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DAVIDSON LABORATORY

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November 1977

HEAD SEA MODEL TESTS OF THE FSHV WITH AN EXTENDED BOW AND SPRAY STRIPS

by

R.L. Van Dyck

Prepared for
Code 03221 of Naval Sea Systems Command
under
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Approved

Ward Brown

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INTRODUCTION

Preliminary trials of the FSHV LVA at Camp Pendleton have indicated a pilot visibility problem during wave operations at low speeds. The LVA Technical Manager called a meeting to discuss this problem and possible retrofit solutions at DTNSRDC on 5 October 1977. Arising out of this meeting a retrofit bow extension and several bow appendages were designed by the LVA Office, Code 112. Appropriate modifications were made to the existing 1/12-scale FSHV model and were tested in Davidson Laboratory's Tank 3 facility from 13 to 18 October.

The primary purpose of these runs was to observe the effects of these retrofit appendages on cockpit wetting. To this end a cockpit and turret were simulated on the model and bow- and stern-view television tape records were made of the test runs. Mr. David Halper of Code 112, DTNSRDC, who had witnessed the Camp Pendleton trials was present throughout the tests and advised on their conduct.

MODEL

The existing 1/12-scale FSHV fibreglass hull with brass adjustable transom flap[1] was fitted with a removable simple straight-line triangular planform wedge bow section and two transverse chine strips made according to sketches supplied by Code 112, DTNSRDC; see the video records and Figures 1 and 2. This "new bow" extension increases the overall length 6.5 ft (full scale) and has a constant 10 degree deadrise starting approximately 4 ft aft of the existing "basic bow." The large transverse spray strip corners are located at 1.3 and 4.1 ft aft of the basic bow as shown in Figure 1. In addition, an alternative flat plate (1/16 inch thick on the model) aluminum bow lip was constructed during the tests for the basic up-turned bow design; see Figure 3. The pilot cockpit and turret were modelled, including the outline of the forward-facing windows. The video bow-view coverage shows this part of the model as well as the various bow configurations and appendages.

The model was towed through a pitch pivot located at a nominal center of gravity equivalent to a location 13 ft forward of the transom and 3.5 ft above the hull baseline. This center of gravity was maintained irrespective of load or bow configuration by means of internal ballast weights.

APPARATUS AND PROCEDURE

The test set-up shown in the video coverage consisted of a free-to-trim, free-to-heave, fixed yaw apparatus with provision for measuring pitch, drag, heave of the center of gravity relative to the water surface and two vertical accelerations -- one at the bow and one at the center of gravity. The bow accelerometer was mounted 14 ft (full scale) forward of the CG or 27 ft forward of the transom for these tests. Because of the time-limited preliminary nature of these tests, only mean and root-mean-square (RMS) motions and accelerations were obtained from the instrumentation setup connected directly to the on-site PDP-8e computer. The bulk of the test effort was devoted to obtaining good bow and stern view television pictorial records of the cockpit wetting in 2.2 ft significant height waves (Sea State 2) and in 4.4 ft significant height waves (Sea State 3) with the average height of the 1/10-highest waves 5.6 ft, approximating a swell of this size.

In order to better represent the bow spray and wind effects on cockpit wetting, a 3/4-horsepower fan with anti-swirl vanes was towed 35 ft forward of the model on the tank centerline just clear of the tallest waves. This fan was turned on during each run and moved down the tank with the model. It produced a 17 knot (± 5 kt) full scale equivalent wind at the model at zero forward velocity.

The standard Pierson-Moskowitz sea spectrum is approximated by the Tank 3 plunger-type wave maker which generates reproducible sets of 100 waves. Again, the preliminary configuration comparison nature of these tests necessitated single runs down the tank, thereby allowing use of only a relatively small but repeatable sample of each wave spectrum.

Brief checks of the instrument rates indicate that the measured data lies within ± 1.5 percent of true values even though detailed calibration procedures were by-passed in order to obtain more run observations.

