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THE EFFECT OF TRANSVERSE SIDE LOAD ON SMALL WATERPLANE AREA TWI--ETC(U)
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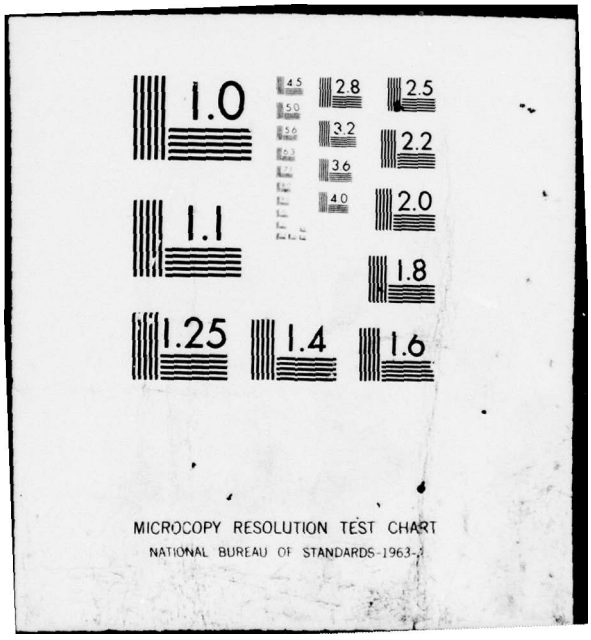
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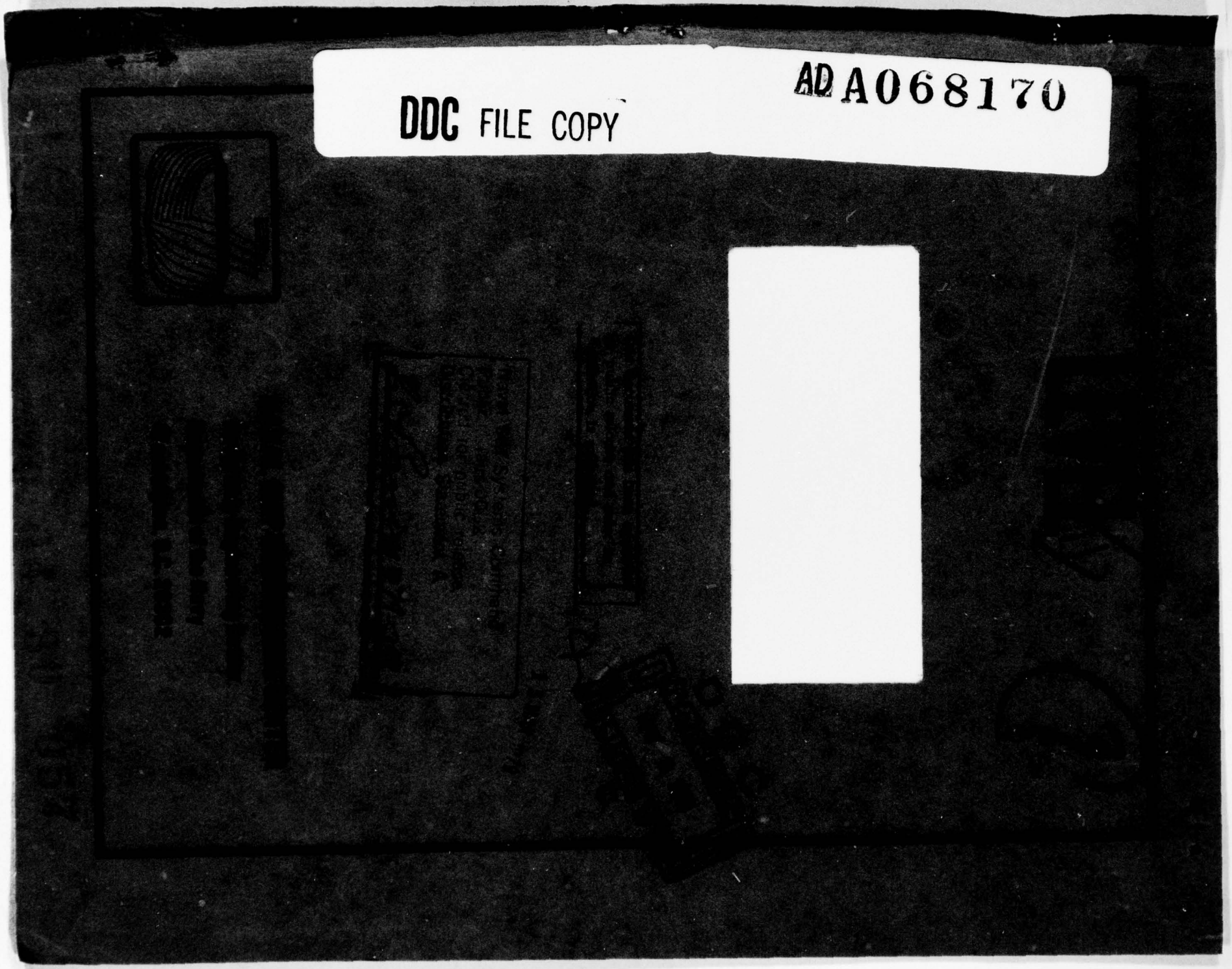

(3)

THE EFFECT OF TRANSVERSE SIDE LOAD ON SMALL WATERPLANE AREA TWIN HULL (SWATH) STRUCTURES

REPORT 6114-041-79

JANUARY 1979

By Colen G. Kennell

Approved for Public Release

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This study examines the influence of transverse side load and ship configuration on the structural weight of SWATH ships. The results show that small ships are less sensitive than large ships to side loads, and that long slender ships will have heavier structure than short full ships.

