	-22.58	-0.90	11.36	0.45
chair	8.00	10.00	0.01	-22.58	-0.23	11.36	0.11

Galley:

Single bed	1.00	35.00	0.04	-33.97	-1.19	4.50	0.16
Cabinet	1.00	25.00	0.03	-33.97	-0.85	4.50	0.11
Wardrobe	1.00	40.00	0.04	-33.97	-1.36	4.50	0.18
Wash room items	3.00	40.00	0.04	-33.97	-1.36	4.50	0.18

Store:

Single bed	1.00	35.00	0.04	-29.62	-1.04	4.50	0.16
Locker	1.00	25.00	0.03	-29.62	-0.74	4.50	0.11
chair	1.00	15.00	0.02	-29.62	-0.44	4.50	0.07

Control room electronics:

Engine Office	100.00	0.10	-24.25	-2.43	2.60	0.26
Engine Controll Room	500.00	0.50	-24.25	-12.13	2.60	1.30
Electric Room	350.00	0.35	-24.25	-9.10	2.60	0.91
Miscelleanous		1.00				

Items	Values	Unit
Total Weight	3.88	tonne
LCG(abt amidship)	-19.98	m
VCG(abt keel)	6.64	m

Machineries weight:

Items	Quantity	Unit weight (tonne)	Total weight (tonnes)	LCG (m)	Moment (about amidship)	VCG (m)	Moment (about keel)
Main Engine	1	5.00	5.00	-24.69	-123.46	1.38	6.90
Gear Box	1	4.70	4.70	-25.18	-118.36	1.40	6.58
Generator	1	2.90	2.90	-32.00	-92.80	1.20	3.48
Rudder	1	2.70	2.70	-38.50	-103.95	0.80	2.16
steering gear	1	1.20	1.20	-34.00	-40.80	4.44	5.33
Anchor, Chain, winch	1	2.00	2.00	33.56	67.12	6.89	13.78
Propeller, Propeller Shaft	1	2.10	2.10	-35.00	-73.50	1.02	2.14
				-155.82	-485.75	17.13	40.37

Items	Values	Unit
Total Machinery Weight	20.60	tonne
LCG (about amidship)	-48.01	m
VCG (about Keel)	3.84	m

Appendix 2:

Waterline 04 at 0 degree (Immersed):

Station No.	Ordinate in meter	SM	Func of ordinate	Sq of ordinate	Func of sq ordinate	Cube of Ord	Func of cube ordinate
0	0.59	0.5	0.29	0.35	0.17	0.20	0.10
0.5	2.10	2	4.21	4.43	8.85	9.31	18.63
1	4.48	1	4.48	20.11	20.11	90.16	90.16
1.5	5.45	2	10.91	29.77	59.54	162.41	324.83
2	5.59	1	5.60	31.33	31.33	175.33	175.33
2.5	5.71	2	11.42	32.60	65.21	186.17	372.34
3	5.71	1.5	8.57	32.60	48.91	186.17	279.25
4	5.71	4	22.84	32.60	130.42	186.17	744.68
5	5.71	2	11.42	32.60	65.21	186.17	372.34
6	5.71	4	22.84	32.60	130.42	186.17	744.68
7	5.71	1.5	8.57	32.60	48.91	186.17	279.25
7.5	5.52	2	11.03	30.44	60.87	167.92	335.85
8	4.91	1	4.91	24.13	24.13	118.52	118.52
8.5	4.20	2	8.41	17.67	35.33	74.25	148.49
9	2.81	1	2.81	7.87	7.87	22.09	22.09
9.5	0.81	2	1.63	0.66	1.32	0.54	1.07
10	0	0.5	0.00	0.00	0.00	0.00	0.00
			139.93		738.59		4027.61

Waterline 04 at 10 degree (Immersed):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ordinate	Func of sq ordinate	Cube of Ord	Func of cube ordinate
0	0.57	0.5	0.29	0.32	0.16	0.19	0.09
0.5	2.08	2	4.15	4.31	8.61	8.93	17.87
1	4.34	1	4.34	18.84	18.84	81.75	81.75
1.5	5.33	2	10.65	28.37	56.73	151.08	302.16
2	5.54	1	5.54	30.70	30.70	170.12	170.12
2.5	5.80	2	11.60	33.62	67.23	194.91	389.82
3	5.80	1.5	8.70	33.62	50.43	194.91	292.37
4	5.80	4	23.19	33.62	134.47	194.91	779.64
5	5.80	2	11.60	33.62	67.23	194.91	389.82
6	5.80	4	23.19	33.62	134.47	194.91	779.64
7	5.80	1.5	8.70	33.62	50.43	194.91	292.37
7.5	5.56	2	11.12	30.91	61.83	171.88	343.76
8	4.88	1	4.88	23.79	23.79	116.00	116.00
8.5	4.12	2	8.23	16.95	33.90	69.78	139.56
9	2.61	1	2.61	6.83	6.83	17.84	17.84
9.5	0.78	2	1.56	0.61	1.21	0.47	0.95
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			140.34		746.85		4113.75

Waterline 04 at 20 degree (Immersed):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	0.57	0.5	0.28	0.32	0.16	0.18	0.09
0.5	2.11	2	4.21	4.44	8.87	9.34	18.68
1	4.34	1	4.34	18.81	18.81	81.58	81.58
1.5	5.33	2	10.66	28.43	56.86	151.59	303.18
2	5.70	1	5.70	32.47	32.47	185.00	185.00
2.5	6.08	2	12.15	36.91	73.81	224.20	448.40
3	6.08	1.5	9.11	36.91	55.36	224.20	336.30
4	6.08	4	24.30	36.91	147.62	224.20	896.81
5	6.08	2	12.15	36.91	73.81	224.20	448.40
6	6.08	4	24.30	36.91	147.62	224.20	896.81
7	6.08	1.5	9.11	36.91	55.36	224.20	336.30
7.5	5.75	2	11.49	33.03	66.06	189.81	379.62
8	4.95	1	4.95	24.52	24.52	121.43	121.43
8.5	4.09	2	8.18	16.74	33.49	68.52	137.04
9	2.53	1	2.53	6.42	6.42	16.25	16.25
9.5	0.77	2	1.54	0.59	1.19	0.46	0.92
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			145.03		802.43		4606.82

Waterline 04 at 30 degree (Immersed):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	0.59	0.5	0.29	0.34	0.17	0.20	0.10
0.5	2.20	2	4.39	4.82	9.64	10.58	21.15
1	4.37	1	4.37	19.12	19.12	83.63	83.63
1.5	5.44	2	10.88	29.60	59.21	161.08	322.16
2	6.04	1	6.04	36.46	36.46	220.13	220.13
2.5	6.51	2	13.03	42.43	84.86	276.40	552.81
3	6.56	1.5	9.84	43.03	64.55	282.30	423.45
4	6.56	4	26.24	43.03	172.13	282.30	1129.20
5	6.56	2	13.12	43.03	86.07	282.30	564.60
6	6.56	4	26.24	43.03	172.13	282.30	1129.20
7	6.52	1.5	9.78	42.55	63.82	277.55	416.33
7.5	6.05	2	12.11	36.65	73.30	221.88	443.77
8	5.03	1	5.03	25.25	25.25	126.88	126.88
8.5	4.15	2	8.29	17.20	34.40	71.32	142.64
9	2.57	1	2.57	6.60	6.60	16.97	16.97
9.5	0.59	2	1.18	0.35	0.69	0.20	0.41
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			153.40		908.42		5593.42

Waterline 04 at 40 degree (Immersed):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	0.62	0.5	0.31	0.38	0.19	0.24	0.12
0.5	2.34	2	4.68	5.48	10.95	12.81	25.63
1	4.32	1	4.32	18.68	18.68	80.73	80.73
1.5	5.49	2	10.99	30.17	60.35	165.74	331.48
2	6.40	1	6.40	40.97	40.97	262.27	262.27
2.5	6.62	2	13.23	43.78	87.57	289.72	579.45
3	6.79	1.5	10.18	46.05	69.07	312.49	468.74
4	6.79	4	27.14	46.05	184.20	312.49	1249.98
5	6.79	2	13.57	46.05	92.10	312.49	624.99
6	6.79	4	27.14	46.05	184.20	312.49	1249.98
7	6.60	1.5	9.90	43.57	65.36	287.63	431.44
7.5	6.31	2	12.61	39.75	79.51	250.64	501.29
8	5.13	1	5.13	26.31	26.31	134.93	134.93
8.5	4.33	2	8.66	18.76	37.52	81.24	162.48
9	2.72	1	2.72	7.39	7.39	20.10	20.10
9.5	0.82	2	1.64	0.67	1.34	0.55	1.09
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			158.63		965.70		6124.68

