Bangladesh University of Engineering and Technology

Department of Naval Architecture and Marine Engineering

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NAME-338 SHIP DESIGN PROJECT AND PRESENTATION

Design of a Stern Trawler for the Coastal Region of Bangladesh

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Abstract

Based on the owner's requirements, a set of basis ships operating under similar conditions were selected which enabled us to determine the principal particulars of our vessel. Iteratively, a lines plan satisfying the requirements was generated and scantling of the structural members of the vessel were referenced from Germanischer Lloyd 2013.
The resistance and powering calculations along with detailed weight estimation have been calculated with numerous iterations which in essence resulted in our final general arrangement plan. It was ensured that the designed vessel complied with IMO-A.749 criteria for stability and was equipped with lifesaving appliances according to SOLAS.
To provide a clear representation of the designed vessel, a 3D model has been generated using Rhino in conjunction with Blender.

As for the report, the summary of the project work has been ordered chronologically and the detailed calculations have been included in the Appendix section.

Contents

1. Introduction

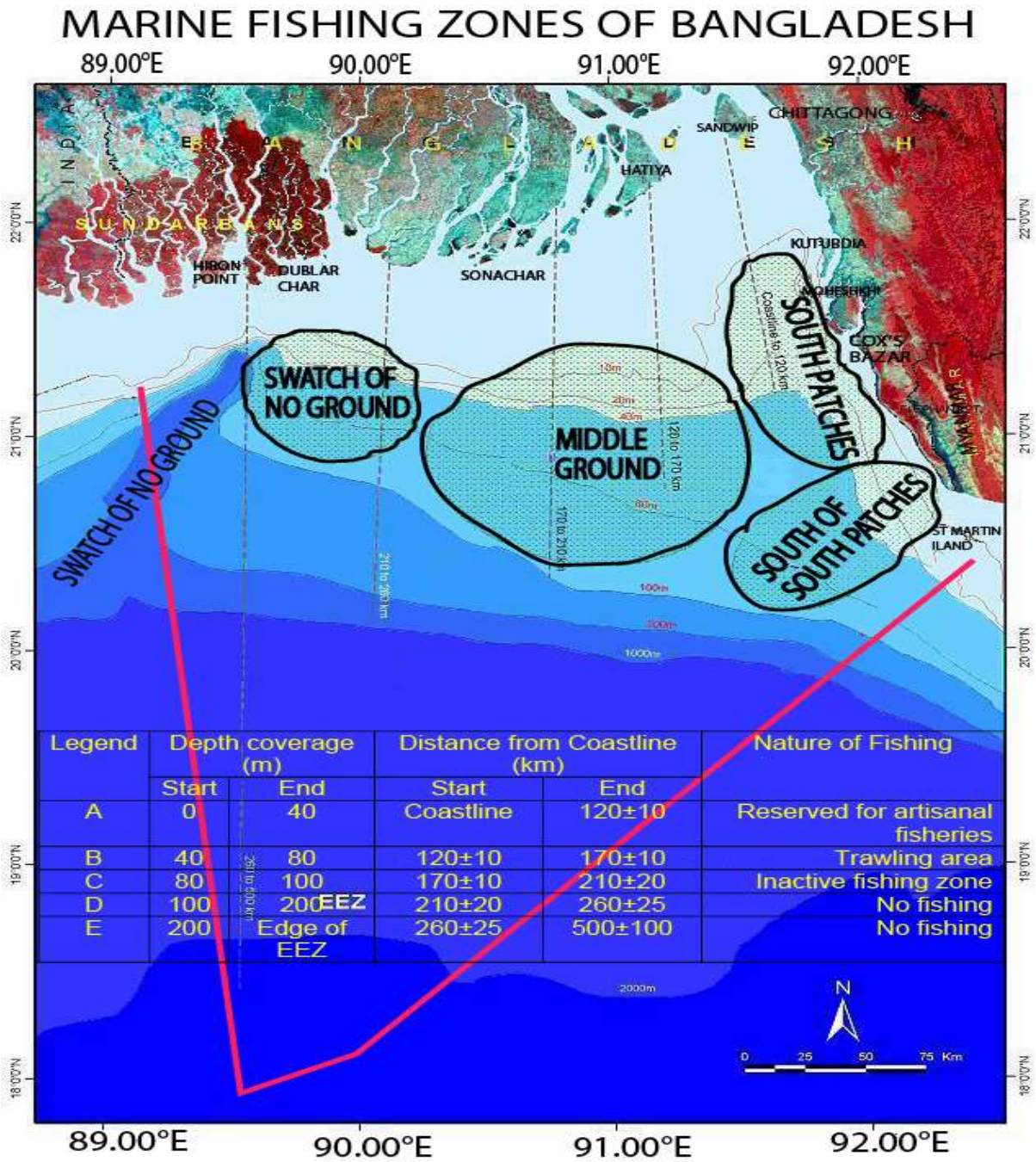
The report is divided into 22 chapters where chapters 2 and 3 holds the owner's requirements and route specification as provided by the owner. Chapter 4 contains a brief overview of the type of vessel to be designed, a Stern trawler. Chapters 5 through 20 contain all the completed calculations, designs and drawings of the designed vessel. Chapter 21 contains a detailed overview of the process that was used to generate the detailed 3D model of the final designed vessel. And finally chapter 22 contains the appendix, which comprises the elaborate calculations and tables used to complete the weight and stability calculations.

2. Owner's Requirement :

- **Type of ship** : Stern Trawler
- **Fish-Hold Capacity** : 600 cubic metre
- **Service Speed** : 10 knots
- **Route** : Coastal Region, Bangladesh
- **Voyage** : 15 Days

3. Route Specification:

The zone of operation will be the coastal region of Bangladesh. The ship will not be entering inland, beyond Chattogram. Due to this, no inland route restrictions apply. A schematic of the coastal fishing zones of Bangladesh is given below as reference.



Legend	Depth coverage (m)		Distance from Coastline (km)		Nature of Fishing
	Start	End	Start	End	
A	0	40	Coastline	120±10	Reserved for artisanal fisheries
B	40	80	120±10	170±10	Trawling area
C	80	100	170±10	210±20	Inactive fishing zone
D	100	200	210±20	260±25	No fishing
E	200	Edge of EEZ	260±25	500±100	No fishing

4. Stern Trawler Overview

Vessel overview

On stern trawlers the trawl is set and hauled over the stern. Stern trawlers are designed with or without a ramp, depending on the size of the vessel. Some pelagic stern trawlers are built without a ramp. Stern trawlers are built for nearly all weather conditions. Trawlers can work as a single vessel in bottom or midwater trawling or as pair trawlers where two vessels tow one large trawl or a double trawl.

Deck Arrangement

The superstructure is placed forward with the working deck aft. Gallows are placed on the stern quarters or there is a stern gantry for the operation of the otter boards. Net drums and gilson-winches are installed to assist in the handling of gear and catch. Fish pumps are often installed on pelagic trawlers. In most cases the handling of the catch and any processing of fish will take place below deck or in deck houses.

Catch Handling and Processing Equipment

Fresh fish in ice (Wet-fish stern trawler) or refrigerated sea water and/or frozen fish in blocks or boxes (Freezer stern trawler) and processed catch (Factory stern trawler).

Equipments

Deck Equipment

There will be various arrangements of the deck equipment depending on the type of trawler concerned. All trawlers will carry trawl winches for handling and storage of the towing warps. Gilson winches, net drums and other auxiliary winches are commonly installed to handle the gear and the catch. Pelagic trawlers may be equipped with fish pumps for emptying the codend.

Fish Detection Equipment

According to its size, the stern trawlers may be fitted with a combination of detection equipment such as sonar, net sounder, various echo sounders and some gear control and monitoring equipment; like catch sensors, that gives information about the filling rate of the codend; symmetry sensors, that provide information about the trawls optimal geometry; tension sensors, that gives information about the tension in warps or sweeps; "trawl eye", that gives additional information about fish concentrations over, under and in the trawl opening, plus clearance from the bottom and opening of the trawl.

Trawls are cone shaped nets which are towed by boats on the bottom or in midwater. The cone shaped body ends in a bag or codend. The horizontal opening of the gear while it is is maintained by beams, otter boards or by the distance between the two towing vessels (pair trawling). Floats and weights and/or hydrodynamic devices provide for the vertical opening.
Two parallel trawls might be rigged between two otterboards (twin trawls). The mesh size in the codend or special designed devices is used to regulate the size and species to be captured.

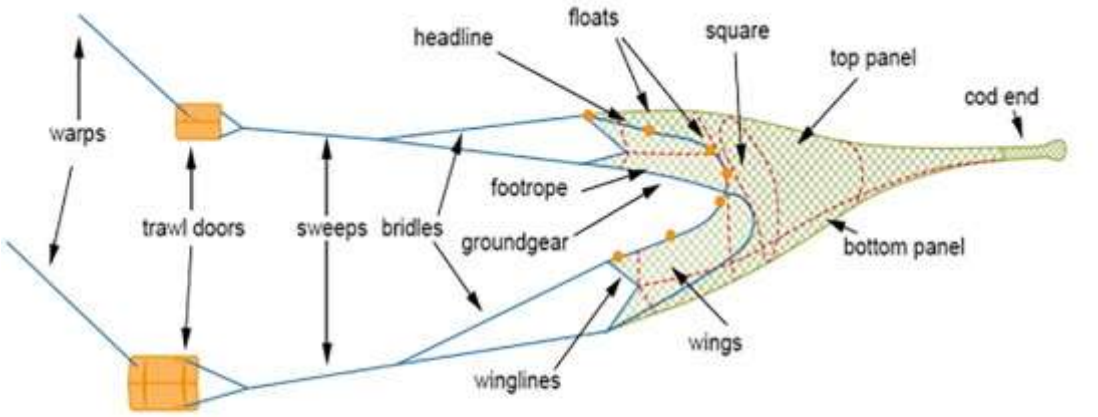


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Fig. 5. Standard otter trawl design of bottom trawl (Weissenberger, 2015).

Net Sounder :

Netsounder is an echo sounder with a transducer mounted on the headline of the net rather than on the bottom of the vessel. As the codend fills up these tension transducers are triggered one by one and this information is transmitted acoustically or by cable to monitors on the bridge of the vessel. The skipper can then decide when to haul the net.

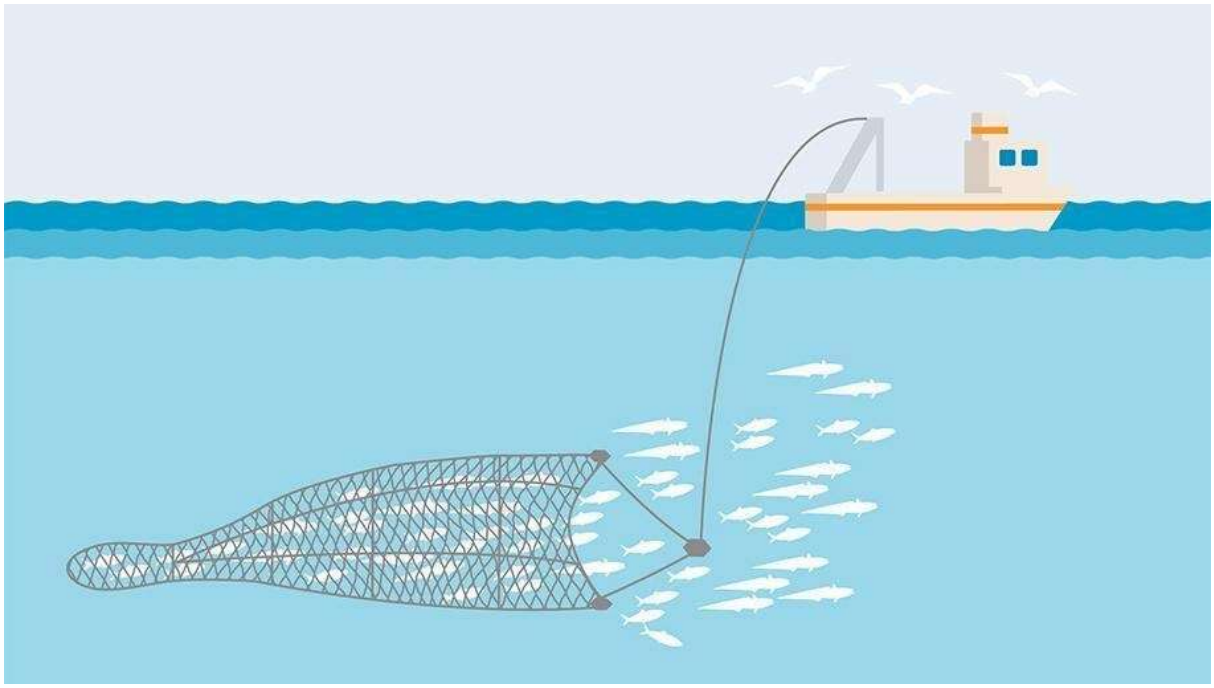


Image Reference : msc.org

Reference:

FAO fishing vessel guidelines for stern trawlers

5. Principal Particulars

First, a set of basis ships with similar operating conditions as to the required design were chosen, and based on this, preliminary particulars were selected.

The preliminary particulars and the final particulars after completion of design are given below.

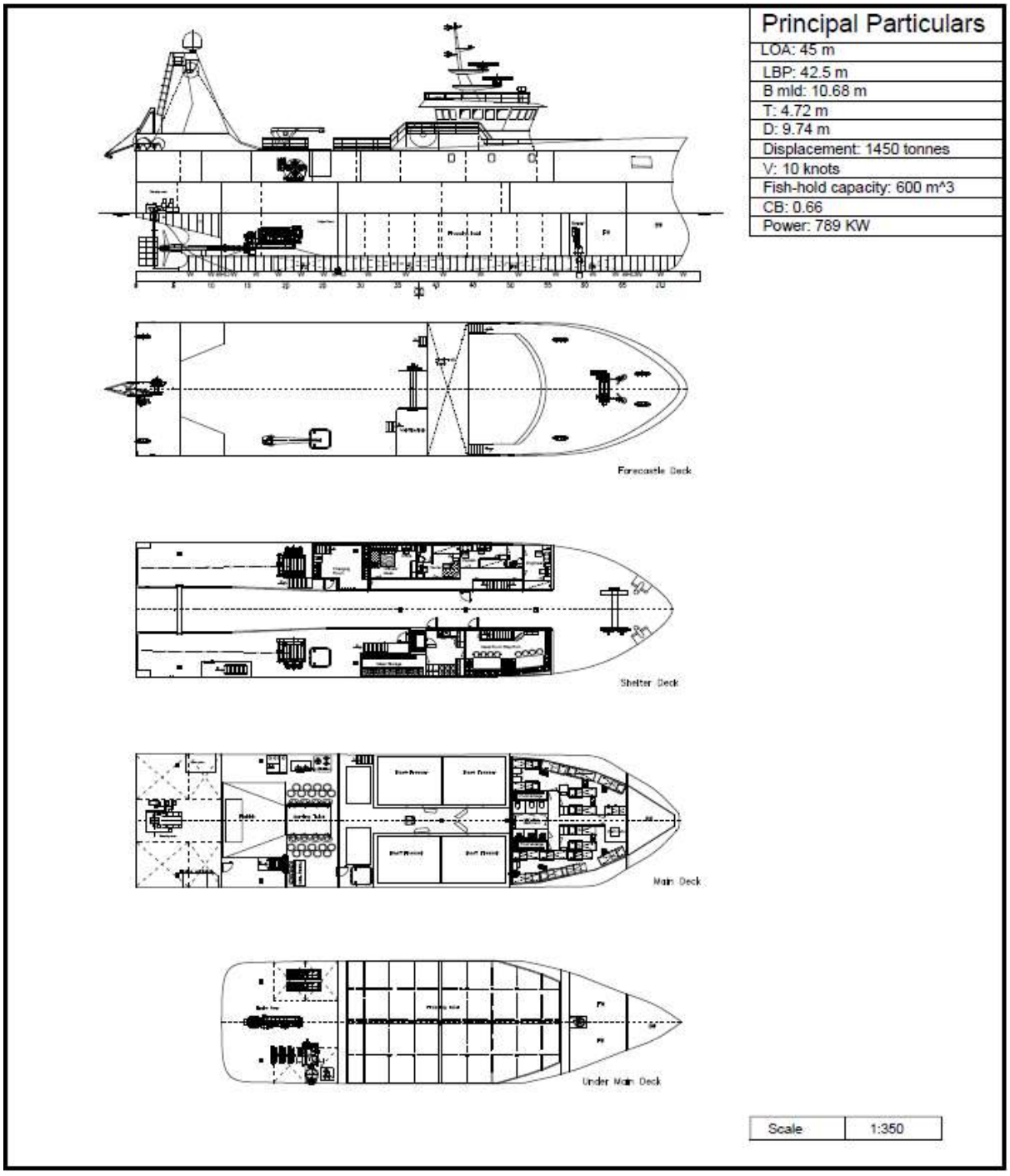
Preliminary Principal Particulars

Properties	Class Fishing Vessel for East African coast	SkipaSyn Class Fishing Vessel	Preliminary Particulars
Length,LBP	36.5 m	39.6 m	39.6 m
Breadth	9.15 m	11 m	11 m
Draft	4.34 m	4.4 m	4.4 m
Depth to Main Deck	4.6 m	4.7 m	5.04 m
Displacement	730 tonnes	1450 tonnes	1450 tonnes
Cb	0.472	0.643	0.6
Power	805 KW	1500 KW	911.6 KW
Speed	11 Kts	11 Kts	10 Kts
Fish hold	330 m^3	486 m^3	600 m^3
Fuel capacity	90 tonnes	-	24 tonnes
Voyage	23 days	-	15 days

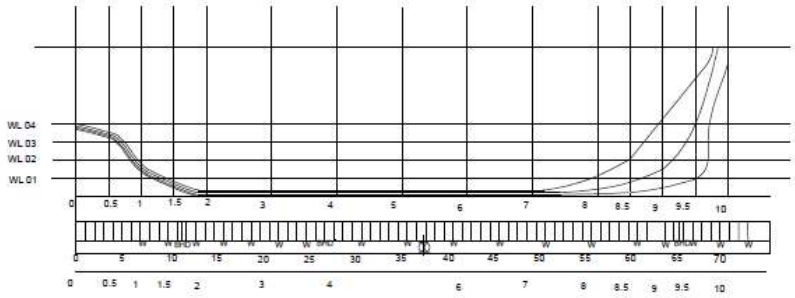
Final Principal Particulars

Properties	Design ship
Length, LOA	45 m
Length, LBP	42.5 m
Breadth	10.68 m
Draft	4.72 m
Depth to Shelter Deck	9.68 m
Displacement	1450 tonnes
Cb	0.66
Power	1030 KW
Speed	10 kts
Fish hold	600 m^3
Fuel capacity	29 tonnes
Voyage	15 days

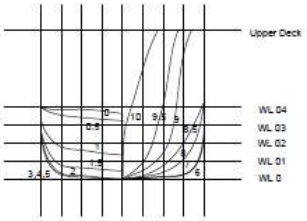
6. General Arrangement



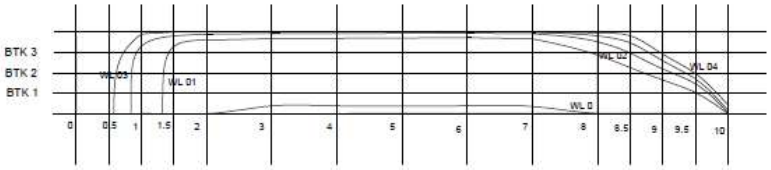
7. Lines Plan



Profile



Body Plan



Half Breadth Plan

Scale	1:280

Offset Table :

Station	Half Breadth					Above Baseline			
	WL 0	WL 1	WL 2	WL 3	WL 4	Keel	BTK 1	BTK 2	BTK 3
0.0	0.00	0.00	0.00	0.00	3269.82	3155.00	3284.00	3424.00	3540.00
0.5	0.00	0.00	0.00	0.00	5227.68	2581.00	2687.00	2809.00	2942.00
1.0	0.00	0.00	0.00	2323.55	5342.85	1519.00	1636.00	1791.00	1960.00
1.5	0.00	0.00	3267.57	5289.42	5342.85	574.00	672.00	812.00	978.00
2.0	0.00	4506.04	5228.87	5342.85	5342.85	92.00	167.00	269.00	381.00
3.0	514.90	5034.86	5304.86	5342.85	5342.85	0.00	59.00	142.00	289.00
4.0	514.90	5034.86	5304.86	5342.85	5342.85	0.00	59.00	142.00	289.00
5.0	514.90	5034.86	5304.86	5342.85	5342.85	0.00	59.00	142.00	289.00
6.0	514.90	5034.86	5304.86	5342.85	5342.85	0.00	59.00	142.00	289.00
7.0	480.00	4442.76	5054.34	5271.61	5340.48	0.00	68.00	172.00	313.00
8.0	0.00	2605.77	3493.04	4294.46	4983.10	0.00	150.00	460.00	1329.00
8.5	0.00	1860.97	2622.75	3545.28	4466.62	0.00	242.00	910.00	2419.00
9.0	0.00	1149.31	1744.14	2667.86	3635.51	0.00	551.00	1753.00	6353.00
9.5	0.00	817.11	1154.06	1754.83	2411.41	0.00	1111.00	4872.00	7097.00
10.0	0.00	470.55	708.82	949.84	908.28	0.00	5931.00	7045.00	8000.00

8. Hydrostatic Calculations

Load Draft : 4.72 m
Number of waterlines : 4
Waterline spacing : 1.18 m

Hydrostatic Calculations for Waterline 4

No. of ordinates	SM	Waterline										F. Of Area	M. of Area	Lever	Moments
		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-6	Col-7	Col-8	Col-9
0	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.27	1.63				
		0.00		0.00		0.00		0.00		3.27		3.27	1.63	0.00	0.00
0.5	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.23	10.46				
		0.00		0.00		0.00		0.00		5.23		5.23	10.46	0.50	5.23
1	1	0.00	0.00	0.00	0.00	0.00	0.00	2.32	2.32	5.34	5.34				
		0.00		0.00		0.00		9.29		5.34		14.64	14.64	1.00	14.64
1.5	2	0.00	0.00	0.00	0.00	3.27	6.54	5.29	10.58	5.34	10.69				
		0.00		0.00		6.54		21.16		5.34		33.04	66.07	1.50	99.11
2	1.5	0.00	0.00	4.51	6.76	5.23	7.84	5.34	8.01	5.34	8.01				
		0.00		18.02		10.46		21.37		5.34		55.20	82.79	2.00	165.59
3	4	0.51	2.06	5.03	20.14	5.30	21.22	5.34	21.37	5.34	21.37				
		0.51		20.14		10.61		21.37		5.34		57.98	231.91	3.00	695.74
4	2	0.51	1.03	5.03	10.07	5.30	10.61	5.34	10.69	5.34	10.69				
		0.51		20.14		10.61		21.37		5.34		57.98	115.96	4.00	463.83
5	4	0.51	2.06	5.03	20.14	5.30	21.22	5.34	21.37	5.34	21.37				
		0.51		20.14		10.61		21.37		5.34		57.98	231.91	5.00	1159.57
6	2	0.51	1.03	5.03	10.07	5.30	10.61	5.34	10.69	5.34	10.69				
		0.51		20.14		10.61		21.37		5.34		57.98	115.96	6.00	695.74
7	4	0.59	2.35	4.44	17.77	5.05	20.22	5.27	21.09	5.34	21.36				
		0.59		17.77		10.11		21.09		5.34		54.89	219.57	7.00	1537.01
8	1.5	0.00	0.00	2.61	3.91	3.49	5.24	4.29	6.44	4.98	7.47				
		0.00		10.42		6.99		17.18		4.98		39.57	59.36	8.00	474.84

8.5	2	0.00	0.00	1.86	3.72	2.62	5.25	3.55	7.09	4.47	8.93				
		0.00		7.44		5.25		14.18		4.47		31.34	62.67	8.50	532.73
9	1	0.00	0.00	1.15	1.15	1.74	1.74	2.67	2.67	3.64	3.64				
		0.00		4.60		3.49		10.67		3.64		22.39	22.39	9.00	201.53
9.5	2	0.00	0.00	0.82	1.63	1.15	2.31	1.75	3.51	2.41	4.82				
		0.00		3.27		2.31		7.02		2.41		15.01	30.01	9.50	285.14
10	0.5	0.00	0.00	0.47	0.24	0.71	0.35	0.95	0.47	0.91	0.45				
		0.00		1.88		1.42		3.80		0.91		8.01	4.00	10.00	40.04
Col-10			8.53		95.60		113.15		126.30		146.93		1269.35		6370.73
Col-11			1.00		4.00		2.00		4.00		1.00				
Col-12			8.53		382.39		226.29		505.21		146.93		1269.35		
Col-13			4.00		3.00		2.00		1.00		0.00				
Col-14			34.10		1147.17		452.58		505.21		0.00		2139.07		

SW Displacement	VCB below WL-4	LCB from aft	KB
1449.98 tonnes	1.99 m	21.33 m	2.73 m

Hydrostatic Calculations for Waterline 3

No. of ordinates	SM	Waterline								F. Of Area	M. of Area	Lever	Moments
		WL - 0		WL - 1		WL - 2		WL - 3					
		SM											
		1		3		3		1					
		Col-1		Col-2		Col-3		Col-4		Col-5	Col-6	Col-7	Col-8
0	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	0.00	0.00
0.5	2	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	0.50	0.00
1	1	0.00	0.00	0.00	0.00	0.00	0.00	2.32	2.32				
		0.00		0.00		0.00		2.32		2.32	2.32	1.00	2.32
1.5	2	0.00	0.00	0.00	0.00	3.27	6.54	5.29	10.58				
		0.00		0.00		9.80		5.29		15.09	30.18	1.50	45.28
2	1.5	0.00	0.00	4.51	6.76	5.23	7.84	5.34	8.01				
		0.00		13.52		15.69		5.34		34.55	51.82	2.00	103.64
3	4	0.51	2.06	5.03	20.14	5.30	21.22	5.34	21.37				
		0.51		15.10		15.91		5.34		36.88	147.51	3.00	442.52
4	2	0.51	1.03	5.03	10.07	5.30	10.61	5.34	10.69				
		0.51		15.10		15.91		5.34		36.88	73.75	4.00	295.02
5	4	0.51	2.06	5.03	20.14	5.30	21.22	5.34	21.37				
		0.51		15.10		15.91		5.34		36.88	147.51	5.00	737.54
6	2	0.51	1.03	5.03	10.07	5.30	10.61	5.34	10.69				
		0.51		15.10		15.91		5.34		36.88	73.75	6.00	442.52
7	4	0.59	2.35	4.44	17.77	5.05	20.22	5.27	21.09				

		0.59		13.33		15.16		5.27		34.35	137.40	7.00	961.79
8	1.5	0.00	0.00	2.61	3.91	3.49	5.24	4.29	6.44				
		0.00		7.82		10.48		4.29		22.59	33.89	8.00	271.09
8.5	2	0.00	0.00	1.86	3.72	2.62	5.25	3.55	7.09				
		0.00		5.58		7.87		3.55		17.00	33.99	8.50	288.94
9	1	0.00	0.00	1.15	1.15	1.74	1.74	2.67	2.67				
		0.00		3.45		5.23		2.67		11.35	11.35	9.00	102.13
9.5	2	0.00	0.00	0.82	1.63	1.15	2.31	1.75	3.51				
		0.00		2.45		3.46		1.75		7.67	15.34	9.50	145.70
10	0.5	0.00	0.00	0.47	0.24	0.71	0.35	0.95	0.47				
		0.00		1.41		2.13		0.95		4.49	2.24	10.00	22.44
Col-9			8.53		95.60		113.15		126.30		761.06		3860.93
Col-10			1.00		3.00		3.00		1.00				
Col-11			8.53		286.79		339.44		126.30		761.06		
Col-12			3.00		2.00		1.00		0.00				
Col-13			25.58		573.59		339.44		0.00		938.60		

SW Displacement	VCB below WL-4	LCB from aft	KB
973.08 tonnes	1.46 m	21.56 m	2.08 m

Hydrostatic Calculations for Waterline 2

No. of ordinates	SM	Waterline						F. Of Area	M. of Area	Lever	Moments
		WL - 0		WL - 1		WL - 2					
		SM									
		1		4		1					
		Col-1		Col-2		Col-3		Col-4	Col-5	Col-6	Col-7
0	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
0.5	2	0.00	0.00	0.00	0.00	0.00	0.00				
		0.00		0.00		0.00		0.00	0.00	0.50	0.00
1	1	0.00	0.00	0.00	0.00	0.00	0.00				
		0.00		0.00		0.00		0.00	0.00	1.00	0.00
1.5	2	0.00	0.00	0.00	0.00	3.27	6.54				
		0.00		0.00		3.27		3.27	6.54	1.50	9.80
2	1.5	0.00	0.00	4.51	6.76	5.23	7.84				
		0.00		18.02		5.23		23.25	34.88	2.00	69.76
3	4	0.51	2.06	5.03	20.14	5.30	21.22				
		0.51		20.14		5.30		25.96	103.84	3.00	311.51
4	2	0.51	1.03	5.03	10.07	5.30	10.61				
		0.51		20.14		5.30		25.96	51.92	4.00	207.67
5	4	0.51	2.06	5.03	20.14	5.30	21.22				
		0.51		20.14		5.30		25.96	103.84	5.00	519.18
6	2	0.51	1.03	5.03	10.07	5.30	10.61				
		0.51		20.14		5.30		25.96	51.92	6.00	311.51
7	4	0.59	2.35	4.44	17.77	5.05	20.22				
		0.59		17.77		5.05		23.41	93.65	7.00	655.54
8	1.5	0.00	0.00	2.61	3.91	3.49	5.24				
		0.00		10.42		3.49		13.92	20.87	8.00	166.99
8.5	2	0.00	0.00	1.86	3.72	2.62	5.25				
		0.00		7.44		2.62		10.07	20.13	8.50	171.13
9	1	0.00	0.00	1.15	1.15	1.74	1.74				
		0.00		4.60		1.74		6.34	6.34	9.00	57.07
9.5	2	0.00	0.00	0.82	1.63	1.15	2.31				
		0.00		3.27		1.15		4.42	8.85	9.50	84.03
10	0.5	0.00	0.00	0.47	0.24	0.71	0.35				
		0.00		1.88		0.71		2.59	1.30	10.00	12.96
Col-8			8.53		95.60		113.15		504.06		2577.16

Col-9		1.00		4.00		1.00				
Col-10		8.53		382.39		113.15		504.06		
Col-11		2.00		1.00		0.00				
Col-12		17.05		382.39		0.00		399.44		

SW Displacement	VCB below WL-4	LCB from aft	KB
575.79 tonnes	0.94 m	21.73 m	1.42 m

Hydrostatic Calculations for Waterline 1

No. of ordinates	SM	Waterline						F. Of Area	M. of Area	Lever	Moments
		WL - 0		WL - 1		WL - 2					
		SM									
		5		8		-1					
		Col-1		Col-2		Col-3		Col-4	Col-5	Col-6	Col-7
0	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
0.5	2	0.00	0.00	0.00	0.00	0.00	0.00				
		0.00		0.00		0.00		0.00	0.00	0.50	0.00
1	1	0.00	0.00	0.00	0.00	0.00	0.00				
		0.00		0.00		0.00		0.00	0.00	1.00	0.00
1.5	2	0.00	0.00	0.00	0.00	3.27	6.54				
		0.00		0.00		-3.27		-3.27	-6.54	1.50	-9.80
2	1.5	0.00	0.00	4.51	6.76	5.23	7.84				
		0.00		36.05		-5.23		30.82	46.23	2.00	92.46
3	4	0.51	2.06	5.03	20.14	5.30	21.22				
		2.57		40.28		-5.30		37.55	150.19	3.00	450.58
4	2	0.51	1.03	5.03	10.07	5.30	10.61				
		2.57		40.28		-5.30		37.55	75.10	4.00	300.39
5	4	0.51	2.06	5.03	20.14	5.30	21.22				
		2.57		40.28		-5.30		37.55	150.19	5.00	750.97
6	2	0.51	1.03	5.03	10.07	5.30	10.61				
		2.57		40.28		-5.30		37.55	75.10	6.00	450.58
7	4	0.59	2.35	4.44	17.77	5.05	20.22				
		2.93		35.54		-5.05		33.42	133.68	7.00	935.79
8	1.5	0.00	0.00	2.61	3.91	3.49	5.24				
		0.00		20.85		-3.49		17.35	26.03	8.00	208.24
8.5	2	0.00	0.00	1.86	3.72	2.62	5.25				
		0.00		14.89		-2.62		12.27	24.53	8.50	208.51
9	1	0.00	0.00	1.15	1.15	1.74	1.74				
		0.00		9.19		-1.74		7.45	7.45	9.00	67.05
9.5	2	0.00	0.00	0.82	1.63	1.15	2.31				
		0.00		6.54		-1.15		5.38	10.77	9.50	102.27
10	0.5	0.00	0.00	0.47	0.24	0.71	0.35				
		0.00		3.76		-0.71		3.06	1.53	10.00	15.28
Col-8			8.53		95.60		113.15		694.26		3572.32
Col-9			5.00		8.00		-1.00				

Col-10		42.63		764.78		-113.15		694.26		
Col-11		1.00		0.00		-1.00				
Col-12		42.63		0.00		113.15		155.77		

SW Displacement	VCB below WL-4	LCB from aft	KB
198.27 tonnes	0.19 m	21.87 m	0.99 m

Transverse Metacentric Height Calculation for Waterline 4

No. of Ordinates	SM	Metacentre							
		WL-4	Transverse		Longitudinal				
			Cubes	Func.of Cubes	Func. of Ordinates	Lever	Func. Of CF	Lever	Func. Of Moment of Inertia
		Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
0	0.5	3.27	34.96	17.48	1.63	0.00	0.00	0.00	0.00
0.5	2	5.23	142.87	285.73	10.46	0.50	5.23	0.50	2.61
1	1	5.34	152.52	152.52	5.34	1.00	5.34	1.00	5.34
1.5	2	5.34	152.52	305.03	10.69	1.50	16.03	1.50	24.04
2	1.5	5.34	152.52	228.78	8.01	2.00	16.03	2.00	32.06
3	4	5.34	152.52	610.07	21.37	3.00	64.11	3.00	192.34
4	2	5.34	152.52	305.03	10.69	4.00	42.74	4.00	170.97
5	4	5.34	152.52	610.07	21.37	5.00	106.86	5.00	534.29
6	2	5.34	152.52	305.03	10.69	6.00	64.11	6.00	384.69
7	4	5.34	152.31	609.26	21.36	7.00	149.53	7.00	1046.73
8	1.5	4.98	123.74	185.60	7.47	8.00	59.80	8.00	478.38
8.5	2	4.47	89.11	178.22	8.93	8.50	75.93	8.50	645.43
9	1	3.64	48.05	48.05	3.64	9.00	32.72	9.00	294.48
9.5	2	2.41	14.02	28.04	4.82	9.50	45.82	9.50	435.26
10	0.5	0.91	0.75	0.37	0.45	10.00	4.54	10.00	45.41
				3869.30	**146.93**		**688.80**		**4292.03**

WL 4 Displacement	KB for WL-4	BMT	Area of WP - 4	TPC	KMT

1449.98 tonnes	2.73 m	0.20 m	416.30 sq. m	4.27 tonnes	2.93 m

Longitudinal I aft	Longitudinal ICF	MCTC	KML	CF from aft	Longitudinal BM
219653.46 m^4	54400.82 m^4	12.80 tonnes	40.25 m	19.92 m	37.52 m

Transverse Metacentric Height Calculation for Waterline 3

No. of Ordinates	SM	Metacentre							
		WL-3	Transverse		Longitudinal				
			Cubes	Func.of Cubes	Func. of Ordinates	Lever	Func. Of CF	Lever	Func. Of Moment of Inertia
		Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
0	0.500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.5	2.000	0.00	0.00	0.00	0.00	0.50	0.00	0.50	0.00
1	1.000	2.32	12.54	12.54	2.32	1.00	2.32	1.00	2.32
1.5	2.000	5.29	147.99	295.97	10.58	1.50	15.87	1.50	23.80
2	1.500	5.34	152.52	228.78	8.01	2.00	16.03	2.00	32.06
3	4.000	5.34	152.52	610.07	21.37	3.00	64.11	3.00	192.34
4	2.000	5.34	152.52	305.03	10.69	4.00	42.74	4.00	170.97
5	4.000	5.34	152.52	610.07	21.37	5.00	106.86	5.00	534.29
6	2.000	5.34	152.52	305.03	10.69	6.00	64.11	6.00	384.69
7	4.000	5.27	146.50	585.99	21.09	7.00	147.61	7.00	1033.24
8	1.500	4.29	79.20	118.80	6.44	8.00	51.53	8.00	412.27
8.5	2.000	3.55	44.56	89.12	7.09	8.50	60.27	8.50	512.29
9	1.000	2.67	18.99	18.99	2.67	9.00	24.01	9.00	216.10
9.5	2.000	1.75	5.40	10.81	3.51	9.50	33.34	9.50	316.75
10	0.500	0.95	0.86	0.43	0.47	10.00	4.75	10.00	47.49
				3191.64	**126.30**		**633.56**		**3878.60**

WL 3 Displacement	KB for WL-3	BMT	Area of WP - 3	TPC	KMT
978.03 tonnes	**2.09 m**	**0.24 m**	**357.86 sq. m**	**3.67 tonnes**	**2.33 m**

Longitudinal I aft	Longitudinal ICF	MCTC	KML	CF from aft	Longitudinal BM
198495.43 m^4	35851.06 m^4	8.44 tonnes	38.74 m	21.32 m	36.66 m

Transverse Metacentric Height Calculation for Waterline 2

No. of Ordinates	SM	Metacentre							
		WL-2	Transverse		Longitudinal				
			Cubes	Func.of Cubes	Func. of Ordinates	Lever	Func. Of CF	Lever	Func. Of Moment of Inertia
		Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
0	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.5	2	0.00	0.00	0.00	0.00	0.50	0.00	0.50	0.00
1	1	0.00	0.00	0.00	0.00	1.00	0.00	1.00	0.00
1.5	2	3.27	34.89	69.78	6.54	1.50	9.80	1.50	14.70
2	1.5	5.23	142.96	214.44	7.84	2.00	15.69	2.00	31.37
3	4	5.30	149.29	597.15	21.22	3.00	63.66	3.00	190.97
4	2	5.30	149.29	298.57	10.61	4.00	42.44	4.00	169.76
5	4	5.30	149.29	597.15	21.22	5.00	106.10	5.00	530.49
6	2	5.30	149.29	298.57	10.61	6.00	63.66	6.00	381.95
7	4	5.05	129.12	516.48	20.22	7.00	141.52	7.00	990.65
8	1.5	3.49	42.62	63.93	5.24	8.00	41.92	8.00	335.33
8.5	2	2.62	18.04	36.08	5.25	8.50	44.59	8.50	378.99
9	1	1.74	5.31	5.31	1.74	9.00	15.70	9.00	141.28
9.5	2	1.15	1.54	3.07	2.31	9.50	21.93	9.50	208.31
10	0.5	0.71	0.36	0.18	0.35	10.00	3.54	10.00	35.44
				2700.71	**113.15**		**570.53**		**3409.23**

WL 2 Displacement	KB for WL-2	BMT	Area of WP - 2	TPC	KMT
575.79 tonnes	1.43 m	0.35 m	320.58 sq. m	3.29 tonnes	1.77 m

Longitudinal I aft	Longitudinal ICF	MCTC	KML	CF from aft	Longitudinal BM
174474.68 m^4	27242.92 m^4	6.41 tonnes	48.74 m	21.43 m	47.31 m

Transverse Metacentric Height Calculation for Waterline 1

No. of Ordinates	SM	Metacentre							
		WL-1	Transverse		Longitudinal				
			Cubes	Func.of Cubes	Func. of Ordinates	Lever	Func. Of CF	Lever	Func. Of Moment of Inertia
		Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
0	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.5	2	0.00	0.00	0.00	0.00	0.50	0.00	0.50	0.00
1	1	0.00	0.00	0.00	0.00	1.00	0.00	1.00	0.00
1.5	2	0.00	0.00	0.00	0.00	1.50	0.00	1.50	0.00
2	1.5	4.51	91.49	137.24	6.76	2.00	13.52	2.00	27.04
3	4	5.03	127.63	510.53	20.14	3.00	60.42	3.00	181.26
4	2	5.03	127.63	255.27	10.07	4.00	40.28	4.00	161.12
5	4	5.03	127.63	510.53	20.14	5.00	100.70	5.00	503.49
6	2	5.03	127.63	255.27	10.07	6.00	60.42	6.00	362.51
7	4	4.44	87.69	350.77	17.77	7.00	124.40	7.00	870.78
8	1.5	2.61	17.69	26.54	3.91	8.00	31.27	8.00	250.15
8.5	2	1.86	6.44	12.89	3.72	8.50	31.64	8.50	268.91
9	1	1.15	1.52	1.52	1.15	9.00	10.34	9.00	93.09

9.5	2	0.82	0.55	1.09	1.63	9.50	15.53	9.50	147.49
10	0.5	0.47	0.10	0.05	0.24	10.00	2.35	10.00	23.53
				2061.69	**95.60**		**490.86**		**2889.36**

WL 1 Displacement	KB for WL-1	BMT	Area of WP - 1	TPC	KMT
193.43 tonnes	**0.99 m**	**0.79 m**	**270.86 sq. m**	**2.78 tonnes**	**1.78 m**

Longitudinal I aft	Longitudinal ICF	MCTC	KML	CF from aft	Longitudinal BM
147868.95 m^4	**18885.21 m^4**	**4.44 tonnes**	**98.62 m**	**21.82 m**	**97.63 m**

9. Scantling Calculations

Particulars:

Length of ship, $L = 42.5\ m$

Breadth of ship, $B = 10.68m$

Draft, $T = 4.72\ m$

Height, $H = 9.74\ m$

Block coefficient, $C_B = 0.66$

Transverse Frame spacing, **a** = 0.5 m [Ref: GL 2013 Sec-9- B.1.1]

Web frame spacing, $e = 1.8m$

Material factor, $K = 1$

Summary

Name of Component	Dimensions
Bottom Plate	Thickness: 8.5 mm
Keel Plate	Thickness:10.5 mm; Width: 1013mm
Inner Bottom Plate	Thickness:6 mm
Deck Plate	Thickness:7 mm
Bulkhead Plate	Thickness: 6 mm
Side Shell Plate	Thickness: 8 mm
Bilge Plate	Thickness:8 mm; Width: 1013mm
Sheer Strake	Thickness:8 mm; Width: 1013 mm
Floor	Thickness:7.31 mm
Center Keelson	T - 841×262×9.31
Side Keelson	T - 511×229×7

Deck Side Girder	T - 465×230×7.5
Deck Beam	L - 75×55×5
Bulkhead Stiffener	L - 60×40×5
Web Frame and Side Stringer	T - 128×128×5
Deck Center Girder	T - 128×136×5
Brackets	Thickness: 7.48 mm, Arm length: 240 mm
Deckhouse Side Plating	Thickness: 5mm

Center Keelson:

Depth of Center Girder, h = 350 + 45.B [Ref: GL 2013, Sec-8, C.2.2.1]

= 350 + 45×10.68 mm = 831mm ≈ 841mm

Thickness of Center Girder,

$t_m = \frac{h}{h_a}\left(\frac{h}{100}+1\right)\sqrt{k}$ mm [Ref: GL 2013, Sec-8, C.2.2.1]

$= \frac{831}{830.6}\left(\frac{831}{100}+1\right)\sqrt{1}$ mm = 9.31 mm

Dimension: T - 841×262×9.31 **(**Ref. Zulfikar.M.M. (2008).*The Inland Shipping Laws & Rules,* P-170)

Side Keelson:

Thickness of side girder, $t = \frac{830.6^2}{120.h_a}.\sqrt{K}$ [Ref: GL 2013, Sec-8, C.3.2]

$= \frac{830.6^2}{120\times831}\cdot\sqrt{1}$ = 6.9 mm ≈ 8 mm

Dimension: T - 709×247×8 **(**Ref. Zulfikar.M.M. (2008).*The Inland Shipping Laws & Rules,* P-170)

Bottom Plate:

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

C_0 = Wave Co-efficient

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

= 5.8

C_L = Length Co-efficient = $\sqrt{\frac{L}{90}}$ = 0.687 [Ref: GL 2013, Sec-4 .A.3]

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

Probability factor, f = 1; for plate panels of outer hull [Ref: GL 2013, Sec-4 .A.3]

Po = Basic external dynamic load [Ref : GL 2013 Sec-4.A.3]

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

$= 2.1 (0.66+0.7) \times 5.8 \times 0.687 \times 1$ KN/m^2

= 11.38 KN/m^2

Distribution factor , C_F = 1 for midship [Ref : GL 2013 Sec-4.A.3]

P = P_B = Load at bottom [Ref: GL 2013, Sec-4, B, 5]

$= 10\mathbf{T} + P_0.C_F$ KN/m^2

$= 10\times4.72 + 11.38\times1$ KN/m^2

= 58.58 KN/m^2

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

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

= 205.72

Maximum bottom design hull girder bending stress,

$\sigma_{LB} = \frac{12.6\sqrt{L}}{K} = 82.14$ [Ref: GL 2013, Sec-6, B, 1.2]

permissible local design stress [N / mm2], defined as:

$\sigma_{pl} = \sqrt{(\sigma_{perm}^2 - 3\tau_L^2)}$ -0.89 σ_{LB} [Ref: GL 2013, Sec-6, A.2]

$= \sqrt{(205.72^2 - 3.(0)^2)}$ -0.89 ×82.14 = 132.62 N/mm^2

Corrosion addition, t_k = 1.5 mm, for thickness ≤10 mm [Ref: GL 2013, Sec-3, G-1]

t_{B1}= 18.3x n_f × a × $\sqrt{\frac{P_B}{\sigma_{pl}}}$ + t_k [Ref: GL 2013, Sec-6, B.1]

= 18.3 x 1 x .5 x $\sqrt{\frac{58.58}{132.62}}$ + 1.5 = 7.58 mm ≈7.6 mm

t_{B2} =1.21 x a x $\sqrt{(P_B.K)}$ + t_K

= 1.21 × 0.5 × $\sqrt{58.58}$ +1.5 = 6.13 mm ≈ 6.2 mm

C_1 1.5 -0.01L For **L**<50 m [Ref: GL 2013, Sec-6, B, 2]

=1.075

Again, Minimum bottom plate thickness,

= c1 $\sqrt{(L.K)}$ + t_k = 8.5 mm

So, Thickness of Bottom Plate, t_B =**8.5 mm**

Keel Plate:

t_B = thickness of bottom plate = 8.5 mm

Width of the flat plate keel, b = 800 + 5 **L** mm

= 800 + 5×42.5 = 1013 mm

Thickness, $t_{F,K} = t_B + 2$ mm

= 8.5 + 2 mm = **10.5 mm** [Ref: GL 2013, Sec-6, B.4.1]

Inner Bottom Plate:

Inner Bottom Plate Thickness, [Ref: GL 2013, Sec-8, C.4.1]

$t = 1.1 \times a \times \sqrt{P.K} + t_K$ mm

$= 1.1 \times 0.5 \times \sqrt{58.58 \times 1} + 1.5\ mm$ = 5.71 mm ≈ 6 **mm**

Deck Plate:

Thickness, $t_{min} = (5.5 + 0.02\ \mathbf{L})\sqrt{K}$ mm [Ref: GL 2013, Sec-7, B.4.3.2]

$= (5.5 + 0.02 \times 42.5)\sqrt{1}$ mm

= 6.35 mm ≈ **7 mm**

Bulkhead Plate:

R_{eH} = Nominal Yield Stress = 235 N/mm^2 , For K=1 [Ref: GL 2013, Sec-2.A]

Material Factor , $f = \frac{235}{ReH} = 1$ [Ref: GL 2013, Sec-11 .A.2]

$t_{min} = 6.0\sqrt{f}\ mm = 6\sqrt{1}\ mm = 6\ mm$ [Ref: GL 2013, Sec-11, B.1]

Side Shell Plate:

Wave coefficient, Co = Wave Coefficient **(***Ref.Sec-4, A 3)*

$= \left[\frac{L}{25} + 4.1\right] . C_{RW}$

$= \left[\frac{42.5}{25} + 4.1\right] .1$

=5.8

C_0 = Wave Co-efficient = 5.8

$t_s = \mathbf{T} + (C_0/2)$ mm [Ref: GL 2013, Sec-6, C, 2]

$= 4.72 + \frac{5.8}{2}\ mm = 7.62\ mm \approx 8\ mm$

Bilge Plate:

Width, b = 800 + 5 **L** mm [Ref: GL 2013, Sec-6, B, 3.2]

= 800 + 5×42.5 = **1013 mm**

Bilge Plate Thickness = Bottom Plate Thickness = **8.5 mm** [Ref: GL 2013, Sec-6, B, 3.1]

Sheer Strake:

Width of Sheer Strake = 800 + 5 **L**

= 800 + 5×42.5 mm = **1013 mm** [Ref: GL 2013, Sec-6, C, 3.1]

t_s = thickness of side shell = 8 mm

t_D = thickness of strength deck = $(4.5 + 0.05 \cdot \mathbf{L}) \cdot \sqrt{K}$ mm [Ref: GL 2013, Sec-7, B.4.3.1.1]

$= (4.5 + 0.05 \times 42.5) \times \sqrt{1}\ mm$

= 6.63 mm

Thickness of Sheer Strake = 0.5 (t_D + t_S) mm [Ref: GL 2013, Sec-6, C.3.2]

= 7.315 mm ≈ **8 mm**

Deck Center Girder:

e= width of plating supported = 2.65 m [Ref: GL 2013, Sec-10, A, 1]

l = unsupported span = 2.65 m

Probability factor, f =0.6 for girders and girder systems of the outer hull (web frames, stringers, grillage systems) [Ref.Sec-4, A.3]

Po = Basic external dynamic load [Ref.Sec-4, A 3]

= $2.1(C_B+0.7)\ C_o \times C_L \times f$

= $2.1(0.66+0.7) \times 5.8 \times 0.687 \times 0.6$

= 6.83 KN/m^2

C_D = Distribution Factor = 1 [Ref: GL 2013, Sec-4, A.3, Table: 4.1]

vertical distance of the structure's load center above base line [m],

z = $\frac{H-h_{DB}}{2}+1 = \frac{9.7-.841}{2}+1 = 5.43\ mm$

P = P_D = Pressure on ship's deck

$= P_o \times \frac{20 \times T}{(10+Z-T)H} \times C_D$ [Ref: GL 2013, Sec-4, B, 1]

= 6.21 KN/m^2

c = 0.6 for beams and girders

Section Modulus, W = c.e.l^2.p.k [Ref: GL 2013 Sec-10, B, 2.2.1]

=0.6× 2.65×(2.65× 2.65) × 6.21× 1 cm^3

=69.34 cm^3 ≈ 100 cm^3

Dimension: T- 128x136x5 (Ref. Zulfikar.M.M. (2008).*The Inland Shipping Laws & Rules,* P-170)

Deck Side Girder:

Section Modulus, W = c.e.l^2.p.k [Ref: GL 2013 Sec-10, B, 2.2.1]

=0.6× 2.65×(2.65× 2.65) × 6.21× 1 cm^3

=69.34 cm^3 ≈ 100 cm^3

Dimension: T-128x136x5 (Ref. Zulfikar.M.M. (2008).*The Inland Shipping Laws & Rules,* P-170)

Deck Web:

P = P_D = Deck Load = 25.84 KN/m^2

Section Modulus, W_d = c. **a**. p. l^2. k..m [Ref: GL 2013, Sec-10, B, 1.1]

= .**6×.5×25.84×(1.8×1.8) ×1** cm^3 =25.11≈ 27 cm^3

Dimension: L- 75x55x5 (Ref. Zulfikar.M.M. (2008).*The Inland Shipping Laws & Rules,* P-164)

Bulkhead Stiffener

f = 0.75 for secondary stiffeners [Ref. GL 2013,Sec-4, A.3]

C_s = 0.265 f [Ref: GL 2013, Sec: 11.A.2 Table: 11.1]

= 0.265 × 0.75 = 0.198

h= $\frac{H-h_{DB}}{2} + 1$ = 2.97m

p = 9.81×h KN/m^2 = 9.81 $\times 2.97$ KN/m^2

= 29.14 KN/m^2

l= 1.8 m

Section Modulus, W = C_s. **a**. p. l^2 [Ref: GL 2013, Sec: 11, C.1]

= 9.35 cm^3

≈16cm^3

Dimension: L- 60x40x5 (Ref. Zulfikar.M.M. (2008).*The Inland Shipping Laws & Rules,* P-164)

Floor

t_m= thickness of center girder = 9.31 mm

Thickness of plate floor, $t_{pf} = t_m - 2.0 \times \sqrt{k}$ mm [Ref: GL 2013, Sec: 8,C 5.2.1]

= 9.31 – 2 $\times \sqrt{1}$ mm

= **7.31 mm**

Web Frame and Stringers

l = unsupported span = 1.8 m

Po = Basic external dynamic load

=6.83 KN/m^2

f = 0.6 for girders and girder systems of the outer hull (web frames, stringers, grillage systems)

[Ref: GL 2013, Sec: 4, A.3]

P = P_s = Load on Side = 10 (**T** – z) + $P_0.C_F \left(1 + \frac{z}{T}\right)$ KN/m^2 [(Ref.Sec-4, B-2]

= 28.63 KN/m^2

n_c = Reduction Co-efficient = 1 [Ref: GL 2013, Sec: 9, Table: 9.1]

Section Modulus, W = 0.55 l^2.e.P.n_c.k [Ref: GL 2013, Sec: 9, B..3.2]

= 91.83 cm^3

≈ 100cm^3

Dimension: T- 128×128×5 (Ref. Zulfikar.M.M. (2008).*The Inland Shipping Laws & Rules,* P-170)

Brackets

Here for bottom frames $p = p_B = 58.58\ kN/m^2$

$$n = 0.7,\ \ c = 1$$

Unsupported span $l = 2.65\ m$

The section modulus of bottom and inner bottom frames should not be less than

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

$$= 0.7 \times 1 \times 0.5 \times 2.65^2 \times 58.58 \times 1$$

$$= 143.98 cm^3$$

For flanged bracket $c = 0.95$

The thickness of the bracket should not be less than

$$t = c \times \sqrt[3]{\frac{W}{1}} + t_K$$

$$= 0.95 \times \sqrt[3]{\frac{143.98}{1}} + 2.5$$

$$= 7.48\ mm$$ [Ref: GL 2013, Sec:3, B..3.5.2.1]

we take the thickness of the brackets as $t_a = 7.5\ mm$

Now $c_t = \sqrt{\frac{t}{t_a}} = \sqrt{\frac{7.48}{7.5}}$ [Ref: GL 2013, Sec: 3, B.5.2.3]

$$= 0.99$$

The arm length of brackets should not be less than [Ref: GL 2013, Sec:3, B.5.2.3]

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

$$= 46.2 \times \sqrt[3]{\frac{143.98}{1}} \times 0.99 \approx 240\ mm$$

Deckhouse Side Plating

Thickness of Side plating ,

$t = 1.21 \times a \times (p \times k)\ \hat{}\ 0.5 + t_k$, where p is the design pressure 25.84 KN/m^2

$= 1.21 \times 0.5 \times (25.84)\hat{}0.5 + 1.5 = 4.5mm \approx 5$ mm .

