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## Technical report



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## M/S Estonia bow visor – calculation of weight and volume

### Summary

*The weight, CoG and volume of the bow visor of M/S Estonia has been calculated based on the original drawing from Meyer Shipyard. The weight was calculated to 64.0 tonnes with a LCG of 5.25 m from frame #156 and VCG of 6,99 m above DWL.*

*Calculated weight and centre of gravity differs from earlier information with abt. 10% regarding both CoG and weight. The weight was later determined, by weighing of the salvaged visor, to be 65,5 tons, abt. 2% difference from the calculated result.*

*Based on the CoG of the visor and the volume of possible air pockets, it is not possible to dismiss that the visor under certain circumstances could float. It cannot be determined whether an air pocket would occur or not and it is not possible to with accuracy say for how long time an air pocket would delay the sinking of the visor.*

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## Revision history

Revision	Description	Date	Sign
0	First issue	2021-06-14	DZ
1	Updated report after weighing of visor	2021-12-15	DZ

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## 1 Introduction

The ro-pax ferry M/S Estonia sank on route from Tallin to Stockholm on 28 September 1994. In 2020 a previously unknown hole in the side of the hull was discovered. One theory is that the hole occurred in a collision between the hull and the detached bow visor. A prerequisite for this would be the visor floating for a time sufficient to collide with the hull.

As a first approach to estimate the buoyancy of the bow visor the weight, centre of gravity and volume of the bow visor has been calculated based on the original drawing from Meyer Shipyard (590-1103 Bugklappe, Ausf. G).

The scope of this analysis is limited to the buoyancy of the bow visor in still water. It does not cover the dynamic effects of waves and movements of the vessel and visor after detachment, nor the possibility of the visor creating the hole in the hull.

## 2 Calculation of weight and centre of gravity

Weight and centre of gravity was calculated by adding up the weights of all structural members of the visor based on the dimensions in the drawing. The weight of one hydraulic cylinder was added at a position based on photos of the salvaged visor. The second hydraulic cylinder was removed after the salvage but was attached to the visor at the time of the accident.

A summary of the weight and centre of gravity is presented in Table 1 below. The complete detailed weight list is presented in Appendix 1.

**Table 1. Summary of weight calculation**

Mass		Centre of gravity					
Section/Part	Weight (ton)	VCG ab. DWL		LCG from #156		TCG PS from CL	
		Lever (m)	Moment (tonm)	Lever (m)	Moment (tonm)	Lever (m)	Moment (tonm)
Frames	11,5	6,47	74,73	4,80	55,36	0,00	0,00
Web & Stringers	13,7	7,13	97,64	5,29	72,40	0,00	0,00
CL stringer	1,3	4,43	5,64	5,53	7,04	0,00	0,00
Plating	26,6	6,84	181,77	6,11	162,41	0,00	0,00
Hinge structure	10,4	8,09	84,56	3,63	37,89	0,00	0,00
Hydraulic cylinder	0,5	7,29	3,53	2,07	1,00	3,40	1,64
<b>Total</b>	<b>64,0</b>	<b>6,99</b>	<b>447,86</b>	<b>5,25</b>	<b>336,12</b>	<b>0,03</b>	<b>1,64</b>

In the JAIC report the bow visor weight is mentioned to be 56 tonnes, however it is not mentioned what this number is based on.

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In Meyer dwg. 590-1103 the centre of gravity of the visor is specified as LCG 4,9 m from frame #156 and VCG as 6,35 m above the design water line (DWL).