Waterline 04 at 50 degree (Immersed):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	0.68	0.5	0.34	0.46	0.23	0.32	0.16
0.5	2.52	2	5.03	6.33	12.65	15.91	31.82
1	4.22	1	4.22	17.82	17.82	75.20	75.20
1.5	5.31	2	10.62	28.22	56.43	149.89	299.78
2	5.74	1	5.74	32.98	32.98	189.42	189.42
2.5	5.74	2	11.49	32.98	65.96	189.42	378.83
3	5.74	1.5	8.61	32.98	49.47	189.42	284.12
4	5.74	4	22.97	32.98	131.93	189.42	757.66
5	5.74	2	11.49	32.98	65.96	189.42	378.83
6	5.74	4	22.97	32.98	131.93	189.42	757.66
7	5.74	1.5	8.61	32.98	49.47	189.42	284.12
7.5	5.74	2	11.49	32.98	65.96	189.42	378.83
8	5.23	1	5.23	27.39	27.39	143.38	143.38
8.5	4.58	2	9.16	20.99	41.99	96.20	192.40
9	2.98	1	2.98	8.90	8.90	26.57	26.57
9.5	0.92	2	1.84	0.85	1.70	0.78	1.56
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			142.81		760.80		4180.36

Waterline 04 at 60 degree (Immersed):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	0.78	0.5	0.39	0.61	0.30	0.47	0.24
0.5	2.66	2	5.32	7.06	14.13	18.78	37.56
1	4.12	1	4.12	17.00	17.00	70.09	70.09
1.5	5.01	2	10.03	25.13	50.26	125.98	251.96
2	5.08	1	5.08	25.81	25.81	131.10	131.10
2.5	5.08	2	10.16	25.81	51.61	131.10	262.19
3	5.08	1.5	7.62	25.81	38.71	131.10	196.64
4	5.08	4	20.32	25.81	103.23	131.10	524.39
5	5.08	2	10.16	25.81	51.61	131.10	262.19
6	5.08	4	20.32	25.81	103.23	131.10	524.39
7	5.08	1.5	7.62	25.81	38.71	131.10	196.64
7.5	5.08	2	10.16	25.81	51.61	131.10	262.19
8	5.08	1	5.08	25.81	25.81	131.10	131.10
8.5	4.80	2	9.61	23.07	46.14	110.80	221.60
9	3.35	1	3.35	11.20	11.20	37.49	37.49
9.5	1.07	2	2.14	1.14	2.28	1.22	2.44
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			131.46		631.64		3112.20

Waterline 04 at 70 degree (Immersed):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	0.94	0.5	0.47	0.88	0.44	0.82	0.41
0.5	2.76	2	5.51	7.59	15.18	20.91	41.82
1	4.06	1	4.06	16.47	16.47	66.82	66.82
1.5	4.68	2	9.36	21.92	43.84	102.63	205.27
2	4.68	1	4.68	21.92	21.92	102.63	102.63
2.5	4.68	2	9.36	21.92	43.84	102.63	205.27
3	4.68	1.5	7.02	21.92	32.88	102.63	153.95
4	4.68	4	18.73	21.92	87.68	102.63	410.54
5	4.68	2	9.36	21.92	43.84	102.63	205.27
6	4.68	4	18.73	21.92	87.68	102.63	410.54
7	4.68	1.5	7.02	21.92	32.88	102.63	153.95
7.5	4.68	2	9.36	21.92	43.84	102.63	205.27
8	4.68	1	4.68	21.92	21.92	102.63	102.63
8.5	4.68	2	9.36	21.92	43.84	102.63	205.27
9	3.71	1	3.71	13.76	13.76	51.06	51.06
9.5	1.34	2	2.67	1.79	3.58	2.39	4.78
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			124.11		553.61		2525.50

Waterline 04 at 80 degree (Immersed):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	1.19	0.5	0.60	1.42	0.71	1.69	0.84
0.5	2.86	2	5.71	8.16	16.32	23.32	46.64
1	4.06	1	4.06	16.47	16.47	66.82	66.82
1.5	4.47	2	8.93	19.95	39.91	89.13	178.27
2	4.47	1	4.47	19.95	19.95	89.13	89.13
2.5	4.47	2	8.93	19.95	39.91	89.13	178.27
3	4.47	1.5	6.70	19.95	29.93	89.13	133.70
4	4.47	4	17.87	19.95	79.82	89.13	356.54
5	4.47	2	8.93	19.95	39.91	89.13	178.27
6	4.47	4	17.87	19.95	79.82	89.13	356.54
7	4.47	1.5	6.70	19.95	29.93	89.13	133.70
7.5	4.47	2	8.93	19.95	39.91	89.13	178.27
8	4.47	1	4.47	19.95	19.95	89.13	89.13
8.5	4.47	2	8.93	19.95	39.91	89.13	178.27
9	4.02	1	4.02	16.19	16.19	65.16	65.16
9.5	1.92	2	3.84	3.69	7.38	7.09	14.18
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			120.97		516.02		2243.75

Waterline 04 at 90 degree (Immersed):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	1.58	0.5	0.79	2.49	1.25	3.93	1.96
0.5	3.02	2	6.03	9.10	18.20	27.46	54.92
1	1.45	1	1.45	2.11	2.11	3.06	3.06
1.5	4.40	2	8.80	19.36	38.72	85.18	170.37
2	4.40	1	4.40	19.36	19.36	85.18	85.18
2.5	4.40	2	8.80	19.36	38.72	85.18	170.37
3	4.40	1.5	6.60	19.36	29.04	85.18	127.78
4	4.40	4	17.60	19.36	77.44	85.18	340.74
5	4.40	2	8.80	19.36	38.72	85.18	170.37
6	4.40	4	17.60	19.36	77.44	85.18	340.74
7	4.40	1.5	6.60	19.36	29.04	85.18	127.78
7.5	4.40	2	8.80	19.36	38.72	85.18	170.37
8	4.40	1	4.40	19.36	19.36	85.18	85.18
8.5	4.40	2	8.80	19.36	38.72	85.18	170.37
9	4.40	1	4.40	19.36	19.36	85.18	85.18
9.5	3.30	2	6.60	10.89	21.78	35.94	71.87
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			120.48		507.98		2176.24

Waterline 04 at 0 degree (Emerged):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	0.59	0.5	0.29	0.35	0.17	0.20	0.10
0.5	2.10	2	4.21	4.43	8.85	9.31	18.63
1	4.48	1	4.48	20.11	20.11	90.16	90.16
1.5	5.46	2	10.91	29.77	59.54	162.41	324.83
2	5.60	1	5.60	31.33	31.33	175.33	175.33
2.5	5.71	2	11.42	32.60	65.21	186.17	372.34
3	5.71	1.5	8.57	32.60	48.91	186.17	279.25
4	5.71	4	22.84	32.60	130.42	186.17	744.68
5	5.71	2	11.42	32.60	65.21	186.17	372.34
6	5.71	4	22.84	32.60	130.42	186.17	744.68
7	5.71	1.5	8.57	32.60	48.91	186.17	279.25
7.5	5.52	2	11.03	30.44	60.87	167.92	335.85
8	4.91	1	4.91	24.13	24.13	118.52	118.52
8.5	4.20	2	8.41	17.67	35.33	74.25	148.49
9	2.81	1	2.81	7.87	7.87	22.09	22.09
9.5	0.81	2	1.63	0.66	1.32	0.54	1.07
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			139.93		738.59		4027.61