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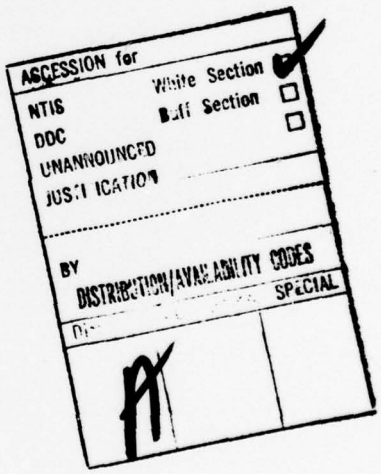

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Section 1
INTRODUCTION

The importance of dynamic transverse side forces in the design of Small Waterplane Area Twin Hull (SWATH) ships has been recognized for several years. Algorithms for predicting these loads have been developed at DTNSRDC by combining theoretical analysis with limited model test data. However, the effect of these predicted side loads on the structure of representative SWATH configurations has not been investigated. This study is intended to partially fill that void.

Section 2 of this report details the approach adopted to investigate the problem including details of the hull forms studied. Section 3 contains the results of the study. Conclusions derived from the study are discussed in Section 4.

This work was completed as part of the NAVSEC SWATH effort funded by NAVSEA Work Request WR9G105. NAVSEC JON 329MP01 was assigned to the task.

Section 2
APPROACH

The approach adopted for this study was to calculate the primary structural weight of representative SWATH configurations as a function of side force. Primary structure includes shell plating, stiffeners, bulkheads, decks, platforms, and inner bottom. The maximum side force considered was twice the displacement of each configuration. The structural weight calculations were made with a computer program developed for the purpose by combining subroutines WTPRI, SSS11, SSS18, and AREO from NAVSEC's SWATH Synthesis Model.

Several important assumptions are made in the program. First, center wells in the box or cross-structure have been excluded from all configurations. While wells may be desirable for some potential missions, a general design approach for wells in SWATH structures has not been developed.

The second assumption is that only the box structure directly above the struts is effective in resisting transverse bending loads. Improvement on this assumption will require detailed examination of stress flow in box and struts of representative SWATH structures.

Third, all strut shell structure has been assumed to be effective in bending. In particular, end effects associated with box/strut transition have been ignored. More detailed analysis of these problems will be required to make an improved assumption.

SWATH configurations selected for this study were chosen to be representative of current design practice. Three parent hulls were selected from a recent parametric study (reference (1)).

Characteristics of the parent forms are given in Table 1. Sketches of the three configurations are shown in Figure 1. It should be noted that present computer programs cannot model the complex hull shape of the multistrut shown in Figure 1. Instead, an approximation to the hull shape was used. This equivalent form consisted of a 180 foot parabolic tail section and a 180 foot elliptical nose section. The maximum hull diameter and draft were selected to provide hull and strut volumes in the equivalent hull equal to those in the parent form. Characteristics of the equivalent multistrut are shown in Table 1. A sketch of the equivalent is also shown in Figure 1.

The proportions of these parent forms were Froude scaled to displacements of 2000, 5000, 10,000, and 20,000 tons. Box height and box clearance were held constant at 14 feet and 20 feet respectively.

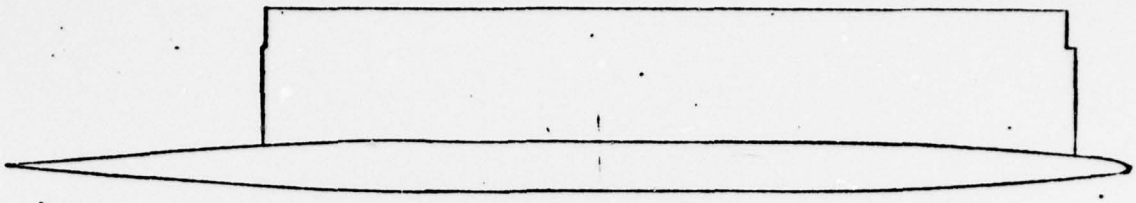
All of the configurations generated in this manner have one interior deck in the box and an inner bottom. Twin deck variants of the 20,000 ton configurations were also examined.

TABLE 1

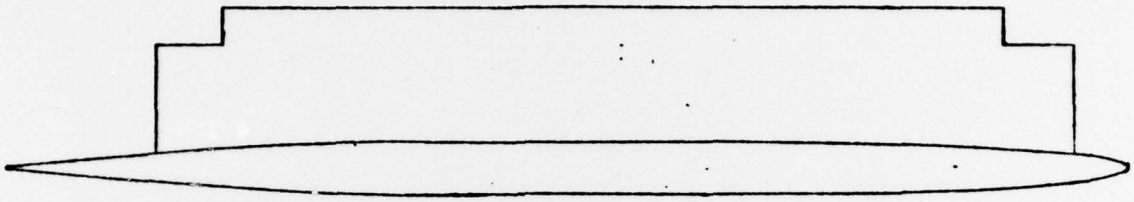
Parent Form Characteristics

	Thin Single Strut	Thick Single Strut	Multi Strut	Equivalent Multi-Strut
Hull Length (ft)	400	400	360	360
Maximum Diameter (ft)	19.3	18.4	25	22.6
Prismatic Coefficient	0.7	0.7	0.5	0.6
Draft (ft)	33.8	32.2	37.8	36.7
Diameter Ratio	1.0	1.0	2.1	1.0
Strut Length (ft)	326	287	110	110
Thickness (ft)	8	11	7	7
Waterplane Coefficient	0.75	0.75	0.88	0.88
Strut Gap (ft)	-	-	86	86
Displacement (tons)	6306	6125	6051	6051
Box Clearance (ft)	20	20	20	20
Box Length (ft)	275	284	233	233
Box Width (ft)	99.2	90.4	117	117
Box Height (ft)	14	14	14	14
GMT (ft)	10	10	10	10
GML (ft)	86	84	-	-
Waterplane Area (Sq. ft)	3913	4736	-	-