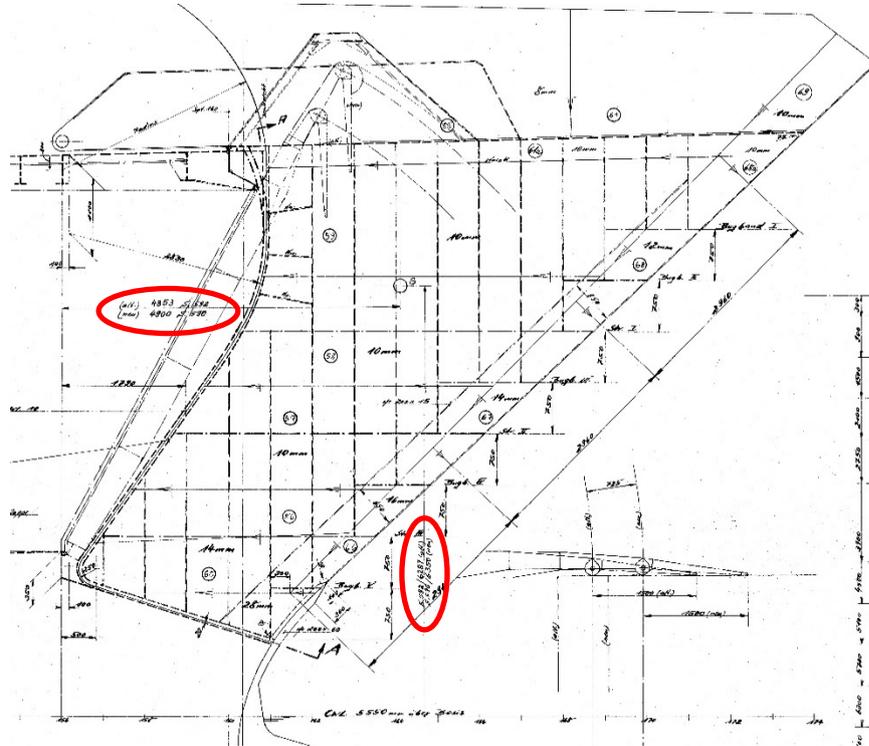


Figure 1. Detail from dwg. 590-1103 with CoG highlighted

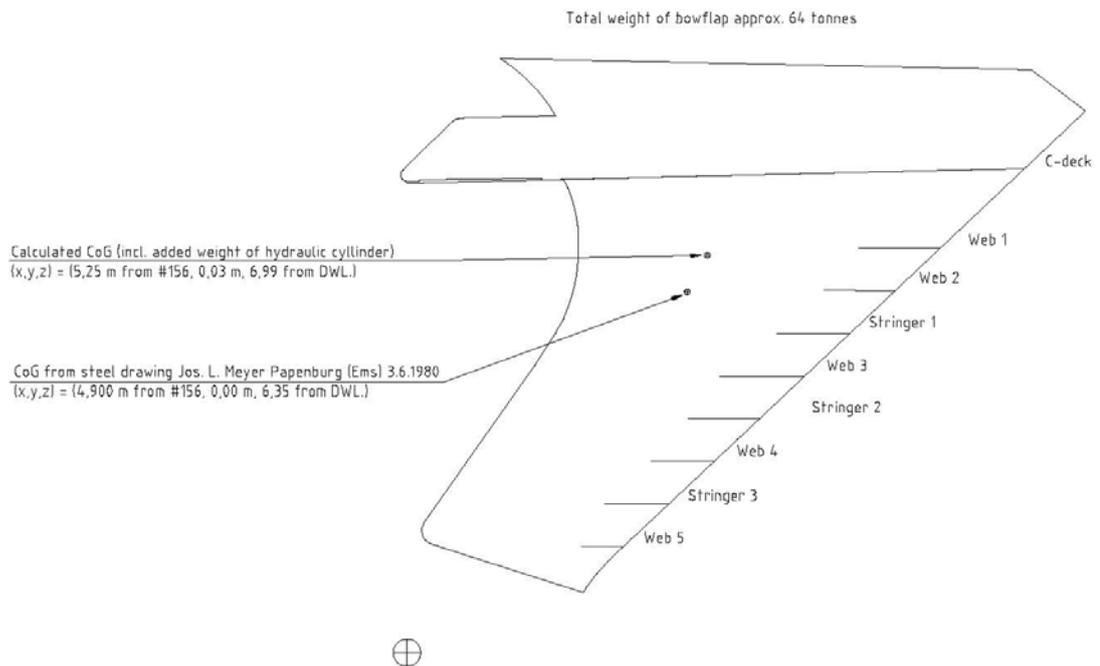


Figure 2. Comparison of calculated CoG and drawing CoG

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### 3 Volume

To estimate the volume of the visor and possible air pockets, the visor geometry was 3D modelled in NAPA. The volume is limited by the shell plating and C-deck and is presented for several levels in Figure 3.

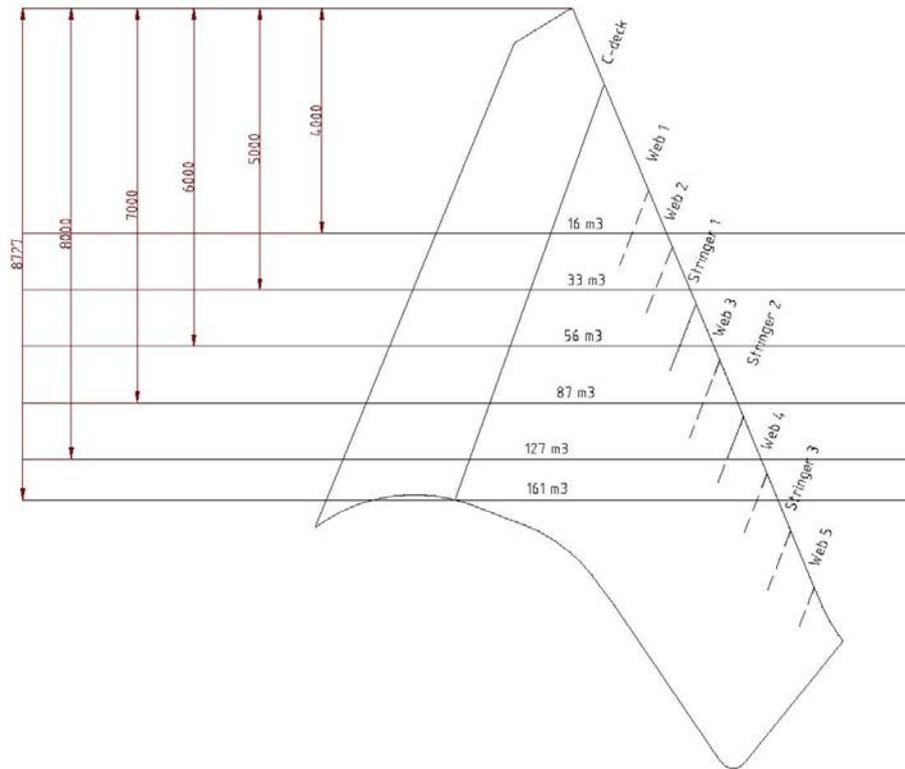


Figure 3. Enclosed volumes

The volume of the side box structure of the visor was calculated to 34 m<sup>3</sup>. The structure is not watertight but have the possibility to create air pockets.