Waterline 04 at 10 degree (Emerged):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	0.63	0.5	0.31	0.39	0.20	0.25	0.12
0.5	2.20	2	4.40	4.84	9.68	10.65	21.30
1	4.79	1	4.79	22.92	22.92	109.76	109.76
1.5	5.74	2	11.48	32.94	65.87	189.02	378.04
2	5.78	1	5.78	33.36	33.36	192.70	192.70
2.5	5.80	2	11.60	33.62	67.23	194.91	389.82
3	5.80	1.5	8.70	33.62	50.43	194.91	292.37
4	5.80	4	23.19	33.62	134.47	194.91	779.64
5	5.80	2	11.60	33.62	67.23	194.91	389.82
6	5.80	4	23.19	33.62	134.47	194.91	779.64
7	5.80	1.5	8.70	33.62	50.43	194.91	292.37
7.5	5.64	2	11.27	31.75	63.51	178.93	357.86
8	5.08	1	5.08	25.76	25.76	130.71	130.71
8.5	4.41	2	8.82	19.47	38.93	85.88	171.77
9	3.13	1	3.13	9.77	9.77	30.52	30.52
9.5	0.88	2	1.76	0.78	1.55	0.68	1.37
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			143.78		775.80		4317.80

Waterline 04 at 20 degree (Emerged):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	0.70	0.5	0.35	0.48	0.24	0.34	0.17
0.5	2.38	2	4.76	5.66	11.33	13.48	26.96
1	3.80	1	3.80	14.45	14.45	54.91	54.91
1.5	3.80	2	7.60	14.45	28.89	54.91	109.83
2	3.80	1	3.80	14.45	14.45	54.91	54.91
2.5	3.80	2	7.60	14.45	28.89	54.91	109.83
3	3.80	1.5	5.70	14.45	21.67	54.91	82.37
4	3.80	4	15.20	14.45	57.79	54.91	219.65
5	3.80	2	7.60	14.45	28.89	54.91	109.83
6	3.80	4	15.20	14.45	57.79	54.91	219.65
7	3.80	1.5	5.70	14.45	21.67	54.91	82.37
7.5	3.80	2	7.60	14.45	28.89	54.91	109.83
8	3.80	1	3.80	14.45	14.45	54.91	54.91
8.5	3.80	2	7.60	14.45	28.89	54.91	109.83
9	3.71	1	3.71	13.74	13.74	50.94	50.94
9.5	1.00	2	1.99	0.99	1.98	0.99	1.98
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			102.03		374.03		1397.95

Waterline 04 at 30 degree (Emerged):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	0.81	0.5	0.40	0.65	0.32	0.52	0.26
0.5	2.60	2	5.20	6.76	13.52	17.58	35.15
1	2.60	1	2.60	6.76	6.76	17.58	17.58
1.5	2.60	2	5.20	6.76	13.52	17.58	35.15
2	2.60	1	2.60	6.76	6.76	17.58	17.58
2.5	2.60	2	5.20	6.76	13.52	17.58	35.15
3	2.60	1.5	3.90	6.76	10.14	17.58	26.36
4	2.60	4	10.40	6.76	27.04	17.58	70.30
5	2.60	2	5.20	6.76	13.52	17.58	35.15
6	2.60	4	10.40	6.76	27.04	17.58	70.30
7	2.60	1.5	3.90	6.76	10.14	17.58	26.36
7.5	2.60	2	5.20	6.76	13.52	17.58	35.15
8	2.60	1	2.60	6.76	6.76	17.58	17.58
8.5	2.60	2	5.20	6.76	13.52	17.58	35.15
9	2.60	1	2.60	6.76	6.76	17.58	17.58
9.5	1.19	2	2.38	1.42	2.84	1.69	3.39
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			72.99		185.69		478.20

Waterline 04 at 40 degree (Emerged):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	0.99	0.5	0.50	0.98	0.49	0.97	0.49
0.5	2.02	2	4.04	4.09	8.18	8.27	16.53
1	2.02	1	2.02	4.09	4.09	8.27	8.27
1.5	2.02	2	4.04	4.09	8.18	8.27	16.53
2	2.02	1	2.02	4.09	4.09	8.27	8.27
2.5	2.02	2	4.04	4.09	8.18	8.27	16.53
3	2.02	1.5	3.03	4.09	6.13	8.27	12.40
4	2.02	4	8.09	4.09	16.35	8.27	33.07
5	2.02	2	4.04	4.09	8.18	8.27	16.53
6	2.02	4	8.09	4.09	16.35	8.27	33.07
7	2.02	1.5	3.03	4.09	6.13	8.27	12.40
7.5	2.02	2	4.04	4.09	8.18	8.27	16.53
8	2.02	1	2.02	4.09	4.09	8.27	8.27
8.5	2.02	2	4.04	4.09	8.18	8.27	16.53
9	2.02	1	2.02	4.09	4.09	8.27	8.27
9.5	1.55	2	3.11	2.41	4.82	3.75	7.49
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			58.20		115.70		231.18

Waterline 04 at 50 degree (Emerged):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	1.33	0.5	0.67	1.78	0.89	2.37	1.19
0.5	1.70	2	3.39	2.88	5.76	4.89	9.77
1	1.70	1	1.70	2.88	2.88	4.89	4.89
1.5	1.70	2	3.39	2.88	5.76	4.89	9.77
2	1.70	1	1.70	2.88	2.88	4.89	4.89
2.5	1.70	2	3.39	2.88	5.76	4.89	9.77
3	1.70	1.5	2.55	2.88	4.32	4.89	7.33
4	1.70	4	6.79	2.88	11.52	4.89	19.55
5	1.70	2	3.39	2.88	5.76	4.89	9.77
6	1.70	4	6.79	2.88	11.52	4.89	19.55
7	1.70	1.5	2.55	2.88	4.32	4.89	7.33
7.5	1.70	2	3.39	2.88	5.76	4.89	9.77
8	1.70	1	1.70	2.88	2.88	4.89	4.89
8.5	1.70	2	3.39	2.88	5.76	4.89	9.77
9	1.70	1	1.70	2.88	2.88	4.89	4.89
9.5	1.70	2	3.39	2.88	5.76	4.89	9.77
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			49.88		84.40		142.91

Waterline 04 at 60 degree (Emerged):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	1.50	0.5	0.75	2.25	1.13	3.38	1.69
0.5	1.50	2	3.00	2.25	4.51	3.38	6.76
1	1.50	1	1.50	2.25	2.25	3.38	3.38
1.5	1.50	2	3.00	2.25	4.51	3.38	6.76
2	1.50	1	1.50	2.25	2.25	3.38	3.38
2.5	1.50	2	3.00	2.25	4.51	3.38	6.76
3	1.50	1.5	2.25	2.25	3.38	3.38	5.07
4	1.50	4	6.00	2.25	9.01	3.38	13.53
5	1.50	2	3.00	2.25	4.51	3.38	6.76
6	1.50	4	6.00	2.25	9.01	3.38	13.53
7	1.50	1.5	2.25	2.25	3.38	3.38	5.07
7.5	1.50	2	3.00	2.25	4.51	3.38	6.76
8	1.50	1	1.50	2.25	2.25	3.38	3.38
8.5	1.50	2	3.00	2.25	4.51	3.38	6.76
9	1.50	1	1.50	2.25	2.25	3.38	3.38
9.5	1.50	2	3.00	2.25	4.51	3.38	6.76
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			44.28		66.46		99.76

Waterline 04 at 70 degree (Emerged):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	1.38	0.5	0.69	1.91	0.96	2.65	1.32
0.5	1.38	2	2.77	1.91	3.83	2.65	5.29
1	1.38	1	1.38	1.91	1.91	2.65	2.65
1.5	1.38	2	2.77	1.91	3.83	2.65	5.29
2	1.38	1	1.38	1.91	1.91	2.65	2.65
2.5	1.38	2	2.77	1.91	3.83	2.65	5.29
3	1.38	1.5	2.07	1.91	2.87	2.65	3.97
4	1.38	4	5.53	1.91	7.65	2.65	10.58
5	1.38	2	2.77	1.91	3.83	2.65	5.29
6	1.38	4	5.53	1.91	7.65	2.65	10.58
7	1.38	1.5	2.07	1.91	2.87	2.65	3.97
7.5	1.38	2	2.77	1.91	3.83	2.65	5.29
8	1.38	1	1.38	1.91	1.91	2.65	2.65
8.5	1.38	2	2.77	1.91	3.83	2.65	5.29
9	1.38	1	1.38	1.91	1.91	2.65	2.65
9.5	1.38	2	2.77	1.91	3.83	2.65	5.29
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			40.80		56.42		78.03

