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ROUGH WATER PERFORMANCE OF HIGH LENGTH TO BEAM RATIO PLANING BOATS

DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Maryland 20084

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ROUGH WATER PERFORMANCE OF HIGH LENGTH TO BEAM RATIO PLANING BOATS

by

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and

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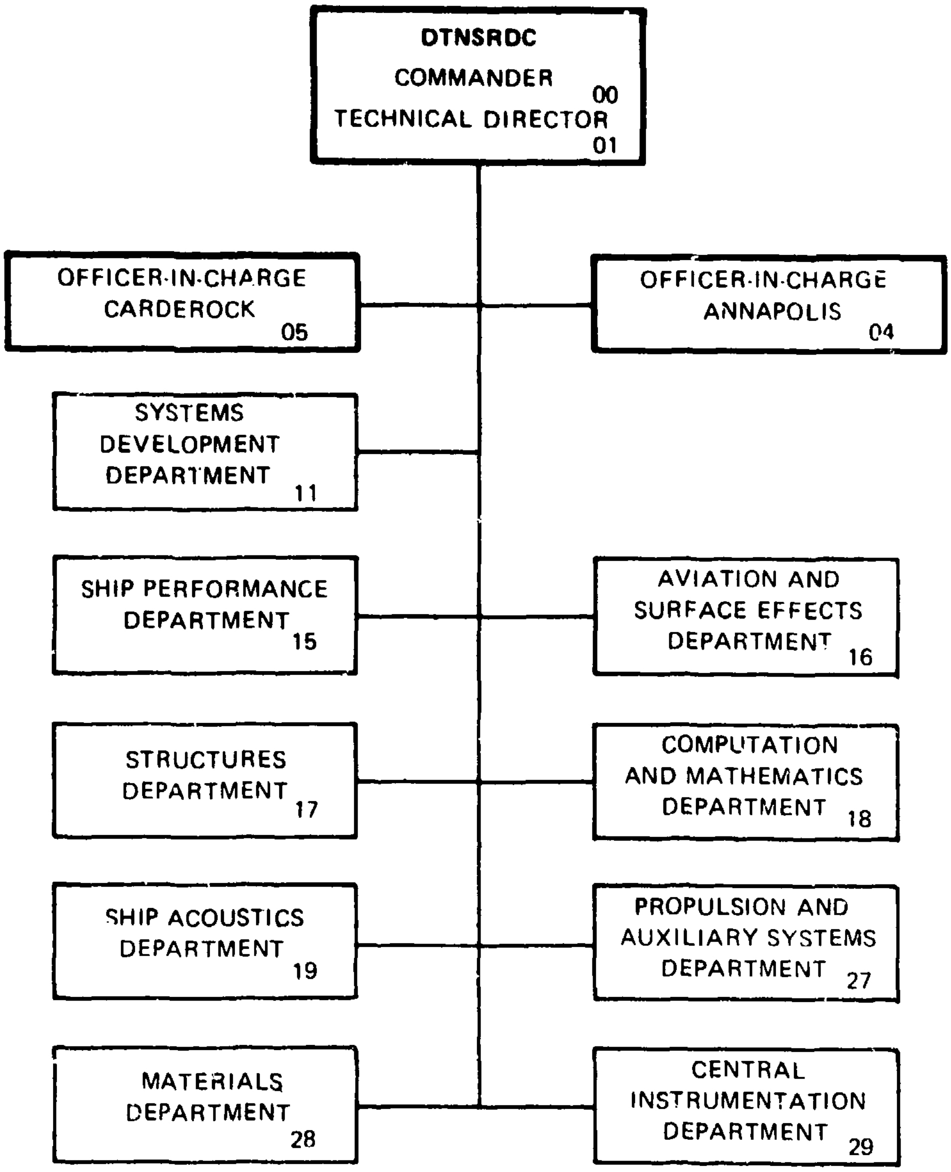

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Experiments were conducted in waves with several constant deadrise models to assess the rough water performance of high length to beam ratio planing craft. Several models with L/b = 7 and one with L/b = 9 were run in waves to determine the effects on performance of basic design parameters such as speed length ratio, loading coefficient, wave height to beam ratio, deadrise angle, trim angle and length to beam ratio. Charts have been prepared for estimating the pitch and heave motions, vertical accelerations and added resistance in

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NOTATION

b	Beam of planing boat
C_Δ	Load coefficient, Δ/wb^3
d	Rise of center of gravity in smooth water
g	Acceleration of gravity
$H_{1/3}$	Significant wave height
h	Amplitude of CG excursion from mean
$\bar{h}$	Average value of h
$h_{1/3}$	Average of 1/3 highest h values (significant value)
$h_{1/10}$	Average of 1/10 highest h values
h_{DC}	Mean vertical position of tow point in waves relative to zero speed floating position in calm water
k	Pitch gyradius, in percent of length
L	Overall hull length
LCG	Longitudinal center of gravity, percent L from stern
R_{aw}	Added resistance in waves
V	Horizontal speed
VCG	Vertical center of gravity, height above keel
$V/\sqrt{L}$	Speed length ratio, knots/ (ft) $^{1/2}$
w	Specific weight of water
β	Deadrise angle in degrees
Δ	Hull displacement
η_{Bow}	Bow vertical acceleration in gs
η_{CG}	CG vertical acceleration in gs
η_{stern}	Stern vertical acceleration in gs
θ	Amplitude of pitch motion in degrees relative to mean
$\bar{\theta}$	Average value of θ
$\theta_{1/3}$	Average of 1/3 highest θ values
$\theta_{1/10}$	Average of 1/10 highest θ values
θ_{DC}	Mean pitch angle in degrees in waves relative to horizontal
τ	Trim angle of keel in degrees relative to horizontal (θ_{DC} in calm water)
τ_o	Static trim angle

ABSTRACT

Experiments were conducted in waves with several constant deadrise models to assess the rough water performance of high length to beam ratio planing craft. Several models with L/b = 7 and one with L/b = 9 were run in waves to determine the effects on performance of basic design parameters such as speed length ratio, loading coefficient, wave height to beam ratio, deadrise angle, trim angle and length to beam ratio. Charts have been prepared for estimating the pitch and heave motions, vertical accelerations and added resistance in waves of the high L/b craft. Two problems encountered with the models which may present obstacles in the design of high length to beam ratio craft were the extremely high impact loads as indicated by the high impact accelerations and, large quantities of water over the deck resulting from the bow plowing through wave crests.

ADMINISTRATIVE INFORMATION

The investigation was authorized by the Naval Sea Systems Command and funded under Task Area ZF - 43 - 421001.

INTRODUCTION

In anticipation of future trends in planing boat design, the data base used in characterizing the rough water performance of planing boats has been extended to include high length to beam ratios. The original data base was provided by Fridsma's[1] systematic study of constant deadrise prismatic models in irregular waves with length to beam ratios of 4,5, and 6. The present study has extended this data base to include length to beam ratios of 7 and 9.

Experiments were conducted in waves with several constant deadrise models to determine the effects on performance of several basic design parameters such as speed length ratio, loading coefficient, wave height to beam ratio, deadrise angle, trim angle and length to beam ratio. Charts were prepared which enable the designer to estimate the pitch, heave, vertical accelerations, and added drag in waves of a high L/b craft.

There did not appear to be any obvious advantages in the rough water performance of high length to beam ratio craft over more conventional length to beam ratios; in fact, the impact loads appear to be higher. The models utilized a constant deadrise parabolic bow and it is expected that a more conventional bow would have greatly reduced the slamming problem. Water over the deck, brought about by the models plowing through successive wave crests at high speed, also appeared to be a

[1]References listed on Page 13

potential problem. This was less of a problem on the L/b = 9 model than on the comparable L/b = 7 model; however, the bow impact accelerations of the L/b = 9 model were higher.

DESCRIPTION OF MODELS AND INSTRUMENTATION

The models used in these experiments were identical in form to those used by Fridsma[1] except for higher L/b ratios. Two models with L/b = 7 and deadrise angles of 10 and 30 degrees were constructed by the Davidson Laboratory under contract to the Center. The Davidson Laboratory also provided on loan to the Center an existing model with an L/b = 7 and deadrise angle of 20 degrees. A fourth model was constructed at the Center with an L/b = 9 and deadrise angle of 20 degrees. All models were fabricated out of aircraft type plywood and high density plastic foam (for the bow shape) to obtain lightweight rigid models appropriate for seaworthiness experiments. A thin plastic strip extending approximately 1 mm below the chine was attached to the sidewalls of the models to insure separation during planing. The model lines are shown in Figure 1 and photographs of all four models used in the experiments are shown in Figure 2.

The models were towed at constant speed by a lightweight strut consisting of a gimbaled heave staff that permitted the models freedom in pitch and heave. In order to accommodate the heave staff an aluminum rail was attached to each model which allowed for quick adjustment of the longitudinal position of the tow point and for quick adjustment of ballast weights to obtain the required trim and radius of gyration conditions. The vertical position of the tow point, which corresponded to the pitch axis, was fixed for each model at a point 0.39 beams above the keel. The vertical center of gravity varied with loading condition, but was always below the tow point. Table 1 lists the location of the vertical center of gravity (VCG) as a function of loading for all four models. Since the ballast weights were moved only along the rail parallel to the baseline, there was no significant change in VCG with trim angle.

Table 1 - VCG* Location

	VCG/b		
MODEL	C_Δ=0.8	C_Δ=1.0	C_Δ=1.2
β=10°, L/B=7	0.34	0.36	0.37
β=20°, L/B=7	0.36	0.37	0.38
β=30°, L/B=7	0.29	0.32	0.33
β=10°, L/B=9	-	0.36	0.37

*Expressed as fraction of beam

The radii of gyration of the unballasted models were determined by suspending each model in air from the pitch gymbal like a pendulum and measuring the period of free oscillations. Calculations of the radius of gyration from the period of free oscillations were made using the classical equations of a pendulum. The location of the corresponding center of gravity, which is also required for these computations, was obtained by applying a small moment to the suspended model and measuring the resulting static trim angle. The above results were used to compute the location of ballast weights along the model rail for the various experimental conditions in order to obtain a specified radius of gyration, or conversely, to compute the radius of gyration knowing the location of ballast weights. A radius of gyration equal to 25 percent ship length was originally specified for all conditions, but could not be achieved in the high displacement conditions.

Vertical accelerometers were installed in each model at the bow, stern, and center of gravity. The bow accelerometer was located 10 cm aft of the stem, the CG accelerometer was located above the pitch pivot point and the stern accelerometer was located 2.5 cm forward of the transom. The gages were force balance type with a range of 50 g and a natural frequency of 1000 Hz (Kistler Model 305A). Special Kistler signal conditioning equipment was used with the transducer.

Pitch and heave motions of the models were measured by potentiometer type transducers mounted on the heave staff or towing strut. A David W. Taylor Naval Ship Research and Development Center (DTNSRDC) designed block gage was also mounted on the strut to measure drag force. Wave height was measured by a sonic probe mounted on the carriage about 20 feet ahead of the model. The models forward of the tow strut were sealed at the deck by a thin sheet of clear plastic to prevent spray and water from entering the models. A lightweight movable breakwater also made of clear plastic was mounted on the models near the tow strut. The aft portions of the models were sealed with thin plastic sheet made of "ziploc bags" for quick access to the ballast weights and tow point attachment.

Data were recorded on an Interdata Model 70 digital computer for on line and off line processing. Vertical accelerations were recorded on analog tape with an Ampex PR 2200 recorder and converted to digital tape, or recorded directly on digital tape for off line processing by the Interdata. The pitch, heave, drag and wave tape height data were sampled at a rate of 75 samples per second after being passed through a 4 pole low pass Butterworth filter with a 15 Hz cutoff. The vertical accelerations were sampled at a rate of 2300 samples per second after being passed through a filter with a 1500 Hz cutoff. A Honeywell Visicorder and a Sanborn recorder were used to visually monitor the data during the experiments.

EXPERIMENTAL PROGRAM AND PROCEDURE

The experiments were conducted in irregular waves with significant wave height to beam ratios of 0.222,0.444, and 0.666, and at model speeds of 4.58.6.87, and 9.16 knots. Typical wave spectra are shown in Figure 3. The above speeds correspond to speed length ratios of 2, 3, and 4 for the models with an L/b ratio of 7 and slightly lower values for the model with an L/b of 9. Three displacement conditions corresponding to load coefficients of 0.8, 1.0, and 1.2 were examined on all models excluding the model with an L/b ratio of 9 which could not be trimmed properly at a C_Δ of 0.8. A trim angle of 3 degrees was used throughout the experiments except for the 10 degrees deadrise model which was also tested at trim angles of 2 and 4 degrees and the 30 degrees deadrise model which was also tested at a trim angle of 2 degrees (both at a load coefficient of 0.8). Early in the test program a judgment was made that running the models at trim angles other than 3 degrees presented an unacceptable risk of severely damaging the models in the high speed sea state conditions. On three occasions the model being tested, along with the towing apparatus were severely damaged. Speeds higher than those used in the program could not be run for the same reason, and in several instances, the high speed - sea state condition had to be aborted for the safety of the model and test equipment. Also, the 2 degrees trim angle condition resulted in higher calm water resistance than for either the 3 or 4 degrees trim conditions which were about equal for the 10 degrees deadrise model.

Several calm water runs were made prior to each series of wave runs to obtain the desired operating trim angle for a given speed and loading condition. Ballast weights were moved along the rail in the model to change the location of the longitudinal center of gravity (along with the tow point) until the proper calm water trim angle was obtained. The tow point was always located at the longitudinal center of gravity. This was verified by suspending the model in air by the pitch gymbal or tow point and assuring that the model hung in a balanced or level position. For any CG location, the corresponding location of the ballast weights required to obtain a specific radius of gyration was determined from calculations using information previously obtained for the unballasted model. A radius of gyration of 25 percent of the ship length was intended for all model experiments, but could not be realized in the light displacement conditions because of insufficient movable ballast weight. In these conditions the models were ballasted to obtain the specified calm water trim irrespective of the radius of gyration. Table 2 lists the model configurations that were used in the experiments including the radius of gyration.

Six passes were made for each condition to obtain approximately 100 samples of amplitude data to ensure adequate statistical analysis. Most of the data runs (approximately 75 percent) exceeded 100 samples with the highest number being about 300. The remaining data had less than 100 samples per run,with a few as low as 60 samples.

DATA ANALYSIS

PITCH AND HEAVE MOTIONS

In order to characterize the rough water performance of the models, a statistical analysis was performed on the amplitudes or peak values of the motions and accelerations to determine the significant values and other statistical parameters. The procedure followed in the case of the pitch and heave motions was first to determine the mean values of the time histories for each run and subtract these values from the corresponding data records so that the mean values became the zero reference for the amplitude measurements. The mean value of the pitch motion is the average change in attitude of the keel relative to the horizontal,and the mean value of the heave motion is the average change of the center of gravity in the vertical direction relative to the calm water floating position at zero speed. The amplitudes were determined by defining a cycle of motion as three consecutive zero crossings,and selecting the largest positive and negative values in the cycle. For the purpose of these experiments,the largest positive value in a cycle was defined as a crest and the largest negative value as a trough. This resulted in pitch bow up and heave down being defined as crests. (Note that this may differ from other conventions.) The crests and troughs collected from a run were sorted, and computations were made to determine various statistical parameters including the significant values and the average of the 1/10 highest values. These data are summarized in Table 3 for the pitch motion and in Table 4 for the heave motion.

The above analysis was performed on the Interdata Model 70 computer which also provided histograms of the data. An attempt was made to fit these histograms to various probability distribution functions. The pitch and heave data (both crests and troughs) for 14 selected runs were fitted to the Rayleigh, Weibull and

Generalized Gamma distribution functions, and a chi-squared goodness of fit test performed to determine the acceptability of each fit. The test was performed at the $\alpha = 0.05$ level of significance. A detailed explanation of the tests can be found in most textbooks on statistics (see Reference 2).

Approximately 52 percent of the histograms passed the acceptance test for a Rayleigh distribution and only slightly more (55 percent total) passed for a Weibull distribution. The Generalized Gamma distribution provided the most acceptance with 71 percent of the histograms passing. Unfortunately, the Generalized Gamma distribution, which requires three parameters to define, is considerably more complicated to use than the Rayleigh distribution. Using the much simpler Rayleigh distribution to characterize the experimental distribution may, in some instances, lead to errors of about 10 to 15 percent: however, this still may be acceptable for some engineering purposes.

ACCELERATIONS

The acceleration data were different in character from the motion data and required a slightly different analysis procedure. Time histories of the accelerations from most of these experiments consisted of impact spikes superimposed upon the rigid body accelerations. In spite of the rigid construction of the models, the impact spikes introduced hull vibrations whose frequencies were in the same range as those of the impact spikes. This presented a dilemma in that some of the vibrations could be falsely identified as impact spikes in the processing routine, and filtering the data to remove them would also remove part of the true impact signals. The alternative employed in the analysis involved an interactive graphic display with an individual in the analysis loop selecting each peak. Time histories of the accelerations were projected onto a Tektronix 4015 display terminal, and by aligning a cross hair in close proximity to an impact or peak and pressing an appropriate key, its value was identified and stored by the computer. Figure 4 shows a representative sample time history of acceleration as projected on the Tektronix screen. The small diamonds indicate those values selected for inclusion in the population of peak values. Both rigid body peaks and impact spikes which were measured with reference to the gage zero were included in the population. Accelerations in the direction opposite to the impact spikes were not analyzed. It should be recognized that the impact acceleration measurements are influenced to some degree by the hull elasticity and some account of this factor should be given in any design considerations.

The peak acceleration data, after being collected, were analyzed in a similar manner to the motion data and computations made of the significant values and other statistical parameters. These results are presented in Table 5 for bow, midship and stern accelerations.

An attempt was made to fit the acceleration data to the exponential distribution which Fridsma[1] had found, in his studies, to be a good fit for planing boat accelerations and a chi-squared goodness of fit test was applied to the acceleration data for 14 runs. The exponential distribution was found to be an acceptable fit for approximately 86 percent of the bow data, 67 percent of the stern data, but only for 30 percent of the CG data. It was further found that the exponential distribution provided a good fit to the acceleration data only when the data was composed mainly of impact spikes. This was primarily the case for the bow accelerations where an impact spike occurred nearly every cycle except in the very low speed-sea state conditions. In contrast the CG acceleration data contained a large number of rigid body peaks and this is reflected in the small number of acceptances. This was brought about by the nature of the impact phenomenon and the decision to include both impact spikes and rigid body peaks in the population. The impacts produced a large impulsive angular deceleration which resulted in a stern acceleration spike with opposite sign to that at the bow and a small CG acceleration spike. In many instances the spike at the CG was less than the corresponding rigid body peak. As a consequence, the rigid body accelerations were selected as the peak values in the cycle instead of the impact spikes and became a significant portion of the population. The rigid body accelerations would be expected to follow a distribution more closely resembling those of pitch and heave motions.

ADDED RESISTANCE IN WAVES

The added resistance in waves was obtained by subtracting the calm water resistance from the corresponding mean resistance measured in waves. Table 6 presents the added wave resistance obtained by averaging the values from six passes down the basin for each condition. Model resistance data was the most sensitive measurement made and perhaps subject to the most experimental error. An additional complication was experienced with the 20 degrees deadrise model (L/B = 7). A small strut was attached to the stern of the model to measure relative motions during the experiments at loading conditions of C_{Δ} = 1.0 and 1.2. The drag of the strut was larger than anticipated and may have affected the relationship between trim angle and LCG location while increasing the calm water drag.

PRESENTATION AND DISCUSSION OF EXPERIMENTAL RESULTS

In order to assist the designer in assessing the rough water performance of a high L/b craft, charts have been prepared for estimating the pitch and heave motions, vertical accelerations and added resistance in waves as a function of significant wave height to beam ratio, loading coefficient, speed length ratio and deadrise angle. A family of faired curves was developed for each set of data corresponding to a particular deadrise angle and speed length ratio,by fitting the experimental data to a polynomial which was cubic in wave height and quadratic in loading coefficient. In most instances the resulting curves passed exactly through the data spots; however, in some cases minor adjustments had to be made in order to more accurately reflect the data trend. Each family of faired curves was plotted on a single chart showing the variation of the parameter in question with the significant wave height to beam ratio and loading coefficient. The charts in Figure 5 present the significant values of pitch crests and troughs for the 10-degree deadrise model at a trim angle of 3 degrees and speed length ratios of 2, 3, and 4. Similar results are shown in Figure 6 for heave crests and troughs. Significant values of vertical acceleration (impact side only) for the same model are presented in Figure 7 and the added drag is presented in Figure 8. A corresponding set of data are presented in Figures 9 through 12 for the 20-degree deadrise angle model with L/b = 7 and in Figures 13 through 16 for the 30-degree deadrise model.

These charts can be used directly for interpolating results for any value of wave height to beam ratio between 0.2 and 0.7 and loading coefficient, C_{Δ}, from 0.8 to 1.2 at speed length ratios of 2, 3, or 4 and deadrise angles of 10, 20 or 30 degrees. A linear interpolation can be used for any value of speed length ratio or deadrise angle between those contained on the charts and the interpolation can be applied sequentially.

Since there was only a small amount of experimental data obtained at trim angles other than 3 degrees,no generalized method was developed for extrapolating the results on the charts to other operating trim angles. Also, no means have been derived for the extrapolating the results to higher length to beam ratios, but a higher length to beam ratio was examined in experiments using a 20-degree deadrise model with a length to beam ratio of 9. Although the gross trends were clearly demonstrated, the data were not considered sufficient to determine the precise variations with length beam ratio in the general case.

The charts not only provide a means of assessing the rough water performance of high L/b craft, but also show the effects of changes in basic hull parameters on this performance. Some of the broad trends in performance can be readily deduced from the charts and this has been incorporated into the discussion below along with other general observations and information not contained in the charts.

The three speed length ratios used in these experiments were selected to cover the broadest possible range of operation of high L/b planing craft. At $\frac{V}{\sqrt{L}} = 2$, the craft essentially operated in the displacement mode. At $\frac{V}{\sqrt{L}} = 3$, separation occurred along the chine with some side wetting near the stern and at $\frac{V}{\sqrt{L}} = 4$, separation occurred along the entire chine. In all cases, there was a clean break away of water behind the transom. At the higher speeds, a large portion of the bow rode out of the water except when pitching downward, during which time, a slam or water impact usually occurred.

The pitch motion decreased with increased speed while the added resistance in waves increased. There was no similar clear cut trend in heave, although it tended to be less at high speed in most cases. Bow acceleration did not show any consistent trend with speed and appeared to be a complex function of both speed and deadrise angle.

At high speed in high waves, there were a few occasions when the entire keel of the L/b = 7 models became completely unwetted while transiting between consecutive crests. A more serious problem encountered in these conditions was that of heavy spray and water spilling over the deck. This problem was sensitive to both trim angle and loading conditions as well as the speed.

Only a small number of experiments were conducted at trim angles other than 3 degrees; nevertheless, some insight into the gross effects of trim angle on performance can be deduced from these results. At a trim angle of 2 degrees, which was run with 10-and 30-degree deadrise models at $C_{\Delta} = 0.8$, the motion and vertical accelerations were substantially less than those obtained at a trim angle of 3 degrees. At 4 degrees of trim angle, which was run with the 10-degree deadrise model, the motions and accelerations in general were larger than those at 3 degrees of trim angle. Calm water resistance was highest at 2 degrees of trim angle. However, the corresponding added resistance in waves was about the same as for the 3 degrees of trim angle, except at $\frac{V}{\sqrt{L}} = 4$ in the high sea condition, where the 10-degrees deadrise model showed a large increase. There was no significant difference in the calm water resistance or added resistance in waves between the 3 degrees and 4 degrees of trim angle conditions.