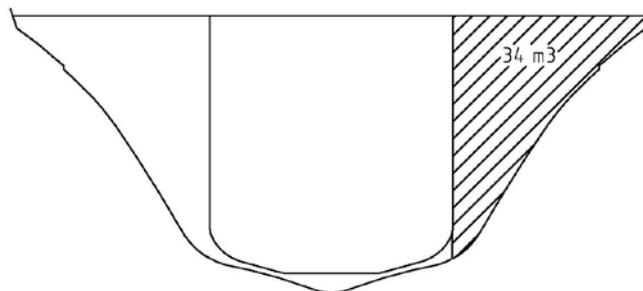


Figure 4. Volume of side box structure

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#### **4 Weighing of salvaged visor**

Since the first issue of this report, the salvaged bow visor was weighed with load cells placed on jacks. The weight was determined to be 65,5 tons.

#### **5 Conclusion**

Calculated weight and centre of gravity differs from earlier information with abt. 10% regarding both CoG and weight. In the first issue of this report one of the conclusions was that the big difference would motivate a more comprehensive survey of the salvaged visor to determine the actual weight. The weight was later determined to be 65,5 tons, abt. 2% difference from the calculated result.

Based on the CoG of the visor and the volume of possible air pockets, it can't be dismissed that the visor under certain circumstances could float. It is assessed possible for the visor to have enough displacement from an air pocket and at the same time have a vertical separation between the centre of gravity and centre of buoyancy that would create a positive rightening moment. However, the actual behaviour of the visor during the accident is dependent of several other factors such as waves and ship movements.

Based on these calculations it cannot be determined whether an air pocket would occur or not and it is not possible to with accuracy say for how long time an air pocket would delay the sinking of the visor.

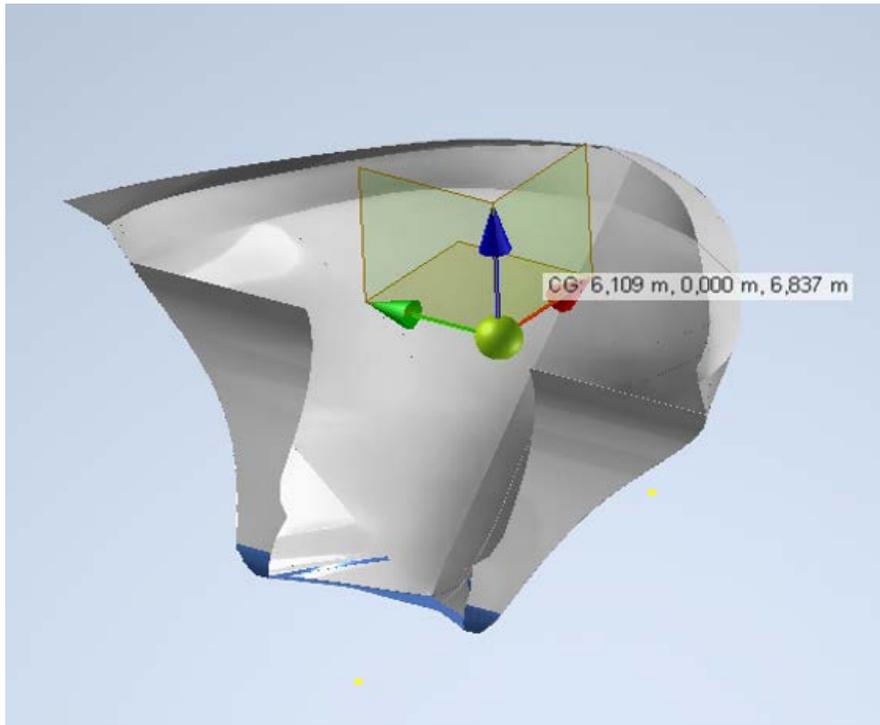
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## Appendix 1 – Calculation of weight and CoG

Bow visor - Weight and center of gravity							
Mass		Centre of gravity					
Section/Part	Weight (ton)	VCG ab. DWL		LCG from #156		TCG PS from CL	
		Lever (m)	Moment (tonm)	Lever (m)	Moment (tonm)	Lever (m)	Moment (tonm)
Frames	11,5	6,47	74,73	4,80	55,36	0,00	0,00
Web & Stringers	13,7	7,13	97,64	5,29	72,40	0,00	0,00
CL stringer	1,3	4,43	5,64	5,53	7,04	0,00	0,00
Plating	26,6	6,84	181,77	6,11	162,41	0,00	0,00
Hinge structure	10,4	8,09	84,56	3,63	37,89	0,00	0,00
Hydraulic cylinder	0,5	7,29	3,53	2,07	1,00	3,40	1,64
<b>Total</b>	<b>64,0</b>	<b>6,99</b>	<b>447,86</b>	<b>5,25</b>	<b>336,12</b>	<b>0,03</b>	<b>1,64</b>

3D CAD model of shell plates:



Section/Part	Profile/Subpart	Area (m2)	Thickness/length (m)	Units	Weight per unit (kg)	Pos X (m)	Moment X (kg * m)	Pos Z (m)	Moment Z (kg * m)	Steel density kg/m3	Tot weight
#157	Plate [9 mm]	0,440	0,009	1	31,10	0,60	18,66	2,31	71,87	7850	31,1
	Flange (100 x 10)	0,001	1,080	1	8,48	0,60	5,09	2,31	19,59	7850	8,5
#158	HP (200 X 9)	0,002	1,700	1	31,57	1,20	37,89	2,85	89,99	7850	31,6
	Plate [9mm]	0,804	0,009	1	56,83	1,20	68,20	2,19	124,35	7850	56,8
	Pipe 177,8 x 8	0,004	2,638	1	88,33	1,20	105,99	2,68	236,81	7850	88,3
	Pipe 177,8 x 5	0,004	1,615	1	54,08	1,20	64,89	3,50	189,26	7850	54,1
#159	Plate [9 mm]	1,165	0,009	1	82,31	1,60	131,69	2,15	176,96	7850	82,3
	Flange (120 x 12)	0,001	1,852	1	20,94	1,60	33,50	2,08	43,54	7850	20,9
	HP (200 X 9)	0,002	2,634	1	48,92	1,60	78,27	3,13	152,93	7850	48,9
#160	Plate [9 mm]	1,080	0,009	1	76,30	2,40	183,12	1,97	150,47	7850	76,3
	Plate [9 mm]	0,193	0,009	1	13,64	2,40	32,73	4,06	55,32	7850	13,6
	HP (200 X 9)	0,002	4,588	1	85,21	2,40	204,51	3,73	317,85	7850	85,2
	Plate [10,5 mm]	0,131	0,011	1	10,80	2,40	25,91	5,18	55,91	7850	10,8
	Pipe 177,8 x 8	0,004	2,991	1	100,15	2,40	240,36	4,10	410,61	7850	100,1
	Pipe 177,8 x 8	0,004	2,557	1	85,62	2,40	205,48	4,10	351,03	7850	85,6
#161	Flange 120 x 12	0,001	0,761	1	8,60	3,00	25,81	1,82	15,62	7850	8,6
	Plate [10,5 mm]	0,138	0,011	1	11,37	3,00	34,12	1,31	14,92	7850	11,4
	HP (200 X 9)	0,002	6,484	1	120,43	3,00	361,28	3,38	407,05	7850	120,4
	Plate [10 mm]	0,197	0,010	1	15,46	3,00	46,39	2,49	38,48	7850	15,5
	Plate [10 mm]	0,197	0,010	1	15,46	3,00	46,39	4,00	61,83	7850	15,5
	Flange 120 x 12	0,001	1,464	1	16,55	3,00	49,65	4,85	80,20	7850	16,5
	Flange 100 x 10	0,001	1,182	1	9,28	3,00	27,84	4,99	46,30	7850	9,3
	Plate [9 mm]	1,560	0,009	1	110,21	3,00	330,64	4,99	549,97	7850	110,2
	Plate [16 mm]	0,199	0,016	1	24,99	3,00	74,98	5,79	144,67	7850	25,0
	Plate [16 mm]	0,380	0,016	1	47,73	3,00	143,18	8,89	424,06	7850	47,7
	Flange 160 x 22	0,004	1,242	1	34,32	3,00	102,96	8,66	297,20	7850	34,3
	Flange 160 x 22	0,004	0,918	1	25,37	3,00	76,10	8,75	221,95	7850	25,4
#162	Plate [10,5 mm]	0,202	0,011	1	16,65	3,60	59,94	2,20	36,63	7850	16,6
	Plate [10 mm]	0,203	0,010	1	15,94	3,60	57,37	2,90	46,21	7850	15,9
	Plate [10 mm]	0,286	0,010	1	22,45	3,60	80,82	4,83	108,48	7850	22,5
	HP (200 X 9)	0,002	9,484	1	176,15	3,60	634,13	5,13	903,64	7850	176,1
	Plate [9 mm]	0,428	0,009	1	30,24	3,60	108,86	5,59	169,03	7850	30,2
	Plate [16 mm]	2,505	0,016	1	314,63	3,60	1132,66	7,26	2282,63	7850	314,6
	HP (200 X 9)	0,002	4,050	1	75,22	3,60	270,80	8,41	632,61	7850	75,2
	Stiffener (270 x 10,5)	0,064	0,011	2	5,28	3,60	37,98	8,26	87,14	7850	10,6
	Stiffener (300 x 9)	0,052	0,009	2	3,69	3,60	26,55	5,60	41,33	7850	7,4
	Stiffener (300 x 9)	0,052	0,009	2	3,69	3,60	26,55	6,01	44,29	7850	7,4
	Stiffener (200 x 9)	0,035	0,009	2	2,46	3,60	17,70	5,80	28,50	7850	4,9
	Pipe 177,8 x 8	0,004	3,148	1	105,41	3,60	379,46	5,78	608,82	7850	105,4
	Pipe 177,8 x 8	0,004	2,501	1	83,74	3,60	301,47	5,80	485,37	7850	83,7
#163	Plate [10,5 mm]	0,225	0,011	1	18,55	4,20	77,89	2,73	50,70	7850	18,5
	Flange (120 x 12)	0,001	1,487	1	16,81	4,20	70,60	3,42	57,44	7850	16,8
	Plate [10 mm]	0,349	0,010	1	27,40	4,20	115,07	3,95	108,11	7850	27,4
	HP (200 X 9)	0,002	3,415	1	63,43	4,20	266,39	3,75	237,85	7850	63,4
	HP (200 X 9)	0,002	3,630	1	67,42	4,20	283,17	6,87	463,18	7850	67,4
	Plate [10 mm]	1,003	0,010	1	78,74	4,20	330,69	5,44	428,64	7850	78,7
	Flange (100 x 10)	0,001	0,671	1	5,27	4,20	22,12	5,25	27,65	7850	5,3
	Flange (100 x 10)	0,001	0,864	1	6,78	4,20	28,49	5,96	40,42	7850	6,8
	Plate [16 mm]	2,080	0,016	1	261,25	4,20	1097,24	7,52	1964,58	7850	261,2
	HP (200 X 9)	0,002	3,692	1	68,57	4,20	288,00	8,23	564,48	7850	68,6