[Ref: GL 2013, Sec:16, D.2.1]

Pillars

5 Stanchions and Pillars

5.1 General

Supports under pillars are to be sufficient strength to distribute the loads effectively. Tween-deck pillars are to be arranged directly above those below, or effective means are to be provided for transmitting their loads to supports below. Tripping brackets are to be fitted on members in way of pillars, both when the pillar is over and under the member.

5.3 Permissible Load

The permissible load a pillar can carry is to be equal to or greater than the pillar load, W, as determined in 3-2-6/5.5. The permissible load may be obtained from the following equation:

$$W_a = (k - n\ell/r)A$$

where

W_a = load, in kN (tf, Ltf)

k = 12.09 (1.232, 7.83)

n = 0.0444 (0.00452, 0.345)

ℓ = unsupported length of the pillar, in cm (ft)

r = least radius of gyration of pillar, in cm (in.) $\quad r = \sqrt{I/A}$

A = area of pillar, in cm^2 (in^2)

5.5 Calculated Load

The load on a pillar is to be obtained from the following equation:

$$W = nbhs$$

where

W	=	load, in kN (tf, Ltf)
n	=	7.04 (0.715, 0.02)
b	=	mean breadth, in m (ft), of area supported
h	=	height, in m (ft), above the deck supported, as defined below
s	=	mean length, in m (ft), of area supported

For a pillar below an exposed deck on which cargo is carried, h is the distance from the deck supported to a point 3.66 m (12 ft) above the exposed deck. Where it is intended to carry deck cargoes in excess of 2636 kilograms per square meter (540 pounds per square foot), this head is to be increased in proportion to the added loads which will be imposed on the structure.

For a pillar below the freeboard deck, h is to be measured to a point not less than $0.02L + 0.76$ m ($0.02L + 2.5$ ft) above the freeboard deck.

For a pillar below the superstructure deck, h is to be measured to a point not less than $0.02L + 0.46$ m ($0.02L + 1.5$ ft) above the superstructure deck.

The height, h, for any pillar is not to be less than the given height in 3-2-6/1.3 for the beams at the top of the pillar plus the sum of the heights given in the same paragraphs for the beams of all complete cargo decks and one-half the heights given for all partial superstructure decks above.

L is the length of vessel, in m (ft), as defined in 3-1-1/3.

```
def W(b, h, s):
  return 7.04*b*h*s

def Wa(l, r, A):
  print('Calculating Wa with l = ', l)
  print('Calculating Wa with r = ', r)
  print('Calculating Wa with A = ', A, '\n')
  return (12.09 - 0.0444*l/r)*A

def rg(H, h):
  return ((H**2 + h**2)/12)**(1/2)
```

```
[9] H =  13   #(cm) # Lenght of one side of square pillar, in cm
    h =   12  #(cm) # Length of one side of hollow in square pillar, in cm
    s =  3    #(m) # Mean length between pillars, in m
    b =   10.68  #(m) # Mean breadth between pillars, in m
    h_ = (0.02*42.5 + 0.76)     # height, in m, above the deck supported
    hd =  3.372  #(m) # Height between decks, where pillar will be placed, in m
```

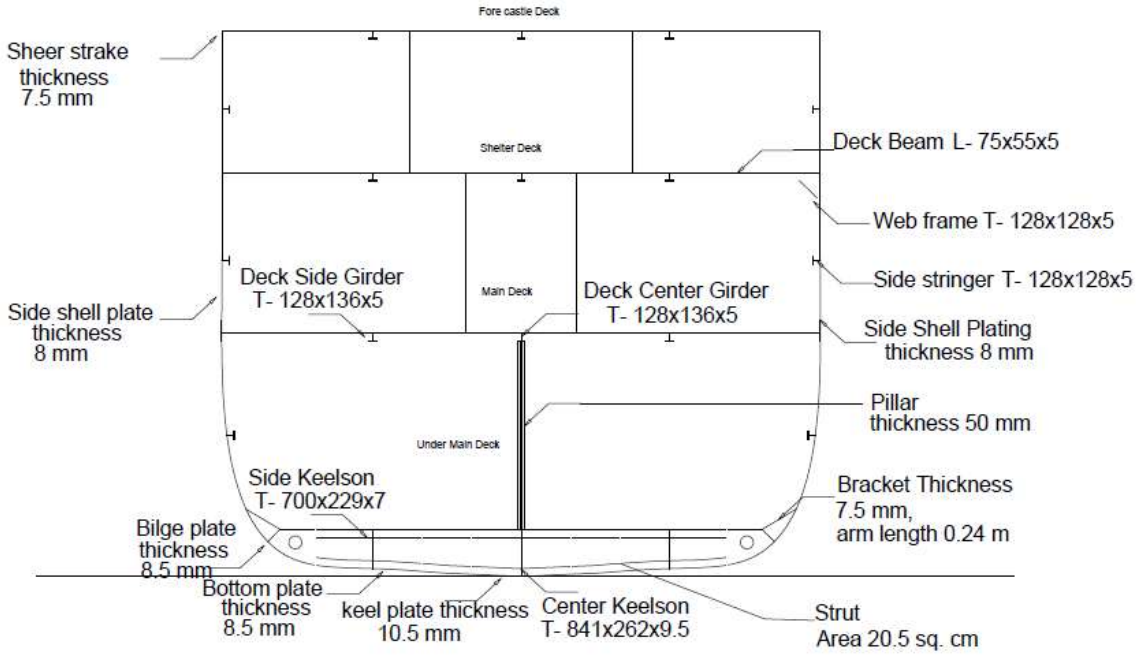
```
print("Thickness of pillar = ", (H-h)/2, ' cm')
print("\nValue of 'h_': ", h_, '\n')
print('Light Weight added per pillar = ', 7.85*(H**2 - h**2)*hd/100**2, ' tonnes')

l = 2*s*100 if 2*s > b else b*100    # unsupported length of the pillar, in cm
print("unsupported length of pillar, 'l' = ", l/100, ' m')
r = ((H**2 + h**2)/12)**(1/2)
print('radius of gyration of pillar, r = ', r, '\n')
A = H**2 # Area of pillar, in cm^2
Wa_ = Wa(l, r, A)
print('Permissible load, Wa = ' + str(Wa_) + ' kN' )
W_ = W(b,h_,s)
```

```
print("Thickness of pillar = ", (H-h)/2, ' cm')
print("\nValue of 'h_': ", h_, '\n')
print('Light Weight added per pillar = ', 7.85*(H**2 - h**2)*hd/100**2, ' tonnes')

l = 2*s*100 if 2*s > b else b*100    # unsupported length of the pillar, in cm
print("unsupported length of pillar, 'l' = ", l/100, ' m')
r = ((H**2 + h**2)/12)**(1/2)
print('radius of gyration of pillar, r = ', r, '\n')
A = H**2 # Area of pillar, in cm^2
Wa_ = Wa(l, r, A)
print('Permissible load, Wa = ' + str(Wa_) + ' kN' )
W_ = W(b,h_,s)
print('Calculated load, W = ' + str(W_) + ' kN' )

print("Wa >= W, OK!") if Wa_ >= W_ else ("W > Wa, PROBLEM!")
```

```
Thickness of pillar =  0.5  cm

Value of 'h_':  1.6099999999999999

Light Weight added per pillar =  0.0661755  tonnes
unsupported length of pillar, 'l' =  10.68  m
radius of gyration of pillar, r =  5.107184482014854

Calculating Wa with l =  1068.0
Calculating Wa with r =  5.107184482014854
Calculating Wa with A =  169

Permissible load, Wa = 474.07835256860943 kN
Calculated load, W = 363.154176 kN
Wa >= W, OK!
```

10. Midship Section

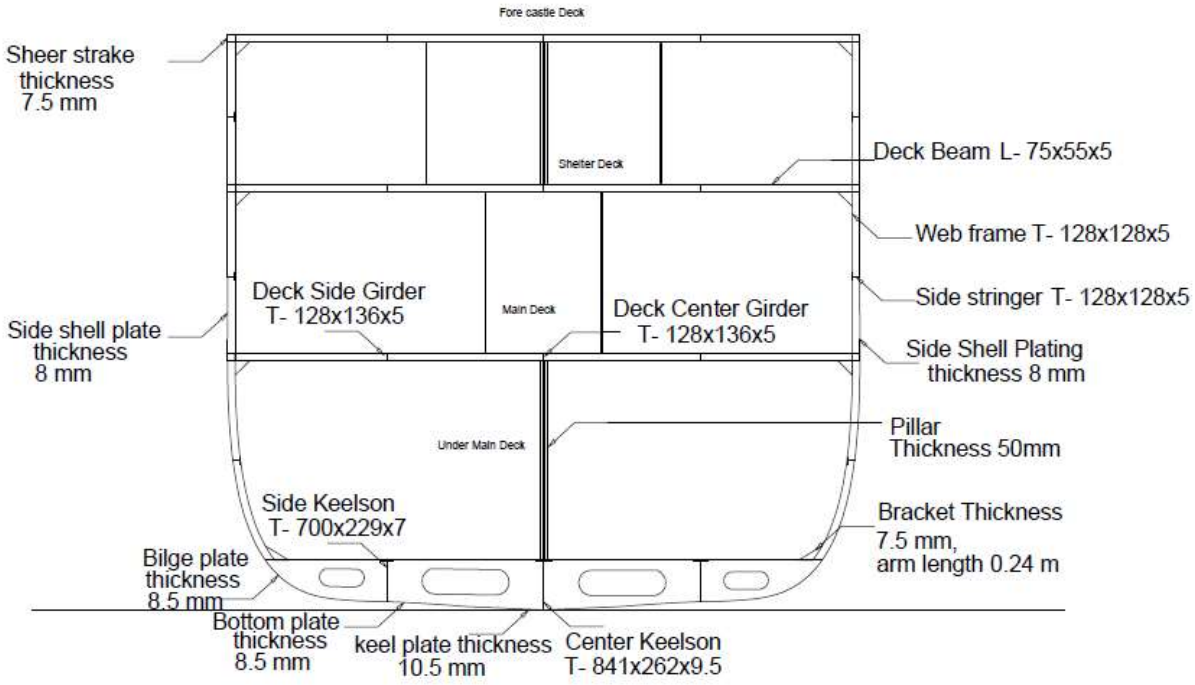
Ordinary Frame



Frame No 38
Ordinary Frame

Scale	1:75

Web Frame

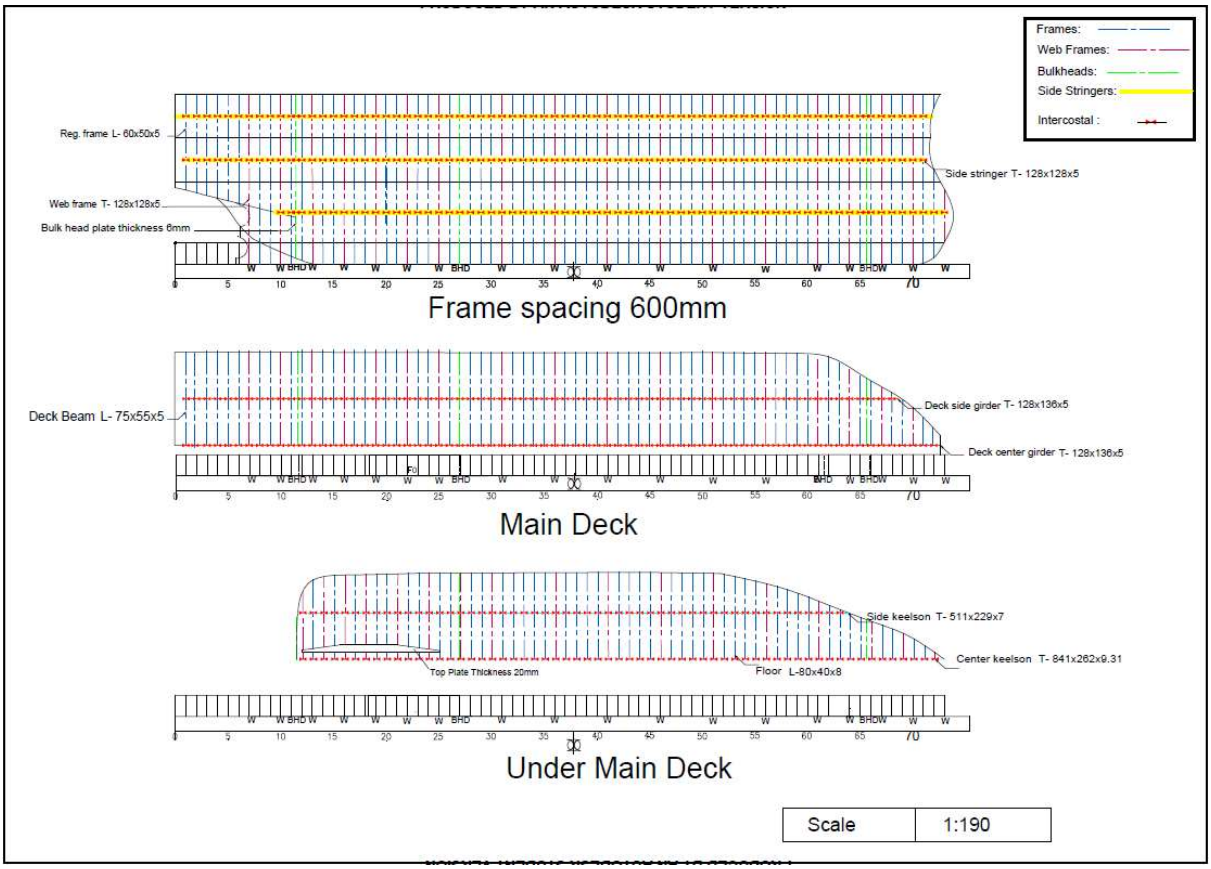


Frame No 36

Web Frame

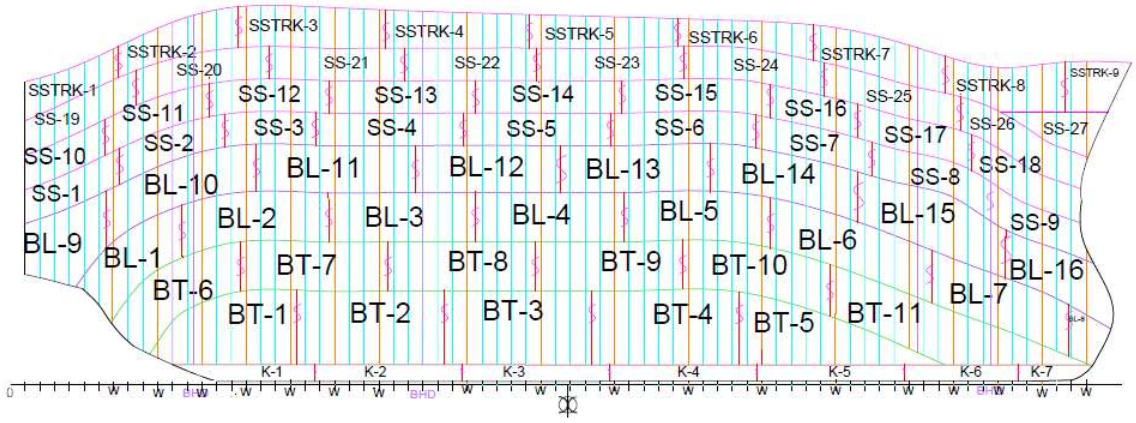
Scale	1:75

11. Longitudinal Construction



12. Shell Expansion

Plate Type	Plate No.	Dimension	Total No. Plate
Keel Plate	K-1 to K-7	6000x1013x10.5	7
Bottom Plate	BT-1 to BT-11	6000x2000x8.5	11
Bilge Plate	BL-1 to BL15	6000x1013x8	16
Side shell Plate	SS-1 to SS-26 SS-27	6000x1800x8 4500x1570x8	27
Sheer Strake	SSTRK-1 to 8 SSTRK-9	6000x1013x8 2800x1013x8	9



Scale	1:150

13. Weight Calculation

Summary

Light Weight Condition (No Ballast; Tanks and Fish-Hold Empty)			
Items	**Weight (tonnes)**	**Longitudinal Moment (tonnes-m)**	**Vertical Moment (tonnes-m)**
Propulsion Machinery	35.09	-421.71	92.99
Auxiliary m. + Generator	30.60	-370.26	81.09
Sonar	1.69	21.46	2.54
Bollard	3.36	31.92	32.12
Plates	66.77	24.26	205.44
Floor	5.39	-0.91	2.27
Transverse Frames	3.87	-2.03	36.25
Bracket	0.96	0.00	5.42
Deck Floor	90.93	-431.47	515.90
Keelson	5.57	0.00	4.55
Deck Girder	4.00	0.00	27.54
Side Stringer	2.54	0.00	13.82
Deck Beam	11.18	0.00	78.15
Pillars	0.77	-3.60	4.56
Superstructure	7.88	5.38	11.76
Bulkheads	4.74	-9.65	4.66
Fishing Equipment	162.40	-1,335.33	1,145.40
Engine Foundation	3.80	-45.19	-67.79
Freezing System (RSW)	3.35	-4.02	-26.93
Lifeboats	4.60	0.00	48.30
Wood and Outfittings Weight	148.18	0.00	0.00
Tanks	19.83	2.84	32.59
Fish Hold	3.26	5.60	9.41
Crew	0.00	0.00	0.00
Crew Provisions	0.00	0.00	0.00
Propeller	3.25	-62.76	5.97
Rudder	2.52	-53.65	10.30
Propeller Shaft	0.85	-14.11	1.49
Anchoring and Mooring Equipment	4.00	17.50	7.20
Solid Ballast (Concrete Blocks)	31.28	-5.10	5.29
Total	662.67	-2,650.84	2,290.27

LCG (m)	VCG (m)
-4.00	3.46

Fully Loaded Condition (Fish-Hold Fully Loaded; Tanks Optimally Loaded)			
Items	**Weight (tonnes)**	**Longitudinal Moment (tonnes-m)**	**Vertical Moment (tonnes-m)**
Propulsion Machinery	35.09	-421.71	92.99
Auxiliary m. + Generator	30.60	-370.26	81.09
Sonar	1.69	21.46	2.54
Bollard	3.36	31.92	32.12
Plates	66.77	24.26	205.44
Floor	5.39	-0.91	2.27
Transverse Frames	3.87	-2.03	36.25
Bracket	0.96	0.00	5.42
Deck Floor	90.93	-431.47	515.90
Keelson	5.57	0.00	4.55
Deck Girder	4.00	0.00	27.54
Side Stringer	2.54	0.00	13.82
Deck Beam	11.18	0.00	78.15
Pillars	0.77	-3.60	4.56
Superstructure	7.88	5.38	11.76
Bulkheads	4.74	-9.65	4.66
Fishing Equipment	162.40	-1,335.33	1,145.40
Engine Foundation	3.80	-45.19	-67.79
Freezing System (RSW)	3.35	-4.02	-26.93
Lifeboats	4.60	0.00	48.30
Wood and Outfittings Weight	148.18	0.00	0.00
Tanks	422.26	978.60	700.38
Fish Hold	378.26	649.10	1,091.66
Crew	8.40	0.00	0.00
Crew Provisions	1.50	0.00	0.00
Propeller	3.25	-62.76	5.97
Rudder	2.52	-53.65	10.30
Propeller Shaft	0.85	-14.11	1.49
Anchoring and Mooring Equipment	4.00	17.50	7.20
Solid Ballast (Concrete Blocks)	31.28	-5.10	5.29
Total	1,450.00	-1,031.59	4,040.31

LCG (m)	VCG (m)
-0.71	2.79

Ballast Condition (Empty Fish Hold; Tanks and Ballast Fully Loaded Condition)			
Items	**Weight (tonnes)**	**Longitudinal Moment (tonnes-m)**	**Vertical Moment (tonnes-m)**
Propulsion Machinery	35.09	-421.71	92.99
Auxiliary m. + Generator	30.60	-370.26	81.09
Sonar	1.69	21.46	2.54
Bollard	3.36	31.92	32.12
Plates	66.77	24.26	205.44
Floor	5.39	-0.91	2.27
Transverse Frames	3.87	-2.03	36.25
Bracket	0.96	0.00	5.42
Deck Floor	90.93	-431.47	515.90
Keelson	5.57	0.00	4.55
Deck Girder	4.00	0.00	27.54
Side Stringer	2.54	0.00	13.82
Deck Beam	11.18	0.00	78.15
Pillars	0.77	-3.60	4.56
Superstructure	7.88	5.38	11.76
Bulkheads	4.74	-9.65	4.66
Fishing Equipment	162.40	-1,335.33	1,145.40
Engine Foundation	3.80	-45.19	-67.79
Freezing System (RSW)	3.35	-4.02	-26.93
Lifeboats	4.60	0.00	48.30
Wood and Outfittings Weight	148.18	0.00	0.00
Tanks	468.31	1,191.19	847.83
Fish Hold	3.26	5.60	9.41
Crew	8.40	0.00	0.00
Crew Provisions	1.50	0.00	0.00
Propeller	3.25	-62.76	5.97
Rudder	2.52	-53.65	10.30
Propeller Shaft	0.85	-14.11	1.49
Anchoring and Mooring Equipment	4.00	17.50	7.20
Solid Ballast (Concrete Blocks)	31.28	-5.10	5.29
Total	1,121.05	-1,462.49	3,105.51

LCG (m)	VCG (m)
-1.30	2.77

Detailed Calculation

A detailed weight calculation is given in the Appendix - A, according to the indices mentioned in the below content table:

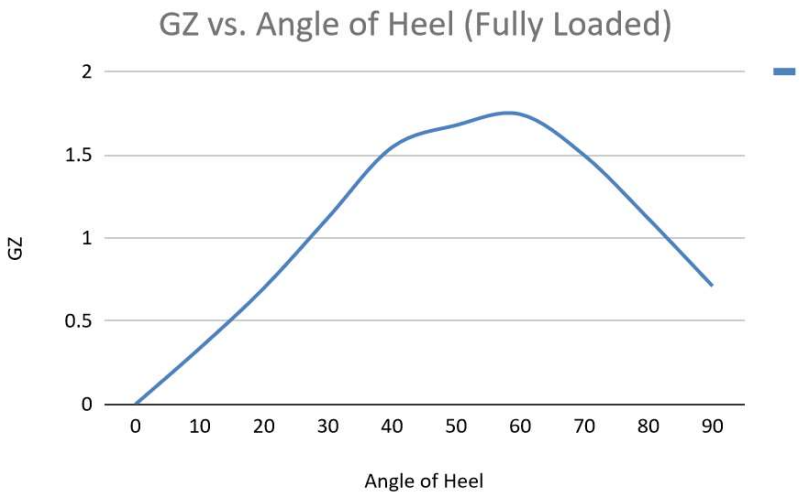
14.1 Stability Calculation Summary :

A summary of stability calculation for fully loaded and ballast conditions is given below. A more detailed breakdown of the calculation is provided in the Appendix - B, page-132.

Summary

Fully Loaded Condition

Fully Loaded Condition	
Angle of Heel	**GZ**
0	0
10	0.336
20	0.698
30	1.121
40	1.545
50	1.677
60	1.743
70	1.496
80	1.115
90	0.710

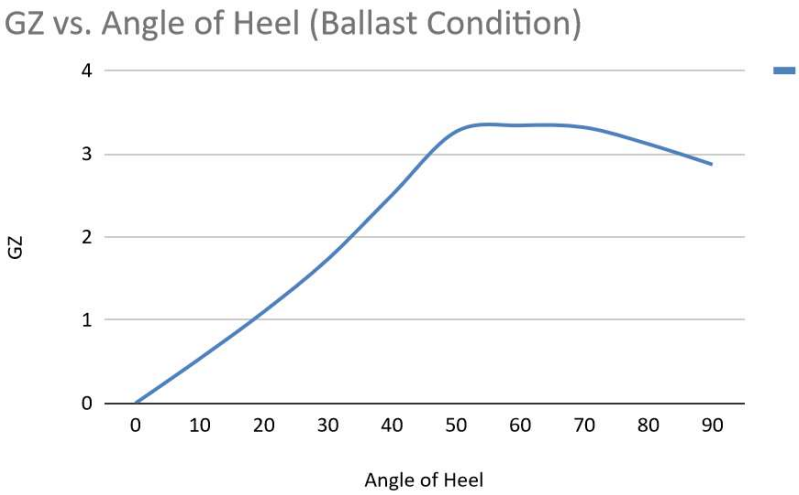


IMO Criteria Check

	IMO A.749 Criteria Check	Remarks	
Fully Loaded	Area from 0 to 30 degree should be greater than 0.055 metre radian	0.278	Satisfied
	Area from 0 to 40 degree should be greater than 0.09 metre radian	0.511	Satisfied
	Area from 30 to 40 degree should be greater than 0.03 metre radian	0.233	Satisfied
	Righting arm at 30 degree should be greater than 0.2 metre	1.121	Satisfied
	Angle from 0 degree to maximum righting arm should be greater than 25 degree	60°	Satisfied
	GM at equilibrium should be greater than 0.15 metre	1.937	Satisfied

Ballast Condition

Ballast Condition	
Angle of Heel	**GZ**
0	0.000
10	0.535
20	1.100
30	1.732
40	2.504
50	3.266
60	3.340
70	3.317
80	3.116
90	2.869



IMO Criteria Check

	IMO A.749 Criteria Check	Remarks	
Ballast Condition	Area from 0 to 30 degree should be greater than 0.055 metre radian	0.436	Satisfied
	Area from 0 to 40 degree should be greater than 0.09 metre radian	0.806	Satisfied
	Area from 30 to 40 degree should be greater than 0.03 metre radian	0.37	Satisfied
	Righting arm at 30 degree should be greater than 0.2 metre	1.732	Satisfied
	Angle from 0 degree to maximum righting arm should be greater than 25 degree	52°	Satisfied
	GM at equilibrium should be greater than 0.15 metre	3.082	Satisfied

A detailed breakdown of the complete calculations is given in the appendix section, page-132.

14.2 Trim Calculation:

Fully Loaded Condition

LCG (Lightweight)	-3.59	
Displacement (loaded condition)	1,450.00	tonnes
Length of Vessel	42.5	m
LCB (loaded condition)	0.08	m
Draft (loaded condition)	4.72	m
LCG (loaded condition)	-0.71	m
MCT 1 cm	12.8	tonnes-m / cm
LCF (loaded condition)	-1.326	m
Change of Trim	89.6552	cm
	0.0897	m
Change in draught at aft perpendicular , WW'	0.0420	m
Change in draught at fore perpendicular , LL'	0.0476	m

Final draught of vessel at fully loaded condition

	Draft at aft perpendicular dA (m)	Draft at fore perpendicular, dF (m)
Mean draught at loaded condition	4.72	4.72
Change in draught	0.042	-0.048
Final draught	4.762	4.672
Trim at aft	**0.090**	**m**

Ballast Condition

LCG (Lightweight)	-3.59	
Displacement (ballast condition)	1,121.05	tonnes
Length of Vessel	42.5	m
LCB (ballast condition)	-0.311	m
Draft (ballast condition)	3.54	m
LCG (ballast condition)	-1.30	m
MCT 1 cm	8.436	tonnes-m / cm
LCF (ballast condition)	-0.069	m
Change of Trim	132.0347	cm
	0.1320	m
Change in draught at aft perpendicular , WW'	0.0662	m
Change in draught at fore perpendicular , LL'	0.0742	m

Final draught of vessel at ballast condition

	Draft at aft perpendicular dA (m)	Draft at fore perpendicular, dF (m)
Mean draught at loaded condition	3.54	3.54
Change in draught	0.066	-0.074
Final draught	3.606	3.466
Trim at aft	**0.140**	**m**

15. Resistance Calculations

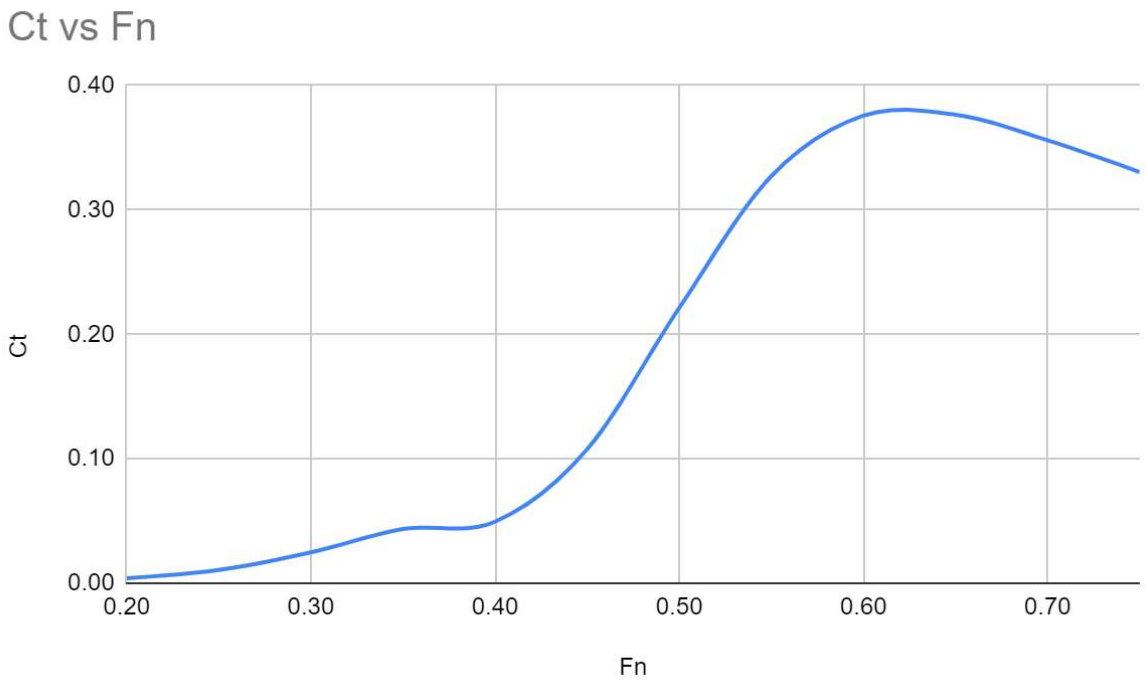
Approximate Calculation of Ship's Resistance		
Holtrop & Mennen's method		
Parameters	**Value**	**Unit**
Waterline Length, LWL	45.00	m
Length Between Perpendicular, LBP	42.50	m
Breadth moulded, B	10.68	m
Draft moulded, T	4.72	m
Block Coefficient, Cb	0.66	
Ship Speed, V	10.00	knots
Prismatic Coefficient, Cp	0.71	
Midship Coefficient, Cm	0.93	
Density of water, ρ	1.03	tons/m3
Volume of displacement, ∇	1413.99	m3
Displacement, Δ	1450.00	tons
Water plane Coefficient, Cwp	0.92	
Longitudinal Center of Buoyancy, L.C.B.	0.08	m (fwd,mid)
L.C.B as a % of LWL	0.18	% of LWL
Transverse sectional area of BULB, A BT	0.00	m2
Immersed Transom area, AT	0.00	m2
Dynamic Viscosity , μ	0.00	m2/s
Propeller Dia, D	2.83	m
Pitch ratio, P/D	0.80	

Parameter	Symbol		Values	Unit	Note	Values
1. Frictional resistance	RF	0.5 ρ V2 S CF	9.98	KN		
Frictional resist. coef.	CF	0.075 / (Log10Re - 2)2	0.00			
Reynold's No.	RE	ρVL /μ	194800492.61			

Form factor of the hull	1+k1	c13{0.93 + c12 (B/LR)0.92497 (0.95-CP)-0.521448 (1-CP+0.0225lcb)0.6906}	1.77			
Length of the run	LR	L (1 - CP + 0.06 CP lcb) /(4CP-1)}	7.17			
	C12	(T/L)0.2228446, if T/L > 0.05; 48.20 (T/L-0.02)2.078 + 0.479948, if 0.02<T/L<0.05; 0.479948, if T/L<0.02	0.61		T/L=	0.10
	C13	1+0.003 Cstern	1.03		Cstern=	10.00
Wetted area of the hull	S	L (2T+B) √CM(0.453 + 0.4425CB -0.2862 CM - 0.003467 B/T + 0.3696 CWP) + 2.38 ABT/CB	707.12		ABT	0.00
2. Appendage Resistance	RAPP	0.5 ρ V2 SAPP (1+k2)eq CF	0.30	KN	SAPP	14.14
Appendage resist. factor	1+k2		1.50			
3. Wave Resistance	RW	c1c2c5 ∇ ρ g exp{m1Fnd + m2 cos(λFn-2}	70.19	KN	Fn	0.24
	c1	2223105 c73.78613 (T/B)1.07961(90-iE)-1.3765 6	56.39		T/B	0.44
	c7	0.229577(B / L)0.33333, if B/L<0.11; B/L , if 0.11<B/L<0.25; 0.5-0.0625 L/B, if B/L>0.25	0.24		B/L	0.24
	c2	exp(−1.89√c3)	1.00			
	c5	1-0.8 AT/(BTCM)	1.00			
	λ	1.446CP-0.03 L/B, if L/B < 12; 1.446CP-0.36, if L/B>12	0.90		L/B	4.21
	m1	0.0140407 L/T - 1.75254 ∇1/3/L - 4.79323B/L- c16	-2.67		L/T	9.53
	c16	8.07981CP-13.8673Cp2+6.9 84388CP3, if Cp<0.8; 1.73014-0.7067CP, if CP > 0.8	1.23		CP	0.71

	m2	c15Cp2 exp(-0.1Fn-2)	-0.16			
	c15	-1.69385 for L3/∇<512; 0 for L3/∇>1727; -1.69385+(L3/∇-8.0)/2.36if 512<L3/∇<1727	-1.69		L3/∇	54.29
	d		-0.90			
Half angle of entrance	iE		68.00			
	c3	0.56 ABT 1.5 / {B T (0.31√ABT+TF-hB) }	0.00		hB	0.00
4. Additional pressure resistance due to bulbous bow	RB	0.11 exp(-3PB-2) Fni3 ABT 1.5 ρg/(1+Fni2)	0.00	KN	ABT	0.00
	PB	0.56 √ABT / (TF - 1.5hB)	0.00			
	Fni	V / √{ g (TF-hB-0.25√ABT) + 0.15 V2 }	0.73			
5. Additional pressure resistance of immersed transom stern	RTR	.5 ρ V2 AT c6	0.00	KN	AT	0.00
	c6	0.2 (1-0.2FnT), if FnT<5; 0, if FnT≥5	0.20			
	FnT	V / √{ 2g AT/ (B+BCWP) }	0.00			
6. Model-ship correlation resistance	RA	0.5 ρ V2 S CA	6.29	KN		
	CA	0.006 (L+100)-0.16-0.00205 + 0.003 √(L/7.5) CB4c2 (0.04-c4)	0.00			
	c4	TF/L, when TF/L ≤ 0.04; 0.04,when TF/L>0.04	0.04		TF/L	0.11
Total resistance	**RT =**	**RF(l +kl) + RAPP + Rw + RB + RTR + RA**	**94.43**	**KN**		

Similarly			
Fn	V	Rt (KN)	Ct
0.20	4.08	22.05	0.00
0.25	5.10	90.39	0.01
0.30	6.12	304.41	0.02
0.35	7.14	729.24	0.04
0.40	8.16	1080.43	0.05
0.45	9.18	2978.67	0.11
0.50	10.20	7561.33	0.22
0.55	11.22	13531.54	0.33
0.60	12.24	18488.37	0.38
0.65	13.27	21747.70	0.38
0.70	14.29	23843.09	0.36
0.75	15.31	25405.69	0.33



Power Calculations

From Holtrop and Mennen Method	Values	Unit
Length	42.50	m
Displacement	1450.00	tonnes
Fn	0.25	
Velocity	10.00	knots
	5.14	ms-1
Density	1.03	tonnes/m3
Wetted Surface Area, S	640.47	m2
Total Resistance Coefficient (Ct)	0.03	
Resistance	94.43	KN
Power, PE	485.76	KW
Thrust deduction factor, t	0.17	
wake fraction	0.29	
Relative rotative efficiency	1.05	
Shaft efficiency	0.98	
Open water efficiency	0.53	
Hull efficiency	1.16	
nD	0.64	
QPC	0.63	
Delivered Power, PD	773.51	KW
Brake Power, PB	789.30	KW
MCR	928.58	KW

Engine and Gearbox Selection

Engine Selected		
Yanmar		
6EY22AW	1030.00	KW
Reduction Gear Ratio	4.50	

6EY22AW

PRINCIPAL DATA

Type 4cycle resin propulsion diesel engine
No. of Cylinder 6
Cylinder Bore 170mm
Stroke 230mm
Mean Effective Pressure 1.05 - 2.21MPa
Mean Piston Speed 10.35/11.12 m/s

Main Data

Specifications

Rated Power

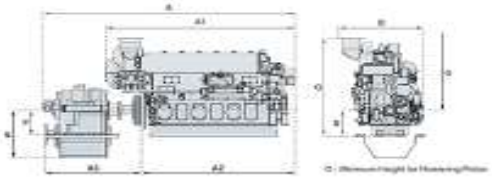
Engine Model	6EY22AW					
Continuous Rated Power [kW(PS)]	736 (1000)	885 (1203)	1030 (1400)	1180 (1604)	1330 (1808)	1370 (1863)
Rated Engine Speed [min⁻¹]	900	850/900		900		
Engine Dry Weight [kg]	10000					

Dimensions / Weights

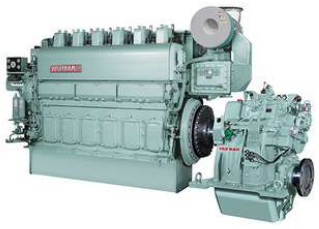
[mm] / [kg]

Engine Model	Marine Gear	A	A1	A2	A3	B	C	D	E	F	G	Total Dry Weight with Marine Gear
6EY22AW 736kW	YX-1000	4574	3647	2965	1488	1548	2326	666	685	435	1922	12565
	YX-1000C	4687	3647	2965	1601	1548	2326	666	450	-	1922	12670
6EY22AW 885kW	YX-1000	4574	3647	2965	1488	1618	2416	666	685	435	1922	12565
	YX-1000C	4687	3647	2965	1601	1618	2416	666	450	-	1922	12670
6EY22AW 1030kW	YX-1000	4503	3647	2965	1517	1618	2416	666	685	435	1922	12556
	YX-1000C	4638	3647	2965	1550	1618	2416	666	450	-	1922	12721
6EY22AW 1100kW 1330kW 1370kW	YXH-2000	4810	3647	2965	1807	1618	2416	666	1165	590	1922	14861
	YXH-2000C	4960	3647	2965	1957	1618	2416	666	555	-	1922	15161

6EY22AW



6EY22AW



PRINCIPAL DATA

Type 4cycle main propulsion diesel engine
No. of Cylinder 6
Cylinder Bore 170mm
Stroke 230mm
Mean Effective Pressure 1.06 - 2.21MPa
Mean Piston Speed 10.35/11.12 m/s

Main Data

Specifications

Rated Power

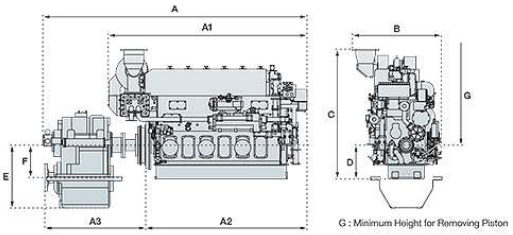
Engine Model	6EY22AW					
Continuous Rated Power [kW(PS)]	736 (1000)	885 (1203)	1030 (1400)	1180 (1604)	1330 (1808)	1370 (1863)
Rated Engine Speed [min-1]	800	850/900		900		
Engine Dry Weight [kg]	10000					

Dimensions / Weights

[mm] / [kg]

Engine Model	Marine Gear	A	A1	A2	A3	B	C	D	E	F	G	Total Dry Weight with Marine Gear
6EY22AW 736kW	YX-1000	4574	3647	2965	1488	1548	2326	666	885	435	1922	12505
	YX-1000C	4687	3647	2965	1601	1548	2326	666	450	-	1922	12670
6EY22AW 885kW	YX-1000	4574	3647	2965	1488	1618	2416	666	885	435	1922	12505
	YX-1000C	4687	3647	2965	1601	1618	2416	666	450	-	1922	12670
6EY22AW 1030kW	YX-1000	4603	3647	2965	1517	1618	2416	666	885	435	1922	12556
	YX-1000C	4636	3647	2965	1550	1618	2416	666	450	-	1922	12721
6EY22AW 1180kW 1330kW 1370kW	YXH-2000	4810	3647	2965	1807	1618	2416	666	1145	590	1922	14861
	YXH-2000C	4960	3647	2965	1957	1618	2416	666	555	-	1922	15161

6EY22AW



17. Rudder & Steering Arrangement

Rudder Calculations :

Particulars

Length, L = 42.5m
Breadth, B = 10.68m
Draft, T = 4.72m
Ship Speed, V = 10kts

Summary

Items	Dimensions	Material
Rudder stock	Diameter 132 mm	Forged Steel
Coupling bolts	Diameter 29 mm	Forged Steel
Coupling flange	Thickness 26mm	Forged Steel
Horizontal web	Spacing 485 mm	Forged Steel
Vertical web	Spacing 626 mm	Forged Steel
Web plate	Thickness 5.5 mm	Forged Steel
Rudder plate	Thickness 7.5 mm	Forged Steel
Neck Bearing	Height 200 mm	Forged Steel
Liner	Thickness 22m	Lignum Vitae
Pintle	Diameter 60mm	Forged Steel
Bush	Thickness 3mm	Lignum Vitae
Sleeve	Thickness 8mm	Forged Steel

Rudder Area :

c1, factor for the ship types = 1
c2, factor for the rudder types = 1
c3, factor for the rudder profiles (NACA) = 1
c4, factor for the rudder arrangement (for rudder in propeller jet) = 1

$$A = c_1.c_2.c_3.c_4 \frac{1.75xLxT}{100}$$

= 3.51 m^2

Applied Naval Architecture by Munro Smith ,

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

= 3.34 m^2

Material : [GL-2013, Section 14]

Yield Strength for Forged steel = 625 N/mm^2

Modulus of Elasticity, ReH = 235 N/mm^2

Material Factor, kr = 0.48

Dimensions of Rudder : [GL-2013, Section 14]

Aspect Ratio = H^2/At

At = 3.51 m^2

Assuming Aspect ratio = 1.5

H = 2.29 m

H/B = 1.5

B = 1.53 m

Clearance

H/T = 0.49 (*which is almost 50% of draft)*

Rudder Force and Torque [GL-2013, Section 14]

A = 3.51 m^2

k1 = 1.167 (*Coefficient depending on aspect ratio*)

k2, ahead = 1.1 (*Coefficient depending upon type of rudder and rudder profile*)

k2, astern = 0.8

k3 = 1 (*Coefficient depending upon the location of rudder*)

kt = 1 (*Coefficient depending upon thrust coefficient*)

$C_r = 132.k_1.k_2.k_3.A.V^2.k_t[N]$

=59467.87 N (for ahead condition)

$C_r = 132.k_1.k_2.k_3.A.V^2.k_t[N]$

= 43249.36 N (for astern condition)

So, design Cr = 59467.87 N

Rudder Torque

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

r = c ($\alpha - K_b$) [m]

α=0.33 for ahead condition

=.66 for astern condition

K_b=balance factor,

=A_f/A_1= .2 (in general, for Balanced rudder 20 percent is on the ahead)

α, ahead = 0.33

α, astern = 0.9

Balance Factor, Kb = 0.2 (*Af/A = 0.2 (Balanced Rudder)*)

mean breadth of rudder, c = 1.53 m

r, ahead = 0.199 (*Distance of centre of pressure from the turning axis, r*)

r, astern = 1.071 (c*(α-Kb))

Torque, QR (ahead) = C_r.r

= 11826.73 Nm

Torque, QR (astern) = C_r.r

= 63682.38 Nm

So, Design Torque, QR = 63682.38 Nm astern

Rudder Stock [GL-2013, Section 14]

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

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

Where,

$k_R =$ Material factor for rudder $= 0.48$

So we have,

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

= 132 mm

Rudder Couplings [GL-2013, Section 14]

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

$$d_b = 0.62 \times \sqrt{\frac{D^3 \times k_b}{k_R \times n \times e}}$$

Where,

$D =$ Rudder stock diameter = 132 mm

$n =$ Total number of bolts $= 6$

$k_R =$ Material factor for rudder $= 0.48$

$k_b =$ Material factor of the bolts $= k_R = 0.48$

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

= 175 mm

Diameter of Horizontal coupling bolts = 29 mm

The thickness of coupling flanges is not to be less than,0.9 d_b

thickness of coupling flange = 26 mm

thickness of coupling flange clear of bolt hole = 17 mm

width of material outside bolt hole = 18 mm

Rudder Frames

Spacing of horizontal rudder frames is to be obtained from the following formula,

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

= 485 mm

Distance from the vertical rudder frame forming the rudder main piece to the adjacent vertical frame is to be obtained by,

$$a_v = 1.29 \times a_h$$

= 626 mm

Rudder Plates and Web

Smaller unsupported plate panel width, a = 0.485 m

Pr = 64.14 KN/m^2

Material Factor, k = 0.48

Rudder Plate Thickness, tp = 7.5 mm

Thickness of web, tw = 5.5 mm

Pintle [GL-2013, Section 14]

Support Reaction at pintle, B1 = 59467.87 N

Material factor, Kr = 0.48

Diameter of Pintle, dp $d_p = 0.35 \times \sqrt{B_1 \times k_R}$

= 60 mm

Bearing [GL-2013, Section 14, sec-4.4]

Support Reaction at neck bearing and carrier bearing, B2 = 59467.87 N

Permissible Surface Pressure, q = 2.5 N/mm^2

Projected surface area, $A_{bn} = \frac{B_2}{q}$

= 23787.148 mm^2

External diameter of liner = 175 mm

Bearing height, hb = 136 mm

Bearing height should be equal to bearing diameter or should not exceed 1.2 times of bearing diameter.

