

APPENDIX G

HULL STRUCTURAL CALCULATIONS

Material: E-glass w/ vinyl ester resin

Length, L (m)	11.05
Breadth, B (m)	3.8
Depth, D (m)	1.8
Draft, d (m)	0.515
Basic Head, h (m)	4.712
Fiber fraction, wt(%)	35
E-glass density (kg/m ³)	2600
Vinyl ester resin density (kg/m ³)	1010
Laminae density (kg/m ³)	1566.5

Material Properties:	Fig 13.5	Fig 14.2	ISO	Average
Source:				
Flex. Mod.1 (N/mm ²)	14675.75			
Flex. Mod.2 (N/mm ²)	6986.25			
Exave (N/mm ²)	7575	6231.5	8234.167	
Flex. Stran.1 (N/mm ²)	261.7			
Flex. Stran.2 (N/mm ²)	181.78			
Flex. Stran. Ave (N/mm ²)	221.74	172	135	176.25
Cre (N/mm ²)	110.87	86.00	67.50	88.12
Tensile Mod1 (N/mm ²)	12639.75			
Tensile Mod2 (N/mm ²)	10566.50			
Tensile Mod. Ave (N/mm ²)	11753.13	5850	10000	9547.71
Comp. Mod1 (N/mm ²)	11951.865			
Comp. Mod2 (N/mm ²)	7998.000			
Comp. Mod. Ave (N/mm ²)	9759.93	5850	9000	8216.64
(Ten+Comp)/2 (N/mm ²)	10756.53	6860.00	9000.00	8882.18
Tensile Str1 (N/mm ²)	183.65			
Tensile Str2 (N/mm ²)	136.40			
Tensile Str. Ave (N/mm ²)	160.01	124.00	130.00	138.00

	Panel	Bow	Bottom Plating (Below d=0.15m)										NOTES
			5% LWI aft of FP	1	2	3	40% LWI aft of FP	4	5	6	Stem		
L (m)		5.80	4.55	4.45	1.89	1.15	1.01	0.24	-2.28	-4.76	-8.20		
D (m)		3.77	5.65	5.65	5.65	5.65	5.65	5.25	4.58	3.77	3.90		
S (mm)		0.00	450.00	500.00	1000.00	1000.00	1000.00	1100.00	1100.00	1100.00	500.00		
L (mm)		600	2560.00	2560.00	2560.00	2000	2000	2000	2500.00	2500.00	1000		
A (mm)		0.00	60.00	50.00	60.00	100.00	95.00	112.00	105.00	50.00	10.00		
Cf		-0.22	0.17	0.21	0.64	0.64	0.64	0.73	0.73	0.73	0.21		
F (a)		1.30	0.60	0.75	0.39	0.39	0.39	0.35	0.35	0.35	0.75		
Fh (a)		4.91	4.53	4.27	2.23	2.23	2.23	1.82	1.80	1.80	2.49	not less than D	
F (b)		1.30	0.60	0.75	0.50	0.50	0.50	0.50	0.50	0.50	0.75	not less than 0.5	
g (a)		0.05	0.05	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.02		
g (b)		0.05	0.05	0.04	0.03	0.03	0.03	0.03	0.02	0.02	0.02		
k		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	not less than 0.5	
k1		0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	not less than 0.028	
c		-0.00	0.67	0.90	0.94	0.90	0.91	0.90	0.90	0.95	0.98		
ta (mm)		0.00	6.25	7.00	10.57	10.12	10.18	10.03	10.06	10.61	5.82		
tb (mm)		0.00	6.78	6.53	11.90	11.39	11.46	12.20	11.74	11.61	5.94		