Although the motions and accelerations were less at the 2 degrees of trim angle condition, the accompanying deck wetness problems were considered too severe at some of the high speed-sea state conditions for it to be a practical operating condition. At high speed, the bow of the L/b = 7 models tended to plunge or crash through consecutive wave crests, with large amounts of water spilling over the top of the deck. In the high sea condition at $\frac{V}{\sqrt{L}} = 4$, the 10-degree deadrise model was torn off the tow strut by the force of the water spilling over the deck. Experiments with the 30 degree deadrise model at 2 degrees of trim showed similar tendencies and experiments in the high sea condition could not be run either at $\frac{V}{\sqrt{L}} = 3$ or 4 because of the high risk of severely damaging the model and test appartatus. This was a major consideration in limiting the experiments to trim angles of 3 degrees where this problem did not appear to be quite as severe except at high loading conditions ($C_\Delta = 1.2$); here again experiments could not be conducted at the high speed condition in high waves. Because of this problem a portion of the charts shown in the figures for $\frac{V}{\sqrt{L}} = 4$ could not be completed. This region is indicated by a broken line on the charts and is defined as a bow wetness limit.

As might have been expected, the deadrise angle had the most pronounced effect upon the impact accelerations. The bow acceleration for the 10-degree deadrise model was more than twice that of the 30-degree model, with the 20-degree deadrise somewhere in between the two extremes. There were differences in the motions and added drag in waves, but they do not appear to be significant.

Experiments were conducted with an L/b = 9 model with 20-degree deadrise angle to establish an upper bound on the effects of increasing length to beam ratio. The results showed that although the differences in the motions were not large, the vertical accelerations for the L/b = 9 model were almost twice as high as for the L/b = 7 model at the same speed. The is probably the result of a higher water entry velocity at the bow of the L/b = 9 model because of its extra length. The added resistance in waves was less for the L/b = 9 model at the higher speeds and about the same at low speed. It was also noted that bow wetness was less with the higher L/b ratio and that experiments could be safely conducted at high speed in the heavy loading condition.

SUMMARY AND CONCLUSIONS

Experiments were conducted in waves with several constant deadrise models to assess the rough water performance of high length to beam ratio planing craft. Several models with L/b = 7 and one with L/b = 9 were run in waves to determine the effects on performance of basic design parameters such as speed length ratio, loading coefficient, wave height to beam ratio, deadrise angle, trim angle and length to beam ratio. Charts have been prepared for estimating the pitch and heave motions, vertical accelerations and added resistance in waves of high L/b craft.

Two problems encountered with the models which may present obstacles in the design of high length to beam ratio craft were the extremely high impact loads as indicated by the high impact accelerations, and large quantities of water over the deck resulting from the bow plowing through wave crests. Operating at trim angles necessary for planing resulted in a portion of the bow riding out of the water which was highly conducive to bow slamming. Also, increasing length to beam ratio for a given beam increased the vertical velocity at the bow because of the corresponding increase in the pitch lever arm. By employing a conventional bow in place of the constant deadrise parabolic bow used on the models, some reduction in the impact loading may be realized by achieving a smoother water entry.

At high speed, conditions existed where the model plowed through wave crests spilling large amounts of water over the deck. This occurred at a low trim angle ($\tau = 2^{o}$) for the lightly loaded conditions ($C_{\Delta} = 0.8$) and at a moderate trim angle ($\tau = 3^{o}$) for the heavily loaded conditions ($C_{\Delta} = 1.2$). These occurrences proved to be disastrous to the model on several occasions. The deck wetness and wave plow-in were somewhat less on the L/b = 9 model; however, as indicated previously, the bow impact accelerations increased. The full-scale vehicle with a more conventional bow and increased freeboard may be better able to recover from such events and, more than likely, would never be operated at such extreme conditions; nevertheless, water over the bow is still a major factor to be considered in any design.

The advantages of the high length to beam ratio craft (from a hydrodynamic point of view) may lie primarily in its resistance characteristics. There does not appear to be any obvious advantages in its overall rough water performance over that of moderate length to beam ratio craft, in fact the impact acceleration and loads appear to be higher. Nevertheless, there may be special applications for which high length to beam planing craft are preferable to conventional length to beam ratio or displacement type craft.

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TABLE 2

MODEL CONFIGURATIONS

Symbol	L/b	β	C_Δ	LCG	τ	k	$V/\sqrt{L}$	$d/_b$	τ_o
A	7	10	0.8	65.5	3.0	28.0	2.00	-.011*	----
B	"	"	"	65.1	"	27.0	3.00	.014	----
C	"	"	"	62.5	"	26.0	4.00	.056	1.10
D	"	"	1.0	60.7	"	25.4	2.00	-.021	1.41
E	"	"	"	59.0	"	25.3	3.00	.013	1.40
F	"	"	"	58.5	"	25.3	4.00	.035	0.97
G	"	"	1.2	59.5	"	23.8	2.00	-.020	1.34
H	"	"	"	58.5	"	24.3	3.00	.015	1.12
I	"	"	"	56.7	"	24.1	4.00	.041	0.72
J	"	"	0.8	59.4	2.0	24.0	2.00	-.011	0.70
K	"	"	"	57.5	"	24.0	3.00	.010	0.49
L	"	"	"	56.3	"	23.0	4.00	.032	0.28
M	"	"	"	69.0	4.0	30.0	2.00	-.008	2.13
N	"	"	"	67.1	"	29.0	3.00	.032	1.80
O	"	"	"	64.7	"	27.0	4.00	.069	1.50
P	"	20	"	64.4	3.0	25.3	2.00	-.015	1.53
Q	"	"	"	64.4	"	25.3	3.00	.016	1.53
R	"	"	"	64.4	"	25.3	4.00	.036	1.30
S	"	"	1.0	61.4	"	25.3	2.00	.001	1.43
T	"	"	"	61.1	"	24.9	3.00	.001	1.36
U	"	"	"	59.1	"	24.3	4.00	.001	1.06
V	7	20	1.2	59.4	3.0	24.3	2.00	.001	1.30
W	"	"	"	58.3	"	25.1	3.00	.003	1.12
X	"	"	"	56.7	"	25.0	4.00	.001	0.91
Y	9	"	1.0	61.9	"	24.8	1.56	.002	1.95
Z	"	"	"	59.3	"	24.6	2.33	.004	1.86
AA	"	"	"	60.0	"	24.4	3.11	.003	1.75
BB	"	"	1.2	67.9	"	23.7	1.56	-.020	----
CC	"	"	"	67.6	"	23.8	2.37	-.009	1.82

*Negative sign indicates sinkage of CG

TABLE 2

MODEL CONFIGURATIONS (CONTINUED)

Symbol	L/b	β	C_Δ	LCG	τ	k	$V/\sqrt{L}$	$d/_b$	τ_o
DD	9	20	1.2	67.1	3.0	24.2	3.11	.034	1.76
EE	7	30	0.8	60.6	"	24.0	2.00	-.013	1.90
FF	"	"	"	59.9	"	24.0	3.00	-.007	1.45
GG	"	"	"	58.7	"	23.0	4.00	.037	1.60
HH	"	"	1.0	62.7	"	25.3	2.00	-.016	1.60
II	"	"	"	62.2	"	25.4	3.00	.010	1.53
JJ	"	"	"	61.2	"	25.4	4.00	.030	1.34
KK	"	"	1.2	60.3	"	25.0	2.00	-.020	1.30
LL	"	"	"	60.3	"	25.0	3.00	.011	1.30
MM	"	"	"	58.7	"	26.0	4.00	.031	0.98
NN	"	"	0.8	65.9	2.0	28.0	2.00	-.012	1.00
OO	"	"	"	64.7	"	27.0	3.00	.003	0.88
PP	"	"	"	64.2	"	27.0	4.00	.018	0.70

TABLE 3

PITCH MOTIONS

Condition	Configu-ration	$H_{1/3}/b$	θ_{dc}	CREST			TROUGH		
				$\bar{\theta}$	$\theta_{1/3}$	$\theta_{1/10}$	$\bar{\theta}$	$\theta_{1/3}$	$\theta_{1/10}$
1	A	.260	3.32	1.22	2.18	3.08	1.27	2.08	2.82
2	A	.417	3.07	2.26	3.91	5.37	2.38	3.80	5.27
3	A	.664	3.23	3.49	5.59	6.90	3.80	5.63	6.59
4	B	.261	3.44	0.99	1.83	2.49	1.16	1.98	2.76
5	B	.409	3.64	1.91	3.22	4.15	2.29	3.70	4.70
6	B	.647	3.77	2.88	4.51	4.94	3.47	5.70	6.82
7	C	.275	3.05	0.82	1.35	1.66	1.08	1.57	1.86
8	C	.436	3.22	1.73	2.72	3.13	2.13	3.54	4.43
9	C	.647	3.36	2.42	3.71	4.49	3.17	5.06	6.18
10	D	.227	3.03	1.48	2.38	3.09	1.50	2.36	3.02
11	D	.475	3.24	2.99	5.10	7.08	3.17	5.01	6.58
12	D	.684	3.47	3.68	6.13	7.79	3.97	6.36	7.79
13	E	.311	2.67	1.26	1.95	2.40	1.51	2.66	3.47
14	E	.503	2.72	2.03	3.10	3.84	2.53	4.17	5.22
15	E	.684	2.87	2.46	3.89	4.62	3.19	5.27	6.48
16	F	.235	3.00	0.92	1.39	1.59	1.21	1.88	2.20
17	F	.424	2.78	1.52	2.36	2.72	1.84	1.46	4.17
18	F	.617	2.12	1.81	3.19	4.19	2.48	4.09	5.20
19	G	.270	2.91	1.01	1.64	1.98	0.93	1.51	2.02
20	G	.368	2.98	1.76	2.80	3.37	1.82	2.77	3.15
21	G	.592	3.07	2.90	4.76	6.10	2.93	4.89	4.98
22	H	.228	2.92	0.63	1.03	1.19	0.70	1.19	1.52
23	H	.463	2.97	1.83	3.01	3.91	2.18	4.06	6.18
24	H	.596	2.73	2.39	3.81	4.82	2.78	4.66	6.14
25	I	.248	2.99	0.69	1.12	1.42	0.77	1.28	1.47
26	I	.389	2.87	1.20	1.83	2.24	1.46	2.44	3.05
27	I	----	----	----	----	----	----	----	----
28	J	.297	2.00	.942	1.55	2.14	0.94	1.56	2.16
29	J	.443	2.07	2.01	3.27	4.04	2.01	3.12	3.85

TABLE 3

PITCH MOTIONS (CONTINUED)

Condition	Conf.	$H_{1/3}/b$	θ_{dc}	CREST $\bar{\theta}$	CREST $\theta_{1/3}$	CREST $\theta_{1/10}$	TROUGH $\bar{\theta}$	TROUGH $\theta_{1/3}$	TROUGH $\theta_{1/10}$
30	J	.734	2.22	3.53	5.53	6.93	3.56	5.54	6.75
31	K	.229	1.93	0.45	0.79	0.99	0.51	0.90	1.24
32	K	.444	1.76	1.34	2.06	2.39	1.60	2.78	3.80
33	K	.694	1.75	2.57	3.86	5.08	2.96	4.59	5.38
34	L	.248	1.99	0.55	0.92	1.10	0.66	1.09	1.36
35	L	.392	1.91	1.18	1.99	2.50	1.38	2.36	3.00
36	L	.750	1.83	2.29	3.45	4.00	3.63	5.68	7.12
37	M	.267	4.47	1.26	2.44	3.65	1.25	2.16	2.88
38	M	.424	5.39	2.66	4.62	6.10	2.82	4.27	5.53
39	M	.714	5.04	4.31	7.15	8.96	4.46	6.47	7.68
40	N	.284	4.16	1.02	1.73	2.18	1.15	1.72	2.11
41	N	.464	4.40	2.45	4.14	5.45	2.92	4.54	5.38
42	N	.617	4.51	2.89	4.76	5.73	3.48	5.44	6.46
43	O	.298	3.89	1.00	1.71	2.08	1.25	1.87	2.29
44	O	.454	4.08	2.12	3.28	3.98	2.58	3.82	4.29
45	O	----	----	----	----	----	----	----	----
46	P	.226	3.01	0.93	1.59	2.11	0.96	1.50	1.95
47	P	.399	3.23	2.16	3.72	5.05	2.31	3.76	4.89
48	P	.705	3.38	3.47	5.82	7.39	3.73	5.90	7.25
49	Q	.238	3.14	0.79	1.28	1.58	0.88	1.39	1.79
50	Q	.355	3.02	1.55	2.63	3.40	1.84	2.95	3.89
51	Q	.620	3.38	2.76	4.53	5.31	3.44	5.25	6.28
52	R	.221	3.04	0.71	1.16	1.47	0.81	1.31	1.62
53	R	.401	3.16	1.52	2.45	2.96	1.94	2.98	3.79
54	R	.602	3.21	2.24	3.71	4.46	2.99	4.59	5.44
55	S	.321	3.00	1.90	3.25	4.23	1.97	3.07	3.87
56	S	.390	3.27	2.65	4.46	5.82	2.76	4.25	5.16
57	S	.659	3.48	3.58	5.95	6.66	3.94	6.16	7.74
58	T	.289	2.92	1.40	2.03	2.22	1.65	2.56	3.22

TABLE 3

PITCH MOTIONS (CONTINUED)

Condition	Conf.	$H_{1/3}/b$	θ_{dc}	CREST $\bar{\theta}$	CREST $\theta_{1/3}$	CREST $\theta_{1/10}$	TROUGH $\bar{\theta}$	TROUGH $\theta_{1/3}$	TROUGH $\theta_{1/10}$
59	T	.414	3.04	1.84	2.91	3.57	2.32	3.76	4.71
60	T	.675	3.36	2.61	4.18	5.08	3.21	5.00	6.05
61	U	.332	2.46	1.07	1.60	1.83	1.30	2.18	2.74
62	U	.483	2.50	1.66	2.38	2.69	2.04	3.18	3.91
63	U	.602	2.32	1.86	2.98	3.65	2.36	4.05	5.26
64	V	.295	2.94	1.81	2.89	3.76	1.81	2.81	3.58
65	V	.485	3.19	3.02	5.02	6.36	3.14	4.93	6.13
66	V	.688	3.50	3.76	5.91	6.62	4.03	5.96	6.81
67	W	.275	2.81	1.14	1.64	1.98	1.28	2.04	2.75
68	W	.479	3.15	2.09	3.06	3.69	2.42	3.85	4.82
69	W	.636	2.94	2.46	3.71	4.44	3.01	4.71	5.77
70	X	.228	2.71	0.83	1.43	1.77	0.92	1.45	1.68
71	X	----	----	----	----	----	----	----	----
72	X	----	----	----	----	----	----	----	----
73	X	.278	3.49	1.69	2.81	3.67	1.68	2.33	2.73
74	Y	.460	3.89	2.62	4.69	5.89	2.74	3.91	4.86
75	Y	.647	3.89	3.39	5.42	5.91	3.82	5.17	6.05
76	Z	.298	3.50	1.39	2.32	2.83	1.56	2.09	2.30
77	Z	.551	3.94	2.28	3.87	5.11	2.69	3.56	3.92
78	Z	.675	4.16	2.69	4.38	5.22	3.11	4.49	5.06
79	AA	.258	3.29	1.01	1.65	2.09	1.21	1.67	2.04
80	AA	.487	3.55	1.55	2.60	3.17	1.80	2.68	3.35
81	AA	.666	3.74	2.33	3.89	4.78	2.73	4.05	4.78
82	BB	.216	3.16	0.72	1.23	1.60	0.67	1.10	1.42
83	BB	.487	3.60	2.81	4.71	5.98	2.87	4.19	4.81
84	BB	.634	3.72	3.31	5.56	6.98	3.39	5.09	6.14
85	CC	.259	3.18	0.83	1.42	1.91	0.86	1.31	1.59
86	CC	.401	3.43	1.70	2.82	3.79	1.87	2.75	3.26
87	CC	.685	3.66	2.89	4.92	6.19	3.30	4.90	5.84

TABLE 3

PITCH MOTIONS (CONTINUED)

Condition	Conf.	$H_{1/3}/b$	θ_{dc}	CREST $\bar{\theta}$	CREST $\theta_{1/3}$	CREST $\theta_{1/10}$	TROUGH $\bar{\theta}$	TROUGH $\theta_{1/3}$	TROUGH $\theta_{1/10}$
88	DD	.222	3.21	0.56	0.96	1.30	0.58	0.96	1.19
89	DD	.481	3.62	1.78	2.97	3.41	2.18	3.44	3.90
90	DD	.614	3.65	2.40	3.97	5.20	3.02	4.53	5.54
91	EE	.269	3.31	1.29	2.21	2.64	1.28	2.00	2.45
92	EE	.462	3.73	2.72	4.78	6.36	2.84	4.36	5.50
93	EE	.632	3.75	3.61	6.05	7.46	3.53	5.57	6.81
94	FF	.223	3.03	0.91	1.56	1.94	0.98	1.55	1.93
95	FF	.365	3.07	1.45	2.66	3.65	1.61	2.95	4.01
96	FF	.620	3.35	2.91	4.76	5.78	3.32	5.23	6.57
97	GG	.218	3.22	0.69	1.20	1.63	0.77	1.23	1.56
98	GG	.355	3.39	1.29	2.15	2.53	1.56	2.66	3.40
99	GG	.621	3.46	2.38	3.68	4.93	3.13	4.63	5.46
100	HH	.247	3.17	1.83	2.94	3.75	1.88	2.74	3.14
101	HH	.503	2.49	3.30	5.52	6.86	3.49	5.37	6.41
102	HH	.616	3.56	3.37	5.74	7.36	3.55	5.49	6.87
103	II	.225	3.01	1.30	2.01	2.44	1.45	2.24	2.78
104	II	.453	3.24	2.17	3.34	3.82	2.63	4.00	4.32
105	II	.748	3.71	2.99	4.60	5.23	3.62	5.55	6.29
106	JJ	.288	3.02	1.03	1.66	2.00	1.25	1.94	2.29
107	JJ	.478	3.00	1.69	2.56	2.98	2.22	3.41	4.14
108	JJ	.694	3.22	2.29	3.55	4.29	2.88	4.63	5.76
109	KK	.219	2.96	0.96	1.55	1.98	0.97	1.58	2.00
110	KK	.362	3.00	1.88	3.25	4.49	1.92	3.21	4.33
111	KK	.634	3.05	3.22	5.60	7.22	3.30	5.35	6.40
112	LL	.219	3.03	0.59	1.00	1.38	0.64	1.07	1.48
113	LL	.380	2.87	1.58	2.62	3.62	1.67	2.92	3.93
114	LL	.587	3.24	2.67	4.30	5.07	3.08	4.99	6.06
115	MM	.228	2.92	0.55	0.88	0.96	0.60	1.02	1.39
116	MM	.330	2.91	1.19	1.79	2.12	1.39	2.18	2.70

TABLE 3

PITCH MOTIONS (CONTINUED)

Condition	Conf.	$H_{1/3}/b$	θ_{dc}	CREST			TROUGH		
				$\bar{\theta}$	$\theta_{1/3}$	$\theta_{1/10}$	$\bar{\theta}$	$\theta_{1/3}$	$\theta_{1/10}$
117	MM	----	----	----	----	----	----	----	----
118	NN	.215	2.18	1.02	1.64	1.99	1.07	1.61	1.93
119	NN	.351	2.33	1.77	3.15	4.43	1.74	2.90	4.07
120	NN	.698	2.46	3.37	5.75	7.31	3.51	5.78	7.25
121	OO	.236	2.00	0.80	1.30	1.71	0.90	1.46	1.89
122	OO	.420	2.13	1.65	2.72	3.52	1.99	3.45	5.15
123	OO	.634	2.01	2.61	4.04	4.82	3.11	4.86	5.88
124	PP	.225	1.99	0.56	0.95	1.19	0.67	1.07	1.42
125	PP	----	----	----	----	----	----	----	----
126	PP	----	----	----	----	----	----	----	----

TABLE 4

HEAVE MOTIONS

Condition	Configu-ration	$H_{1/3}/b$	h_{dc}/b	CREST h/b	CREST $h_{1/3}/b$	CREST $h_{1/10}/b$	TROUGH h/b	TROUGH $h_{1/3}/b$	TROUGH $h_{1/10}/b$
1	A	.260	-.003	.035	.064	.088	.041	.080	.121
2	A	.417	-.002	.089	.156	.231	.100	.185	.286
3	A	.664	-.014	.178	.290	.359	.206	.340	.441
4	B	.261	.038	.036	.061	.084	.042	.080	.120
5	B	.409	.045	.090	.152	.194	.113	.198	.265
6	B	.647	.039	.197	.330	.383	.238	.391	.462
7	C	.275	.064	.033	.052	.062	.039	.066	.082
8	C	.436	.071	.100	.166	.213	.111	.191	.256
9	C	.647	.063	.179	.295	.342	.204	.335	.423
10	D	.227	-.020	.043	.072	.095	.049	.082	.114
11	D	.475	-.013	.112	.187	.241	.126	.236	.337
12	D	.684	-.009	.183	.305	.389	.209	.359	.470
13	E	.311	.009	.043	.076	.105	.048	.081	.114
14	E	.503	.009	.098	.161	.216	.112	.184	.239
15	E	.684	.008	.174	.285	.368	.189	.318	.490
16	F	.235	.032	.031	.051	.059	.035	.055	.065
17	F	.424	.024	.064	.118	.168	.074	.129	.164
18	F	.617	.001	.125	.239	.302	.132	.225	.286
19	G	.270	-.002	.034	.058	.078	.033	.047	.078
20	G	.368	-.020	.083	.141	.183	.081	.134	.164
21	G	.592	-.022	.182	.313	.413	.167	.277	.346
22	H	.228	.013	.029	.043	.054	.026	.108	.059
23	H	.463	.008	.126	.223	.322	.116	.201	.284
24	H	.596	.010	.205	.393	.454	.186	.304	.383
25	I	.248	.039	.028	.048	.059	.026	.048	.064
26	I	.389	.030	.083	.132	.181	.078	.134	.195
27	I	----	----	----	----	----	----	----	----
28	J	.297	-.013	.025	.045	.071	.026	.051	.085
29	J	.443	-.013	.075	.122	.165	.085	.152	.217

TABLE 4

HEAVE MOTIONS (CONTINUED)

Condition	Configuration	$H_{1/3}/b$	h_{dc}/b	CREST h/b	CREST $h_{1/3}/b$	CREST $h_{1/10}/b$	TROUGH h/b	TROUGH $h_{1/3}/b$	TROUGH $h_{1/10}/b$
30	J	.734	-.018	.198	.314	.372	.206	.327	.407
31	K	.229	.009	.014	.026	.038	.014	.055	.042
32	K	.444	.017	.057	.106	.152	.064	.111	.143
33	K	.694	.010	.195	.298	.356	.202	.325	.425
34	L	.248	.031	.020	.036	.046	.021	.034	.048
35	L	.392	.024	.057	.221	.277	.062	.109	.137
36	L	.750	.014	.199	.297	.329	.183	.294	.327
37	M	.267	-.001	.031	.559	.081	.041	.085	.139
38	M	.424	-.000	.096	.159	.214	.115	.219	.314
39	M	.714	-.005	.213	.335	.418	.239	.398	.509
40	N	.284	.047	.030	.052	.068	.036	.069	.094
41	N	.464	.056	.122	.195	.243	.144	.263	.342
42	N	.617	.053	.185	.284	.358	.212	.363	.494
43	O	.298	.083	.041	.062	.075	.046	.086	.121
44	O	.454	.089	.111	.180	.222	.128	.218	.278
45	O	----	-----	----	----	----	----	----	----
46	P	.226	-.012	.029	.052	.076	.026	.042	.061
47	P	.399	-.006	.099	.177	.243	.088	.156	.209
48	P	.705	-.008	.229	.364	.452	.205	.307	.373
49	Q	.238	.020	.032	.053	.069	.027	.046	.058
50	Q	.355	.021	.090	.164	.228	.081	.134	.185
51	Q	.620	.027	.206	.352	.445	.187	.308	.379
52	R	.221	.043	.032	.054	.068	.029	.048	.063
53	R	.401	.060	.090	.151	.187	.079	.129	.171
54	R	.602	.065	.210	.347	.443	.181	.277	.319
55	S	.321	.020	.064	.108	.136	.072	.127	.175
56	S	.390	.014	.096	.155	.201	.110	.192	.253
57	S	.659	.008	.177	.294	.368	.201	.336	.436
58	T	.289	.013	.050	.081	.102	.055	.092	.117