A solenoid, holding the bow up clear of the waves until steady speed was reached, was released during the data-collecting phase of each run in order to minimize the effects of taking excess water into the model during rapid forward acceleration up to test velocity. Data reference voltages were taken with the model raised up in the air at zero pitch angle at known height above the water surface for motions and acceleration data channels. A special floating drag zero was taken several times during the day when the water was very calm.

TEST CONDITIONS AND CONFIGURATIONS

The general scope of the test program is indicated by Table 1. The tests were exploratory in nature and were intended to provide a quick visual evaluation of potential improvements, which were recorded on video tape. After Run 25 advantage was taken of the on-line PDP-8e computer to collect numerical data.

In all, two bow shapes were tested -- both with and without transverse spray strips. In addition two runs (48 and 49) were made with a flat-plate forward deck extension on the basic bow called the bow "lip." Transom flap angles ranged from -10 to +15 degrees relative to the hull baseline, with many of the tests made at flap settings near 0 degrees. Two loadings of 49,000 and 55,000 lb were used, with the bulk of the tests at 55,000 lb. All tests were run in head seas having significant wave heights of either 2.2 ft or 4.4 ft as noted in Table 1. Aerodynamic drag tares, including the effect of wind due to the fan, have been removed from the plotted data.

RESULTS AND DISCUSSION

Figures 4 through 6 show the results of these brief comparisons graphically, while the bow- and stern-view video coverage -- delivered to Mr. Halper on October 18 -- permits direct visual comparisons of the several bow configurations operating in equivalent rough water conditions.

Figures 4 and 5 show the effects of forward velocity on the Froude-scaled (no allowance for Reynolds Number) mean hydrodynamic drag, pitch angle, CG heave relative to the calm water level and root-mean-square (RMS) accelerations at the center of gravity. The RMS bow accelerations have not been plotted. They are approximately 2.2 times the CG acceleration but exhibit much more scatter, particularly at velocities above 20 knots. This scatter occurs because the small number of waves encountered produces more variability in each small data sample. Note that a significant drag reduction of about 1260 lb is achieved at 16 knots by use of the new wedge bow extension with the removal of the two transverse spray strips. This reduction is achievable with no apparent increase in RMS accelerations at speeds of 18 knots and above.

Figure 6 shows the effects of mean running pitch angle on mean drag, CG heave and RMS CG acceleration. Mean pitch angle is determined by transom flap setting for each bow. Optimum drag is seen to occur at from 11 to 13 degrees pitch angle at 20 knots in both 2.2 ft and 4.4 ft significant height waves with flap settings near 0 degrees. The figure shows a maximum RMS acceleration near 8 degrees without spray strips as compared with near 11 degrees with spray strips on the new bow. A minimum RMS acceleration of 0.21 g is achieved at from 12 to 13 degrees mean pitch angle for 20 knots in 4.4 ft significant height waves.

Visual observations of cockpit wetting showed that worst wetting occurred at 12 knots, where Figure 5 shows minimum heave occurs. In the vicinity of this speed, water is pushed up on the deck of the basic bow and obscures forward vision completely. Use of the new bow helps substantially but does not eliminate the wetting. Use of negative transom flap is definitely recommended for the basic bow when passing through this speed region -- which should be passed through as quickly as power permits. The substantially lower drag of the new bow without spray strips should help here also.

CONCLUDING REMARKS

The 6.5 ft increase in the length of the FSHV (20 percent) together with the finer water line entry angle provided by the retrofit bow, results in improved performance of the FSHV as regards both spray and drag. While reduction of drag in the vicinity of hump speed is not the object of the bow extension it is believed that drag and deck wetting are related. The sudden increase in drag at 12 degrees trim for the basic FSHV (see Figure 6) has been eliminated by the bow extension and it has already been shown[2] that this drag rise is associated with excessive bow wetting.

With the bow extension the FSHV appears to exhibit acceptable spray characteristics even in seas having a 4.4 ft significant wave height.