So, 1.2*175 = 210mm

So, bearing height, hb = 200 mm

Area = 35000 mm^2

Sleeve

Thickness = 8 mm for metallic sleeve

Liner and Bush

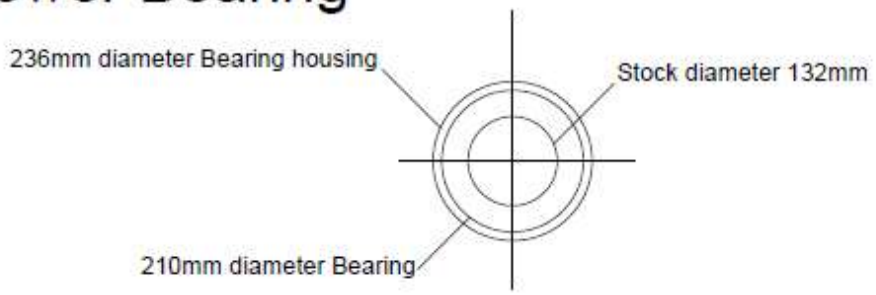
Minimum thickness, tmin = 22 mm *(for lignum materials)*

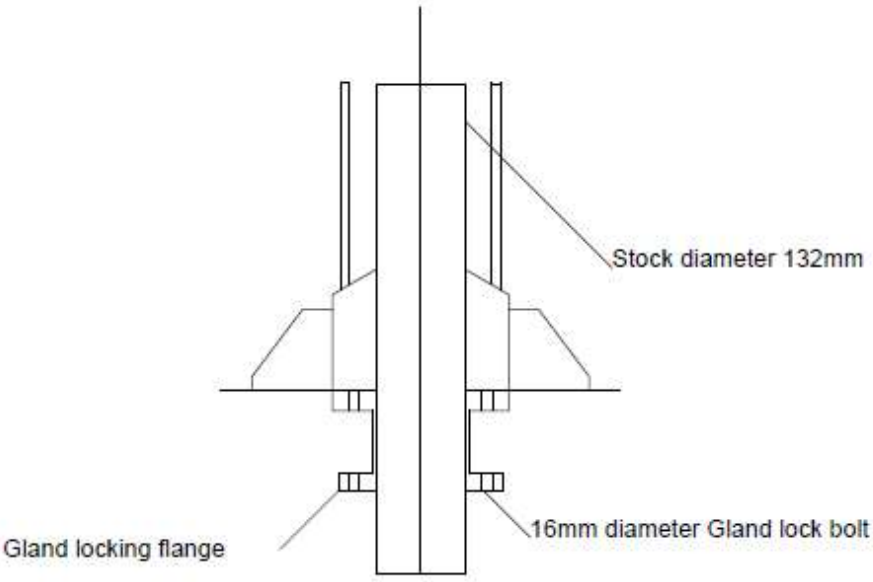
B1 = 89201.81 N

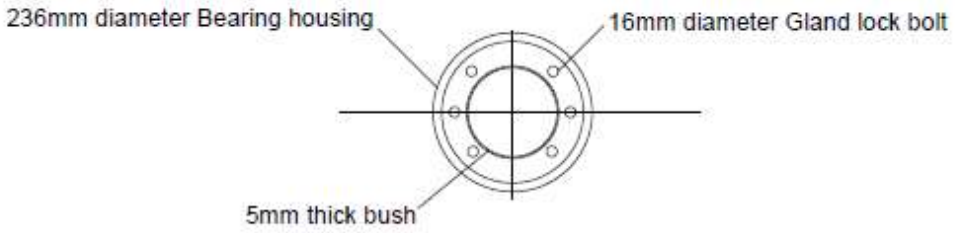
Thickness of bush, $d = 0.01\sqrt{B_1}$

= 3 mm

Lower Bearing







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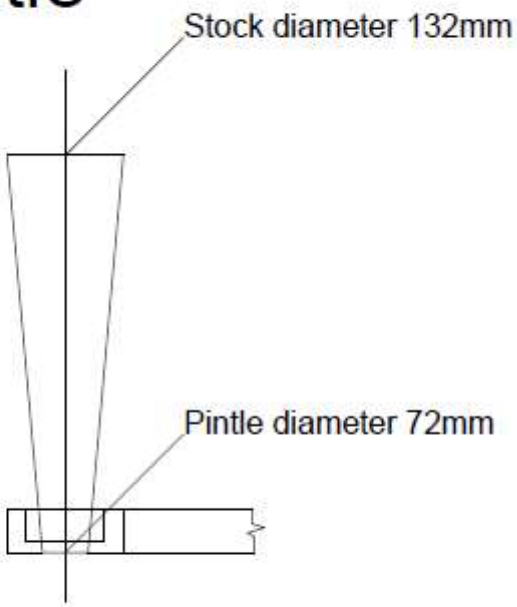
Pintle



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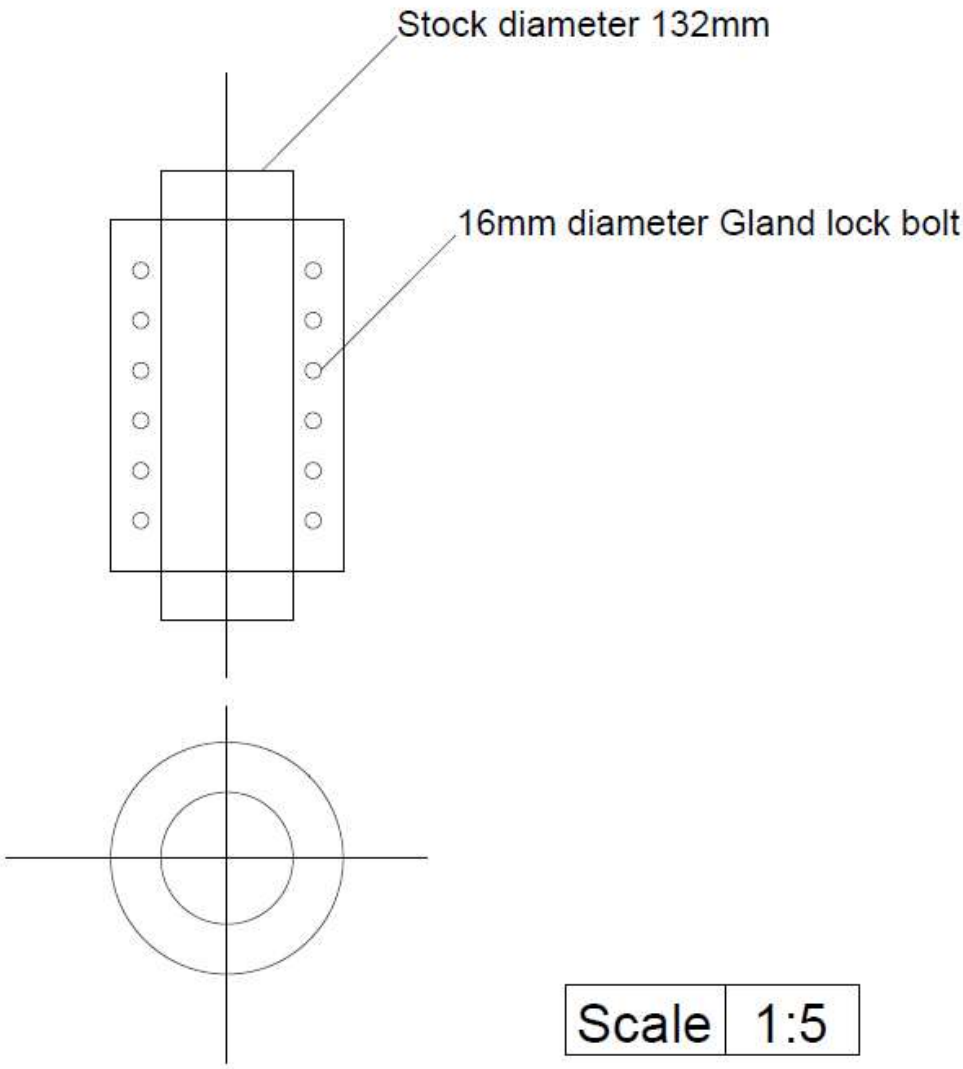
Jumping Clamp



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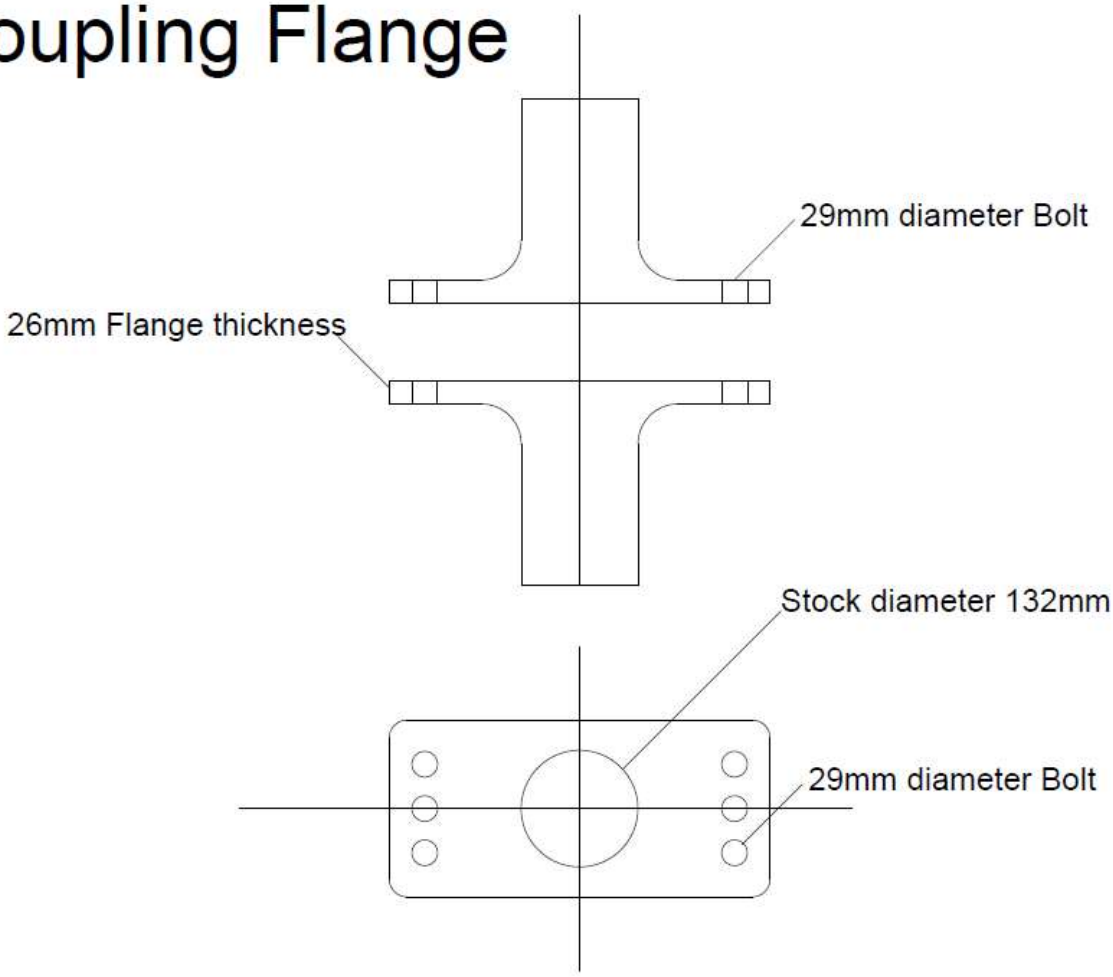
Coupling Flange



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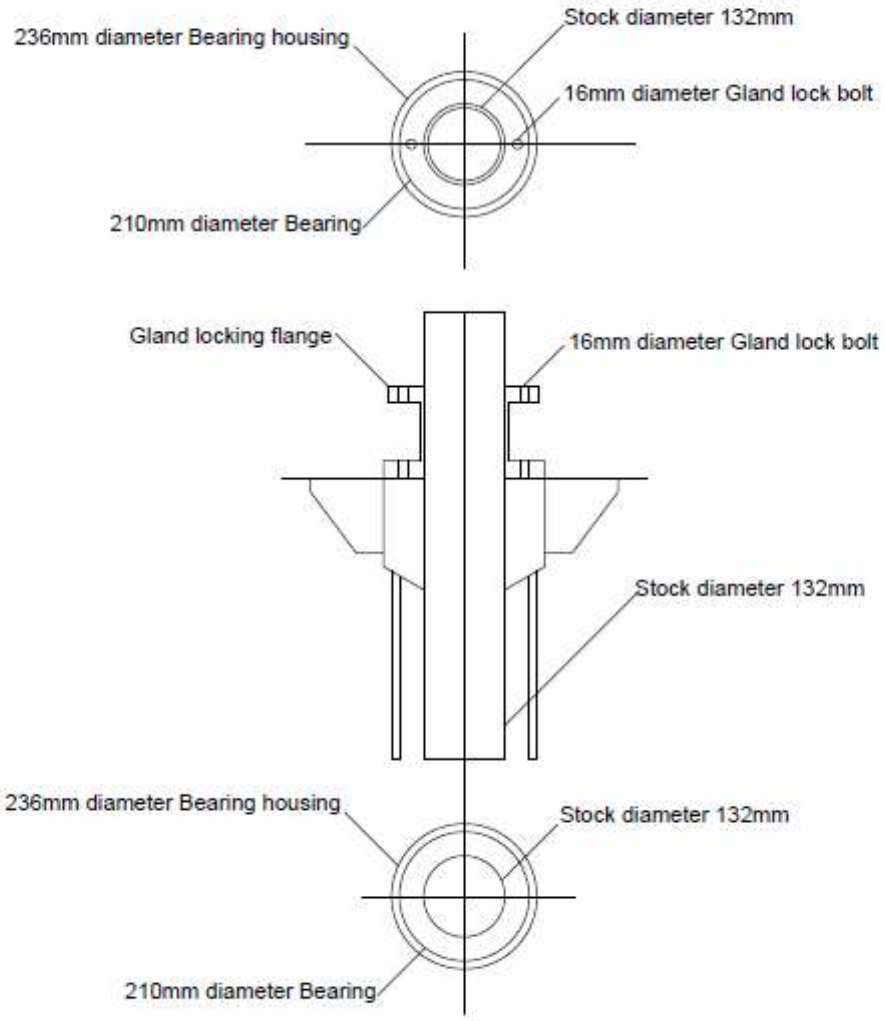
Upper Bearing



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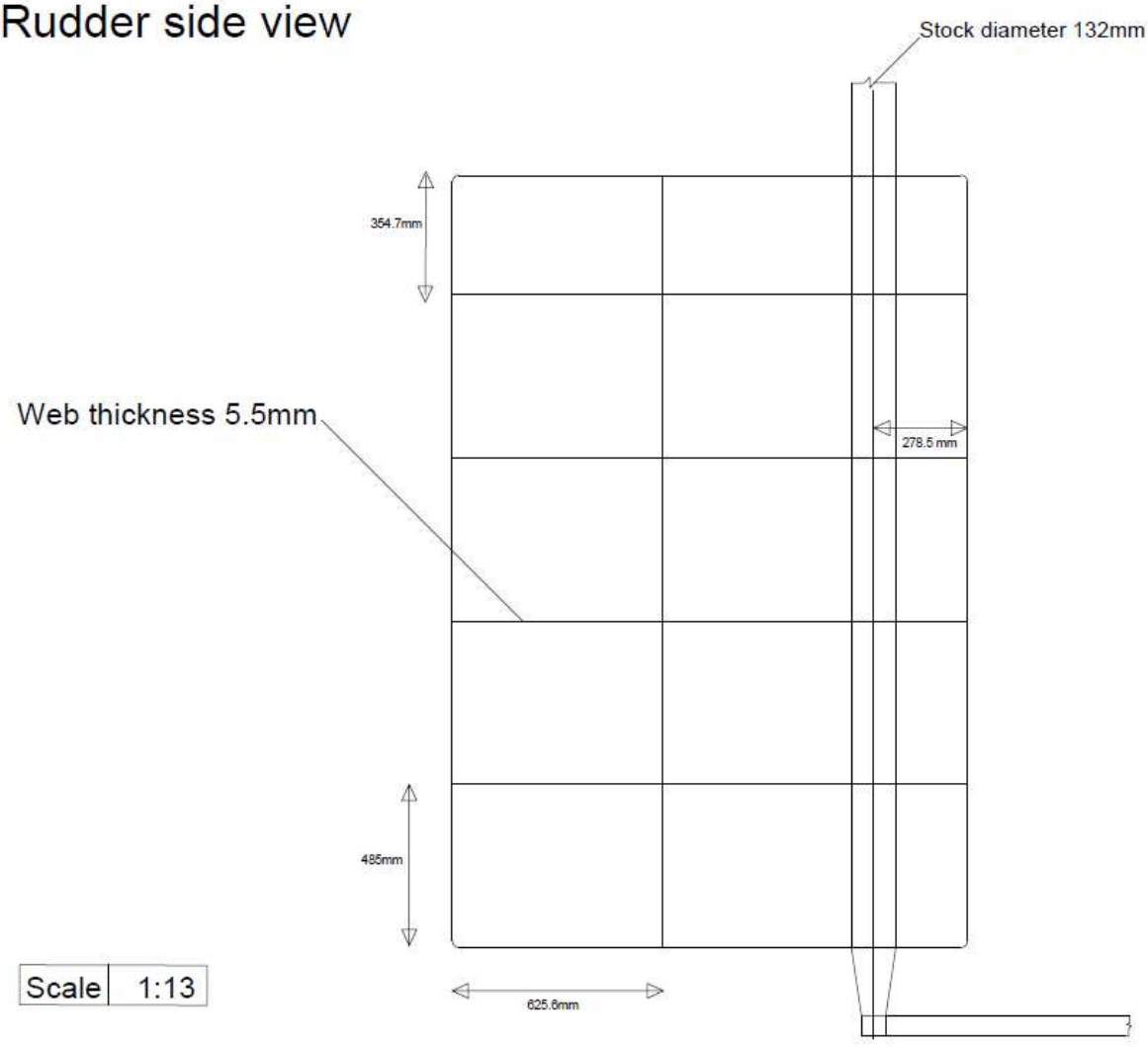
Rudder side view



Steering Arrangement

Rudder Force and Torque [GL-2013, Section 14]

A = 3.51 m^2

k1 = 1.167 (*Coefficient depending on aspect ratio*)

k2, ahead = 1.1 (*Coefficient depending upon type of rudder and rudder profile*)

k2, astern = 0.8

k3 = 1 (*Coefficient depending upon the location of rudder*)

kt = 1 (*Coefficient depending upon thrust coefficient*)

$C_r = 132.k_1.k_2.k_3.A.V^2.k_t[N]$

=59467.87 N (for ahead condition)

$C_r = 132.k_1.k_2.k_3.A.V^2.k_t[N]$

= 43249.36 N (for astern condition)

So, design Cr = 59467.87 N

Rudder Torque

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

r = c ($\alpha - K_b$) [m]

α=0.33 for ahead condition

=.66 for astern condition

K_b=balance factor,

=A_f/A_1= .2 (in general, for Balanced rudder 20 percent is on the ahead)

α, ahead = 0.33

α, astern = 0.9

Balance Factor, Kb = 0.2 (*Af/A = 0.2 (Balanced Rudder)*)

mean breadth of rudder, c = 1.53 m

r, ahead = 0.199 (*Distance of centre of pressure from the turning axis, r*)

r, astern = 1.071 (c*(α-Kb))

Torque, QR (ahead) = $C_r.r$

= 11826.73 Nm

Torque, QR (astern) = $C_r.r$

= 63682.38 Nm

So, Design Torque, QR = 63682.38 Nm astern

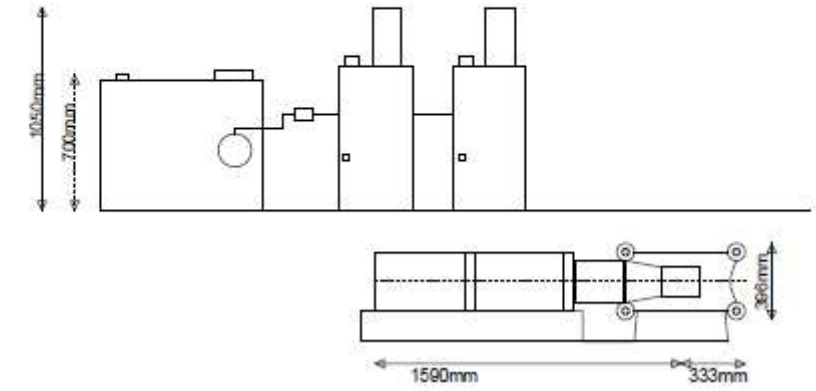
Steering Arrangement model : Hydroster Model MS 80-35

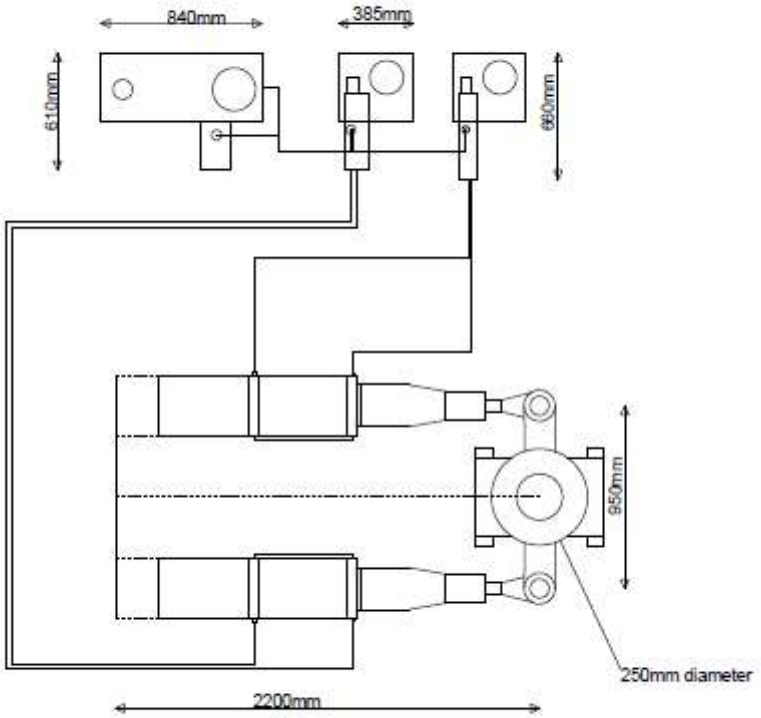
	Dimensions [mm]														
Type	A	B	C	D_{max}	E	F	G	H	J	K	L	M	N	P	W
MS 25-35	1048	160	600	140	1600	75	150	80	400	830	750	520	990	1080	500
MS 32-35	1133	228	700	170	1600	140	280	97	400	830	750	520	990	1080	680
MS 50-35	1283	298	800	220	1800	183	366	109	400	830	750	520	1045	1150	680
MS 80-35	1590	333	950	250	2200	198	396	125	660	385	840	610	1050	1150	700
MS 125-35	1744	374	1100	290	2450	215	430	150	475	750	840	610	1110	1200	1000
MS 200-35	2025	435	1250	340	2800	256	512	170	475	750	1230	680	1392	1510	840
MS 320-35	2462	500	1575	400	3360	283	566	185	620	1200	1230	680	1285	1645	1120

MS series steering gear technical specification with rudder deflection angle ±35.

Parameter	Symbol	Unit	MS20-35	MS32-35	MS50-35	MS80-35	MS125-35	MS200-35	MS320-35
Working torque at working pressure p_{nom} and rudder deflection angle α=35°	M_r	[kNm]	20	32	50	80	125	200	320
Design torque at open safety valve pressure pmax and rudder deflection angle α=35°	M_k	[kNm]	25	40	62,5	100	156	250	400
Maximal tiller turn angle limited by rudder actuator design	α_{max}	[deg]	±38						
Rudder putting over time from α=-35° to α=+30°	t_1	[s]	≤28						
	t_2	[s]	~ 0,5 t_1						
Electric motors supply voltage	U_1	[V], [f]	3x380, 50						
	U_2	[V], [f]	3x440, 60						
Directional proportional valves supply voltage	U	[V]	24 DC						
Power of solenoid	N	[W]	30						
Ambient temperature during steering gear operation	T_o	[K]/[°C]	273 ÷ 318K (0°C ÷ +45°C)						
Ambient temperature permissible for idle steering gear	T_{od}	[K]/[°C]	248 ÷ 343K (-25°C ÷ +70°C)						
Hydraulic oil operating temperature	T_{pr}	[K]/[°C]	273 ÷ 353K (0°C÷ +80°C)						
Hydraulic oil high temperature signalling	T_s	[K]/[°C]	≥ 343K (+70°C)						
Working medium			hydraulic mineral oils of kinematic viscosity v=68mm²/s (68 cSt) at T=40°C and viscosity index W≥95						

Steering arrangement





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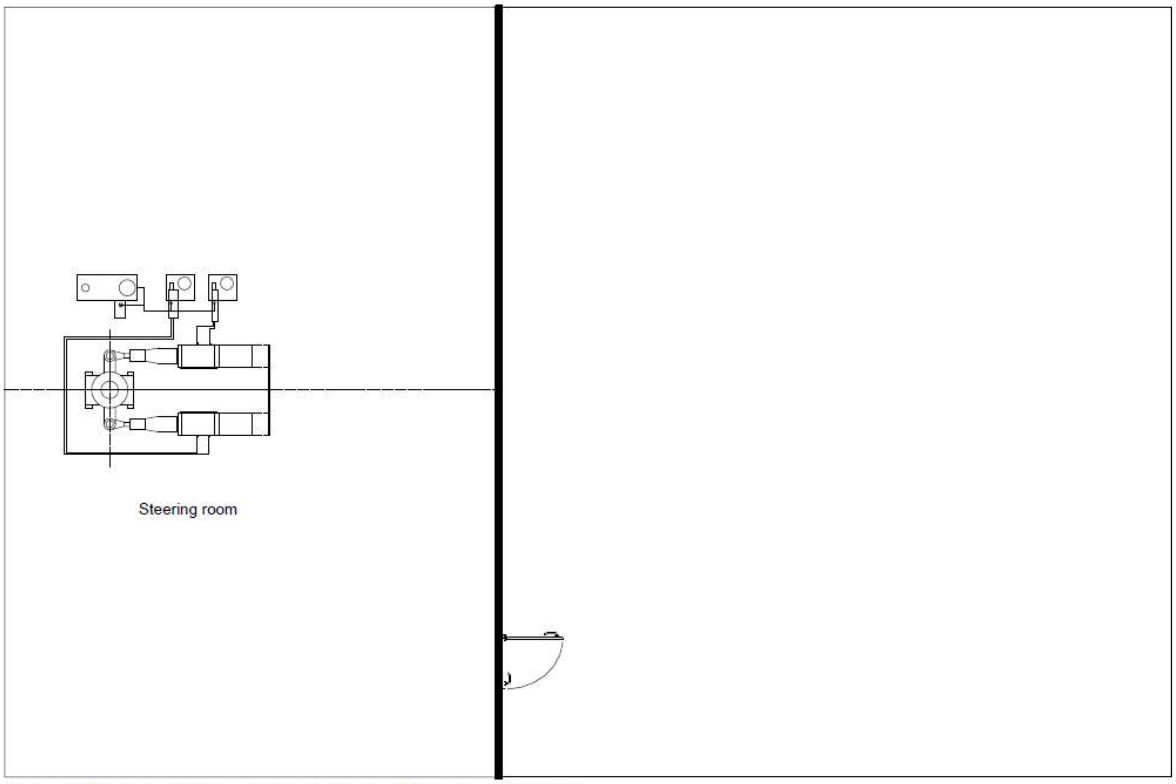
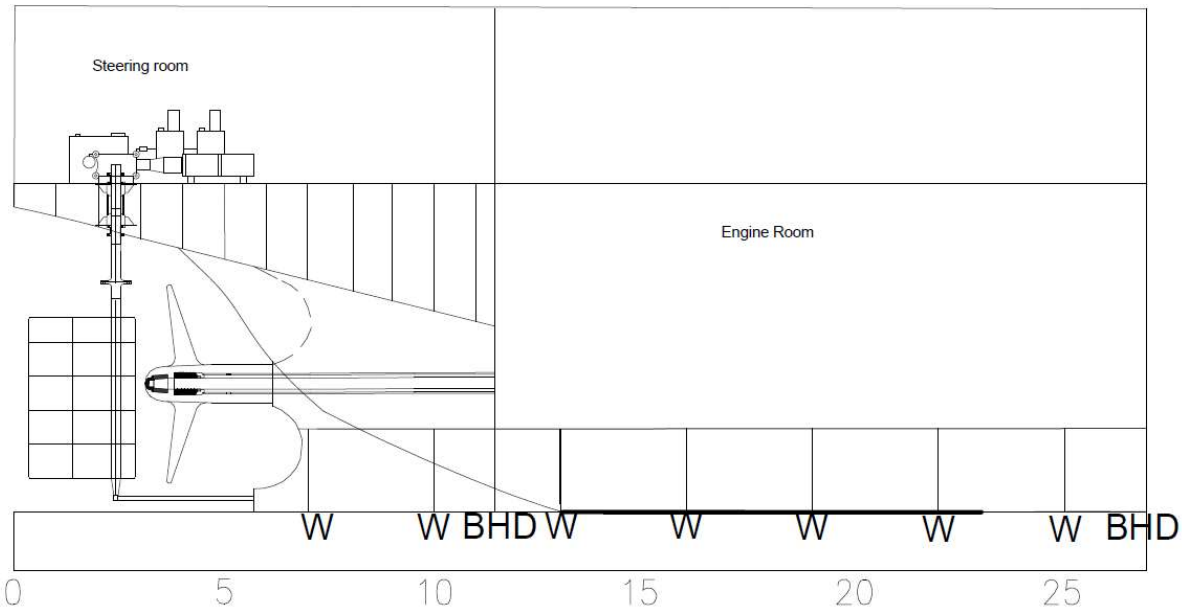


Top View of the Steering Arrangement

Scale	1:50



Side View of the Rudder and Steering Arrangement

Scale	1:46

18. Propeller Design and Calculation :

Length, L = 42.50 m
Breadth, B = 10.68 m
Draft, T = 4.72 m
Speed = 10.00 kts
= 5.14 m/s
Density = 1.03
Blades, Z = 3
Brake Power, Pb = 789.30 KW
Delivered power, Pd = 773.51 KW
BAR = 0.50
Propeller Diameter, D = 2.83 m
h = 1.62 m
t = 0.17
w = 0.29
H = 3.10 m
Resistance, R = **94.43 KN** (From Holtrop and Mennen Method)

Thrust,T = R/(1-t)
=113.77 KN

$V_a=V_s(1-w)$ = 7.14 Kts
= 3.67 m/s

KT/J^2 = T/(ρD^2*Va^2) = 1.03

From BAR chart,

Open water efficiency, n = 0.50
Velocity of advance coefficient, J = 0.39
P/D = 0.8

n = $\frac{V_a}{JD}$ = 3.33 rps = 200 rpm

From Bp delta chart

$$B_p = \frac{N\sqrt{P}}{V_A^{2.5}} = 40.74$$

$$\delta = 3.28\frac{ND}{V_A} = 259.57$$

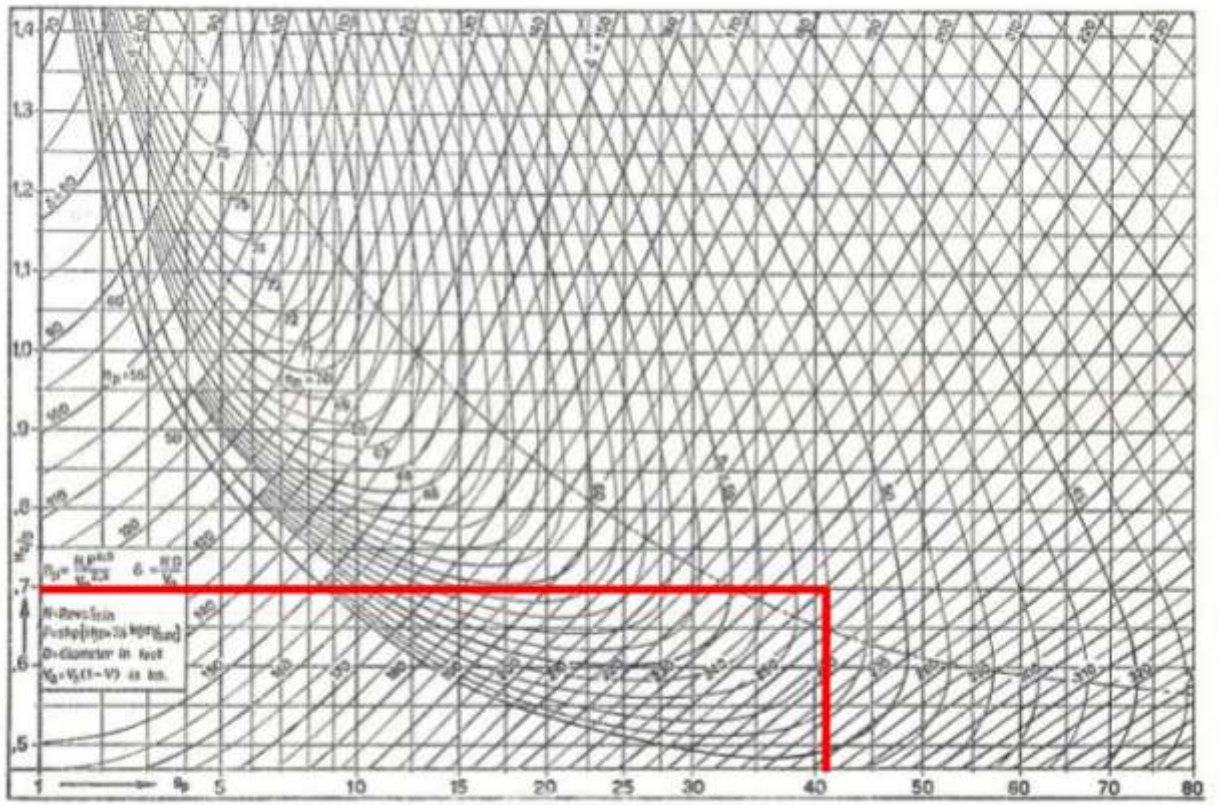


Fig. 3.13 Troost B.3 – 50 *Bp* – *δ* Chart

P/D = 0.70

propeller efficiency, n = 0.52

P = 1.98 m

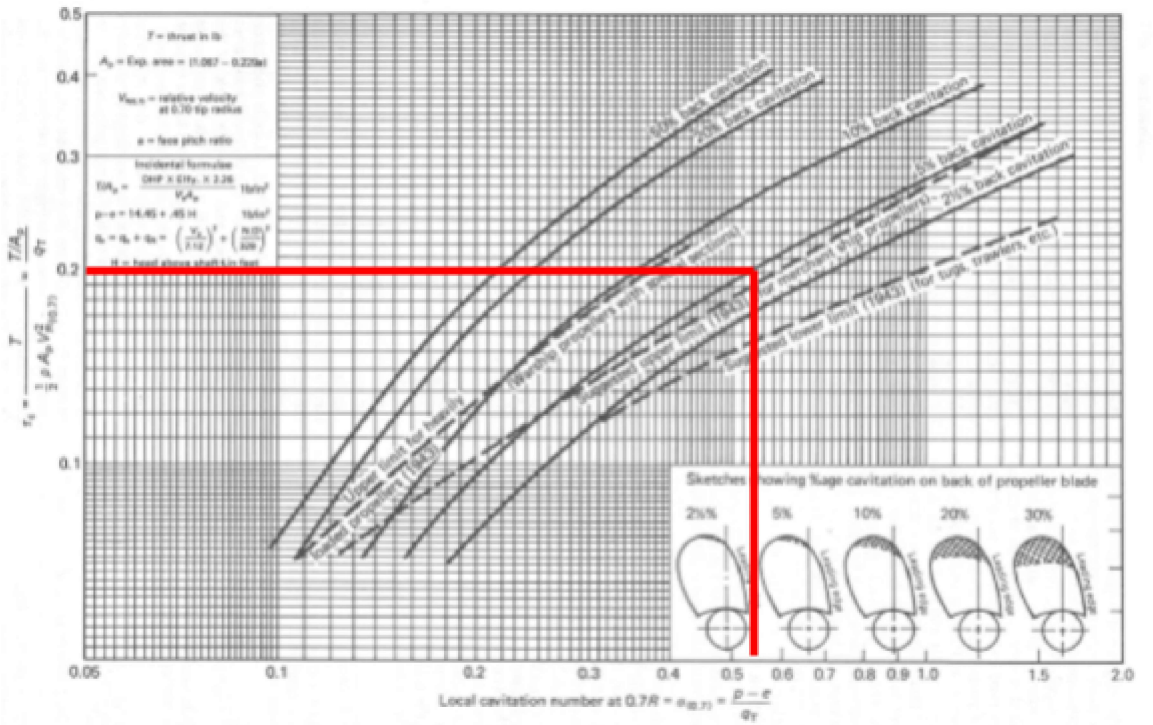
Cavitation Check

$\sigma_{0.7R} = \frac{99.62+9.8h}{.5(V a^2+(7*3.1416*nD)^2)} = 0.52$

$\tau_C = 0.031+0.3886\ \sigma_{0.7R} - 0.1984\ (\sigma_{0.7R})^2 + 0.0501\ (\sigma_{0.7R})^3$

$= 0.19$

from Burrill diagram



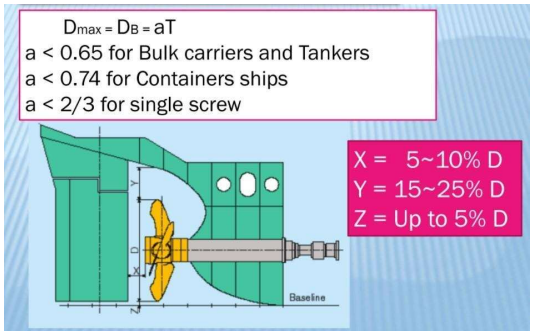
$\tau_C = 0.20$

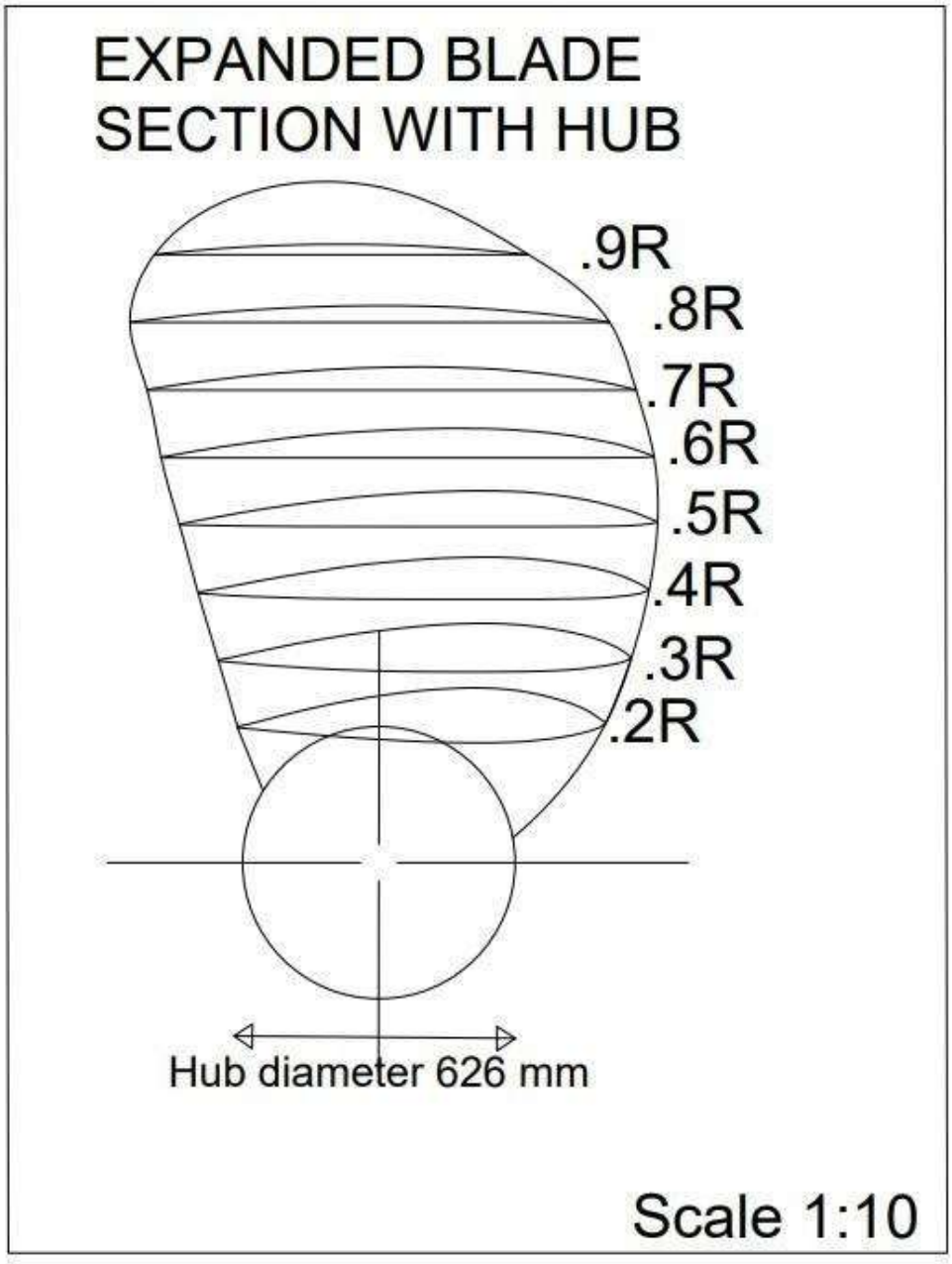
This satisfies cavitation check.

Propeller Specification	
Number of Blades	3.00
P/D	0.80
Propeller diameter	2.83m
Pitch	2.27m
BAR	0.50
Propeller Characteristics	
Number of Blades	3.00
RPM	199.52
Propeller diameter	2.83m
Pitch	2.27m
BAR	0.50
Expanded Blade Area	3.15m^2
Projected Blade Area	2.8m^2
Efficiency	0.50

BAR	**n**	**J**	**P/D**	**RPM**	**BP**	**Delta**	**From Graph**		**Cavitation check**		
							n	**P/D**	**sigma**	**T**	**Remark**
0.35	0.51	0.38	0.76	205.00	42.00	266.00	0.56	0.70	0.50	0.17	Not satisfied
0.50	0.50	0.39	0.80	200.00	41.00	260.00	0.52	0.70	0.52	0.20	Satisfied

Clearance	
X	5% of D
Y	15.2 % of D
Z	6.78 % of D


Dmax = DB = aT
a < 0.65 for Bulk carriers and Tankers
a < 0.74 for Containers ships
a < 2/3 for single screw
X = 5~10% D
Y = 15~25% D
Z = Up to 5% D
Baseline


EXPANDED BLADE SECTION WITH HUB
.9R
.8R
.7R
.6R
.5R
.4R
.3R
.2R
Hub diameter 626 mm
Scale 1:10

19. Shafting Arrangement Calculation :

Particulars :

Length of the ship, L =42.5 m

Breadth of the ship, B = 10.68 m

Draft of the ship, T = 4.72 m

Block coefficient, $C_B = 0.66$

Engine speed = 900 rpm

Engine power, P = 789 KW

Gear Ratio = 4.5 : 1

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

= $\frac{900}{4.5}$

= 200 rpm

Theoretical Approach :

Calculation of Shaft Diameter :

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

= $\frac{789\times1000\times60}{2\times\pi\times200}$

=37671.89 N-m

Stress, τ = $\frac{TC}{J}$

Here, τ = 60×10^6 N/m^2

T =37671.89 N-m

C = $\frac{d}{2}$

$J = \frac{\pi d^4}{32}$

Then, $60\times10^6 = \frac{= 37671.89 \times d/2}{\frac{\pi d^4}{32}}$

$d = \sqrt[3]{V}\left(\frac{37939.97N \times 16}{\pi\times60000000}\right)$

= 0.1473 m

= 148 mm

Diameter of the shaft = **148 mm .**

Calculation of Shaft Diameter [GL Machinery Installation (I-1-2) Section 4, D.5.2]:

Shaft Diameter:

Minimum shaft dia according to GL rule

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

Where,

d = Required outside diameter of shaft

d_i = Actual diameter of shaft bore, where present.

d_a = Actual shaft diameter

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

P_W = Power transmitted by shaft

= 773.22 KW

f = Shaft speed

$= 200\ rpm$

Here,

R_m = Tensile strength of shaft material

$= 600\ N/mm$

C_W = Material factor

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

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

$=$ 0.7368

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

$K =$ Factor for shaft type

$= 1.4$ For intermediate propeller shaft

So we have,

$$d = F \times K \times \sqrt[3]{\frac{P_W}{f \times \left[1-\left\{\frac{d_i}{d_a}\right\}^4\right]}} \times \mathbf{C_w}$$

$$= 100 \times 1.4 \times \sqrt[3]{\frac{773.22}{200 \times 1}} \times 0.7368$$

$=$ 162 mm

From two methods and according to available diameter of shaft in the market we take the shaft diameter as **162 mm .**

Twisting Angle:

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

Here length of the shaft is taken **L = 5.422 m**

And, J = $\frac{\pi d^4}{32}$ =6.76 E-5

And G = $8.3E10$

$\theta = \frac{37671.89\ N \times 5.422}{8.3E10 \times 6.76\ E-5}$ rad.

= .0364 rad

=2.09 ^{0}

So we take $\theta = 2.09^0$

Since the angle of twist is greater than 1 degree so intermediate support is required .

Minimum wall thickness :

$s = 0.03 \times d + 7.5$ mm

$= 0.03 \times 162 + 7.5$ mm

= 12.36 mm

= **13 mm .**

Coupling :

The thickness of coupling flanges on the intermediate and thrust shafts and on the forward end of the propeller shaft must be equal to at least 20 % of the calculated diameter of the shaft.

Thickness of coupling flange $= 0.20 \times 162 = 32.4$ mm = **33 mm .**

Shaft Bearings :

$l_{max} = K_1 . \sqrt{d}$

Where,

l_{max} = Maximum permissible distance between bearings

d = Diameter of shaft between bearings (mm) = 140 mm

K_1 = 280 ~ 350 (for water-lubricated rubber bearings in stern tubes and shaft Brackets)

So, $\mathbf{l_{max}} = K_1 . \sqrt{d} = 280 \times \sqrt{162} = 3563.82$ mm = **3.56 m**

Stern tube bearing :

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

Length of after stern tube bearing = 4d

Length of forward stern tube bearing= 1.5d

So,

Length of after stern tube bearing = 4 x 162 = **648 mm .**

Length of forward stern tube bearing = 1.5 x 162 = **243 mm .**

Shaft details :

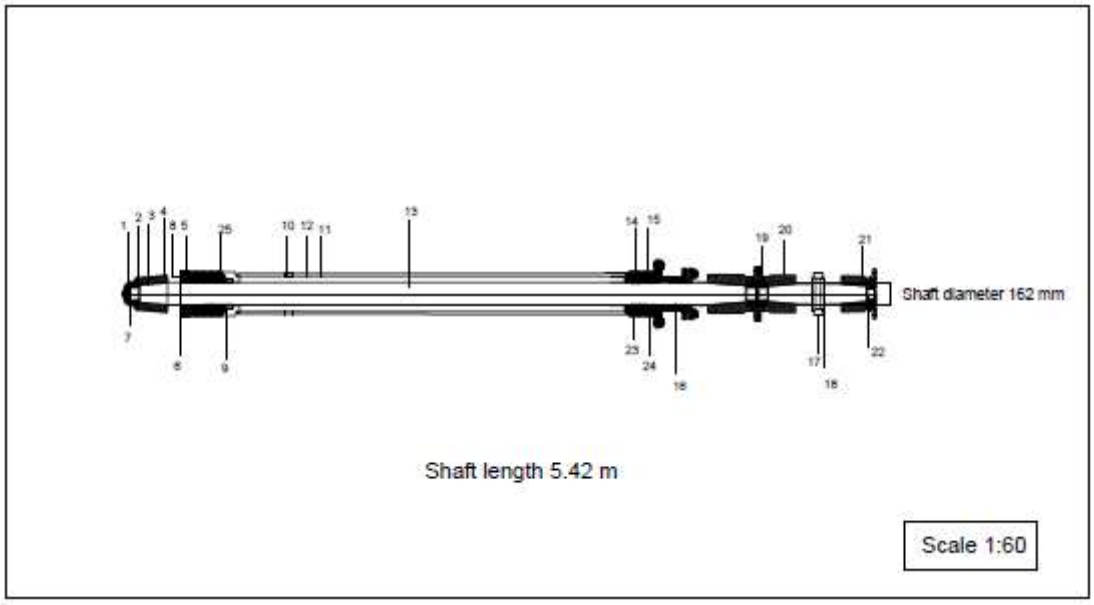
Details of the elements are given in following table according to their serial no. in CAD drawing:

SL. NO	DESCRIPTION	MATERIALS	NUMBER OF COMPONENT
1	Cone nut	Mild Steel	1
2	Cone nut securing screw	Mild Steel	2
3	Propeller key	Mild Steel	1
4	Propeller dia X pitch	Mild Steel	1
5	Aft. Brg . securing screw	Mild Steel	3
6	Cover plate securing screw	Mild Steel	3
7	Aft locking ring	Mild Steel	1
8	Cover plate	Mild Steel	1
9	Lock ring securing screw	Mild Steel	3
10	Forward locking ring	Mild Steel	1
11	Rubber bearing	Mild Steel	
12	Stern Tube	Mild Steel	1

13	Tailshaft	Mild Steel	1
14	Forward gland housing	Mild Steel	1
15	Forward bearing	Mild Steel	1
16	Greasy packing	Mild Steel	3 turns
17	Gland ring	Mild Steel	1
18	Gland studs and nuts	Mild Steel	2
19	Coupling key	Mild Steel	1
20	Half coupling	Mild Steel	1
21	Backing washer	Mild Steel	1
22	Locking nut	Mild Steel	1
23	Sealing ring	Mild Steel	1
24	Fwd.brg. securing screw	Mild Steel	1
25	Bearing lock ring	Mild Steel	1

Shaft Dimensions	
Diameter of shaft	162 mm
Length of shaft	5.422m
Shaft speed	200 rpm
Stress	60000000 N/mm^2
Twisting angle	2.09 degree

Shafting Arrangement Drawing :



20. Engine Foundation :

Particulars :

Length of ship , L = 42.5 m

Breadth of ship , B = 10.68 m

Draft of the ship , T = 4.72 m

Block coefficient , $C_B = 0.66$

Frame spacing , a = 0.6 m

Engine power output , P = 486 KW

Engine Foundation Calculation [GL 2013 Section 8 D]

Summary

Items	Dimension
Floor plate thickness	9 mm
Inner bottom plating	8 mm
Foundation bolts	20 mm
Top plate	385 mm

Floor plate thickness :

The floor thickness is to be increased as follows,

Here,

$t_f =$ Floor thickness = 6.5 + 0.035L = 7.9875 mm

$$t_{fe} = t_f + t_f \left(3.6 + \frac{P}{500}\right)\%$$

= 8.3526885 mm

So we take floor plate thickness as in way of engine **9 mm .**

Inner Bottom Plating :

Between the foundation girders, the thickness of the inner bottom plating required is to be increased by 2 mm.