#164	Stiffener (270 x 10,5)	0,064	0,011	1	5,28	4,20	22,16	8,09	42,68	7850	5,3
	Plate [10,5 mm]	0,308	0,011	1	25,39	4,80	121,86	4,03	102,28	7850	25,4
	HP (200 X 9)	0,002	2,655	1	49,31	4,80	236,70	4,80	236,70	7850	49,3
	Flange (150 x 15)	0,002	2,000	1	35,33	4,80	169,56	4,53	159,92	7850	35,3
	Plate [10 mm]	0,383	0,010	1	30,07	4,80	144,31	5,86	176,27	7850	30,1
	HP (200 X 9)	0,002	3,774	1	70,09	4,80	336,46	7,41	519,40	7850	70,1
	HP (200 X 9)	0,002	3,266	1	60,66	4,80	291,17	8,77	531,99	7850	60,7
	Flange (100 x 10)	0,001	0,555	1	4,36	4,80	20,91	5,86	25,54	7850	4,4
	Plate [16 mm]	0,166	1,956	1	245,67	4,80	1179,23	8,03	1973,00	7850	245,7
	Stiffener (270 x 10,5)	0,064	0,011	1	5,28	4,80	25,32	8,63	45,51	7850	5,3
#165	Plate [10,5 mm]	0,237	0,011	1	19,53	5,40	105,49	4,22	82,34	7850	19,5
	HP (200 X 9)	0,002	2,192	1	40,71	5,40	219,85	4,75	193,38	7850	40,7
	Stiffener (200 x 15)	0,003	2,185	1	51,46	5,40	277,87	4,86	250,03	7850	51,5
	Plate [10 mm]	0,313	0,010	1	24,57	5,40	132,68	5,43	133,34	7850	24,6
	Plate [16 mm]	1,978	0,016	1	248,44	5,40	1341,56	7,46	1853,34	7850	248,4
	Stiffener (400 x 10)	0,096	0,010	1	7,54	5,40	40,69	5,74	43,29	7850	7,5
	Plate [10 mm]	0,089	0,010	1	6,99	5,40	37,73	6,00	41,92	7850	7,0
	HP (200 X 9)	0,002	3,329	1	61,83	5,40	333,88	7,07	437,20	7850	61,8
	Stiffener (270 x 10,5)	0,064	0,011	2	5,28	5,40	56,97	8,06	85,07	7850	10,6
#166	HP (200 X 9)	0,002	2,814	1	52,26	5,40	282,23	8,15	426,06	7850	52,3
	Plate [9 mm]	1,553	0,009	1	109,72	6,00	658,32	6,35	696,72	7850	109,7
	Flange (120 x 12)	0,001	3,000	1	33,91	6,00	203,47	6,43	217,95	7850	33,9
	Plate [16 mm]	1,755	0,016	1	220,43	6,00	1322,57	8,58	1891,27	7850	220,4
	Plate [9 mm]	2,818	0,009	1	199,09	6,00	1194,55	8,62	1715,77	7850	199,1
	Plate [9 mm]	1,075	0,009	1	75,95	6,00	455,69	9,05	687,64	7850	75,9
	Pipe 177,8 x 8	0,004	0,522	1	17,48	6,00	104,87	8,58	149,96	7850	17,5
	Stiffener (300 x 9)	0,052	0,009	1	3,69	6,00	22,13	8,60	31,72	7850	3,7
#167	Flange (150 x 15)	0,002	3,190	1	56,34	6,00	338,06	8,82	497,06	7850	56,3
	Plate [9 mm]	2,260	0,009	1	159,67	6,60	1053,82	8,14	1299,71	7850	159,7
	Plate [9 mm]	2,420	0,009	1	170,97	6,60	1128,42	6,35	1085,68	7850	171,0
	HP (200 X 9)	0,002	2,954	1	54,86	6,60	362,11	8,58	470,74	7850	54,9
	Flange 120 x 12	0,001	5,876	1	66,42	6,60	438,39	7,00	464,96	7850	66,4
	Plate [9 mm]	0,400	0,009	1	28,26	6,60	186,52	8,40	237,38	7850	28,3
#168	Plate [10,5 mm]	0,328	0,011	1	27,04	7,20	194,65	5,69	153,83	7850	27,0
	Stiffener (200 x 15)	0,003	2,035	1	47,92	7,20	345,05	6,31	302,16	7850	47,9
	HP (200 X 9)	0,002	4,360	1	80,98	7,20	583,05	6,83	553,08	7850	81,0
	Stiffener (270 x 10,5)	0,064	0,011	1	5,28	7,20	37,98	8,10	42,73	7850	5,3
	HP (200 X 9)	0,002	4,984	1	92,57	7,20	666,49	8,25	763,69	7850	92,6
#169	Plate [10,5]	0,268	0,011	1	22,09	7,80	172,30	7,07	156,22	7850	22,1
	Stiffener (200 x 15)	0,003	2,411	1	56,78	7,80	442,88	7,69	436,74	7850	56,8
	HP 200 x 9	0,002	2,983	1	55,40	7,80	432,15	7,86	435,47	7850	55,4
	HP 180 x 8	0,002	4,468	1	66,15	7,80	515,96	8,91	589,39	7850	66,1
	Plate [9 mm]	0,480	0,009	1	33,91	7,80	264,51	8,74	296,29	7850	33,9
	Stiffener (270 x 10,5)	0,064	0,011	1	5,28	7,80	41,15	8,76	46,23	7850	5,3
#170	Plate [9 mm]	1,520	0,009	1	107,39	8,40	902,06	8,64	927,83	7850	107,4
	HP 180 x 8	0,002	2,460	1	36,42	8,40	305,93	9,15	333,07	7850	36,4
	Stiffener (120 x 12)	0,001	2,364	1	26,72	8,40	224,47	8,62	230,38	7850	26,7
#171	Plate (9 mm)	1,518	0,009	1	107,25	9,00	965,22	8,16	874,92	7850	107,2
	HP 140 x 7	0,001	1,285	1	12,58	9,00	113,21	8,62	108,43	7850	12,6
	Stiffener 120 x 12	0,001	1,269	1	14,34	9,00	129,10	8,04	115,32	7850	14,3
	Plate [9 mm]	0,046	0,009	1	3,26	9,00	29,38	8,40	27,41	7850	3,3
SUB TOTAL (one side)						4,80	27680,66	6,47	37365,48		5772,3