Even with the bow extension it is desirable to avoid the use of too low a trim angle which could be brought about by either running light, with a forward CG or with positive flap angle.

It is considered that further improvement would require an objective measure of spray height and deck wetness on the prototype FSHV together with documentation of the test conditions including speed, load, LCG, flap angle, trim and sea spectrum.

REFERENCES

1. Brown, P.W., "Hydrodynamic Model Evaluation of the FSHV for the Planing LVA Concept. Part 1: Calm Water and Head Sea Tests," Davidson Laboratory Report 1908, November 1976.

2. Brown, P.W., Hydrodynamic Model Evaluation of a Series of Planing LVA Concepts," Davidson Laboratory Report 1880, April 1976.

TABLE 1

TEST CONDITIONS

SIGNIFICANT WAVE HEIGHT ft	LOAD lb	RUNS	SPEEDS knots
		BASIC BOW	
2.2	49,000	47	20
	55,000	98-92	10-25
4.4	55,000	32,33,41-46	20,25
		BASIC BOW WITH LIP	
2.2	49,000	48	20
		BASIC BOW WITH FORWARD STRIP ONLY	
2.2	49,000	8	25
		BASIC BOW WITH STRIPS	
2.2	49,000	1-7	10-25
	55,000	9-15	10-25
4.4	55,000	31	20
		NEW BOW	
2.2	49,690	50	20
	55,000	22-26	20,25
4.4	55,000	27-30,70-78	10-30
		NEW BOW WITH STRIPS	
2.2	49,690	51	20
	55,000	16-21,80-85	10-25
4.4	55,000	52-69,79	10-30