$t_b =$ Thickness of inner bottom plating in other place = 6 mm

So the thickness of inner bottom plating will be,

$t_{be} = t_b + 2$ = 8 mm

So we take the thickness of inner bottom plating in way of engine as **8 mm .**

Longitudinal girders :

The thickness of longitudinal girders above the inner bottom is not to be less than, for P < 1500 kW

t = √p/15 + 6

= 11.692 mm

So we take the thickness of longitudinal girder as **12 mm .**

Foundation bolts :

The foundation bolts for fastening the engine at the seating shall be spaced no more than apart,

$$s = 3 \times d$$

From the longitudinal foundation girder. Where the distance of the foundation bolts from the longitudinal foundation girder is greater, proof of equivalence is to be provided.
Where,

d = diameter of the foundation bolt = 20 mm [From Yanmar's Catalogue]

So we have

$s = 3 \times d$ = 60 mm

So we take the spacing of the foundation bolt from the foundation girder as **60 mm .**

Top plate dimension :

The thickness of the top plate should approximately be equal to the diameter of the fitted-in bolts. So we have the thickness of the top plate as 30 mm

Again the sectional area of the top plate should not be less than, for $P > 750\ kW$

$$A_T = \frac{P}{75} + 70\ cm^2$$

=76.48 cm^2

So the width of top plate will be,

$b_T = \frac{A_T \times 100}{t_T}$ = 382.4 mm

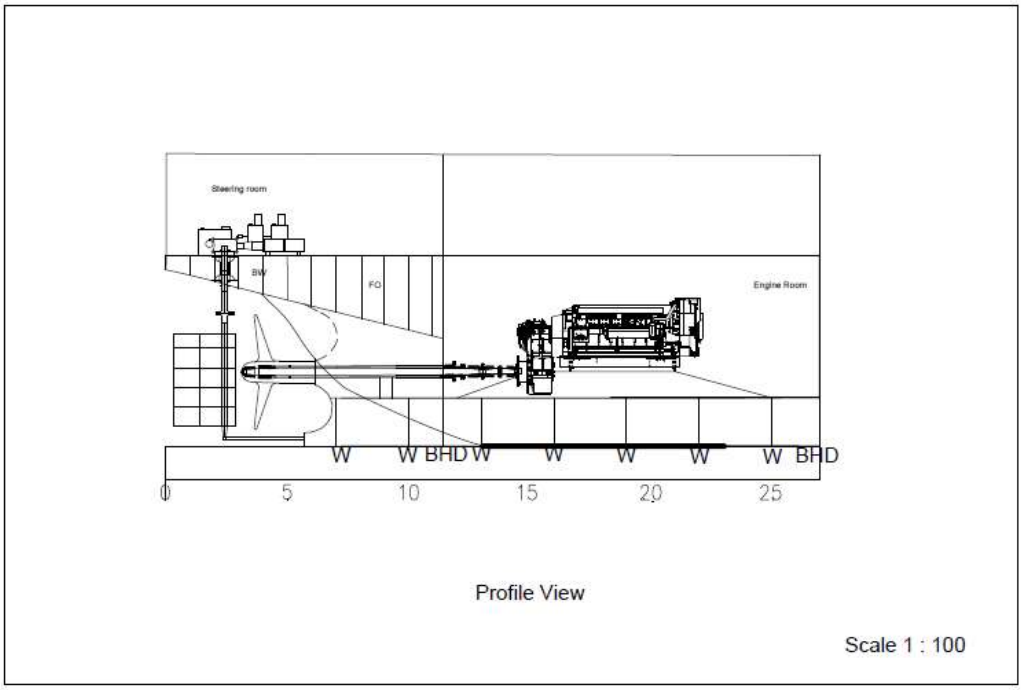
So we take the width of the top plate as **385 mm .**

Web frame :

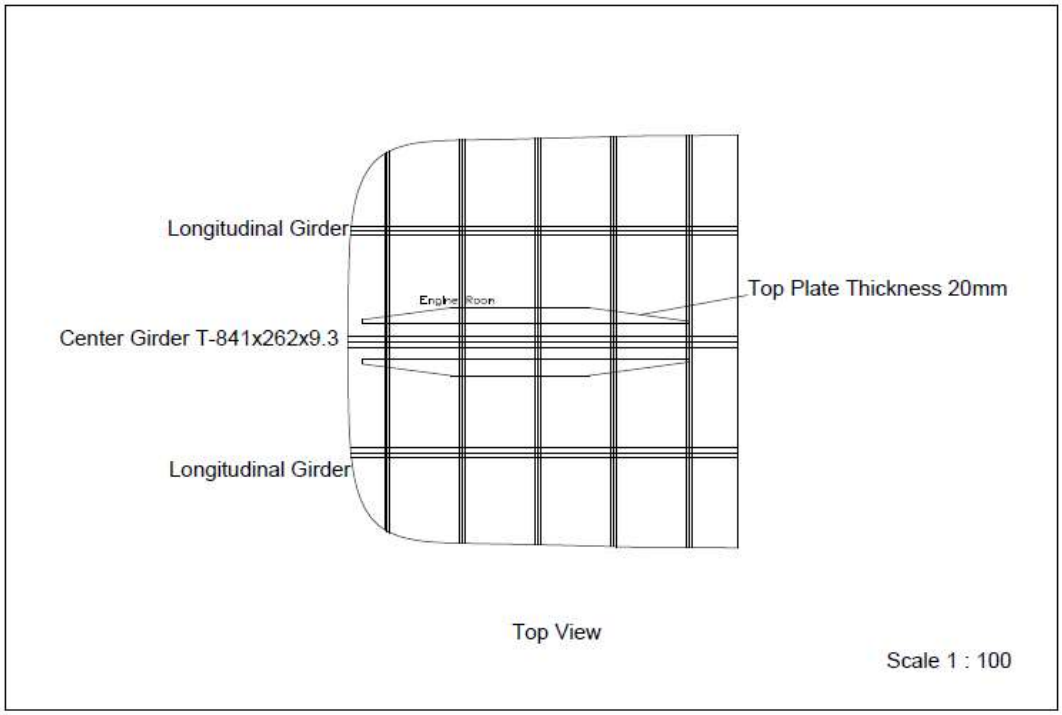
The longitudinal girders of the engine seatingare to be supported transversely by means of web frames. The scantlings of web frames are to be taken as before.
Hence the dimension of the web frame T -section is **128*128*5**

Engine Foundation Drawing :

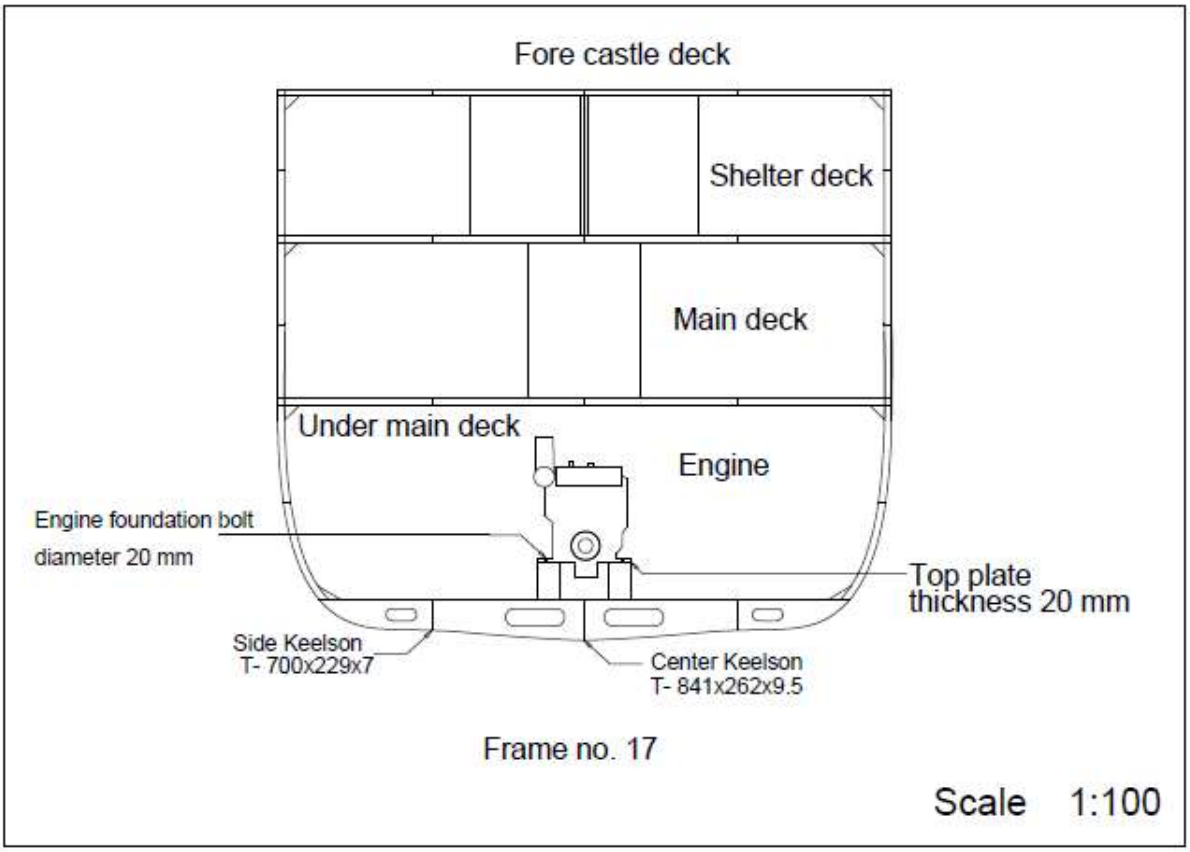
Profile View :

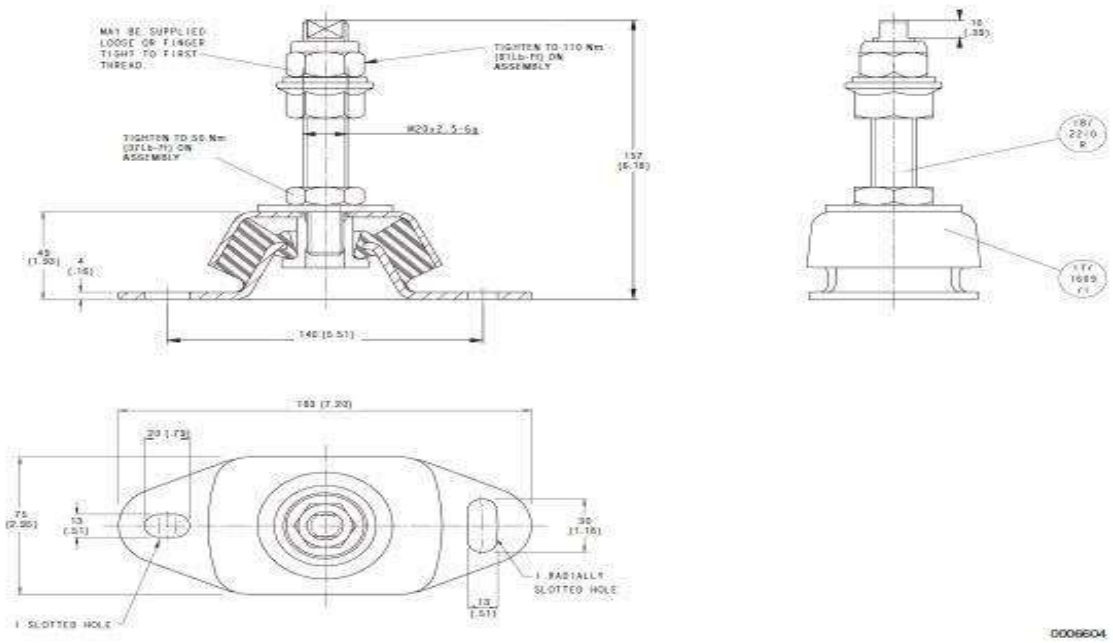


Top View :


Longitudinal Girder
Engine Room
Top Plate Thickness 20mm
Center Girder T-841x262x9.3
Longitudinal Girder
Top View
Scale 1 : 100

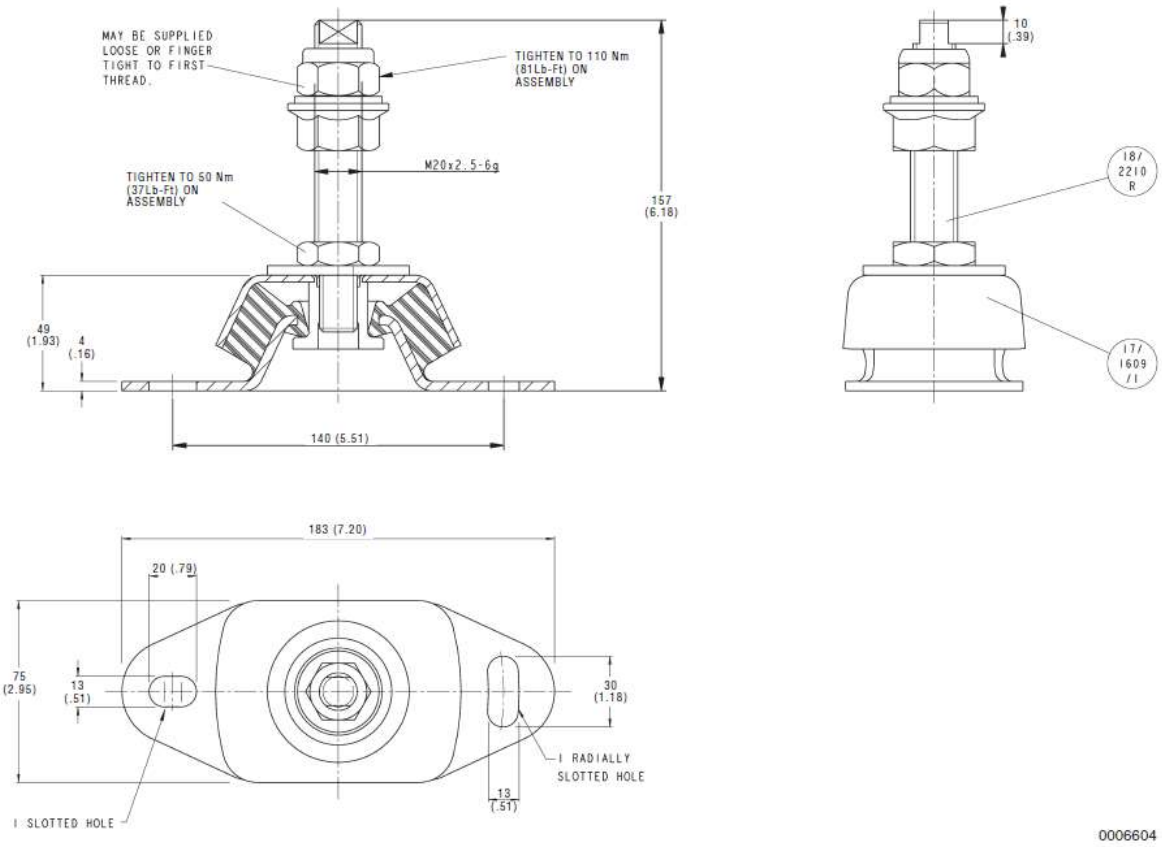
Main Engine Sectional View :




MAY BE SUPPLIED LOOSE OR FINGER TIGHT TO FIRST THREAD.
TIGHTEN TO 110 Nm (81 lb-ft) ON ASSEMBLY
TIGHTEN TO 50 Nm (37 lb-ft) ON ASSEMBLY
M20x2, 5-6g
137 (5.39)
43 (1.69)
4 (.16)
140 (5.51)
183 (7.20)
29 (1.73)
75 (2.95)
13 (.51)
30 (1.18)
1 RADIALLY SLOTTED HOLE
13 (.51)
1 SLOTTED HOLE
0006604

Unit: mm (in.)

Engine Mount



Unit: mm (in.)

21. 3D Modelling

The 3D model of the ship is designed following a few steps. The steps are sequentially mentioned below:

1. Generating lines plan 2d in Autocad
2. Adding extra dense lines and sections to high curvature sections of hull in 2d lines plan
3. Plotting 2D sections in rhino 3D
4. Generating 3D hull from 2d lines plan sections
5. Exporting 3D object from rhino 5; importing 3D object to blender
6. Generating final 3D model in blender and adding all components

All these points are now discussed elaborately below:

1. Generating lines plan 2D in Autocad :

The main basis of generating 3D drawing is the lines plan of the ship. It has been done in an iterative process and the final lines plan has been used as the primary reference to generate the 3D Mesh.

2. Adding extra dense lines and sections to high curvature sections of hull in 2D lines plan :

Since the curvature of the ship is more towards the forward and aft portion of the ship, to ensure accuracy of the curves, some extra stations have been taken in these portions so that appropriate curve lines can be generated from the points. On the lower portion of the ship as well, extra waterlines have been taken and the relevant data points have been recorded to get a clear idea of the curves through the obtained points.

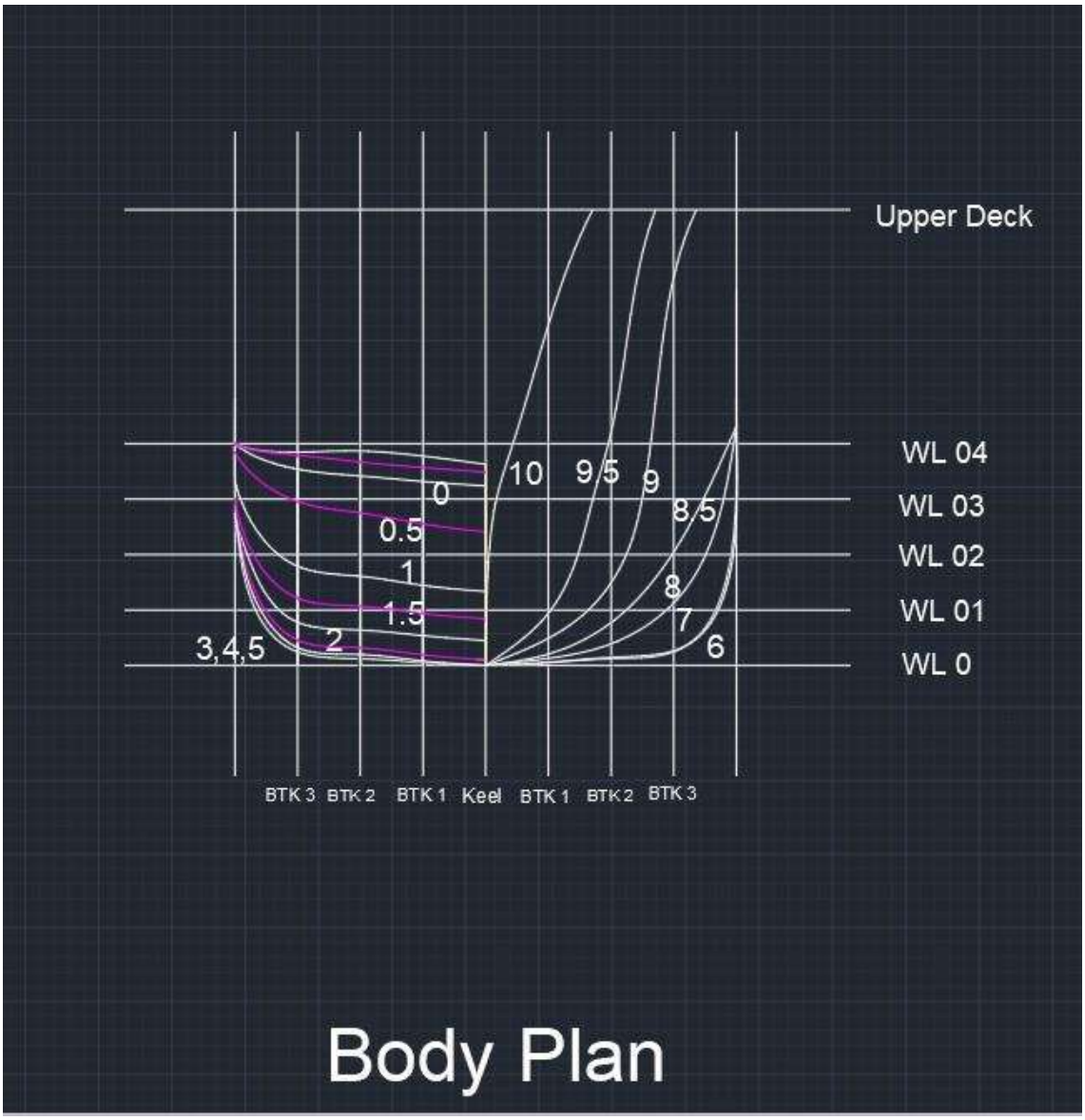


Fig: Extra stations taken in the highly curved portions marked in purple.

3. Plotting 2D sections in Rhino 3D :

Next, the 2D sections obtained in the lines plan drawing, from Autocad, are plotted in rhino 5. This is done in the following steps:

I. First the keel points of all the sections from the lines plan are noted, and the x, y, z coordinates of these points, taking the centre-most station of the ship as origin are noted.

II. Next, according to the obtained coordinates, all the keel points are plotted in rhino 3d view. The appropriate x, y, z coordinates are maintained.

III. Next, all the sections from the Autocad 2D drawing lines plan drawing are imported into rhino 5, and are aligned in the 3D view by rotating around necessary axes.

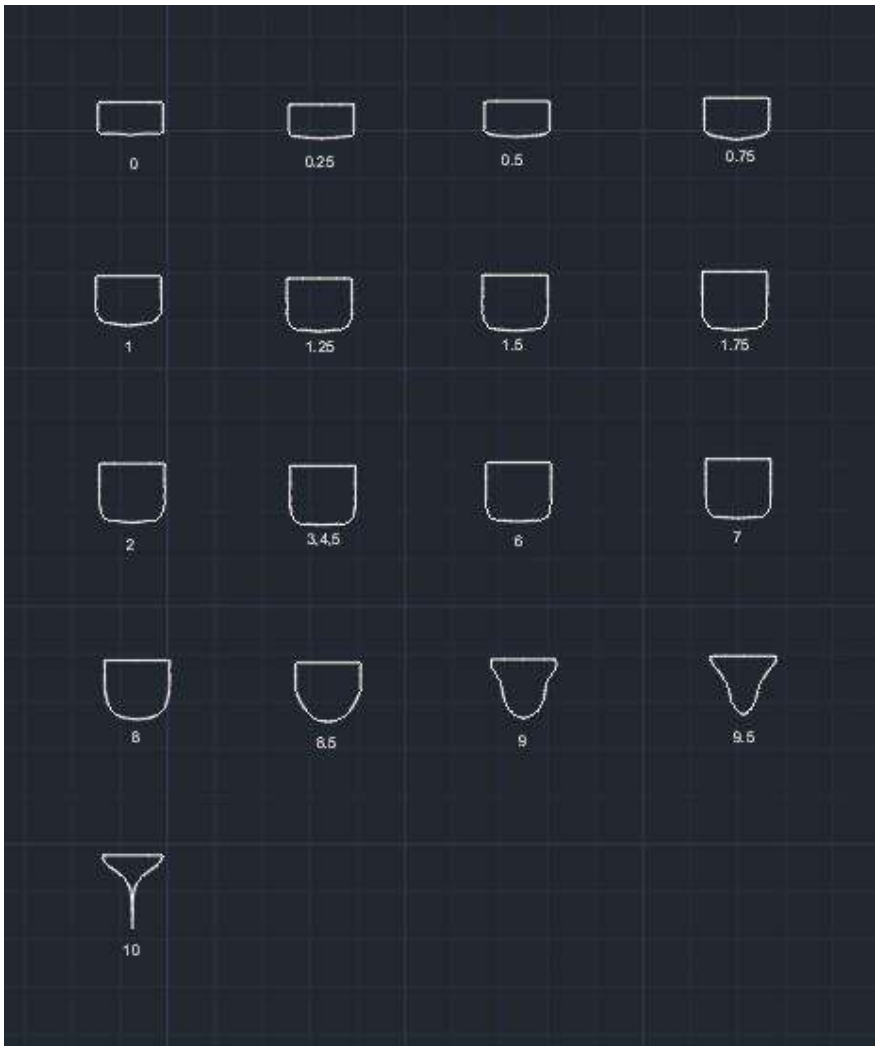


Fig: Different sections of Body Plan taken from Autocad to Rhino 5

IV. Next, the keel points of the stations are connected to their respective keel points that were previously plotted. This gives the progessive view of the sections of the hull in a 3D view.

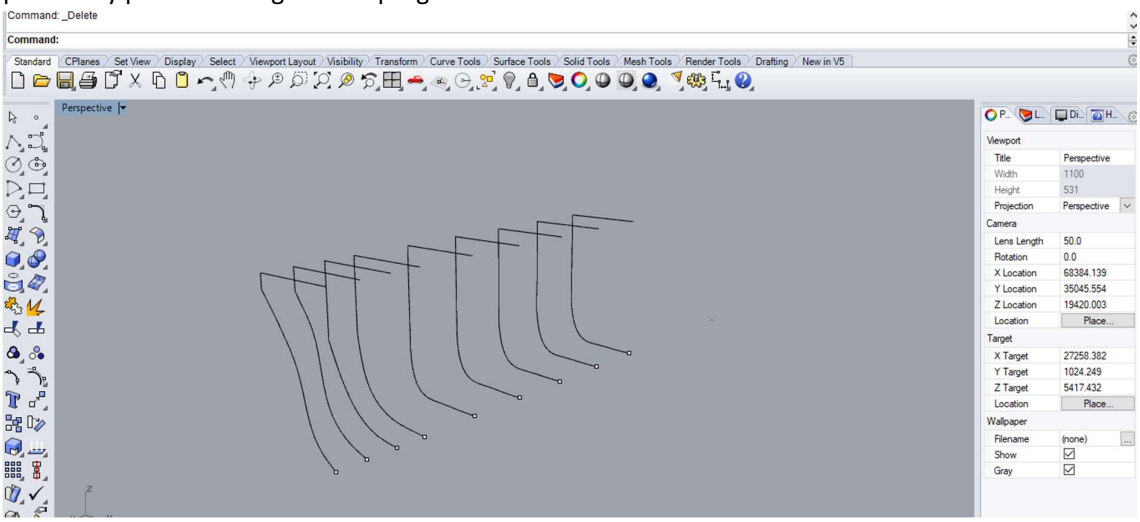


Fig: Hull sections (3-10) plotted from lines plan into Rhino 5 in 3D view

4. Generating 3D hull from 2D lines plan sections :

In this step, the section curves that have been plotted in 3D view in the previous section are connected together using the loft command. Afterwards, the half hull surface is mirrored about the centreline running aft to forward, and joined to form the complete hull form.

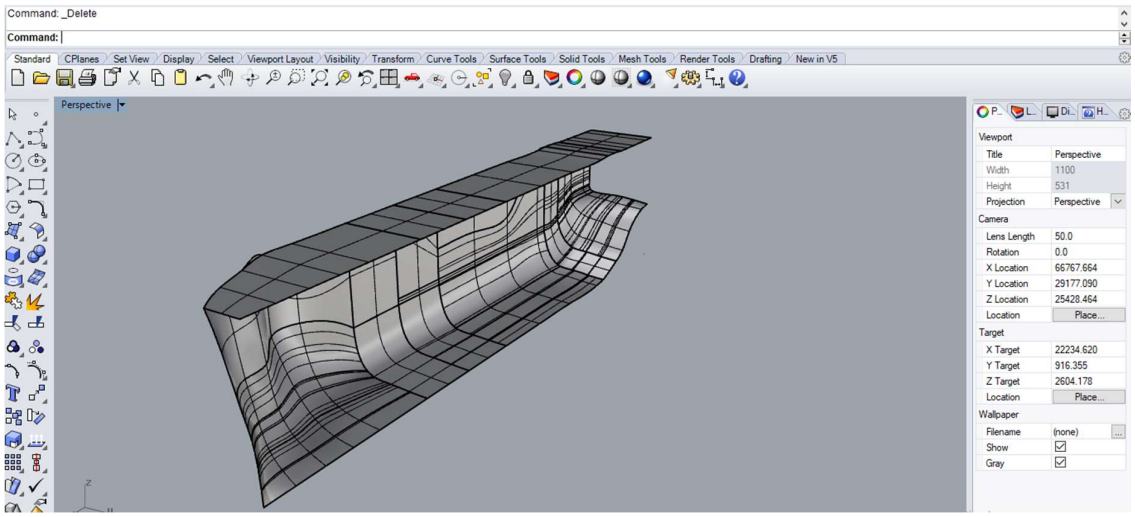


Fig: Half hull surface created from sections

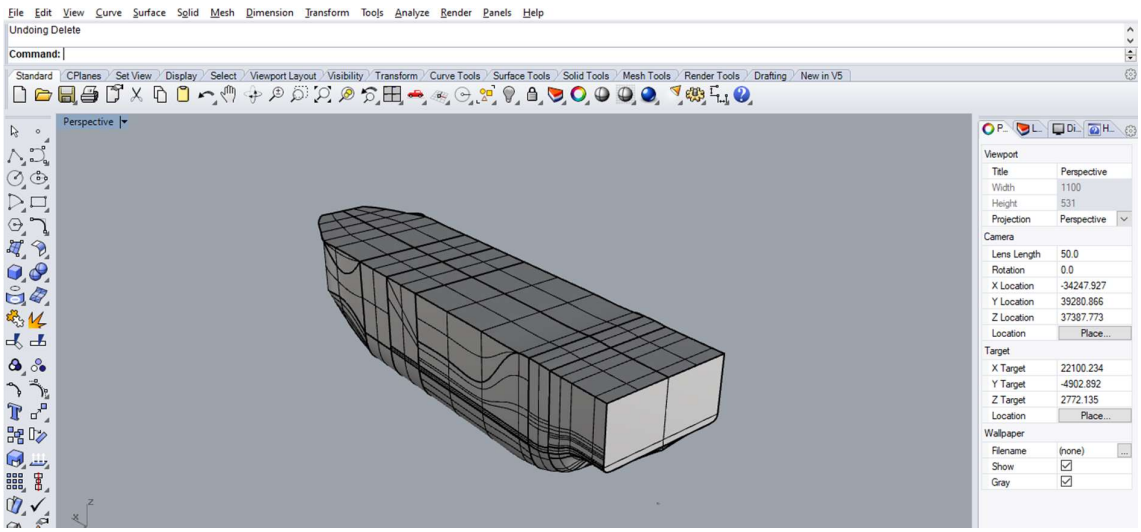


Fig: Total hull surface after mirroring half hull

5. Exporting 3d object from rhino 5; importing to Blender :

After generating the hull form in Rhino 5, the 3D file is exported in (.obj) file format. The (.obj) file is now imported to Blender. It is made sure that the model stays in proper scale and it is checked while importing. Also, the cursor is set to the origin and the imported file is placed in such a way that the aftmost point of the ship coincides with the origin.

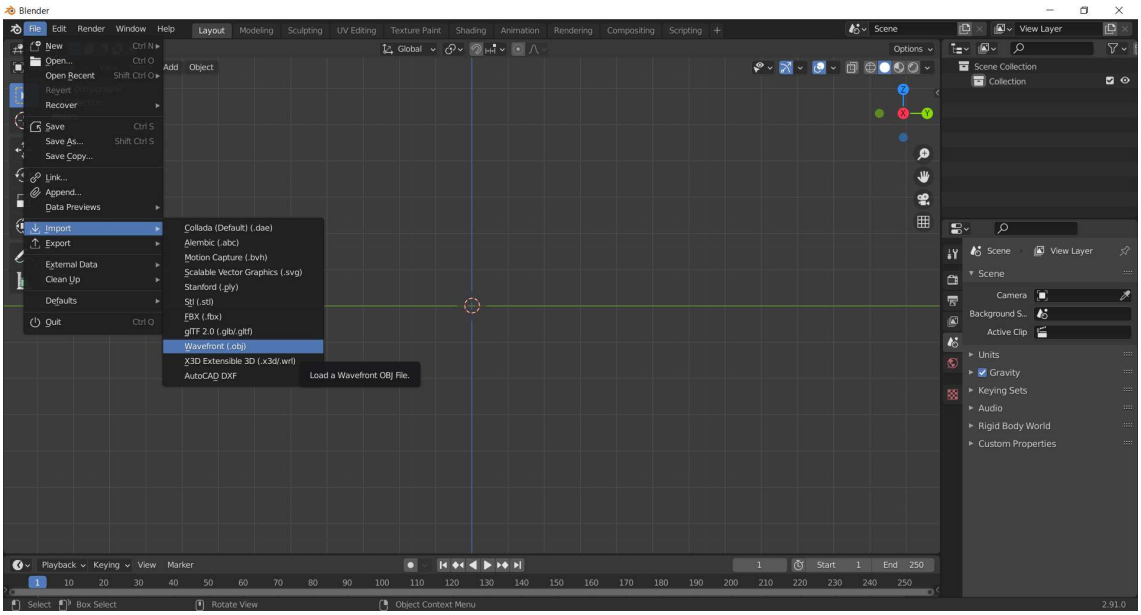


Fig: Importing 3D(.obj) file to Blender

6. Generating Final 3D Model in Blender and adding all components:

I. After importing the hull form 3D file, the projections of different views of the General Arrangement Plan are matched with the Hull form in three views- Top, Side and Front.

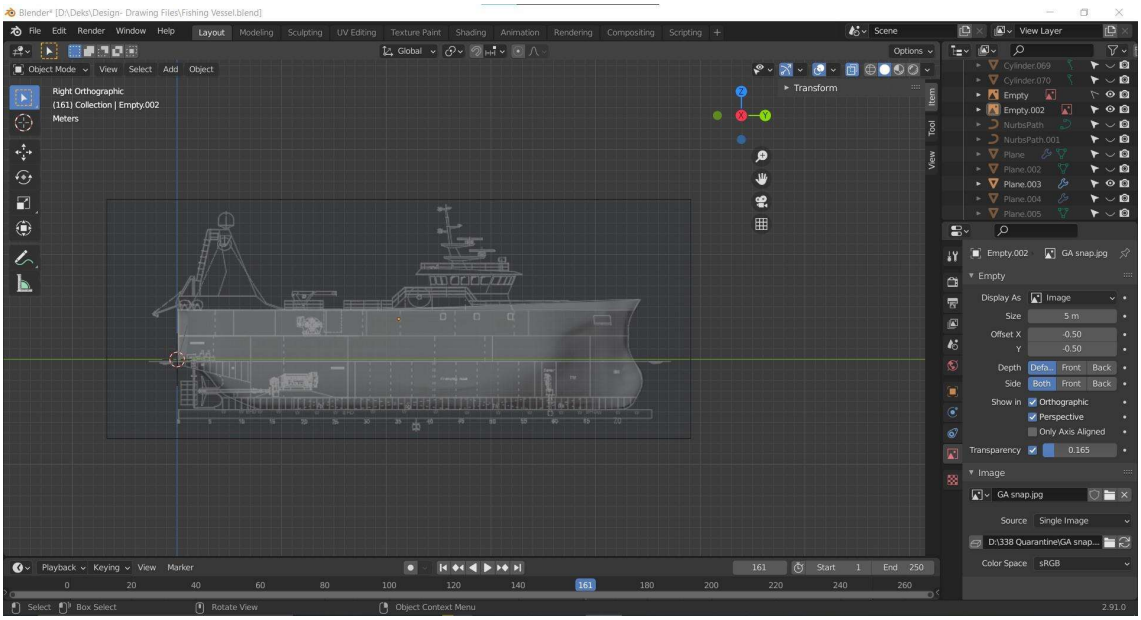


Fig: Matching the projection of 3D imported Hull and GA in proper scale and dimensions

II. After the views match with the existing 3D shape, the remaining portions of the ship superstructure including deck house, winches, gantry cranes etc are modelled by creating the 3D form based on the three view projections.

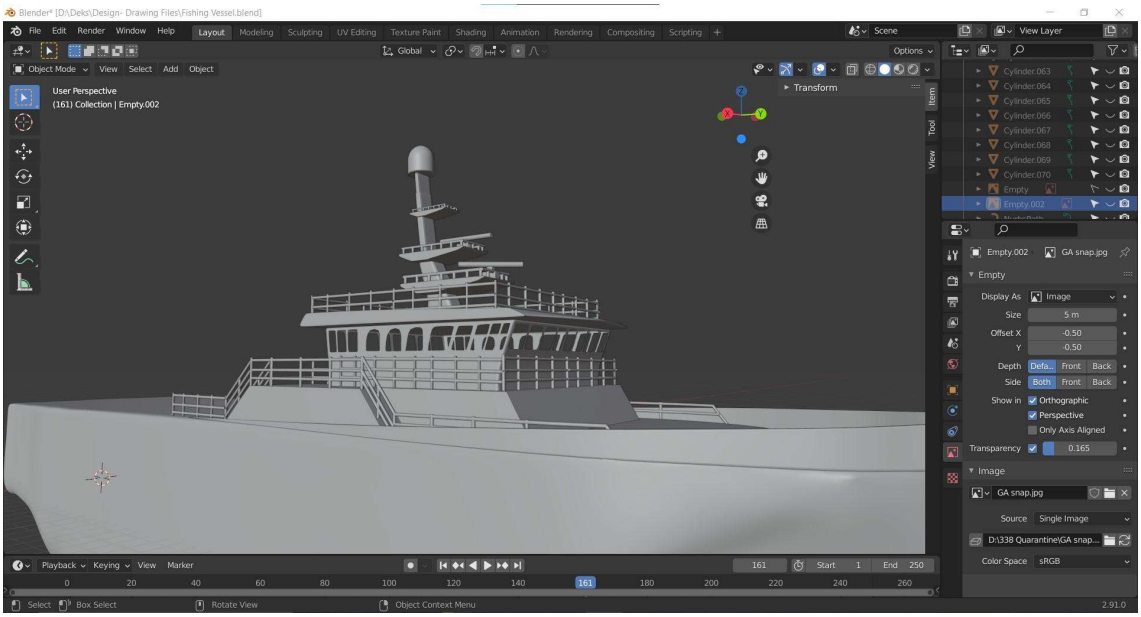


Fig: Deckhouse

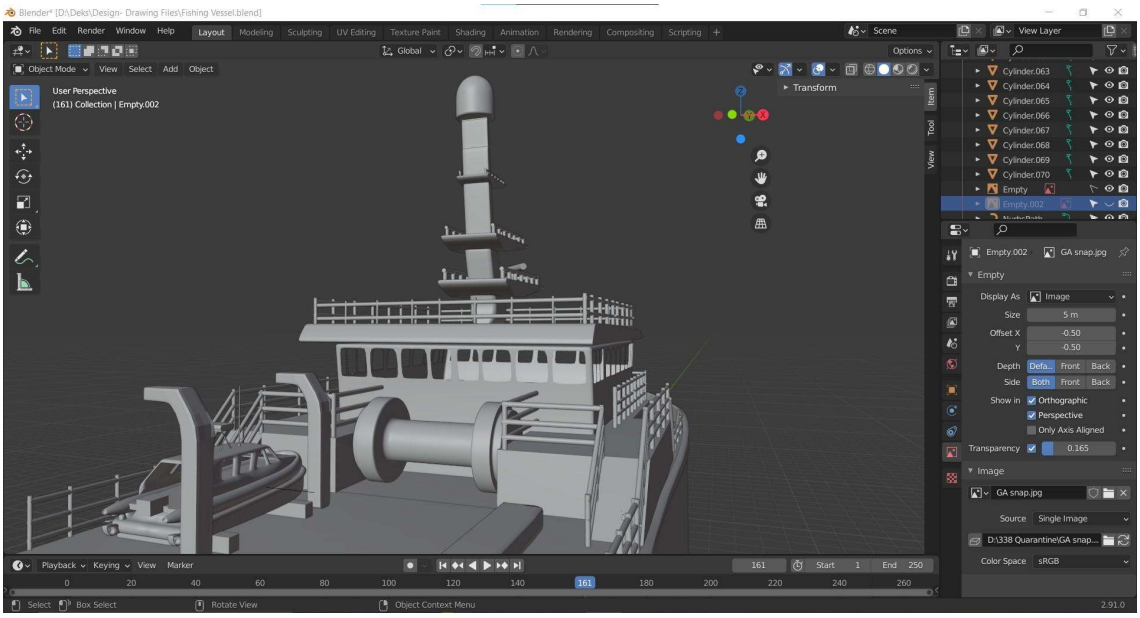


Fig: Sweep line Winch

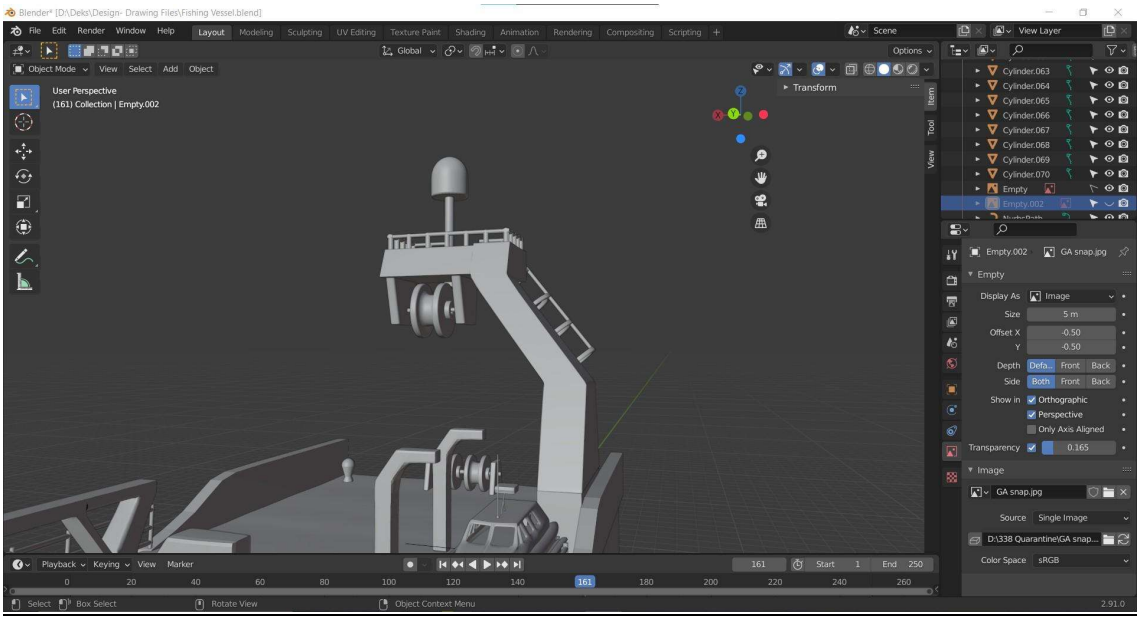


Fig: Gantry Crane

III. The lifesaving appliances are modelled in a similar way taking the blueprints of a lifeboat and developing the 3D form from the three views respectively.

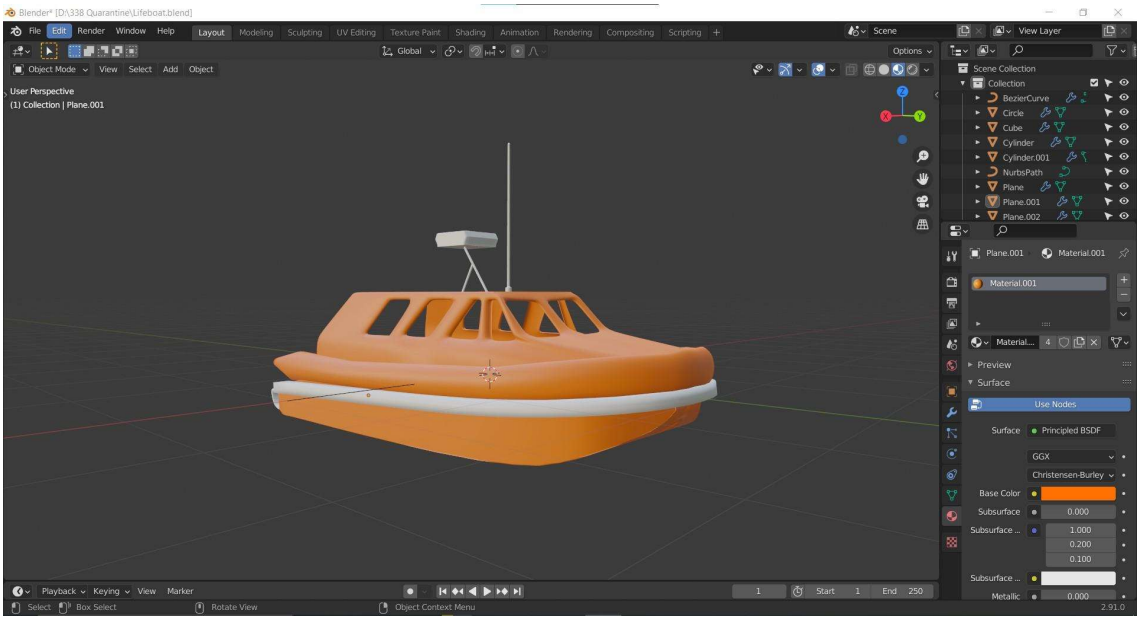


Fig: Modelling of a lifeboat satisfying the criteria of SOLAS

IV. The rudder has been modelled from the 2D autocad drawing of rudder and the Wageningen B series propeller has been modelled from their official website (Wageningen B series Propeller Generator) where they generated the propeller model based on the propeller characteristics given.

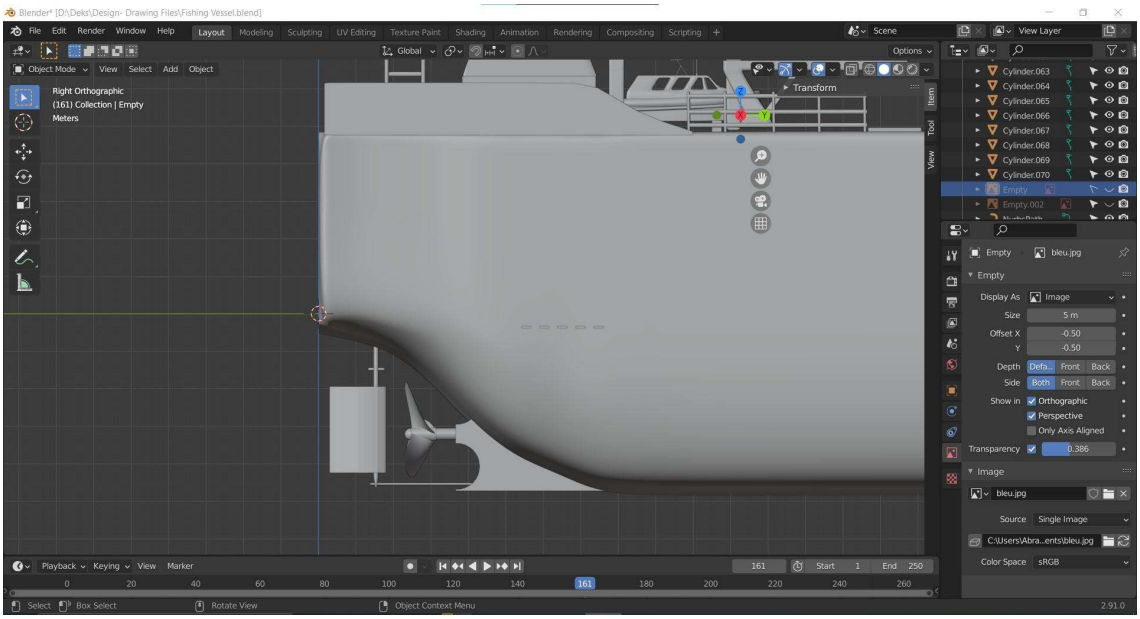


Fig: Rudder and Propeller Modelling

V. After the formation of 3D shape, proper shading has been given to show color and realism.

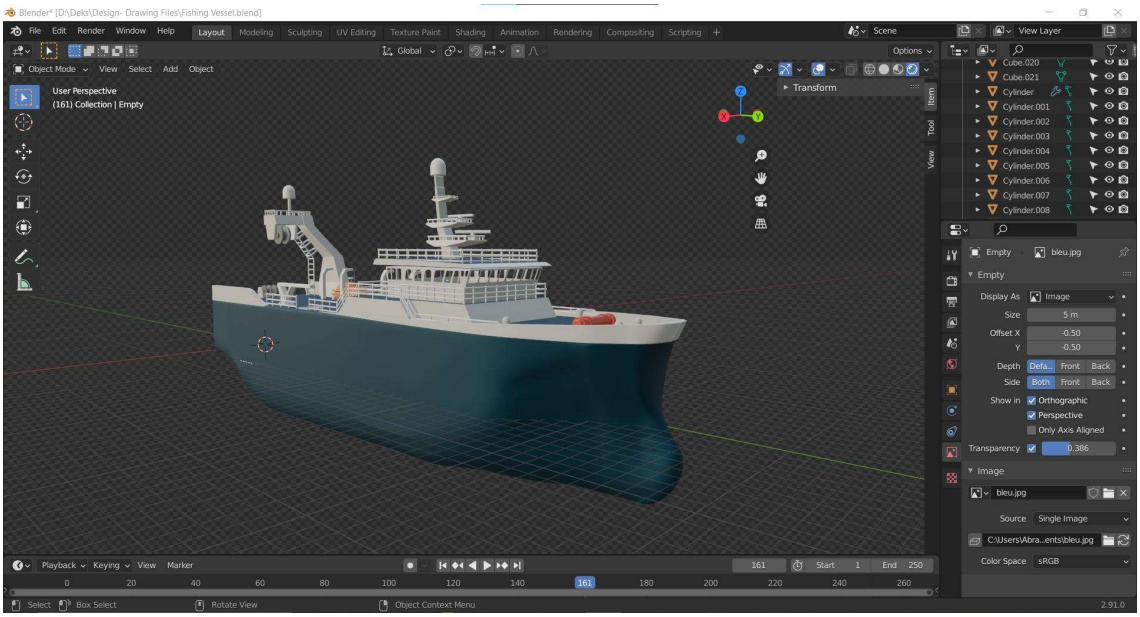
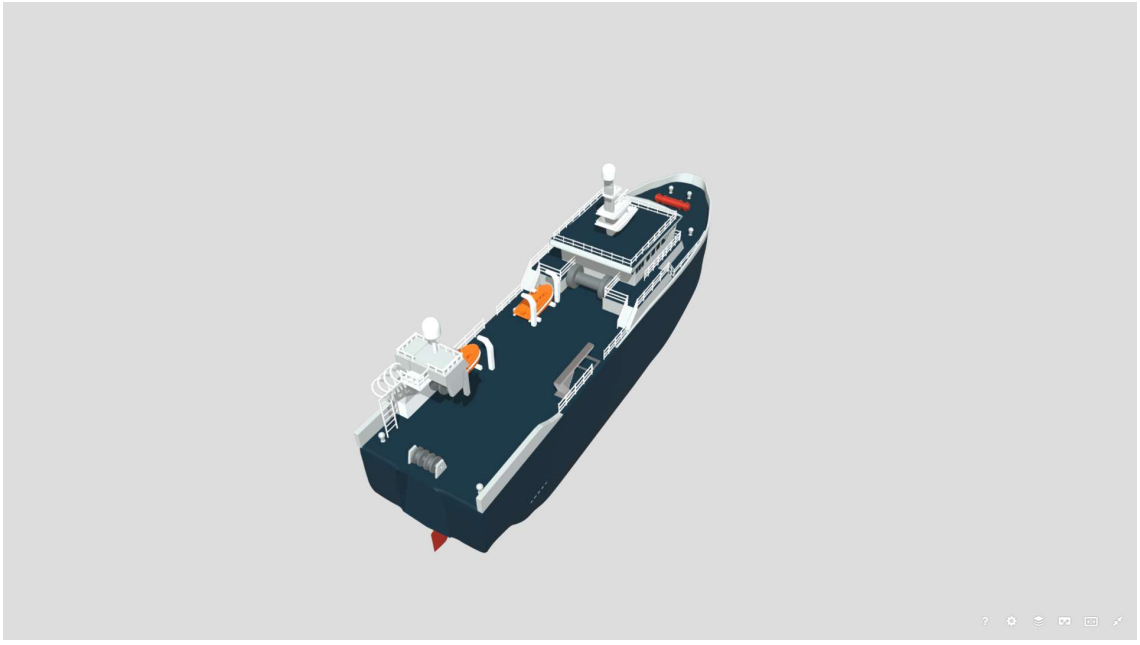


Fig: Shading of the final 3D Model

VI. Finally for presentation, the 3D Model has been uploaded to a 3D viewer hosting website called sketchfab.

Here is the link to the site : SketchFab



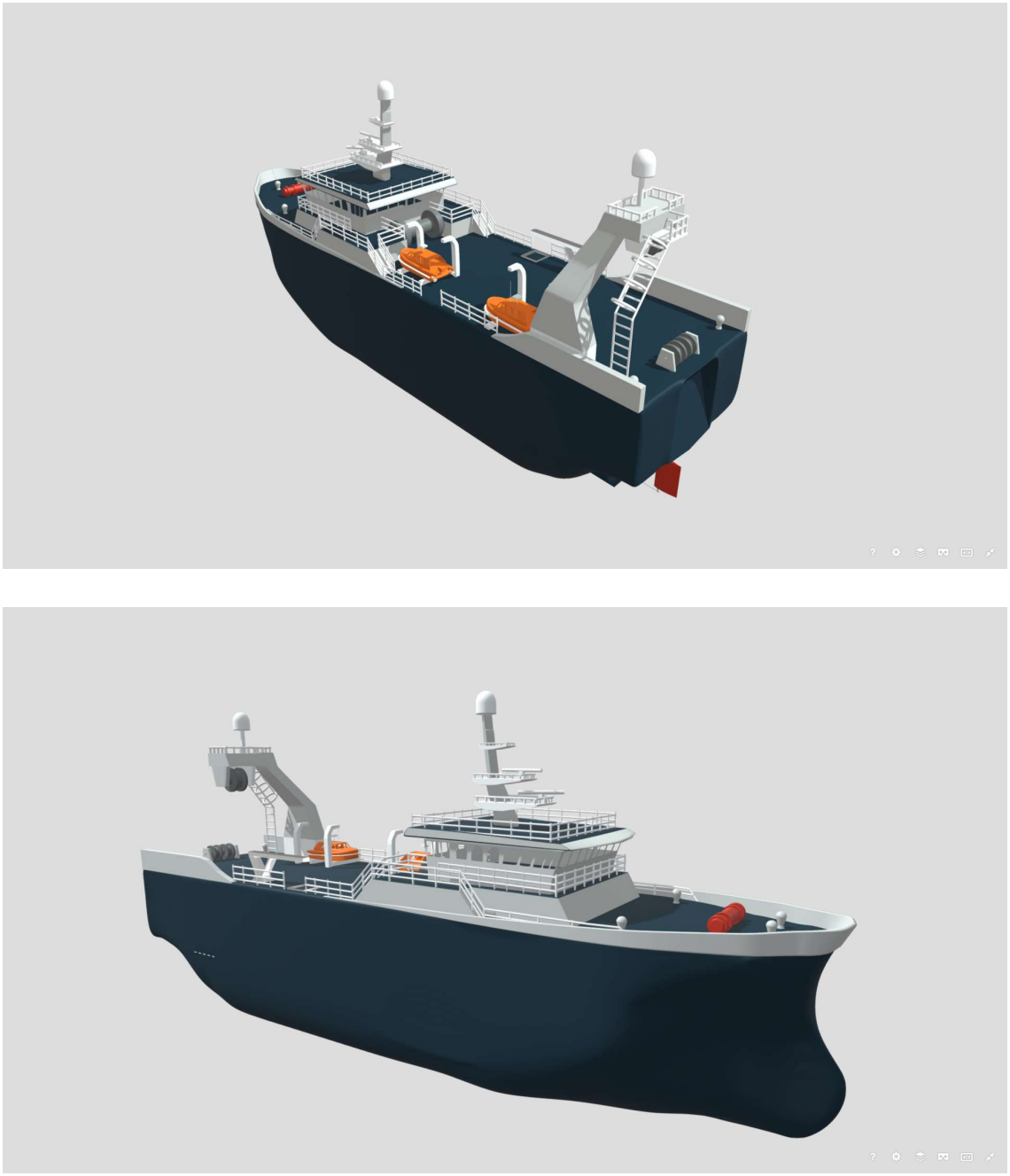


Fig: Final Render of different perspective views of the 3D Model

References:

Propeller 3D model generation website: https://www.wageningen-b-series-propeller.com/
Complete 3D model of our fishing vessel: https://skfb.ly/6XFAF