TABLE 4

HEAVE MOTIONS (CONTINUED)

Condition	Configuration	$H_{1/3}/b$	h_{dc}/b	CREST h/b	CREST $h_{1/3}/b$	CREST $h_{1/10}/b$	TROUGH h/b	TROUGH $h_{1/3}/b$	TROUGH $h_{1/10}/b$
59	T	.414	.012	.085	.142	.182	.096	.171	.250
60	T	.675	.018	.160	.271	.340	.182	.313	.383
61	U	.332	.016	.044	.076	.105	.046	.074	.094
62	U	.483	.017	.081	.129	.164	.086	.138	.168
63	U	.602	.001	.136	.227	.281	.142	.252	.341
64	V	.295	.029	.059	.096	.126	.064	.115	.166
65	V	.485	.030	.121	.201	.262	.133	.237	.320
66	V	.688	.029	.182	.302	.394	.204	.356	.458
67	W	.275	.001	.040	.068	.094	.042	.066	.087
68	W	.479	.009	.095	.155	.183	.103	.169	.234
69	W	.636	.011	.164	.279	.367	.174	.283	.353
70	X	.228	-.017	.027	.044	.054	.028	.047	.065
71	X	----	-----	----	----	----	----	----	----
72	X	----	-----	----	----	----	----	----	----
73	Y	.278	.012	.040	.059	.066	.049	.087	.121
74	Y	.460	.001	.094	.156	.208	.113	.221	.343
75	Y	.647	.009	.153	.241	.294	.180	.324	.442
76	Z	.298	.024	.045	.068	.076	.055	.098	.125
77	Z	.551	.058	.106	.161	.208	.133	.252	.333
78	Z	.675	.047	.180	.285	.356	.206	.352	.460
79	AA	.258	.048	.037	.057	.071	.045	.084	.111
80	AA	.487	.058	.080	.130	.166	.104	.191	.290
81	AA	.666	.067	.184	.287	.355	.213	.369	.478
82	BB	.216	-.019	.022	.040	.056	.020	.035	.046
83	BB	.487	-.012	.126	.223	.299	.110	.175	.225
84	BB	.634	-.011	.189	.312	.419	.164	.253	.318
85	CC	.259	.014	.034	.064	.101	.029	.051	.067
86	CC	.401	.020	.092	.167	.242	.082	.129	.169

TABLE 4

HEAVE MOTIONS (CONTINUED)

Condition	Configuration	$H_{1/3}/b$	h_{dc}/b	CREST			TROUGH		
				h/b	$h_{1/3}/b$	$h_{1/10}/b$	h/b	$h_{1/3}/b$	$h_{1/10}/b$
87	CC	.685	.023	.227	.384	.497	.192	.298	.364
88	DD	.222	.040	.029	.050	.070	.028	.046	.059
89	DD	.481	.056	.146	.267	.343	.118	.184	.221
90	DD	.614	.067	.202	.356	.452	.174	.293	.385
91	EE	.269	-.006	.050	.085	.112	.043	.071	.092
92	EE	.462	+.002	.136	.246	.352	.117	.193	.252
93	EE	.632	.000	.203	.377	.436	.183	.298	.382
94	FF	.223	.011	.039	.068	.085	.033	.057	.080
95	FF	.365	.015	.100	.188	.303	.089	.156	.194
96	FF	.620	.024	.171	.312	.478	.198	.307	.370
97	GG	.218	.044	.035	.061	.080	.029	.047	.059
98	GG	.355	.051	.094	.161	.223	.088	.144	.194
99	GG	.621	.059	.204	.353	.453	.185	.308	.353
100	HH	.247	-.015	.053	.083	.103	.059	.101	.131
101	HH	.503	-.008	.125	.204	.257	.145	.267	.354
102	HH	.616	-.009	.165	.282	.367	.189	.332	.450
103	II	.225	.012	.056	.089	.112	.062	.108	.139
104	II	.453	.018	.197	.169	.205	.121	.209	.270
105	II	.748	.019	.201	.319	.403	.222	.370	.447
106	JJ	.288	.032	.041	.069	.087	.046	.077	.096
107	JJ	.478	.026	.091	.145	.188	.097	.162	.197
108	JJ	.694	.030	.167	.293	.403	.203	.337	.041
109	KK	.219	-.024	.034	.059	.079	.032	.055	.072
110	KK	.362	-.026	.089	.156	.221	.081	.141	.184
111	KK	.634	-.024	.201	.357	.467	.190	.310	.392
112	LL	.219	.007	.024	.042	.053	.023	.040	.056
113	LL	.380	.004	.095	.166	.238	.093	.166	.234
114	LL	.587	.007	.210	.357	.441	.192	.304	.377

TABLE 4

HEAVE MOTIONS (CONTINUED)

Condition	Configuration	$H_{1/3}/b$	h_{dc}/b	CREST h/b	CREST $h_{1/3}/b$	CREST $h_{1/10}/b$	TROUGH h/b	TROUGH $h_{1/3}/b$	TROUGH $h_{1/10}/b$
115	MM	.228	.033	.027	.047	.066	.027	.441	.583
116	MM	.330	.028	.075	.120	.162	.076	.127	.168
117	MM	----	-----	----	----	----	----	----	----
118	NN	.215	-.011	.033	.056	.073	.031	.051	.063
119	NN	.351	-.010	.085	.148	.207	.079	.131	.172
120	NN	.698	-.009	.226	.368	.461	.206	.326	.422
121	OO	.236	-.002	.035	.059	.075	.029	.052	.075
122	OO	.420	-.003	.112	.206	.318	.101	.179	.254
123	OO	.634	.005	.216	.342	.405	.198	.298	.337
124	PP	.225	.018	.026	.044	.052	.025	.042	.057
125	PP	----	-----	----	----	----	----	----	----
126	PP	----	-----	----	----	----	----	----	----

TABLE 5

VERTICAL ACCELERATIONS

Condition	Configuration	$H_{1/3}/b$	BOW $\bar{\eta}_B$	BOW $\eta_{B_{1/3}}$	BOW $\eta_{B_{1/10}}$	CG $\bar{\eta}_{CG}$	CG $\eta_{CG_{1/3}}$	CG $\eta_{CG_{1/10}}$	STERN $\bar{\eta}_S$	STERN $\eta_{S_{1/3}}$	STERN $\eta_{S_{1/10}}$
1	A	.260	0.52	1.01	1.66	0.39	0.70	1.19	0.51	0.95	1.53
2	A	.417	2.14	4.49	7.56	0.76	1.64	3.25	0.98	2.04	3.41
3	A	.664	3.45	7.72	14.13	1.35	2.99	6.13	1.39	2.96	5.17
4	B	.261	1.60	3.21	5.33	0.64	1.20	2.30	0.73	1.43	2.53
5	B	.409	3.21	6.84	10.58	1.26	2.62	4.52	1.37	2.84	4.38
6	B	.647	4.69	10.21	15.89	1.86	4.10	6.85	1.93	4.06	6.26
7	C	.275	2.40	4.60	6.87	1.07	2.03	3.12	1.20	2.25	3.31
8	C	.436	4.26	9.02	14.75	1.87	4.16	7.71	1.84	3.84	5.97
9	C	.647	5.54	11.89	17.83	2.54	5.38	9.22	2.45	5.03	7.19
10	D	.227	0.81	1.67	3.16	0.25	0.49	1.02	0.52	0.96	1.81
11	D	.475	3.68	9.02	15.74	1.38	3.63	7.02	1.82	4.36	16.23
12	D	.684	5.15	11.52	18.10	1.96	4.83	8.63	2.41	5.12	7.53
13	E	.311	1.94	4.10	6.97	0.63	1.44	2.81	1.15	2.45	4.08
14	E	.503	3.66	7.87	12.39	1.30	3.08	5.29	1.94	4.13	5.95
15	E	.684	4.50	10.35	15.30	1.64	3.98	6.06	2.34	5.14	7.05
16	F	.235	1.68	3.29	4.76	0.56	1.18	2.07	0.91	1.80	2.77
17	F	.424	3.11	6.85	10.76	1.19	2.82	4.78	1.66	3.59	5.42
18	F	.617	4.50	8.28	11.42	1.79	3.55	5.07	2.29	4.16	5.46
19	G	.270	0.54	1.11	2.26	0.14	0.29	0.61	----	----	----
20	G	.368	0.92	2.00	3.77	0.23	0.50	1.05	0.57	1.02	1.74
21	G	.592	1.15	2.69	5.19	0.32	0.73	1.58	0.72	1.51	2.73
22	H	.228	0.85	1.80	3.63	0.21	0.39	0.70	0.45	0.78	1.25

TABLE 5

VERTICAL ACCLERATIONS (CONTINUED)

Condition	Configu-ratio..	$H_{1/3}/b$	BOW $\bar{\eta}_B$	$\eta_{B_{1/3}}$	$\eta_{B_{1/10}}$	CG $\bar{\eta}_{CG}$	$\eta_{CG_{1/3}}$	$\eta_{CG_{1/10}}$	STERN $\bar{\eta}_s$	$\eta_{s_{1/3}}$	$\eta_{s_{1/10}}$
23	H	.463	1.81	4.23	8.36	0.60	1.40	2.92	0.93	2.07	3.74
24	H	.596	1.70	4.05	8.02	0.54	1.27	2.75	0.95	2.11	3.69
25	I	.248	1.27	2.57	4.26	0.44	0.89	1.62	0.72	1.33	2.12
26	I	.380	1.94	4.20	7.54	0.61	1.30	2.62	0.91	1.87	3.21
27	I	----	----	----	----	----	----	----	----	----	----
28	J	.297	0.75	1.47	2.79	0.36	0.59	1.06	0.40	0.77	1.47
29	J	.443	1.51	3.48	6.73	0.71	1.40	2.60	0.86	1.96	3.79
30	J	.734	1.91	3.75	6.80	1.03	1.74	2.66	1.06	2.21	3.95
31	K	.229	0.82	1.50	2.28	0.41	0.64	0.92	0.43	0.77	1.22
32	K	.444	1.80	4.17	7.83	0.82	1.66	3.22	0.95	2.18	4.06
33	K	.694	2.57	5.39	9.79	1.29	2.35	4.11	1.39	2.98	5.00
34	L	.248	1.7 0	3.16	5.01	1.02	2.12	4.70	0.91	1.69	2.67
35	L	.392	2.16	4.19	7.05	0.96	1.73	2.95	1.13	2.26	3.68
36	L	.750	3.04	6.55	12.26	1.75	3.31	6.83	1.39	3.05	5.40
37	M	.267	1.49	3.25	5.93	0.50	0.98	1.89	0.56	1.14	2.03
38	M	.424	3.40	7.85	15.42	0.99	1.99	3.52	0.97	2.00	3.20
39	M	.714	4.17	8.72	14.43	1.39	2.69	5.03	1.43	2.70	4.26
40	N	.284	2.13	4.31	7.29	0.83	1.55	2.73	0.79	1.46	2.29
41	N	.464	2.98	6.90	12.98	1.38	2.89	5.60	1.01	2.20	3.81
42	N	.617	4.60	10.87	20.03	1.95	4.24	8.08	1.51	3.20	5.12
43	O	.298	3.25	6.53	10.58	1.39	.285	5.10	1.16	2.39	3.79

TABLE 5

VERTICAL ACCELERATIONS (CONTINUED)

Condition	Configuration	$H_{1/3}/b$	BOW $\bar{\eta}_B$	BOW $\eta_{B_{1/3}}$	BOW $\eta_{B_{1/10}}$	CG $\bar{\eta}_{CG}$	CG $\eta_{CG_{1/3}}$	CG $\eta_{CG_{1/10}}$	STERN $\bar{\eta}_s$	STERN $\eta_{s_{1/3}}$	STERN $\eta_{s_{1/10}}$
44	O	.454	3.52	8.08	14.45	1.69	4.26	6.92	1.27	2.90	5.41
45	O	----	----	----	----	----	----	----	----	----	----
46	P	.226	0.52	1.08	1.84	0.09	0.19	0.36	0.43	0.73	1.18
47	P	.399	0.93	2.15	3.88	0.22	0.49	1.03	0.64	1.32	2.27
48	P	.705	1.39	3.14	5.56	0.35	0.79	1.59	0.94	1.92	3.15
49	Q	.238	0.72	1.40	2.10	0.15	0.30	0.53	0.54	0.91	1.34
50	Q	.355	0.89	2.03	3.67	0.25	0.52	1.01	0.59	1.20	2.08
51	Q	.620	1.98	4.51	7.55	0.63	1.47	2.91	0.47	2.39	3.72
52	R	.221	1.01	2.04	3.12	0.27	0.56	0.95	0.72	1.30	1.90
53	R	.401	2.14	4.01	5.57	1.02	2.40	5.50	1.18	2.26	3.17
54	R	.602	3.17	6.34	9.09	1.05	2.29	3.50	1.56	3.22	4.67
55	S	.321	1.01	2.20	3.82	0.33	0.69	1.56	0.71	1.52	2.96
56	S	.390	1.31	2.72	4.47	0.37	0.74	1.41	0.82	1.68	2.81
57	S	.659	2.65	5.57	6.99	0.98	2.28	3.49	1.92	4.16	6.00
58	T	.289	1.07	2.00	3.11	0.37	0.67	1.39	0.71	1.33	2.29
59	T	.414	1.64	3.46	5.73	0.58	1.26	2.30	1.09	2.34	3.83
60	T	.675	2.72	5.49	7.13	1.08	2.41	3.71	1.86	3.87	5.68
61	U	.332	1.40	2.52	3.42	0.46	0.80	1.34	0.89	1.68	2.65
62	U	.483	1.94	3.76	6.00	0.72	1.48	2.74	1.23	2.50	4.25
63	U	.602	2.31	4.34	6.18	0.83	1.69	2.77	1.60	3.16	4.64
64	U	.295	0.67	1.36	2.31	0.25	0.40	0.68	0.52	1.01	1.77

TABLE 5

VERTICAL ACCELERATIONS (CONTINUED)

Condition	Configu-ration	$H_{1/3}/b$	BOW			CG			STERN		
			$\bar{\eta}_B$	$\eta_{B_{1/3}}$	$\eta_{B_{1/10}}$	$\bar{\eta}_{CG}$	$\eta_{CG_{1/3}}$	$\eta_{CG_{1/10}}$	$\bar{\eta}_S$	$\eta_{S_{1/3}}$	$\eta_{S_{1/10}}$
65	V	.485	1.50	3.23	5.34	0.50	0.99	1.84	1.07	2.25	3.73
66	V	.688	1.73	3.08	3.69	0.71	1.48	2.08	1.50	3.01	3.65
67	W	.275	0.55	0.99	1.73	0.21	0.29	0.41	0.40	0.70	1.15
68	W	.479	1.35	2.43	2.87	0.56	1.10	1.84	1.11	2.25	3.44
69	W	.636	1.90	3.56	5.94	0.97	2.07	3.47	----	----	----
70	X	.228	0.61	1.10	1.70	0.23	0.34	0.50	0.41	0.70	1.02
71	X	----	----	----	----	----	----	----	----	----	----
72	X	----	----	----	----	----	----	----	----	----	----
73	Y	.278	2.06	4.00	6.07	0.39	0.86	1.44	0.88	1.80	2.69
74	Y	.460	4.75	10.29	15.79	1.32	3.25	6.11	1.97	4.18	6.06
75	Y	.647	6.31	12.84	17.64	1.73	4.01	6.22	2.50	5.00	6.18
76	Z	.298	2.96	5.19	6.96	0.72	1.40	2.01	1.45	2.59	3.35
77	Z	.551	6.18	11.66	15.98	1.78	3.72	5.19	2.64	4.74	5.64
78	Z	.675	5.93	11.23	14.93	1.72	3.59	5.39	2.44	4.50	5.85
79	AA	.258	2.63	4.59	6.15	0.63	1.21	1.74	1.21	2.12	2.79
80	AA	.487	4.45	8.19	10.98	1.32	2.65	4.02	2.06	3.80	5.11
81	AA	.666	5.62	10.42	14.10	1.76	3.57	5.47	2.40	4.59	6.31
82	BB	.216	0.51	0.88	1.35	0.11	0.20	0.28	0.37	0.53	0.73
83	BB	.487	2.79	6.09	10.74	0.64	1.61	3.06	1.31	2.72	4.29
84	BB	.637	3.53	7.59	10.41	0.92	2.28	4.32	1.50	2.95	5.18
85	CC	.259	1.03	1.95	3.24	0.20	0.42	0.77	0.67	1.15	1.74
86	CC	.401	2.47	4.91	7.72	0.59	1.33	2.23	1.36	2.53	3.49

TABLE 5

VERTICAL ACCELERATIONS (CONTINUED)

Condition	Configu-ration	$H_{1/3}/b$	BOW			CG			STERN		
			$\bar{\eta}_B$	$\eta_{B_{1/3}}$	$\eta_{B_{1/10}}$	$\bar{\eta}_{CG}$	$\eta_{CG_{1/3}}$	$\eta_{CG_{1/10}}$	$\bar{\eta}_s$	$\eta_{s_{1/3}}$	$\eta_{s_{1/10}}$
87	CC	.685	4.90	9.99	13.78	1.44	3.32	5.37	2.36	4.57	6.36
88	DD	.222	0.77	1.34	1.91	0.18	0.33	0.49	0.52	0.81	1.10
89	DD	.481	3.34	6.90	11.90	0.95	2.19	4.24	1.64	3.01	4.83
90	DD	.614	4.41	9.55	15.38	1.42	3.39	5.62	3.02	5.69	9.25
91	EE	.269	0.48	0.94	1.44	0.17	0.24	0.31	0.32	0.60	0.93
92	EE	.462	0.84	1.88	3.45	0.28	0.48	0.82	0.45	0.93	1.58
93	EE	.632	0.93	2.01	3.47	0.29	0.49	0.77	0.51	1.04	1.71
94	FF	.223	0.45	0.89	1.39	0.19	0.28	0.34	0.31	0.56	0.79
95	FF	.365	0.75	1.52	2.46	0.24	0.40	0.61	0.46	0.87	1.30
96	FF	.620	1.41	3.26	5.82	0.47	0.95	1.94	0.90	1.85	3.14
97	GG	.218	0.67	1.34	2.05	0.26	0.38	0.52	0.40	0.75	1.04
98	GG	.355	.104	2.22	3.65	0.37	0.63	1.00	0.62	1.22	1.91
99	GG	.621	1.81	4.34	9.66	0.50	0.89	1.51	0.77	1.54	2.48
100	HH	.247	0.54	1.06	1.82	0.10	0.17	0.31	0.40	0.70	1.09
101	HH	.503	1.79	3.97	5.90	0.48	1.19	2.12	1.09	2.33	3.49
102	HH	.616	1.25	2.86	4.94	0.36	0.74	1.40	0.84	1.82	3.06
103	II	.225	0.44	0.79	1.11	0.19	0.28	0.33	0.33	0.56	0.75
104	II	.453	1.44	3.11	4.47	0.38	0.68	1.07	0.93	1.84	2.62
105	II	.748	1.67	3.99	6.64	0.67	1.35	2.52	1.40	2.97	4.74
106	JJ	.288	0.88	1.63	2.50	0.26	0.37	0.48	0.54	0.93	1.34
107	JJ	.478	1.82	3.51	4.82	0.44	0.86	1.45	1.02	1.97	2.85
108	JJ	.694	2.09	4.01	5.89	0.60	1.19	2.04	1.31	2.54	3.98

TABLE 5

VERTICAL ACCELERATION (CONTINUED)

Condition	Configu-ration	$H_{1/3}/b$	BOW $\bar{\eta}_B$	$\eta_{B_{1/3}}$	$\eta_{B_{1/10}}$	CG $\bar{\eta}_{CG}$	$\eta_{CG_{1/3}}$	$\eta_{CG_{1/10}}$	STERN $\bar{\eta}_S$	$\eta_{S_{1/3}}$	$\eta_{S_{1/10}}$
109	KK	.219	0.25	0.40	0.58	0.12	0.16	0.21	0.16	0.28	0.41
110	KK	.362	0.37	0.66	1.01	0.16	0.25	0.33	0.26	0.44	0.66
111	KK	.634	0.75	1.37	2.35	0.31	0.50	0.76	0.59	0.99	1.52
112	LL	.219	0.34	0.59	0.84	0.14	0.20	0.26	0.38	0.79	1.84
113	LL	.380	0.62	1.11	1.56	0.22	0.33	0.42	0.40	0.74	1.09
114	LL	.587	0.92	1.68	2.80	0.28	0.47	0.64	0.61	1.16	1.71
115	MM	.228	0.89	1.84	4.30	0.23	0.37	0.45	0.38	0.61	0.84
116	MM	.330	0.94	1.54	2.19	0.30	0.45	0.58	0.56	0.90	1.23
117	MM	----	----	----	----	----	----	----	----	----	----
118	NN	.215	0.27	0.48	0.73	0.13	0.19	0.28	0.21	0.36	0.51
119	NN	.351	0.38	0.66	1.09	0.15	0.23	0.33	0.29	0.51	0.82
120	NN	.698	----	----	----	----	----	----	----	----	----
121	OO	.236	0.38	0.73	1.11	0.16	0.23	0.30	0.27	0.48	0.73
122	OO	.420	0.65	1.33	2.43	0.23	0.38	0.59	0.42	0.85	1.46
123	OO	.634	0.75	1.56	2.93	0.30	0.50	0.69	0.50	1.06	1.81
124	PP	.225	0.49	0.90	1.36	0.20	0.31	0.40	0.33	0.58	0.82
125	PP	----	----	----	----	----	----	----	----	----	----
126	PP	----	----	----	----	----	----	----	----	----	----

TABLE 6

ADDED DRAG IN WAVES

Condition	Configuration	$\frac{V}{\sqrt{L}}$	$H_{1/3}/b$	$\frac{R_a}{w\ b^3}$
1	A	2.0	.260	.019
2	A	2.0	.417	.027
3	A	2.0	.664	.035
4	B	3.0	.261	.024
5	B	3.0	.409	.035
6	B	3.0	.647	.044
7	C	4.0	.275	.025
8	C	4.0	.436	.049
9	C	4.0	.647	.076
10	D	2.0	.227	.009
11	D	2.0	.475	.026
12	D	2.0	.684	.039
13	E	3.0	.311	.045
14	E	3.0	.503	.066
15	E	3.0	.684	.078
16	F	4.0	.235	.065
17	F	4.0	.424	.110
18	F	4.0	.617	.155
19	G	2.0	.270	.012
20	G	2.0	.368	.017
21	G	2.0	.592	.022
22	H	3.0	.228	.028
23	H	3.0	.463	.058
24	H	3.0	.596	.060
25	I	4.0	.248	.057
26	I	4.0	.380	.096
27	I	4.0	----	----
28	J	2.0	.297	----
29	J	2.0	.443	.013

TABLE 6

ADDED DRAG IN WAVES (CONTINUED)