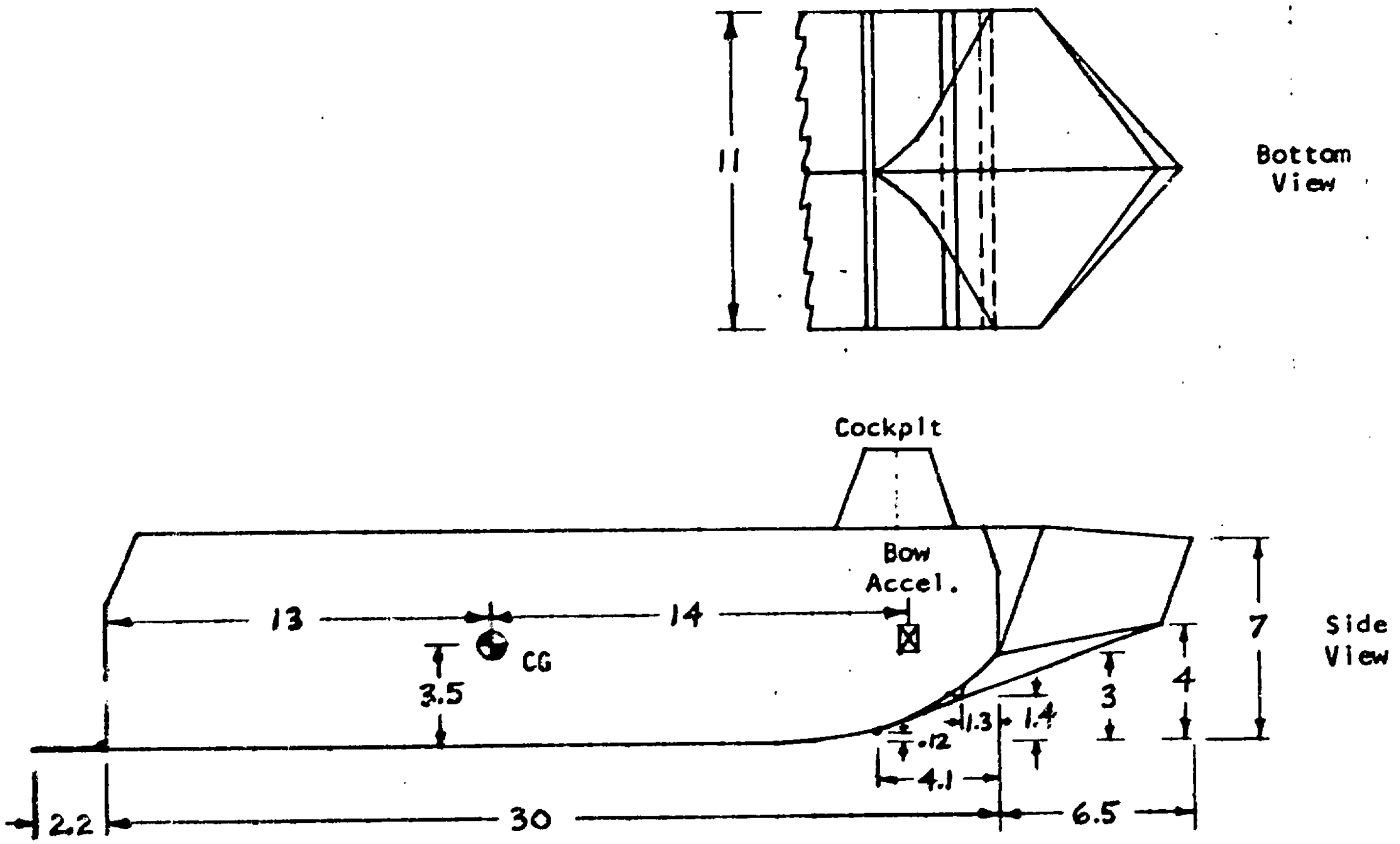

FIGURE 1 DIMENSIONS OF FSHV LVA AND EXTENDED BOW

Note: Dimensions are full scale, feet.