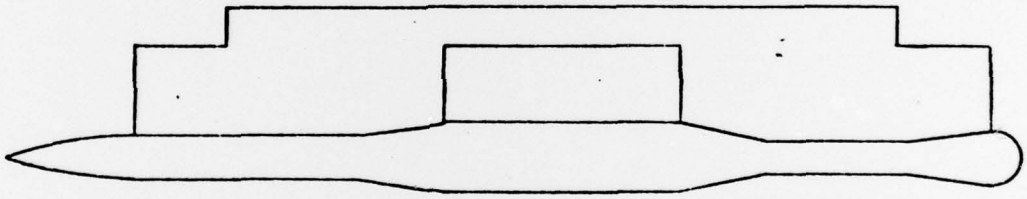
THICK SINGLE STRUT



THIN SINGLE STRUT



MULTI STRUT



EQUIVALENT MULTI STRUT

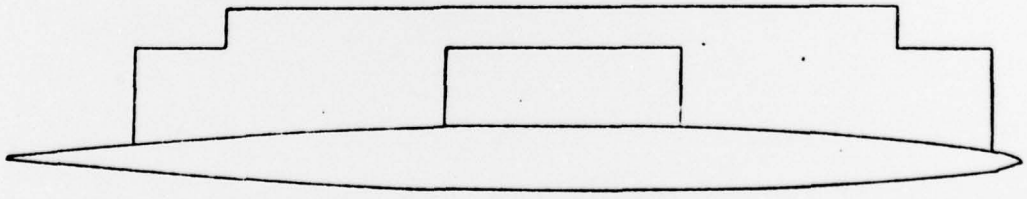


FIGURE 1
PARENT FORM SKETCHES

The two single strut parent forms were selected to demonstrate the effects of strut thickness and waterplane area. Both forms have roughly the same longitudinal GM and transverse GM in keeping with DTNSRDC recommendations (reference (1)). However, the thick strut form requires 20 percent more waterplane area than the thin strut form to achieve these metacentric heights and the thin strut is forty feet longer than the thick strut. The thick strut form is more in line with DTNSRDC seakeeping guidelines on waterplane area than the thin strut. This variation in strut form is particularly interesting since the side load algorithms presently available are particularly sensitive to strut length.

The multistrut forms have a total strut length of 306 feet and a box length of 233 feet. The two assumptions discussed previously result in 147 feet of the box structure (63 percent of box length) being effective in carrying bending loads. Use of a centerwell in such a concept would result in more box structure being effective in bending. However, added weight would be required to beef up structural members around the well to keep stresses within material limits.

Section 3
RESULTS

The parent hull configurations and their geosyms were used as input to the computer program. Data calculated include predicted side load as well as weights and densities for box, strut, and hull primary structure of each configuration. Figure 2 shows the total primary structure of the single strut forms plotted against side load/displacement. The upper boundary on each band is the thin strut curve and the lower boundary is the thick strut curve. Figure 3 is a similar plot for the multistrut forms. The circles on both plots represent the predicted side loads for the different configurations.

For single strut forms, predicted side load was calculated as:

$$\text{side load/displacement} = (-0.5 + LBT) \times D$$

Where

$$L = 0.511 + 0.0038 \times (\text{strut length})^2/(\text{Displacement})^{2/3}$$

$$B = 0.9582 + 0.0025 \times (\text{strut CL separation})^2/(\text{Displacement})^{2/3}$$

$$T = 0.3245 + 0.1905 \times (\text{draft})^2/(\text{Displacement})^{2/3}$$

$$D = 1.43 - 0.0995 \times \text{Ln}(\text{Displacement}/1000)$$

The corresponding multistrut equation is:

$$\text{side load/displacement} = LBTD$$

Where

$$L = 0.5449 + 0.0215 \times (\text{FWD STRUT LENGTH} + \text{AFT STRUT LENGTH})^2/4 \times (\text{Displacement})^{2/3}$$

$$B = 0.951 + 0.0006 \times (\text{strut CL separation})^2/(\text{Displacement})^{2/3}$$

$$T = 0.7731 + 0.0696 \times (\text{Draft})^2/(\text{Displacement})^{2/3}$$

$$D = 0.3707 - 0.0282 \times \text{LN}(\text{Displacement}/1000)$$

Clearly in all cases, side loads have negligible effect on the structures of small ships for the range of side load investigated. At 2,000 tons the curves are flat. At 5,000 tons, structural weight increases for side loads greater than about one times displacement. For larger displacements, structural weight increases are required for smaller side loads. This trend is due to the assumption that the same minimum scantlings are used for all sizes.