Appendix - A

Detailed Weight Calculation

The detailed weight calculations and weight breakdowns of different section of the ship are given below, according to the following sequence:

I. Transverse Frames

Frame no.	Frame Type	stations	Frame Length(m)	Cross Section Area (sq. m)	Volume (cubic m)	Density (kg/m^3)	Weight (tonnes)	Longitudinal lever (m)	Longitudinal Moment	Vertical lever (m)	Vertical Moment
0	Ordinary	0-0.5	11.00	0.00053	0.0058	7850	0.0453	-22.80	-1.034	7.52	0.341
1	Ordinary	0-0.5	11.00	0.00053	0.0058	7850	0.0453	-22.20	-1.007	7.52	0.341
2	Ordinary	0-0.5	11.00	0.00053	0.0058	7850	0.0453	-21.60	-0.979	7.52	0.341
3	Ordinary	0-0.5	11.00	0.00053	0.0058	7850	0.0453	-21.00	-0.952	7.52	0.341
4	Ordinary	0-0.5	11.00	0.00053	0.0058	7850	0.0453	-20.40	-0.925	7.52	0.341
5	Ordinary	0-0.5	11.00	0.00053	0.0058	7850	0.0453	-19.80	-0.898	7.52	0.341
6	Ordinary	0.5-1	11.76	0.00053	0.0062	7850	0.0485	-19.20	-0.931	7.52	0.364
7	Ordinary	0.5-1	11.76	0.00053	0.0062	7850	0.0485	-18.60	-0.902	7.52	0.364
8	Ordinary	0.5-1	11.76	0.00053	0.0062	7850	0.0485	-18.00	-0.872	7.52	0.364
9	Ordinary	1-1.5	11.07	0.00053	0.0058	7850	0.0456	-17.40	-0.794	7.52	0.343
10	**web**	1-1.5	11.07	0.00126	0.0139	7850	0.1091	-16.80	-1.833	7.52	0.820
11	Ordinary	1-1.5	11.07	0.00053	0.0058	7850	0.0456	-16.20	-0.739	9.70	0.443
12	Ordinary	1-1.5	11.07	0.00053	0.0058	7850	0.0456	-15.60	-0.712	9.70	0.443
13	**web**	1-1.5	11.07	0.00126	0.0139	7850	0.1091	-15.00	-1.637	9.70	1.058
14	Ordinary	1.5-2	9.45	0.00053	0.0050	7850	0.0390	-14.40	-0.561	9.70	0.378
15	Ordinary	1.5-2	9.45	0.00053	0.0050	7850	0.0390	-13.80	-0.538	9.70	0.378
16	**web**	1.5-2	9.45	0.00126	0.0119	7850	0.0931	-13.20	-1.230	9.70	0.904
17	Ordinary	2-3	8.98	0.00053	0.0047	7850	0.0370	-12.60	-0.466	9.70	0.359
18	Ordinary	2-3	8.98	0.00053	0.0047	7850	0.0370	-12.00	-0.444	9.70	0.359
19	**web**	2-3	8.98	0.00126	0.0113	7850	0.0884	-11.40	-1.008	9.70	0.858
20	Ordinary	2-3	8.98	0.00053	0.0047	7850	0.0370	-10.80	-0.400	9.70	0.359
21	Ordinary	2-3	8.98	0.00053	0.0047	7850	0.0370	-10.20	-0.377	9.70	0.359
22	**web**	2-3	8.98	0.00126	0.0113	7850	0.0884	-9.60	-0.849	9.70	0.858
23	Ordinary	2-3	8.98	0.00053	0.0047	7850	0.0370	-9.00	-0.333	9.70	0.359
24	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	-8.40	-0.310	9.70	0.358

25	**web**	3-7	8.97	0.00126	0.0113	7850	0.0883	-7.80	-0.689	9.70	0.857
26	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	-7.20	-0.266	9.70	0.358
27	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	-6.60	-0.244	9.70	0.358
28	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	-6.00	-0.222	9.70	0.358
29	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	-5.40	-0.200	9.70	0.358
30	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	-4.80	-0.177	9.70	0.358
31	**web**	3-7	8.97	0.00126	0.0113	7850	0.0883	-4.20	-0.371	9.70	0.857
32	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	-3.60	-0.133	9.70	0.358
33	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	-3.00	-0.111	9.70	0.358
34	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	-2.40	-0.089	9.70	0.358
35	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	-1.80	-0.067	9.70	0.358
36	**web**	3-7	8.97	0.00126	0.0113	7850	0.0883	-1.20	-0.106	9.70	0.857
37	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	-0.60	-0.022	9.70	0.358
38	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	0.00	0.000	9.70	0.358
39	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	0.60	0.022	9.70	0.358
40	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	1.20	0.044	9.70	0.358
41	**web**	3-7	8.97	0.00126	0.0113	7850	0.0883	1.80	0.159	9.70	0.857
42	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	2.40	0.089	9.70	0.358
43	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	3.00	0.111	9.70	0.358
44	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	3.60	0.133	9.70	0.358
45	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	4.20	0.155	9.70	0.358
46	**web**	3-7	8.97	0.00126	0.0113	7850	0.0883	4.80	0.424	9.70	0.857
47	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	5.40	0.200	9.70	0.358
48	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	6.00	0.222	9.70	0.358
49	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	6.60	0.244	9.70	0.358
50	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	7.20	0.266	9.70	0.358
51	**web**	3-7	8.97	0.00126	0.0113	7850	0.0883	7.80	0.689	9.70	0.857
52	Ordinary	3-7	8.97	0.00053	0.0047	7850	0.0370	8.40	0.310	9.70	0.358
53	Ordinary	7-8	9.20	0.00053	0.0048	7850	0.0379	9.00	0.341	9.70	0.368

54	Ordinary	7-8	9.20	0.00053	0.0048	7850	0.0379	9.60	0.364	9.70	0.368
55	Ordinary	7-8	9.20	0.00053	0.0048	7850	0.0379	10.20	0.387	9.70	0.368
56	**web**	7-8	9.20	0.00126	0.0115	7850	0.0906	10.80	0.979	9.70	0.879
57	Ordinary	7-8	9.20	0.00053	0.0048	7850	0.0379	11.40	0.432	9.70	0.368
58	Ordinary	7-8	9.20	0.00053	0.0048	7850	0.0379	12.00	0.455	9.70	0.368
59	Ordinary	7-8	9.20	0.00053	0.0048	7850	0.0379	12.60	0.478	9.70	0.368
60	Ordinary	8-8.5	9.59	0.00053	0.0050	7850	0.0395	13.20	0.522	9.70	0.383
61	**web**	8-8.5	9.59	0.00126	0.0120	7850	0.0945	13.80	1.304	9.70	0.916
62	Ordinary	8-8.5	9.59	0.00053	0.0050	7850	0.0395	14.40	0.569	9.70	0.383
63	Ordinary	8.5-9	9.80	0.00053	0.0051	7850	0.0404	15.00	0.606	9.70	0.392
64	**web**	8.5-9	9.80	0.00126	0.0123	7850	0.0965	15.60	1.506	9.70	0.936
65	Ordinary	8.5-9	9.80	0.00053	0.0051	7850	0.0404	16.20	0.654	9.70	0.392
66	Ordinary	8.5-9	9.80	0.00053	0.0051	7850	0.0404	16.80	0.678	9.70	0.392
67	**web**	9-9.5	9.95	0.00126	0.0125	7850	0.0980	17.40	1.706	9.70	0.951
68	Ordinary	9-9.5	9.95	0.00053	0.0052	7850	0.0410	18.00	0.738	9.70	0.398
69	Ordinary	9-9.5	9.95	0.00053	0.0052	7850	0.0410	18.60	0.763	9.70	0.398
70	**web**	9.5-10	10.42	0.00126	0.0131	7850	0.1026	19.20	1.970	9.70	0.995
71	Ordinary	9.5-10	10.42	0.00053	0.0055	7850	0.0429	19.80	0.850	9.70	0.416
72	Ordinary	9.5-10	10.42	0.00053	0.0055	7850	0.0429	20.40	0.876	9.70	0.416
73	**web**	9.5-10	10.42	0.00126	0.0131	7850	0.1026	21.00	2.155	9.70	0.995

Total Weight (tonnes)	3.866	**Longitudinal Moment (tonnes-m)**	-2.025	**Vertical Moment (tonnes-m)**	36.252

II. Brackets

Bracket Weight								
Bracket Type	**Number of Brackets**	**Area (sq. m)**	**Thickness (m)**	**Volume (cubic m)**	**Density (kg/m^3)**	**Weight (tonnes)**	**Vertical Lever (m)**	**Vertical Moment (tonnes-m)**
Floor Brackets	116	0.0299	0.0075	0.0261	7850	0.205	0.841	0.172
Deck Brackets	438	0.0295	0.0075	0.0967	7850	0.759	6.915	5.251
					Total	0.964	**Vertical Moment**	5.424

III. Deck Floors

Deck Floor Weights									
Floor Name	**Area (sq. m)**	**Thickn-ess (m)**	**Volume (cubic m)**	**Density (kg/m^3)**	**Weight (tonnes)**	**Longitudinal Lever**	**Longitudinal Moment**	**Vertical Lever**	**Vertical Moment**
Under Main Deck	358.319	0.007	2.508	7850	19.690	-0.376	-7.399	0.841	16.559
Main Deck	406.530	0.007	2.846	7850	22.339	-1.690	-37.753	4.163	92.996
Shelter Deck	438.322	0.007	3.068	7850	24.086	-7.900	-190.278	7.021	169.106
Forecastle Deck	451.604	0.007	3.161	7850	24.816	-7.900	-196.044	9.560	237.238

Total Weight	90.930	**Longitudinal Moment (tonnes-m)**	-431.472	**Vertical Moment (tonnes-m)**	515.899

IV. Keelson

Keelsons								
Member Name	**Number**	**Cross Section Area (m^3)**	**Member length (m)**	**Volume (m^3)**	**Density (kg/m^3)**	**Weight (tonnes)**	**Vertical lever (m)**	**Moment (tonnes-m)**
Centre Keelson	1	0.010	34.717	0.353	7850	2.775	0.816	2.264
Side Keelson	2	0.005	34.717	0.178	7850	2.797	0.816	2.282
					Total Weight	5.572	**Vertical Moment (tonnes-m)**	4.546

V. Side Stringers

Side Stringer								
Member Name	**Number**	**Cross Section Area (m^3)**	**Member length (m)**	**Volume (m^3)**	**Density (kg/m^3)**	**Weight (tonnes)**	**Vertical lever (m)**	**Moment (tonnes-m)**
Side Stringer	2	0.00126	43.582	0.055	7850	0.859	8.247	7.082
Side Stringer	2	0.00126	43.215	0.054	7850	0.851	5.544	4.721
Side Stringer	2	0.00126	42.143	0.053	7850	0.830	2.430	2.018
					Total Weight	2.541	**Vertical Moment (tonnes-m)**	13.820

VI. Deck Girders

Deck Girders									
Deck Name	**Member Name**	**Number**	**Cross Section Area (m^3)**	**Member length (m)**	**Volume (m^3)**	**Density (kg/m^3)**	**Weight (tonnes)**	**Vertical lever (m)**	**Moment (tonnes-m)**
Forecastle Deck	Centre Girder	1	0.001295	44.3	0.057	7850	0.450	9.516	4.286
	Side Girder	2	0.001295	44.3	0.057	7850	0.901	9.516	8.571
Shelter Deck	Centre Girder	1	0.001295	43.1	0.056	7850	0.438	6.976	3.057
	Side Girder	2	0.001295	43.1	0.056	7850	0.876	6.976	6.113

Main Deck	Centre Girder	1	0.001295	43.9	0.057	7850	0.446	4.116	1.837
	Side Girder	2	0.001295	43.9	0.057	7850	0.893	4.116	3.674
						Total Weight	4.0043	**Vertical Moment**	27.537

VII. Deck Beams

Deck Name	Frame no.	stations	Half Breadth (m)	Cross Section Area (m^2)	Volume per Beam (m^3)	Number of Beams	Density (kg/m^3)	Weight (tonnes)	Vertical lever (m)	Moment
Forecastle Deck	0-8	0-0.5	5.340	0.000625	0.00668	9	7850	0.472	9.560	4.508
	9-16	1-1.5	5.340	0.000625	0.00668	8	7850	0.419	9.560	4.007
	17-23	2-3	5.340	0.000625	0.00668	7	7850	0.367	9.560	3.507
	24-52	3-7	5.340	0.000625	0.00668	29	7850	1.520	9.560	14.527
	53-59	7-8	5.340	0.000625	0.00668	7	7850	0.367	9.560	3.507
	60-62	8-8.5	5.340	0.000625	0.00668	3	7850	0.157	9.560	1.503
	63-66	8.5-9	5.340	0.000625	0.00668	4	7850	0.210	9.560	2.004
	67-69	9-9.5	5.340	0.000625	0.00668	3	7850	0.157	9.560	1.503
	70-73	9.5-10	5.181	0.000625	0.00648	4	7850	0.203	9.560	1.944
Shelter Deck	0-8	0-0.5	5.340	0.000625	0.00668	9	7850	0.472	7.021	3.311
	9-16	1-1.5	5.340	0.000625	0.00668	8	7850	0.419	7.021	2.943
	17-23	2-3	5.340	0.000625	0.00668	7	7850	0.367	7.021	2.575
	24-52	3-7	5.340	0.000625	0.00668	29	7850	1.520	7.021	10.669
	53-59	7-8	5.340	0.000625	0.00668	7	7850	0.367	7.021	2.575
	60-62	8-8.5	5.340	0.000625	0.00668	3	7850	0.157	7.021	1.104
	63-66	8.5-9	4.875	0.000625	0.00609	4	7850	0.191	7.021	1.343
	67-69	9-9.5	4.199	0.000625	0.00525	3	7850	0.124	7.021	0.868
	70-73	9.5-10	3.349	0.000625	0.00419	4	7850	0.131	7.021	0.923
Main Deck	0-8	0-0.5	4.962	0.000625	0.00620	9	7850	0.438	4.163	1.824
	9-16	1-1.5	5.286	0.000625	0.00661	8	7850	0.415	4.163	1.727
	17-23	2-3	5.340	0.000625	0.00668	7	7850	0.367	4.163	1.527
	24-52	3-7	5.340	0.000625	0.00668	29	7850	1.520	4.163	6.326
	53-59	7-8	5.270	0.000625	0.00659	7	7850	0.362	4.163	1.507
	60-62	8-8.5	5.077	0.000625	0.00635	3	7850	0.149	4.163	0.622

	63-66	8.5-9	4.207	0.000625	0.00526	4	7850	0.165	4.163	0.687
	67-69	9-9.5	2.996	0.000625	0.00375	3	7850	0.088	4.163	0.367
	70-73	9.5-10	1.465	0.000625	0.00183	4	7850	0.057	4.163	0.239

Total Weight (tonnes)	11.180	**Vertical Moment (tonnes-m)**	78.148

VIII. Wood and Outfitting Weight

Wood and Outfittings Weight		Calculation Formula	References
Process 1 approximation	140.675 tonnes	0.1*L^2 - 1.17*L + 9.775	Stephen Chidozie Duru (2016). Lightweight Component Masses in Preliminary Design Examplified for Fishing Vessel. ISSN 2229-5518
Process 2 approximation	155.68 tonnes	K*L*B (K=0.25 for L=20m; K=0.5 for L=80m)	Juvenal J. M. Shiundu (1983). Design Of An Efficient Vessel For The East African Coast.
Mean Weight Approximation	**148.1775 tonnes**		

Machinery Weight

Machinery Weight		Calculation Formula	References
Process 1 approximation	33.88 tonnes	12*(MCR/RPM)^0.84	Empirical Formula. Propulsion Machinery Weight for slow and medium speed vessels.
Process 2 approximation	36.3 tonnes	C_m(MCR/RPM)^0.75	Juvenal J. M. Shiundu(1983). Design Of An Efficient Vessel For The East African Coast.
Mean Weight Approximation	**35.09 tonnes**		

IX. Floor Weight

					Floor						
Frame no.	Frame Type	stations	floor area m^2	Thickness	Volume m^3	Lightening Factor	Volume w/ L.F.	Strut Volume m^3	Total Volume	Density kg/m^3	We (to
0	Ordinary	0-0.5	0	0.00731	0.000000	0.48	0.000000	0.000000	0.000000	7850	
1	Ordinary	0-0.5	0	0.00731	0.000000	0.48	0.000000	0.000000	0.000000	7850	
2	Ordinary	0-0.5	0	0.00731	0.000000	0.48	0.000000	0.000000	0.000000	7850	
3	Ordinary	0-0.5	0	0.00731	0.000000	0.48	0.000000	0.000000	0.000000	7850	
4	Ordinary	0-0.5	0	0.00731	0.000000	0.48	0.000000	0.000000	0.000000	7850	
5	Ordinary	0-0.5	0	0.00731	0.000000	0.48	0.000000	0.000000	0.000000	7850	
6	Ordinary	0.5-1	0	0.00731	0.000000	0.48	0.000000	0.000000	0.000000	7850	
7	Ordinary	0.5-1	0	0.00731	0.000000	0.48	0.000000	0.000000	0.000000	7850	
8	Ordinary	0.5-1	0	0.00731	0.000000	0.48	0.000000	0.000000	0.000000	7850	
9	Ordinary	1-1.5	0	0.00731	0.000000	0.48	0.000000	0.000000	0.000000	7850	
10	**web**	1-1.5	0.020408	0.00731	0.000149	0.75	0.000112	0.000000	0.000112	7850	
11	Ordinary	1-1.5	0.020408	0.00731	0.000149	0.48	0.000072	0.000000	0.000072	7850	
12	Ordinary	1-1.5	0.020408	0.00731	0.000149	0.48	0.000072	0.000000	0.000072	7850	
13	**web**	1-1.5	0.020408	0.00731	0.000149	0.75	0.000112	0.000000	0.000112	7850	
14	Ordinary	1.5-2	1.3547535	0.00731	0.009903	0.48	0.004754	0.002139	0.006893	7850	
15	Ordinary	1.5-2	1.3547535	0.00731	0.009903	0.48	0.004754	0.002139	0.006893	7850	

16	**web**	1.5-2	1.3547535	0.00731	0.009903	0.75	0.007427	0.000000	0.007427	7850	
17	Ordinary	2-3	2.9360745	0.00731	0.021463	0.48	0.010302	0.004073	0.014375	7850	
18	Ordinary	2-3	2.9360745	0.00731	0.021463	0.48	0.010302	0.004073	0.014375	7850	
19	**web**	2-3	2.9360745	0.00731	0.021463	0.75	0.016097	0.000000	0.016097	7850	
20	Ordinary	2-3	2.9360745	0.00731	0.021463	0.48	0.010302	0.004073	0.014375	7850	
21	Ordinary	2-3	2.9360745	0.00731	0.021463	0.48	0.010302	0.004073	0.014375	7850	
22	**web**	2-3	2.9360745	0.00731	0.021463	0.75	0.016097	0.000000	0.016097	7850	
23	Ordinary	2-3	2.9360745	0.00731	0.021463	0.48	0.010302	0.004073	0.014375	7850	
24	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
25	**web**	3-7	3.18305	0.00731	0.023268	0.75	0.017451	0.000000	0.017451	7850	
26	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
27	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
28	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
29	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
30	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
31	**web**	3-7	3.18305	0.00731	0.023268	0.75	0.017451	0.000000	0.017451	7850	
32	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
33	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
34	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
35	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	

36	**web**	3-7	3.18305	0.00731	0.023268	0.75	0.017451	0.000000	0.017451	7850	
37	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
38	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
39	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
40	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
41	**web**	3-7	3.18305	0.00731	0.023268	0.75	0.017451	0.000000	0.017451	7850	
42	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
43	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
44	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
45	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
46	**web**	3-7	3.18305	0.00731	0.023268	0.75	0.017451	0.000000	0.017451	7850	
47	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
48	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
49	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
50	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
51	**web**	3-7	3.18305	0.00731	0.023268	0.75	0.017451	0.000000	0.017451	7850	
52	Ordinary	3-7	3.18305	0.00731	0.023268	0.48	0.011169	0.004073	0.015242	7850	
53	Ordinary	7-8	2.2005655	0.00731	0.016086	0.48	0.007721	0.002139	0.009861	7850	
54	Ordinary	7-8	2.2005655	0.00731	0.016086	0.48	0.007721	0.002139	0.009861	7850	
55	Ordinary	7-8	2.2005655	0.00731	0.016086	0.48	0.007721	0.002139	0.009861	7850	

56	**web**	7-8	2.2005655	0.00731	0.016086	0.75	0.012065	0.000000	0.012065	7850	
57	Ordinary	7-8	2.2005655	0.00731	0.016086	0.48	0.007721	0.002139	0.009861	7850	
58	Ordinary	7-8	2.2005655	0.00731	0.016086	0.48	0.007721	0.002139	0.009861	7850	
59	Ordinary	7-8	2.2005655	0.00731	0.016086	0.48	0.007721	0.002139	0.009861	7850	
60	Ordinary	8-8.5	0.77265	0.00731	0.005648	0.48	0.002711	0.002139	0.004850	7850	
61	**web**	8-8.5	0.77265	0.00731	0.005648	0.75	0.004236	0.000000	0.004236	7850	
62	Ordinary	8-8.5	0.77265	0.00731	0.005648	0.48	0.002711	0.002139	0.004850	7850	
63	Ordinary	8.5-9	0.590764	0.00731	0.004318	0.48	0.002073	0.002139	0.004212	7850	
64	**web**	8.5-9	0.590764	0.00731	0.004318	0.75	0.003239	0.000000	0.003239	7850	
65	Ordinary	8.5-9	0.590764	0.00731	0.004318	0.48	0.002073	0.002139	0.004212	7850	
66	Ordinary	8.5-9	0.590764	0.00731	0.004318	0.48	0.002073	0.002139	0.004212	7850	
67	**web**	9-9.5	0.555512	0.00731	0.004061	0.75	0.003046	0.000000	0.003046	7850	
68	Ordinary	9-9.5	0.555512	0.00731	0.004061	0.48	0.001949	0.000000	0.001949	7850	
69	Ordinary	9-9.5	0	0.00731	0.000000	0.48	0.000000	0.000000	0.000000	7850	
70	**web**	9.5-10	0	0.00731	0.000000	0.75	0.000000	0.000000	0.000000	7850	
71	Ordinary	9.5-10	0	0.00731	0.000000	0.48	0.000000	0.000000	0.000000	7850	
72	Ordinary	9.5-10	0	0.00731	0.000000	0.48	0.000000	0.000000	0.000000	7850	
73	**web**	9.5-10	0	0.00731	0.000000	0.75	0.000000	0.000000	0.000000	7850	

Total Floor Weight (tonnes)	5.393	**Vertical Moment**

X. Plates

Plates										
Items	Area (m^2)	Thickness	Amount	Volume	Density	Weight	LCG (from midship)	VCG (above keel)	Moment for LCG	Moment for VCG
Keel Plate										
1	2.45	0.0105	2	0.051	7850	0.404	-13.34	0.0053	-5.39	0.00
2	3.05	0.0105	2	0.064	7850	0.503	-7.34	0.0053	-3.69	0.00
3	3.04	0.0105	2	0.064	7850	0.501	-1.34	0.0053	-0.67	0.00
4	3.04	0.0105	2	0.064	7850	0.501	4.66	0.0053	2.34	0.00
5	3.01	0.0105	2	0.063	7850	0.496	10.66	0.0053	5.29	0.00
6	2.36	0.0105	2	0.050	7850	0.389	16.66	0.0053	6.48	0.00
7	0.371	0.0105	2	0.008	7850	0.061	18.16	0.0053	1.11	0.00
Bottom Plate										
1	8.3	0.0085	2	0.141	7850	1.108	-12.56	0.0503	-13.91	0.06
2	10.13	0.0085	2	0.172	7850	1.352	-6.56	0.0503	-8.87	0.07
3	11.08	0.0085	2	0.188	7850	1.479	-0.56	0.0503	-0.83	0.07
4	9.12	0.0085	2	0.155	7850	1.217	5.44	0.0503	6.62	0.06
5	5.94	0.0085	2	0.101	7850	0.793	8.44	0.0503	6.69	0.04
6	9.73	0.0085	2	0.165	7850	1.298	-16.40	0.1202	-21.29	0.16
7	12	0.0085	2	0.204	7850	1.601	-10.40	0.1202	-16.65	0.19
8	12	0.0085	2	0.204	7850	1.601	-4.40	0.1202	-7.05	0.19
9	12	0.0085	2	0.204	7850	1.601	1.60	0.1202	2.56	0.19
10	11.52	0.0085	2	0.196	7850	1.537	7.60	0.1202	11.68	0.18
11	10.5	0.0085	2	0.179	7850	1.401	13.60	0.1202	19.06	0.17
Bilge Plate										
Bilge plate										

1	9.23	0.008	2	0.148	7850	1.159	-18.50	0.2240	-21.45	0.26
2	5.76	0.008	2	0.092	7850	0.723	-12.50	0.2240	-9.04	0.16
3	11.9	0.008	2	0.190	7850	1.495	-6.50	0.2240	-9.72	0.33
4	12	0.008	2	0.192	7850	1.507	-0.50	0.2240	-0.75	0.34
5	11.43	0.008	2	0.183	7850	1.436	5.50	0.2240	7.90	0.32
6	13.91	0.008	2	0.223	7850	1.747	11.50	0.2240	20.09	0.39
7	9.83	0.008	2	0.157	7850	1.235	17.50	0.2240	21.61	0.28
8	0.648	0.008	2	0.010	7850	0.081	17.67	0.2240	1.44	0.02
9	7.94	0.008	2	0.127	7850	0.997	-18.80	1.5070	-18.75	1.50
10	13.7	0.008	2	0.219	7850	1.721	-12.80	1.5070	-22.03	2.59
11	12.4	0.008	2	0.198	7850	1.557	-6.80	1.5070	-10.59	2.35
12	12.4	0.008	2	0.198	7850	1.557	-0.80	1.5070	-1.25	2.35
13	11.39	0.008	2	0.182	7850	1.431	5.20	1.5070	7.44	2.16
14	5.97	0.008	2	0.096	7850	0.750	11.20	1.5070	8.40	1.13
15	7.4	0.008	2	0.118	7850	0.929	17.20	1.5070	15.99	1.40
16	4.16	0.008	2	0.067	7850	0.522	19.30	1.5070	10.08	0.79

Side Shell Plate

1	5.7	0.008	2	0.091	7850	0.716	-20.10	3.4000	-14.39	2.43
2	5.83	0.008	2	0.093	7850	0.732	-13.07	3.4000	-9.57	2.49
3	4.87	0.008	2	0.078	7850	0.612	-7.07	3.4000	-4.32	2.08
4	7.87	0.008	2	0.126	7850	0.988	-1.07	3.4000	-1.06	3.36
5	7.93	0.008	2	0.127	7850	0.996	4.93	3.4000	4.91	3.39
6	7.79	0.008	2	0.125	7850	0.978	11.10	3.4000	10.86	3.33
7	6.69	0.008	2	0.107	7850	0.840	13.90	3.4000	11.68	2.86
8	6.58	0.008	2	0.105	7850	0.826	16.16	3.4000	13.36	2.81
9	2.16	0.008	2	0.035	7850	0.271	18.72	3.4000	5.08	0.92
10	6.18	0.008	2	0.099	7850	0.776	-20.10	5.2000	-15.60	4.04

11	6.03	0.008	2	0.096	7850	0.757	-13.07	5.2000	-9.90	3.94
12	6.35	0.008	2	0.102	7850	0.798	-7.07	5.2000	-5.64	4.15
13	7.81	0.008	2	0.125	7850	0.981	-1.07	5.2000	-1.05	5.10
14	7.87	0.008	2	0.126	7850	0.988	4.93	5.2000	4.87	5.14
15	6.86	0.008	2	0.110	7850	0.862	11.10	5.2000	9.56	4.48
16	4.81	0.008	2	0.077	7850	0.604	13.90	5.2000	8.40	3.14
17	6.37	0.008	2	0.102	7850	0.800	16.16	5.2000	12.93	4.16
18	5.82	0.008	2	0.093	7850	0.731	18.72	5.2000	13.68	3.80
19	7.92	0.008	2	0.127	7850	0.995	-20.10	7.0000	-19.99	6.96
20	7.33	0.008	2	0.117	7850	0.921	-13.07	7.0000	-12.03	6.44
21	7.26	0.008	2	0.116	7850	0.912	-7.07	7.0000	-6.45	6.38
22	7.1	0.008	2	0.114	7850	0.892	-1.07	7.0000	-0.95	6.24
23	7.9	0.008	2	0.126	7850	0.992	4.93	7.0000	4.89	6.95
24	3.6	0.008	2	0.058	7850	0.452	11.10	7.0000	5.02	3.17
25	7.7	0.008	2	0.123	7850	0.967	13.90	7.0000	13.44	6.77
26	7.15	0.008	2	0.114	7850	0.898	16.16	7.0000	14.51	6.29
27	2.58	0.008	2	0.041	7850	0.324	18.72	7.2000	6.07	2.33

Sheer Strake

1	7.92	0.008	2	0.127	7850	0.995	-20.10	8.8000	-19.99	8.75
2	8.66	0.008	2	0.139	7850	1.088	-13.07	8.8000	-14.22	9.57
3	9.98	0.008	2	0.160	7850	1.253	-7.07	8.8000	-8.86	11.03
4	9.15	0.008	2	0.146	7850	1.149	-1.07	8.8000	-1.23	10.11
5	8.24	0.008	2	0.132	7850	1.035	4.93	8.8000	5.10	9.11
6	6.5	0.008	2	0.104	7850	0.816	11.10	8.8000	9.06	7.18
7	8.23	0.008	2	0.132	7850	1.034	13.90	8.8000	14.37	9.10

8	5.87	0.008	2	0.094	7850	0.737	16.16	8.8000	11.91	6.49
9	2.88	0.008	2	0.046	7850	0.362	19.25	8.8000	6.96	3.18

Total Weight (tonnes)	66.773	**Longitudinal Moment (tonnes-m)**	24.26	**Vertical Moment (tonnes-m)**	205.44

XI. Equipment Numeral

Item	Number/Length(m)	Weight (tonnes)	Longitudinal Lever	Longitudinal Moment (tonnes-m)	Vertical Lever	Vertical Moment (tonnes-m)
Anchor	2	0.88	17.50	15.40	7.20	6.34
Chain cable	275	3	17.50	52.50	7.20	21.60
Mooring cable	250	4	17.50	70.00	7.20	28.80
	Total Weight	7.88	**Longitudinal Moment**	137.90	**Vertical Moment**	56.74

XII. Fish Hold

Fish Hold									
Loading Condition	**Amount**	**Light Weight Each (tonnes)**	**Tank Volume (m^3)**	**Cargo Weight (tonnes)**	**Total Weight**	**L lever**	**L Moment**	**V lever**	**V moment**
Empty	1.00	3.26	600.00	0.00	3.26	1.72	5.60	2.89	9.41
Fully Loaded	1.00	3.26	600.00	375.00	378.26	1.72	649.10	2.89	1,091.66

XIII. Bulkheads

Bulkheads							
Location	**Volume (m^3)**	**Density (kg/m^3)**	**Weight (tonnes)**	**Longitudinal lever (m)**	**Longitudinal Moment (tonnes-m)**	**Vertical lever (m)**	**Vertical Moment (tonnes-m)**
Fwd	0.150	7850	1.181	16.642	19.647	4.224	4.986
Aft	0.454	7850	3.564	-18.364	-65.452	4.800	17.108
		Total weight	4.745	**LCG (m)**	-9.654	**VCG (m)**	4.657

XIV, XV. Rudder and Propeller

Item Name	**Weight (tonnes)**	**Longitudinal Lever (m)**	**Vertical Lever (m)**	**Longitudinal Moment (tonnes-m)**	**Vertical Moment (tonnes-m)**
Rudder	2.519	-21.3	4.09	-53.653	10.302
Propeller	3.248	-19.32	1.84	-62.761	5.967432731
Propeller Shaft	0.85	-16.6	1.75	-14.110	1.488

XVI. Superstructure

Superstructure						
Volume (m^3)	**Density (kg/m^3)**	**Weight (tonnes)**	**Longitudinal lever (m)**	**Longitudinal Moment (tonnes-m)**	**Vertical lever (m)**	**Vertical Moment (tonnes-m)**
1.00342	7850	7.876	5.382	42.393	11.762	92.647
	Total Weight	7.877	**LCG (m)**	5.382	**VCG (m)**	11.762

XVII. Fishing Equipment

Fishing Equipment						
Item Name	**Amount**	**Weight (tonnes)**	**L lever**	**L moment (tonnes-m)**	**V lever**	**V moment (tonnes-m)**
Net Drum Winch	1	26.00	-9.98	-259.48	8.28	215.15
Trawl Winch	3	50.00	-20.30	-1,015.00	13.00	650.00
Sweep Line Winch	1	18.60	0.27	5.02	10.20	189.72
Knuckle Boom Crane	1	8.50	-7.75	-65.88	10.65	90.53
Gantry	1	59.30	-18.40	-1,091.12	13.25	785.73
Lifeboats	2	4.60	0.00	0.00	10.50	48.30
Total		167.00		-259.48		1,979.42

XVIII. Refrigerated Salt Water Cooling System (RSW)

Freezing System (RSW)						
Unit Name	**Company Name**	**Weight (tonnes)**	**L lever**	**L moment (tonnes-m)**	**V lever**	**V moment (tonnes-m)**
VKN2 x 22"/4 2 x F268	Teknotherm	3.35	-1.20	-4.02	6.70	-26.93
Total		3.35		-4.02		-26.93

XIX. Tanks

Loaded Condition

Loaded Condition (Ballast and Tanks Optimally Loaded)									
Tank Name	**Amount**	**Light Weight Each (tonnes)**	**Tank Volume (m^3)**	**Cargo Weight (tonnes)**	**Total Weight**	**L lever (m)**	**L Moment**	**V lever (m)**	**V moment**
Fwd Ballast water tank	1.00	1.10	28.80	0.00	1.10	18.90	20.86	2.70	2.98
Aft Ballast water tank	2.00	0.80	16.12	0.00	1.59	-20.90	-33.24	4.10	6.52
Fuel oil tank - 1	1.00	0.70	15.33	13.03	13.74	-17.20	-236.26	3.60	49.45
Fuel oil tank - 2	1.00	0.70	15.33	13.03	13.74	-17.20	-236.26	3.60	49.45
Fuel oil tank - 3	1.00	1.29	28.00	23.80	25.09	-9.91	-248.60	0.60	15.05
Fresh water tank - 1	1.00	0.92	18.91	18.91	19.84	-9.20	-182.49	0.60	11.90
Ballast DB - 1	1.00	4.27	114.06	116.91	121.18	-1.07	-1,114.90	0.60	72.71
Ballast DB - 2	2.00	1.99	75.59	77.48	81.46	15.20	1,238.13	2.76	225.02
Fresh water tank - 2	2.00	2.64	66.28	66.28	71.55	7.50	536.65	0.60	42.93
Ballast DB - 3	1.00	1.10	39.02	40.00	41.10	14.20	583.56	0.60	24.66
Ballast DB - 4	1.00	0.90	33.00	33.83	34.73	18.00	625.05	5.80	201.41
				Total	425.10		952.50		702.08

Ballast Condition

Ballast Condition (Tanks Optimally and Ballast Fully Loaded)									
Tank Name	**Amount**	**Light Weight Each (tonnes)**	**Tank Volume (m^3)**	**Cargo Weight (tonnes)**	**Total Weight**	**L lever (m)**	**L Moment**	**V lever (m)**	**V moment**
Fwd Ballast water tank	1.00	1.10	28.80	29.52	30.62	18.90	578.81	2.70	82.69
Aft Ballast water tank	2.00	0.80	16.12	16.52	18.11	-20.90	-378.59	4.10	74.27
Fuel oil tank - 1	1.00	0.70	15.33	13.03	13.74	-17.20	-236.26	3.60	49.45
Fuel oil tank - 2	1.00	0.70	15.33	13.03	13.74	-17.20	-236.26	3.60	49.45
Fuel oil tank - 3	1.00	1.29	28.00	23.80	25.09	-9.91	-248.60	0.60	15.05
Fresh water tank - 1	1.00	0.92	18.91	18.91	19.84	-9.20	-182.49	0.60	11.90
Ballast DB - 1	1.00	4.27	114.06	116.91	121.18	-1.07	-1,114.90	0.60	72.71
Ballast DB - 2	2.00	1.99	75.59	77.48	81.46	15.20	1,238.13	2.76	225.02
Fresh water tank - 2	2.00	2.64	66.28	66.28	71.55	7.50	536.65	0.60	42.93
Ballast DB - 3	1.00	1.10	39.02	40.00	41.10	14.20	583.56	0.60	24.66
Ballast DB - 4	1.00	0.90	33.00	33.83	34.73	18.00	625.05	5.80	201.41
				Total	471.15		1,165.09		849.54

XX. Pillars

Deck	Location	Lightweight per pillar (tonnes)	No. of pillars	Total Weight (tonnes)	Longitudinal lever (m)	Longitudinal Moment	Vertical lever (m)	Vertical Moment
Under-main Deck	Fish-hold	0.0662	6	0.3972	3.7	1.4696	2.886	1.1463
	Engine Room	0.0397	2	0.0794	-10.833	-0.8601	2.886	0.2292
Main Deck	Aft	0.0344	4	0.1376	-15.148	-2.0844	5.938	0.8171
Shelter Deck	Aft	0.0249	4	0.0996	-16.376	-1.6311	8.526	0.8491
	Fwd	0.0268	2	0.0536	6.382	0.3421	8.526	0.4569

Total Weight (tonnes)	0.767	**Longitudinal Moment (tonnes-m)**	-2.764	**Vertical Moment (tonnes-m)**	3.499

Theory:

[ABS, Section 6.5.1 Stanchions and Pillars]

5.1 General

Supports under pillars are to be sufficient strength to distribute the loads effectively. Tween-deck pillars are to be arranged directly above those below, or effective means are to be provided for transmitting their loads to supports below. Tripping brackets are to be fitted on members in a way of pillars, both when the pillar is over and under the member.

5.3 Permissible Load

The permissible load a pillar can carry is to be equal to or greater than the pillar load, W, as determined in 3-2-6/5.5. The permissible load may be obtained from the following equation:

$W_a = (k – nl/r)A$

where

W_a = load, in kN (tf, Ltf)

k = 12.09 (1.232, 7.83)

n = 0.0444 (0.00452, 0.345)

l = unsupported length of the pillar, in cm (ft)

r = least radius of gyration of pillar, in cm (in.)

A = area of pillar, in cm2 (in2)

5.5 Calculated Load

The load on a pillar is to be obtained from the following equation:

W = nbhs

where

W = load, in kN (tf, Ltf)

n = 7.04 (0.715, 0.02)

b = mean breadth, in m (ft), of area supported

h = height, in m (ft), above the deck supported, as defined below

s = mean length, in m (ft), of area supported

For a pillar below an exposed deck on which cargo is carried, h is the distance from the deck supported to a point 3.66 m (12 ft) above the exposed deck. Where it is intended to carry deck cargoes in excess of 2636 kilograms per square meter (540 pounds per square foot), this head is to be increased in proportion to the added loads which will be imposed on the structure.

For a pillar below the freeboard deck, h is to be measured to a point not less than 0.02L + 0.76 m (0.02L + 2.5 ft) above the freeboard deck.

For a pillar below the superstructure deck, h is to be measured to a point not less than 0.02L + 0.46 m (0.02L + 1.5 ft) above the superstructure deck.

The height, h, for any pillar is not to be less than the given height in 3-2-6/1.3 for the beams at the top of the pillar plus the sum of the heights given in the same paragraphs for the beams of all complete cargo decks and one-half the heights given for all partial superstructure decks above.

Calculation:

The above mentioned theory was used to determine the necessary scantlings of pillars on each deck. The optimal pillar scantlings were obtained after multiple iterations of the above formula on a program, using python 3.0. A sample of the python code is given below.

Pillar Calculations

```
[ ]  def W(b, h, s):  # Calculated Load
       return 7.04*b*h*s

     def Wa(l, r, A): # Permissible Load
       return (12.09 - 0.0444*l/r)*A

     def rg(H, h):  # Radius of Gyration for hollow square structure
       return ((H**2 + h**2)/12)**(1/2)
```

```
[ ]  H = 7.5   #(cm) # Lenght of one side of square pillar, in cm
     h = 6.5  #(cm) # Length of one side of hollow in square pillar, in cm
     s = 30/2   #(m) # Mean length between pillars, in m
     b = 3  #(m) # Mean breadth between pillars, in m
     h_ = (0.02*42.5 + 0.76)     # height, in m, above the deck supported
     hd =  2.44  #(m) # Height between decks, where pillar will be placed, in m
```

```
[ ]  print("Thickness of pillar = ", (H-h)/2, ' cm')
     print("\nValue of 'h_': ", round(h_, 4), '\n')
     print('Light Weight added per pillar = ', round(7.85*(H**2 - h**2)*hd/100**2,4), ' tonnes')

     l = 10 #14.02 #10.124 #2*s*100 if 2*s > b else b*100    # unsupported length of the pillar, in cm
     print("unsupported length of pillar, 'l' = ", l/100, ' m')
     r = ((H**2 + h**2)/12)**(1/2)
     print('radius of gyration of pillar, r = ', round(r,4), '\n')
     A = H**2 # Area of pillar, in cm^2
     Wa_ = Wa(l, r, A)
     print('Permissible load, Wa = ' + str(round(Wa_,4)) + ' kN' )
     W_ = W(b,h_,s)
     print('Calculated load, W = ' + str(round(W_,4)) + ' kN' )

     print("Wa >= W, OK!") if Wa_ >= W_ else ("W > Wa, PROBLEM!")
```

```
Thickness of pillar =  0.5  cm

Value of 'h_':  1.61

Light Weight added per pillar =  0.0268  tonnes
unsupported length of pillar, 'l' =  0.1  m
radius of gyration of pillar, r =  2.865

Permissible load, Wa = 671.3453 kN
Calculated load, W = 510.048 kN
Wa >= W, OK!
```

```
[ ]  round(Wa_/W_, 4)   # Ratio of Permissible load to Calculated load
```

```
1.3162
```

Appendix - B

Detailed Stability Calculation

A detailed breakdown of the stability calculation of the ship at different angles of heel are given below:

Waterline 1 Emerged and Immersed Wedge Calculations

WL 1 inclined at 0°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00
1.50	4.35	2.00	8.71	18.96	2.00	37.91	82.54	2.00	165.08
2.00	4.86	1.50	7.29	23.63	1.50	35.44	114.86	1.50	172.29
3.00	4.90	4.00	19.59	23.99	4.00	95.96	117.50	4.00	470.02
4.00	4.90	2.00	9.80	23.99	2.00	47.98	117.50	2.00	235.01
5.00	4.90	4.00	19.59	23.99	4.00	95.96	117.50	4.00	470.02
6.00	4.95	2.00	9.90	24.50	2.00	49.01	121.29	2.00	242.57
7.00	4.90	4.00	19.59	23.99	4.00	95.96	117.50	4.00	470.02
8.00	3.85	1.50	5.78	14.85	1.50	22.27	57.20	1.50	85.80
8.50	3.00	2.00	5.99	8.97	2.00	17.94	26.87	2.00	53.73
9.00	2.19	1.00	2.19	4.79	1.00	4.79	10.47	1.00	10.47
9.50	1.39	2.00	2.78	1.93	2.00	3.86	2.68	2.00	5.36
10.00	0.01	0.50	0.01	0.00	0.50	0.00	0.00	0.50	0.00
		Σ2=	111.21		Σ4=	507.08		Σ6=	2380.38

WL 1 inclined at 0°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes

0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00
1.50	4.35	2.00	8.71	18.96	2.00	37.91	82.54	2.00	165.08
2.00	4.86	1.50	7.29	23.63	1.50	35.44	114.86	1.50	172.29
3.00	4.90	4.00	19.59	23.99	4.00	95.96	117.50	4.00	470.02
4.00	4.90	2.00	9.80	23.99	2.00	47.98	117.50	2.00	235.01
5.00	4.90	4.00	19.59	23.99	4.00	95.96	117.50	4.00	470.02
6.00	4.95	2.00	9.90	24.50	2.00	49.01	121.29	2.00	242.57
7.00	4.90	4.00	19.59	23.99	4.00	95.96	117.50	4.00	470.02
8.00	3.85	1.50	5.78	14.85	1.50	22.27	57.20	1.50	85.80
8.50	3.00	2.00	5.99	8.97	2.00	17.94	26.87	2.00	53.73
9.00	2.19	1.00	2.19	4.79	1.00	4.79	10.47	1.00	10.47
9.50	1.39	2.00	2.78	1.93	2.00	3.86	2.68	2.00	5.36
10.00	0.01	0.50	0.01	0.00	0.50	0.00	0.00	0.50	0.00
		Σ1=	111.21		Σ3=	507.08		Σ5=	2380.38

WL 1 inclined at 10°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00
1.50	5.03	2.00	10.05	25.27	2.00	50.54	127.04	2.00	254.07
2.00	5.25	1.50	7.87	27.51	1.50	41.27	144.29	1.50	216.44
3.00	5.26	4.00	21.05	27.69	4.00	110.75	145.70	4.00	582.79
4.00	5.26	2.00	10.52	27.69	2.00	55.38	145.70	2.00	291.40
5.00	5.26	4.00	21.05	27.69	4.00	110.75	145.70	4.00	582.79
6.00	4.35	2.00	8.69	18.88	2.00	37.76	82.03	2.00	164.06

7.00	4.35	4.00	17.38	18.88	4.00	75.52	82.03	4.00	328.12
8.00	3.12	1.50	4.68	9.72	1.50	14.57	30.28	1.50	45.43
8.50	2.48	2.00	4.96	6.14	2.00	12.28	15.22	2.00	30.43
9.00	1.84	1.00	1.84	3.39	1.00	3.39	6.23	1.00	6.23
9.50	1.23	2.00	2.46	1.51	2.00	3.02	1.86	2.00	3.71
10.00	0.01	0.50	0.01	0.00	0.50	0.00	0.00	0.50	0.00
		Σ2=	110.55		Σ4=	515.23		Σ6=	2505.46

WL 1 inclined at 10^o									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00
1.50	2.31	2.00	4.61	5.32	2.00	10.64	12.28	2.00	24.56
2.00	4.23	1.50	6.34	17.88	1.50	26.81	75.58	1.50	113.37
3.00	4.35	4.00	17.38	18.88	4.00	75.52	82.03	4.00	328.12
4.00	4.35	2.00	8.69	18.88	2.00	37.76	82.03	2.00	164.06
5.00	4.35	4.00	17.38	18.88	4.00	75.52	82.03	4.00	328.12
6.00	5.31	2.00	10.62	28.19	2.00	56.37	149.64	2.00	299.27
7.00	5.26	4.00	21.05	27.69	4.00	110.75	145.70	4.00	582.79
8.00	4.56	1.50	6.83	20.76	1.50	31.14	94.57	1.50	141.85
8.50	3.63	2.00	7.26	13.18	2.00	26.35	47.83	2.00	95.66
9.00	2.63	1.00	2.63	6.91	1.00	6.91	18.17	1.00	18.17
9.50	1.60	2.00	3.20	2.55	2.00	5.11	4.08	2.00	8.16
10.00	0.01	0.50	0.01	0.00	0.50	0.00	0.00	0.50	0.00
		Σ1$^=$	106.00		Σ3=	462.88		Σ5=	2104.13

WL 1 inclined at 20°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	1.13	1.00	1.13	1.27	1.00	1.27	1.44	1.00	1.44
1.50	5.55	2.00	11.10	30.81	2.00	61.63	171.05	2.00	342.09
2.00	5.64	1.50	8.46	31.84	1.50	47.77	179.69	1.50	269.54
3.00	5.65	4.00	22.60	31.92	4.00	127.69	180.36	4.00	721.45
4.00	5.65	2.00	11.30	31.92	2.00	63.85	180.36	2.00	360.72
5.00	5.65	4.00	22.60	31.92	4.00	127.69	180.36	4.00	721.45
6.00	3.02	2.00	6.04	9.13	2.00	18.26	27.60	2.00	55.20
7.00	2.94	4.00	11.74	8.61	4.00	34.46	25.28	4.00	101.13
8.00	2.45	1.50	3.68	6.02	1.50	9.03	14.78	1.50	22.17
8.50	2.07	2.00	4.13	4.27	2.00	8.54	8.83	2.00	17.66
9.00	1.58	1.00	1.58	2.50	1.00	2.50	3.95	1.00	3.95
9.50	1.11	2.00	2.23	1.24	2.00	2.48	1.38	2.00	2.76
10.00	0.01	0.50	0.01	0.00	0.50	0.00	0.00	0.50	0.00
		Σ2=	106.61		Σ4=	505.17		Σ6=	2619.56

WL 1 inclined at 20°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00
1.50	1.47	2.00	2.94	2.16	2.00	4.32	3.18	2.00	6.35

2.00	2.68	1.50	4.02	7.18	1.50	10.77	19.23	1.50	28.84
3.00	3.02	4.00	12.09	9.13	4.00	36.53	27.60	4.00	110.39
4.00	3.02	2.00	6.04	9.13	2.00	18.26	27.60	2.00	55.20
5.00	3.02	4.00	12.09	9.13	4.00	36.53	27.60	4.00	110.39
6.00	5.68	2.00	11.36	32.25	2.00	64.50	183.15	2.00	366.31
7.00	5.65	4.00	22.60	31.92	4.00	127.69	180.36	4.00	721.45
8.00	5.23	1.50	7.85	27.35	1.50	41.03	143.06	1.50	214.58
8.50	4.45	2.00	8.90	19.79	2.00	39.59	88.06	2.00	176.12
9.00	3.14	1.00	3.14	9.83	1.00	9.83	30.81	1.00	30.81
9.50	1.87	2.00	3.75	3.51	2.00	7.02	6.58	2.00	13.16
10.00	0.01	0.50	0.01	0.00	0.50	0.00	0.00	0.50	0.00
		$\Sigma 1^{=}$	94.77		$\Sigma 3=$	396.07		$\Sigma 5=$	1833.61

WL 1 inclined at 30^{o}									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	3.26	2.00	6.53	10.65	2.00	21.29	34.74	2.00	69.48
1.00	0.78	1.00	0.78	0.61	1.00	0.61	0.47	1.00	0.47
1.50	6.10	2.00	12.20	37.20	2.00	74.40	226.87	2.00	453.74
2.00	6.17	1.50	9.25	38.02	1.50	57.03	234.43	1.50	351.64
3.00	6.17	4.00	24.69	38.09	4.00	152.37	235.11	4.00	940.45
4.00	6.17	2.00	12.34	38.09	2.00	76.19	235.11	2.00	470.23
5.00	6.17	4.00	24.69	38.09	4.00	152.37	235.11	4.00	940.45
6.00	2.16	2.00	4.32	4.67	2.00	9.33	10.08	2.00	20.16
7.00	2.14	4.00	8.55	4.57	4.00	18.27	9.76	4.00	39.04
8.00	1.95	1.50	2.93	3.80	1.50	5.70	7.41	1.50	11.12
8.50	1.76	2.00	3.51	3.08	2.00	6.17	5.41	2.00	10.83
9.00	1.39	1.00	1.39	1.94	1.00	1.94	2.71	1.00	2.71

9.50	1.03	2.00	2.07	1.07	2.00	2.14	1.11	2.00	2.21
10.00	0.01	0.50	0.01	0.00	0.50	0.00	0.00	0.50	0.00
		Σ2=	113.25		Σ4=	577.81		Σ6=	3312.54

WL 1 inclined at 30°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00
1.50	1.09	2.00	2.18	1.18	2.00	2.37	1.29	2.00	2.58
2.00	1.96	1.50	2.94	3.84	1.50	5.76	7.53	1.50	11.29
3.00	2.16	4.00	8.64	4.67	4.00	18.66	10.08	4.00	40.31
4.00	2.16	2.00	4.32	4.67	2.00	9.33	10.08	2.00	20.16
5.00	2.16	4.00	8.64	4.67	4.00	18.66	10.08	4.00	40.31
6.00	6.18	2.00	12.37	38.23	2.00	76.46	236.37	2.00	472.75
7.00	6.17	4.00	24.66	38.02	4.00	152.08	234.43	4.00	937.71
8.00	6.00	1.50	9.00	35.98	1.50	53.96	215.78	1.50	323.68
8.50	5.60	2.00	11.19	31.30	2.00	62.61	175.15	2.00	350.29
9.00	3.72	1.00	3.72	13.82	1.00	13.82	51.35	1.00	51.35
9.50	2.25	2.00	4.50	5.06	2.00	10.13	11.39	2.00	22.78
10.00	0.01	0.50	0.01	0.00	0.50	0.00	0.00	0.50	0.00
		Σ1=	92.16		Σ3=	423.84		Σ5=	2273.21