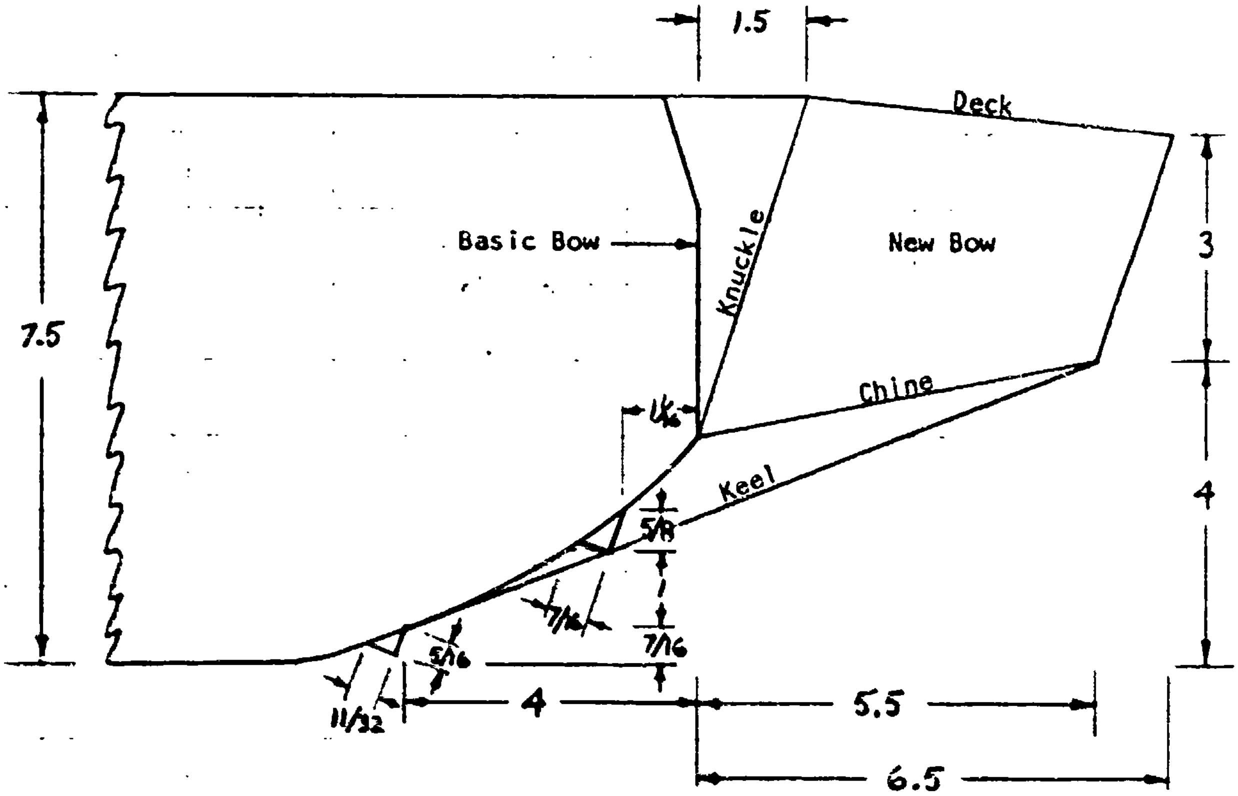

FIGURE 2 DETAILS OF TRANSVERSE SPRAY STRIPS AND NEW BOW

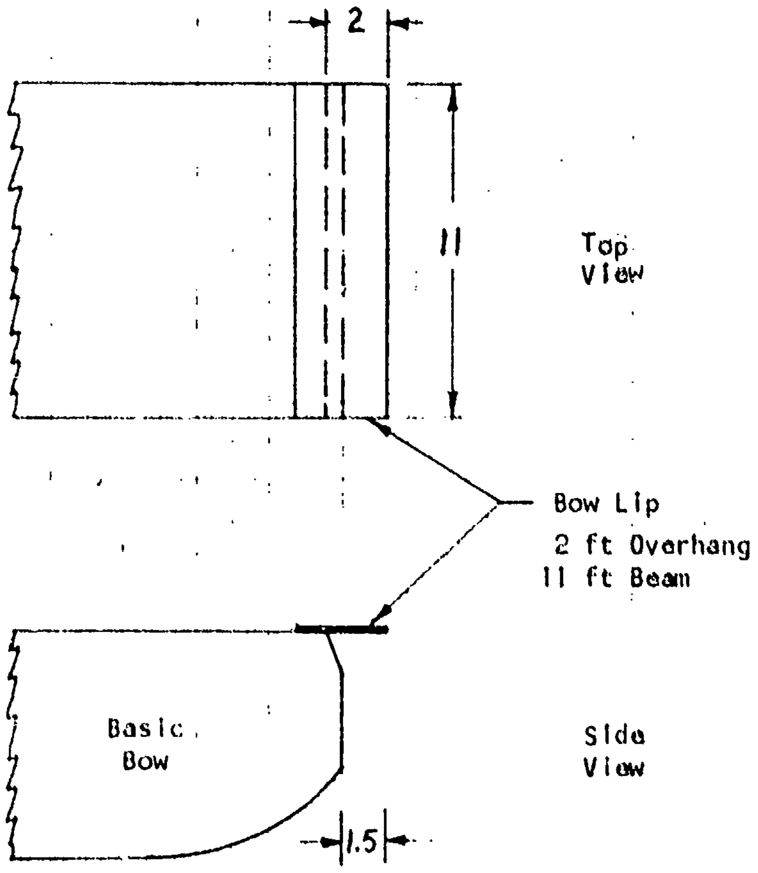