Condition	Configuration	$\frac{V}{\sqrt{L}}$	$H_{1/3}/b$	$\frac{R_a}{w\ b^3}$
30	J	2.0	.734	.018
31	K	3.0	.229	.026
32	K	3.0	.444	.057
33	K	3.0	.694	.068
34	L	4.0	.248	.055
35	L	4.0	.392	.084
36	L	4.0	.750	----
37	M	2.0	.267	.014
38	M	2.0	.424	.030
39	M	2.0	.714	.034
40	N	3.0	.284	.015
41	N	3.0	.464	.031
42	N	3.0	.617	.035
43	O	4.0	.298	.031
44	O	4.0	.454	.055
45	O	4.0	----	----
46	P	2.0	.226	.014
47	P	2.0	.399	.024
48	P	2.0	.705	.030
49	Q	3.0	.238	.019
50	Q	3.0	.355	.029
51	Q	3.0	.620	.043
52	R	4.0	.221	.020
53	R	4.0	.401	.044
54	R	4.0	.602	.058
55	S	2.0	.321	.024
56	S	2.0	.390	.033
57	S	2.0	.659	.045
58	T	3.0	.289	.030

TABLE 6

ADDED DRAG IN WAVES (CONTINUED)

Condition	Configuration	$\frac{V}{\sqrt{L}}$	$H_{1/3}/b$	$\frac{R_a}{w \, b^3}$
59	T	3.0	.414	.054
60	T	3.0	.675	.070
61	U	4.0	.332	.079
62	U	4.0	.483	.101
63	U	4.0	.602	.127
64	V	2.0	.295	.016
65	V	2.0	.485	.031
66	V	2.0	.688	.043
67	W	3.0	.275	.024
68	W	3.0	.479	.058
69	W	3.0	.636	.064
70	X	4.0	.228	.044
71	X	4.0	----	----
72	X	4.0	----	----
73	Y	1.76	.278	.021
74	Y	1.76	.460	.036
75	Y	1.76	.647	.053
76	Z	2.64	.298	.022
77	Z	2.64	.551	----
78	Z	2.64	.675	.051
79	AA	3.53	.258	.033
80	AA	3.53	.487	.059
81	AA	3.53	.666	.097
82	BB	1.76	.216	.011
83	BB	1.76	.487	.035
84	BB	1.76	.634	.036
85	CC	2.64	.259	.019
86	CC	2.64	.401	.039
87	CC	2.64	.685	.061

TABLE 6

ADDED DRAG IN WAVES (CONTINUED)

Condition	Configuration	$\frac{V}{\sqrt{L}}$	$H_{1/3}/b$	$\frac{R_a}{w\ b^3}$
88	DD	3.53	.222	.014
89	DD	3.53	.481	.051
90	DD	3.53	.614	.063
91	EE	2.0	.269	.014
92	EE	2.0	.462	.018
93	EE	2.0	.632	----
94	FF	3.0	.223	.016
95	FF	3.0	.365	.025
96	FF	3.0	.620	.038
97	GG	4.0	.218	.018
98	GG	4.0	.355	.037
99	GG	4.0	.621	.063
100	HH	2.0	.247	.012
101	HH	2.0	.503	.026
102	HH	2.0	.616	.030
103	II	3.0	.225	.035
104	II	3.0	.453	.081
105	II	3.0	.748	.103
106	JJ	4.0	.288	.038
107	JJ	4.0	.468	.084
108	JJ	4.0	.694	.093
109	KK	2.0	.219	.012
110	KK	2.0	.362	.024
111	KK	2.0	.634	.027
112	LL	3.0	.219	.020
113	LL	3.0	.380	.046
114	LL	3.0	.587	.060
115	MM	4.0	.228	.025
116	MM	4.0	.330	.055

TABLE 6

ADDED DRAG IN WAVES (CONTINUED)

Condition	Configuration	$\frac{V}{\sqrt{L}}$	$H_{1/3}/b$	$\frac{R_a}{w\ b^3}$
117	MM	4.0	----	----
118	NN	1.0	.215	.012
119	NN	2.0	.351	.020
120	NN	2.0	.698	.032
121	OO	3.0	.236	.017
122	OO	3.0	.420	.033
123	OO	3.0	.634	.040
124	PP	4.0	.225	.650
125	PP	4.0	----	----
126	PP	4.0	----	----

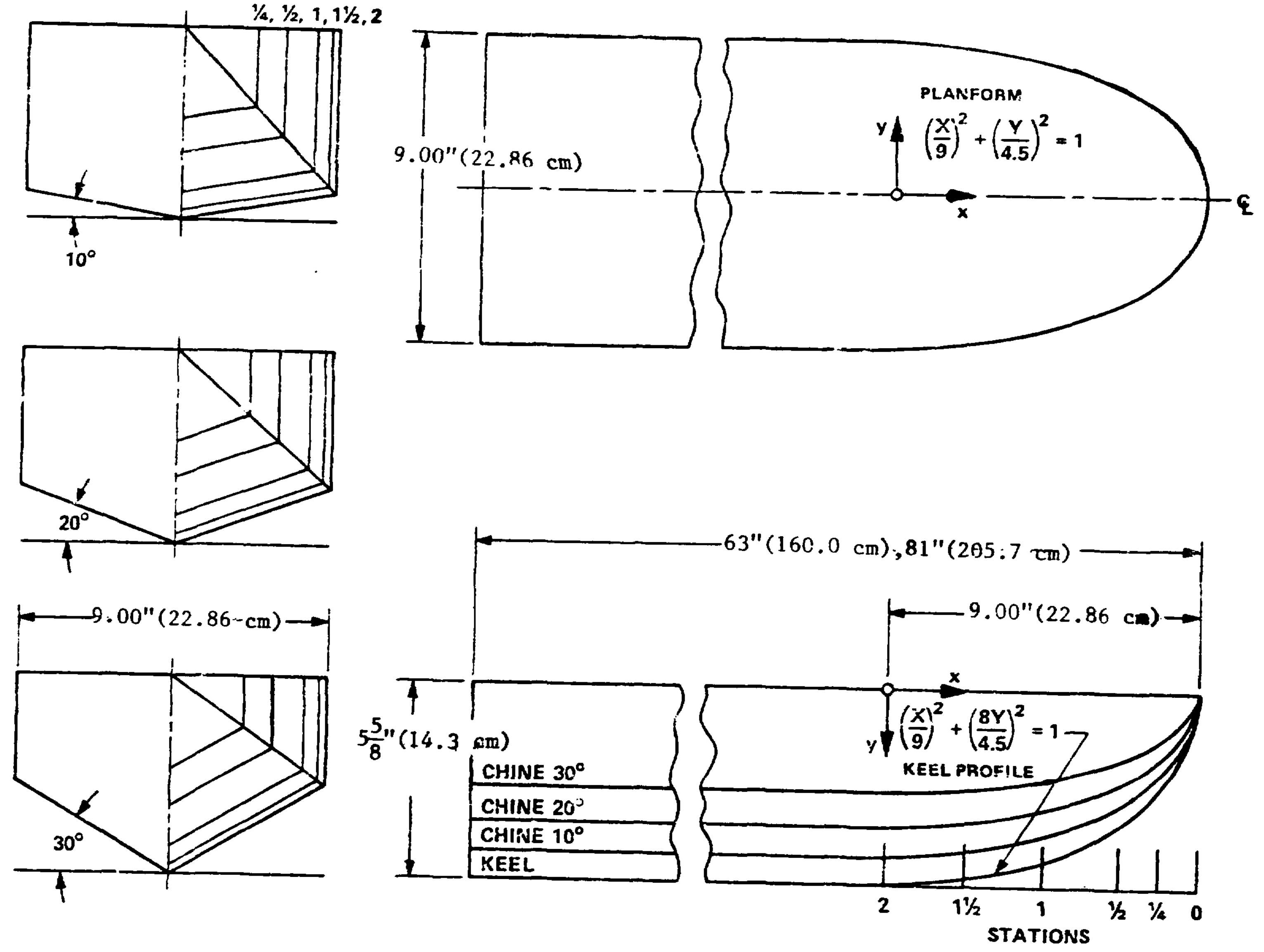


Figure 1 - Model Lines

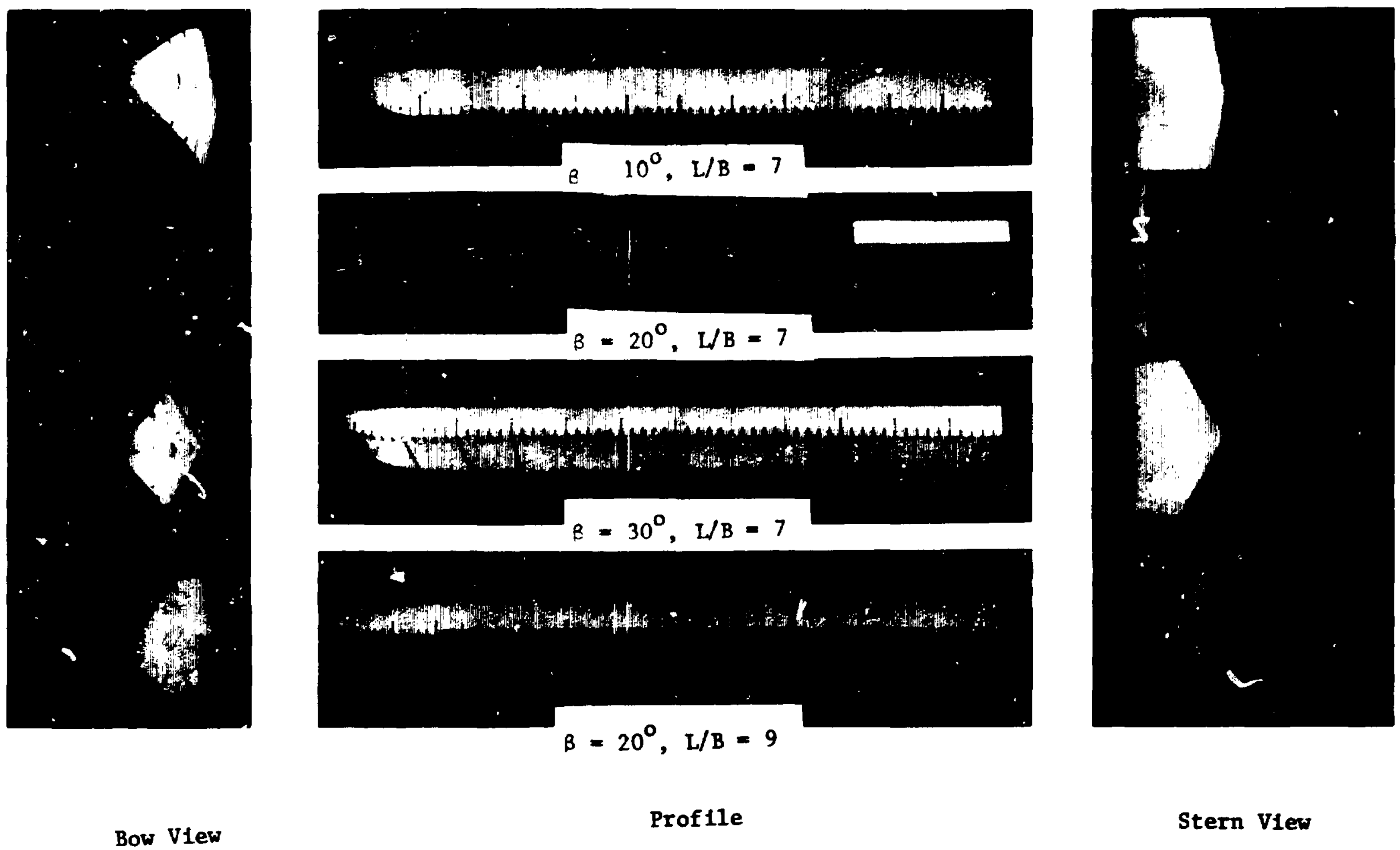


Figure 2 - Photographs of Models

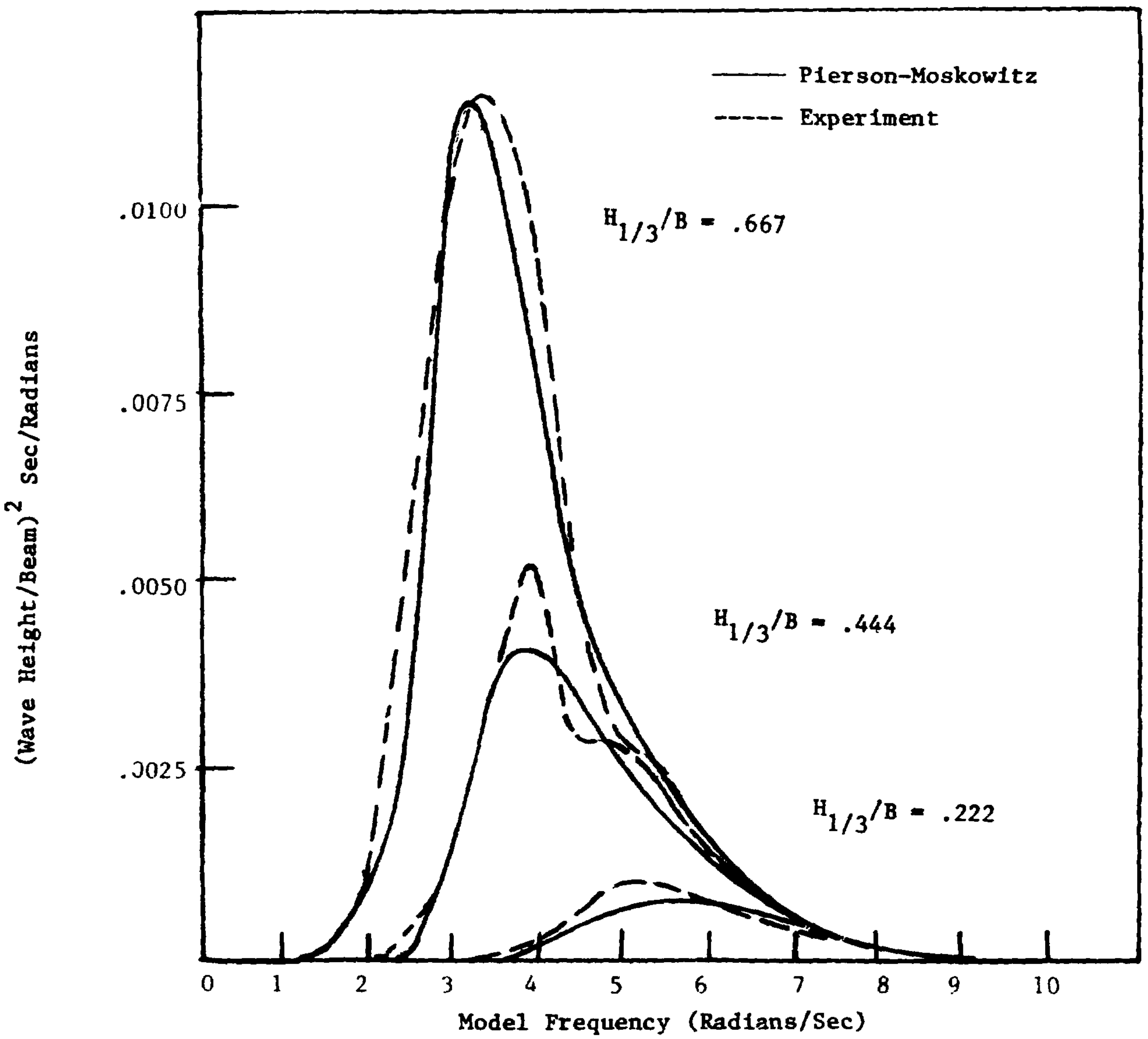


Figure 3 - Wave Spectra

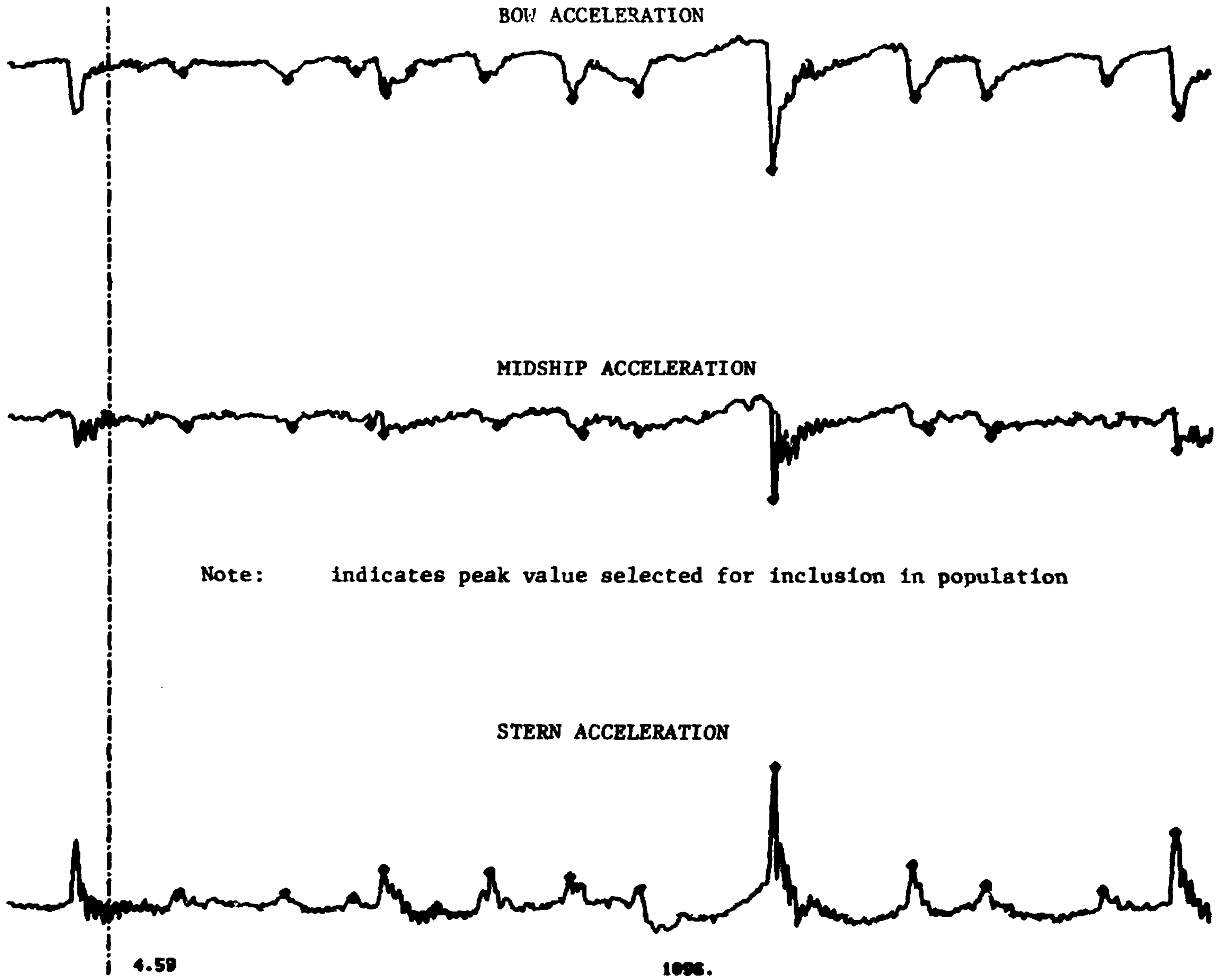
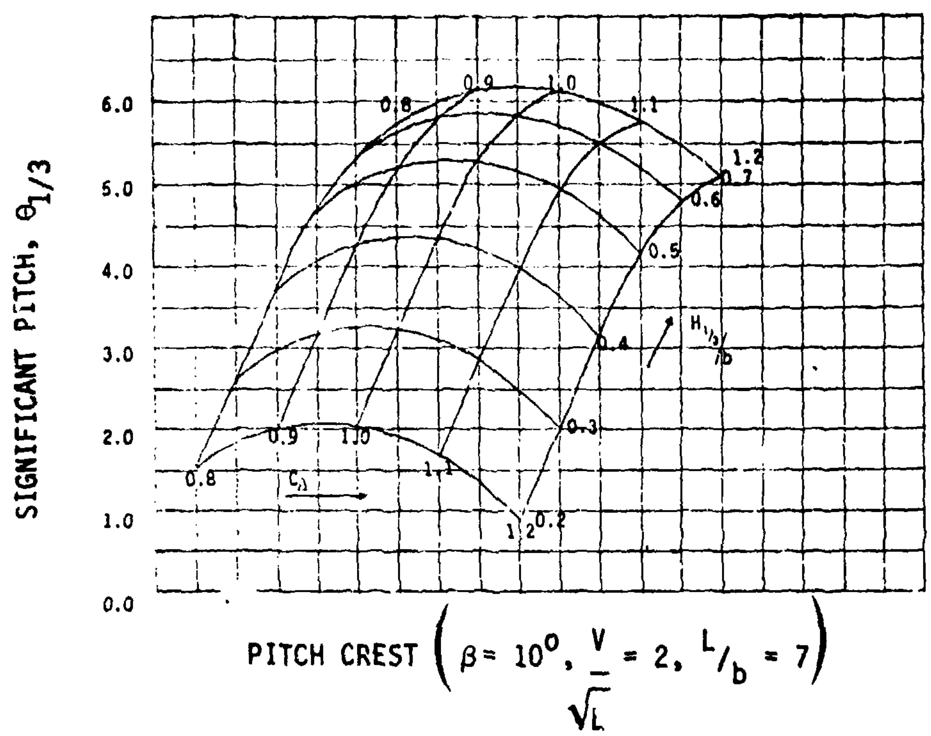


Figure 4 - Sample Acceleration Record



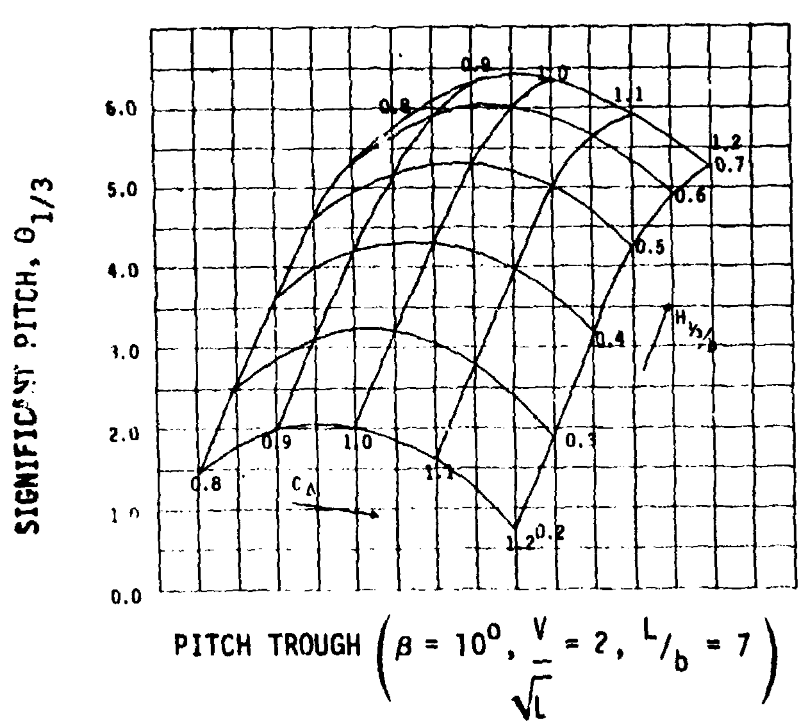
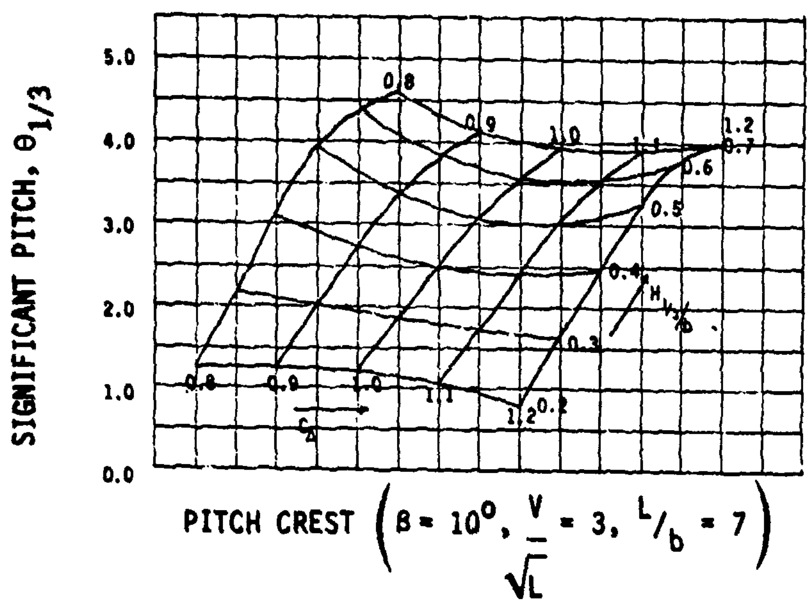