Waterline 04 at 80 degree (Emerged):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	1.32	0.5	0.66	1.74	0.87	2.30	1.15
0.5	1.32	2	2.64	1.74	3.48	2.30	4.60
1	1.32	1	1.32	1.74	1.74	2.30	2.30
1.5	1.32	2	2.64	1.74	3.48	2.30	4.60
2	1.32	1	1.32	1.74	1.74	2.30	2.30
2.5	1.32	2	2.64	1.74	3.48	2.30	4.60
3	1.32	1.5	1.98	1.74	2.61	2.30	3.45
4	1.32	4	5.28	1.74	6.97	2.30	9.20
5	1.32	2	2.64	1.74	3.48	2.30	4.60
6	1.32	4	5.28	1.74	6.97	2.30	9.20
7	1.32	1.5	1.98	1.74	2.61	2.30	3.45
7.5	1.32	2	2.64	1.74	3.48	2.30	4.60
8	1.32	1	1.32	1.74	1.74	2.30	2.30
8.5	1.32	2	2.64	1.74	3.48	2.30	4.60
9	1.32	1	1.32	1.74	1.74	2.30	2.30
9.5	1.32	2	2.64	1.74	3.48	2.30	4.60
10	0	0.5	0.00	0.00	0.00	0.00	0.00
			38.28		51.40		67.85

Waterline 04 at 90 degree (Emerged):

Station No.	Ordinate in metre	SM	Func of ordinate	Sq of ord	Func of sq ord	Cube of Ord	Func of cube ord
0	1.30	0.5	0.65	1.69	0.85	2.20	1.10
0.5	1.30	2	2.60	1.69	3.38	2.20	4.39
1	1.30	1	1.30	1.69	1.69	2.20	2.20
1.5	1.30	2	2.60	1.69	3.38	2.20	4.39
2	1.30	1	1.30	1.69	1.69	2.20	2.20
2.5	1.30	2	2.60	1.69	3.38	2.20	4.39
3	1.30	1.5	1.95	1.69	2.54	2.20	3.30
4	1.30	4	5.20	1.69	6.76	2.20	8.79
5	1.30	2	2.60	1.69	3.38	2.20	4.39
6	1.30	4	5.20	1.69	6.76	2.20	8.79
7	1.30	1.5	1.95	1.69	2.54	2.20	3.30
7.5	1.30	2	2.60	1.69	3.38	2.20	4.39
8	1.30	1	1.30	1.69	1.69	2.20	2.20
8.5	1.30	2	2.60	1.69	3.38	2.20	4.39
9	1.30	1	1.30	1.69	1.69	2.20	2.20
9.5	1.30	2	2.60	1.69	3.38	2.20	4.39
10	0.00	0.5	0.00	0.00	0.00	0.00	0.00
			37.70		49.01		63.71

Waterline 04 at 10 degree:

Heel	Product of sq ord of imm	SM	Product1	Product of sq ord of emrgd	SM	PRODUCT2
0.00	738.59	5.00	3692.93	738.59	5.00	3692.93
10.00	746.85	8.00	5974.80	775.80	8.00	6206.40
20.00	802.43	-1.00	-802.43	374.03	-1.00	-374.03
			8865.30			9525.30

Heel	Moment sum	SM	Moment Product	Angle Difference	cosine of angle diff	Final Moment Product
0.00	8055.22	5.00	40276.12	10.00	0.98	39631.70
10.00	8431.55	8.00	67452.40	0.00	1.00	67452.40
20.00	6004.77	-1.00	-6004.77	-10.00	0.98	-5908.69
						101175.40

Volume immersed	75.10
Volume emerged	80.70
Volume	1847.49
Moment	1154.07
Br	0.63
Bg(kg-kb)	1.00
GZ	0.46
Sum of area product	284.12
Area	670.53
Lambda	1.72

Waterline 04 at 20 degree:

Heel	Product of sq ord of imm	SM	Product1	Product of sq ord of emrgd	SM	PRODUCT2
0.00	738.59	1.00	738.59	738.59	1.00	738.59
10.00	746.85	4.00	2987.40	775.80	4.00	3103.20
20.00	802.43	1.00	802.43	374.03	1.00	374.03
			4528.41			4215.81

Heel	Moment sum	SM	Moment Product	Angle Difference	cosine of angle diff	Final Moment Product
0.00	8055.22	1.00	8055.22	20.00	0.94	7563.86
10.00	8431.55	4.00	33726.20	10.00	0.98	33186.58
20.00	6004.77	1.00	6004.77	0.00	1.00	6004.77
			47786.19			46755.21

Volume immersed	153.45
Volume emerged	142.86
Volume	1863.67
Moment	2133.28
Br	1.12
BG(kg-kb)	1.00
GZ	0.78
Sum of area product	247.06
Area	583.05
Lambda	3.66

Waterline 04 at 30 degree:.

Heel	Product of sq ord of in mm	SM	Product1	Product of sq ord of emrgd	SM	PRODUCT2
0.00	738.59	1.00	738.59	738.59	1.00	738.59
10.00	746.85	3.00	2240.55	775.80	3.00	2327.40
20.00	802.43	3.00	2407.28	374.03	3.00	1122.09
30.00	908.42	1.00	908.42	185.69	1.00	185.69
			6294.83			4373.76

Heel	Moment sum	SM	Moment Product	Angle Difference	cosine of angle diff	Final Moment Product
0.00	8055.22	1.00	8055.22	30.00	0.87	6975.82
10.00	8431.55	3.00	25294.65	20.00	0.94	23751.68
20.00	6004.77	3.00	18014.31	10.00	0.98	17726.08
30.00	6071.62	1.00	6071.62	0.00	1.00	6071.62
						54525.21

Volume immersed	239.98
Volume emerged	166.74
Volume	1926.32
Moment	2798.78
Br	1.25
Bg(kg-kb)	1.00
Gz	0.75
Sum of area product	226.39
Area	534.28
Lambda	5.24

Waterline 04 at 40 degree:

Heel	Product of sq ord of imm	SM	Product1	Product of sq ord of emrgd	SM	PRODUCT2
0.00	738.59	1.00	738.59	738.59	1.00	738.59
10.00	746.85	4.00	2987.40	775.80	4.00	3103.20
20.00	802.43	2.00	1604.85	374.03	2.00	748.06
30.00	908.42	4.00	3633.67	185.69	4.00	742.74
40.00	965.70	1.00	965.70	115.70	1.00	115.70
			9930.21			5448.29

Heel	Moment sum	SM	Moment Product	Angle Difference	cosine of angle diff	Final Moment Product
0.00	8055.22	1.00	8055.22	40.00	0.77	6170.30
10.00	8431.55	4.00	33726.20	30.00	0.87	29206.89
20.00	6004.77	2.00	12009.54	20.00	0.94	11276.96
30.00	6071.62	4.00	24286.50	10.00	0.98	23897.91
40.00	6355.86	1.00	6355.86	0.00	1.00	6355.86
						76907.92

Volume immersed	336.51
Volume emerged	184.63
Volume	2004.96
Moment	3509.05
Br	1.23
Bg(kg-kb)	1.10
Gz	0.59
Sum of area product	216.82
Area	511.71
Lambda	6.86

Waterline 04 at 50 degree:

Heel	Product of sq ord of imm	SM	Product1	Product of sq ord of emrgd	SM	PRODUCT2
0.00	738.59	0.40	295.43	738.59	0.40	295.43
10.00	746.85	1.00	746.85	775.80	1.00	775.80
20.00	802.43	1.00	802.43	374.03	1.00	374.03
30.00	908.42	1.00	908.42	185.69	1.00	185.69
40.00	965.70	1.00	965.70	115.70	1.00	115.70
50.00	760.80	0.40	304.32	84.40	0.40	33.76
			4023.15			1780.41