FIGURE 3 DETAIL OF BOW LIP PLATE

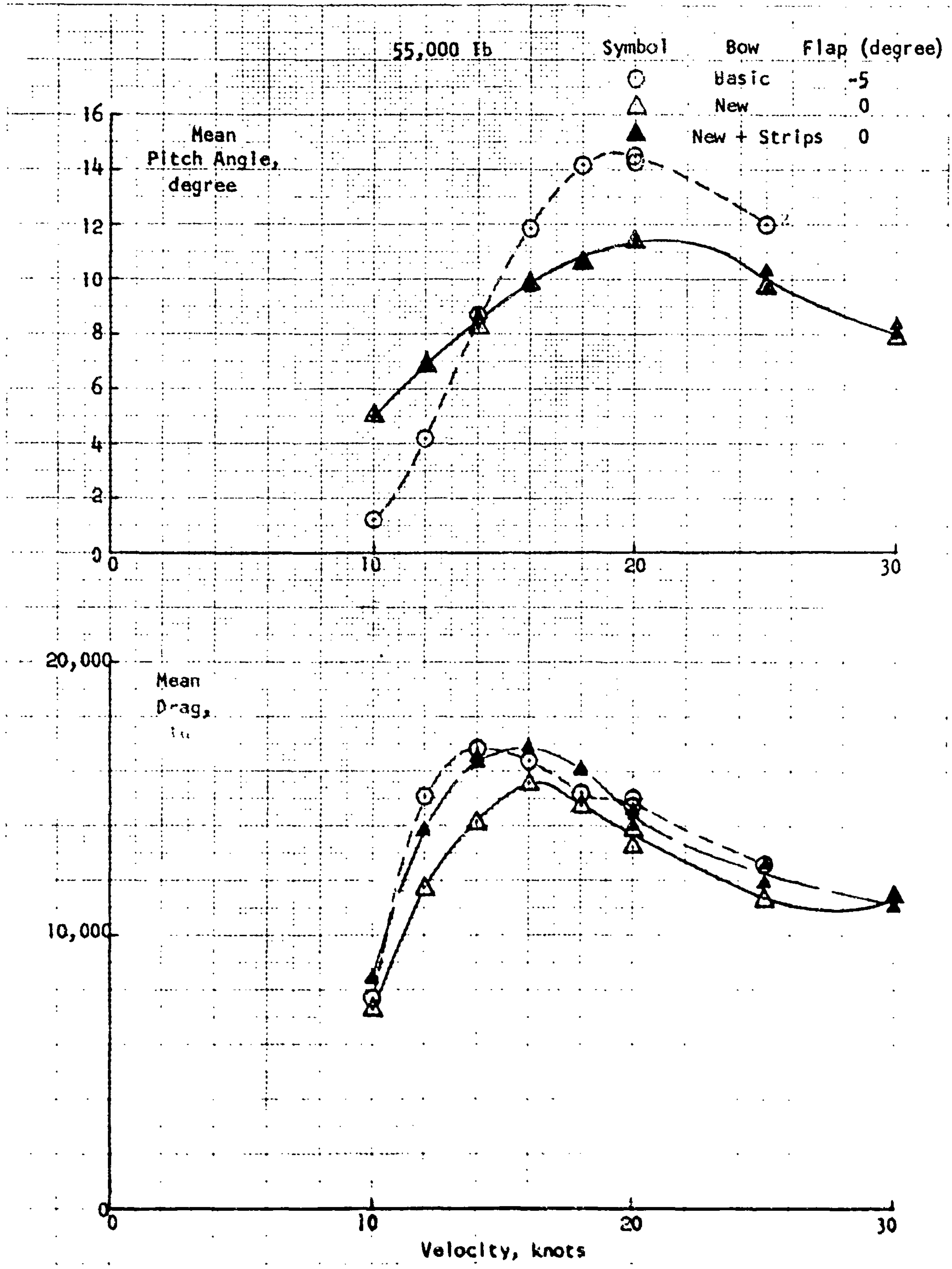

FIGURE 4 EFFECT OF VELOCITY ON MEAN DRAG AND PITCH ANGLE IN 2.2 FT and 4.4 FT SIGNIFICANT HEIGHT WAVES