Figure 5 - Significant Pitch, $\beta = 10^o$, $\tau = 3^o$



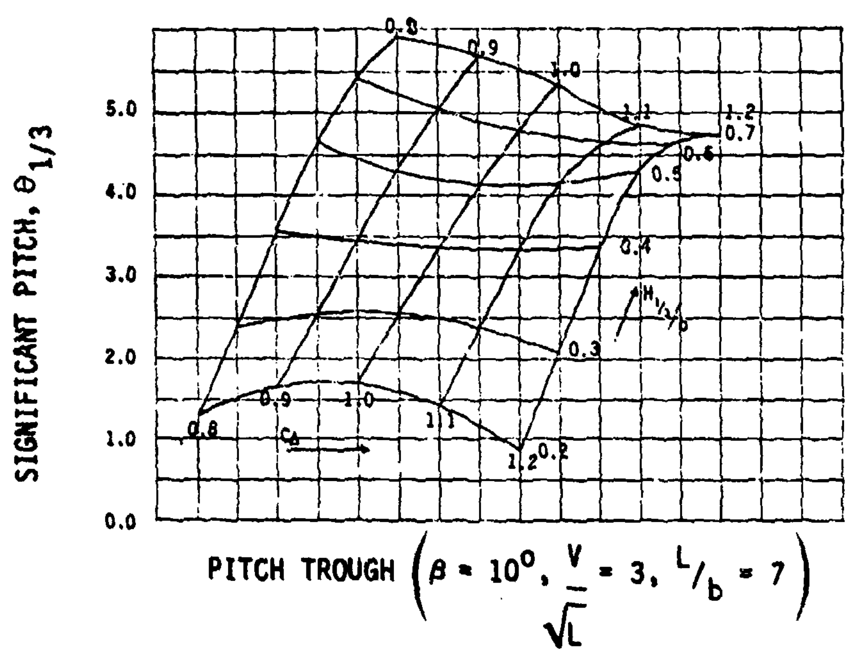
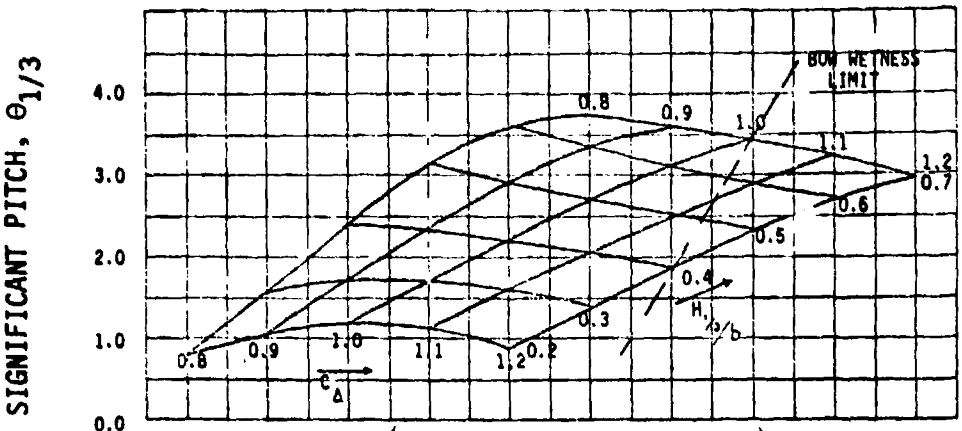
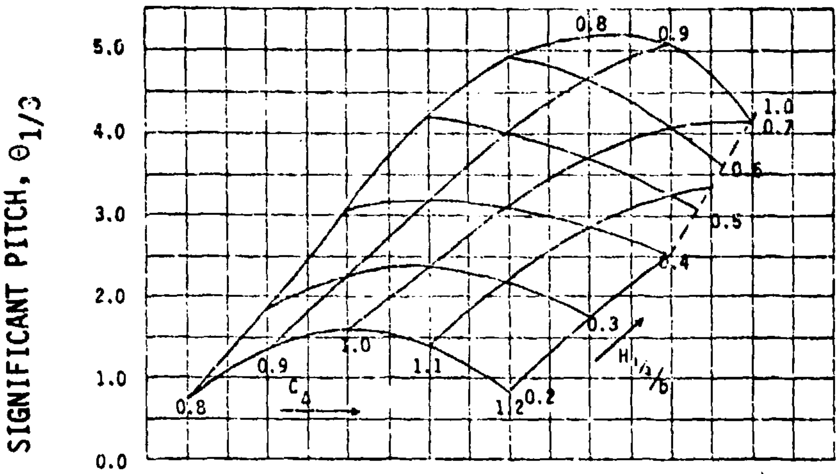


Figure 5 - Continued

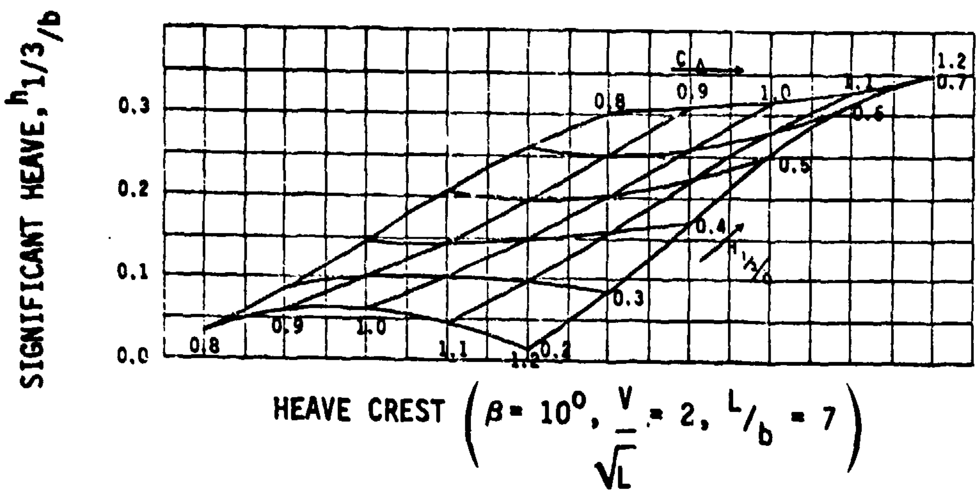


PITCH CREST $\left(\beta = 10^o, \frac{V}{\sqrt{L}} = 4, L/_b = 7\right)$



PITCH TROUGH $\left(\beta = 10^o, \frac{V}{\sqrt{L}} = 4, L/_b = 7\right)$

Figure 5 - Continued



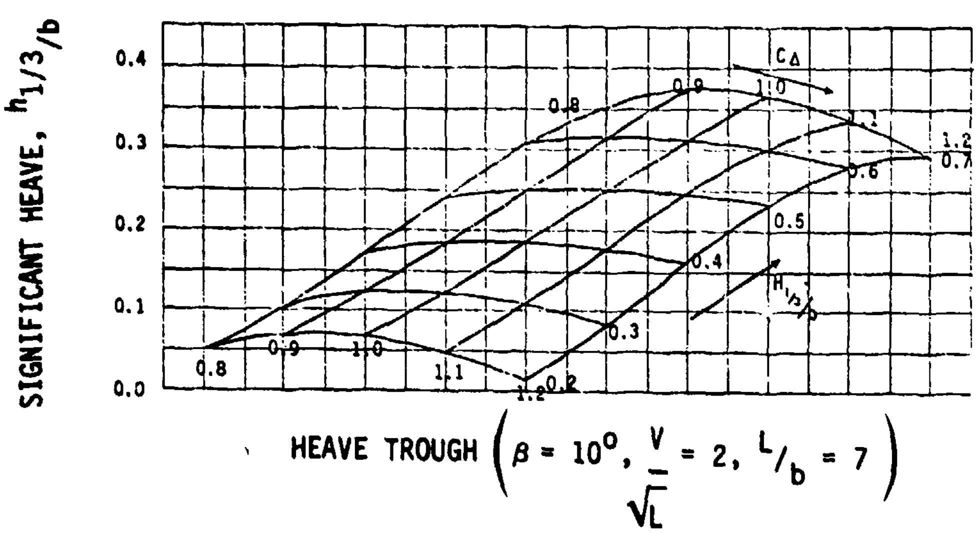
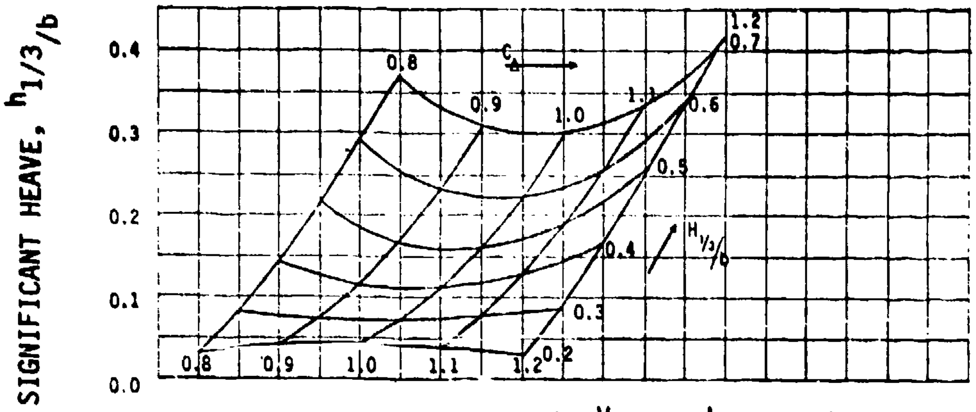
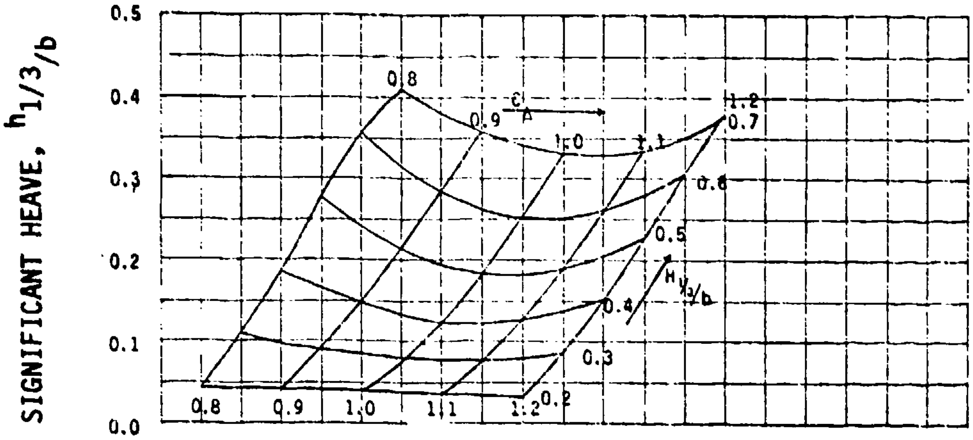


Figure 6 - Significant Heave $\beta = 10^{o}$, $\tau = 3^{o}$

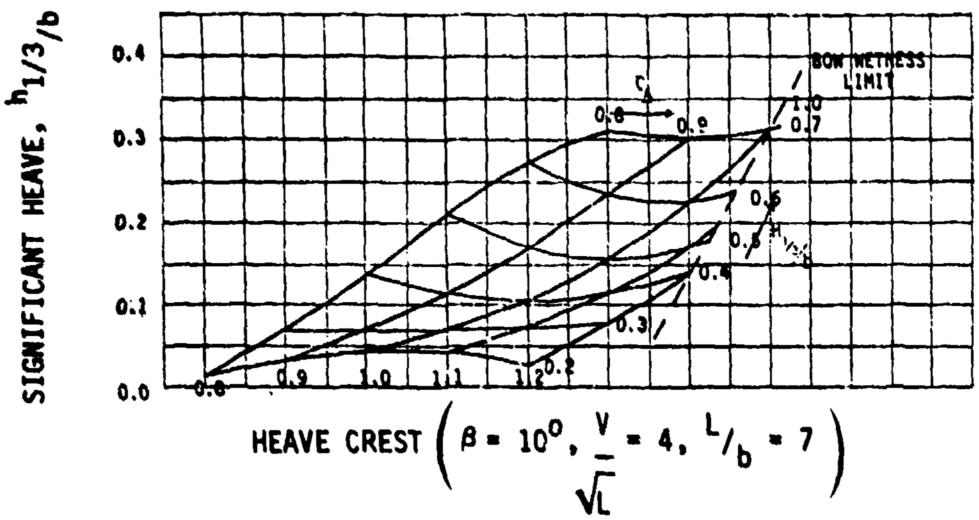


HEAVE CREST $\left(\beta = 10^o, \frac{V}{\sqrt{L}} = 3, L/b = 7\right)$



HEAVE TROUGH $\left(\beta = 10^o, \frac{V}{\sqrt{L}} = 3, L/b = 7\right)$

Figure 6 - Continued



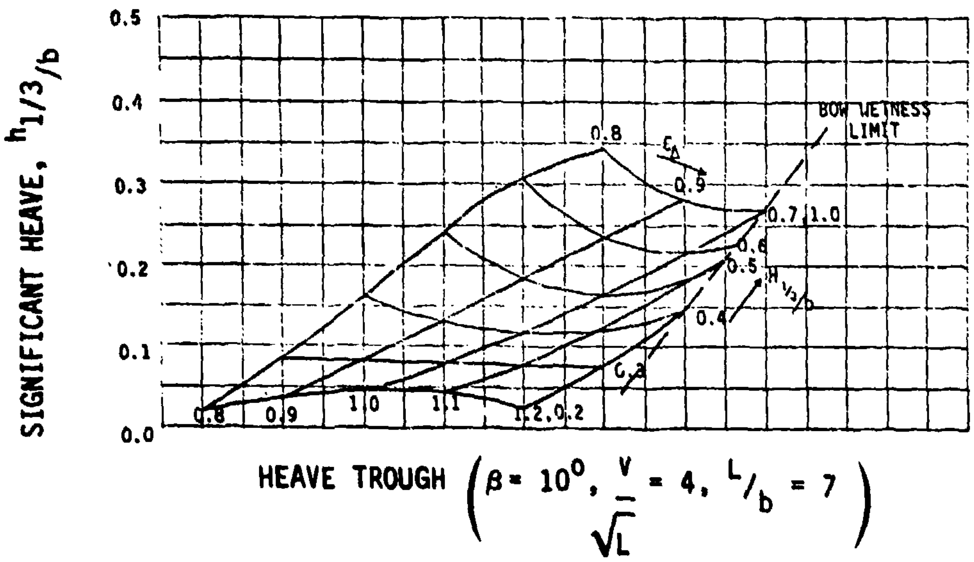


Figure 6 - Continued

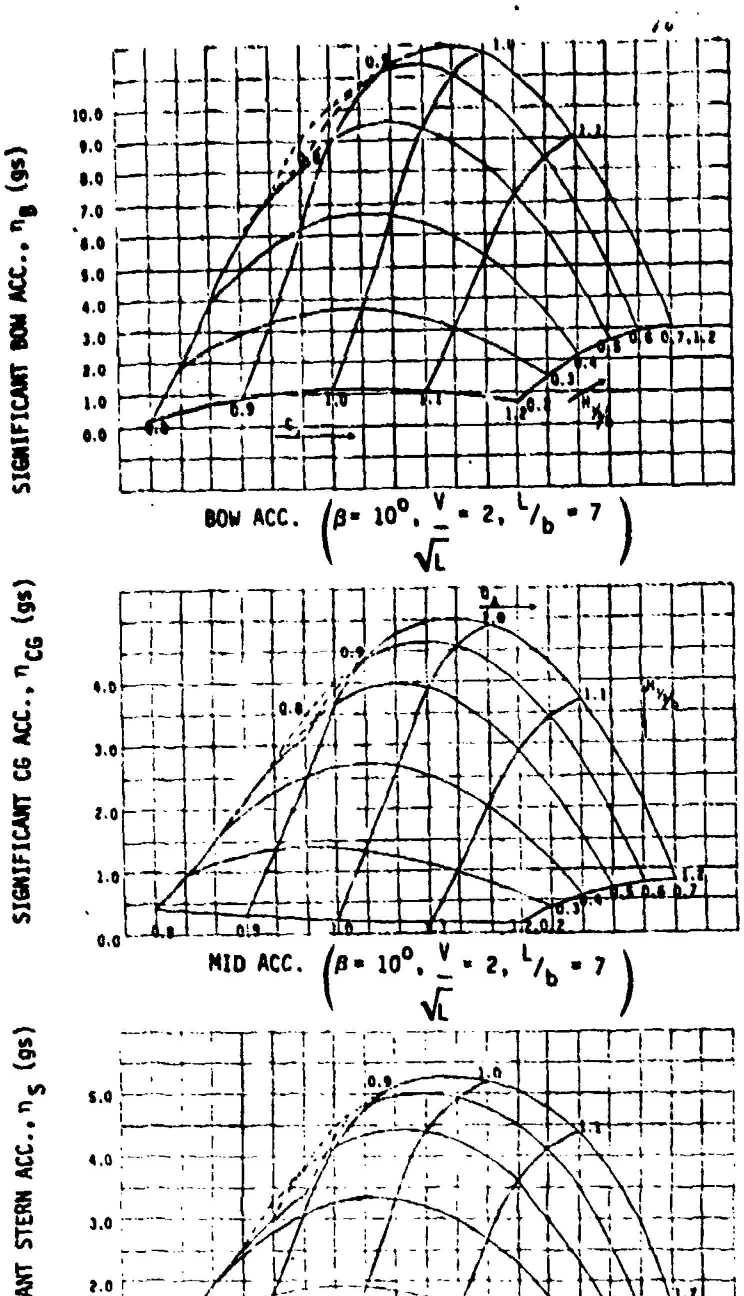


Figure 7 - Significant Bow, CG, and Stern Acceleration $\beta = 10^o, \tau = 3^o$

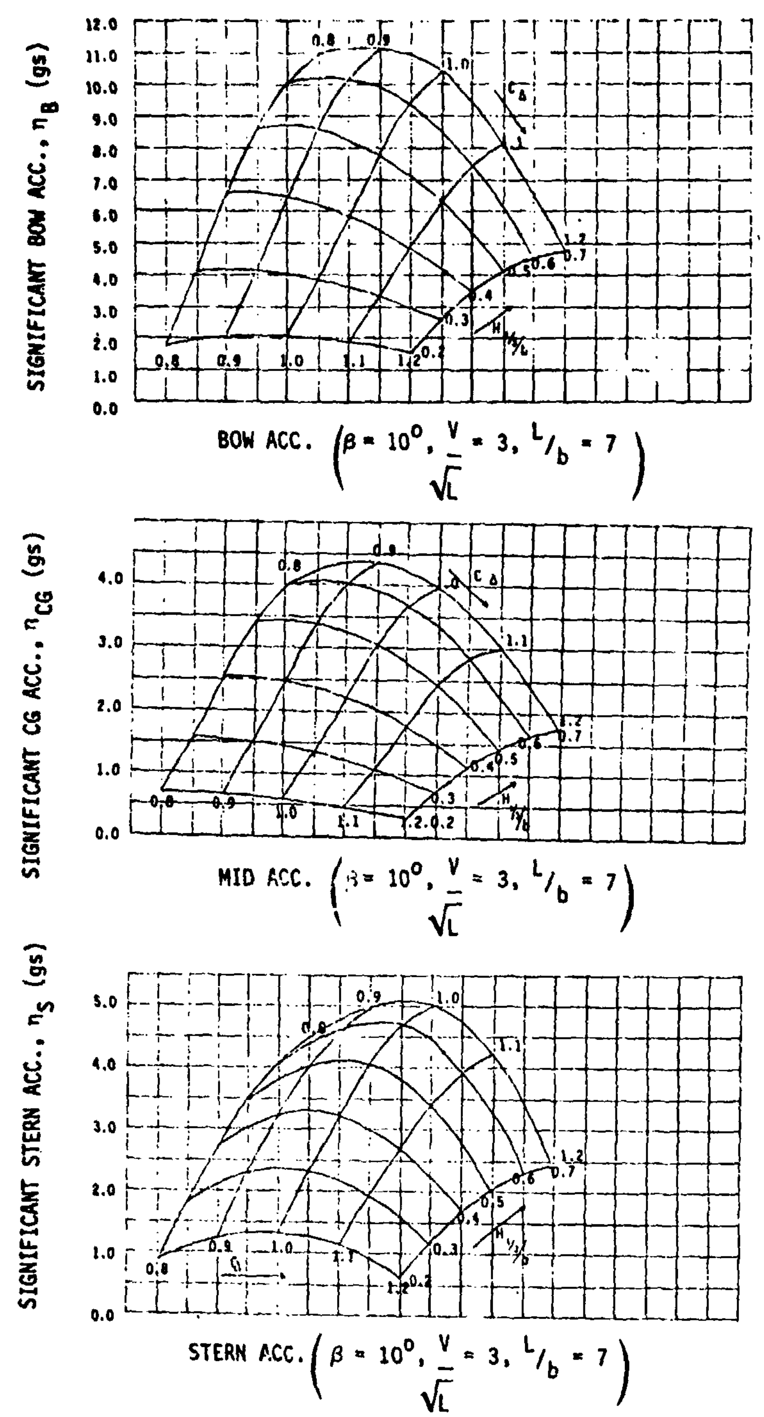
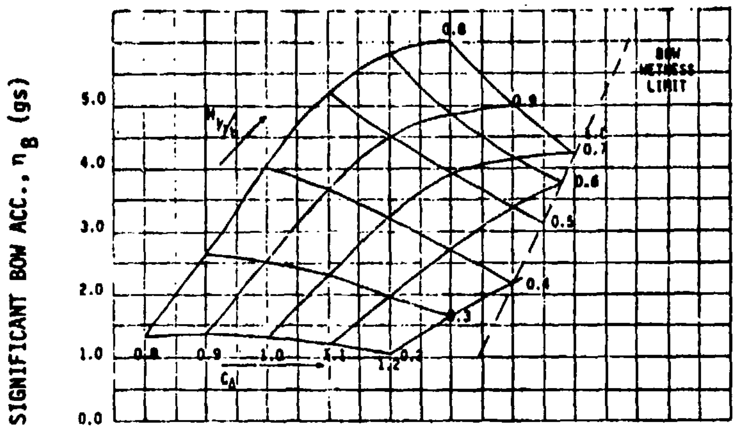
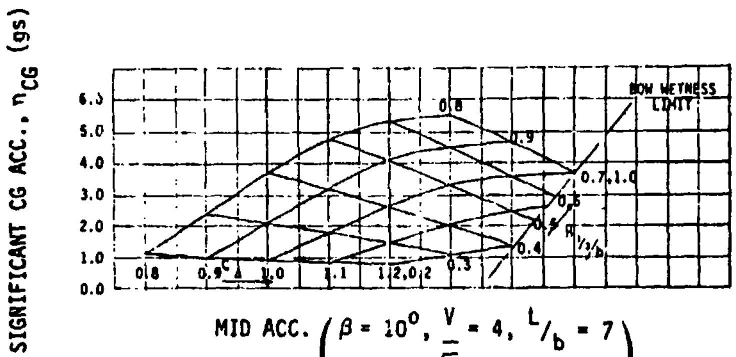