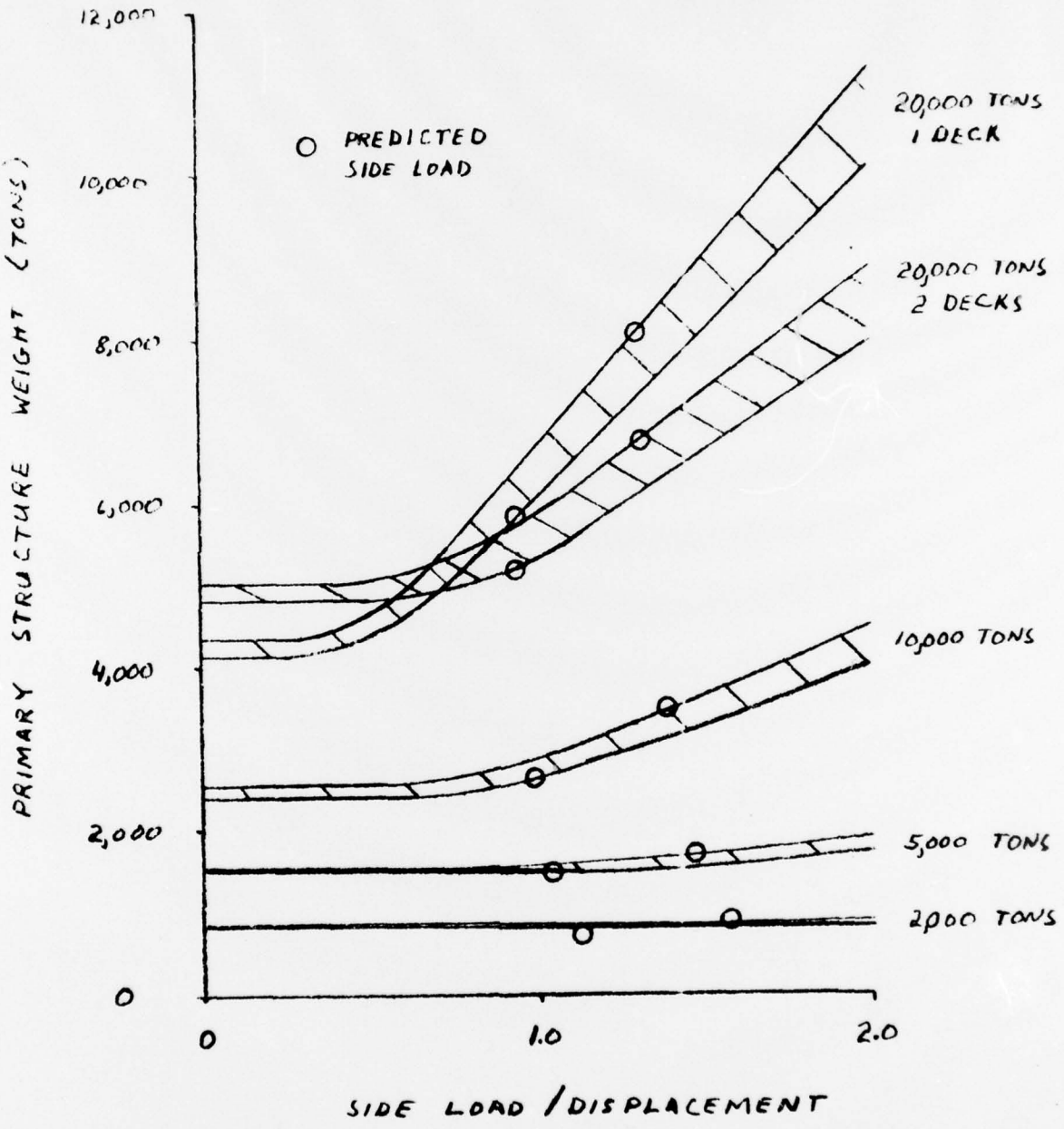


FIGURE 2

SINGLE STRUT PRIMARY STRUCTURE WEIGHT VERSUS SIDE FORCE / DISPLACEMENT

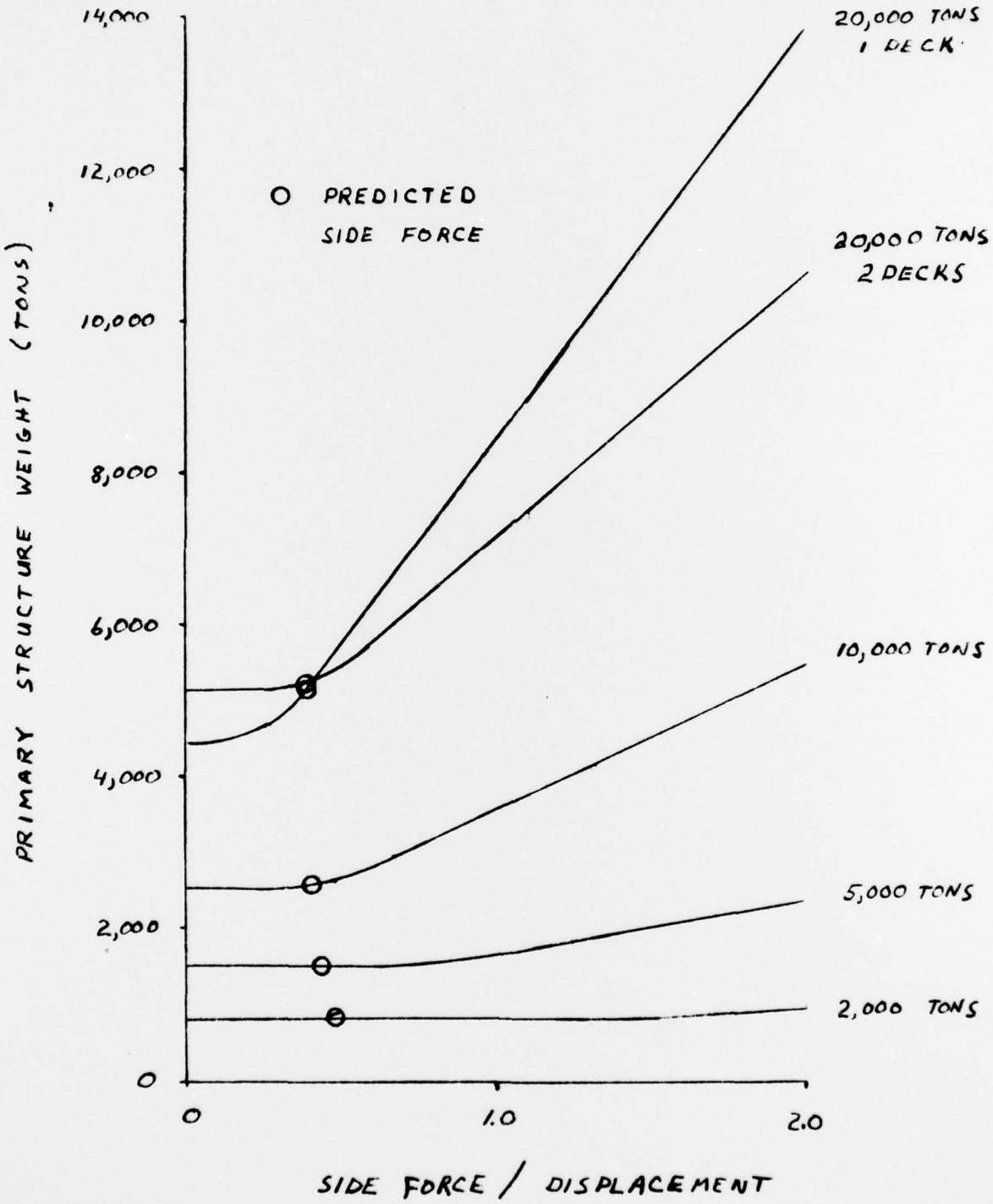


FIGURE 3
MULTI STRUT PRIMARY STRUCTURE WEIGHT
VERSUS SIDE LOAD / DISPLACEMENT

The single strut curves (Figure 2) show that the thick strut form is generally lighter than the thin strut from. This is particularly true for the larger sizes where the effects of the thin struts higher predicted side load are amplified by the lower structural efficiency of the thin struts.