Heel	Moment sum	SM	Moment Product	Angle Difference	cosine of angle diff	Final Moment Product
0.00	8055.22	0.40	3222.09	50.00	0.64	2068.58
10.00	8431.55	1.00	8431.55	40.00	0.77	6458.57
20.00	6004.77	1.00	6004.77	30.00	0.87	5200.13
30.00	6071.62	1.00	6071.62	20.00	0.94	5701.26
40.00	6355.86	1.00	6355.86	10.00	0.98	6254.17
50.00	4323.27	0.40	1729.31	0.00	1.00	1729.31
						27412.01

Volume immersed	426.04
Volume emerged	188.54
Volume	2090.58
Moment	3908.50
BR	0.89
BG(kg-kb)	1.00
GZ	0.13
Sum of area product	192.69
Area	454.76
Lambda	8.59

Waterline 04 at 60 degree:

Heel	Product of sq ord of imm	SM	Product1	Product of sq ord of emrgd	SM	PRODUCT2
0.00	738.59	1.00	738.59	738.59	1.00	738.59
10.00	746.85	4.00	2987.40	775.80	4.00	3103.20
20.00	802.43	2.00	1604.85	374.03	2.00	748.06
30.00	908.42	4.00	3633.67	185.69	4.00	742.74
40.00	965.70	2.00	1931.41	115.70	2.00	231.41
50.00	760.80	4.00	3043.18	84.40	4.00	337.62
60.00	631.64	1.00	631.64	66.46	1.00	66.46
			14570.73			5968.07

Heel	Moment sum	SM	Moment Product	Angle Difference	cosine of angle diff	Final Moment Product
0.00	8055.22	1.00	8055.22	60.00	0.50	4027.61
10.00	8431.55	4.00	33726.20	50.00	0.64	21652.22
20.00	6004.77	2.00	12009.54	40.00	0.77	9199.31
30.00	6071.62	4.00	24286.50	30.00	0.87	21032.11
40.00	6355.86	2.00	12711.73	20.00	0.94	11936.31
50.00	4323.27	4.00	17293.08	10.00	0.98	17016.39
60.00	3211.96	1.00	3211.96	0.00	1.00	3211.96
						88075.91

Volume immersed	493.76
Volume emerged	202.24
Volume	2144.60
Moment	4018.61
BR	0.56
BG(kg-kb)	1.00
GZ	-0.31
Sum of area product	175.74
Area	414.75
Lambda	9.69

Waterline 04 at 70 degree:

Heel	Product of sq ord of imm	SM	Product1	Product of sq ord of emrgd	SM	PRODUCT2
0.00	738.59	1.00	738.59	738.59	1.00	738.59
10.00	746.85	4.00	2987.40	775.80	4.00	3103.20
20.00	802.43	2.00	1604.85	374.03	2.00	748.06
30.00	908.42	4.00	3633.67	185.69	4.00	742.74
40.00	965.70	1.00	965.70	115.70	1.00	115.70
		∑	9930.21		∑	5448.29
40.00	965.70	1.00	965.70	115.70	1.00	115.70
50.00	760.80	3.00	2282.39	84.40	3.00	253.21
60.00	631.64	3.00	1894.91	66.46	3.00	199.39
70.00	553.61	1.00	553.61	56.42	1.00	56.42
		∑	5696.61		∑	624.73

Heel	Moment sum	SM	Moment Product	Angle Difference	cosine of angle diff	Final Moment Product
0.00	8055.22	1.00	8055.22	70.00	0.34	2754.89
10.00	8431.55	4.00	33726.20	60.00	0.50	16863.10
20.00	6004.77	2.00	12009.54	50.00	0.64	7710.13
30.00	6071.62	4.00	24286.50	40.00	0.77	18603.46
40.00	6355.86	1.00	6355.86	30.00	0.87	5504.18
		∑			∑	51435.75
40.00	6355.86	1.00	6355.86	30.00	0.87	5504.18
50.00	4323.27	3.00	12969.81	20.00	0.94	12178.65
60.00	3211.96	3.00	9635.88	10.00	0.98	9481.71
70.00	2603.53	1.00	2603.53	0.00	1.00	2603.53
		∑			∑	29768.07

Volume immersed	4983.09
Volume emerged	208.44
Volume	6627.73
Moment	14913.96
Br	-25.36
Bg(kg-kb)	1.00
Gz	-26.30
Sum of area product	164.90
Area	389.17
Lambda	38.32

Waterline 04 at 80 degree:

Heel	Product of sq ord of imm	SM	Product1	Product of sq ord of emrgd	SM	PRODUCT2
0.00	738.59	1.00	738.59	738.59	1.00	738.59
10.00	746.85	4.00	2987.40	775.80	4.00	3103.20
20.00	802.43	2.00	1604.85	374.03	2.00	748.06
30.00	908.42	4.00	3633.67	185.69	4.00	742.74
40.00	965.70	2.00	1931.41	115.70	2.00	231.41
50.00	760.80	4.00	3043.18	84.40	4.00	337.62
60.00	631.64	2.00	1263.27	66.46	2.00	132.93
70.00	553.61	4.00	2214.44	56.42	4.00	225.70
80.00	516.02	1.00	516.02	50.53	1.00	50.53
			17932.83			6310.76

Heel	Moment sum	SM	Moment Product	Angle Difference	cosine of angle diff	Final Moment Product
0.00	8055.22	1.00	8055.22	80.00	0.17	1393.55
10.00	8431.55	4.00	33726.20	70.00	0.34	11534.36
20.00	6004.77	2.00	12009.54	60.00	0.50	6004.77
30.00	6071.62	4.00	24286.50	50.00	0.64	15591.93
40.00	6355.86	2.00	12711.73	40.00	0.77	9737.18
50.00	4323.27	4.00	17293.08	30.00	0.87	14975.81
60.00	3211.96	2.00	6423.92	20.00	0.94	6032.06
70.00	2603.53	4.00	10414.13	10.00	0.98	10247.51
80.00	582.72	1.00	582.72	0.00	1.00	582.72
						76099.89

Volume immersed	607.69
Volume emerged	213.85
Volume	2246.92
Moment	3472.18
Br	-0.07
Bg(kg-kb)	1.00
Gz	-1.06
Sum of area product	159.25
Area	375.84
Lambda	9.24

Waterline 04 at 90 degree:

Heel	Product of sq ord of imm	SM	Product1	Product of sq ord of emrgd	SM	PRODUCT2
0.00	738.59	1.00	738.59	738.59	1.00	738.59
10.00	746.85	3.00	2240.55	775.80	3.00	2327.40
20.00	802.43	3.00	2407.28	374.03	3.00	1122.09
30.00	908.42	2.00	1816.84	185.69	2.00	371.37
40.00	965.70	3.00	2897.11	115.70	3.00	347.11
50.00	760.80	3.00	2282.39	84.40	3.00	253.21
60.00	631.64	2.00	1263.27	66.46	2.00	132.93
70.00	553.61	3.00	1660.83	56.42	3.00	169.27
80.00	516.02	3.00	1548.05	50.53	3.00	151.59
90.00	507.98	1.00	507.98	49.01	1.00	49.01
			17362.88			5662.56

Heel	Moment sum	SM	Moment Product	Angle Difference	cosine of angle diff	Final Moment Product
0.00	8055.22	1.00	8055.22	90.00	0.00	0.00
10.00	8431.55	3.00	25294.65	80.00	0.17	4375.97
20.00	6004.77	3.00	18014.31	70.00	0.34	6160.90
30.00	6071.62	2.00	12143.25	60.00	0.50	6071.62
40.00	6355.86	3.00	19067.59	50.00	0.64	12241.39
50.00	4323.27	3.00	12969.81	40.00	0.77	9934.87
60.00	3211.96	2.00	6423.92	30.00	0.87	5563.12
70.00	2603.53	3.00	7810.60	20.00	0.94	7334.15
80.00	2311.60	3.00	6934.79	10.00	0.98	6823.83
90.00	2239.95	1.00	2239.95	0.00	1.00	2239.95
						60745.81

Volume immersed	661.92
Volume emerged	215.87
Volume	2299.13
Moment	1543.87
Br	-0.13
Bg(kg-kb)	1.00
Gz	-1.13
Sum of area product	158.18
Area	373.29
Lambda	4.14

Appendix 3:

Power and Engine Selection:

Total resistance, R=102.6 kN

Effective power, P_E = 102.6X10X.5144=579.24 kW

Ship Length, L_{BP}=70.8 m= 232.28 ft

Breadth, B=11.42 m = 37.46 ft

Draft, T=4.4m = 14.44 ft

Speed, V=10 knots

Volume displacement, =2660m^3=99652.04 ft^3

Propeller diameter, D=.6T=2.6ft

Co-efficient ,D_W= $\frac{D}{\sqrt{\nabla^{\frac{1}{3}}}.D}$ =0.429

LCB=0.34M=1.12ft

Taylor wake fraction,

ω_t= 0.22

$D_t = \frac{DXB}{\nabla^{\frac{2}{3}}}$ = 0.149

Thrust Deduction factor, t = 0.204

We know,

T(1-t) = R

T = 141.45 kN

$\eta_H = \frac{(1-t)}{1-\omega_t}$ = 1.02

η_R = 1.04

$V_A = V(1-\omega_t)$=7.8 knot=4.01 ms^{-1}

Shaft immersion, h= D/2+0.2 = 1.5 m

H= T(Draft)- h

= 2.9m

Thrust ,T =141.45 kN

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

$= 129745\ N/m^2$

$P_V = 1646 N/m^2$

K=0.2(for single screw)

Z=3

D= 3.08m

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

= 0.5

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

= 1.3

From chart,

n_m = .5

j=.4

and $\frac{P}{D} = .79$

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

so, n = 3.85 rps = 231.34 rpm

assume, η_D = .7

$P_D = \frac{P_E}{\eta_D}$ = 579.24/.7 = 827.48 kw

Va = 7.7 knots

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

= 45.35

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

= 252.93

And, P/D = .79

So , From Bp -δ chart we get,

η_o = .52

P/D=.67

Here,

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

= 0.55

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

= 0.55 – 0.7 < 0.005

So, η_D = 0.55

Now, P_D = 579.24/.55=1053.16kW

And $P_B = P_D/\eta_s$ = 1074.65 kW

So, Break Power(85% MCR) = 1074.65 kW

And Installed Power (100% MCR) = 1265 kW

Appendix 4:

Propeller Calculation:

Total resistance, R=112.6 kN

Effective power, P_E = 112.6X10X.5144=579.24 kW

Ship Length, L_{BP}=70.8 m= 232.28 ft

Breadth, B=11.42 m = 37.46 ft

Draft, T=4.4m = 14.44 ft

Speed, V=10 knots

Volume displacement, =2660m^3=99652.04 ft^3

Propeller diameter, D=.6T=2.6ft

Co-efficient ,D_W= $\frac{D}{\sqrt{\nabla^{\frac{1}{3}}}.D}$ =0.429

LCB=0.34M=1.12ft

Taylor wake fraction,

ω_t= 0.22

$D_t = \frac{DXB}{\frac{2}{\nabla^3}}$ = 0.149

Thrust Deduction factot, t = 0.204

We know,

T(1-t) = R

T = 141.45 kN

$\eta_H = \frac{(1-t)}{1-\omega_t}$ = 1.02

η_R = 1.04

$V_A = V(1-\omega_t) = 7.8$ knot=4.01 ms^{-1}

Shaft immersion, h= D/2+0.2 = 1.5 m

H= T(Draft)- h

= 2.9m

Thrust , T =141.45 kN

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

=129745 N/m^2

P_V = 1646N/m^2

K=0.2(for single screw)

Z=3

D= 3.08m

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

= 0.5

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

= 1.3

From chart,

n_m = .5

j=.4

and $\frac{P}{D} = .79$

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

so, n = 3.85 rps = 231.34 rpm

assume, η_D = .7

P_D= $\frac{P_E}{\eta_D}$ = 579.24/.7 = 827.48 kw

Va = 7.7 knots

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

= 45.35

δ = 3.28 $\frac{nD}{Va}$

= 252.93

And, P/D = .79

So , From Bp -δ chart we get,

η_o = .52

P/D=.67

Cavitation Check:

$p_0 - p_v = 99.6 - 10.05 \times shaft\ immersion$

$p_0 - p_v = 99.6 - 10.05 \times 1.5m$

=83.85 kPa

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

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

$= \frac{1}{2} \times 1.000 \times (4.01^2 + (0.7 \times \pi \times 3.85 \times 2.6)^2$

=250.33 kPa

$\sigma_{0.7R} = \frac{p_0 - p_v}{q_{0.7R}} = \frac{83.85}{250.33}$=0.33

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

$$= \frac{141.45}{\frac{\pi}{4} \times 2.6^2 (1.067 - 0.229 \times 0.67)(0.3 \times 0.33^{0.5} - 0.03)250.33}$$

Therefore, A_E =0.818m^2

Assuming$A_E = A_D$,

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

$$A_P = 3.97\ m^2$$

$$\tau_c = \frac{\frac{T}{A_P}}{q_{0.7R}} = 0.14$$

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

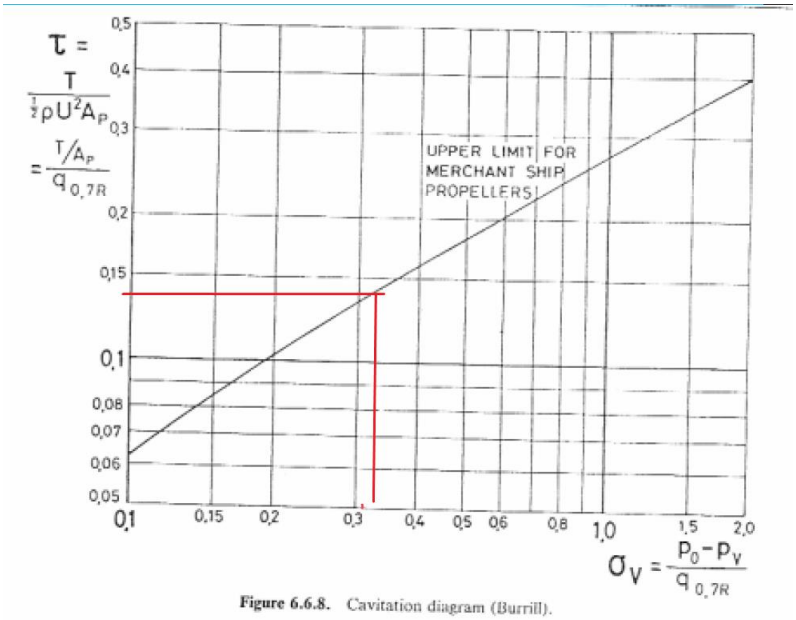


Figure 6.6.8. Cavitation diagram (Burrill).

Here,

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

= 0.55

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

= 0.55 – 0.7 < 0.005

So, $\eta_D = 0.55$

Propeller profile generation:

r/R	(cr.Z)/ [D.(AE/Ao)]	a/c	b/c	t/D =Ar – Br.Z									
				Ar	Br	r	c	a	b	t	a_mm	a-c_mm	b_mm
0.20	1.63	0.62	0.35	0.05	0.00	0.30	0.66	0.41	0.23	0.13	407.74	254.17	231.67
0.30	1.83	0.61	0.35	0.05	0.00	0.45	0.74	0.45	0.26	0.11	453.71	288.86	259.90
0.40	2.00	0.60	0.35	0.04	0.00	0.60	0.81	0.49	0.28	0.10	485.59	325.08	283.73
0.50	2.12	0.58	0.36	0.03	0.00	0.76	0.86	0.50	0.31	0.08	500.98	358.33	305.05
0.60	2.19	0.56	0.39	0.03	0.00	0.91	0.89	0.49	0.34	0.07	494.42	391.64	344.68
0.70	2.17	0.53	0.44	0.02	0.00	1.06	0.88	0.46	0.39	0.05	462.23	416.53	388.41
0.80	2.13	0.48	0.48	0.02	0.00	1.21	0.86	0.41	0.41	0.04	414.69	447.45	412.10
0.90	1.66	0.40	0.50	0.01	0.00	1.36	0.67	0.27	0.34	0.02	268.65	402.98	335.82
1.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	0.00	0.00	0.01	0.00	0.00	0.00