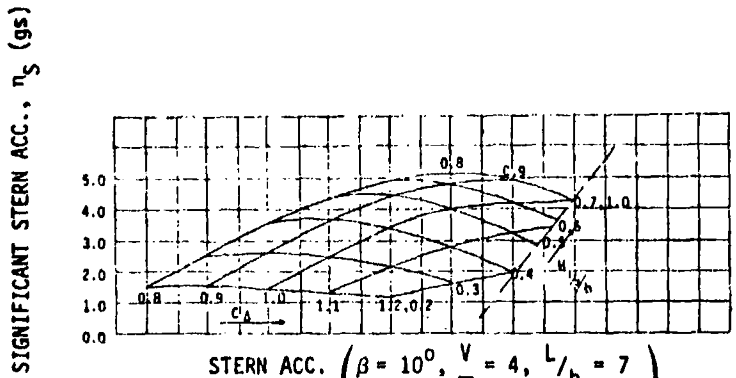
Figure 7 - Continued



BOW ACC. $\left(\beta = 10^o, \frac{V}{\sqrt{L}} = 4, L/b = 7\right)$



MID ACC. $\left(\beta = 10^o, \frac{V}{\sqrt{L}} = 4, L/b = 7\right)$



STERN ACC. $\left(\beta = 10^o, \frac{V}{\sqrt{L}} = 4, L/b = 7\right)$

Figure 7 - Continued

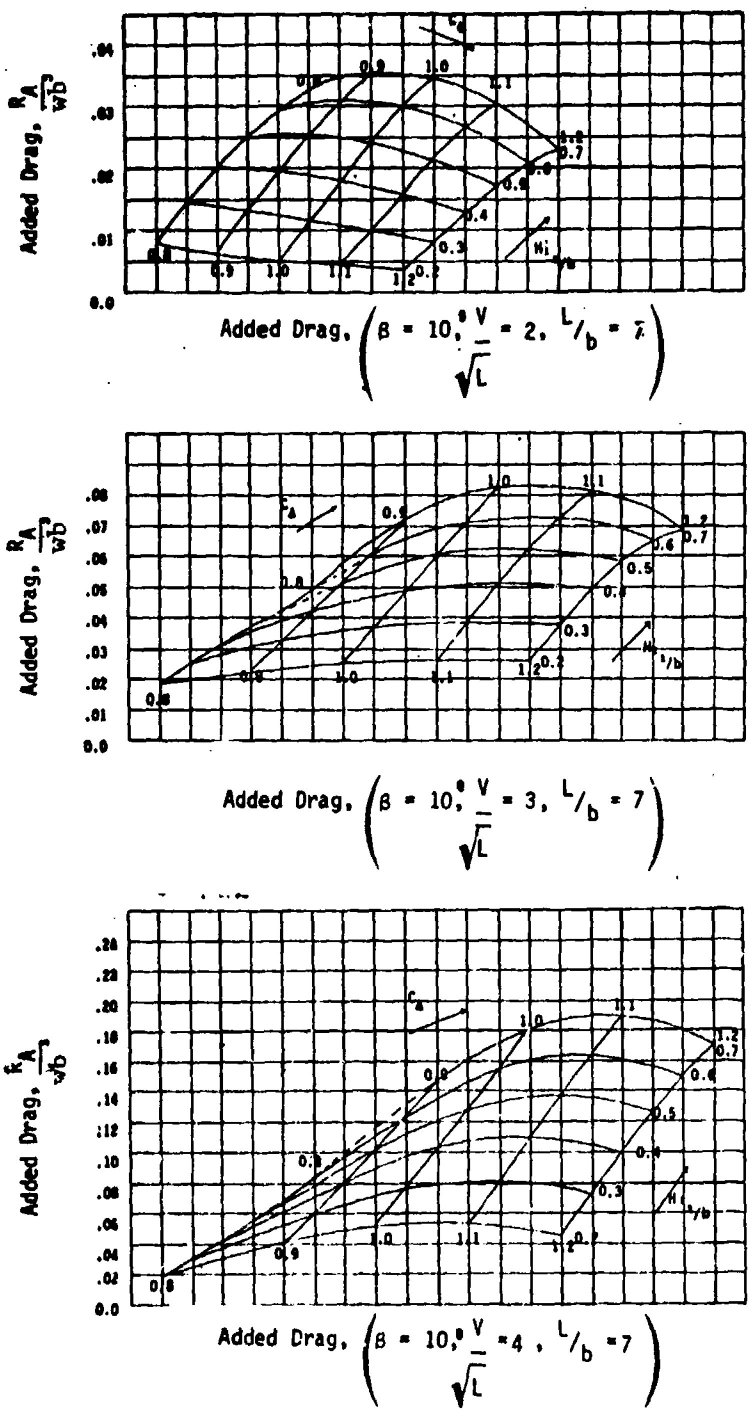
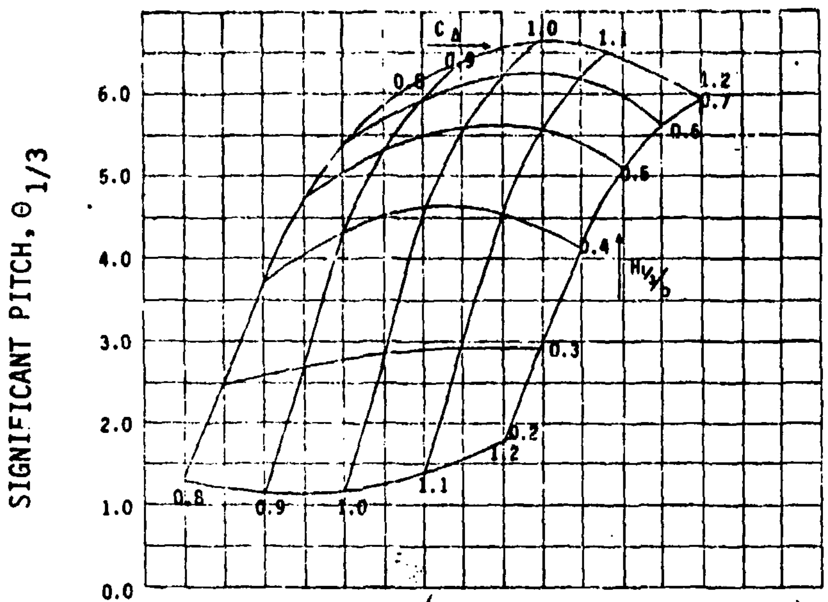
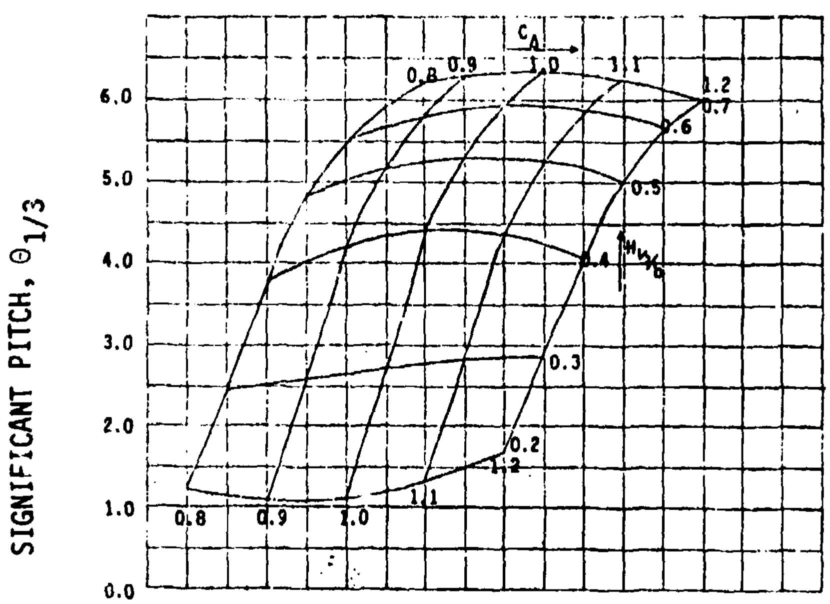


Figure 8 - Added Wave Resistance $\beta = 10^\circ, \tau = 3^\circ$

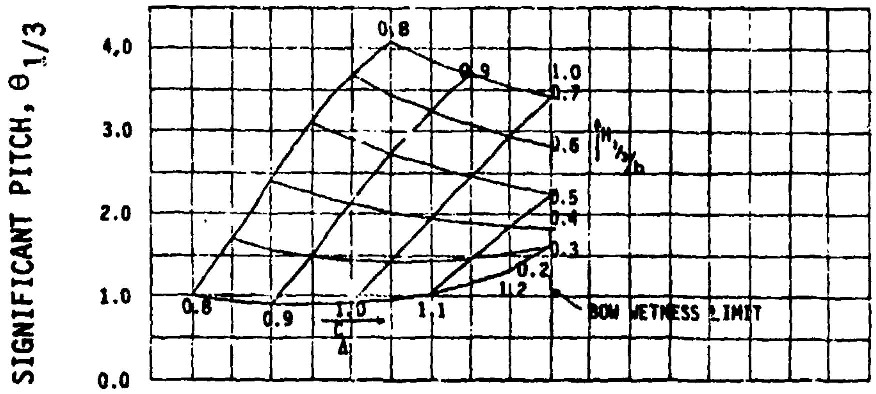


PITCH CREST $\left(\beta = 20^{o}, \frac{V}{\sqrt{L}} = 2, L/b = 7\right)$

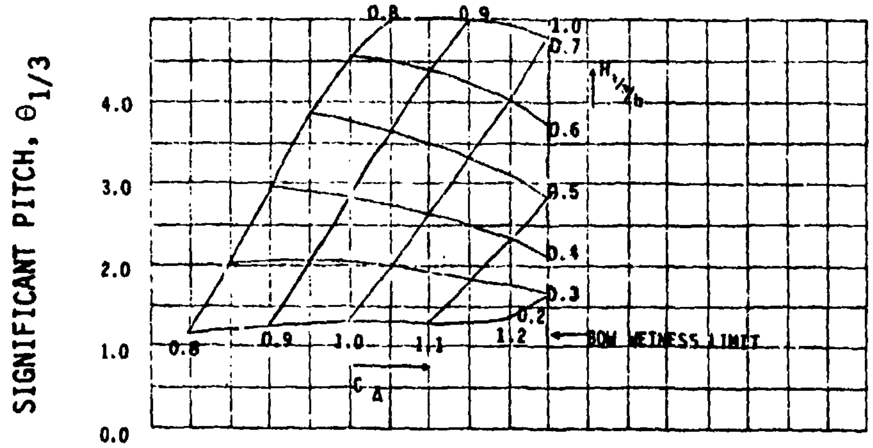


PITCH TROUGH $\left(\beta = 20^{o}, \frac{V}{\sqrt{L}} = 2, L/b = 7\right)$

Figure 9 - Significant Pitch $\beta = 20^{o}, \tau = 3^{o}$

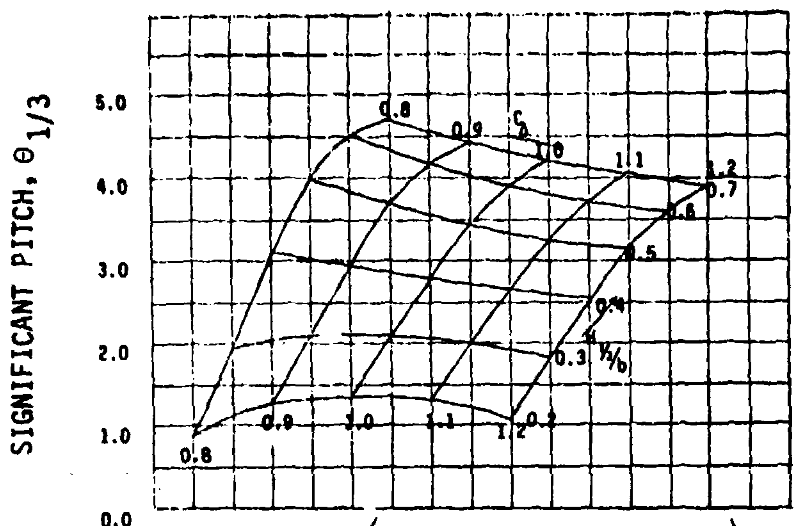


PITCH CREST $\left(\beta = 20^{\circ}, \frac{V}{\sqrt{L}} = 4, L/b = 7\right)$

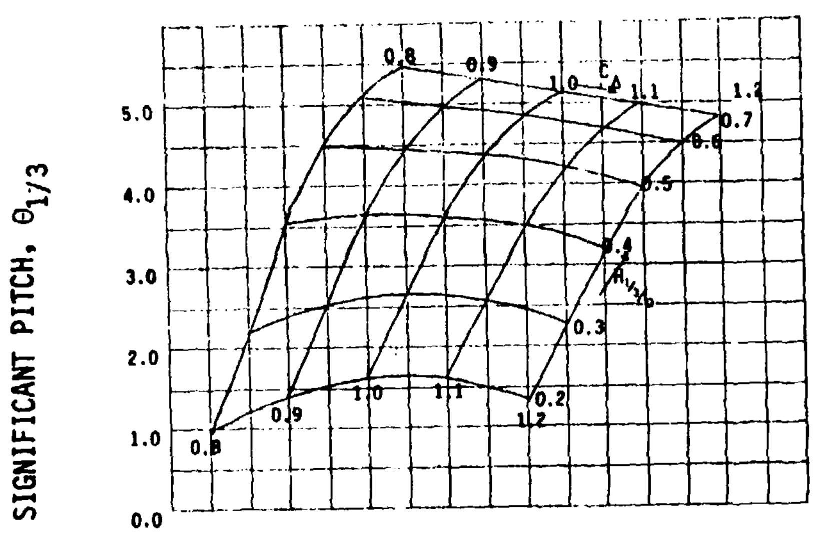


PITCH TROUGH $\left(\beta = 20^{\circ}, \frac{V}{\sqrt{L}} = 4, L/b = 7\right)$

Figure 9 - Continued

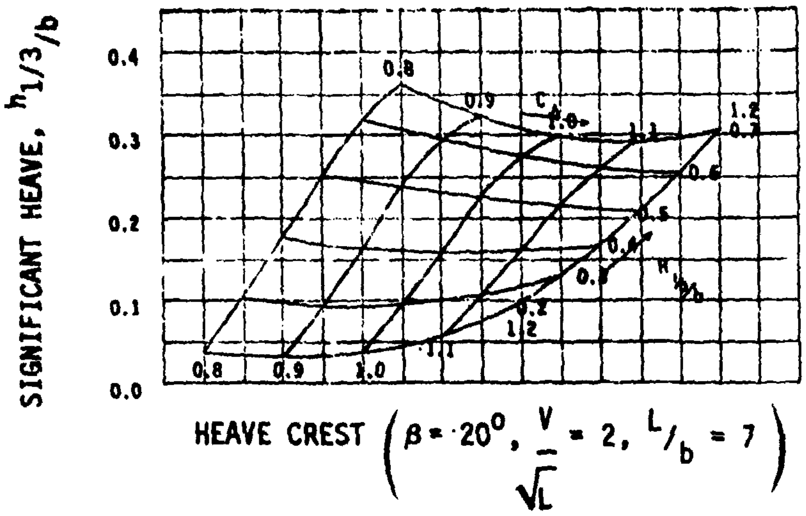


PITCH CREST $\left(\beta = 20^{o}, \frac{V}{\sqrt{L}} = 3, L/b = 7\right)$



PITCH TROUGH $\left(\beta = 20^{o}, \frac{V}{\sqrt{L}} = 3, L/b = 7\right)$

Figure 9 - Continued



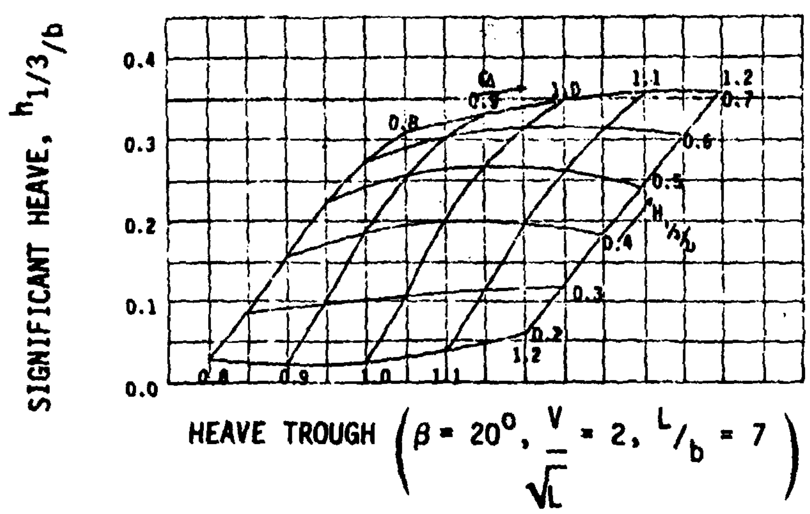
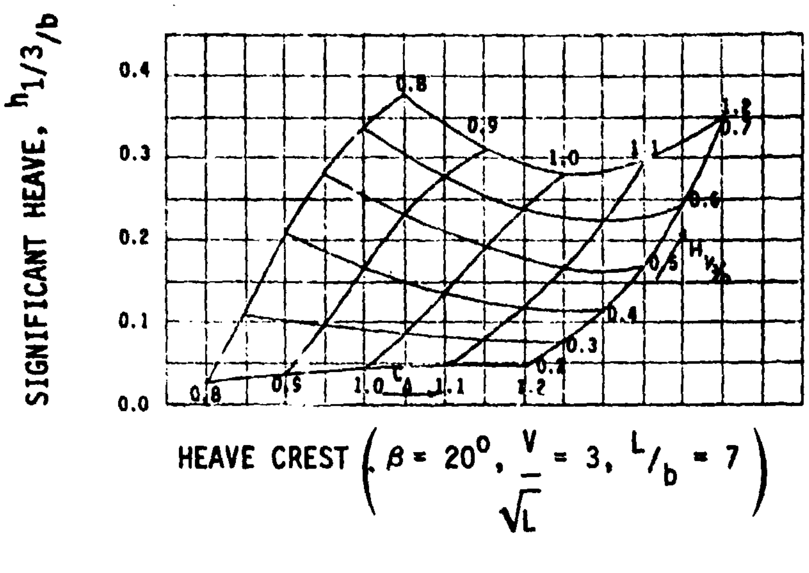


Figure 10 - Significant Heave $\beta = 20^{o}$, $\tau = 3^{o}$



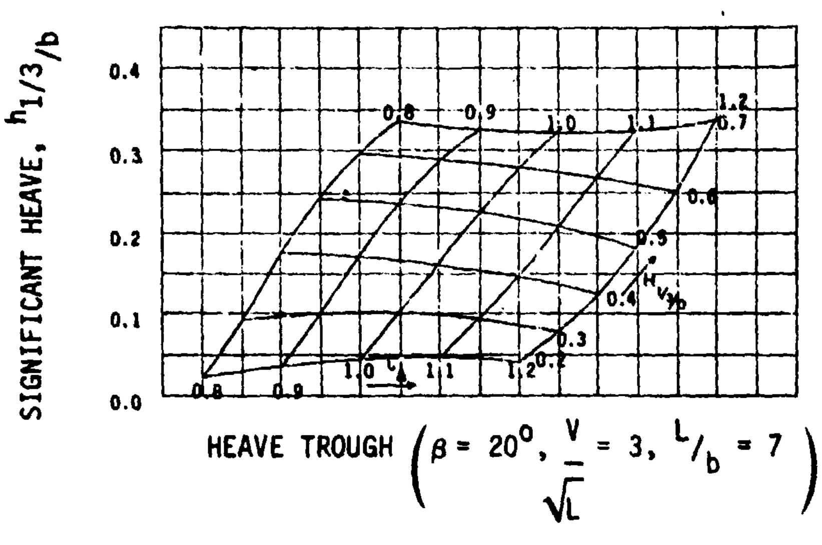
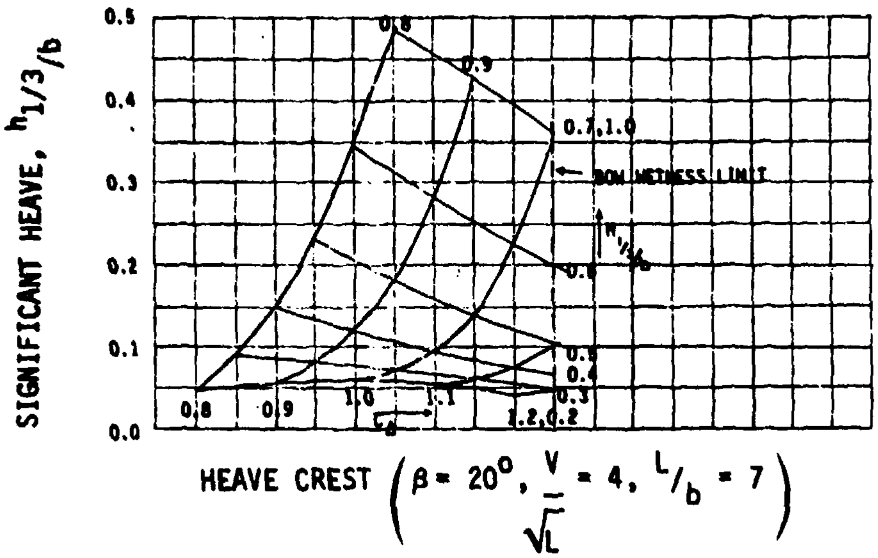