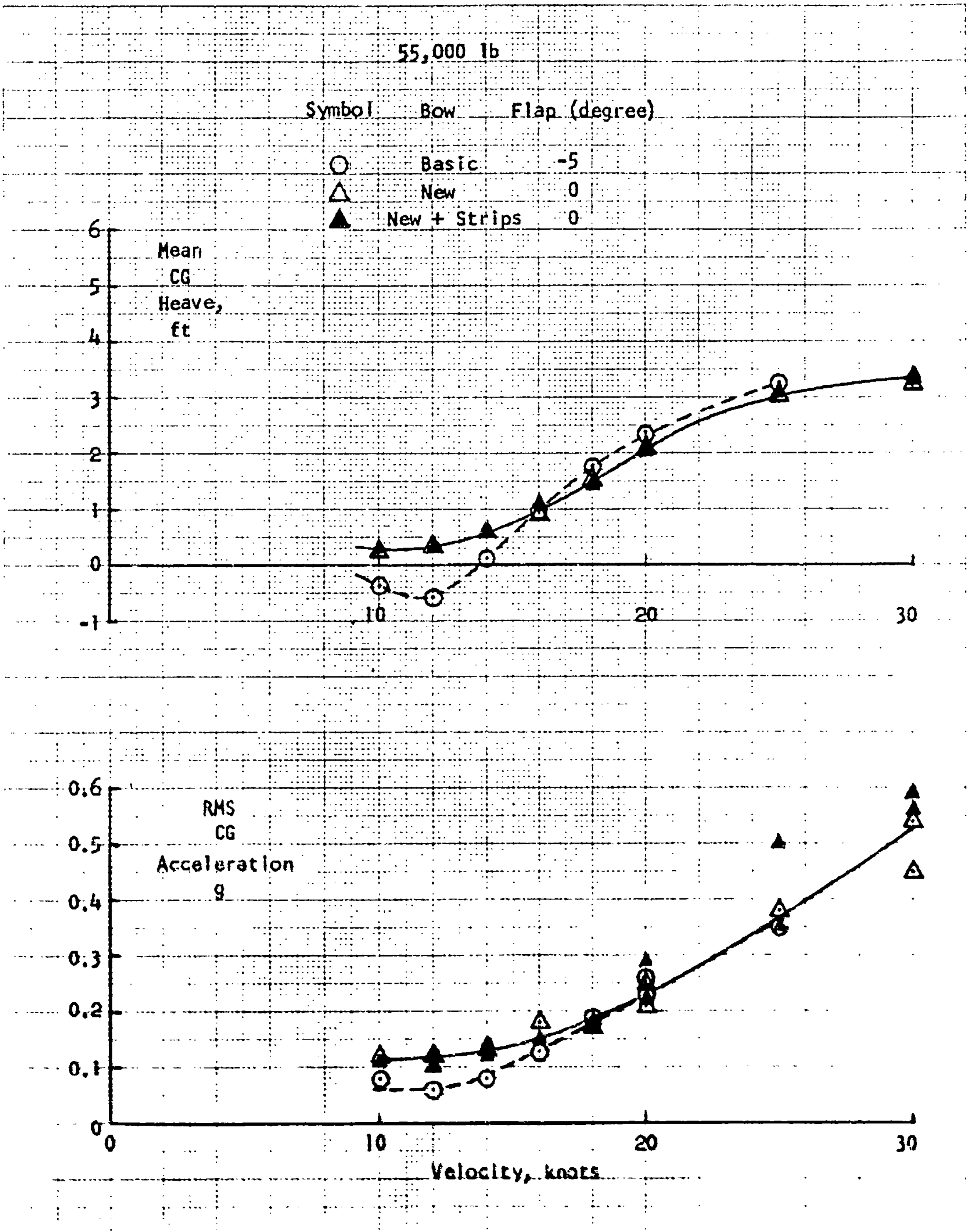

FIGURE 5 EFFECT OF VELOCITY ON ACCELERATION AND HEAVE IN 2.2 FT AND 4.4 FT SIGNIFICANT HEIGHT WAVES