r/R = .2	P	-1.00	-0.95	-0.90	-0.80	-0.70	-0.60	-0.50	-0.40	-0.20	0.00
	t max =	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
	V1	0.28	0.26	0.24	0.20	0.16	0.12	0.09	0.06	0.02	0.00
	V2	0.00	0.06	0.15	0.31	0.45	0.58	0.70	0.80	0.94	1.00
	t_te	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y face	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.00	0.00
	Y back	0.04	0.04	0.05	0.06	0.08	0.09	0.10	0.11	0.12	0.13
	P	1.00	0.95	0.90	0.85	0.80	0.70	0.60	0.50	0.40	0.20
	t max =	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
	V1	0.36	0.28	0.24	0.20	0.17	0.12	0.08	0.05	0.03	0.00
	V2	0.00	0.16	0.28	0.39	0.48	0.62	0.73	0.82	0.89	0.98
	t_le=	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y face	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.00	0.00
	Y back	0.05	0.06	0.07	0.07	0.08	0.09	0.10	0.11	0.11	0.12

r/R = .3	P	-1.00	-0.95	-0.90	-0.80	-0.70	-0.60	-0.50	-0.40	-0.20	0.00
	t max =	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
	V1	0.23	0.20	0.18	0.13	0.09	0.06	0.04	0.02	0.00	0.00
	V2	0.00	0.08	0.17	0.34	0.49	0.62	0.73	0.83	0.96	1.00
	t_te	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y face	0.02	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00
	Y back	0.03	0.03	0.04	0.05	0.07	0.08	0.09	0.09	0.11	0.11
	P	1.00	0.95	0.90	0.85	0.80	0.70	0.60	0.50	0.40	0.20
	t max =	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
	V1	0.29	0.22	0.18	0.14	0.12	0.08	0.05	0.03	0.01	0.00
	V2	0.00	0.19	0.32	0.43	0.51	0.65	0.75	0.83	0.89	0.98
	t_le=	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y face	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00
	Y back	0.03	0.05	0.06	0.06	0.07	0.08	0.09	0.10	0.10	0.11

r/R = .4	P	-1.00	-0.95	-0.90	-0.80	-0.70	-0.60	-0.50	-0.40	-0.20	0.00
	t max =	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
	V1	0.15	0.12	0.10	0.06	0.04	0.02	0.01	0.00	0.00	0.00
	V2	0.00	0.09	0.18	0.35	0.50	0.64	0.75	0.84	0.96	1.00
	t_te	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y face	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	Y back	0.02	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10
	P	1.00	0.95	0.90	0.85	0.80	0.70	0.60	0.50	0.40	0.20
	t max =	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
	V1	0.22	0.15	0.11	0.08	0.06	0.04	0.02	0.01	0.00	0.00
	V2	0.00	0.19	0.32	0.43	0.52	0.66	0.76	0.83	0.89	0.97
	t_le=	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y face	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
	Y back	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.08	0.09	0.09

r/R = .5	P	-1.00	-0.95	-0.90	-0.80	-0.70	-0.60	-0.50	-0.40	-0.20	0.00
	t max =	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
	V1	0.05	0.04	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00
	V2	0.00	0.10	0.19	0.36	0.51	0.64	0.76	0.85	0.96	1.00
	t_te	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y face	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y back	0.01	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.08
	P	1.00	0.95	0.90	0.85	0.80	0.70	0.60	0.50	0.40	0.20
	t max =	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
	V1	0.13	0.08	0.05	0.03	0.02	0.01	0.00	0.00	0.00	0.00
	V2	0.00	0.18	0.31	0.41	0.50	0.64	0.75	0.83	0.89	0.97
	t_le=	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y face	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y back	0.01	0.02	0.03	0.04	0.04	0.05	0.06	0.07	0.07	0.08

r/R = .6	P	-1.00	-0.95	-0.90	-0.80	-0.70	-0.60	-0.50	-0.40	-0.20	0.00
	t max =	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	V2	0.00	0.10	0.19	0.36	0.51	0.64	0.75	0.84	0.96	1.00
	t_te	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y face	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y back	0.00	0.01	0.01	0.03	0.04	0.04	0.05	0.06	0.06	0.07
	P	1.00	0.95	0.90	0.85	0.80	0.70	0.60	0.50	0.40	0.20
	t max =	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
	V1	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	V2	0.00	0.15	0.27	0.38	0.46	0.61	0.72	0.81	0.88	0.97
	t_le=	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y face	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y back	0.00	0.01	0.02	0.03	0.03	0.04	0.05	0.05	0.06	0.07

r/R = .7	P	-1.00	-0.95	-0.90	-0.80	-0.70	-0.60	-0.50	-0.40	-0.20	0.00
	t max =	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	V2	0.00	0.10	0.19	0.36	0.51	0.64	0.75	0.84	0.96	1.00
	t_te	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y face	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y back	0.00	0.01	0.01	0.02	0.03	0.03	0.04	0.04	0.05	0.05
	P	1.00	0.95	0.90	0.85	0.80	0.70	0.60	0.50	0.40	0.20
	t max =	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	V2	0.00	0.12	0.23	0.33	0.41	0.56	0.68	0.79	0.87	0.97
	t_le	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y face	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y back	0.00	0.01	0.01	0.02	0.02	0.03	0.04	0.04	0.05	0.05

r/R = .8	P	-1.00	-0.95	-0.90	-0.80	-0.70	-0.60	-0.50	-0.40	-0.20	0.00
	t max =	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	V2	0.00	0.10	0.19	0.36	0.51	0.64	0.75	0.84	0.96	1.00
	t_te	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y face	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y back	0.00	0.00	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04
	P	1.00	0.95	0.90	0.85	0.80	0.70	0.60	0.50	0.40	0.20
	t max =	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	V2	0.00	0.11	0.20	0.29	0.38	0.53	0.65	0.76	0.85	0.96
	t_le	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y face	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y back	0.00	0.00	0.01	0.01	0.01	0.02	0.03	0.03	0.03	0.04

	P	-1.00	-0.95	-0.90	-0.80	-0.70	-0.60	-0.50	-0.40	-0.20	0.00
	t max =	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

r/R = .9	V2	0.00	0.10	0.19	0.36	0.51	0.64	0.75	0.84	0.96	1.00
	t_te	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y face	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y back	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02	0.02
	P	1.00	0.95	0.90	0.85	0.80	0.70	0.60	0.50	0.40	0.20
	t max =	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	V1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	V2	0.00	0.10	0.19	0.28	0.36	0.51	0.64	0.75	0.84	0.96
	t_le	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y face	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Y back	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02

Appendix 5:

Airfoil Generator:

Name	NACA 0018
Chord(mm)	2670
Radius(mm)	0
Thickness(%)	50
Origin(%)	50
X(mm)	Y(mm)
1335	2.52315
1201.5	16.1535
1068	28.9962
801	52.53225
534	73.3716
267	91.38075
0	106.01235
-267	116.21175
-534	120.19005
-667.5	118.9752
-801	114.8901
-934.5	107.0403
-1068	93.7704
-1134.75	84.105
-1201.5	71.1822
-1268.25	52.3587
-1301.625	37.92735
-1335	0
-1301.625	-37.92735
-1268.25	-52.3587
-1201.5	-71.1822
-1134.75	-84.105
-1068	-93.7704
-934.5	-107.0403
-801	-114.8901
-667.5	-118.9752
-534	-120.19005
-267	-116.21175
0	-106.01235
267	-91.38075
534	-73.3716
801	-52.53225
1068	-28.9962
1201.5	-16.1535
1335	-2.52315

Rudder Calculation:

L_{BP} = 70.8 m

L_{WL} = 73.75

T/L = .0621 m

T =4.4 m

L/B = 6.2

B = 11.4 m

Rudder Area:

$$A = c_1 \times c_2 \times c_3 \times c_4 \times \frac{1.75 \times L_{WL} \times T}{100}$$

$$A = 1 \times 1 \times 1 \times 1.5 \times \frac{1.75 \times 73.75 \times 4.4}{100}$$

$$= 3.14\, m^2$$

Yield Strength of mild steel = 235 N/m^2

$$K_r = (\frac{235}{250})^{.75}$$

Aspect ratio= $\frac{b^2}{a} = \frac{b}{c} = \frac{height}{breadth}$

$$\Rightarrow 1.5 = \frac{b^2}{A}$$

$$b^2 = 4.71$$

$$b = 2.17$$

Since $\frac{b}{T} = \frac{2.17}{2.5} = .86$ = 86% of the draft but the mean height should be as much as 60%-70% of the draft