Decision: All bottom plating is 13 mm

Shell Plating (Above d=0.15m)										
Panel	Bow	1	2	3	40% LWL aft of FP	4	5	6	Stem	NOTES
X (m)	5.80	4.55	4.45	1.89	1.15	1.01	-0.24	-2.28	-4.76	-6.20
Y (m)	2.94	4.53	4.53	4.53	4.53	4.21	3.67	3.02	2.64	
Z (mm)	625	625	635	625	500	500	500	500	625	650
L (mm)	600	2560	2560	2000	2000	2000	2500	2500	1000	
A (mm)	0	37	30	25	10	10	10	10	20	10
Ch	0.66	0.66	0.66	0.66	0.44	0.44	0.44	0.44	0.66	0.71
F (a)	0.38	0.38	0.38	0.38	0.54	0.54	0.54	0.54	0.38	0.36
Fh (a)	1.12	1.73	1.73	1.73	2.45	2.45	2.27	1.98	1.16	0.96 not less than .5D
F (b)	0.50	0.50	0.50	0.50	0.54	0.54	0.54	0.54	0.50	0.50 not less than 0.5
Fh (b)	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
P (a)	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01
P (b)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50 not less than 0.5
k	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028 not less than 0.028
k1	1.00	0.94	0.95	0.96	0.98	0.98	0.98	0.98	0.97	0.98
c	4.99	5.83	5.90	5.95	5.77	5.77	5.56	5.20	4.50	4.69
ba (mm)	6.36	6.91	7.00	7.05	5.91	5.91	5.76	5.51	6.21	6.29

All shell plating forward of bulkhead 2 is 8mm, remaining shell plating is 7mm

Decision:

Deck (including cabin top and side) Plating										
Panel	Bow	1	2	3	40% LWL aft of FP	4	5	6	Stem	NOTES
X (m)	5.80	4.55	4.45	1.89	1.15	1.01	-0.24	-2.28	-4.76	-6.20
Y (m)	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27	2.27
Z (mm)	10	700	675	460	500	500	590	590	600	400
L (mm)	600	2560	2560	2000	2000	2000	2500	2500	1000	
A (mm)	5	5	5	50	50	50	50	50	0	0
Ch	-0.34	0.62	0.59	0.29	0.37	0.43	0.45	0.45	0.48	0.20
F	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00 not less than .59
Fs	1.10	0.82	0.83	0.92	0.88	0.88	0.87	0.87	0.86	0.94 not less than .59
P	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
P (a)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
k1	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
c	0.50	0.99	0.99	0.88	0.90	0.91	0.91	0.91	1.00	1.00
ba (mm)	0.06	7.15	6.94	4.46	5.05	5.43	5.61	5.61	6.32	4.41
bb (mm)	0.06	7.68	7.42	4.68	5.33	5.75	5.95	5.95	6.72	4.61

All deck plating is 8mm, all cabin top and side plating is 6mm

Decision:

Stiffener Dimensions

type	Side Stringer (reqd)	min req.	Side Stringer (alt)	min req.	Bottom Stringer (reqd)	min req.	Bottom Stringer (alt)	min req.	Bottom Stringer (alt)	min req.	Floor	min req.	NOTES
Panel thickness (cm)	0.8		0.7		1.3		1.3		1.3		1.3		
Base b (cm)	7.00		6.00		7.00		6.00		7.00		4.00		max 18t
tr eff (cm)	21.4		18.6		19.6		29.4		27.4		27.4		
t1 (cm)	0.50		0.50		0.50		0.50		0.50		0.50		
t2 (cm)	0.75		0.75		0.75		0.75		0.50		0.75		
Wc (cm)	9.00		8.00		9.00		6.00		4.00		4.00		max 18t
height (cm)	8.00		6.00		7.00		12.00		8.00		9.00		30t max
Flange Length (cm)	4.00		4.00		4.00		4.00		4.00		4.00		8t max
Effective area (cm ²)	35.87		29.02		31.47		58.72		49.62		51.62		
Stiffener Area (cm ²)	17.25		14.50		16.25		20.50		14.00		16.00		
NA (cm)	2.16		1.66		2.08		1.71		0.51		0.66		
Ina (cm4)	375.64		318.78		152.01		253.00		530.10		300.51		123.54
SMA (cm ³)	64.37		62.19		37.96		49.36		103.29		38.56		47.55

ABS reqs.