Figure 2 also shows that the structure of large ships with two decks will probably be lighter than similar single deck ships. This trend is due to the greater structural efficiency of the deeper two deck boxes. The cross-over for 20,000 ton forms occurs for a side load of about 0.75 times displacement. Predicted side loads for both single strut forms are greater than this amount.

Comparison of the curves in Figure 2 and Figure 3 shows that the structural weights of the single strut and multi strut forms studied are generally similar. The multi strut curves show a side load dependence at somewhat lower values than the single strut curves. However, the predicted side loads are somewhat lower for the multi strut forms. As a result, the multi strut structural weights are roughly comparable to those of the thick single strut forms and somewhat lighter than the thin single strut weights. For the 2000 ton forms, no significant structural weight differences can be observed.

The data used to develop Figures 2 and 3 and the hull, strut, and box structural weight and density have been tabulated in Appendix A.

Section 4
CONCLUSIONS AND RECOMMENDATIONS

The data generated cannot be used to determine structural weight for a real design. However, conclusions regarding trends and generalities which can be reached are:

a. Independent trade-offs of seakeeping performance, resistance, or structural weight will be inconclusive.

b. Dynamic side loads are more important for large ships than for small ships.

c. Ships with long thin struts will have heavier structure than similar ships with short thick struts.

Also, several recommendations can be made based on the experience gained during this study.

a. Validity of existing side load algorithms should be ascertained for long slender forms.

b. Structural studies should eventually address:

(1) the amount of effective box material in bending for realistic box/strut combinations,

(2) the amount of effective strut material in bending for realistic strut shapes and sizes.

c. Design methods for wells should eventually be developed.

d. Structural design methodology for complex hull shapes eventually should be developed.

References

1. Kennell, C. and Anderson, T., "Small Waterplane Area Twin Hull (SWATH) Combatant Ship Parametric Study," NAVSEC Report 6114-048-78 dated September 1978

APPENDIX A

STRUCTURAL WEIGHT DATA

XL,DIALM,CP,TD,AG,ALUMS 276.000 12.670 .700 1.750 20.000 1.000
XLS,XTNVS,CWP,STGAP 198.000 7.580 .750
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3) 195.000 62.300 4.000 10.000 0.000 0.000
BOX,STRUT,HULL,TOTAL VOLUME= 170079. 66410. 48717. 285214.
DISP= 2003. PREDICTED SIDE LOAD= 1.124

SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	5.213	5.213	5.213	5.213	5.213	5.213	5.213	5.213	5.213
STRUT DENSITY	8.530	8.530	8.530	8.530	8.553	8.630	8.706	8.859	9.113
HULL DENSITY	8.055	8.055	8.055	8.055	8.055	8.055	8.055	8.055	8.055
TOTAL DENSITY	6.471	6.471	6.471	6.471	6.476	6.494	6.512	6.547	6.606
BOX WEIGHT	395.784	395.784	395.784	395.784	395.784	395.784	395.784	395.784	395.784
STRUT WEIGHT	252.922	252.922	252.922	252.922	253.613	255.875	258.136	262.667	270.220
HULL WEIGHT	175.177	175.177	175.177	175.177	175.177	175.177	175.177	175.177	175.177
TOTAL WEIGHT	823.882	823.882	823.882	823.882	824.573	826.835	829.097	833.627	841.180

XL,DIALM,CP,TD,AG,ALUMS 174.000 17.200 .700 1.750 20.000 1.000
XLS,XTNVS,CWP,STGAP 268.000 10.300 .750
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3) 265.000 84.500 4.000 10.000 0.000 0.000
BOX,STRUT,HULL,TOTAL VOLUME= 313495. 136226. 121660. 571380.
DISP= 5002. PREDICTED SIDE LOAD= 1.045

SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	5.063	5.063	5.063	5.063	5.063	5.246	5.547	5.846	6.215
STRUT DENSITY	6.671	6.671	6.671	6.681	6.789	7.044	7.390	7.776	8.188
HULL DENSITY	7.190	7.190	7.190	7.190	7.190	7.190	7.190	7.190	7.190
TOTAL DENSITY	5.899	5.899	5.899	5.902	5.927	6.086	6.336	6.592	6.893
BOX WEIGHT	708.584	708.584	708.584	708.584	708.584	734.128	776.274	818.096	869.809
STRUT WEIGHT	405.681	405.681	405.681	406.310	412.850	428.376	449.426	472.925	497.954
HULL WEIGHT	390.493	390.493	390.493	390.493	390.493	390.493	390.493	390.493	390.493
TOTAL WEIGHT	1504.758	1504.758	1504.758	1505.387	1511.927	1552.997	1616.193	1681.514	1758.255

XL,DIALM,CP,TD,AG,ALUMS 471.000 21.700 .700 1.750 20.000 1.000
XLS,XTNVS,CWP,STGAP 337.000 12.950 .750
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3) 334.000 106.400 4.000 10.000 0.000 0.000
BOX,STRUT,HULL,TOTAL VOLUME= 497526. 237464. 243870. 978860.
DISP= 10012. PREDICTED SIDE LOAD= .985

SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	4.952	4.952	4.952	5.205	5.730	6.710	8.177	9.644	11.111
STRUT DENSITY	5.543	5.543	5.543	5.664	6.035	6.483	6.970	7.460	8.003
HULL DENSITY	6.773	6.773	6.773	6.773	6.773	6.773	6.773	6.773	6.773
TOTAL DENSITY	5.549	5.549	5.549	5.707	6.064	6.671	7.535	8.404	9.276
BOX WEIGHT	1099.927	1099.927	1099.927	1156.002	1272.660	1490.384	1816.194	2142.034	2467.813
STRUT WEIGHT	587.606	587.606	587.606	600.419	639.758	687.300	738.945	792.933	848.386
HULL WEIGHT	737.418	737.418	737.418	737.418	737.418	737.418	737.418	737.418	737.418
TOTAL WEIGHT	2424.950	2424.950	2424.950	2493.839	2649.836	2915.102	3292.556	3672.354	4053.617

XL,DIALM,CP,TD,AG,ALUMS 593.000 27.290 .700 1.750 20.000 1.000
XLS,XTNVS,CWP,STGAP 426.000 16.300 .750
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3) 420.000 134.100 4.000 10.000 0.000 0.000
BOX,STRUT,HULL,TOTAL VOLUME= 788508. 421497. 485681. 1695606.
DISP= 19969. PREDICTED SIDE LOAD= .935

SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	4.938	4.938	5.466	7.116	9.701	12.285	14.871	17.456	20.041
STRUT DENSITY	5.077	5.077	5.102	5.551	6.105	6.700	7.316	7.943	8.573
HULL DENSITY	6.798	6.798	6.798	6.798	6.798	6.798	6.798	6.798	6.798
TOTAL DENSITY	5.505	5.505	5.757	6.636	7.976	9.326	10.681	12.039	13.398
BOX WEIGHT	1738.283	1738.283	1924.089	2505.011	3414.917	4324.822	5234.728	6144.634	7054.540
STRUT WEIGHT	955.241	955.241	960.810	1044.503	1148.691	1260.724	1376.661	1494.686	1613.160
HULL WEIGHT	1473.799	1473.799	1473.799	1473.799	1473.799	1473.799	1473.799	1473.799	1473.799
TOTAL WEIGHT	4167.323	4167.323	4357.898	5023.312	6037.406	7059.346	8085.208	9113.119	10141.498

XL,DIALM,CP,TD,AG,ALUMS 593.000 27.290 .700 1.750 20.000 1.000
XLS,XTNVS,CWP,STGAP 426.000 16.300 .750
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3) 420.000 134.100 4.000 10.000 10.000 0.000
BOX,STRUT,HULL,TOTAL VOLUME= 1351728. 421497. 485681. 2258826.
DISP= 19965. PREDICTED SIDE LOAD= .935

SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	3.952	3.952	3.952	4.894	4.407	5.355	6.281	7.207	8.134
STRUT DENSITY	5.077	5.077	5.102	5.551	6.105	6.700	7.316	7.943	8.573
HULL DENSITY	6.798	6.798	6.798	6.798	6.798	6.798	6.798	6.798	6.798
TOTAL DENSITY	4.774	4.774	4.778	4.948	5.238	5.916	6.586	7.257	7.928
BOX WEIGHT	2384.725	2384.725	2384.725	2470.819	2659.401	3231.671	3790.506	4349.341	4908.176
STRUT WEIGHT	955.241	955.241	960.810	1044.503	1148.691	1260.724	1376.661	1494.686	1613.160
HULL WEIGHT	1473.799	1473.799	1473.799	1473.799	1473.799	1473.799	1473.799	1473.799	1473.799
TOTAL WEIGHT	4813.765	4813.765	4818.534	4989.121	5281.891	5966.194	6640.986	7317.826	7995.135

STRUCTURAL WEIGHT DATA
THICK SINGLE STRUT

XL,DIALM,CP,TD,AG,ALUMS 273.000 13.170 .700 1.750 20.000 1.000
XLS,XTNVS,CWP,STGAP 222.000 5.460 .750
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DISP= 2001. PREDICTED SIDE LOAD= 1.567

SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	5.163	5.163	5.163	5.163	5.163	5.163	5.163	5.163	5.163
STRUT DENSITY	11.244	11.244	11.244	11.244	11.315	11.410	11.737	12.191	12.705
HULL DENSITY	7.927	7.927	7.927	7.927	7.927	7.927	7.927	7.927	7.927
TOTAL DENSITY	6.830	6.830	6.830	6.830	6.843	6.861	6.924	7.010	7.108
BOX WEIGHT	410.686	410.686	410.686	410.686	410.686	410.686	410.686	410.686	410.686
STRUT WEIGHT	272.689	272.689	272.689	272.689	274.398	276.696	284.648	295.642	308.105
HULL WEIGHT	184.261	184.261	184.261	184.261	184.261	184.261	184.261	184.261	184.261
TOTAL WEIGHT	867.636	867.636	867.636	867.636	869.344	871.643	879.586	890.589	903.051

XL,DIALM,CP,TD,AG,ALUMS 370.000 17.860 .700 1.750 20.000 1.000
XLS,XTNVS,CWP,STGAP 302.000 7.400 .750
XLENG,WIDTH,HINNR,DECK(1),DECK(2),DECK(3) 255.000 91.800 4.000 10.000 0.000 0.000
BOX,STRUT,HULL,TOTAL VOLUME= 327726. 111947. 129772. 569445.
DISP= 4991. PREDICTED SIDE LOAD= 1.470

SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	4.989	4.989	4.989	4.989	4.989	5.250	5.566	5.877	6.190
STRUT DENSITY	8.653	8.653	8.653	8.731	9.077	9.648	10.299	10.997	11.723
HULL DENSITY	7.028	7.028	7.028	7.028	7.028	7.028	7.028	7.028	7.028
TOTAL DENSITY	6.174	6.174	6.174	6.189	6.257	6.520	6.830	7.146	7.641
BOX WEIGHT	729.934	729.934	729.934	729.934	729.934	768.048	814.389	859.809	949.468
STRUT WEIGHT	432.448	432.448	432.448	436.356	453.649	482.166	514.714	549.564	585.854
HULL WEIGHT	407.177	407.177	407.177	407.177	407.177	407.177	407.177	407.177	407.177
TOTAL WEIGHT	1569.559	1569.559	1569.559	1573.467	1590.759	1657.391	1736.280	1816.549	1942.498