Again, Aspect Ratio= 1.3

$$= \frac{b^2}{A}$$

$$\Rightarrow b^2 = 1.3 \times 3.14$$

$$\Longrightarrow b = 2.02$$

Now, $\frac{b}{T} = \frac{2.02}{2.5} = .80$ = 80% of the draft

Now, considering aspect ratio as 1.2,

$$\frac{b^2}{A} = 1.2$$

$$b = 1.94$$

$$c = \frac{1.94}{1.2} = 1.616$$

Rudder Force and Torque:

Rudder force, $C_R = 132 \times A^2 \times V^2 \times k_1 \times k_2 \times k_3 \times k_t$

k1=$\frac{Aspect\ Ratio+2}{3} = 1.067$

k2= 1.1(ahead condition)

k3= 0.8

k_t=1

$C_R = 132 \times 3.14 \times 12^2 \times 1.067 \times 1.1 \times .8 \times 1$

$C_R = 56041.94\ kN$

Rudder Torque, Q_R=C_R x r

Again, r= $c \times (\alpha \times K_b)$

$\alpha = .33 = for\ ahead\ condition$

Now, $K_b = \frac{A_f}{A} = .02$

r = 1.616 x (.33 x .2)

= .11 m

Q_R= 56041.94 x .11

=6164.61 Nm

Rudder Stock:

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

$= 4.2 \times \sqrt[3]{28600 \times 1}$

= 128.4 mm

Couplings:

$D_b = .62 \times \sqrt{\frac{D^3 \times K_b}{K_r \times n \times e}}$

K_r= 0.95

n= total no of bolts

k_b= metal factor for flanges

e= mean distance of of the bolt axis from the center of the bolt system

$= \frac{105}{100} \times 80$

=84

$D_b = .62 \times \sqrt{\frac{80^3 \times 1}{.95 \times 6 \times 84}}$

= 20.27 mm

=21 mm

Thickness of the coupling flanges:

t_r= 0.9 x d_b

= 0.9 x 21

= 18.9 mm

Thickness of coupling flange clear of the bolt hole,

T_s= (.65 x 21)mm

= 13.65 mm

Rudder Plating:

$t_p = 1.74 \times a \times \sqrt{P_r \times k} + 2.9$

a= unsupported width

= 0.34 m

Design Pressure, $P_r = 10T + \frac{C_R}{10^3 \times A}$

$= 102.51 + \frac{56.041}{10^3 \times 3.44}$

=25.11 kN/mm^2

Thickness of rudder plating, $t_p = 1.74 \times .340 \times \sqrt{25.11 \times 1} + 2.5$

= 5.46 mm

=6 mm

Thickness of the web is not to be less than, t_w= .7 x 6mm= 4.2 mm

Rudder Bearings:

T_{min}= 8 mm(since metallic material would be used)

Projected Surface, $A_b = \frac{B_i}{q}$

B_i= 56041.94 N = support reaction at carrier bearing

q= 7 N/mm^2

Again, A_{bn}= bearing height x external diameter of liner

External diameter of the liner= (D_t x t_{min} x 2)

= (80 + 18.9 x 2)

= 117. 8 mm

The diameter of the pintle, $d_p = 0.35 \times \sqrt{B_i \times K_r}$

B_i= 56041.94= support reaction at the pintle

d_p=80.75 mm

=81 m

Appendix 6:

Steering Gear:

Principle Particulars:

L_{BP} = 70.8 m

L_{WL} = (1+.0167) x 70.8 = 72m

B = 11.4 m

T = 4.4 m

Particulars of Rudder:

b= height= 3.2

c= breadth= 2.27

Rudder Area, A = 8.52 m^2

Aspect Ratio = 1.2

Rudder Stock:

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

= 4.2 x $\sqrt[3]{11615.912 \times 1}$

= 100 mm

Force and Torque Calculation:

Rudder Force, $C_R = 132 \times A^1 \times V^2 \times k_1 \times k_2 \times k_3 \times k_t$

= v = v_0 for ahead condition

$k_1 = \frac{Aspect\ ratio+2}{3}$ = 1.067

k_2 = 1.1 (ahead condition)

k_3= .8 (rudder outside the propeller jet)

k_t= 1(normally)

C_R = 132 x 8.52 x 10^2 x 1.067 x 1.1 x .8 x 1

= 105599.2 N

Rudder Torque, Q_R= C_R x r

Again, r = c ($\alpha \times K_b$) α = .33 = for ahead condition

$K_b = \frac{A_f}{A}$ = .2

r = 2.27x (.33 x 0.2)

= 0.15 m

QR = 105599.2 x .11

= 11615.912 Nm

This value is for ahead condition.

Now, for astern condition,

Taking 40% of 10 knot yields 4 knot which is below 5 knot. So as per instruction 6 knot is taken for calculating astern condition.

$$C_R = 132 \times A^2 \times V^2 \times k_1 \times k_2 \times k_3 \times k_t$$

= 132 x 8.52 x 6^2 x 1.067 x 1.4 x .8 x 1

= 48383.63

Rudder Torque, QR= CR x r

Again, r = c ($\alpha \times Kb$)

α = .33 = for ahead condition

Kb = Af /A= 0.2

r = 2.27 x (.33 x 0.2)

= 0.15 m

QR = 105599.2 x .11

= 11615.912 Nm

Which is still greater than astern condition. Therefore, value for ahead condition is taken and previous calculation is taken as final result. And previous calculation is given below:

$$C_R = 132 \times A^2 \times V^2 \times k_1 \times k_2 \times k_3 \times k_t$$

= v = v_0 for astern condition

C_R = 132 x 3.14 x 7^2 x 1.067 x 1.4 x .8 x 1

Here, other than k_2 all the coefficients are as same as the ahead condition.

Therefore, C_R= 24300 N

Rudder Torque, QR= CR x r

Again, r = c ($\alpha \times Kb$)

α = .33 = for ahead condition

Kb = Af /A= 0.2

r = 2.27 x (.33 x 0.2)

= 0.15 m

QR = 105599.2 x .11

= 11615.912 Nm

=12 kN

Steering Gear Arrangement Selection:

From 12 kN-m torque result we end up with Hydroster's MS Series Piston type hydraulic steering gear arrangement.

And the design-model is "MS-25-35"

This particular model is capable of delivering 12 kN of working torque at working pressure wth $\alpha = 35°$

And design torque is 25 kN with the angle, $\alpha = 35°$

Appendix 7:

Trim calculation:

For no load condition:

LCG = -2.69 m = 2.69 m aft

Half Length = 36.87 m

Displacement = 638.349 m^3

LCB = -.11m

LCF = -.17 m

MCT 1cm = 52.97 ton-m/cm

WF = 36.87 -.17 = 36.7m

FL = 36.87+ .17 =37.07 m

Change of Trim, $x = \frac{(LCG + LCB)\Delta}{MCT\,1\,cm}$

= 0..311 m

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

= 0.155 m

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

= 0.156 m

Final Draft of Vessel at No Load Condition			
	Draft (aft)	Draft (fore)	Comment
Mean Draft (m)	1.1	1.1	Trim by Stern
Change in Draft (m)	0.155	0.156	
Final Draft (m)	1.255	.944	

For Full Load Condition:

LCG = 1.76 m = 1.76m (fore)

Half Length = 36.87 m

Displacement = 2659 m^3

LCB = -.43 m

LCF = -1.33 m

MCT 1cm = 57.23 ton-m/cm

WF = 36.87 – 1.33 = 35.54 m

FL = 36.87 + 1.33 = 38.2 m

Change of Trim, $x = \frac{(LCG - LCB)\Delta}{MCT\,1\,cm}$

= 0.622 m

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

= 0.3 m

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

= 0.322 m

Final Draft of Vessel at full Load Condition			
	Draft (aft)	Draft (fore)	Comment
Mean Draft (m)	4.4	4.4	Trim by Stern
Change in Draft (m)	0.3	0.322	
Final Draft (m)	4.7	4.078	