C	817.00		817.00		817.00		817.00		817.00		817.00		817.00
C1	255.00		255.00		255.00		255.00		255.00		255.00		255.00
I (m)	2.56		2.00		2.56		2.60		1.90		1.90		1.00
Cf	1.99		1.51		1.99		2.03		0.64		1.16		0.64
F	0.25		0.25		0.25		0.25		0.39		0.25		0.39
h (m)	1.27		1.27		1.27		1.27		2.01		1.27		2.01
g (m)	0.63		0.63		0.50		1.00		1.00		1.00		1.00
N													0.70
Wk (N)													31666.00
Yk (m)													0.40
h													4.00
SMAk	0.00		0.00		0.00		0.00		0.00		0.00		32.14
SMA req. (cm ³)	62.19		37.96		49.36		101.83		23.75		38.56		55.89

Decision:

Stiffeners are sized as shown in chart, some are oversized to reduce the number of different stiffeners required

Keel Bolts:	
Keel Weight (N)	24525
Yield Strength of Steel (N/mm ²)	205
Shear Strength (N/mm ²)	300
Ultimate Strength (N/mm ²)	490
Yk (m)	0.585
ΣI ₁ (m)	1.62
min. bolt diameter (mm)	10.50

Boat Loads:	
Boat Displacement (N)	70072.83
Load Factor	1.5
Grounding Load (N)	105109.2
Boat Shear Stress (N/mm ²)	121.3454
Maximum Shear Stress (N/mm ²)	225
Maximum Axial Stress (N/mm ²)	153.75

Decision:

Use 5 pairs of 12mm Steel Keel bolts spaced as shown above

bolt	x (%)	y (%)	y	y ²	y-y/2	f (m)
	0	0	0	0	0	0
	1.25	0.389	0.009134	0.004567	0.013701	0
	2.5	0.726	0.017971	0.006895	0.026956	0
	5	1.406	0.034603	0.017401	0.052204	0
	7.5	2.039	0.050471	0.025526	0.075707	0
	10	2.625	0.064976	0.032488	0.097464	0.194929
	15	3.656	0.090496	0.045248	0.135745	0
	20	4.5	0.111368	0.055694	0.167082	0.334163
	25	5.156	0.127626	0.063913	0.191439	0
	30	5.625	0.138265	0.069617	0.208662	0
	40	6	0.148517	0.074259	0.222776	0.445651
	50	5.833	0.144393	0.072192	0.216575	0
	60	5.333	0.132007	0.069003	0.199011	0.396021
	70	4.5	0.111368	0.055694	0.167082	0
	80	3.333	0.062501	0.041251	0.123752	0.247504
	90	1.833	0.045372	0.022686	0.068058	0
	95	0.958	0.023713	0.011657	0.03557	0
	100	0	0	0	0	0