Figure 10 - Continued



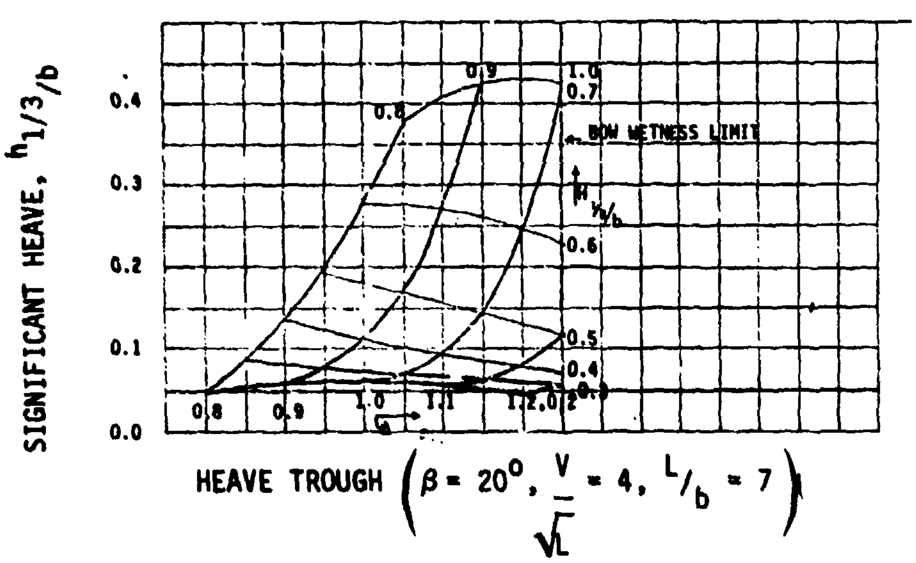


Figure 10 - Continued

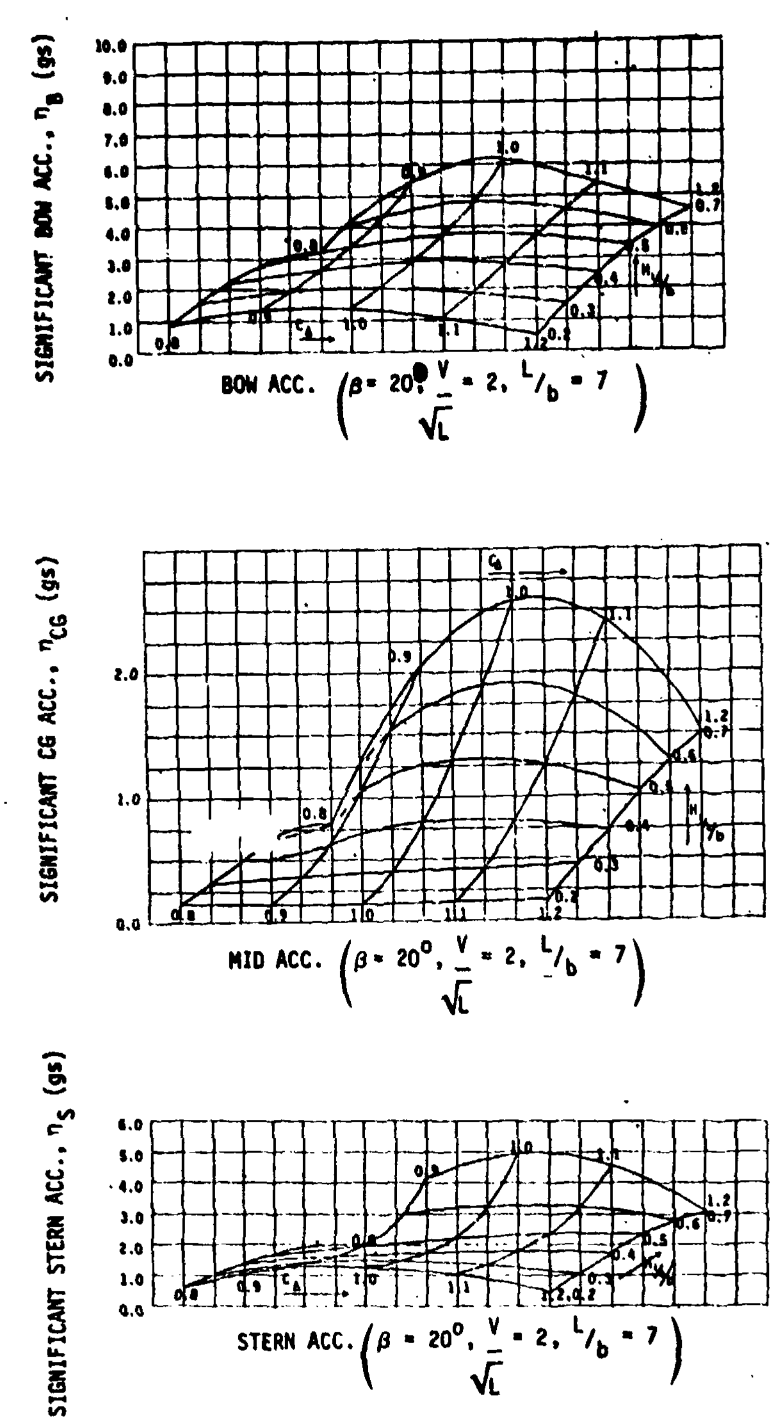


Figure 11 - Significant Bow, CG, and Stern Acceleration $\beta = 20^\circ$, $\tau = 3^\circ$

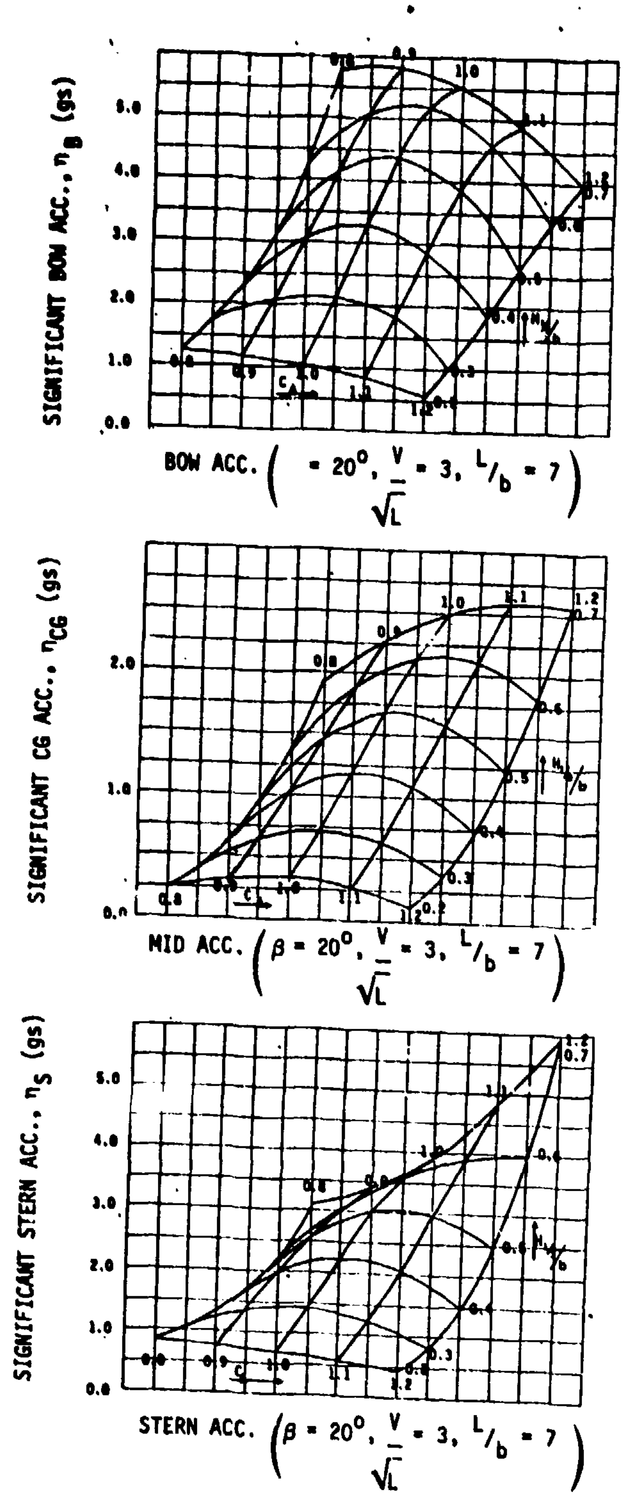
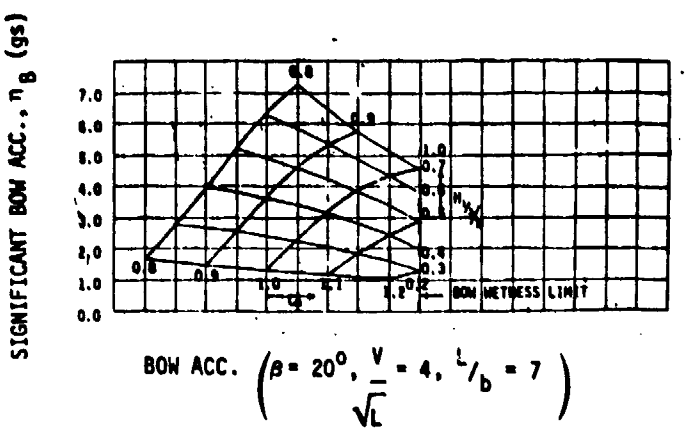
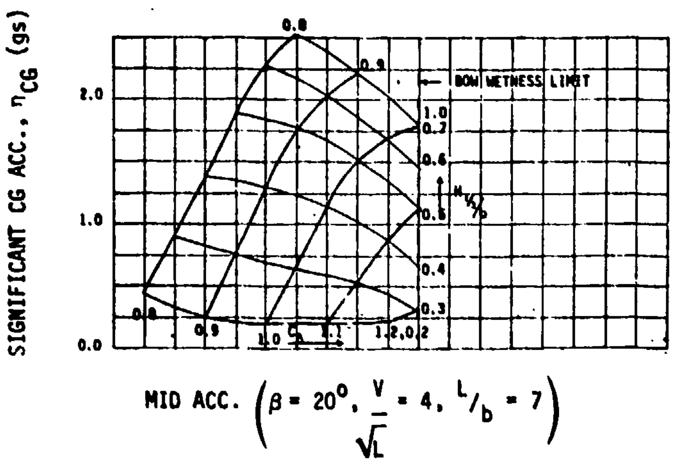


Figure 11 - Continued





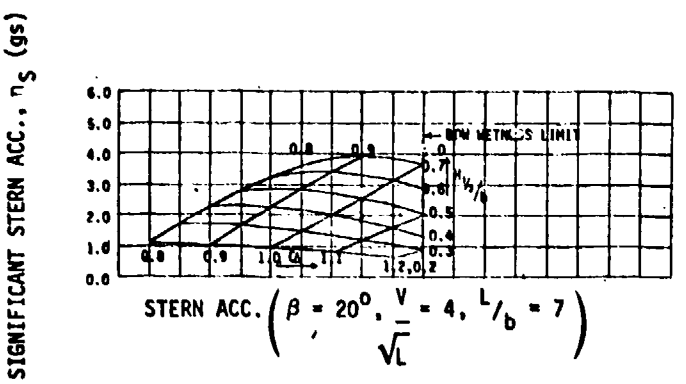


Figure 11 - Continued

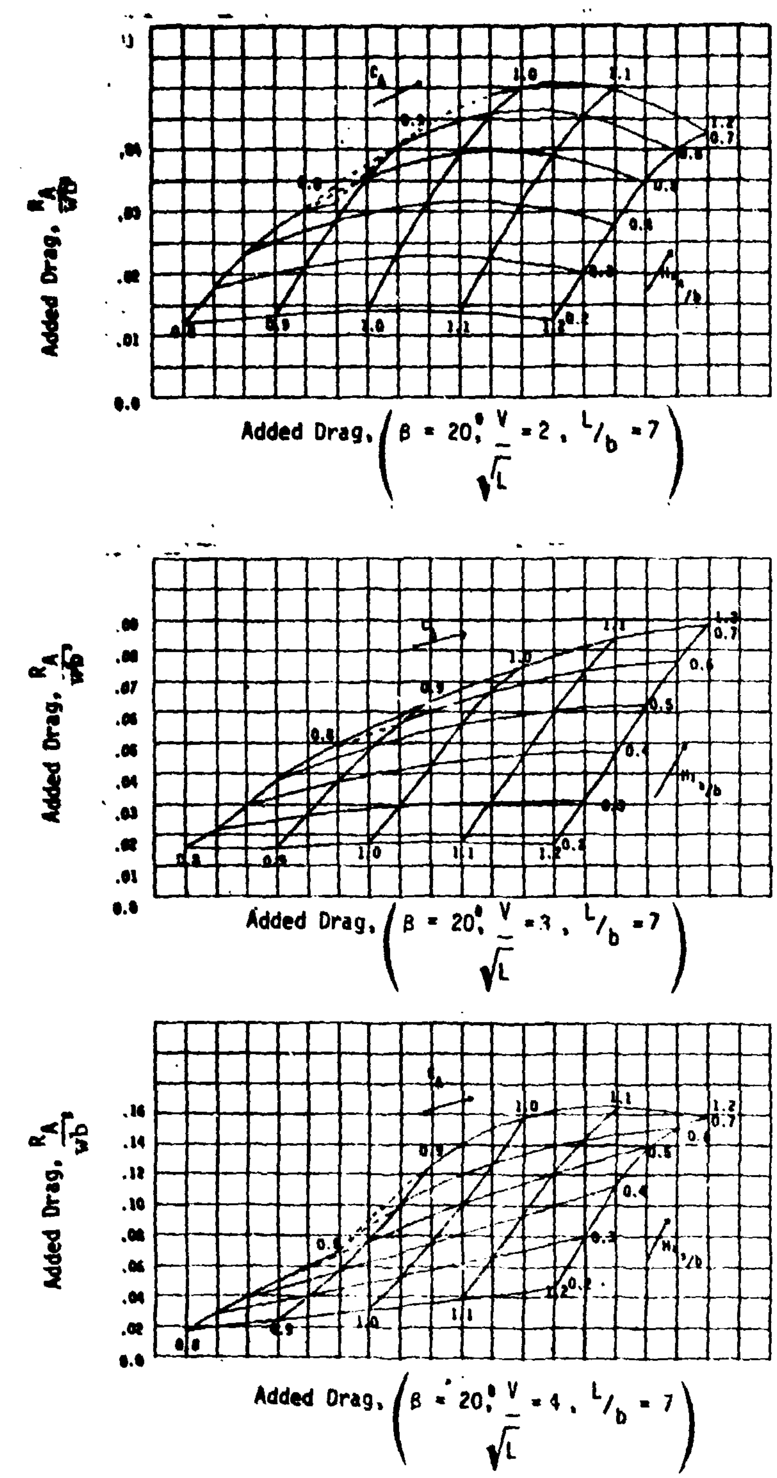
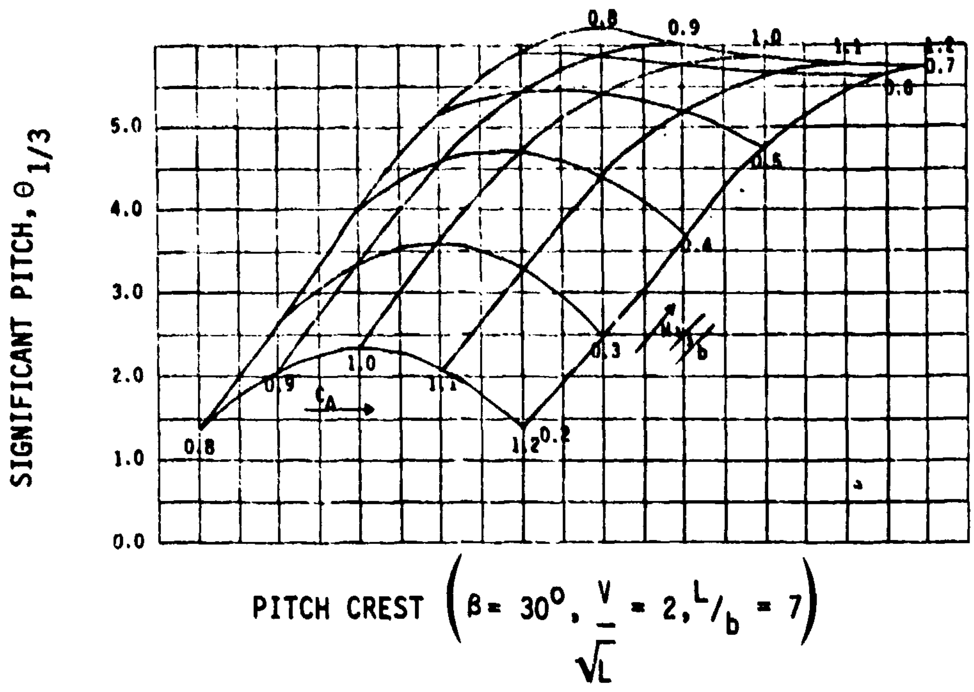


Figure 12 - Added Wave Resistance $\beta = 20^\circ$, $\tau = 3^\circ$



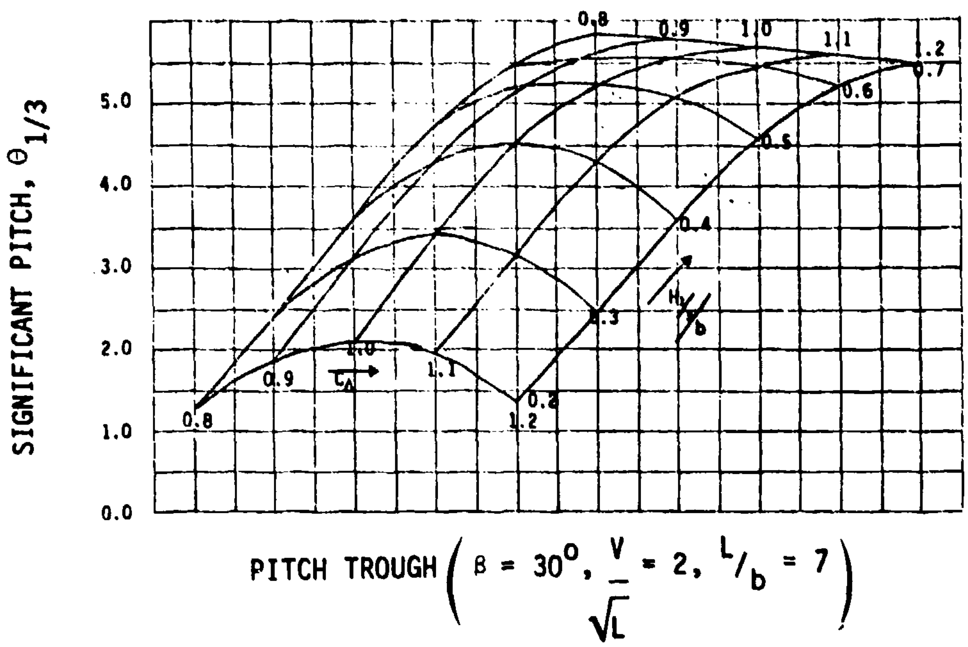
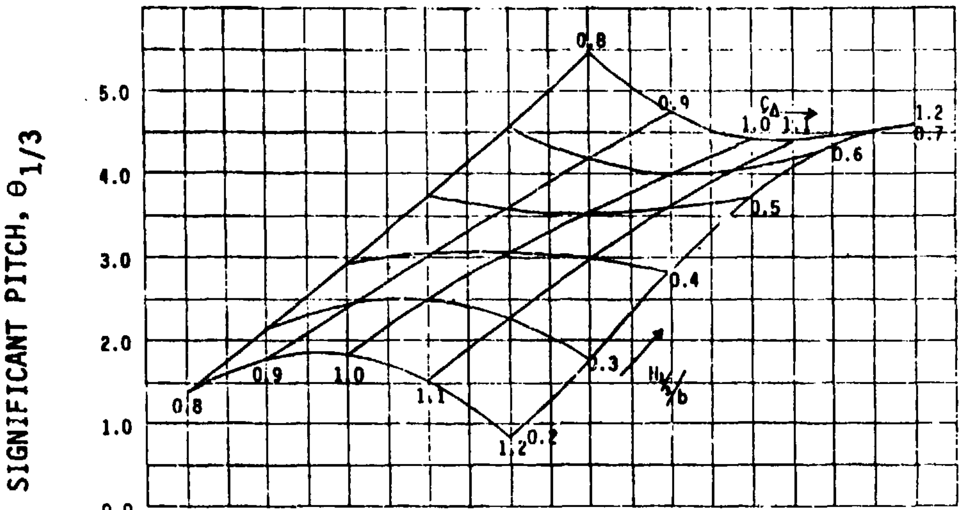
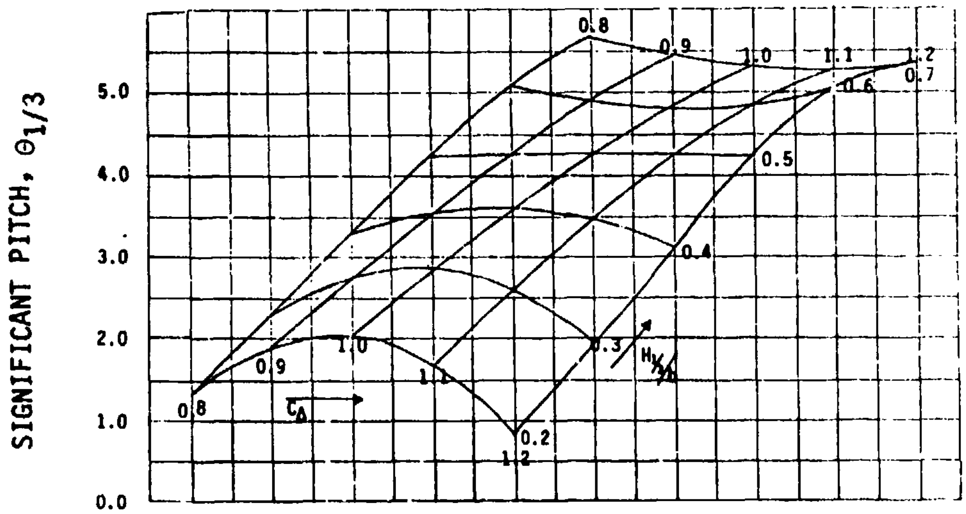