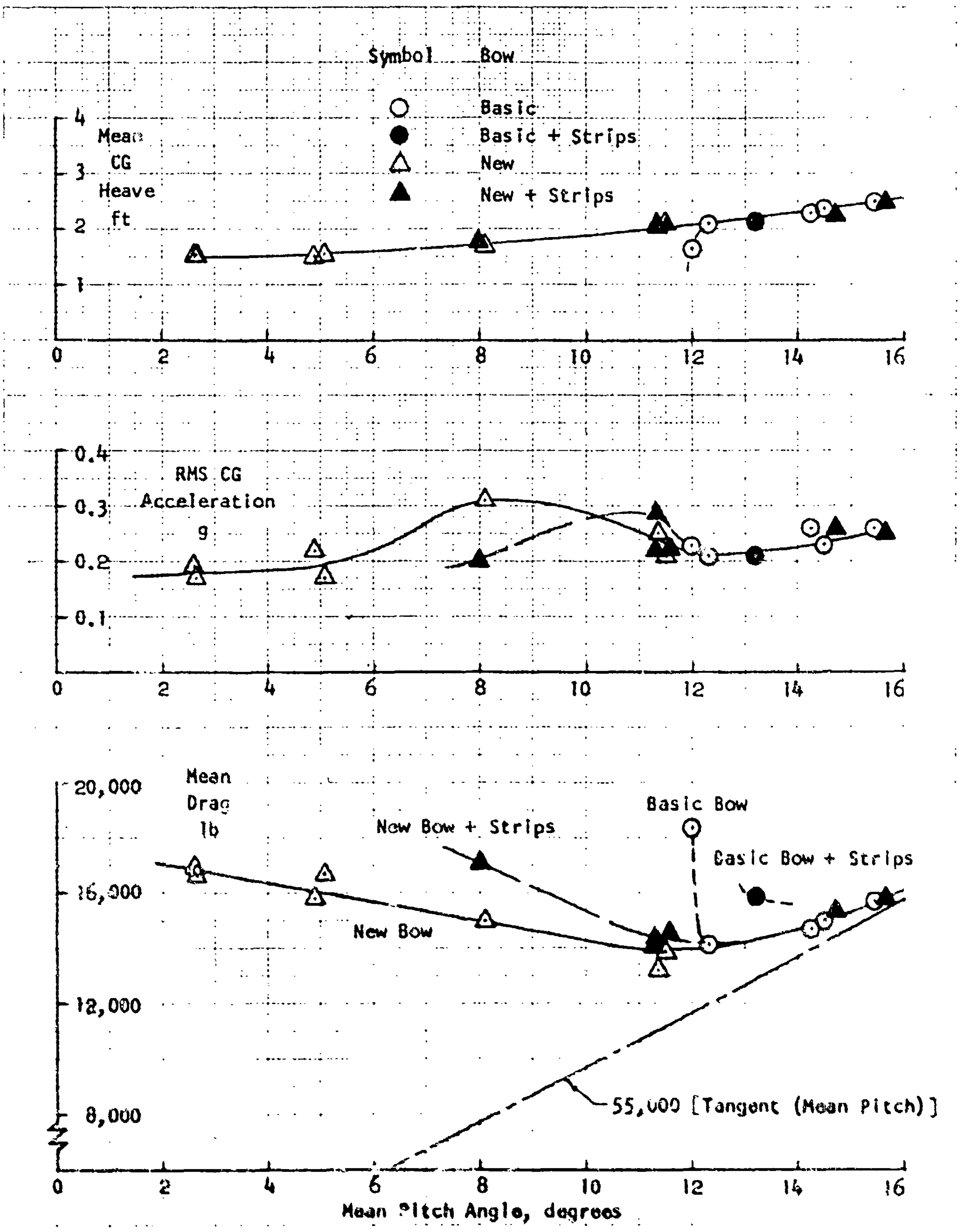

FIGURE 6 EFFECT OF MEAN PITCH ANGLE AT 20 KNOTS
IN 2.2 FT AND 4.4 FT SIGNIFICANT HEIGHT WAVES
55,000 LB