TOTAL

11544,69084

Section/Part	Stiffener	Area (m2)	Thickness/length (m)	Units	Weight per unit (kg)	Pos X (m)	Moment X (kg * m)	Pos Z (m)	Moment Z (kg * m)	Steel density kg/m3	Tot weight
Web 5	Plate [10 mm]	0,544	0,010	1	42,70	3,30	140,71	1,87	79,86	7850	42,7
	Stiffener 120 x 12	0,001	0,900	1	10,17	3,01	30,61	1,87	19,02	7850	10,2
Stringer 3	Plate [10 mm]	1,318	0,010	1	103,46	3,93	406,92	2,62	271,07	7850	103,5
	Stiffener 120 x 12	0,001	1,511	1	17,08	3,47	59,32	2,62	44,75	7850	17,1
Web 4	Plate [10 mm]	2,265	0,010	1	177,80	4,45	791,04	3,37	599,19	7850	177,8
	HP 120 x 6	0,001	1,193	1	8,73	4,55	39,67	3,37	29,41	7850	8,7
Stringer 2	Stiffener 200 x 15	0,003	2,162	1	50,92	3,90	198,57	3,37	171,58	7850	50,9
	Plate [10 mm]	1,957	0,010	1	153,62	5,32	816,51	4,12	632,93	7850	153,6
Web 3	Stiffener 200 x 15	0,003	2,188	1	51,53	4,92	253,26	4,12	212,29	7850	51,5
	HP 120 x 6	0,001	1,129	1	8,26	5,58	46,12	4,12	34,03	7850	8,3
Stringer 1	Plate [10 mm]	2,632	0,010	1	206,61	6,15	1270,04	4,87	1006,20	7850	206,6
	Stiffener 200 x 15	0,003	2,588	1	60,95	5,51	336,00	4,87	296,81	7850	60,9
Web 2	HP 120 x 6	0,001	2,324	1	17,00	6,14	104,31	4,87	82,80	7850	17,0
	Pipe 177,8 x 8	0,004	2,653	1	88,83	4,41	391,92	5,62	499,23	7850	88,8
Stringer 1	Pipe 177,8 x 8	0,004	1,850	1	61,94	5,73	354,63	5,62	348,12	7850	61,9
	Plate [9 mm]	0,108	0,009	1	7,63	4,67	35,63	5,62	42,88	7850	7,6
Web 1	Plate [10 mm]	3,930	0,010	1	308,51	6,00	1851,03	5,62	1733,80	7850	308,5
	Stiffener 300 x 9	0,350	0,009	1	24,73	4,19	103,58	5,62	138,97	7850	24,7
Stringer 1	Stiffener 300 x 9	0,350	0,009	1	24,73	4,61	114,07	5,62	138,97	7850	24,7
	Plate [9 mm]	0,044	0,009	1	3,11	6,30	19,57	5,62	17,47	7850	3,1
Web 2	HP 120 x 6	0,001	1,164	1	8,52	7,08	60,29	5,62	47,86	7850	8,5
	Stiffener 150 x 15	0,002	1,662	1	29,36	6,50	190,72	5,62	164,98	7850	29,4
Stringer 1	Stiffener 150 x 15	0,002	3,896	1	68,81	5,11	351,84	5,62	386,73	7850	68,8
	Pipe 177,8 x 8	0,004	3,007	1	100,68	4,83	485,90	6,37	641,36	7850	100,7
Web 2	Pipe 177,8 x 8	0,004	2,185	1	73,16	6,10	446,57	6,37	466,03	7850	73,2
	Plate [9 mm]	0,108	0,009	1	7,63	5,04	38,47	6,37	48,60	7850	7,6
Stringer 1	Plate [10 mm]	6,220	0,010	1	488,25	6,50	3173,65	6,37	3110,18	7850	488,3
	Stiffener 150 x 15	0,002	4,775	1	84,34	5,73	483,43	6,37	537,24	7850	84,3
Web 1	HP 120 x 6	0,001	1,233	1	9,02	7,84	70,74	6,37	57,46	7850	9,0
	Stiffener 300 x 9	0,350	0,009	1	24,73	7,05	174,33	6,37	157,51	7850	24,7
Stringer 1	Plate [9 mm]	0,187	0,009	1	13,21	5,48	72,43	7,12	94,07	7850	13,2
	Pipe 177,8 x 8	0,004	3,080	1	103,13	5,24	540,08	7,12	734,27	7850	103,1
Web 1	Stiffener 300 x 9	0,350	0,009	1	24,73	7,83	193,49	7,12	176,06	7850	24,7
	Pipe 177,8 x 8	0,004	2,487	1	83,27	6,88	573,25	7,12	592,90	7850	83,3
Stringer 1	Stiffener 150 x 15	0,002	2,850	1	50,34	7,23	364,10	7,12	358,41	7850	50,3
	Stiffener 300 x 9	0,350	0,009	1	24,73	5,05	124,80	7,12	176,06	7850	24,7
Web 1	Stiffener 300 x 9	0,350	0,009	1	24,73	5,46	135,06	7,12	176,06	7850	24,7
	Stiffener 150 x 15	0,002	1,464	1	25,86	8,00	206,86	7,12	184,11	7850	25,9
Stringer 1	Stiffener 150 x 15	0,002	2,812	1	49,67	8,30	412,24	7,12	353,63	7850	49,7
	Plate [10 mm]	8,015	0,010	1	629,18	7,00	4404,24	7,12	4479,74	7850	629,2
C-deck	Plate [8 mm]	45,022	0,008	1	2827,38	4,55	12864,59	8,43	23834,83	7850	2827,4
	Plate [10 mm]	3,240	0,010	1	254,34	9,26	2355,19	8,43	2144,09	7850	254,3
Stringer 1	Plate [15 mm]	1,900	0,015	1	223,73	1,26	281,89	8,43	1886,00	7850	223,7
	Flange 100 x 15	0,002	1,570	1	18,49	1,37	25,23	8,43	155,84	7850	18,5
Web 1	HP 120 x 7	0,001	2,494	1	20,60	1,98	40,72	8,43	173,62	7850	20,6
	HP 120 x 7	0,001	2,494	1	20,60	2,81	57,96	8,43	173,62	7850	20,6
Stringer 1	HP 160 x 7	0,001	2,494	1	28,58	4,00	114,45	8,43	240,96	7850	28,6
	HP 140 x 7	0,001	3,115	1	30,39	4,56	138,51	8,43	256,23	7850	30,4
Stringer 1	HP 200 x 9	0,002	2,072	1	38,48	3,18	122,49	8,43	324,42	7850	38,5
	HP 140 x 7	0,001	2,385	1	23,27	9,70	225,64	8,43	196,18	7850	23,3
Stringer 1	HP 140 x 7	0,001	1,118	1	10,91	9,94	108,40	8,43	91,96	7850	10,9
	<b>SUB TOTAL (one side)</b>					<b>5,29</b>	<b>36201,11</b>	<b>7,13</b>	<b>48820,43</b>		<b>6848,4</b>