Figure 13 - Significant Pitch $\beta = 30^o$, $\tau = 3^o$

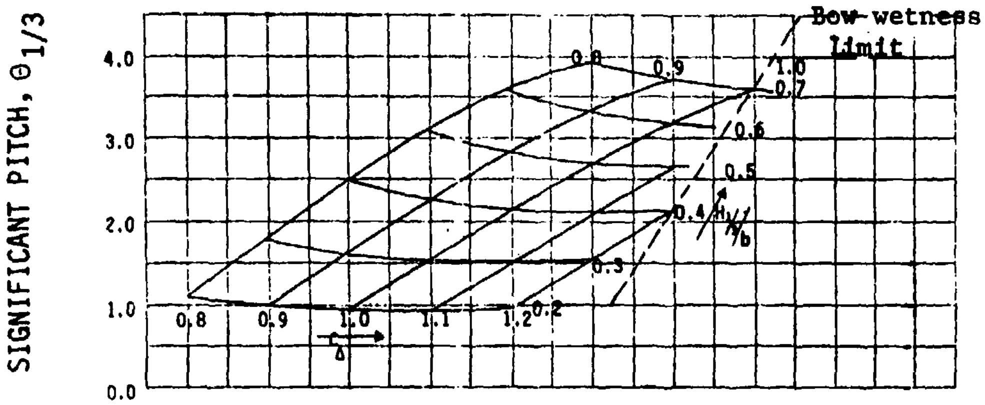


PITCH CREST $\left(\beta = 30^0, \frac{V}{\sqrt{L}} = 3, {}^L/_b = 7\right)$

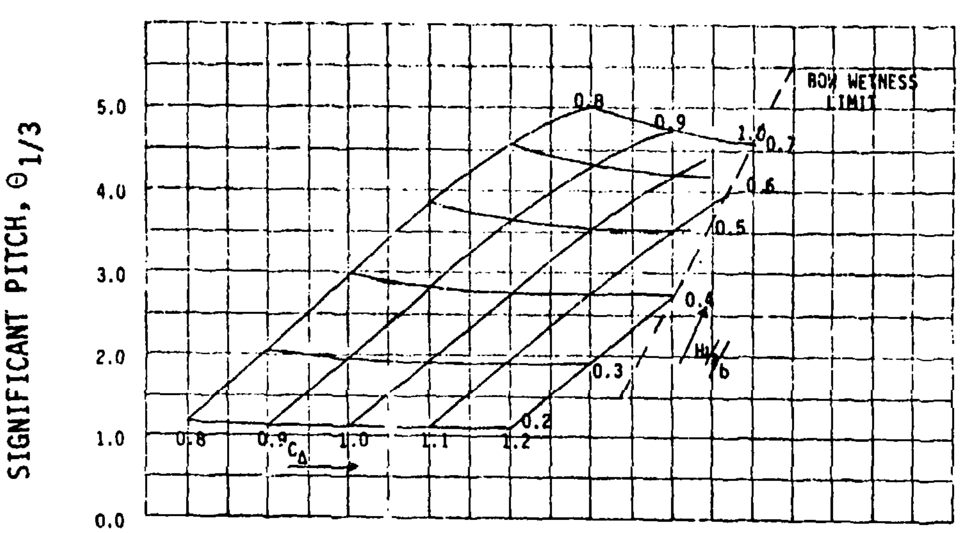


PITCH TROUGH $\left(\beta = 30^0, \frac{V}{\sqrt{L}} = 3, {}^L/_b = 7\right)$

Figure 13 - Continued

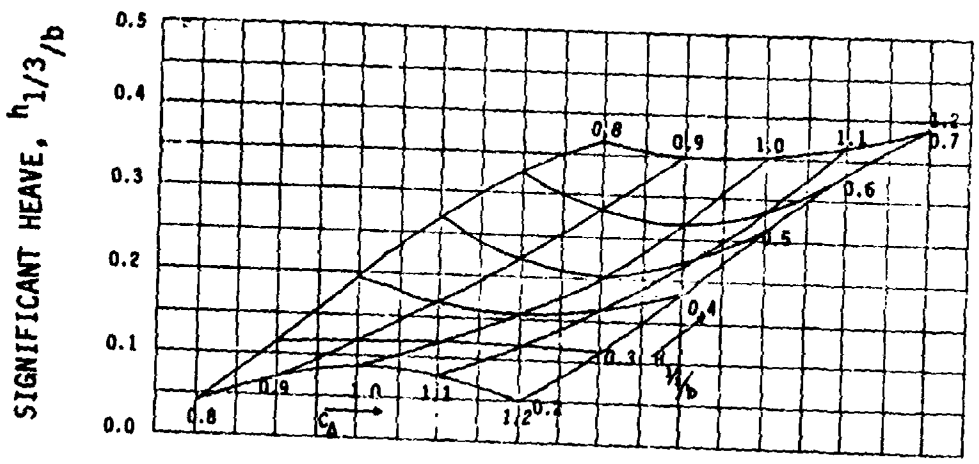


PITCH CREST $\left(\beta = 30^o, \frac{V}{\sqrt{L}} = 4, L/b = 7\right)$

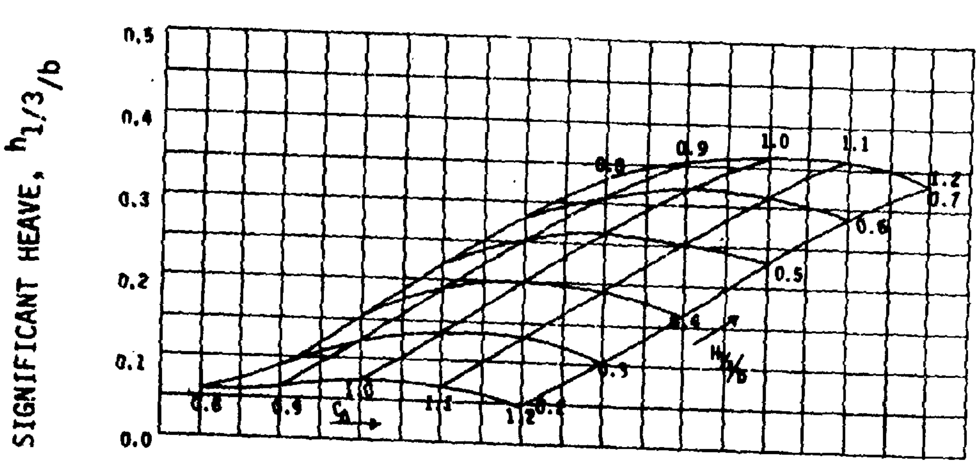


PITCH TROUGH $\left(\beta = 30^o, \frac{V}{\sqrt{L}} = 4, L/b = 7\right)$

Figure 13 - Continued

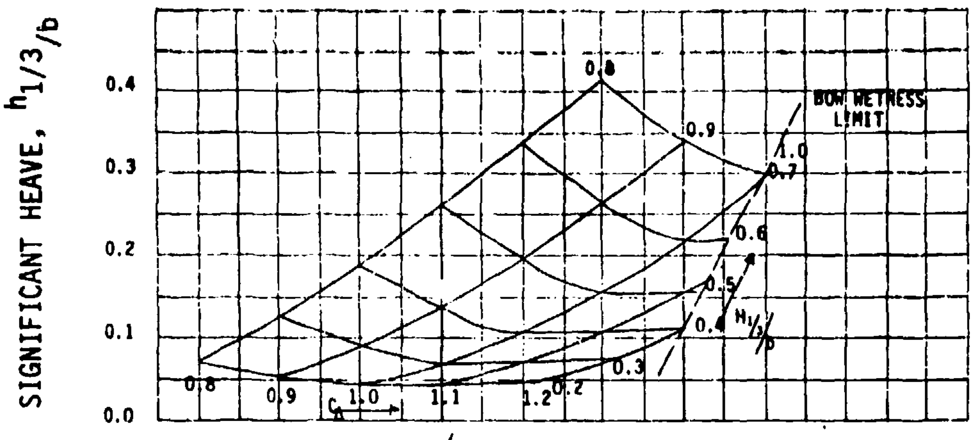


HEAVE CREST $\left(\beta = 30^o, \frac{V}{\sqrt{L}} = 2, L/_b = 7\right)$

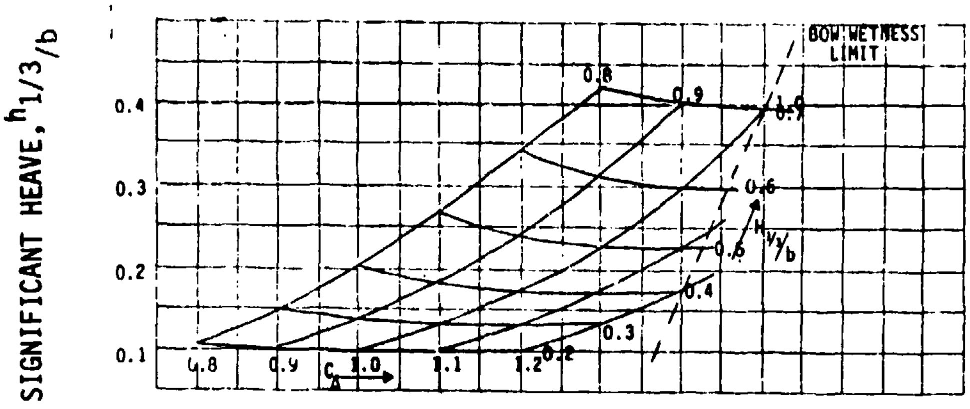


HEAVE TROUGH $\left(\beta = 30^o, \frac{V}{\sqrt{L}} = 2, L/_b = 7\right)$

Figure 14 - Significant Heave $\beta = 30^o$, $\tau = 3^o$

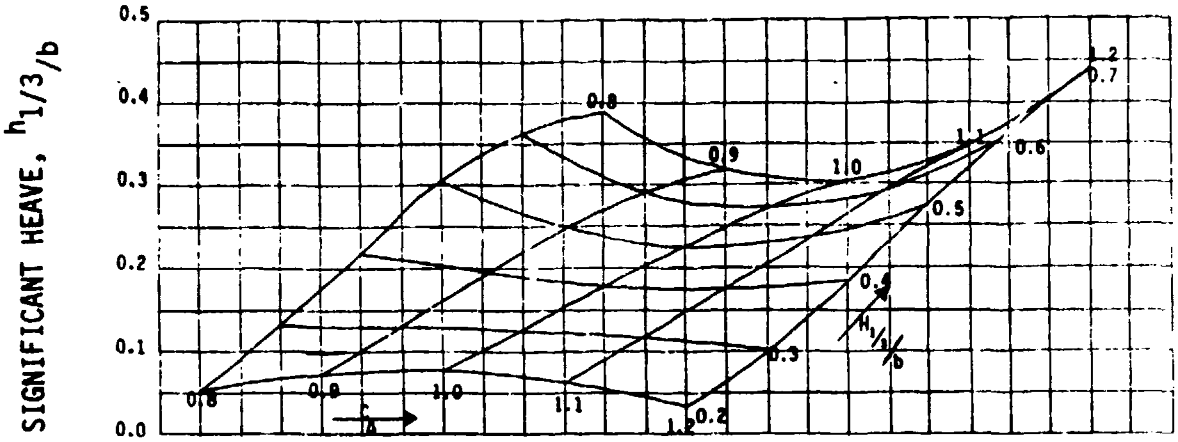


HEAVE CREST $\left(\beta = 30^{o}, \frac{V}{\sqrt{L}} = 4, L/b = 7\right)$

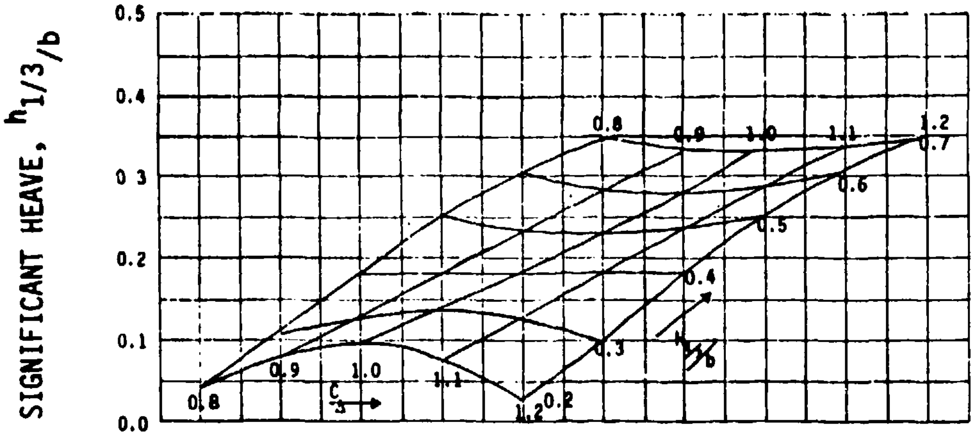


HEAVE TROUGH $\left(\beta = 30^{o}, \frac{V}{\sqrt{L}} = 4, L/b = 7\right)$

Figure 14 - Continued



HEAVE CREST $\left(\beta = 30^{\circ}, \frac{V}{\sqrt{L}} = 3, L/b = 7\right)$



HEAVE TROUGH $\left(\beta = 30^{\circ}, \frac{V}{\sqrt{L}} = 3, L/b = 7\right)$

Figure 14 - Continued

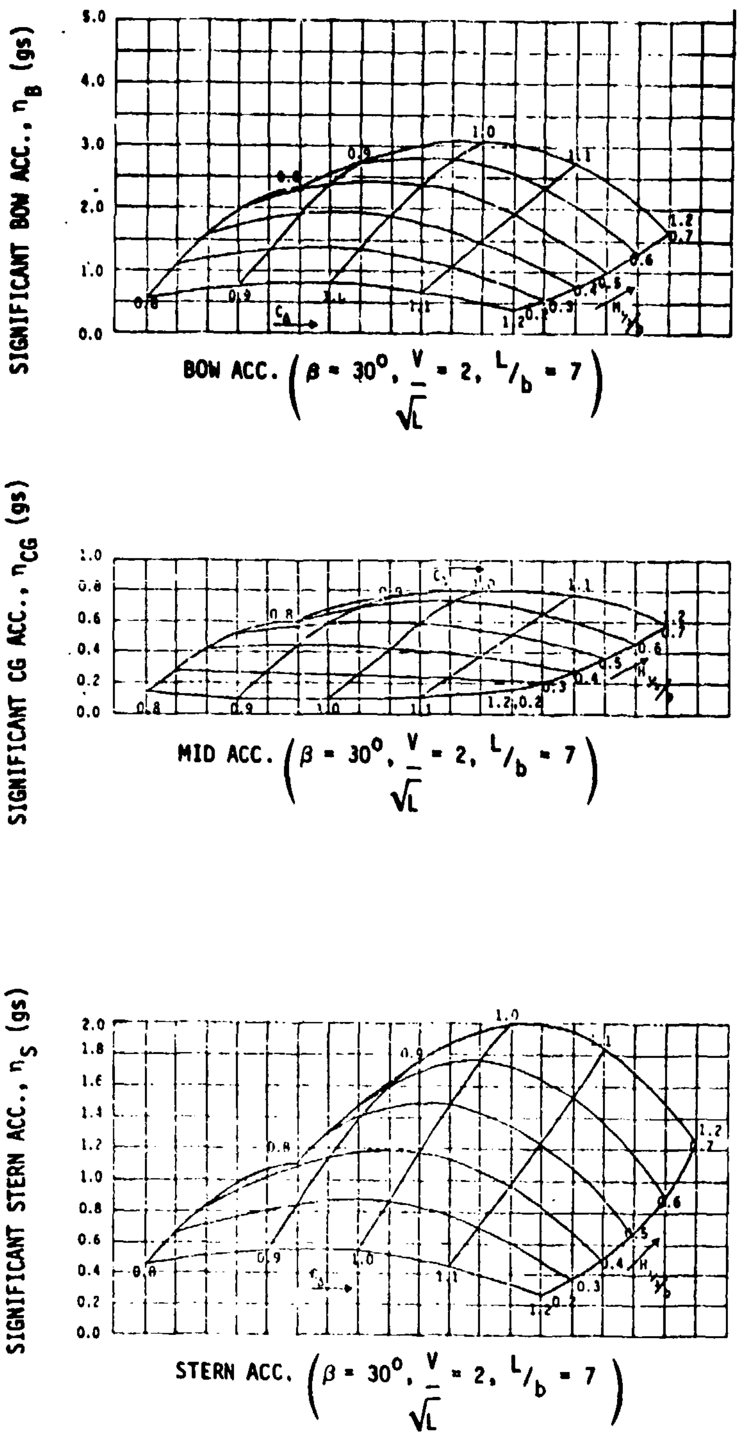


Figure 15 - Significant Bow, CG, and Stern Acceleration $\beta = 30^{\circ}$, $\tau = 3^{\circ}$

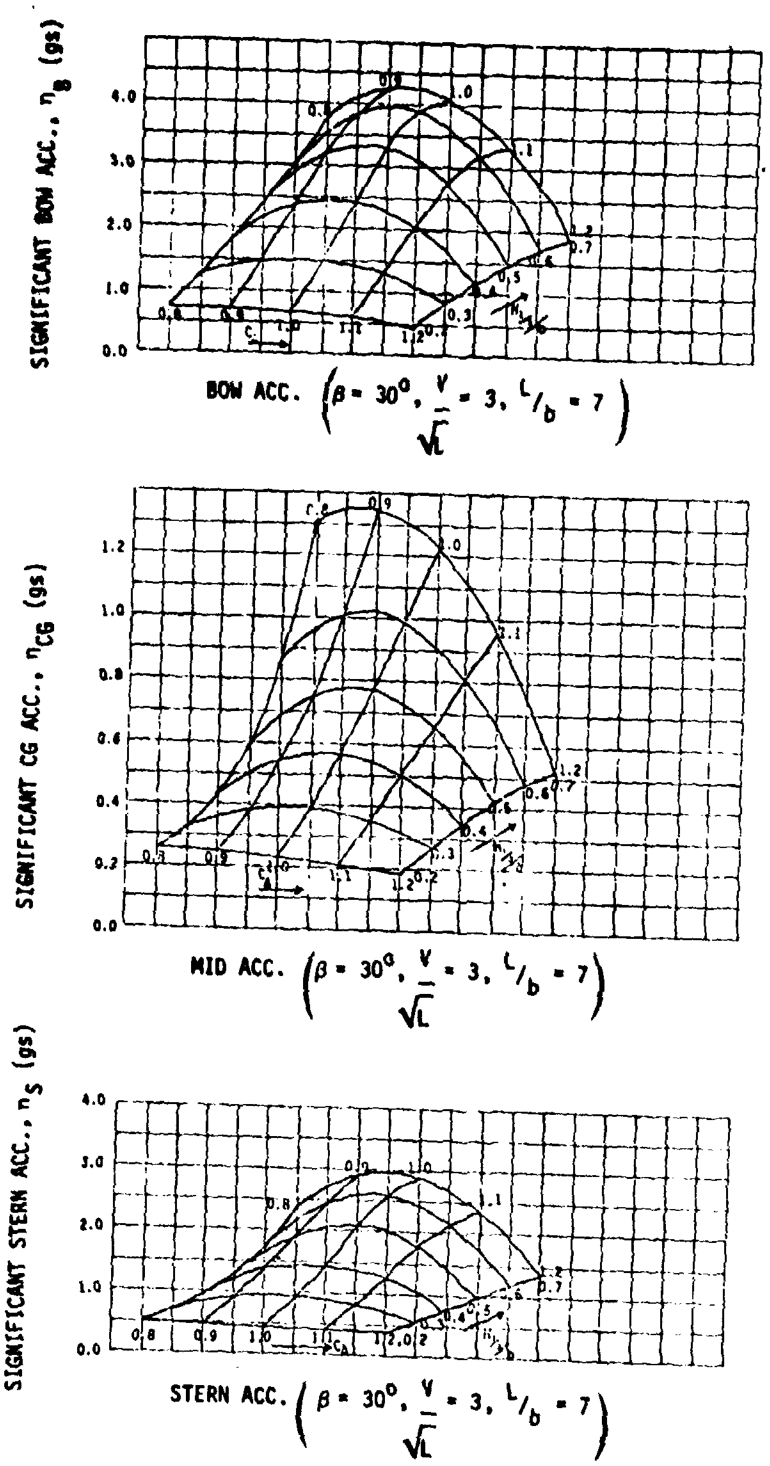


Figure 15 - Continued

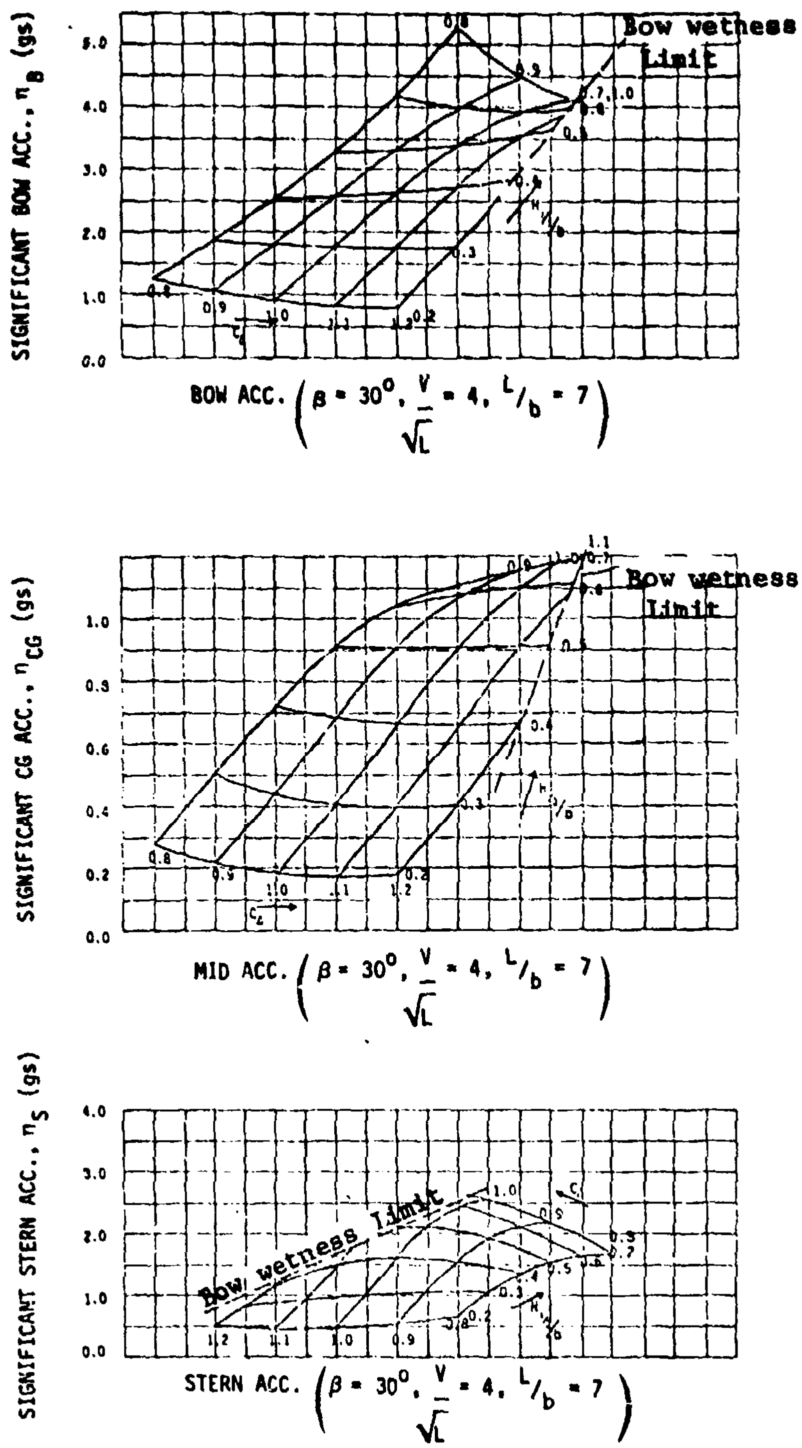


Figure 15 - Continued

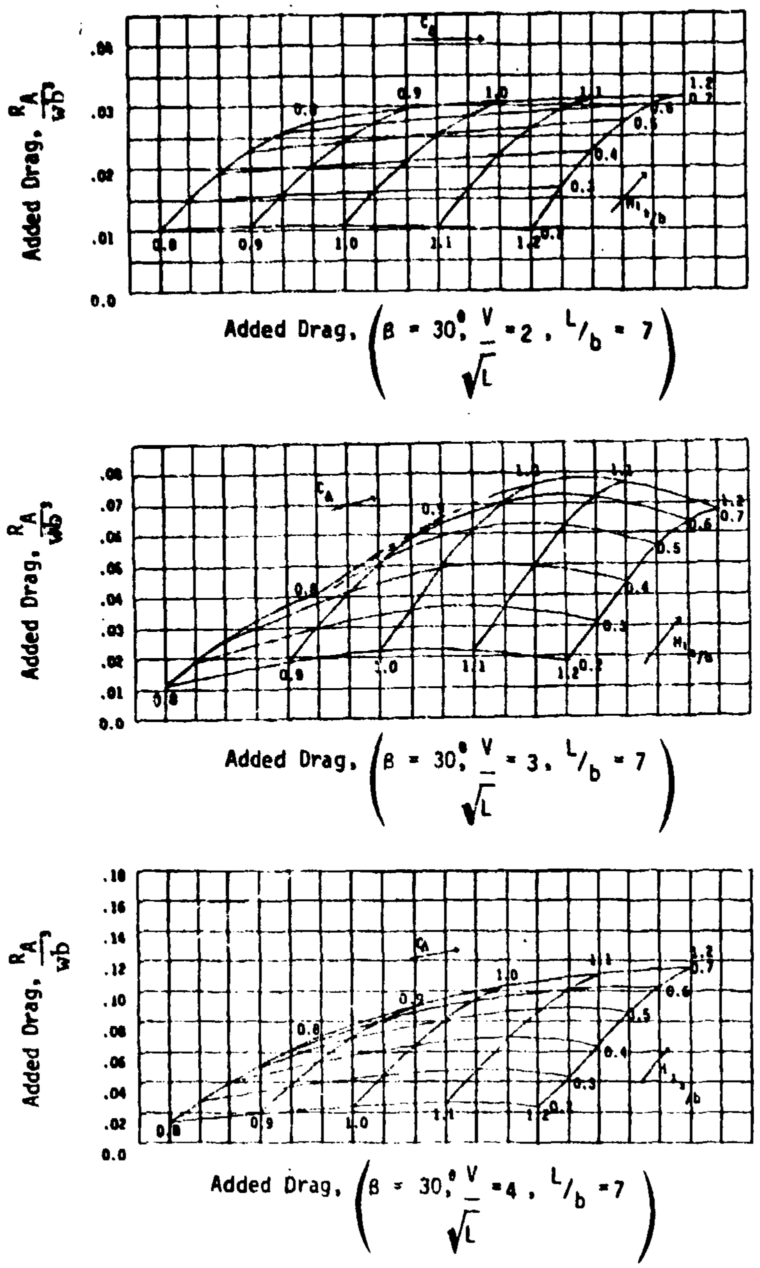


Figure 16 - Added Wave Resistance $\beta = 30^o$, $\tau = 3^o$

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