WL 1 inclined at 40°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	3.49	0.50	1.75	12.19	0.50	6.09	42.55	0.50	21.27

0.50	2.44	2.00	4.87	5.94	2.00	11.88	14.47	2.00	28.95
1.00	0.58	1.00	0.58	0.33	1.00	0.33	0.19	1.00	0.19
1.50	6.98	2.00	13.95	48.66	2.00	97.33	339.48	2.00	678.97
2.00	6.98	1.50	10.46	48.66	1.50	73.00	339.48	1.50	509.23
3.00	6.98	4.00	27.90	48.66	4.00	194.66	339.48	4.00	1357.94
4.00	6.98	2.00	13.95	48.66	2.00	97.33	339.48	2.00	678.97
5.00	6.98	4.00	27.90	48.66	4.00	194.66	339.48	4.00	1357.94
6.00	1.74	2.00	3.49	3.04	2.00	6.08	5.30	2.00	10.59
7.00	1.73	4.00	6.92	2.99	4.00	11.97	5.18	4.00	20.71
8.00	1.62	1.50	2.43	2.63	1.50	3.95	4.27	1.50	6.40
8.50	1.53	2.00	3.06	2.34	2.00	4.68	3.57	2.00	7.15
9.00	1.26	1.00	1.26	1.60	1.00	1.60	2.02	1.00	2.02
9.50	0.99	2.00	1.97	0.97	2.00	1.94	0.96	2.00	1.91
10.00	0.02	0.50	0.01	0.00	0.50	0.00	0.00	0.50	0.00
		Σ2=	120.51		Σ4=	705.48		Σ6=	4682.23

WL 1 inclined at 40°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00
1.50	0.88	2.00	1.76	0.77	2.00	1.54	0.68	2.00	1.35
2.00	1.59	1.50	2.39	2.53	1.50	3.79	4.02	1.50	6.03
3.00	1.74	4.00	6.97	3.04	4.00	12.15	5.30	4.00	21.18
4.00	1.74	2.00	3.49	3.04	2.00	6.08	5.30	2.00	10.59
5.00	1.74	4.00	6.97	3.04	4.00	12.15	5.30	4.00	21.18
6.00	6.97	2.00	13.94	48.58	2.00	97.16	338.61	2.00	677.22

7.00	6.97	4.00	27.88	48.58	4.00	194.32	338.61	4.00	1354.44
8.00	6.97	1.50	10.46	48.58	1.50	72.87	338.61	1.50	507.91
8.50	6.97	2.00	13.94	48.58	2.00	97.16	338.61	2.00	677.22
9.00	4.48	1.00	4.48	20.09	1.00	20.09	90.04	1.00	90.04
9.50	2.80	2.00	5.60	7.83	2.00	15.66	21.90	2.00	43.81
10.00	0.02	0.50	0.01	0.00	0.50	0.00	0.00	0.50	0.00
		Σ1=	97.87		Σ3=	532.98		Σ5=	3410.97

WL 1 inclined at 50^o									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	2.83	0.50	1.41	8.00	0.50	4.00	22.62	0.50	11.31
0.50	1.96	2.00	3.91	3.83	2.00	7.65	7.48	2.00	14.97
1.00	0.47	1.00	0.47	0.22	1.00	0.22	0.10	1.00	0.10
1.50	8.31	2.00	16.61	69.01	2.00	138.01	573.23	2.00	1146.47
2.00	8.31	1.50	12.46	69.01	1.50	103.51	573.23	1.50	859.85
3.00	8.31	4.00	33.23	69.01	4.00	276.02	573.23	4.00	2292.94
4.00	8.31	2.00	16.61	69.01	2.00	138.01	573.23	2.00	1146.47
5.00	8.31	4.00	33.23	69.01	4.00	276.02	573.23	4.00	2292.94
6.00	1.48	2.00	2.97	2.20	2.00	4.40	3.27	2.00	6.54
7.00	1.48	4.00	5.94	2.20	4.00	8.81	3.27	4.00	13.07
8.00	1.42	1.50	2.12	2.00	1.50	3.00	2.83	1.50	4.25
8.50	1.37	2.00	2.74	1.87	2.00	3.74	2.56	2.00	5.12
9.00	1.18	1.00	1.18	1.39	1.00	1.39	1.63	1.00	1.63
9.50	0.97	2.00	1.93	0.93	2.00	1.86	0.90	2.00	1.80
10.00	0.02	0.50	0.01	0.00	0.50	0.00	0.00	0.50	0.00
		Σ2=	134.82		Σ4=	966.67		Σ6=	7797.46

WL 1 inclined at 50°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00
1.50	0.75	2.00	1.51	0.57	2.00	1.13	0.43	2.00	0.85
2.00	1.36	1.50	2.05	1.86	1.50	2.79	2.54	1.50	3.81
3.00	1.49	4.00	5.94	2.21	4.00	8.82	3.27	4.00	13.10
4.00	1.49	2.00	2.97	2.21	2.00	4.41	3.27	2.00	6.55
5.00	1.49	4.00	5.94	2.21	4.00	8.82	3.27	4.00	13.10
6.00	8.31	2.00	16.61	69.01	2.00	138.01	573.23	2.00	1146.47
7.00	8.31	4.00	33.23	69.01	4.00	276.02	573.23	4.00	2292.94
8.00	8.31	1.50	12.46	69.01	1.50	103.51	573.23	1.50	859.85
8.50	8.31	2.00	16.61	69.01	2.00	138.01	573.23	2.00	1146.47
9.00	5.85	1.00	5.85	34.19	1.00	34.19	199.89	1.00	199.89
9.50	3.75	2.00	7.50	14.07	2.00	28.14	52.78	2.00	105.55
10.00	0.02	0.50	0.01	0.00	0.50	0.00	0.00	0.50	0.00
		Σ1=	110.68		Σ3=	743.86		Σ5=	5788.59

WL 1 inclined at 60°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	2.41	0.50	1.21	5.81	0.50	2.91	14.01	0.50	7.01
0.50	1.69	2.00	3.37	2.85	2.00	5.69	4.80	2.00	9.60
1.00	0.41	1.00	0.41	0.17	1.00	0.17	0.07	1.00	0.07
1.50	7.88	2.00	15.75	62.02	2.00	124.03	488.37	2.00	976.75
2.00	7.88	1.50	11.81	62.02	1.50	93.02	488.37	1.50	732.56

3.00	7.88	4.00	31.50	62.02	4.00	248.06	488.37	4.00	1953.49
4.00	7.88	2.00	15.75	62.02	2.00	124.03	488.37	2.00	976.75
5.00	7.88	4.00	31.50	62.02	4.00	248.06	488.37	4.00	1953.49
6.00	1.33	2.00	2.66	1.76	2.00	3.53	2.34	2.00	4.68
7.00	1.33	4.00	5.31	1.76	4.00	7.05	2.34	4.00	9.37
8.00	1.29	1.50	1.93	1.65	1.50	2.48	2.13	1.50	3.19
8.50	1.26	2.00	2.52	1.59	2.00	3.18	2.01	2.00	4.01
9.00	1.13	1.00	1.13	1.27	1.00	1.27	1.44	1.00	1.44
9.50	0.97	2.00	1.94	0.94	2.00	1.88	0.91	2.00	1.83
10.00	0.02	0.50	0.01	0.00	0.50	0.00	0.00	0.50	0.00
		Σ2=	126.80		Σ4=	865.37		Σ6=	6634.23

WL 1 inclined at 60^o									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00
1.50	0.68	2.00	1.35	0.46	2.00	0.91	0.31	2.00	0.62
2.00	1.22	1.50	1.83	1.50	1.50	2.24	1.83	1.50	2.74
3.00	1.33	4.00	5.31	1.76	4.00	7.05	2.34	4.00	9.37
4.00	1.33	2.00	2.66	1.76	2.00	3.53	2.34	2.00	4.68
5.00	1.33	4.00	5.31	1.76	4.00	7.05	2.34	4.00	9.37
6.00	7.88	2.00	15.75	62.02	2.00	124.03	488.37	2.00	976.75
7.00	7.88	4.00	31.50	62.02	4.00	248.06	488.37	4.00	1953.49
8.00	7.88	1.50	11.81	62.02	1.50	93.02	488.37	1.50	732.56
8.50	7.88	2.00	15.75	62.02	2.00	124.03	488.37	2.00	976.75
9.00	7.88	1.00	7.88	62.02	1.00	62.02	488.37	1.00	488.37

9.50	7.88	2.00	15.75	62.02	2.00	124.03	488.37	2.00	976.75
10.00	0.03	0.50	0.01	0.00	0.50	0.00	0.00	0.50	0.00
		Σ1=	114.92		Σ3=	795.99		Σ5=	6131.45

WL 1 inclined at 70°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	2.17	0.50	1.09	4.71	0.50	2.35	10.22	0.50	5.11
0.50	1.53	2.00	3.06	2.34	2.00	4.68	3.57	2.00	7.15
1.00	0.37	1.00	0.37	0.14	1.00	0.14	0.05	1.00	0.05
1.50	7.26	2.00	14.51	52.66	2.00	105.33	382.18	2.00	764.37
2.00	7.26	1.50	10.89	52.66	1.50	79.00	382.18	1.50	573.27
3.00	7.26	4.00	29.03	52.66	4.00	210.66	382.18	4.00	1528.73
4.00	7.26	2.00	14.51	52.66	2.00	105.33	382.18	2.00	764.37
5.00	7.26	4.00	29.03	52.66	4.00	210.66	382.18	4.00	1528.73
6.00	1.24	2.00	2.47	1.53	2.00	3.05	1.88	2.00	3.77
7.00	1.24	4.00	4.94	1.53	4.00	6.10	1.88	4.00	7.53
8.00	1.21	1.50	1.82	1.47	1.50	2.20	1.78	1.50	2.66
8.50	1.20	2.00	2.40	1.44	2.00	2.87	1.72	2.00	3.44
9.00	1.11	1.00	1.11	1.24	1.00	1.24	1.38	1.00	1.38
9.50	1.00	2.00	2.00	1.00	2.00	2.01	1.01	2.00	2.01
10.00	0.03	0.50	0.02	0.00	0.50	0.00	0.00	0.50	0.00
		Σ2=	117.24		Σ4=	735.60		Σ6=	5192.57

WL 1 inclined at 70°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00

0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00
1.50	0.63	2.00	1.26	0.40	2.00	0.80	0.25	2.00	0.50
2.00	1.14	1.50	1.71	1.30	1.50	1.95	1.48	1.50	2.22
3.00	1.24	4.00	4.94	1.53	4.00	6.10	1.88	4.00	7.53
4.00	1.24	2.00	2.47	1.53	2.00	3.05	1.88	2.00	3.77
5.00	1.24	4.00	4.94	1.53	4.00	6.10	1.88	4.00	7.53
6.00	7.26	2.00	14.51	52.66	2.00	105.33	382.18	2.00	764.37
7.00	7.26	4.00	29.03	52.66	4.00	210.66	382.18	4.00	1528.73
8.00	7.26	1.50	10.89	52.66	1.50	79.00	382.18	1.50	573.27
8.50	7.26	2.00	14.51	52.66	2.00	105.33	382.18	2.00	764.37
9.00	7.26	1.00	7.26	52.66	1.00	52.66	382.18	1.00	382.18
9.50	7.26	2.00	14.51	52.66	2.00	105.33	382.18	2.00	764.37
10.00	0.04	0.50	0.02	0.00	0.50	0.00	0.00	0.50	0.00
		Σ1=	106.05		Σ3=	676.30		Σ5=	4798.84

WL 1 inclined at 80°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	2.04	0.50	1.02	4.14	0.50	2.07	8.43	0.50	4.21
0.50	1.44	2.00	2.88	2.07	2.00	4.14	2.98	2.00	5.96
1.00	0.35	1.00	0.35	0.12	1.00	0.12	0.04	1.00	0.04
1.50	6.93	2.00	13.85	47.96	2.00	95.91	332.09	2.00	664.19
2.00	6.93	1.50	10.39	47.96	1.50	71.93	332.09	1.50	498.14
3.00	6.93	4.00	27.70	47.96	4.00	191.82	332.09	4.00	1328.37
4.00	6.93	2.00	13.85	47.96	2.00	95.91	332.09	2.00	664.19
5.00	6.93	4.00	27.70	47.96	4.00	191.82	332.09	4.00	1328.37
6.00	1.19	2.00	2.38	1.41	2.00	2.83	1.68	2.00	3.36

7.00	1.19	4.00	4.76	1.41	4.00	5.65	1.68	4.00	6.72
8.00	1.18	1.50	1.77	1.39	1.50	2.08	1.63	1.50	2.45
8.50	1.17	2.00	2.34	1.37	2.00	2.74	1.61	2.00	3.21
9.00	1.13	1.00	1.13	1.27	1.00	1.27	1.44	1.00	1.44
9.50	1.07	2.00	2.14	1.14	2.00	2.28	1.22	2.00	2.44
10.00	0.06	0.50	0.03	0.00	0.50	0.00	0.00	0.50	0.00
		Σ2=	112.27		Σ4=	670.59		Σ6=	4513.09

WL 1 inclined at 80^o									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00
1.50	0.61	2.00	1.22	0.37	2.00	0.74	0.23	2.00	0.45
2.00	1.09	1.50	1.64	1.19	1.50	1.79	1.31	1.50	1.96
3.00	1.19	4.00	4.75	1.41	4.00	5.65	1.68	4.00	6.71
4.00	1.19	2.00	2.38	1.41	2.00	2.82	1.68	2.00	3.35
5.00	1.19	4.00	4.75	1.41	4.00	5.65	1.68	4.00	6.71
6.00	6.93	2.00	13.85	47.96	2.00	95.91	332.09	2.00	664.19
7.00	6.93	4.00	27.70	47.96	4.00	191.82	332.09	4.00	1328.37
8.00	6.93	1.50	10.39	47.96	1.50	71.93	332.09	1.50	498.14
8.50	6.93	2.00	13.85	47.96	2.00	95.91	332.09	2.00	664.19
9.00	6.93	1.00	6.93	47.96	1.00	47.96	332.09	1.00	332.09
9.50	6.93	2.00	13.85	47.96	2.00	95.91	332.09	2.00	664.19
10.00	0.08	0.50	0.04	0.01	0.50	0.00	0.00	0.50	0.00
		Σ1$^=$	101.34		Σ3=	616.10		Σ5=	4170.34

WL 1 inclined at 90°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	6.82	0.50	3.41	46.51	0.50	23.26	317.21	0.50	158.61
0.50	6.82	2.00	13.64	46.51	2.00	93.02	317.21	2.00	634.43
1.00	6.82	1.00	6.82	46.51	1.00	46.51	317.21	1.00	317.21
1.50	6.82	2.00	13.64	46.51	2.00	93.02	317.21	2.00	634.43
2.00	6.82	1.50	10.23	46.51	1.50	69.77	317.21	1.50	475.82
3.00	6.82	4.00	27.28	46.51	4.00	186.05	317.21	4.00	1268.86
4.00	6.82	2.00	13.64	46.51	2.00	93.02	317.21	2.00	634.43
5.00	6.82	4.00	27.28	46.51	4.00	186.05	317.21	4.00	1268.86
6.00	1.18	2.00	2.36	1.39	2.00	2.78	1.64	2.00	3.29
7.00	1.18	4.00	4.72	1.39	4.00	5.57	1.64	4.00	6.57
8.00	1.18	1.50	1.77	1.39	1.50	2.09	1.64	1.50	2.46
8.50	1.18	2.00	2.36	1.39	2.00	2.78	1.64	2.00	3.29
9.00	1.18	1.00	1.18	1.39	1.00	1.39	1.64	1.00	1.64
9.50	1.18	2.00	2.36	1.39	2.00	2.78	1.64	2.00	3.29
10.00	1.18	0.50	0.59	1.39	0.50	0.70	1.64	0.50	0.82
		Σ2=	131.28		Σ4=	808.81		Σ6=	5414.01

WL 1 inclined at 90°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	1.18	0.50	0.59	1.39	0.50	0.70	1.64	0.50	0.82
0.50	1.18	2.00	2.36	1.39	2.00	2.78	1.64	2.00	3.29
1.00	1.18	1.00	1.18	1.39	1.00	1.39	1.64	1.00	1.64
1.50	1.18	2.00	2.36	1.39	2.00	2.78	1.64	2.00	3.29

2.00	1.18	1.50	1.77	1.39	1.50	2.09	1.64	1.50	2.46
3.00	1.18	4.00	4.72	1.39	4.00	5.57	1.64	4.00	6.57
4.00	1.18	2.00	2.36	1.39	2.00	2.78	1.64	2.00	3.29
5.00	1.18	4.00	4.72	1.39	4.00	5.57	1.64	4.00	6.57
6.00	6.82	2.00	13.64	46.51	2.00	93.02	317.21	2.00	634.43
7.00	6.82	4.00	27.28	46.51	4.00	186.05	317.21	4.00	1268.86
8.00	6.82	1.50	10.23	46.51	1.50	69.77	317.21	1.50	475.82
8.50	6.82	2.00	13.64	46.51	2.00	93.02	317.21	2.00	634.43
9.00	6.82	1.00	6.82	46.51	1.00	46.51	317.21	1.00	317.21
9.50	6.82	2.00	13.64	46.51	2.00	93.02	317.21	2.00	634.43
10.00	6.82	0.50	3.41	46.51	0.50	23.26	317.21	0.50	158.61
		Σ1=	108.72		Σ3=	628.33		Σ5=	4151.72

GZ Calculation

Waterline-1 Combination Table						
Angle of heel : 10˚						
	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	507.084	5.000	2535.419	507.084	5.000	2535.419
10.000	462.883	8.000	3703.062	515.228	8.000	4121.825

20.000	396.073	-1.000	-396.073	505.169	-1.000	-505.169
Σ7			5842.408	Σ8		6152.075

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	4760.766	5.000	23803.832	10.000	0.985	23442.199
10.000	4609.594	8.000	36876.755	0.000	1.000	36876.755
20.000	4453.173	-1.000	-4453.173	-10.000	0.985	-4385.519
Σ9						55933.434

Immersed Volume	60.190
Emerged Volume	63.380
Volume	190.240
Moment	384.162
BR	2.019
BG=KG-KB	1.802
BGsinθ	0.313
GZ=BR-BGsinθ	1.706

Waterline-1 Combination Table

Angle of heel : 20˚

	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	507.084	1.000	507.084	507.084	1.000	507.084
10.000	462.883	4.000	1851.531	515.228	4.000	2060.913
20.000	396.073	1.000	396.073	505.169	1.000	505.169
Σ7			2754.687	Σ8		3073.166

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	4760.766	1.000	4760.766	20.000	0.940	4473.657
10.000	4609.594	4.000	18438.377	10.000	0.985	18158.257

20.000	4453.173	1.000	4453.173	0.000	1.000	4453.173
Σ9						27085.087

Immersed Volume	113.518
Emerged Volume	126.643
Volume	180.306
Moment	744.103
BR	4.127
BG=KG-KB	1.802
BGsinθ	0.616
GZ=BR-BGsinθ	3.511

Waterline-1 Combination Table

Angle of heel : 30˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	507.084	1.000	507.084	507.084	1.000	507.084
10.000	462.883	3.000	1388.648	515.228	3.000	1545.684
20.000	396.073	3.000	1188.219	505.169	3.000	1515.508
30.000	423.836	1.000	423.836	577.814	1.000	577.814
Σ7			3507.787	Σ8		4146.090

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	4760.766	1.000	4760.766	30.000	0.866	4122.945
10.000	4609.594	3.000	13828.783	20.000	0.940	12994.805
20.000	4453.173	3.000	13359.519	10.000	0.985	13156.558
30.000	5585.750	1.000	5585.750	0.000	1.000	5585.750
Σ9						35860.059

Immersed Volume	162.622
Emerged Volume	192.214
Volume	163.838
Moment	1108.322
BR	6.765
BG=KG-KB	1.802
BGsinθ	0.901
GZ=BR-BGsinθ	5.864

Waterline-1 Combination Table

Angle of heel : 40˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	507.084	1.000	507.084	507.084	1.000	507.084
10.000	462.883	4.000	1851.531	515.228	4.000	2060.913
20.000	396.073	2.000	792.146	505.169	2.000	1010.338
30.000	423.836	4.000	1695.345	577.814	4.000	2311.257
40.000	532.979	1.000	532.979	705.484	1.000	705.484

Σ7	5379.085	Σ8	6595.076

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	4760.766	1.000	4760.766	40.000	0.766	3646.959
10.000	4609.594	4.000	18438.377	30.000	0.866	15968.103
20.000	4453.173	2.000	8906.346	20.000	0.940	8369.228
30.000	5585.750	4.000	22343.002	10.000	0.985	22003.561
40.000	8093.195	1.000	8093.195	0.000	1.000	8093.195
Σ9						58081.046

Immersed Volume	221.668
Emerged Volume	271.778
Volume	143.320
Moment	1595.648
BR	11.133
BG=KG-KB	1.802
BGsinθ	1.158
GZ=BR-BGsinθ	9.975

With New Simpson's Mult. (Waterline 1)

Angle of heel : 50˚

HEEL ANGLE (α)		Σ3	SM	PRD.	Σ4	SM	PRD.
0.000		507.084	1.000	507.084	507.084	1.000	507.084
10.000		462.883	3.000	1388.648	515.228	3.000	1545.684
20.000		396.073	3.000	1188.219	505.169	3.000	1515.508
30.000		423.836	1.000	423.836	577.814	1.000	577.814
30.000		423.836	1.000	423.836	577.814	1.000	577.814
40.000		532.979	4.000	2131.916	705.484	4.000	2821.937
50.000		743.864	1.000	743.864	966.667	1.000	966.667
Σ7				6807.403	Σ8		8512.508
HEEL ANGLE (α)		Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000		4760.766	1.000	4760.766	50.000	0.643	3060.162
10.000		4609.594	3.000	13828.783	40.000	0.766	10593.462
20.000		4453.173	3.000	13359.51	30.000	0.866	11569.68

				9			3
30.000		5585.750	1.000	5585.750	20.000	0.940	5248.888
30.000		5585.750	1.000	5585.750	20.000	0.940	5248.888
40.000		8093.195	4.000	32372.781	10.000	0.985	31880.966
50.000		13586.049	1.000	13586.049	0.000	1.000	13586.049
Σ9							81188.099
Immersed Volume							298.597
Emerged Volume							372.150
Volume							119.876
Moment							2335.107
BR							19.479
BG=KG-KB							1.802
BGsinθ							1.380
GZ=BR-BGsinθ							18.099

Waterline-1 Combination Table

Angle of heel : 60˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.

0.000	507.084	1.000	507.084	507.084	1.000	507.084
10.000	462.883	4.000	1851.531	515.228	4.000	2060.913
20.000	396.073	2.000	792.146	505.169	2.000	1010.338
30.000	423.836	4.000	1695.345	577.814	4.000	2311.257
40.000	532.979	2.000	1065.958	705.484	2.000	1410.968
50.000	743.864	4.000	2975.456	966.667	4.000	3866.668
60.000	795.989	1.000	795.989	865.375	1.000	865.375
Σ7			9683.509	Σ8		12032.603

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	4760.766	1.000	4760.766	60.000	0.500	2380.383
10.000	4609.594	4.000	18438.377	50.000	0.643	11851.961
20.000	4453.173	2.000	8906.346	40.000	0.766	6822.657
30.000	5585.750	4.000	22343.002	30.000	0.866	19349.607
40.000	8093.195	2.000	16186.390	20.000	0.940	15210.232
50.000	13586.049	4.000	54344.195	10.000	0.985	53518.585
60.000	12765.676	1.000	12765.676	0.000	1.000	12765.676
Σ9						121899.101

Immersed Volume	399.049
Emerged Volume	495.853

Volume	96.626
Moment	3348.907
BR	34.658
BG=KG-KB	1.802
BGsinθ	1.561
GZ=BR-BGsinθ	33.098

Waterline-1 Combination Table

Angle of heel : 70˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	507.084	1.000	507.084	507.084	1.000	507.084
10.000	462.883	4.000	1851.531	515.228	4.000	2060.913
20.000	396.073	2.000	792.146	505.169	2.000	1010.338
30.000	423.836	4.000	1695.345	577.814	4.000	2311.257
40.000	532.979	2.000	1065.958	705.484	2.000	1410.968

50.000	743.864	4.000	2975.456	966.667	4.000	3866.668
60.000	795.989	1.000	795.989	865.375	1.000	865.375
Σ7			9683.509	Σ8		12032.603
60.000	795.989	5.000	3979.945	865.375	5.000	4326.875
70.000	676.296	8.000	5410.367	735.601	8.000	5884.805
80.000	616.096	-1.000	-616.096	670.595	-1.000	-670.595
Σ7			8774.217	Σ8		9541.085

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	4760.766	1.000	4760.766	70.000	0.342	1628.278
10.000	4609.594	4.000	18438.377	60.000	0.500	9219.189
20.000	4453.173	2.000	8906.346	50.000	0.643	5724.889
30.000	5585.750	4.000	22343.002	40.000	0.766	17115.732
40.000	8093.195	2.000	16186.390	30.000	0.866	14017.825
50.000	13586.049	4.000	54344.195	20.000	0.940	51066.839
60.000	12765.676	1.000	12765.676	10.000	0.985	12571.737
Σ9						111344.490
60.000	12765.676	5.000	63828.381	10.000	0.985	62858.684

70.000	9991.418	8.000	79931.343	0.000	1.000	79931.343
80.000	8683.421	-1.000	-8683.421	-10.000	0.985	-8551.501
Σ9						134238.527

Immersed Volume	489.444
Emerged Volume	594.149
Volume	88.726
Moment	3980.918
BR	44.868
BG=KG-KB	1.802
BGsinθ	1.693
GZ=BR-BGsinθ	43.174

Waterline-1 Combination Table

Angle of heel : 80˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	507.084	1.000	507.084	507.084	1.000	507.084
10.000	462.883	4.000	1851.531	515.228	4.000	2060.913
20.000	396.073	2.000	792.146	505.169	2.000	1010.338

30.000	423.836	4.000	1695.345	577.814	4.000	2311.257
40.000	532.979	2.000	1065.958	705.484	2.000	1410.968
50.000	743.864	4.000	2975.456	966.667	4.000	3866.668
60.000	795.989	2.000	1591.978	865.375	2.000	1730.750
70.000	676.296	4.000	2705.184	735.601	4.000	2942.402
80.000	616.096	1.000	616.096	670.595	1.000	670.595
Σ7			13800.777	Σ8		16510.975

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	4760.766	1.000	4760.766	80.000	0.174	826.698
10.000	4609.594	4.000	18438.377	70.000	0.342	6306.296
20.000	4453.173	2.000	8906.346	60.000	0.500	4453.173
30.000	5585.750	4.000	22343.002	50.000	0.643	14361.805
40.000	8093.195	2.000	16186.390	40.000	0.766	12399.494
50.000	13586.049	4.000	54344.195	30.000	0.866	47063.454
60.000	12765.676	2.000	25531.352	20.000	0.940	23991.623
70.000	9991.418	4.000	39965.672	10.000	0.985	39358.503
80.000	8683.421	1.000	8683.421	0.000	1.000	8683.421

Σ9	157444.469

Immersed Volume	568.718
Emerged Volume	680.403
Volume	81.745
Moment	4325.437
BR	52.914
BG=KG-KB	1.802
BGsinθ	1.775
GZ=BR-BGsinθ	51.139

Waterline-1 Combination Table

Angle of heel : 90˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	507.084	1.000	507.084	507.084	1.000	507.084
10.000	462.883	3.000	1388.648	515.228	3.000	1545.684
20.000	396.073	3.000	1188.219	505.169	3.000	1515.508
30.000	423.836	2.000	847.673	577.814	2.000	1155.629
40.000	532.979	3.000	1598.937	705.484	3.000	2116.452

50.000	743.864	3.000	2231.592	966.667	3.000	2900.001
60.000	795.989	2.000	1591.978	865.375	2.000	1730.750
70.000	676.296	3.000	2028.888	735.601	3.000	2206.802
80.000	616.096	3.000	1848.288	670.595	3.000	2011.784
90.000	628.332	1.000	628.332	808.812	1.000	808.812
Σ7			13859.638	Σ8		16498.506

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	4760.766	1.000	4760.766	90.000	0.000	0.000
10.000	4609.594	3.000	13828.783	80.000	0.174	2401.343
20.000	4453.173	3.000	13359.519	70.000	0.342	4569.225
30.000	5585.750	2.000	11171.501	60.000	0.500	5585.750
40.000	8093.195	3.000	24279.586	50.000	0.643	15606.617
50.000	13586.049	3.000	40758.147	40.000	0.766	31222.552
60.000	12765.676	2.000	25531.352	30.000	0.866	22110.800
70.000	9991.418	3.000	29974.254	20.000	0.940	28166.585
80.000	8683.421	3.000	26050.264	10.000	0.985	25654.502

90.000	9565.728	1.000	9565.728	0.000	1.000	9565.728
Σ9						144883.102

Immersed Volume	642.537
Emerged Volume	764.876
Volume	71.092
Moment	4477.884
BR	62.988
BG=KG-KB	1.802
BGsinθ	1.802
GZ=BR-BGsinθ	61.186

Waterline 2 Emerged and Immersed Wedge Calculations

WL 2 inclined at 0°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes

0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	4.55	1.00	4.55	20.67	1.00	20.67	93.95	1.00	93.95
1.50	5.06	2.00	10.11	25.56	2.00	51.13	129.25	2.00	258.49
2.00	5.22	1.50	7.82	27.20	1.50	40.79	141.83	1.50	212.74
3.00	5.23	4.00	20.92	27.34	4.00	109.37	142.97	4.00	571.89
4.00	5.23	2.00	10.46	27.34	2.00	54.68	142.97	2.00	285.95
5.00	5.23	4.00	20.92	27.34	4.00	109.37	142.97	4.00	571.89
6.00	5.27	2.00	10.54	27.76	2.00	55.52	146.28	2.00	292.56
7.00	5.23	4.00	20.92	27.34	4.00	109.37	142.97	4.00	571.89
8.00	4.69	1.50	7.03	21.96	1.50	32.94	102.90	1.50	154.35
8.50	3.97	2.00	7.94	15.75	2.00	31.49	62.48	2.00	124.95
9.00	2.99	1.00	2.99	8.96	1.00	8.96	26.81	1.00	26.81
9.50	1.97	2.00	3.93	3.87	2.00	7.73	7.60	2.00	15.20
10.00	0.07	0.50	0.04	0.00	0.50	0.00	0.00	0.50	0.00
		Σ2=	128.15		Σ4=	632.02		Σ6=	3180.68

WL 2 inclined at 0°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	4.55	1.00	4.55	20.67	1.00	20.67	93.95	1.00	93.95
1.50	5.06	2.00	10.11	25.56	2.00	51.13	129.25	2.00	258.49
2.00	5.22	1.50	7.82	27.20	1.50	40.79	141.83	1.50	212.74
3.00	5.23	4.00	20.92	27.34	4.00	109.37	142.97	4.00	571.89
4.00	5.23	2.00	10.46	27.34	2.00	54.68	142.97	2.00	285.95
5.00	5.23	4.00	20.92	27.34	4.00	109.37	142.97	4.00	571.89
6.00	5.27	2.00	10.54	27.76	2.00	55.52	146.28	2.00	292.56

7.00	5.23	4.00	20.92	27.34	4.00	109.37	142.97	4.00	571.89
8.00	4.69	1.50	7.03	21.96	1.50	32.94	102.90	1.50	154.35
8.50	3.97	2.00	7.94	15.75	2.00	31.49	62.48	2.00	124.95
9.00	2.99	1.00	2.99	8.96	1.00	8.96	26.81	1.00	26.81
9.50	1.97	2.00	3.93	3.87	2.00	7.73	7.60	2.00	15.20
10.00	0.07	0.50	0.04	0.00	0.50	0.00	0.00	0.50	0.00
		Σ1=	128.15		Σ3=	632.02		Σ5=	3180.68

WL 2 inclined at 10°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	2.55	2.00	5.10	6.49	2.00	12.98	16.54	2.00	33.08
1.00	5.12	1.00	5.12	26.22	1.00	26.22	134.30	1.00	134.30
1.50	5.33	2.00	10.65	28.38	2.00	56.75	151.16	2.00	302.33
2.00	5.40	1.50	8.10	29.13	1.50	43.69	157.20	1.50	235.80
3.00	5.40	4.00	21.59	29.13	4.00	116.51	157.20	4.00	628.81
4.00	5.40	2.00	10.79	29.13	2.00	58.26	157.20	2.00	314.40
5.00	5.40	4.00	21.59	29.13	4.00	116.51	157.20	4.00	628.81
6.00	5.15	2.00	10.29	26.47	2.00	52.94	136.19	2.00	272.39
7.00	5.10	4.00	20.38	25.97	4.00	103.88	132.34	4.00	529.36
8.00	4.31	1.50	6.47	18.60	1.50	27.90	80.23	1.50	120.35
8.50	3.57	2.00	7.14	12.76	2.00	25.52	45.58	2.00	91.15
9.00	2.79	1.00	2.79	7.79	1.00	7.79	21.74	1.00	21.74
9.50	1.88	2.00	3.76	3.53	2.00	7.06	6.63	2.00	13.27
10.00	0.07	0.50	0.04	0.00	0.50	0.00	0.00	0.50	0.00
		Σ2=	133.81		Σ4=	656.02		Σ6=	3325.78

WL 2 inclined at 10°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	3.17	1.00	3.17	10.02	1.00	10.02	31.73	1.00	31.73
1.50	4.75	2.00	9.50	22.58	2.00	45.16	107.31	2.00	214.61
2.00	5.07	1.50	7.60	25.68	1.50	38.53	130.17	1.50	195.25
3.00	5.10	4.00	20.38	25.97	4.00	103.88	132.34	4.00	529.36
4.00	5.10	2.00	10.19	25.97	2.00	51.94	132.34	2.00	264.68
5.00	5.10	4.00	20.38	25.97	4.00	103.88	132.34	4.00	529.36
6.00	5.42	2.00	10.84	29.40	2.00	58.80	159.40	2.00	318.79
7.00	5.40	4.00	21.61	29.19	4.00	116.77	157.73	4.00	630.91
8.00	5.07	1.50	7.60	25.69	1.50	38.54	130.25	1.50	195.37
8.50	4.50	2.00	8.99	20.22	2.00	40.45	90.94	2.00	181.89
9.00	3.24	1.00	3.24	10.47	1.00	10.47	33.89	1.00	33.89
9.50	2.11	2.00	4.22	4.44	2.00	8.89	9.37	2.00	18.73
10.00	0.07	0.50	0.04	0.01	0.50	0.00	0.00	0.50	0.00
		$\Sigma 1^{=}$	127.77		$\Sigma 3=$	627.32		$\Sigma 5=$	3144.57

WL 2 inclined at 20°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	3.12	0.50	1.56	9.73	0.50	4.87	30.37	0.50	15.19
0.50	0.80	2.00	1.60	0.64	2.00	1.29	0.52	2.00	1.03
1.00	5.63	1.00	5.63	31.70	1.00	31.70	178.45	1.00	178.45
1.50	5.67	2.00	11.34	32.15	2.00	64.30	182.28	2.00	364.57
2.00	5.68	1.50	8.52	32.29	1.50	48.43	183.44	1.50	275.17

3.00	5.68	4.00	22.73	32.29	4.00	129.14	183.44	4.00	733.78
4.00	5.68	2.00	11.36	32.29	2.00	64.57	183.44	2.00	366.89
5.00	5.68	4.00	22.73	32.29	4.00	129.14	183.44	4.00	733.78
6.00	4.91	2.00	9.81	24.06	2.00	48.12	118.01	2.00	236.02
7.00	4.88	4.00	19.52	23.80	4.00	95.22	116.14	4.00	464.57
8.00	3.90	1.50	5.86	15.24	1.50	22.86	59.50	1.50	89.25
8.50	3.26	2.00	6.52	10.63	2.00	21.26	34.65	2.00	69.29
9.00	2.61	1.00	2.61	6.83	1.00	6.83	17.84	1.00	17.84
9.50	1.83	2.00	3.66	3.35	2.00	6.71	6.14	2.00	12.28
10.00	0.07	0.50	0.04	0.01	0.50	0.00	0.00	0.50	0.00
		Σ2=	133.49		Σ4=	674.42		Σ6=	3558.10

WL 2 inclined at 20^{o}									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	1.93	1.00	1.93	3.73	1.00	3.73	7.20	1.00	7.20
1.50	4.15	2.00	8.30	17.21	2.00	34.43	71.42	2.00	142.84
2.00	4.82	1.50	7.23	23.24	1.50	34.86	112.05	1.50	168.07
3.00	4.88	4.00	19.52	23.80	4.00	95.22	116.14	4.00	464.57
4.00	4.88	2.00	9.76	23.80	2.00	47.61	116.14	2.00	232.29
5.00	4.88	4.00	19.52	23.80	4.00	95.22	116.14	4.00	464.57
6.00	5.68	2.00	11.36	32.29	2.00	64.57	183.44	2.00	366.89
7.00	5.68	4.00	22.73	32.29	4.00	129.14	183.44	4.00	733.78
8.00	5.54	1.50	8.31	30.71	1.50	46.07	170.22	1.50	255.32
8.50	5.24	2.00	10.48	27.48	2.00	54.96	144.04	2.00	288.09
9.00	3.56	1.00	3.56	12.66	1.00	12.66	45.04	1.00	45.04

9.50	2.33	2.00	4.66	5.42	2.00	10.84	12.62	2.00	25.23
10.00	0.08	0.50	0.04	0.01	0.50	0.00	0.00	0.50	0.00
		Σ1=	127.39		Σ3=	629.31		Σ5=	3193.90

WL 2 inclined at 30º									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	1.94	0.50	0.97	3.75	0.50	1.88	7.27	0.50	3.63
0.50	0.50	2.00	1.00	0.25	2.00	0.50	0.13	2.00	0.25
1.00	6.17	1.00	6.17	38.02	1.00	38.02	234.43	1.00	234.43
1.50	6.17	2.00	12.33	38.02	2.00	76.04	234.43	2.00	468.86
2.00	6.17	1.50	9.25	38.02	1.50	57.03	234.43	1.50	351.64
3.00	6.17	4.00	24.66	38.02	4.00	152.08	234.43	4.00	937.71
4.00	6.17	2.00	12.33	38.02	2.00	76.04	234.43	2.00	468.86
5.00	6.17	4.00	24.66	38.02	4.00	152.08	234.43	4.00	937.71
6.00	4.30	2.00	8.59	18.45	2.00	36.89	79.23	2.00	158.46
7.00	4.24	4.00	16.97	17.99	4.00	71.98	76.33	4.00	305.33
8.00	3.49	1.50	5.24	12.18	1.50	18.27	42.51	1.50	63.76
8.50	3.00	2.00	6.01	9.02	2.00	18.04	27.08	2.00	54.16
9.00	2.46	1.00	2.46	6.07	1.00	6.07	14.94	1.00	14.94
9.50	1.81	2.00	3.63	3.29	2.00	6.58	5.97	2.00	11.94
10.00	0.08	0.50	0.04	0.01	0.50	0.00	0.00	0.50	0.00
		Σ2=	134.30		Σ4=	711.49		Σ6=	4011.69

WL 2 inclined at 30º									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes

0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	1.46	1.00	1.46	2.14	1.00	2.14	3.13	1.00	3.13
1.50	3.09	2.00	6.19	9.57	2.00	19.15	29.62	2.00	59.24
2.00	4.13	1.50	6.19	17.04	1.50	25.56	70.34	1.50	105.51
3.00	4.30	4.00	17.18	18.45	4.00	73.79	79.23	4.00	316.92
4.00	4.30	2.00	8.59	18.45	2.00	36.89	79.23	2.00	158.46
5.00	4.30	4.00	17.18	18.45	4.00	73.79	79.23	4.00	316.92
6.00	6.17	2.00	12.33	38.02	2.00	76.04	234.43	2.00	468.86
7.00	6.17	4.00	24.66	38.02	4.00	152.08	234.43	4.00	937.71
8.00	6.17	1.50	9.25	38.02	1.50	57.03	234.43	1.50	351.64
8.50	6.17	2.00	12.33	38.02	2.00	76.04	234.43	2.00	468.86
9.00	4.03	1.00	4.03	16.22	1.00	16.22	65.30	1.00	65.30
9.50	2.68	2.00	5.36	7.18	2.00	14.35	19.23	2.00	38.45
10.00	0.09	0.50	0.04	0.01	0.50	0.00	0.00	0.50	0.00
		Σ1=	124.80		Σ3=	623.08		Σ5=	3291.01

WL 2 inclined at 40°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	1.39	0.50	0.69	1.93	0.50	0.96	2.67	0.50	1.34
0.50	0.37	2.00	0.75	0.14	2.00	0.28	0.05	2.00	0.10
1.00	6.97	1.00	6.97	48.58	1.00	48.58	338.61	1.00	338.61
1.50	6.97	2.00	13.94	48.58	2.00	97.16	338.61	2.00	677.22
2.00	6.97	1.50	10.46	48.58	1.50	72.87	338.61	1.50	507.91
3.00	6.97	4.00	27.88	48.58	4.00	194.32	338.61	4.00	1354.44
4.00	6.97	2.00	13.94	48.58	2.00	97.16	338.61	2.00	677.22
5.00	6.97	4.00	27.88	48.58	4.00	194.32	338.61	4.00	1354.44
6.00	3.45	2.00	6.90	11.91	2.00	23.82	41.10	2.00	82.20

7.00	3.41	4.00	13.63	11.61	4.00	46.46	39.58	4.00	158.33
8.00	3.11	1.50	4.66	9.66	1.50	14.49	30.02	1.50	45.03
8.50	2.79	2.00	5.57	7.76	2.00	15.52	21.62	2.00	43.25
9.00	2.35	1.00	2.35	5.51	1.00	5.51	12.94	1.00	12.94
9.50	1.82	2.00	3.64	3.32	2.00	6.64	6.05	2.00	12.10
10.00	0.09	0.50	0.04	0.01	0.50	0.00	0.00	0.50	0.00
		Σ2=	139.31		Σ4=	818.11		Σ6=	5265.12

WL 2 inclined at 40^o									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	1.20	1.00	1.20	1.43	1.00	1.43	1.71	1.00	1.71
1.50	2.52	2.00	5.04	6.34	2.00	12.68	15.96	2.00	31.93
2.00	3.26	1.50	4.89	10.64	1.50	15.96	34.71	1.50	52.06
3.00	3.45	4.00	13.80	11.91	4.00	47.64	41.10	4.00	164.40
4.00	3.45	2.00	6.90	11.91	2.00	23.82	41.10	2.00	82.20
5.00	3.45	4.00	13.80	11.91	4.00	47.64	41.10	4.00	164.40
6.00	6.97	2.00	13.94	48.58	2.00	97.16	338.61	2.00	677.22
7.00	6.97	4.00	27.88	48.58	4.00	194.32	338.61	4.00	1354.44
8.00	6.97	1.50	10.46	48.58	1.50	72.87	338.61	1.50	507.91
8.50	6.97	2.00	13.94	48.58	2.00	97.16	338.61	2.00	677.22
9.00	4.84	1.00	4.84	23.44	1.00	23.44	113.45	1.00	113.45
9.50	3.31	2.00	6.62	10.96	2.00	21.93	36.30	2.00	72.60
10.00	0.10	0.50	0.05	0.01	0.50	0.00	0.00	0.50	0.00
		Σ1$^=$	123.36		Σ3=	656.05		Σ5=	3899.52

WL 2 inclined at 50°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	1.12	0.50	0.56	1.25	0.50	0.63	1.40	0.50	0.70
0.50	0.31	2.00	0.61	0.09	2.00	0.19	0.03	2.00	0.06
1.00	7.36	1.00	7.36	54.20	1.00	54.20	399.01	1.00	399.01
1.50	7.36	2.00	14.72	54.20	2.00	108.40	399.01	2.00	798.03
2.00	7.36	1.50	11.04	54.20	1.50	81.30	399.01	1.50	598.52
3.00	7.36	4.00	29.45	54.20	4.00	216.80	399.01	4.00	1596.05
4.00	7.36	2.00	14.72	54.20	2.00	108.40	399.01	2.00	798.03
5.00	7.36	4.00	29.45	54.20	4.00	216.80	399.01	4.00	1596.05
6.00	2.95	2.00	5.90	8.69	2.00	17.38	25.62	2.00	51.24
7.00	2.93	4.00	11.72	8.59	4.00	34.36	25.18	4.00	100.72
8.00	2.79	1.50	4.18	7.78	1.50	11.67	21.69	1.50	32.54
8.50	2.61	2.00	5.22	6.82	2.00	13.63	17.80	2.00	35.60
9.00	2.27	1.00	2.27	5.14	1.00	5.14	11.67	1.00	11.67
9.50	1.85	2.00	3.70	3.42	2.00	6.85	6.33	2.00	12.66
10.00	0.10	0.50	0.05	0.01	0.50	0.00	0.00	0.50	0.00
		Σ2=	140.96		Σ4=	875.74		Σ6=	6030.88

WL 2 inclined at 50°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	1.03	1.00	1.03	1.07	1.00	1.07	1.10	1.00	1.10
1.50	2.19	2.00	4.39	4.81	2.00	9.62	10.55	2.00	21.09

2.00	2.81	1.50	4.21	7.88	1.50	11.82	22.12	1.50	33.18
3.00	2.95	4.00	11.79	8.69	4.00	34.76	25.62	4.00	102.48
4.00	2.95	2.00	5.90	8.69	2.00	17.38	25.62	2.00	51.24
5.00	2.95	4.00	11.79	8.69	4.00	34.76	25.62	4.00	102.48
6.00	7.36	2.00	14.72	54.20	2.00	108.40	399.01	2.00	798.03
7.00	7.36	4.00	29.45	54.20	4.00	216.80	399.01	4.00	1596.05
8.00	7.36	1.50	11.04	54.20	1.50	81.30	399.01	1.50	598.52
8.50	7.36	2.00	14.72	54.20	2.00	108.40	399.01	2.00	798.03
9.00	7.36	1.00	7.36	54.20	1.00	54.20	399.01	1.00	399.01
9.50	6.62	2.00	13.24	43.81	2.00	87.62	289.99	2.00	579.97
10.00	0.12	0.50	0.06	0.01	0.50	0.01	0.00	0.50	0.00
		Σ1=	129.71		Σ3=	766.13		Σ5=	5081.18

WL 2 inclined at 60°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.97	0.50	0.48	0.93	0.50	0.47	0.90	0.50	0.45
0.50	0.27	2.00	0.53	0.07	2.00	0.14	0.02	2.00	0.04
1.00	6.52	1.00	6.52	42.52	1.00	42.52	277.30	1.00	277.30
1.50	6.52	2.00	13.04	42.52	2.00	85.05	277.30	2.00	554.59
2.00	6.52	1.50	9.78	42.52	1.50	63.79	277.30	1.50	415.94
3.00	6.52	4.00	26.08	42.52	4.00	170.09	277.30	4.00	1109.18
4.00	6.52	2.00	13.04	42.52	2.00	85.05	277.30	2.00	554.59
5.00	6.52	4.00	26.08	42.52	4.00	170.09	277.30	4.00	1109.18
6.00	2.65	2.00	5.29	7.01	2.00	14.01	18.55	2.00	37.09
7.00	2.65	4.00	10.59	7.01	4.00	28.03	18.55	4.00	74.19
8.00	2.56	1.50	3.84	6.55	1.50	9.83	16.78	1.50	25.17
8.50	2.48	2.00	4.95	6.14	2.00	12.27	15.20	2.00	30.40
9.00	2.22	1.00	2.22	4.94	1.00	4.94	10.99	1.00	10.99

9.50	1.90	2.00	3.80	3.62	2.00	7.24	6.88	2.00	13.76
10.00	0.12	0.50	0.06	0.02	0.50	0.01	0.00	0.50	0.00
		Σ2=	126.33		Σ4=	693.52		Σ6=	4212.86

WL 2 inclined at 60^o									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	0.93	1.00	0.93	0.87	1.00	0.87	0.81	1.00	0.81
1.50	1.99	2.00	3.97	3.94	2.00	7.89	7.83	2.00	15.67
2.00	2.54	1.50	3.81	6.44	1.50	9.66	16.35	1.50	24.52
3.00	2.66	4.00	10.63	7.06	4.00	28.24	18.76	4.00	75.03
4.00	2.66	2.00	5.31	7.06	2.00	14.12	18.76	2.00	37.51
5.00	2.66	4.00	10.63	7.06	4.00	28.24	18.76	4.00	75.03
6.00	6.51	2.00	13.02	42.41	2.00	84.81	276.15	2.00	552.30
7.00	6.51	4.00	26.05	42.41	4.00	169.62	276.15	4.00	1104.60
8.00	6.51	1.50	9.77	42.41	1.50	63.61	276.15	1.50	414.22
8.50	6.51	2.00	13.02	42.41	2.00	84.81	276.15	2.00	552.30
9.00	6.51	1.00	6.51	42.41	1.00	42.41	276.15	1.00	276.15
9.50	6.51	2.00	13.02	42.41	2.00	84.81	276.15	2.00	552.30
10.00	0.17	0.50	0.08	0.03	0.50	0.01	0.00	0.50	0.00
		Σ1$^=$	116.76		Σ3=	619.10		Σ5=	3680.43

WL 2 inclined at 70^o									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.87	0.50	0.44	0.76	0.50	0.38	0.66	0.50	0.33

0.50	0.24	2.00	0.48	0.06	2.00	0.12	0.01	2.00	0.03
1.00	6.00	1.00	6.00	36.01	1.00	36.01	216.11	1.00	216.11
1.50	6.00	2.00	12.00	36.01	2.00	72.02	216.11	2.00	432.22
2.00	6.00	1.50	9.00	36.01	1.50	54.02	216.11	1.50	324.16
3.00	6.00	4.00	24.00	36.01	4.00	144.05	216.11	4.00	864.43
4.00	6.00	2.00	12.00	36.01	2.00	72.02	216.11	2.00	432.22
5.00	6.00	4.00	24.00	36.01	4.00	144.05	216.11	4.00	864.43
6.00	2.47	2.00	4.94	6.11	2.00	12.21	15.09	2.00	30.18
7.00	2.47	4.00	9.88	6.11	4.00	24.42	15.09	4.00	60.35
8.00	2.42	1.50	3.63	5.85	1.50	8.78	14.15	1.50	21.23
8.50	2.38	2.00	4.77	5.68	2.00	11.37	13.55	2.00	27.10
9.00	2.22	1.00	2.22	4.91	1.00	4.91	10.88	1.00	10.88
9.50	1.99	2.00	3.98	3.97	2.00	7.94	7.90	2.00	15.81
10.00	0.17	0.50	0.08	0.03	0.50	0.01	0.00	0.50	0.00
		Σ2=	117.44		Σ4=	592.31		Σ6=	3299.48

WL 2 inclined at 70°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	0.87	1.00	0.87	0.76	1.00	0.76	0.66	1.00	0.66
1.50	1.86	2.00	3.72	3.46	2.00	6.92	6.43	2.00	12.87
2.00	2.37	1.50	3.56	5.63	1.50	8.44	13.35	1.50	20.02
3.00	2.47	4.00	9.88	6.11	4.00	24.42	15.09	4.00	60.35
4.00	2.47	2.00	4.94	6.11	2.00	12.21	15.09	2.00	30.18
5.00	2.47	4.00	9.88	6.11	4.00	24.42	15.09	4.00	60.35
6.00	6.00	2.00	12.00	36.01	2.00	72.02	216.11	2.00	432.22

7.00	6.00	4.00	24.00	36.01	4.00	144.05	216.11	4.00	864.43
8.00	6.00	1.50	9.00	36.01	1.50	54.02	216.11	1.50	324.16
8.50	6.00	2.00	12.00	36.01	2.00	72.02	216.11	2.00	432.22
9.00	6.00	1.00	6.00	36.01	1.00	36.01	216.11	1.00	216.11
9.50	6.00	2.00	12.00	36.01	2.00	72.02	216.11	2.00	432.22
10.00	0.27	0.50	0.14	0.08	0.50	0.04	0.02	0.50	0.01
		Σ1=	108.01		Σ3=	527.37		Σ5=	2885.79