XL,DIALM,CP,TD,AG,ALUMS 466.000 22.500 .700 1.750 20.000 1.000
XLS,XTNVS,CWP,STGAP 380.000 9.330 .750
XLENG,WIDTH,HINNR,DECK(1),DECK(2),DECK(3) 321.000 115.700 4.000 10.000 0.000 0.000
BOX,STRUT,HULL,TOTAL VOLUME= 519956. 196105. 259399. 975460.
DISP= 9975. PREDICTED SIDE LOAD= 1.387

SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	4.992	4.992	4.992	5.329	5.882	7.141	8.686	10.231	11.775
STRUT DENSITY	7.127	7.127	7.139	7.564	8.274	9.074	9.919	10.790	11.677
HULL DENSITY	6.870	6.870	6.870	6.870	6.870	6.870	6.870	6.870	6.870
TOTAL DENSITY	5.921	5.921	5.923	6.188	6.625	7.457	8.451	9.449	10.451
BOX WEIGHT	1158.817	1158.817	1158.817	1236.888	1365.295	1657.497	2016.119	2374.741	2733.363
STRUT WEIGHT	623.948	623.948	625.032	662.190	724.381	794.430	868.406	944.628	1022.252
HULL WEIGHT	795.538	795.538	795.538	795.538	795.538	795.538	795.538	795.538	795.538
TOTAL WEIGHT	2578.295	2578.295	2579.387	2694.617	2885.215	3247.465	3680.063	4114.907	4551.153

XL,DIALM,CP,TD,AG,ALUMS 587.000 28.340 .700 1.750 20.000 1.000
XLS,XTNVS,CWP,STGAP 479.000 11.750 .750
XLENG,WIDTH,HINNR,DECK(1),DECK(2),DECK(3) 404.000 146.000 4.000 10.000 0.000 0.000
BOX,STRUT,HULL,TOTAL VOLUME= 825776. 348290. 518388. 1692455.
DISP= 19936. PREDICTED SIDE LOAD= 1.309

SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	4.882	4.882	5.517	7.508	10.242	12.976	15.710	18.444	21.178
STRUT DENSITY	6.311	6.311	6.596	7.449	8.423	9.447	10.488	11.533	12.580
HULL DENSITY	6.840	6.840	6.840	6.840	6.840	6.840	6.840	6.840	6.840
TOTAL DENSITY	5.776	5.776	6.144	7.291	8.825	10.370	11.918	13.467	15.017
BOX WEIGHT	1799.743	1799.743	2033.702	2767.645	3775.536	4783.426	5791.316	6799.206	7807.097
STRUT WEIGHT	981.284	981.284	1025.552	1158.157	1309.722	1468.872	1630.822	1793.262	1955.971
HULL WEIGHT	1582.937	1582.937	1582.937	1582.937	1582.937	1582.937	1582.937	1582.937	1582.937
TOTAL WEIGHT	4363.964	4363.964	4642.191	5508.740	6668.196	7835.235	9005.076	10175.406	11346.005

XL,DIALM,CP,TD,AG,ALUMS 587.000 28.340 .700 1.750 20.000 1.000
XLS,XTNVS,CWP,STGAP 479.000 11.750 .750
XLENG,WIDTH,HINNR,DECK(1),DECK(2),DECK(3) 404.000 146.000 4.000 10.000 10.000 0.000
BOX,STRUT,HULL,TOTAL VOLUME= 1415616. 348290. 518388. 2282295.
DISP= 19938. PREDICTED SIDE LOAD= 1.309

SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	3.896	3.896	3.896	4.094	4.579	5.559	6.537	7.515	8.493
STRUT DENSITY	6.311	6.311	6.596	7.449	8.423	9.447	10.488	11.533	12.580
HULL DENSITY	6.840	6.840	6.840	6.840	6.840	6.840	6.840	6.840	6.840
TOTAL DENSITY	4.933	4.933	4.976	5.230	5.679	6.443	7.209	7.975	8.741
BOX WEIGHT	2461.954	2461.954	2461.954	2587.429	2894.051	3513.136	4131.225	4749.314	5367.403
STRUT WEIGHT	981.284	981.284	1025.552	1158.157	1309.722	1468.872	1630.822	1793.262	1955.971
HULL WEIGHT	1582.937	1582.937	1582.937	1582.937	1582.937	1582.937	1582.937	1582.937	1582.937
TOTAL WEIGHT	5026.176	5026.176	5070.443	5328.523	5786.711	6564.945	7344.984	8125.513	8906.311

STRUCTURAL WEIGHT DATA
THIN SINGLE STRUT

XL,DIALM,CP,TD,AG,ALUMS 249.000 15.650 .600 1.620 20.000 1.000
XLS,XTNVS,CWP,STGAP 76.000 4.840 .880
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3) 161.000 81.000 4.000 10.000 0.000 0.000
BOX,STRUT,HULL,TOTAL VOLUME= 182574. 38459. 57478. 278511.
DISP= 2001. PREDICTED SIDE LOAD= .478

SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	5.177	5.177	5.177	5.177	5.177	5.276	5.462	5.639	5.807
STRUT DENSITY	10.629	10.629	10.659	10.727	11.039	11.446	11.899	12.378	12.875
HULL DENSITY	8.084	8.084	8.084	8.084	8.084	8.084	8.084	8.084	8.084
TOTAL DENSITY	6.530	6.530	6.534	6.543	6.587	6.707	6.892	7.074	7.253
BOX WEIGHT	421.966	421.966	421.966	421.966	421.966	430.000	445.205	459.573	473.347
STRUT WEIGHT	182.497	182.497	183.088	184.183	189.535	196.514	204.294	212.530	221.052
HULL WEIGHT	207.437	207.437	207.437	207.437	207.437	207.437	207.437	207.437	207.437
TOTAL WEIGHT	811.899	811.899	812.403	813.586	818.937	833.951	856.935	879.540	901.836