TOTAL

13696,83663

Section/Part	Profile /Subpart	Area (m2)	Thickness/length (m)	Units	Weight per unit (kg)	Pos X (m)	Moment X (kg * m)	Pos Z (m)	Moment Z (kg * m)	Steel density kg/m3	Tot weight
	Plate [9 mm]	6,127	0,009	1	432,87	6,20	2683,81	4,57	1978,23	7850	432,9
	Plate [9 mm]	1,350	0,009	1	95,38	8,68	827,88	8,13	775,42	7850	95,4
	Ladder FB 150 x 15	0,002	5,950	2	105,09	4,17	876,89	3,88	815,09	7850	210,2
	Ladder FB 150 x 15	0,002	2,771	2	48,94	7,22	707,03	7,27	711,14	7850	97,9
	Profile 200 x 140	0,028	1,116	1	245,30	3,55	869,58	1,58	388,55	7850	245,3
	HP 140 x 7	0,001	1,484	1	14,48	10,58	153,22	9,70	140,50	7850	14,5
	Profile 100 x 8	0,087	0,008	1	5,46	2,46	13,43	1,46	7,97	7850	5,5
	Pipe 177,8 x 8	0,004	0,928	1	31,07	2,99	92,84	2,71	84,24	7850	31,1
	Pipe 177,8 x 8	0,004	0,928	1	31,07	4,31	134,05	4,19	130,07	7850	31,1
	Pipe 177,8 x 8	0,004	0,928	1	31,07	5,69	176,80	5,67	176,03	7850	31,1
	Plate [8 mm]	0,096	0,008	1	6,00	3,53	21,20	2,63	15,80	7850	6,0
	Plate [8 mm]	0,028	0,008	1	1,76	4,27	7,50	3,48	6,12	7850	1,8
	Plate [8 mm]	0,090	0,008	1	5,65	5,07	28,66	4,16	23,49	7850	5,7
	Plate [8 mm]	0,090	0,008	1	5,65	5,78	32,66	4,86	27,47	7850	5,7
	Plate [8 mm]	0,199	0,008	1	12,50	6,53	81,57	5,71	71,30	7850	12,5
	Plate [8 mm]	0,128	0,008	1	8,04	7,45	59,87	6,42	51,57	7850	8,0
	Plate [8 mm]	0,073	0,008	1	4,58	8,10	37,12	7,00	32,08	7850	4,6
	Plate [8 mm]	0,155	0,009	1	10,95	9,14	100,08	7,98	87,38	7850	11,0
	Plate [8 mm]	0,068	0,008	1	4,27	11,29	48,23	9,63	41,11	7850	4,3
	Stiffener 100 x 8	0,001	0,120	2	0,75	2,38	3,59	1,55	2,33	7850	1,5
	Stiffener 150 x 15	0,002	0,120	2	2,12	3,42	14,48	2,70	11,45	7850	4,2
	Stiffener 150 x 15	0,002	0,120	2	2,12	4,99	21,14	4,18	17,71	7850	4,2
	Stiffener 150 x 15	0,002	0,120	2	2,12	5,58	23,64	4,98	21,11	7850	4,2
	Stiffener 150 x 15	0,002	0,120	2	2,12	6,46	27,38	5,59	23,70	7850	4,2
	Stiffener 100 x 10	0,001	0,001	2	0,01	8,92	0,14	7,91	0,12	7850	0,0
<b>TOTAL</b>						5,53	7042,76	4,43	5639,97		1272,7