WL 2 inclined at 80^o									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.82	0.50	0.41	0.67	0.50	0.34	0.55	0.50	0.27
0.50	0.23	2.00	0.45	0.05	2.00	0.10	0.01	2.00	0.02
1.00	5.73	1.00	5.73	32.80	1.00	32.80	187.84	1.00	187.84
1.50	5.73	2.00	11.45	32.80	2.00	65.60	187.84	2.00	375.67
2.00	5.73	1.50	8.59	32.80	1.50	49.20	187.84	1.50	281.76
3.00	5.73	4.00	22.91	32.80	4.00	131.19	187.84	4.00	751.35
4.00	5.73	2.00	11.45	32.80	2.00	65.60	187.84	2.00	375.67
5.00	5.73	4.00	22.91	32.80	4.00	131.19	187.84	4.00	751.35
6.00	2.38	2.00	4.75	5.65	2.00	11.30	13.43	2.00	26.86
7.00	2.38	4.00	9.51	5.65	4.00	22.60	13.43	4.00	53.72
8.00	2.35	1.50	3.53	5.54	1.50	8.31	13.04	1.50	19.57
8.50	2.34	2.00	4.68	5.48	2.00	10.97	12.85	2.00	25.69
9.00	2.26	1.00	2.26	5.09	1.00	5.09	11.48	1.00	11.48
9.50	2.13	2.00	4.27	4.55	2.00	9.11	9.72	2.00	19.44
10.00	0.29	0.50	0.14	0.08	0.50	0.04	0.02	0.50	0.01
		Σ2=	113.05		Σ4=	543.44		Σ6=	2880.71

WL 2 inclined at 80°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.50	0.00
0.50	0.00	2.00	0.00	0.00	2.00	0.00	0.00	2.00	0.00
1.00	0.84	1.00	0.84	0.71	1.00	0.71	0.60	1.00	0.60
1.50	1.79	2.00	3.59	3.22	2.00	6.44	5.77	2.00	11.55
2.00	2.29	1.50	3.43	5.22	1.50	7.83	11.93	1.50	17.90
3.00	2.38	4.00	9.51	5.65	4.00	22.60	13.43	4.00	53.72
4.00	2.38	2.00	4.75	5.65	2.00	11.30	13.43	2.00	26.86
5.00	2.38	4.00	9.51	5.65	4.00	22.60	13.43	4.00	53.72
6.00	5.73	2.00	11.45	32.80	2.00	65.60	187.84	2.00	375.67
7.00	5.73	4.00	22.91	32.80	4.00	131.19	187.84	4.00	751.35
8.00	5.73	1.50	8.59	32.80	1.50	49.20	187.84	1.50	281.76
8.50	5.73	2.00	11.45	32.80	2.00	65.60	187.84	2.00	375.67
9.00	5.73	1.00	5.73	32.80	1.00	32.80	187.84	1.00	187.84
9.50	5.73	2.00	11.45	32.80	2.00	65.60	187.84	2.00	375.67
10.00	5.73	0.50	2.86	32.80	0.50	16.40	187.84	0.50	93.92
		Σ1=	106.08		Σ3=	497.86		Σ5=	2606.23

WL 2 inclined at 90°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	5.64	0.50	2.82	31.81	0.50	15.90	179.41	0.50	89.70
0.50	5.64	2.00	11.28	31.81	2.00	63.62	179.41	2.00	358.81
1.00	5.64	1.00	5.64	31.81	1.00	31.81	179.41	1.00	179.41
1.50	5.64	2.00	11.28	31.81	2.00	63.62	179.41	2.00	358.81
2.00	5.64	1.50	8.46	31.81	1.50	47.71	179.41	1.50	269.11

3.00	5.64	4.00	22.56	31.81	4.00	127.24	179.41	4.00	717.62
4.00	5.64	2.00	11.28	31.81	2.00	63.62	179.41	2.00	358.81
5.00	5.64	4.00	22.56	31.81	4.00	127.24	179.41	4.00	717.62
6.00	2.36	2.00	4.72	5.57	2.00	11.14	13.14	2.00	26.29
7.00	2.36	4.00	9.44	5.57	4.00	22.28	13.14	4.00	52.58
8.00	2.36	1.50	3.54	5.57	1.50	8.35	13.14	1.50	19.72
8.50	2.36	2.00	4.72	5.57	2.00	11.14	13.14	2.00	26.29
9.00	2.36	1.00	2.36	5.57	1.00	5.57	13.14	1.00	13.14
9.50	2.36	2.00	4.72	5.57	2.00	11.14	13.14	2.00	26.29
10.00	2.36	0.50	1.18	5.57	0.50	2.78	13.14	0.50	6.57
		Σ2=	126.56		Σ4=	613.17		Σ6=	3220.78

WL 2 inclined at 90°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	2.36	0.50	1.18	5.57	0.50	2.78	13.14	0.50	6.57
0.50	2.36	2.00	4.72	5.57	2.00	11.14	13.14	2.00	26.29
1.00	2.36	1.00	2.36	5.57	1.00	5.57	13.14	1.00	13.14
1.50	2.36	2.00	4.72	5.57	2.00	11.14	13.14	2.00	26.29
2.00	2.36	1.50	3.54	5.57	1.50	8.35	13.14	1.50	19.72
3.00	2.36	4.00	9.44	5.57	4.00	22.28	13.14	4.00	52.58
4.00	2.36	2.00	4.72	5.57	2.00	11.14	13.14	2.00	26.29
5.00	2.36	4.00	9.44	5.57	4.00	22.28	13.14	4.00	52.58
6.00	5.64	2.00	11.28	31.81	2.00	63.62	179.41	2.00	358.81
7.00	5.64	4.00	22.56	31.81	4.00	127.24	179.41	4.00	717.62
8.00	5.64	1.50	8.46	31.81	1.50	47.71	179.41	1.50	269.11
8.50	5.64	2.00	11.28	31.81	2.00	63.62	179.41	2.00	358.81
9.00	5.64	1.00	5.64	31.81	1.00	31.81	179.41	1.00	179.41

9.50	5.64	2.00	11.28	31.81	2.00	63.62	179.41	2.00	358.81
10.00	5.64	0.50	2.82	31.81	0.50	15.90	179.41	0.50	89.70
		Σ1=	113.44		Σ3=	508.21		Σ5=	2555.73

GZ Calculation

Waterline-2 Combination Table						
Angle of heel : 10˚						
	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	632.024	5.000	3160.122	632.024	5.000	3160.122
10.000	627.321	8.000	5018.569	656.024	8.000	5248.194
20.000	629.307	-1.000	-629.307	674.416	-1.000	-674.416
Σ7			7549.385	Σ8		7733.900

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	6361.369	5.000	31806.844	10.000	0.985	31323.627
10.000	6470.349	8.000	51762.795	0.000	1.000	51762.795
20.000	6751.995	-1.000	-6751.995	-10.000	0.985	-6649.417
Σ9						76437.004

Immersed Volume	77.776
Emerged Volume	79.677
Volume	559.849
Moment	524.984
BR	0.938
BG=KG-KB	2.035
BGsinθ	0.353
GZ=BR-BGsinθ	0.584

Waterline-2 Combination Table

Angle of heel : 20˚

	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	632.024	1.000	632.024	632.024	1.000	632.024
10.000	627.321	4.000	2509.285	656.024	4.000	2624.097
20.000	629.307	1.000	629.307	674.416	1.000	674.416
Σ7			3770.616	Σ8		3930.538

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	6361.369	1.000	6361.369	20.000	0.940	5977.731
10.000	6470.349	4.000	25881.397	10.000	0.985	25488.201
20.000	6751.995	1.000	6751.995	0.000	1.000	6751.995
Σ9						38217.928

Immersed Volume	155.384

Emerged Volume	161.974
Volume	555.160
Moment	1049.953
BR	1.891
BG=KG-KB	2.035
BGsinθ	0.696
GZ=BR-BGsinθ	1.195

Waterline-2 Combination Table

Angle of heel : 30˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	632.024	1.000	632.024	632.024	1.000	632.024

10.000	627.321	3.000	1881.964	656.024	3.000	1968.073
20.000	629.307	3.000	1887.920	674.416	3.000	2023.249
30.000	623.077	1.000	623.077	711.489	1.000	711.489
Σ7			5024.985	Σ8		5334.835

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	6361.369	1.000	6361.369	30.000	0.866	5509.107
10.000	6470.349	3.000	19411.048	20.000	0.940	18240.419
20.000	6751.995	3.000	20255.986	10.000	0.985	19948.252
30.000	7302.708	1.000	7302.708	0.000	1.000	7302.708
Σ9						51000.486

Immersed Volume	232.960
Emerged Volume	247.325
Volume	547.386
Moment	1576.266
BR	2.880
BG=KG-KB	2.035
BGsinθ	1.018

GZ=BR-BGsinθ	1.862

Waterline-2 Combination Table

Angle of heel : 40˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	632.024	1.000	632.024	632.024	1.000	632.024
10.000	627.321	4.000	2509.285	656.024	4.000	2624.097
20.000	629.307	2.000	1258.613	674.416	2.000	1348.833
30.000	623.077	4.000	2492.308	711.489	4.000	2845.954
40.000	656.048	1.000	656.048	818.110	1.000	818.110
Σ7			7548.278	Σ8		8269.019

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	6361.369	1.000	6361.369	40.000	0.766	4873.091
10.000	6470.349	4.000	25881.397	30.000	0.866	22413.948
20.000	6751.995	2.000	13503.991	20.000	0.940	12689.601
30.000	7302.708	4.000	29210.832	10.000	0.985	28767.054
40.000	9164.645	1.000	9164.645	0.000	1.000	9164.645
Σ9						77908.338

Immersed Volume	311.058
Emerged Volume	340.759
Volume	532.049
Moment	2140.358
BR	4.023
BG=KG-KB	2.035
BGsinθ	1.308
GZ=BR-BGsinθ	2.715

With New Simpson's Mult. (Waterline 2)

Angle of heel : 50˚

HEEL ANGLE (α)		Σ3	SM	PRD.	Σ4	SM	PRD.
0.000		632.024	1.000	632.024	735.870	1.000	735.870
10.000		627.321	3.000	1881.964	760.837	3.000	2282.510
20.000		629.307	3.000	1887.920	811.896	3.000	2435.687
30.000		623.077	1.000	623.077	905.827	1.000	905.827
30.000		623.077	1.000	623.077	760.837	1.000	760.837
40.000		656.048	4.000	2624.191	811.896	4.000	3247.582
50.000		766.129	1.000	766.129	905.827	1.000	905.827
Σ7				9038.382	Σ8		11274.140

HEEL ANGLE (α)		Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000		6361.369	1.000	6361.369	50.000	0.643	4089.009
10.000		6470.349	3.000	19411.048	40.000	0.766	14869.725
20.000		6751.995	3.000	20255.986	30.000	0.866	17542.199
30.000		7302.708	1.000	7302.708	20.000	0.940	6862.301
30.000		7302.708	1.000	7302.708	20.000	0.940	6862.301
40.000		9164.645	4.000	36658.581	10.000	0.985	36101.654

50.000		11112.064	1.000	11112.064	0.000	1.000	11112.064
Σ9							97439.254
Immersed Volume							398.349
Emerged Volume							497.359
Volume							462.740
Moment							2825.840
BR							6.107
BG=KG-KB							2.035
BGsinθ							1.559
GZ=BR-BGsinθ							4.548

Waterline-2 Combination Table

Angle of heel : 60˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	632.024	1.000	632.024	632.024	1.000	632.024
10.000	627.321	4.000	2509.285	656.024	4.000	2624.097

20.000	629.307	2.000	1258.613	674.416	2.000	1348.833
30.000	623.077	4.000	2492.308	711.489	4.000	2845.954
40.000	656.048	2.000	1312.095	818.110	2.000	1636.221
50.000	766.129	4.000	3064.516	875.739	4.000	3502.955
60.000	619.104	1.000	619.104	693.522	1.000	693.522
Σ7			11887.946	Σ8		13283.606

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	6361.369	1.000	6361.369	60.000	0.500	3180.684
10.000	6470.349	4.000	25881.397	50.000	0.643	16636.242
20.000	6751.995	2.000	13503.991	40.000	0.766	10344.657
30.000	7302.708	4.000	29210.832	30.000	0.866	25297.322
40.000	9164.645	2.000	18329.290	20.000	0.940	17223.899
50.000	11112.064	4.000	44448.257	10.000	0.985	43772.988
60.000	7893.290	1.000	7893.290	0.000	1.000	7893.290
Σ9						124349.083

Immersed Volume	489.892
Emerged Volume	547.406
Volume	504.236
Moment	3416.214
BR	6.775
BG=KG-KB	2.035
BGsinθ	1.762
GZ=BR-BGsinθ	5.013

Waterline-2 Combination Table

Angle of heel : 70˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	632.024	1.000	632.024	632.024	1.000	632.024
10.000	627.321	4.000	2509.285	656.024	4.000	2624.097
20.000	629.307	2.000	1258.613	674.416	2.000	1348.833
30.000	623.077	4.000	2492.308	711.489	4.000	2845.954

40.000	656.048	2.000	1312.095	818.110	2.000	1636.221
50.000	766.129	4.000	3064.516	875.739	4.000	3502.955
60.000	619.104	1.000	619.104	693.522	1.000	693.522
Σ7			11887.946	Σ8		13283.606
60.000	619.104	5.000	3095.521	693.522	5.000	3467.608
70.000	527.365	8.000	4218.921	592.311	8.000	4738.486
80.000	497.862	-1.000	-497.862	543.438	-1.000	-543.438
Σ7			6816.581	Σ8		7662.656

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	6361.369	1.000	6361.369	70.000	0.342	2175.716
10.000	6470.349	4.000	25881.397	60.000	0.500	12940.699
20.000	6751.995	2.000	13503.991	50.000	0.643	8680.198
30.000	7302.708	4.000	29210.832	40.000	0.766	22376.795
40.000	9164.645	2.000	18329.290	30.000	0.866	15873.631
50.000	11112.064	4.000	44448.257	20.000	0.940	41767.699
60.000	7893.290	1.000	7893.290	10.000	0.985	7773.373
Σ9						111588.112

60.000	7893.290	5.000	39466.452	10.000	0.985	38866.867
70.000	6185.263	8.000	49482.101	0.000	1.000	49482.101
80.000	5486.936	-1.000	-5486.936	-10.000	0.985	-5403.578
Σ9						82945.390

Immersed Volume	560.119
Emerged Volume	626.349
Volume	495.520
Moment	3635.320
BR	7.336
BG=KG-KB	2.035
BGsinθ	1.912
GZ=BR-BGsinθ	5.424

Waterline-2 Combination Table

Angle of heel : 80˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	632.024	1.000	632.024	632.024	1.000	632.024
10.000	627.321	4.000	2509.285	656.024	4.000	2624.097
20.000	629.307	2.000	1258.613	674.416	2.000	1348.833

30.000	623.077	4.000	2492.308	711.489	4.000	2845.954
40.000	656.048	2.000	1312.095	818.110	2.000	1636.221
50.000	766.129	4.000	3064.516	875.739	4.000	3502.955
60.000	619.104	2.000	1238.208	693.522	2.000	1387.043
70.000	527.365	4.000	2109.460	592.311	4.000	2369.243
80.000	497.862	1.000	497.862	543.438	1.000	543.438
Σ7			15114.373	Σ8		16889.809

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	6361.369	1.000	6361.369	80.000	0.174	1104.640
10.000	6470.349	4.000	25881.397	70.000	0.342	8851.959
20.000	6751.995	2.000	13503.991	60.000	0.500	6751.995
30.000	7302.708	4.000	29210.832	50.000	0.643	18776.361
40.000	9164.645	2.000	18329.290	40.000	0.766	14041.051
50.000	11112.064	4.000	44448.257	30.000	0.866	38493.320
60.000	7893.290	2.000	15786.581	20.000	0.940	14834.533
70.000	6185.263	4.000	24741.050	10.000	0.985	24365.178

80.000	5486.936	1.000	5486.936	0.000	1.000	5486.936
Σ9						132705.974

Immersed Volume	622.851
Emerged Volume	696.015
Volume	488.586
Moment	3645.801
BR	7.462
BG=KG-KB	2.035
BGsinθ	2.004
GZ=BR-BGsinθ	5.458

Waterline-2 Combination Table

Angle of heel : 90˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	632.024	1.000	632.024	632.024	1.000	632.024
10.000	627.321	3.000	1881.964	656.024	3.000	1968.073
20.000	629.307	3.000	1887.920	674.416	3.000	2023.249
30.000	623.077	2.000	1246.154	711.489	2.000	1422.977

40.000	656.048	3.000	1968.143	818.110	3.000	2454.331
50.000	766.129	3.000	2298.387	875.739	3.000	2627.217
60.000	619.104	2.000	1238.208	693.522	2.000	1387.043
70.000	527.365	3.000	1582.095	592.311	3.000	1776.932
80.000	497.862	3.000	1493.585	543.438	3.000	1630.314
90.000	508.208	1.000	508.208	613.168	1.000	613.168
Σ7			14736.689	Σ8		16535.328

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	6361.369	1.000	6361.369	90.000	0.000	0.000
10.000	6470.349	3.000	19411.048	80.000	0.174	3370.693
20.000	6751.995	3.000	20255.986	70.000	0.342	6927.955
30.000	7302.708	2.000	14605.416	60.000	0.500	7302.708
40.000	9164.645	3.000	27493.936	50.000	0.643	17672.761
50.000	11112.064	3.000	33336.193	40.000	0.766	25537.005
60.000	7893.290	2.000	15786.581	30.000	0.866	13671.580
70.000	6185.263	3.000	18555.788	20.000	0.940	17436.737
80.000	5486.936	3.000	16460.809	10.000	0.985	16210.733
90.000	5776.512	1.000	5776.512	0.000	1.000	5776.512
Σ9						113906.684

Immersed Volume	683.197
Emerged Volume	766.583
Volume	478.365
Moment	3520.499
BR	7.359
BG=KG-KB	2.035

BGsinθ	2.035
GZ=BR-BGsinθ	5.324

Waterline 3 Emerged and Immersed Wedge Calculations

WL 3 inclined at 0°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	4.01	0.50	2.00	16.04	0.50	8.02	64.24	0.50	32.12
0.50	4.76	2.00	9.53	22.69	2.00	45.37	108.05	2.00	216.11
1.00	5.14	1.00	5.14	26.39	1.00	26.39	135.56	1.00	135.56
1.50	5.28	2.00	10.55	27.84	2.00	55.67	146.86	2.00	293.73
2.00	5.33	1.50	7.99	28.39	1.50	42.58	151.25	1.50	226.87
3.00	5.33	4.00	21.33	28.43	4.00	113.72	151.59	4.00	606.36
4.00	5.33	2.00	10.66	28.43	2.00	56.86	151.59	2.00	303.18
5.00	5.33	4.00	21.33	28.43	4.00	113.72	151.59	4.00	606.36
6.00	5.35	2.00	10.70	28.63	2.00	57.27	153.22	2.00	306.43
7.00	5.33	4.00	21.33	28.43	4.00	113.72	151.59	4.00	606.36
8.00	5.07	1.50	7.60	25.66	1.50	38.50	130.02	1.50	195.02

8.50	4.64	2.00	9.27	21.48	2.00	42.97	99.57	2.00	199.15
9.00	3.34	1.00	3.34	11.13	1.00	11.13	37.13	1.00	37.13
9.50	2.23	2.00	4.46	4.96	2.00	9.93	11.06	2.00	22.12
10.00	0.23	0.50	0.11	0.05	0.50	0.03	0.01	0.50	0.01
		Σ2=	145.34		Σ4=	735.87		Σ6=	3786.50

WL 3 inclined at 0º									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	4.01	0.50	2.00	16.04	0.50	8.02	64.24	0.50	32.12
0.50	4.76	2.00	9.53	22.69	2.00	45.37	108.05	2.00	216.11
1.00	5.14	1.00	5.14	26.39	1.00	26.39	135.56	1.00	135.56
1.50	5.28	2.00	10.55	27.84	2.00	55.67	146.86	2.00	293.73
2.00	5.33	1.50	7.99	28.39	1.50	42.58	151.25	1.50	226.87
3.00	5.33	4.00	21.33	28.43	4.00	113.72	151.59	4.00	606.36
4.00	5.33	2.00	10.66	28.43	2.00	56.86	151.59	2.00	303.18
5.00	5.33	4.00	21.33	28.43	4.00	113.72	151.59	4.00	606.36
6.00	5.35	2.00	10.70	28.63	2.00	57.27	153.22	2.00	306.43
7.00	5.33	4.00	21.33	28.43	4.00	113.72	151.59	4.00	606.36
8.00	5.07	1.50	7.60	25.66	1.50	38.50	130.02	1.50	195.02
8.50	4.64	2.00	9.27	21.48	2.00	42.97	99.57	2.00	199.15
9.00	3.34	1.00	3.34	11.13	1.00	11.13	37.13	1.00	37.13
9.50	2.23	2.00	4.46	4.96	2.00	9.93	11.06	2.00	22.12
10.00	0.23	0.50	0.11	0.05	0.50	0.03	0.01	0.50	0.01
		Σ1=	145.34		Σ3=	735.87		Σ5=	3786.50

WL 3 inclined at 10º
Emerged

Station no.	Ordinate	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	4.98	0.50	2.49	24.81	0.50	12.41	123.58	0.50	61.79
0.50	5.31	2.00	10.62	28.20	2.00	56.39	149.72	2.00	299.44
1.00	5.39	1.00	5.39	29.10	1.00	29.10	156.94	1.00	156.94
1.50	5.42	2.00	10.83	29.33	2.00	58.67	158.87	2.00	317.74
2.00	5.43	1.50	8.14	29.45	1.50	44.18	159.84	1.50	239.76
3.00	5.43	4.00	21.71	29.46	4.00	117.85	159.93	4.00	639.70
4.00	5.43	2.00	10.86	29.46	2.00	58.93	159.93	2.00	319.85
5.00	5.43	4.00	21.71	29.46	4.00	117.85	159.93	4.00	639.70
6.00	5.38	2.00	10.76	28.93	2.00	57.87	155.63	2.00	311.27
7.00	5.34	4.00	21.38	28.56	4.00	114.23	152.62	4.00	610.46
8.00	4.89	1.50	7.34	23.95	1.50	35.93	117.22	1.50	175.83
8.50	4.30	2.00	8.60	18.49	2.00	36.98	79.51	2.00	159.01
9.00	3.25	1.00	3.25	10.57	1.00	10.57	34.36	1.00	34.36
9.50	2.22	2.00	4.44	4.93	2.00	9.87	10.96	2.00	21.91
10.00	0.23	0.50	0.11	0.05	0.50	0.03	0.01	0.50	0.01
		Σ2=	147.64		Σ4=	760.84		Σ6=	3987.77

WL 3 inclined at 10^o									
Immersed									
Station no.	Ordinate	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	1.43	0.50	0.71	2.03	0.50	1.02	2.89	0.50	1.45
0.50	3.84	2.00	7.67	14.72	2.00	29.45	56.49	2.00	112.98
1.00	4.86	1.00	4.86	23.63	1.00	23.63	114.86	1.00	114.86
1.50	5.21	2.00	10.42	27.12	2.00	54.25	141.26	2.00	282.52
2.00	5.33	1.50	8.00	28.44	1.50	42.66	151.68	1.50	227.51
3.00	5.34	4.00	21.38	28.56	4.00	114.23	152.62	4.00	610.46

4.00	5.34	2.00	10.69	28.56	2.00	57.12	152.62	2.00	305.23
5.00	5.34	4.00	21.38	28.56	4.00	114.23	152.62	4.00	610.46
6.00	5.44	2.00	10.87	29.54	2.00	59.08	160.55	2.00	321.09
7.00	5.42	4.00	21.69	29.40	4.00	117.59	159.40	4.00	637.59
8.00	5.32	1.50	7.98	28.33	1.50	42.50	150.82	1.50	226.24
8.50	5.13	2.00	10.26	26.31	2.00	52.61	134.93	2.00	269.85
9.00	3.50	1.00	3.50	12.26	1.00	12.26	42.95	1.00	42.95
9.50	2.42	2.00	4.85	5.87	2.00	11.74	14.23	2.00	28.45
10.00	0.24	0.50	0.12	0.06	0.50	0.03	0.01	0.50	0.01
		Σ1=	144.37		Σ3=	732.40		Σ5=	3791.65

WL 3 inclined at 20°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	5.68	0.50	2.84	32.30	0.50	16.15	183.54	0.50	91.77
0.50	5.68	2.00	11.37	32.30	2.00	64.59	183.54	2.00	367.08
1.00	5.68	1.00	5.68	32.30	1.00	32.30	183.54	1.00	183.54
1.50	5.68	2.00	11.37	32.30	2.00	64.59	183.54	2.00	367.08
2.00	5.68	1.50	8.52	32.30	1.50	48.44	183.54	1.50	275.31
3.00	5.68	4.00	22.73	32.30	4.00	129.19	183.54	4.00	734.16
4.00	5.68	2.00	11.37	32.30	2.00	64.59	183.54	2.00	367.08
5.00	5.68	4.00	22.73	32.30	4.00	129.19	183.54	4.00	734.16
6.00	5.42	2.00	10.83	29.33	2.00	58.67	158.87	2.00	317.74
7.00	5.41	4.00	21.65	29.29	4.00	117.16	158.52	4.00	634.06
8.00	4.74	1.50	7.11	22.49	1.50	33.73	106.63	1.50	159.95
8.50	4.07	2.00	8.14	16.56	2.00	33.13	67.42	2.00	134.84
9.00	3.20	1.00	3.20	10.25	1.00	10.25	32.83	1.00	32.83
9.50	2.22	2.00	4.45	4.95	2.00	9.89	11.00	2.00	22.00
10.00	0.23	0.50	0.11	0.05	0.50	0.03	0.01	0.50	0.01

		Σ2=	152.11		Σ4=	811.90		Σ6=	4421.61

WL 3 inclined at 20º									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.91	0.50	0.45	0.82	0.50	0.41	0.74	0.50	0.37
0.50	2.25	2.00	4.49	5.04	2.00	10.08	11.31	2.00	22.63
1.00	4.42	1.00	4.42	19.49	1.00	19.49	86.06	1.00	86.06
1.50	5.14	2.00	10.28	26.40	2.00	52.80	135.64	2.00	271.28
2.00	5.39	1.50	8.09	29.05	1.50	43.58	156.59	1.50	234.89
3.00	5.41	4.00	21.65	29.29	4.00	117.16	158.52	4.00	634.06
4.00	5.41	2.00	10.82	29.29	2.00	58.58	158.52	2.00	317.03
5.00	5.41	4.00	21.65	29.29	4.00	117.16	158.52	4.00	634.06
6.00	5.68	2.00	11.37	32.30	2.00	64.59	183.54	2.00	367.08
7.00	5.68	4.00	22.73	32.30	4.00	129.19	183.54	4.00	734.16
8.00	5.68	1.50	8.52	32.30	1.50	48.44	183.54	1.50	275.31
8.50	5.68	2.00	11.37	32.30	2.00	64.59	183.54	2.00	367.08
9.00	3.80	1.00	3.80	14.44	1.00	14.44	54.87	1.00	54.87
9.50	2.69	2.00	5.38	7.24	2.00	14.47	19.47	2.00	38.93
10.00	0.26	0.50	0.13	0.07	0.50	0.03	0.02	0.50	0.01
		Σ1=	145.14		Σ3=	755.02		Σ5=	4037.83

WL 3 inclined at 30º									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	6.17	0.50	3.08	38.02	0.50	19.01	234.43	0.50	117.21
0.50	6.17	2.00	12.33	38.02	2.00	76.04	234.43	2.00	468.86
1.00	6.17	1.00	6.17	38.02	1.00	38.02	234.43	1.00	234.43

1.50	6.17	2.00	12.33	38.02	2.00	76.04	234.43	2.00	468.86
2.00	6.17	1.50	9.25	38.02	1.50	57.03	234.43	1.50	351.64
3.00	6.17	4.00	24.66	38.02	4.00	152.08	234.43	4.00	937.71
4.00	6.17	2.00	12.33	38.02	2.00	76.04	234.43	2.00	468.86
5.00	6.17	4.00	24.66	38.02	4.00	152.08	234.43	4.00	937.71
6.00	5.45	2.00	10.91	29.75	2.00	59.49	162.24	2.00	324.47
7.00	5.42	4.00	21.68	29.39	4.00	117.55	159.31	4.00	637.23
8.00	4.55	1.50	6.83	20.71	1.50	31.07	94.26	1.50	141.39
8.50	3.91	2.00	7.82	15.30	2.00	30.59	59.82	2.00	119.64
9.00	3.21	1.00	3.21	10.32	1.00	10.32	33.17	1.00	33.17
9.50	2.29	2.00	4.57	5.22	2.00	10.44	11.93	2.00	23.86
10.00	0.24	0.50	0.12	0.06	0.50	0.03	0.01	0.50	0.01
		Σ2=	159.96		Σ4=	905.83		Σ6=	5265.06

WL 3 inclined at 30°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.67	0.50	0.34	0.45	0.50	0.22	0.30	0.50	0.15
0.50	1.68	2.00	3.36	2.82	2.00	5.64	4.74	2.00	9.48
1.00	3.47	1.00	3.47	12.03	1.00	12.03	41.75	1.00	41.75
1.50	4.89	2.00	9.78	23.91	2.00	47.82	116.93	2.00	233.86
2.00	5.37	1.50	8.06	28.88	1.50	43.32	155.20	1.50	232.80
3.00	5.42	4.00	21.68	29.39	4.00	117.55	159.31	4.00	637.23
4.00	5.42	2.00	10.84	29.39	2.00	58.77	159.31	2.00	318.62
5.00	5.42	4.00	21.68	29.39	4.00	117.55	159.31	4.00	637.23
6.00	6.17	2.00	12.33	38.02	2.00	76.04	234.43	2.00	468.86
7.00	6.17	4.00	24.66	38.02	4.00	152.08	234.43	4.00	937.71
8.00	6.17	1.50	9.25	38.02	1.50	57.03	234.43	1.50	351.64

8.50	6.17	2.00	12.33	38.02	2.00	76.04	234.43	2.00	468.86
9.00	4.36	1.00	4.36	19.01	1.00	19.01	82.88	1.00	82.88
9.50	3.22	2.00	6.44	10.36	2.00	20.71	33.32	2.00	66.65
10.00	0.30	0.50	0.15	0.09	0.50	0.05	0.03	0.50	0.01
		Σ1=	148.74		Σ3=	803.87		Σ5=	4487.74

WL 3 inclined at 40°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	6.94	0.50	3.47	48.14	0.50	24.07	333.97	0.50	166.98
0.50	6.94	2.00	13.88	48.14	2.00	96.27	333.97	2.00	667.93
1.00	6.94	1.00	6.94	48.14	1.00	48.14	333.97	1.00	333.97
1.50	6.94	2.00	13.88	48.14	2.00	96.27	333.97	2.00	667.93
2.00	6.94	1.50	10.41	48.14	1.50	72.20	333.97	1.50	500.95
3.00	6.94	4.00	27.75	48.14	4.00	192.54	333.97	4.00	1335.87
4.00	6.94	2.00	13.88	48.14	2.00	96.27	333.97	2.00	667.93
5.00	6.94	4.00	27.75	48.14	4.00	192.54	333.97	4.00	1335.87
6.00	5.11	2.00	10.21	26.07	2.00	52.14	133.12	2.00	266.24
7.00	5.07	4.00	20.29	25.73	4.00	102.90	130.48	4.00	521.91
8.00	4.31	1.50	6.47	18.58	1.50	27.86	80.06	1.50	120.09
8.50	3.79	2.00	7.59	14.39	2.00	28.79	54.61	2.00	109.22
9.00	3.21	1.00	3.21	10.33	1.00	10.33	33.20	1.00	33.20
9.50	2.40	2.00	4.80	5.75	2.00	11.50	13.79	2.00	27.58
10.00	0.26	0.50	0.13	0.07	0.50	0.03	0.02	0.50	0.01
		Σ2=	170.64		Σ4=	1051.87		Σ6=	6755.69

WL 3 inclined at 40°
Immersed

Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.54	0.50	0.27	0.30	0.50	0.15	0.16	0.50	0.08
0.50	1.37	2.00	2.74	1.88	2.00	3.75	2.57	2.00	5.14
1.00	2.80	1.00	2.80	7.82	1.00	7.82	21.88	1.00	21.88
1.50	4.20	2.00	8.40	17.66	2.00	35.31	74.19	2.00	148.39
2.00	4.99	1.50	7.49	24.90	1.50	37.35	124.25	1.50	186.38
3.00	5.11	4.00	20.42	26.07	4.00	104.28	133.12	4.00	532.48
4.00	5.11	2.00	10.21	26.07	2.00	52.14	133.12	2.00	266.24
5.00	5.11	4.00	20.42	26.07	4.00	104.28	133.12	4.00	532.48
6.00	6.94	2.00	13.88	48.14	2.00	96.27	333.97	2.00	667.93
7.00	6.94	4.00	27.75	48.14	4.00	192.54	333.97	4.00	1335.87
8.00	6.94	1.50	10.41	48.14	1.50	72.20	333.97	1.50	500.95
8.50	6.94	2.00	13.88	48.14	2.00	96.27	333.97	2.00	667.93
9.00	6.14	1.00	6.14	37.64	1.00	37.64	230.91	1.00	230.91
9.50	4.76	2.00	9.51	22.63	2.00	45.26	107.65	2.00	215.29
10.00	0.37	0.50	0.18	0.13	0.50	0.07	0.05	0.50	0.02
		$\Sigma 1^{=}$	154.50		$\Sigma 3=$	885.35		$\Sigma 5=$	5311.98

WL 3 inclined at 50°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	5.82	0.50	2.91	33.90	0.50	16.95	197.34	0.50	98.67
0.50	5.82	2.00	11.64	33.90	2.00	67.79	197.34	2.00	394.68
1.00	5.82	1.00	5.82	33.90	1.00	33.90	197.34	1.00	197.34
1.50	5.82	2.00	11.64	33.90	2.00	67.79	197.34	2.00	394.68
2.00	5.82	1.50	8.73	33.90	1.50	50.84	197.34	1.50	296.01
3.00	5.82	4.00	23.29	33.90	4.00	135.58	197.34	4.00	789.36

4.00	5.82	2.00	11.64	33.90	2.00	67.79	197.34	2.00	394.68
5.00	5.82	4.00	23.29	33.90	4.00	135.58	197.34	4.00	789.36
6.00	4.43	2.00	8.86	19.62	2.00	39.23	86.88	2.00	173.76
7.00	4.39	4.00	17.55	19.25	4.00	77.02	84.49	4.00	337.96
8.00	4.05	1.50	6.08	16.42	1.50	24.63	66.53	1.50	99.79
8.50	3.70	2.00	7.39	13.66	2.00	27.32	50.49	2.00	100.98
9.00	3.22	1.00	3.22	10.37	1.00	10.37	33.42	1.00	33.42
9.50	2.56	2.00	5.11	6.54	2.00	13.08	16.72	2.00	33.44
10.00	0.29	0.50	0.15	0.09	0.50	0.04	0.02	0.50	0.01
		Σ2=	147.34		Σ4=	767.92		Σ6=	4134.14

WL 3 inclined at 50º									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.47	0.50	0.23	0.22	0.50	0.11	0.10	0.50	0.05
0.50	1.18	2.00	2.36	1.39	2.00	2.79	1.65	2.00	3.29
1.00	2.45	1.00	2.45	5.98	1.00	5.98	14.62	1.00	14.62
1.50	3.60	2.00	7.20	12.95	2.00	25.89	46.58	2.00	93.16
2.00	4.27	1.50	6.40	18.21	1.50	27.31	77.69	1.50	116.54
3.00	4.43	4.00	17.72	19.62	4.00	78.46	86.88	4.00	347.52
4.00	4.43	2.00	8.86	19.62	2.00	39.23	86.88	2.00	173.76
5.00	4.43	4.00	17.72	19.62	4.00	78.46	86.88	4.00	347.52
6.00	5.82	2.00	11.64	33.90	2.00	67.79	197.34	2.00	394.68
7.00	5.82	4.00	23.29	33.90	4.00	135.58	197.34	4.00	789.36
8.00	5.82	1.50	8.73	33.90	1.50	50.84	197.34	1.50	296.01
8.50	5.82	2.00	11.64	33.90	2.00	67.79	197.34	2.00	394.68
9.00	5.82	1.00	5.82	33.90	1.00	33.90	197.34	1.00	197.34
9.50	5.82	2.00	11.64	33.90	2.00	67.79	197.34	2.00	394.68

10.00	0.49	0.50	0.24	0.24	0.50	0.12	0.12	0.50	0.06
		Σ1=	135.95		Σ3=	682.06		Σ5=	3563.27

WL 3 inclined at 60º									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	5.15	0.50	2.57	26.51	0.50	13.26	136.51	0.50	68.26
0.50	5.15	2.00	10.30	26.51	2.00	53.02	136.51	2.00	273.02
1.00	5.15	1.00	5.15	26.51	1.00	26.51	136.51	1.00	136.51
1.50	5.15	2.00	10.30	26.51	2.00	53.02	136.51	2.00	273.02
2.00	5.15	1.50	7.72	26.51	1.50	39.77	136.51	1.50	204.77
3.00	5.15	4.00	20.60	26.51	4.00	106.05	136.51	4.00	546.05
4.00	5.15	2.00	10.30	26.51	2.00	53.02	136.51	2.00	273.02
5.00	5.15	4.00	20.60	26.51	4.00	106.05	136.51	4.00	546.05
6.00	3.96	2.00	7.93	15.71	2.00	31.41	62.24	2.00	124.48
7.00	3.95	4.00	15.78	15.57	4.00	62.28	61.44	4.00	245.77
8.00	3.81	1.50	5.71	14.48	1.50	21.72	55.09	1.50	82.63
8.50	3.61	2.00	7.22	13.05	2.00	26.09	47.12	2.00	94.25
9.00	3.25	1.00	3.25	10.54	1.00	10.54	34.23	1.00	34.23
9.50	2.75	2.00	5.50	7.55	2.00	15.10	20.75	2.00	41.50
10.00	0.35	0.50	0.18	0.12	0.50	0.06	0.04	0.50	0.02
		Σ2=	133.09		Σ4=	617.92		Σ6=	2943.58

WL 3 inclined at 60º									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.42	0.50	0.21	0.18	0.50	0.09	0.08	0.50	0.04

0.50	1.07	2.00	2.13	1.13	2.00	2.27	1.21	2.00	2.42
1.00	2.23	1.00	2.23	4.96	1.00	4.96	11.04	1.00	11.04
1.50	3.27	2.00	6.54	10.71	2.00	21.41	35.03	2.00	70.06
2.00	3.83	1.50	5.75	14.69	1.50	22.04	56.31	1.50	84.47
3.00	3.96	4.00	15.85	15.71	4.00	62.82	62.24	4.00	248.96
4.00	3.96	2.00	7.93	15.71	2.00	31.41	62.24	2.00	124.48
5.00	3.96	4.00	15.85	15.71	4.00	62.82	62.24	4.00	248.96
6.00	5.15	2.00	10.30	26.51	2.00	53.02	136.51	2.00	273.02
7.00	5.15	4.00	20.60	26.51	4.00	106.05	136.51	4.00	546.05
8.00	5.15	1.50	7.72	26.51	1.50	39.77	136.51	1.50	204.77
8.50	5.15	2.00	10.30	26.51	2.00	53.02	136.51	2.00	273.02
9.00	5.15	1.00	5.15	26.51	1.00	26.51	136.51	1.00	136.51
9.50	5.15	2.00	10.30	26.51	2.00	53.02	136.51	2.00	273.02
10.00	0.82	0.50	0.41	0.67	0.50	0.33	0.54	0.50	0.27
		$\Sigma 1^{=}$	121.26		$\Sigma 3=$	539.56		$\Sigma 5=$	2497.10

WL 3 inclined at 70°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	4.75	0.50	2.37	22.52	0.50	11.26	106.90	0.50	53.45
0.50	4.75	2.00	9.49	22.52	2.00	45.05	106.90	2.00	213.80
1.00	4.75	1.00	4.75	22.52	1.00	22.52	106.90	1.00	106.90
1.50	4.75	2.00	9.49	22.52	2.00	45.05	106.90	2.00	213.80
2.00	4.75	1.50	7.12	22.52	1.50	33.79	106.90	1.50	160.35
3.00	4.75	4.00	18.98	22.52	4.00	90.10	106.90	4.00	427.61
4.00	4.75	2.00	9.49	22.52	2.00	45.05	106.90	2.00	213.80
5.00	4.75	4.00	18.98	22.52	4.00	90.10	106.90	4.00	427.61
6.00	3.70	2.00	7.40	13.69	2.00	27.38	50.65	2.00	101.31

7.00	3.71	4.00	14.83	13.74	4.00	54.97	50.94	4.00	203.76
8.00	3.62	1.50	5.43	13.11	1.50	19.67	47.48	1.50	71.22
8.50	3.55	2.00	7.09	12.57	2.00	25.15	44.59	2.00	89.18
9.00	3.30	1.00	3.30	10.86	1.00	10.86	35.81	1.00	35.81
9.50	2.95	2.00	5.90	8.71	2.00	17.43	25.72	2.00	51.45
10.00	0.45	0.50	0.23	0.21	0.50	0.10	0.09	0.50	0.05
		Σ2=	124.86		Σ4=	538.48		Σ6=	2370.09

WL 3 inclined at 70^{o}									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.40	0.50	0.20	0.16	0.50	0.08	0.06	0.50	0.03
0.50	1.00	2.00	1.99	0.99	2.00	1.98	0.99	2.00	1.98
1.00	2.09	1.00	2.09	4.38	1.00	4.38	9.16	1.00	9.16
1.50	3.08	2.00	6.16	9.49	2.00	18.97	29.22	2.00	58.44
2.00	3.60	1.50	5.40	12.95	1.50	19.42	46.58	1.50	69.87
3.00	3.71	4.00	14.83	13.74	4.00	54.97	50.94	4.00	203.76
4.00	3.71	2.00	7.41	13.74	2.00	27.48	50.94	2.00	101.88
5.00	3.71	4.00	14.83	13.74	4.00	54.97	50.94	4.00	203.76
6.00	4.75	2.00	9.49	22.52	2.00	45.05	106.90	2.00	213.80
7.00	4.75	4.00	18.98	22.52	4.00	90.10	106.90	4.00	427.61
8.00	4.75	1.50	7.12	22.52	1.50	33.79	106.90	1.50	160.35
8.50	4.75	2.00	9.49	22.52	2.00	45.05	106.90	2.00	213.80
9.00	4.75	1.00	4.75	22.52	1.00	22.52	106.90	1.00	106.90
9.50	4.75	2.00	9.49	22.52	2.00	45.05	106.90	2.00	213.80
10.00	4.75	0.50	2.37	22.52	0.50	11.26	106.90	0.50	53.45
		Σ1$^{=}$	114.61		Σ3=	475.07		Σ5=	2038.59

WL 3 inclined at 80°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	4.53	0.50	2.26	20.50	0.50	10.25	92.84	0.50	46.42
0.50	4.53	2.00	9.06	20.50	2.00	41.01	92.84	2.00	185.67
1.00	4.53	1.00	4.53	20.50	1.00	20.50	92.84	1.00	92.84
1.50	4.53	2.00	9.06	20.50	2.00	41.01	92.84	2.00	185.67
2.00	4.53	1.50	6.79	20.50	1.50	30.75	92.84	1.50	139.25
3.00	4.53	4.00	18.11	20.50	4.00	82.01	92.84	4.00	371.35
4.00	4.53	2.00	9.06	20.50	2.00	41.01	92.84	2.00	185.67
5.00	4.53	4.00	18.11	20.50	4.00	82.01	92.84	4.00	371.35
6.00	3.57	2.00	7.13	12.72	2.00	25.43	45.35	2.00	90.69
7.00	3.57	4.00	14.26	12.72	4.00	50.87	45.35	4.00	181.39
8.00	3.53	1.50	5.30	12.47	1.50	18.70	44.02	1.50	66.04
8.50	3.51	2.00	7.02	12.31	2.00	24.63	43.21	2.00	86.41
9.00	3.38	1.00	3.38	11.43	1.00	11.43	38.65	1.00	38.65
9.50	3.20	2.00	6.40	10.24	2.00	20.48	32.77	2.00	65.54
10.00	0.69	0.50	0.35	0.48	0.50	0.24	0.33	0.50	0.17
		Σ2=	120.81		Σ4=	500.33		Σ6=	2107.10

WL 3 inclined at 80°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	0.39	0.50	0.19	0.15	0.50	0.07	0.06	0.50	0.03
0.50	0.96	2.00	1.92	0.93	2.00	1.85	0.89	2.00	1.78
1.00	2.03	1.00	2.03	4.10	1.00	4.10	8.32	1.00	8.32
1.50	2.98	2.00	5.96	8.88	2.00	17.76	26.46	2.00	52.93
2.00	3.47	1.50	5.21	12.06	1.50	18.09	41.89	1.50	62.84

3.00	3.57	4.00	14.26	12.72	4.00	50.87	45.35	4.00	181.39
4.00	3.57	2.00	7.13	12.72	2.00	25.43	45.35	2.00	90.69
5.00	3.57	4.00	14.26	12.72	4.00	50.87	45.35	4.00	181.39
6.00	4.53	2.00	9.06	20.50	2.00	41.01	92.84	2.00	185.67
7.00	4.53	4.00	18.11	20.50	4.00	82.01	92.84	4.00	371.35
8.00	4.53	1.50	6.79	20.50	1.50	30.75	92.84	1.50	139.25
8.50	4.53	2.00	9.06	20.50	2.00	41.01	92.84	2.00	185.67
9.00	4.53	1.00	4.53	20.50	1.00	20.50	92.84	1.00	92.84
9.50	4.53	2.00	9.06	20.50	2.00	41.01	92.84	2.00	185.67
10.00	4.53	0.50	2.26	20.50	0.50	10.25	92.84	0.50	46.42
		Σ1=	109.84		Σ3=	435.58		Σ5=	1786.23

WL 3 inclined at 90°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	4.45	0.50	2.22	19.77	0.50	9.88	87.88	0.50	43.94
0.50	4.45	2.00	8.89	19.77	2.00	39.53	87.88	2.00	175.77
1.00	4.45	1.00	4.45	19.77	1.00	19.77	87.88	1.00	87.88
1.50	4.45	2.00	8.89	19.77	2.00	39.53	87.88	2.00	175.77
2.00	4.45	1.50	6.67	19.77	1.50	29.65	87.88	1.50	131.83
3.00	4.45	4.00	17.78	19.77	4.00	79.07	87.88	4.00	351.53
4.00	4.45	2.00	8.89	19.77	2.00	39.53	87.88	2.00	175.77
5.00	4.45	4.00	17.78	19.77	4.00	79.07	87.88	4.00	351.53
6.00	3.54	2.00	7.08	12.53	2.00	25.06	44.36	2.00	88.72
7.00	3.54	4.00	14.16	12.53	4.00	50.13	44.36	4.00	177.45
8.00	3.54	1.50	5.31	12.53	1.50	18.80	44.36	1.50	66.54
8.50	3.54	2.00	7.08	12.53	2.00	25.06	44.36	2.00	88.72
9.00	3.54	1.00	3.54	12.53	1.00	12.53	44.36	1.00	44.36

9.50	3.54	2.00	7.08	12.53	2.00	25.06	44.36	2.00	88.72
10.00	3.54	0.50	1.77	12.53	0.50	6.27	44.36	0.50	22.18
		Σ2=	121.60		Σ4=	498.95		Σ6=	2070.73

WL 3 inclined at 90°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	3.54	0.50	1.77	12.53	0.50	6.27	44.36	0.50	22.18
0.50	3.54	2.00	7.08	12.53	2.00	25.06	44.36	2.00	88.72
1.00	3.54	1.00	3.54	12.53	1.00	12.53	44.36	1.00	44.36
1.50	3.54	2.00	7.08	12.53	2.00	25.06	44.36	2.00	88.72
2.00	3.54	1.50	5.31	12.53	1.50	18.80	44.36	1.50	66.54
3.00	3.54	4.00	14.16	12.53	4.00	50.13	44.36	4.00	177.45
4.00	3.54	2.00	7.08	12.53	2.00	25.06	44.36	2.00	88.72
5.00	3.54	4.00	14.16	12.53	4.00	50.13	44.36	4.00	177.45
6.00	4.45	2.00	8.89	19.77	2.00	39.53	87.88	2.00	175.77
7.00	4.45	4.00	17.78	19.77	4.00	79.07	87.88	4.00	351.53
8.00	4.45	1.50	6.67	19.77	1.50	29.65	87.88	1.50	131.83
8.50	4.45	2.00	8.89	19.77	2.00	39.53	87.88	2.00	175.77
9.00	4.45	1.00	4.45	19.77	1.00	19.77	87.88	1.00	87.88
9.50	4.45	2.00	8.89	19.77	2.00	39.53	87.88	2.00	175.77
10.00	4.45	0.50	2.22	19.77	0.50	9.88	87.88	0.50	43.94
		Σ1=	117.98		Σ3=	470.01		Σ5=	1896.64

GZ Calculation

Waterline-3 Combination Table

Angle of heel : 10˚

	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	735.870	5.000	3679.352	735.870	5.000	3679.352
10.000	732.401	8.000	5859.212	760.837	8.000	6086.692
20.000	755.019	-1.000	-755.019	811.896	-1.000	-811.896
Σ7			8783.545	Σ8		8954.149

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	7573.010	5.000	37865.049	10.000	0.985	37289.794
10.000	7779.423	8.000	62235.385	0.000	1.000	62235.385
20.000	8459.447	-1.000	-8459.447	-10.000	0.985	-8330.929
Σ9						91194.250

Immersed Volume	90.491
Emerged Volume	92.248
Volume	952.419
Moment	626.340
BR	0.658

BG=KG-KB	0.705
BGsinθ	0.122
GZ=BR-BGsinθ	0.535

Waterline-3 Combination Table

Angle of heel : 20˚

	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	735.870	1.000	735.870	735.870	1.000	735.870
10.000	732.401	4.000	2929.606	760.837	4.000	3043.346
20.000	755.019	1.000	755.019	811.896	1.000	811.896
Σ7			4420.495	Σ8		4591.112

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	7573.010	1.000	7573.010	20.	0.940	7116.301

				000		
10.000	7779.423	4.000	31117.692	10.000	0.985	30644.945
20.000	8459.447	1.000	8459.447	0.000	1.000	8459.447
Σ9						46220.693

Immersed Volume	182.165
Emerged Volume	189.196
Volume	947.146
Moment	1269.811
BR	1.341
BG=KG-KB	0.705
BGsinθ	0.241
GZ=BR-BGsinθ	1.100

Waterline-3 Combination Table

Angle of heel : 30˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	735.870	1.000	735.870	735.870	1.000	735.870
10.000	732.401	3.000	2197.204	760.837	3.000	2282.510
20.000	755.019	3.000	2265.057	811.896	3.000	2435.687
30.000	803.871	1.000	803.871	905.827	1.000	905.827
Σ7			6002.004	Σ8		6359.894

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	7573.010	1.000	7573.010	30.000	0.866	6558.419
10.000	7779.423	3.000	23338.269	20.000	0.940	21930.799
20.000	8459.447	3.000	25378.341	10.000	0.985	24992.787
30.000	9752.797	1.000	9752.797	0.000	1.000	9752.797
Σ9						63234.802

Immersed Volume	278.255
Emerged Volume	294.847
Volume	937.585
Moment	1954.390

BR	2.084
BG=KG-KB	0.705
BGsinθ	0.353
GZ=BR-BGsinθ	1.732

Waterline-3 Combination Table

Angle of heel : 40˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	735.870	1.000	735.870	735.870	1.000	735.870
10.000	732.401	4.000	2929.606	760.837	4.000	3043.346
20.000	755.019	2.000	1510.038	811.896	2.000	1623.791
30.000	803.871	4.000	3215.485	905.827	4.000	3623.308
40.000	885.355	1.000	885.355	1051.869	1.000	1051.869
Σ7			9276.355	Σ8		10078.185