XL,DIALM,CP,TD,AG,ALUMS 338.000 21.240 .600 1.620 20.000 1.000
XLS,XTNVS,CWP,STGAP 103.000 6.570 .880
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3) 219.000 110.000 4.000 10.000 0.000 0.000
BOX,STRUT,HULL,TOTAL VOLUME= 337260. 79009. 143713. 559982.
DISP= 5002. PREDICTED SIDE LOAD= .442

SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	4.958	4.958	4.958	5.276	5.734	6.807	7.879	8.952	10.024
STRUT DENSITY	8.245	8.245	8.318	8.735	9.258	9.823	10.410	11.008	11.610
HULL DENSITY	7.343	7.343	7.343	7.343	7.343	7.343	7.343	7.343	7.343
TOTAL DENSITY	6.034	6.034	6.044	6.295	6.644	7.370	8.099	8.829	9.560
BOX WEIGHT	746.520	746.520	746.520	794.435	863.364	1024.842	1186.320	1347.798	1509.276
STRUT WEIGHT	290.823	290.823	293.405	308.098	326.540	346.481	367.173	388.283	409.511
HULL WEIGHT	471.085	471.085	471.085	471.085	471.085	471.085	471.085	471.085	471.085
TOTAL WEIGHT	1508.428	1508.428	1511.011	1573.618	1660.989	1842.408	2024.578	2207.166	2389.871

XL,DIALM,CP,TD,AG,ALUMS 426.000 26.750 .600 1.620 20.000 1.000
XLS,XTNVS,CWP,STGAP 130.000 8.270 .880
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3) 275.000 138.000 4.000 10.000 0.000 0.000
BOX,STRUT,HULL,TOTAL VOLUME= 531300. 138451. 287295. 957045.
DISP= 10002. PREDICTED SIDE LOAD= .416

SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	4.933	4.933	5.453	7.090	8.978	10.866	12.755	14.643	16.531
STRUT DENSITY	6.748	6.748	7.085	7.681	8.335	9.006	9.679	10.354	11.030
HULL DENSITY	7.399	7.399	7.399	7.399	7.399	7.399	7.399	7.399	7.399
TOTAL DENSITY	5.936	5.936	6.273	7.268	8.411	9.556	10.702	11.848	12.994
BOX WEIGHT	1170.144	1170.144	1293.423	1681.649	2129.511	2577.373	3025.235	3473.097	3920.959
STRUT WEIGHT	417.111	417.111	437.909	474.773	515.145	556.636	598.273	639.976	681.717
HULL WEIGHT	948.976	948.976	948.976	948.976	948.976	948.976	948.976	948.976	948.976
TOTAL WEIGHT	2536.231	2536.231	2680.308	3105.398	3593.632	4082.985	4572.483	5062.049	5551.652

XL,DIALM,CP,TD,AG,ALUMS 536.000 33.700 .600 1.620 20.000 1.000
XLS,XTNVS,CWP,STGAP 164.000 10.420 .880
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3) 347.000 174.000 4.000 10.000 0.000 0.000
BOX,STRUT,HULL,TOTAL VOLUME= 845292. 245988. 573714. 1664994.
DISP= 19983. PREDICTED SIDE LOAD= .396

SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	4.869	5.253	8.070	11.421	14.771	18.121	21.472	24.822	28.172
STRUT DENSITY	6.033	6.075	6.710	7.459	8.220	8.983	9.747	10.511	11.275
HULL DENSITY	7.726	7.726	7.726	7.726	7.726	7.726	7.726	7.726	7.726
TOTAL DENSITY	6.035	6.227	7.751	9.562	11.375	13.189	15.003	16.817	18.631
BOX WEIGHT	1844.921	1982.468	3045.394	4309.684	5573.974	6838.264	8102.554	9366.844	10631.134
STRUT WEIGHT	662.526	667.095	736.911	819.133	902.686	986.460	1070.328	1154.246	1238.193
HULL WEIGHT	1978.742	1978.742	1978.742	1978.742	1978.742	1978.742	1978.742	1978.742	1978.742
TOTAL WEIGHT	4486.189	4628.305	5761.048	7187.559	8455.403	9803.466	11151.625	12499.833	13848.070

XL,DIALM,CP,TD,AG,ALUMS 536.000 33.700 .600 1.620 20.000 1.000
XLS,XTNVS,CWP,STGAP 164.000 10.420 .880
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3) 347.000 174.000 4.000 10.000 10.000 0.000
BOX,STRUT,HULL,TOTAL VOLUME= 1449072. 245988. 573714. 2268774.
DISP= 19983. PREDICTED SIDE LOAD= .396

SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	3.903	3.903	4.217	5.448	6.642	7.836	9.030	10.224	11.418
STRUT DENSITY	6.033	6.075	6.710	7.459	8.220	8.983	9.747	10.511	11.275
HULL DENSITY	7.726	7.726	7.726	7.726	7.726	7.726	7.726	7.726	7.726
TOTAL DENSITY	5.100	5.105	5.375	6.242	7.087	7.932	8.778	9.623	10.469
BOX WEIGHT	2524.672	2524.672	2727.905	3524.354	4296.738	5069.106	5841.482	6613.857	7386.233
STRUT WEIGHT	662.526	667.095	736.911	819.133	902.686	986.460	1070.328	1154.246	1238.193
HULL WEIGHT	1978.742	1978.742	1978.742	1978.742	1978.742	1978.742	1978.742	1978.742	1978.742
TOTAL WEIGHT	5165.948	5170.509	5443.559	6322.229	7178.158	8034.308	8890.552	9746.846	10603.169

STRUCTURAL WEIGHT DATA
MULTI STRUT

DISTRIBUTION:
DDC (3)
DTNSRDC (Codes 117 & 1730)
NAVSEA (SEA 0322)
NAVSEC (SEC 6110)
(SEC 6110A)
(SEC 6114) (20)
(SEC 6128)
(SEC 6136)