Section/Part	Profile /Subpart	Area (m2)	Thickness/length (m)	Units	Weight per unit (kg)	Pos X (m)	Moment X (kg * m)	Pos Z (m)	Moment Z (kg * m)	Steel density kg/m3	Tot weight
Hinge foundation	Plating [60 mm]	0,37	0,060	2,0	174,03	0,33	115,56	8,46	2943,90	7850	348,1
	Plating [30 mm]	1,10	0,030	2,0	258,13	1,11	573,62	8,74	4512,68	7850	516,3
	Plating [20 mm]	1,03	0,020	2,0	161,55	2,06	666,24	8,65	2795,84	7850	323,1
	Plating [16 mm]	12,26	0,016	2,0	1539,84	4,62	14228,14	7,57	23316,28	7850	3079,7
Ramp housing	Top plate [8 mm]	2,02	0,008	0,5	126,60	3,98	251,94	10,00	633,02	7850	63,3
	Aft plate [8 mm]	6,46	0,008	0,5	405,53	3,03	614,38	9,16	1857,33	7850	202,8
	Fore plate [8 mm]	7,25	0,008	0,5	454,99	5,15	1171,59	9,21	2095,21	7850	227,5
	22 mm plating (160 x 22 profile)	0,11	0,022	1,0	18,65	0,00	0,00	8,55	159,38	7850	18,7
#156	20 mm plating	0,08	0,020	1,0	12,10	0,00	0,00	8,55	103,50	7850	12,1
	22 mm plating (160 x 22 profile)	0,15	0,022	1,0	26,09	0,60	15,66	8,67	226,24	7850	26,1
	20 mm plating	0,13	0,020	1,0	21,12	0,60	12,67	8,67	183,08	7850	21,1
#157	22 mm plating (160 x 22 profile)	0,15	0,022	1,0	26,09	1,20	31,31	8,86	231,20	7850	26,1
	20 mm plating	0,13	0,020	1,0	21,12	1,20	25,34	8,86	187,09	7850	21,1
	22 mm plating (160 x 22 profile)	0,15	0,022	1,0	26,09	1,80	46,97	8,88	231,72	7850	26,1
#158	20 mm plating	0,13	0,020	1,0	21,12	1,80	38,01	8,88	187,51	7850	21,1
	22 mm plating (160 x 22 profile)	0,15	0,022	1,0	26,09	2,40	62,63	8,90	232,25	7850	26,1
	20 mm plating	0,13	0,020	1,0	21,12	2,40	50,68	8,90	187,94	7850	21,1
#159	22 mm plating (160 x 22 profile)	0,15	0,022	1,0	26,09	3,00	78,28	8,90	232,25	7850	26,1
	20 mm plating	0,13	0,020	1,0	21,12	3,00	63,35	9,90	209,05	7850	21,1
	22 mm plating (160 x 22 profile)	0,15	0,022	1,0	26,08	3,60	93,88	8,92	232,61	7850	26,1
#160	20 mm plating	0,14	0,020	1,0	21,82	3,60	78,56	8,92	194,66	7850	21,8
	22 mm plating (160 x 22 profile)	0,15	0,022	1,0	26,08	4,20	109,53	8,94	233,13	7850	26,1
	20 mm plating	0,14	0,020	1,0	21,82	4,20	91,66	8,94	195,10	7850	21,8
#161	22 mm plating (160 x 22 profile)	0,15	0,022	1,0	26,08	4,80	125,17	8,96	233,66	7850	26,1
	20 mm plating	0,14	0,020	1,0	21,82	4,80	104,75	8,96	195,53	7850	21,8
	22 mm plating (160 x 22 profile)	0,15	0,022	1,0	26,08	5,40	140,82	8,97	233,92	7850	26,1
#162	20 mm plating	0,15	0,022	1,0	26,08	6,00	156,47	8,99	234,44	7850	26,1
	22 mm plating (160 x 22 profile)	0,15	0,022	1,0	26,08	6,00	156,47	8,99	234,44	7850	26,1

<b>SUB TOTAL (one side)</b>					<b>3583,35</b>	<b>3,63</b>	<b>18947,21</b>	<b>8,09</b>	<b>42278,53</b>		<b>5223,3</b>
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TOTAL

10446,6971

Section/Part	Profile /Subpart	Area (m2)	Thickness/length (m)	Units	Weight per unit (kg)	Pos X (m)	Moment X (kg * m)	Pos Z (m)	Moment Z (kg * m)	Pos y (m)	Moment y (kg	Steel densi	Tot weight
Hydraulic cylinder	Piston rod	0,016	3,100	1	396,12	2,00	792,24	7,40	2931,28	3,40	1346,81	7850	396,1
	Cylinder	0,008	1,400	1	87,65	2,40	210,36	6,80	596,03	3,40	298,02	7850	87,7
<b>TOTAL</b>						<b>2,07</b>	<b>1002,60</b>	<b>7,29</b>	<b>3527,32</b>	<b>3,40</b>	<b>1644,82</b>		<b>483,8</b>