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	7573.010	1.000	7573.010	40.000	0.766	5801.262
10.000	7779.423	4.000	31117.692	30.000	0.866	26948.712
20.000	8459.447	2.000	16918.894	20.000	0.940	15898.560
30.000	9752.797	4.000	39011.186	10.000	0.985	38418.519
40.000	12067.665	1.000	12067.665	0.000	1.000	12067.665
Σ9						99134.718

Immersed Volume	382.271
Emerged Volume	415.314
Volume	921.134
Moment	2723.506
BR	2.957
BG=KG-KB	0.705
BGsinθ	0.453
GZ=BR-BGsinθ	2.504

Waterline 3 Combination Table

Angle of heel : 50˚

HEEL ANGLE (α)		Σ3	SM	PRD.	Σ4	SM	PRD.
0.000		735.870	1.000	735.870	735.870	1.000	735.870
10.000		732.401	3.000	2197.204	760.837	3.000	2282.510
20.000		755.019	3.000	2265.057	811.896	3.000	2435.687
30.000		803.871	1.000	803.871	905.827	1.000	905.827
30.000		803.871	1.000	803.871	905.827	1.000	905.827
40.000		885.355	4.000	3541.418	1051.869	4.000	4207.478
50.000		682.055	1.000	682.055	767.920	1.000	767.920
Σ7				11029.348	Σ8		12241.118
HEEL ANGLE (α)		Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000		7573.010	1.000	7573.010	50.000	0.643	4867.837
10.000		7779.423	3.000	23338.269	40.000	0.766	17878.151
20.000		8459.447	3.000	25378.341	30.000	0.866	21978.288
30.000		9752.797	1.000	9752.797	20.000	0.940	9164.631
30.000		9752.797	1.000	9752.797	20.000	0.940	9164.631
40.000		12067.66	4.000	48270.66	10.000	0.985	47537.32

		5		2			2
50.000		7697.409	1.000	7697.409	0.000	1.000	7697.409
Σ9							118288.269
Immersed Volume							485.427
Emerged Volume							537.207
Volume							902.397
Moment							3434.767
BR							3.806
BG=KG-KB							0.705
BGsinθ							0.540
GZ=BR-BGsinθ							3.266

Waterline-3 Combination Table

Angle of heel : 60˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	735.870	1.000	735.870	735.870	1.000	735.870
10.000	732.401	4.000	2929.606	760.837	4.000	3043.346
20.000	755.019	2.000	1510.038	811.896	2.000	1623.791
30.000	803.871	4.000	3215.485	905.827	4.000	3623.308
40.000	885.355	2.000	1770.709	1051.869	2.000	2103.739

50.000	682.055	4.000	2728.221	767.920	4.000	3071.679
60.000	539.557	1.000	539.557	617.919	1.000	617.919
Σ7			13429.487	Σ8		14819.653

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	7573.010	1.000	7573.010	60.000	0.500	3786.505
10.000	7779.423	4.000	31117.692	50.000	0.643	20002.067
20.000	8459.447	2.000	16918.894	40.000	0.766	12960.625
30.000	9752.797	4.000	39011.186	30.000	0.866	33784.678
40.000	12067.665	2.000	24135.331	20.000	0.940	22679.792
50.000	7697.409	4.000	30789.635	10.000	0.985	30321.871
60.000	5440.681	1.000	5440.681	0.000	1.000	5440.681
Σ9						128976.219

Immersed Volume	553.418
Emerged Volume	610.705
Volume	896.889
Moment	3543.335
BR	3.951
BG=KG-KB	0.705
BGsinθ	0.611
GZ=BR-BGsinθ	3.340

Waterline-3 Combination Table

Angle of heel : 70˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	735.870	1.000	735.870	735.870	1.000	735.870
10.000	732.401	4.000	2929.606	760.837	4.000	3043.346
20.000	755.019	2.000	1510.038	811.896	2.000	1623.791
30.000	803.871	4.000	3215.485	905.827	4.000	3623.308
40.000	885.355	2.000	1770.709	1051.869	2.000	2103.739
50.000	682.055	4.000	2728.221	767.920	4.000	3071.679
60.000	539.557	1.000	539.557	617.919	1.000	617.919
Σ7			13429.487	Σ8		14819.653
60.000	539.557	5.000	2697.784	617.919	5.000	3089.596
70.000	475.068	8.000	3800.542	538.475	8.000	4307.801
80.000	435.583	-1.000	-435.583	500.326	-1.000	-500.326
Σ7			6062.743	Σ8		6897.072

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	7573.010	1.000	7573.010	70.000	0.342	2590.122

10.000	7779.423	4.000	31117.692	60.000	0.500	15558.846
20.000	8459.447	2.000	16918.894	50.000	0.643	10875.255
30.000	9752.797	4.000	39011.186	40.000	0.766	29884.303
40.000	12067.665	2.000	24135.331	30.000	0.866	20901.810
50.000	7697.409	4.000	30789.635	20.000	0.940	28932.793
60.000	5440.681	1.000	5440.681	10.000	0.985	5358.024
Σ9						114101.153
60.000	5440.681	5.000	27203.403	10.000	0.985	26790.122
70.000	4408.682	8.000	35269.453	0.000	1.000	35269.453
80.000	3893.332	-1.000	-3893.332	-10.000	0.985	-3834.184
Σ9						58225.392

Immersed Volume	615.878
Emerged Volume	681.761
Volume	888.294
Moment	3534.579
BR	3.979
BG=KG-KB	0.705
BGsinθ	0.662
GZ=BR-BGsinθ	3.317

Waterline-3 Combination Table

Angle of heel : 80˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	735.870	1.000	735.870	735.870	1.000	735.870
10.000	732.401	4.000	2929.606	760.837	4.000	3043.346
20.000	755.019	2.000	1510.038	811.896	2.000	1623.791
30.000	803.871	4.000	3215.485	905.827	4.000	3623.308
40.000	885.355	2.000	1770.709	1051.869	2.000	2103.739
50.000	682.055	4.000	2728.221	767.920	4.000	3071.679
60.000	539.557	2.000	1079.114	617.919	2.000	1235.838
70.000	475.068	4.000	1900.271	538.475	4.000	2153.901
80.000	435.583	1.000	435.583	500.326	1.000	500.326
Σ7			16304.897	Σ8		18091.798

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	7573.010	1.000	7573.010	80.000	0.174	1315.039

10.000	7779.423	4.000	31117.692	70.000	0.342	10642.878
20.000	8459.447	2.000	16918.894	60.000	0.500	8459.447
30.000	9752.797	4.000	39011.186	50.000	0.643	25075.907
40.000	12067.665	2.000	24135.331	40.000	0.766	18488.736
50.000	7697.409	4.000	30789.635	30.000	0.866	26664.606
60.000	5440.681	2.000	10881.361	20.000	0.940	10225.135
70.000	4408.682	4.000	17634.727	10.000	0.985	17366.816
80.000	3893.332	1.000	3893.332	0.000	1.000	3893.332
Σ9						122131.896

Immersed Volume	671.911
Emerged Volume	745.548
Volume	880.540
Moment	3355.302
BR	3.811
BG=KG-KB	0.705
BGsinθ	0.694
GZ=BR-BGsinθ	3.116

Waterline-3 Combination Table

Angle of heel : 90˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	735.870	1.000	735.870	735.870	1.000	735.870
10.000	732.401	3.000	2197.204	760.837	3.000	2282.510
20.000	755.019	3.000	2265.057	811.896	3.000	2435.687
30.000	803.871	2.000	1607.743	905.827	2.000	1811.654
40.000	885.355	3.000	2656.064	1051.869	3.000	3155.608
50.000	682.055	3.000	2046.166	767.920	3.000	2303.759
60.000	539.557	2.000	1079.114	617.919	2.000	1235.838
70.000	475.068	3.000	1425.203	538.475	3.000	1615.425
80.000	435.583	3.000	1306.748	500.326	3.000	1500.977
90.000	470.007	1.000	470.007	498.948	1.000	498.948
Σ7			15789.177	Σ8		17576.277

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	7573.010	1.000	7573.010	90.000	0.000	0.000
10.000	7779.423	3.000	23338.269	80.000	0.174	4052.648

20.000	8459.447	3.000	25378.341	70.000	0.342	8679.904
30.000	9752.797	2.000	19505.593	60.000	0.500	9752.797
40.000	12067.665	3.000	36202.996	50.000	0.643	23270.838
50.000	7697.409	3.000	23092.226	40.000	0.766	17689.672
60.000	5440.681	2.000	10881.361	30.000	0.866	9423.535
70.000	4408.682	3.000	13226.045	20.000	0.940	12428.417
80.000	3893.332	3.000	11679.996	10.000	0.985	11502.551
90.000	3967.367	1.000	3967.367	0.000	1.000	3967.367
Σ9						100767.728

Immersed Volume	731.991
Emerged Volume	814.842
Volume	871.326
Moment	3114.415
BR	3.574
BG=KG-KB	0.705
BGsinθ	0.705
GZ=BR-BGsinθ	2.869

Emerged and Immersed Wedge Calculation:

WL 4 inclined at 0°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	5.08	0.50	2.54	25.85	0.50	12.92	131.41	0.50	65.70
0.50	5.29	2.00	10.59	28.03	2.00	56.05	148.37	2.00	296.74
1.00	5.33	1.00	5.33	28.43	1.00	28.43	151.59	1.00	151.59
1.50	5.34	2.00	10.67	28.48	2.00	56.97	152.02	2.00	304.03
2.00	5.34	1.50	8.01	28.52	1.50	42.77	152.27	1.50	228.41
3.00	5.34	4.00	21.37	28.55	4.00	114.19	152.53	4.00	610.12
4.00	5.34	2.00	10.69	28.55	2.00	57.10	152.53	2.00	305.06
5.00	5.34	4.00	21.37	28.55	4.00	114.19	152.53	4.00	610.12
6.00	5.34	2.00	10.69	28.55	2.00	57.10	152.53	2.00	305.06
7.00	5.34	4.00	21.37	28.55	4.00	114.19	152.53	4.00	610.12
8.00	5.28	1.50	7.92	27.91	1.50	41.87	147.45	1.50	221.17
8.50	5.18	2.00	10.36	26.81	2.00	53.62	138.83	2.00	277.66
9.00	3.55	1.00	3.55	12.60	1.00	12.60	44.70	1.00	44.70
9.50	2.61	2.00	5.23	6.83	2.00	13.67	17.86	2.00	35.72
10.00	0.58	0.50	0.29	0.34	0.50	0.17	0.20	0.50	0.10
		Σ2=	149.98		Σ4=	775.83		Σ6=	4066.32
WL 4 inclined at 0°									
Immersed									

Station no.	Ordinate	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	5.08	0.50	2.54	25.85	0.50	12.92	131.41	0.50	65.70
0.50	5.29	2.00	10.59	28.03	2.00	56.05	148.37	2.00	296.74
1.00	5.33	1.00	5.33	28.43	1.00	28.43	151.59	1.00	151.59
1.50	5.34	2.00	10.67	28.48	2.00	56.97	152.02	2.00	304.03
2.00	5.34	1.50	8.01	28.52	1.50	42.77	152.27	1.50	228.41
3.00	5.34	4.00	21.37	28.55	4.00	114.19	152.53	4.00	610.12
4.00	5.34	2.00	10.69	28.55	2.00	57.10	152.53	2.00	305.06
5.00	5.34	4.00	21.37	28.55	4.00	114.19	152.53	4.00	610.12
6.00	5.34	2.00	10.69	28.55	2.00	57.10	152.53	2.00	305.06
7.00	5.34	4.00	21.37	28.55	4.00	114.19	152.53	4.00	610.12
8.00	5.28	1.50	7.92	27.91	1.50	41.87	147.45	1.50	221.17
8.50	5.18	2.00	10.36	26.81	2.00	53.62	138.83	2.00	277.66
9.00	3.55	1.00	3.55	12.60	1.00	12.60	44.70	1.00	44.70
9.50	2.61	2.00	5.23	6.83	2.00	13.67	17.86	2.00	35.72
10.00	0.58	0.50	0.29	0.34	0.50	0.17	0.20	0.50	0.10
		Σ1=	149.98		Σ3=	775.83		Σ5=	4066.32

WL 4 inclined at 10°									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	5.42	0.50	2.71	29.38	0.50	14.69	159.22	0.50	79.61
0.50	5.42	2.00	10.84	29.38	2.00	58.75	159.22	2.00	318.44
1.00	5.42	1.00	5.42	29.38	1.00	29.38	159.22	1.00	159.22
1.50	5.42	2.00	10.84	29.38	2.00	58.75	159.22	2.00	318.44
2.00	5.42	1.50	8.13	29.38	1.50	44.06	159.22	1.50	238.83
3.00	5.42	4.00	21.68	29.38	4.00	117.51	159.22	4.00	636.88
4.00	5.42	2.00	10.84	29.38	2.00	58.75	159.22	2.00	318.44

5.00	5.42	4.00	21.68	29.38	4.00	117.51	159.22	4.00	636.88
6.00	5.44	2.00	10.88	29.59	2.00	59.19	160.99	2.00	321.98
7.00	5.42	4.00	21.68	29.38	4.00	117.51	159.22	4.00	636.88
8.00	5.20	1.50	7.80	27.04	1.50	40.56	140.61	1.50	210.91
8.50	4.87	2.00	9.74	23.72	2.00	47.43	115.50	2.00	231.00
9.00	3.50	1.00	3.50	12.25	1.00	12.25	42.88	1.00	42.88
9.50	2.51	2.00	5.02	6.30	2.00	12.60	15.81	2.00	31.63
10.00	0.55	0.50	0.27	0.30	0.50	0.15	0.17	0.50	0.08
		Σ2=	151.03		Σ4=	789.09		Σ6=	4182.10

WL 4 inclined at 10^o									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	4.62	0.50	2.31	21.30	0.50	10.65	98.29	0.50	49.15
0.50	5.04	2.00	10.08	25.42	2.00	50.84	128.18	2.00	256.35
1.00	5.28	1.00	5.28	27.91	1.00	27.91	147.45	1.00	147.45
1.50	5.38	2.00	10.76	28.94	2.00	57.89	155.72	2.00	311.44
2.00	5.42	1.50	8.13	29.37	1.50	44.05	159.13	1.50	238.70
3.00	5.42	4.00	21.68	29.39	4.00	117.55	159.31	4.00	637.23
4.00	5.42	2.00	10.84	29.39	2.00	58.77	159.31	2.00	318.62
5.00	5.42	4.00	21.68	29.39	4.00	117.55	159.31	4.00	637.23
6.00	5.42	2.00	10.84	29.39	2.00	58.77	159.31	2.00	318.62
7.00	5.42	4.00	21.69	29.40	4.00	117.59	159.40	4.00	637.59
8.00	5.42	1.50	8.13	29.40	1.50	44.10	159.40	1.50	239.09
8.50	5.42	2.00	10.84	29.40	2.00	58.80	159.40	2.00	318.79
9.00	3.74	1.00	3.74	13.99	1.00	13.99	52.31	1.00	52.31
9.50	2.86	2.00	5.72	8.19	2.00	16.37	23.42	2.00	46.84
10.00	0.64	0.50	0.32	0.41	0.50	0.20	0.26	0.50	0.13

		Σ1=	152.06		Σ3=	795.03		Σ5=	4209.54

WL 4 inclined at 20º									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	5.70	0.50	2.85	32.49	0.50	16.25	185.19	0.50	92.60
0.50	5.70	2.00	11.40	32.49	2.00	64.98	185.19	2.00	370.39
1.00	5.70	1.00	5.70	32.49	1.00	32.49	185.19	1.00	185.19
1.50	5.70	2.00	11.40	32.49	2.00	64.98	185.19	2.00	370.39
2.00	5.70	1.50	8.55	32.49	1.50	48.74	185.19	1.50	277.79
3.00	5.70	4.00	22.80	32.49	4.00	129.96	185.19	4.00	740.77
4.00	5.70	2.00	11.40	32.49	2.00	64.98	185.19	2.00	370.39
5.00	5.70	4.00	22.80	32.49	4.00	129.96	185.19	4.00	740.77
6.00	5.65	2.00	11.30	31.92	2.00	63.85	180.36	2.00	360.72
7.00	5.62	4.00	22.48	31.58	4.00	126.34	177.50	4.00	710.02
8.00	5.22	1.50	7.83	27.25	1.50	40.87	142.24	1.50	213.35
8.50	4.70	2.00	9.40	22.09	2.00	44.18	103.82	2.00	207.65
9.00	3.54	1.00	3.54	12.53	1.00	12.53	44.36	1.00	44.36
9.50	2.51	2.00	5.02	6.30	2.00	12.60	15.81	2.00	31.63
10.00	0.54	0.50	0.27	0.29	0.50	0.15	0.16	0.50	0.08
		Σ2=	156.74		Σ4=	852.84		Σ6=	4716.09

WL 4 inclined at 20º									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	3.74	0.50	1.87	13.98	0.50	6.99	52.27	0.50	26.14
0.50	4.63	2.00	9.27	21.47	2.00	42.95	99.51	2.00	199.02

1.00	5.23	1.00	5.23	27.33	1.00	27.33	142.89	1.00	142.89
1.50	5.51	2.00	11.01	30.31	2.00	60.61	166.83	2.00	333.66
2.00	5.61	1.50	8.42	31.51	1.50	47.26	176.84	1.50	265.26
3.00	5.62	4.00	22.49	31.62	4.00	126.47	177.79	4.00	711.15
4.00	5.62	2.00	11.25	31.62	2.00	63.24	177.79	2.00	355.58
5.00	5.62	4.00	22.49	31.62	4.00	126.47	177.79	4.00	711.15
6.00	5.68	2.00	11.37	32.30	2.00	64.59	183.54	2.00	367.08
7.00	5.68	4.00	22.73	32.30	4.00	129.19	183.54	4.00	734.16
8.00	5.68	1.50	8.52	32.30	1.50	48.44	183.54	1.50	275.31
8.50	5.68	2.00	11.37	32.30	2.00	64.59	183.54	2.00	367.08
9.00	4.17	1.00	4.17	17.41	1.00	17.41	72.62	1.00	72.62
9.50	3.37	2.00	6.74	11.36	2.00	22.73	38.31	2.00	76.61
10.00	0.74	0.50	0.37	0.55	0.50	0.27	0.40	0.50	0.20
		$\Sigma 1^{=}$	157.30		Σ3=	848.54		Σ5=	4637.93

WL 4 inclined at 30º									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	6.17	0.50	3.09	38.07	0.50	19.03	234.89	0.50	117.44
0.50	6.17	2.00	12.34	38.07	2.00	76.14	234.89	2.00	469.77
1.00	6.17	1.00	6.17	38.07	1.00	38.07	234.89	1.00	234.89
1.50	6.17	2.00	12.34	38.07	2.00	76.14	234.89	2.00	469.77
2.00	6.17	1.50	9.26	38.07	1.50	57.10	234.89	1.50	352.33
3.00	6.17	4.00	24.68	38.07	4.00	152.28	234.89	4.00	939.54
4.00	6.17	2.00	12.34	38.07	2.00	76.14	234.89	2.00	469.77
5.00	6.17	4.00	24.68	38.07	4.00	152.28	234.89	4.00	939.54
6.00	5.94	2.00	11.88	35.28	2.00	70.57	209.58	2.00	419.17
7.00	5.89	4.00	23.56	34.69	4.00	138.77	204.34	4.00	817.35

8.00	5.26	1.50	7.89	27.67	1.50	41.50	145.53	1.50	218.30
8.50	4.62	2.00	9.24	21.34	2.00	42.69	98.61	2.00	197.22
9.00	3.66	1.00	3.66	13.40	1.00	13.40	49.03	1.00	49.03
9.50	2.59	2.00	5.18	6.71	2.00	13.42	17.37	2.00	34.75
10.00	0.54	0.50	0.27	0.29	0.50	0.15	0.16	0.50	0.08
		Σ2=	166.57		Σ4=	967.66		Σ6=	5728.94
WL 4 inclined at 30º									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	2.64	0.50	1.32	6.97	0.50	3.48	18.40	0.50	9.20
0.50	3.80	2.00	7.61	14.47	2.00	28.94	55.05	2.00	110.09
1.00	5.06	1.00	5.06	25.55	1.00	25.55	129.17	1.00	129.17
1.50	5.64	2.00	11.28	31.82	2.00	63.64	179.50	2.00	359.00
2.00	5.88	1.50	8.82	34.54	1.50	51.81	202.99	1.50	304.48
3.00	5.90	4.00	23.60	34.80	4.00	139.19	205.27	4.00	821.10
4.00	5.90	2.00	11.80	34.80	2.00	69.60	205.27	2.00	410.55
5.00	5.90	4.00	23.60	34.80	4.00	139.19	205.27	4.00	821.10
6.00	6.17	2.00	12.33	38.02	2.00	76.04	234.43	2.00	468.86
7.00	6.17	4.00	24.66	38.02	4.00	152.08	234.43	4.00	937.71
8.00	6.17	1.50	9.25	38.02	1.50	57.03	234.43	1.50	351.64
8.50	6.17	2.00	12.33	38.02	2.00	76.04	234.43	2.00	468.86
9.00	5.35	1.00	5.35	28.65	1.00	28.65	153.39	1.00	153.39
9.50	4.53	2.00	9.06	20.53	2.00	41.06	93.02	2.00	186.04
10.00	0.93	0.50	0.46	0.86	0.50	0.43	0.80	0.50	0.40
		Σ1=	166.53		Σ3=	952.74		Σ5=	5531.59

WL 4 inclined at 40º

Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	5.11	0.50	2.56	26.11	0.50	13.06	133.43	0.50	66.72
0.50	5.11	2.00	10.22	26.11	2.00	52.22	133.43	2.00	266.87
1.00	5.11	1.00	5.11	26.11	1.00	26.11	133.43	1.00	133.43
1.50	5.11	2.00	10.22	26.11	2.00	52.22	133.43	2.00	266.87
2.00	5.11	1.50	7.67	26.11	1.50	39.17	133.43	1.50	200.15
3.00	5.11	4.00	20.44	26.11	4.00	104.45	133.43	4.00	533.73
4.00	5.11	2.00	10.22	26.11	2.00	52.22	133.43	2.00	266.87
5.00	5.11	4.00	20.44	26.11	4.00	104.45	133.43	4.00	533.73
6.00	6.12	2.00	12.24	37.45	2.00	74.91	229.22	2.00	458.44
7.00	6.09	4.00	24.36	37.09	4.00	148.35	225.87	4.00	903.47
8.00	5.24	1.50	7.86	27.46	1.50	41.19	143.88	1.50	215.82
8.50	4.60	2.00	9.20	21.16	2.00	42.32	97.34	2.00	194.67
9.00	3.83	1.00	3.83	14.67	1.00	14.67	56.18	1.00	56.18
9.50	2.76	2.00	5.52	7.62	2.00	15.24	21.02	2.00	42.05
10.00	0.56	0.50	0.28	0.31	0.50	0.16	0.17	0.50	0.09
		Σ2=	150.16		Σ4=	780.73		Σ6=	4139.07
WL 4 inclined at 40°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	2.17	0.50	1.08	4.70	0.50	2.35	10.19	0.50	5.10
0.50	3.00	2.00	6.01	9.02	2.00	18.05	27.11	2.00	54.22
1.00	4.49	1.00	4.49	20.19	1.00	20.19	90.70	1.00	90.70
1.50	5.59	2.00	11.18	31.25	2.00	62.50	174.68	2.00	349.35
2.00	6.05	1.50	9.08	36.63	1.50	54.94	221.66	1.50	332.50
3.00	6.10	4.00	24.40	37.21	4.00	148.84	226.98	4.00	907.92

4.00	6.10	2.00	12.20	37.21	2.00	74.42	226.98	2.00	453.96
5.00	6.10	4.00	24.40	37.21	4.00	148.84	226.98	4.00	907.92
6.00	5.10	2.00	10.20	26.03	2.00	52.06	132.81	2.00	265.61
7.00	5.10	4.00	20.41	26.03	4.00	104.12	132.81	4.00	531.23
8.00	5.10	1.50	7.65	26.03	1.50	39.05	132.81	1.50	199.21
8.50	5.10	2.00	10.20	26.03	2.00	52.06	132.81	2.00	265.61
9.00	5.10	1.00	5.10	26.03	1.00	26.03	132.81	1.00	132.81
9.50	5.10	2.00	10.20	26.03	2.00	52.06	132.81	2.00	265.61
10.00	1.43	0.50	0.72	2.06	0.50	1.03	2.95	0.50	1.47
		Σ1=	157.34		Σ3=	856.53		Σ5=	4763.24

WL 4 inclined at 50º									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	4.26	0.50	2.13	18.15	0.50	9.07	77.31	0.50	38.65
0.50	4.26	2.00	8.52	18.15	2.00	36.30	77.31	2.00	154.62
1.00	4.26	1.00	4.26	18.15	1.00	18.15	77.31	1.00	77.31
1.50	4.26	2.00	8.52	18.15	2.00	36.30	77.31	2.00	154.62
2.00	4.26	1.50	6.39	18.15	1.50	27.22	77.31	1.50	115.96
3.00	4.26	4.00	17.04	18.15	4.00	72.59	77.31	4.00	309.24
4.00	4.26	2.00	8.52	18.15	2.00	36.30	77.31	2.00	154.62
5.00	4.26	4.00	17.04	18.15	4.00	72.59	77.31	4.00	309.24
6.00	5.88	2.00	11.76	34.57	2.00	69.15	203.30	2.00	406.59
7.00	5.84	4.00	23.36	34.11	4.00	136.42	199.18	4.00	796.71
8.00	5.16	1.50	7.74	26.63	1.50	39.94	137.39	1.50	206.08
8.50	4.65	2.00	9.30	21.62	2.00	43.25	100.54	2.00	201.09
9.00	4.04	1.00	4.04	16.32	1.00	16.32	65.94	1.00	65.94
9.50	3.08	2.00	6.16	9.49	2.00	18.97	29.22	2.00	58.44

10.00	0.65	0.50	0.32	0.42	0.50	0.21	0.27	0.50	0.14
		Σ2=	135.10		Σ4=	632.77		Σ6=	3049.23

WL 4 inclined at 50º									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	1.89	0.50	0.95	3.58	0.50	1.79	6.78	0.50	3.39
0.50	2.60	2.00	5.21	6.78	2.00	13.56	17.66	2.00	35.31
1.00	3.84	1.00	3.84	14.76	1.00	14.76	56.71	1.00	56.71
1.50	5.06	2.00	10.13	25.64	2.00	51.29	129.86	2.00	259.72
2.00	5.76	1.50	8.63	33.12	1.50	49.68	190.61	1.50	285.91
3.00	5.87	4.00	23.48	34.46	4.00	137.83	202.26	4.00	809.05
4.00	5.87	2.00	11.74	34.46	2.00	68.91	202.26	2.00	404.52
5.00	5.87	4.00	23.48	34.46	4.00	137.83	202.26	4.00	809.05
6.00	4.28	2.00	8.56	18.32	2.00	36.64	78.40	2.00	156.81
7.00	4.28	4.00	17.12	18.32	4.00	73.27	78.40	4.00	313.61
8.00	4.28	1.50	6.42	18.32	1.50	27.48	78.40	1.50	117.60
8.50	4.28	2.00	8.56	18.32	2.00	36.64	78.40	2.00	156.81
9.00	4.28	1.00	4.28	18.32	1.00	18.32	78.40	1.00	78.40
9.50	4.28	2.00	8.56	18.32	2.00	36.64	78.40	2.00	156.81
10.00	4.28	0.50	2.14	18.32	0.50	9.16	78.40	0.50	39.20
		Σ1=	143.10		Σ3=	713.79		Σ5=	3682.91

WL 4 inclined at 60º									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	3.78	0.50	1.89	14.29	0.50	7.14	54.01	0.50	27.01
0.50	3.78	2.00	7.56	14.29	2.00	28.58	54.01	2.00	108.02

1.00	3.78	1.00	3.78	14.29	1.00	14.29	54.01	1.00	54.01
1.50	3.78	2.00	7.56	14.29	2.00	28.58	54.01	2.00	108.02
2.00	3.78	1.50	5.67	14.29	1.50	21.43	54.01	1.50	81.02
3.00	3.78	4.00	15.12	14.29	4.00	57.15	54.01	4.00	216.04
4.00	3.78	2.00	7.56	14.29	2.00	28.58	54.01	2.00	108.02
5.00	3.78	4.00	15.12	14.29	4.00	57.15	54.01	4.00	216.04
6.00	5.29	2.00	10.58	27.98	2.00	55.97	148.04	2.00	296.07
7.00	5.25	4.00	21.00	27.56	4.00	110.25	144.70	4.00	578.81
8.00	4.99	1.50	7.49	24.90	1.50	37.35	124.25	1.50	186.38
8.50	4.66	2.00	9.32	21.72	2.00	43.43	101.19	2.00	202.39
9.00	4.19	1.00	4.19	17.56	1.00	17.56	73.56	1.00	73.56
9.50	3.45	2.00	6.90	11.90	2.00	23.81	41.06	2.00	82.13
10.00	0.72	0.50	0.36	0.52	0.50	0.26	0.38	0.50	0.19
		Σ2=	124.10		Σ4=	531.53		Σ6=	2337.70

WL 4 inclined at 60º									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	1.18	0.50	0.59	1.39	0.50	0.70	1.64	0.50	0.82
0.50	2.37	2.00	4.73	5.59	2.00	11.19	13.23	2.00	26.46
1.00	3.50	1.00	3.50	12.24	1.00	12.24	42.80	1.00	42.80
1.50	4.55	2.00	9.10	20.70	2.00	41.41	94.20	2.00	188.39
2.00	5.14	1.50	7.71	26.45	1.50	39.68	136.03	1.50	204.05
3.00	5.29	4.00	21.15	27.95	4.00	111.81	147.78	4.00	591.14
4.00	5.29	2.00	10.57	27.95	2.00	55.90	147.78	2.00	295.57
5.00	5.29	4.00	21.15	27.95	4.00	111.81	147.78	4.00	591.14
6.00	3.79	2.00	7.57	14.34	2.00	28.68	54.31	2.00	108.62
7.00	3.79	4.00	15.15	14.34	4.00	57.37	54.31	4.00	217.24

8.00	3.79	1.50	5.68	14.34	1.50	21.51	54.31	1.50	81.47
8.50	3.79	2.00	7.57	14.34	2.00	28.68	54.31	2.00	108.62
9.00	3.79	1.00	3.79	14.34	1.00	14.34	54.31	1.00	54.31
9.50	3.79	2.00	7.57	14.34	2.00	28.68	54.31	2.00	108.62
10.00	3.79	0.50	1.89	14.34	0.50	7.17	54.31	0.50	27.16
		Σ1=	127.73		Σ3=	571.16		Σ5=	2646.40

WL 4 inclined at 70º									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	3.49	0.50	1.75	12.18	0.50	6.09	42.51	0.50	21.25
0.50	3.49	2.00	6.98	12.18	2.00	24.36	42.51	2.00	85.02
1.00	3.49	1.00	3.49	12.18	1.00	12.18	42.51	1.00	42.51
1.50	3.49	2.00	6.98	12.18	2.00	24.36	42.51	2.00	85.02
2.00	3.49	1.50	5.24	12.18	1.50	18.27	42.51	1.50	63.76
3.00	3.49	4.00	13.96	12.18	4.00	48.72	42.51	4.00	170.03
4.00	3.49	2.00	6.98	12.18	2.00	24.36	42.51	2.00	85.02
5.00	3.49	4.00	13.96	12.18	4.00	48.72	42.51	4.00	170.03
6.00	4.93	2.00	9.86	24.30	2.00	48.61	119.82	2.00	239.65
7.00	4.92	4.00	19.68	24.21	4.00	96.83	119.10	4.00	476.38
8.00	4.81	1.50	7.22	23.14	1.50	34.70	111.28	1.50	166.93
8.50	4.67	2.00	9.34	21.81	2.00	43.62	101.85	2.00	203.70
9.00	4.34	1.00	4.34	18.84	1.00	18.84	81.75	1.00	81.75
9.50	3.86	2.00	7.72	14.90	2.00	29.80	57.51	2.00	115.02
10.00	0.89	0.50	0.45	0.80	0.50	0.40	0.71	0.50	0.36
		Σ2=	117.93		Σ4=	479.85		Σ6=	2006.42
WL 4 inclined at 70º									

Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	1.62	0.50	0.81	2.61	0.50	1.30	4.21	0.50	2.11
0.50	2.22	2.00	4.44	4.92	2.00	9.85	10.93	2.00	21.85
1.00	3.31	1.00	3.31	10.93	1.00	10.93	36.13	1.00	36.13
1.50	4.29	2.00	8.58	18.42	2.00	36.84	79.06	2.00	158.13
2.00	4.82	1.50	7.22	23.18	1.50	34.78	111.63	1.50	167.45
3.00	4.93	4.00	19.72	24.30	4.00	97.22	119.82	4.00	479.29
4.00	4.93	2.00	9.86	24.30	2.00	48.61	119.82	2.00	239.65
5.00	4.93	4.00	19.72	24.30	4.00	97.22	119.82	4.00	479.29
6.00	3.49	2.00	6.98	12.18	2.00	24.36	42.51	2.00	85.02
7.00	3.49	4.00	13.96	12.18	4.00	48.72	42.51	4.00	170.03
8.00	3.49	1.50	5.24	12.18	1.50	18.27	42.51	1.50	63.76
8.50	3.49	2.00	6.98	12.18	2.00	24.36	42.51	2.00	85.02
9.00	3.49	1.00	3.49	12.18	1.00	12.18	42.51	1.00	42.51
9.50	3.49	2.00	6.98	12.18	2.00	24.36	42.51	2.00	85.02
10.00	3.49	0.50	1.75	12.18	0.50	6.09	42.51	0.50	21.25
		$\Sigma 1^{=}$	119.03		Σ3=	495.09		Σ5=	2136.51

WL 4 inclined at 80^{o}									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	3.33	0.50	1.67	11.09	0.50	5.54	36.93	0.50	18.46
0.50	3.33	2.00	6.66	11.09	2.00	22.18	36.93	2.00	73.85
1.00	3.33	1.00	3.33	11.09	1.00	11.09	36.93	1.00	36.93
1.50	3.33	2.00	6.66	11.09	2.00	22.18	36.93	2.00	73.85
2.00	3.33	1.50	5.00	11.09	1.50	16.63	36.93	1.50	55.39
3.00	3.33	4.00	13.32	11.09	4.00	44.36	36.93	4.00	147.70

4.00	3.33	2.00	6.66	11.09	2.00	22.18	36.93	2.00	73.85
5.00	3.33	4.00	13.32	11.09	4.00	44.36	36.93	4.00	147.70
6.00	4.76	2.00	9.52	22.66	2.00	45.32	107.85	2.00	215.70
7.00	4.76	4.00	19.04	22.66	4.00	90.63	107.85	4.00	431.40
8.00	4.71	1.50	7.07	22.18	1.50	33.28	104.49	1.50	156.73
8.50	4.67	2.00	9.34	21.81	2.00	43.62	101.85	2.00	203.70
9.00	4.50	1.00	4.50	20.25	1.00	20.25	91.13	1.00	91.13
9.50	4.25	2.00	8.50	18.06	2.00	36.13	76.77	2.00	153.53
10.00	1.26	0.50	0.63	1.58	0.50	0.79	1.98	0.50	0.99
		Σ2=	115.20		Σ4=	458.51		Σ6=	1880.92
WL 4 inclined at 80°									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	1.57	0.50	0.78	2.45	0.50	1.23	3.84	0.50	1.92
0.50	2.15	2.00	4.29	4.61	2.00	9.21	9.88	2.00	19.77
1.00	3.21	1.00	3.21	10.29	1.00	10.29	33.01	1.00	33.01
1.50	4.16	2.00	8.33	17.34	2.00	34.68	72.20	2.00	144.40
2.00	4.66	1.50	6.99	21.72	1.50	32.57	101.19	1.50	151.79
3.00	4.76	4.00	19.02	22.62	4.00	90.48	107.58	4.00	430.31
4.00	4.76	2.00	9.51	22.62	2.00	45.24	107.58	2.00	215.16
5.00	4.76	4.00	19.02	22.62	4.00	90.48	107.58	4.00	430.31
6.00	3.33	2.00	6.66	11.09	2.00	22.18	36.93	2.00	73.85
7.00	3.33	4.00	13.32	11.09	4.00	44.36	36.93	4.00	147.70
8.00	3.33	1.50	5.00	11.09	1.50	16.63	36.93	1.50	55.39
8.50	3.33	2.00	6.66	11.09	2.00	22.18	36.93	2.00	73.85
9.00	3.33	1.00	3.33	11.09	1.00	11.09	36.93	1.00	36.93
9.50	3.33	2.00	6.66	11.09	2.00	22.18	36.93	2.00	73.85

10.00	3.33	0.50	1.67	11.09	0.50	5.54	36.93	0.50	18.46
		Σ1=	114.45		Σ3=	458.33		Σ5=	1906.71

WL 4 inclined at 90º									
Emerged									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	3.28	0.50	1.64	10.76	0.50	5.38	35.29	0.50	17.64
0.50	3.28	2.00	6.56	10.76	2.00	21.52	35.29	2.00	70.58
1.00	3.28	1.00	3.28	10.76	1.00	10.76	35.29	1.00	35.29
1.50	3.28	2.00	6.56	10.76	2.00	21.52	35.29	2.00	70.58
2.00	3.28	1.50	4.92	10.76	1.50	16.14	35.29	1.50	52.93
3.00	3.28	4.00	13.12	10.76	4.00	43.03	35.29	4.00	141.15
4.00	3.28	2.00	6.56	10.76	2.00	21.52	35.29	2.00	70.58
5.00	3.28	4.00	13.12	10.76	4.00	43.03	35.29	4.00	141.15
6.00	4.72	2.00	9.44	22.28	2.00	44.56	105.15	2.00	210.31
7.00	4.72	4.00	18.88	22.28	4.00	89.11	105.15	4.00	420.62
8.00	4.72	1.50	7.08	22.28	1.50	33.42	105.15	1.50	157.73
8.50	4.72	2.00	9.44	22.28	2.00	44.56	105.15	2.00	210.31
9.00	4.72	1.00	4.72	22.28	1.00	22.28	105.15	1.00	105.15
9.50	4.72	2.00	9.44	22.28	2.00	44.56	105.15	2.00	210.31
10.00	4.72	0.50	2.36	22.28	0.50	11.14	105.15	0.50	52.58
		Σ2=	117.12		Σ4=	472.51		Σ6=	1966.89

WL 4 inclined at 90º									
Immersed									
Station no.	**Ordinate**	SM	F. of ordinate	Sq. of ordinate	SM	F. of square	Cube of ordinate	SM	F. of cubes
0.00	1.57	0.50	0.78	2.45	0.50	1.22	3.83	0.50	1.92
0.50	2.14	2.00	4.28	4.58	2.00	9.15	9.79	2.00	19.57

1.00	3.20	1.00	3.20	10.25	1.00	10.25	32.80	1.00	32.80
1.50	4.15	2.00	8.29	17.19	2.00	34.38	71.27	2.00	142.53
2.00	4.63	1.50	6.94	21.42	1.50	32.13	99.12	1.50	148.69
3.00	4.72	4.00	18.88	22.28	4.00	89.11	105.15	4.00	420.62
4.00	4.72	2.00	9.44	22.28	2.00	44.56	105.15	2.00	210.31
5.00	4.72	4.00	18.88	22.28	4.00	89.11	105.15	4.00	420.62
6.00	3.28	2.00	6.56	10.76	2.00	21.52	35.29	2.00	70.58
7.00	3.28	4.00	13.12	10.76	4.00	43.03	35.29	4.00	141.15
8.00	3.28	1.50	4.92	10.76	1.50	16.14	35.29	1.50	52.93
8.50	3.28	2.00	6.56	10.76	2.00	21.52	35.29	2.00	70.58
9.00	3.28	1.00	3.28	10.76	1.00	10.76	35.29	1.00	35.29
9.50	3.28	2.00	6.56	10.76	2.00	21.52	35.29	2.00	70.58
10.00	3.28	0.50	1.64	10.76	0.50	5.38	35.29	0.50	17.64
		$\Sigma 1^{=}$	113.34		Σ3=	449.77		Σ5=	1855.79

GZ Calculation :

Waterline-4 Combination Table
Angle of heel : 10˚

	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	775.828	5.000	3879.138	775.828	5.000	3879.138
10.000	795.034	8.000	6360.271	789.086	8.000	6312.690
20.000	848.542	-1.000	-848.542	852.842	-1.000	-852.842
Σ7			9390.867	Σ8		9338.986

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	8132.638	5.000	40663.189	10.000	0.985	40045.424
10.000	8391.638	8.000	67133.104	0.000	1.000	67133.104
20.000	9354.017	-1.000	-9354.017	-10.000	0.985	-9211.909
Σ9						97966.619

Immersed Volume	96.747
Emerged Volume	96.213
Volume	1415.169
Moment	672.854
BR	0.475
BG=KG-KB	0.801
BGsinθ	0.139
GZ=BR-BGsinθ	0.336

Waterline-4 Combination Table

Angle of heel : 20˚

	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	775.828	1.000	775.828	775.828	1.000	775.828
10.000	795.034	4.000	3180.135	789.086	4.000	3156.345
20.000	848.542	1.000	848.542	852.842	1.000	852.842
Σ7			4804.505	Σ8		4785.015

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	8132.638	1.000	8132.638	20.000	0.940	7642.180
10.000	8391.638	4.000	33566.552	10.000	0.985	33056.600
20.000	9354.017	1.000	9354.017	0.000	1.000	9354.017
Σ9						50052.797

Immersed Volume	197.990
Emerged Volume	197.186
Volume	1415.437
Moment	1375.089
BR	0.971
BG=KG-KB	0.801
BGsinθ	0.274
GZ=BR-BGsinθ	0.698

Waterline-4 Combination Table						
Angle of heel : 30˚						
HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	775.828	1.000	775.828	775.828	1.000	775.828

10.000	795.034	3.000	2385.102	789.086	3.000	2367.259
20.000	848.542	3.000	2545.627	852.842	3.000	2558.527
30.000	952.743	1.000	952.743	967.656	1.000	967.656
Σ7			6659.299	Σ8		6669.269

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	8132.638	1.000	8132.638	30.000	0.866	7043.071
10.000	8391.638	3.000	25174.914	20.000	0.940	23656.681
20.000	9354.017	3.000	28062.051	10.000	0.985	27635.726
30.000	11260.530	1.000	11260.530	0.000	1.000	11260.530
Σ9						69596.007

Immersed Volume	308.727
Emerged Volume	309.189
Volume	1414.172
Moment	2150.995
BR	1.521
BG=KG-KB	0.801
BGsinθ	0.401
GZ=BR-BGsinθ	1.121

Waterline-4 Combination Table

Angle of heel : 40˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	775.828	1.000	775.828	775.828	1.000	775.828
10.000	795.034	4.000	3180.135	789.086	4.000	3156.345
20.000	848.542	2.000	1697.085	852.842	2.000	1705.685
30.000	952.743	4.000	3810.971	967.656	4.000	3870.623
40.000	856.530	1.000	856.530	780.733	1.000	780.733
Σ7			10320.548	Σ8		10289.214

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	8132.638	1.000	8132.638	40.000	0.766	6229.962
10.000	8391.638	4.000	33566.552	30.000	0.866	29069.487
20.000	9354.017	2.000	18708.034	20.000	0.940	17579.802
30.000	11260.530	4.000	45042.119	10.000	0.985	44357.828
40.000	8902.309	1.000	8902.309	0.000	1.000	8902.309

Σ9	106139.387
Immersed Volume	425.301
Emerged Volume	424.010
Volume	1415.925
Moment	2915.944
BR	2.059
BG=KG-KB	0.801
BGsinθ	0.515
GZ=BR-BGsinθ	1.545

Waterline-4 Combination Table

Angle of heel : 50˚

HEEL ANGLE (α)		Σ3	SM	PRD.	Σ4	SM	PRD.
0.000		775.828	1.000	775.828	775.828	1.000	775.828

10.000		795.034	3.000	2385.102	789.086	3.000	2367.259
20.000		848.542	3.000	2545.627	852.842	3.000	2558.527
30.000		952.743	1.000	952.743	967.656	1.000	967.656
30.000		952.743	1.000	952.743	967.656	1.000	967.656
40.000		856.530	4.000	3426.119	780.733	4.000	3122.932
50.000		713.791	1.000	713.791	632.768	1.000	632.768
Σ7				11751.951	Σ8		11392.625
HEEL ANGLE (α)		Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000		8132.638	1.000	8132.638	50.000	0.643	5227.559
10.000		8391.638	3.000	25174.914	40.000	0.766	19285.103
20.000		9354.017	3.000	28062.051	30.000	0.866	24302.449
30.000		11260.530	1.000	11260.530	20.000	0.940	10581.437
30.000		11260.530	1.000	11260.530	20.000	0.940	10581.437
40.000		8902.309	4.000	35609.236	10.000	0.985	35068.251
50.000		6732.139	1.000	6732.139	0.000	1.000	6732.139
Σ9							111778.375
Immersed Volume							518.591
Emerged Volume							503.835
Volume							1429.390
Moment							3274.836
BR							2.291
BG=KG-KB							0.801
BGsinθ							0.614

GZ=BR-BGsinθ		1.677

Waterline-4 Combination Table						
Angle of heel : 60˚						
HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	775.828	1.000	775.828	775.828	1.000	775.828
10.000	795.034	4.000	3180.135	789.086	4.000	3156.345
20.000	848.542	2.000	1697.085	852.842	2.000	1705.685
30.000	952.743	4.000	3810.971	967.656	4.000	3870.623
40.000	856.530	2.000	1713.059	780.733	2.000	1561.466
50.000	713.791	4.000	2855.163	632.768	4.000	2531.070
60.000	571.160	1.000	571.160	531.526	1.000	531.526
Σ7			14603.400	Σ8		14132.542

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	8132.638	1.000	8132.638	60.000	0.500	4066.319
10.000	8391.638	4.000	33566.552	50.000	0.643	21576.164

20.000	9354.017	2.000	18708.034	40.000	0.766	14331.186
30.000	11260.530	4.000	45042.119	30.000	0.866	39007.619
40.000	8902.309	2.000	17804.618	20.000	0.940	16730.868
50.000	6732.139	4.000	26928.556	10.000	0.985	26519.450
60.000	4984.104	1.000	4984.104	0.000	1.000	4984.104
Σ9						127215.710

Immersed Volume	601.794
Emerged Volume	582.390
Volume	1434.038
Moment	3494.969
BR	2.437
BG=KG-KB	0.801
BGsinθ	0.694
GZ=BR-BGsinθ	1.743

Waterline-4 Combination Table

Angle of heel : 70˚

	Σ3	SM	PRD.	Σ4	SM	PRD.

HEEL ANGLE (α)						
0.000	775.828	1.000	775.828	775.828	1.000	775.828
10.000	795.034	4.000	3180.135	789.086	4.000	3156.345
20.000	848.542	2.000	1697.085	852.842	2.000	1705.685
30.000	952.743	4.000	3810.971	967.656	4.000	3870.623
40.000	856.530	2.000	1713.059	780.733	2.000	1561.466
50.000	713.791	4.000	2855.163	632.768	4.000	2531.070
60.000	571.160	1.000	571.160	531.526	1.000	531.526
Σ7			14603.400	Σ8		14132.542
60.000	571.160	5.000	2855.798	531.526	5.000	2657.628
70.000	495.091	8.000	3960.727	479.853	8.000	3838.821
80.000	458.330	-1.000	-458.330	458.515	-1.000	-458.515
Σ7			6358.195	Σ8		6037.934

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	15924.388	1.000	15924.388	70.000	0.342	5446.461
10.000	16484.374	4.000	65937.495	60.000	0.500	32968.748
20.000	11922.403	2.000	23844.806	50.000	0.643	15327.146
30.000	10016.665	4.000	40066.662	40.000	0.766	30692.844
40.000	5820.869	2.000	11641.739	30.000	0.866	10082.041
50.000	3595.030	4.000	14380.118	20.000	0.940	13512.891
60.000	2604.848	1.000	2604.848	10.000	0.985	2565.275
Σ9						110595.406
60.000	2604.848	5.000	13024.242	10.000	0.985	12826.374
70.000	2154.242	8.000	17233.932	0.000	1.000	17233.932

80.000	1912.997	-1.000	-1912.997	-10.000	0.985	-1883.935
Σ9						28176.372
Immersed Volume			667.298			
Emerged Volume			644.595			
Volume			1437.337			
Moment			3231.884			
BR			2.249			
BG=KG-KB			0.801			
BGsinθ			0.753			
GZ=BR-BGsinθ			1.496			

Waterline-4 Combination Table

Angle of heel : 80˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	775.828	1.000	775.828	775.828	1.000	775.828
10.000	795.034	4.000	3180.135	789.086	4.000	3156.345
20.000	848.542	2.000	1697.085	852.842	2.000	1705.685
30.000	952.743	4.000	3810.971	967.656	4.000	3870.623
40.000	856.530	2.000	1713.059	780.733	2.000	1561.466
50.000	713.791	4.000	2855.163	632.768	4.000	2531.070
60.000	571.160	2.000	1142.319	531.526	2.000	1063.051
70.000	495.091	4.000	1980.363	479.853	4.000	1919.410
80.000	458.330	1.000	458.330	458.515	1.000	458.515
Σ7			17613.254	Σ8		17041.993

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	15924.388	1.000	15924.388	80.000	0.174	2765.241
10.000	16484.374	4.000	65937.495	70.000	0.342	22551.952
20.000	11922.403	2.000	23844.806	60.000	0.500	11922.403
30.000	10016.665	4.000	40066.662	50.000	0.643	25754.354
40.000	5820.869	2.000	11641.739	40.000	0.766	8918.089
50.000	3595.030	4.000	14380.118	30.000	0.866	12453.548
60.000	2604.848	2.000	5209.697	20.000	0.940	4895.514
70.000	2154.242	4.000	8616.966	10.000	0.985	8486.055
80.000	1912.997	1.000	1912.997	0.000	1.000	1912.997
Σ9						99660.152

Immersed Volume	725.827
Emerged Volume	702.286
Volume	1438.175
Moment	2737.941
BR	1.904
BG=KG-KB	0.801
BGsinθ	0.789
GZ=BR-BGsinθ	1.115

Waterline-4 Combination Table

Angle of heel : 90˚

HEEL ANGLE (α)	Σ3	SM	PRD.	Σ4	SM	PRD.
0.000	775.828	1.000	775.828	775.828	1.000	775.828
10.000	795.034	3.000	2385.102	789.086	3.000	2367.259
20.000	848.542	3.000	2545.627	852.842	3.000	2558.527
30.000	952.743	2.000	1905.485	967.656	2.000	1935.312
40.000	856.530	3.000	2569.589	780.733	3.000	2342.199
50.000	713.791	3.000	2141.372	632.768	3.000	1898.303
60.000	571.160	2.000	1142.319	531.526	2.000	1063.051
70.000	495.091	3.000	1485.273	479.853	3.000	1439.558
80.000	458.330	3.000	1374.991	458.515	3.000	1375.544
90.000	449.771	1.000	449.771	472.512	1.000	472.512
Σ7			16775.357	Σ8		16228.091

HEEL ANGLE (α)	Σ5+Σ6	SM	PRD.	(φ-α)	Cos(φ-α)	PRD.
0.000	15924.388	1.000	15924.388	90.000	0.000	0.000
10.000	16484.374	3.000	49453.121	80.000	0.174	8587.444
20.000	11922.403	3.000	35767.208	70.000	0.342	12233.106
30.000	10016.665	2.000	20033.331	60.000	0.500	10016.665
40.000	5820.869	3.000	17462.608	50.000	0.643	11224.748
50.000	3595.030	3.000	10785.089	40.000	0.766	8261.857
60.000	2604.848	2.000	5209.697	30.000	0.866	4511.730

70.000	2154.242	3.000	6462.725	20.000	0.940	6072.975
80.000	1912.997	3.000	5738.992	10.000	0.985	5651.804
90.000	3822.678	1.000	3822.678	0.000	1.000	3822.678
Σ9						70383.008

Immersed Volume	777.711
Emerged Volume	752.339
Volume	1440.006
Moment	2175.319
BR	1.511
BG=KG-KB	0.801
BGsinθ	0.801
GZ=BR-BGsinθ	0.710