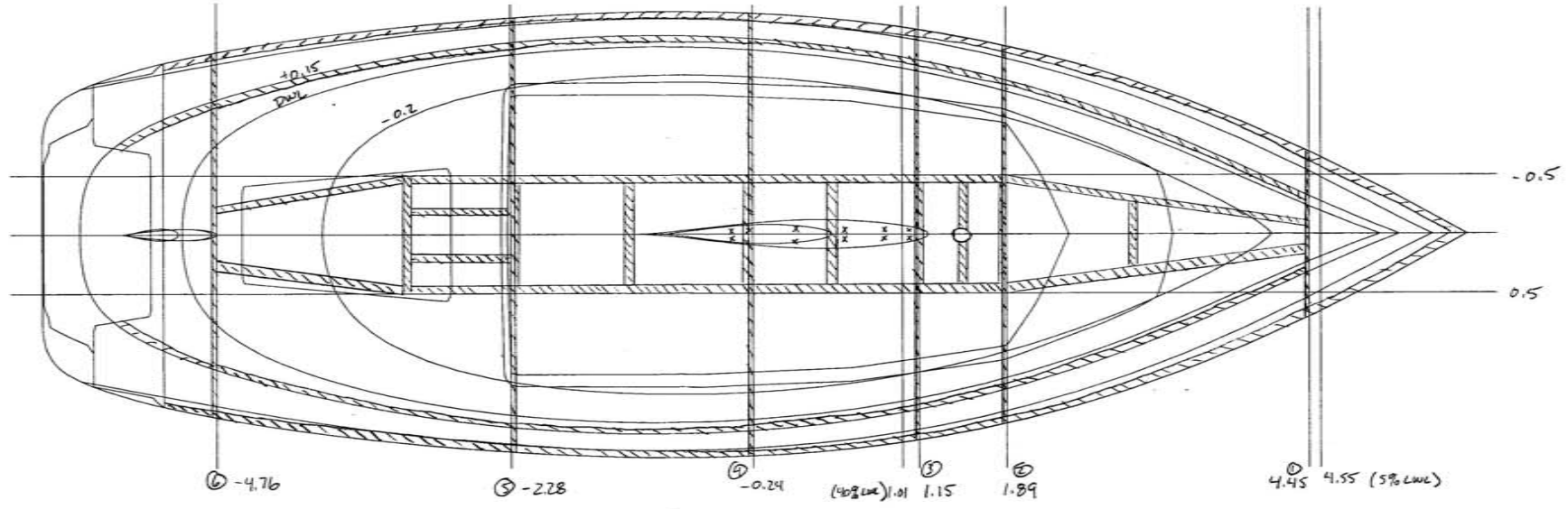
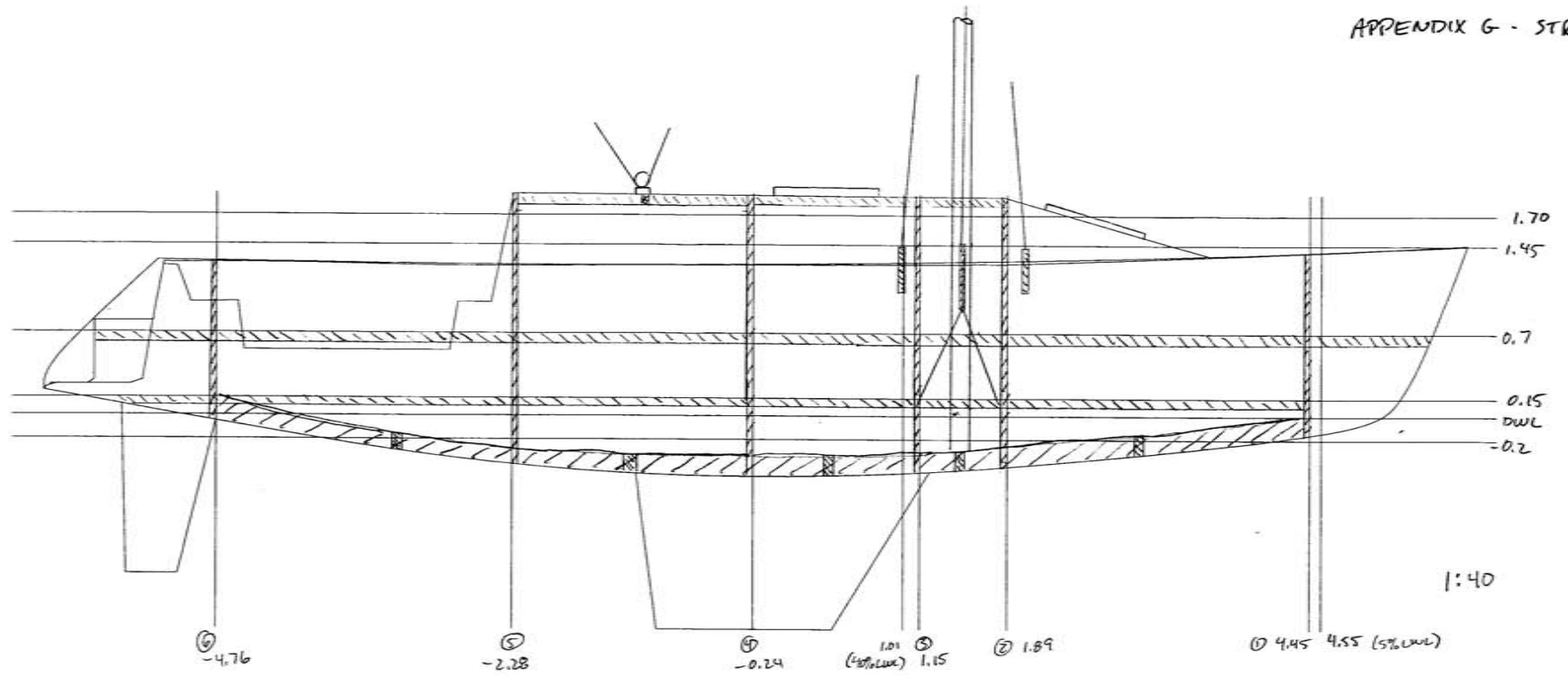
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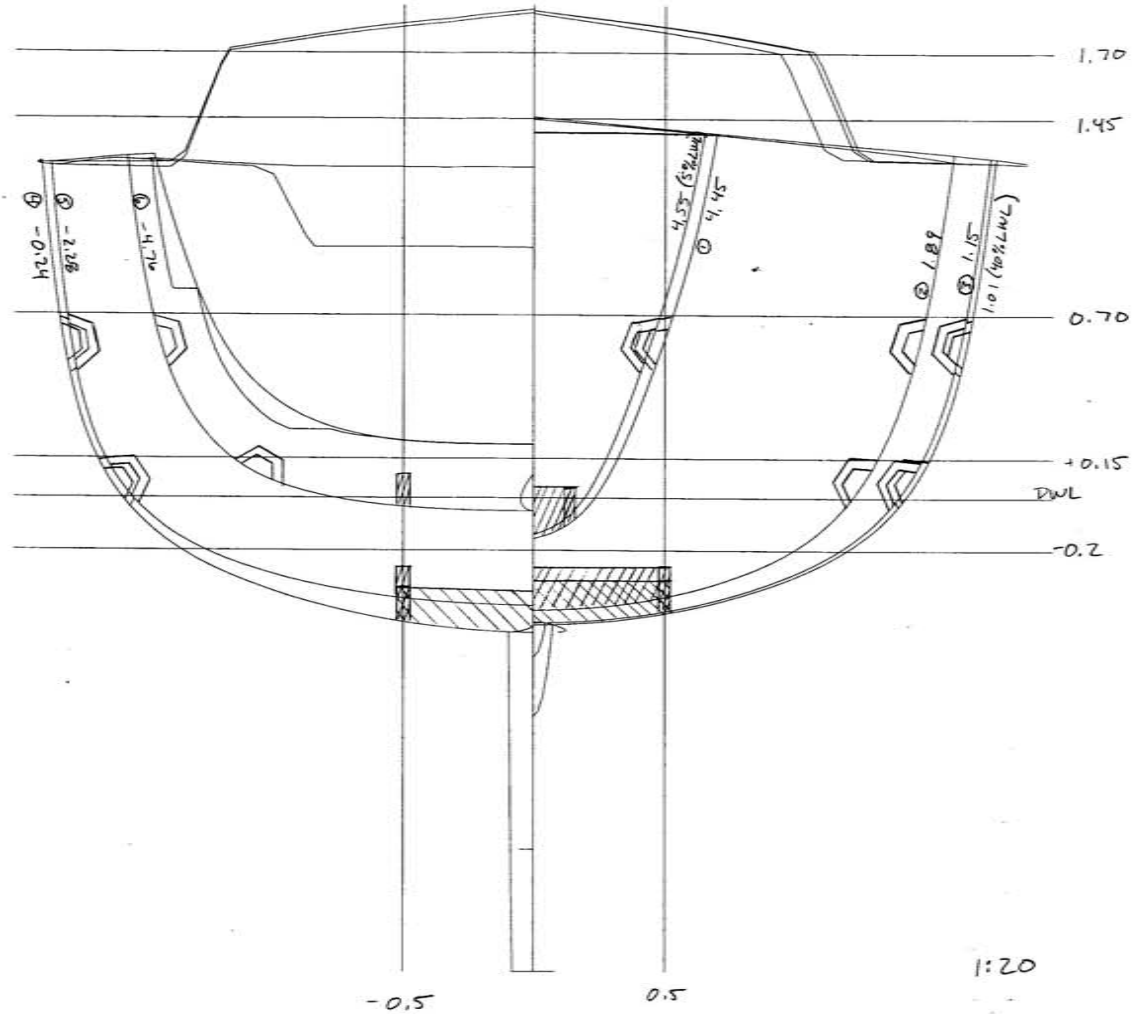
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ΣI₁ (m)

1.618168

APPENDIX G - STRUCTURE





Body Plan View