"RESISTANCE CHARACTERISTICS OF THE TRADITIONAL GREEK FISHING VESSELS"

by

A.C. Prifti and G.J. Grigoropoulos

Dept. of Naval Architecture and Marine Engineering
National Technical University of Athens
9 Heroon Politechniou str. 15573 Zografos, Athens

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Abstract

The trechantiri, karavoskaro and perama type boats, are the most common types of traditional hull forms used in the Greek seas as fishing vessels, pleasure boats or to carry passengers for short trips. Despite their extensive use, the hydrodynamic characteristics of these hull forms are not well known and the builders tend to excessively overpower them.

To contribute to the proper design of these vessels, systematic calm water resistance tests for three models, representative of the trechantiri, the karavoskaro and the perama types, have been carried out at the Towing Tank of the Laboratory for Ship and Marine Hydrodynamics of National Technical University of Athens. In this paper the respective experimental results are presented and compared to one another and with the predictions of the regression analysis curves proposed by Doust et al (FAO, 1967) and Antoniou (1969).

1. Introduction

There are more than 11000 traditional boats of various sizes, ranging from 5 to 30 m in length, in the Greek seas. The vast majority of them are used as fishing vessels, while quite a lot of them are used as pleasure boats or for the transportation of passengers or cargo in short distances. The trechantiri, karavoskaro and perama are the most frequently used types of hull forms.

Despite their extensive use, the hydrodynamic characteristics of the traditional Greek hull forms have not been adequately investigated up to now. In fact the only results to be found in the literature refer to the resistance characteristics of the trechantiri type vessel, three models of which have been tested in the Laboratory for Ship and Marine Hydrodynamics of the National Technical University of Athens, ten years ago (Ganos and Loukakis, 1984). As a consequence, due to lack of data, the builders tend to excessively overpower these vessels.

As a contribution to a more rational design, a research program has been initiated at the same as above Laboratory aiming at the improvement of the state-of-the-art in the performance prediction and the design of these types of vessels. Within this program, their calm water resistance, propulsive performance and seakeeping behaviour characteristics are experimentally investigated. The results of this self-supported research will be stored systematically in a data base for future use by the designers of traditional vessels.

In this paper the experimental results related to calm water resistance are presented and compared to one another, for the trechantiri, the karavoskaro and the perama hull forms. The results for the trechantiri hull form refer to model No. 1 of the systematic series proposed by Ganos and Loukakis (1984) and Ganos (1989). This model has been re-tested at the appropriate loading conditions. The L/B and B/T ratios of the karavoskaro and perama type models have been selected after examining more that 20 such boats, sizing between 10 and 30 m in length.

The particulars of the three model under investigation are presented in Tables 1, 2 and 3. The respective body plans are given in Figures 1, 2 and 3. All models were fitted with wooden keels.

The experimental results are presented in non-dimensional graphs. Furthermore, they have been extrapolated to the same size of vessel, defined by the waterline length and the displacement. In addition, the experimental results are used to check the regression analysis curves proposed by Doust et al (FAO, 1967) and Antoniou (1969).

2. Model tests

All three models have been tested at a grid of three displacements and three trimming angles, 0°, 1.5° and 3.0° by stern. It should be noted here, that traditional vessels operate, usually, at stern trims of the order of 2°, to avoid propeller emergence.

The experiments have been conducted in fresh water at the Towing Tank of the Laboratory for Ship and Marine Hydrodynamics which has a length of 91 m, a width of 4.55 m and a water depth of 3.00 m. The speed range of the experiments was extended up to Fn = 0.45. Since most of the existing traditional vessels are excessively overpowered, this is a reasonable speed range.

The model was attached to the towing carriage resistance dynamometer via a trim pivot located longitudinally at the corresponding LCG and vertically at a height of 93 mm above the Base Line. This type of attachment allows the model only to heave and pitch, while all the other degrees of freedom are restrained.

During the tests, the calm water resistance, the sinkage at the point of attachment to the dynamometer and the trim with respect to the towing speed of the model were measured and recorded for each run. The models were fitted with trip wires as turbulence stimulators.

3. Experimental results

According to Froude method the total resistance R_T of a vessel is the sum of frictional resistance R_F and residual resistance R_R :

$$R_T = R_F + R_R \qquad \text{... (1)}$$

Non-dimensionalizing relation (1) by $1/2\ \rho\ WS\ V_S^2$ one can derive :

$$C_T = C_F + C_R \qquad \text{... (2)}$$

where

C_T = total resistance coefficient,

C_F = frictional resistance coefficient,

$$= \frac{0.075}{(\mathrm{Log}_{10}Rn - 2)^2}\text{, according to ITTC 1957 friction line,} \qquad \text{... (3)}$$

C_R = residual resistance coefficient,

WS = wetted surface,

Rn = Reynolds number,

ρ = water density and

V_S = ship speed.

The basic Froude assumption is that C_R is the same for the model and the full scale vessel at speeds with equal Froude numbers Fn.

However, the primary design parameters for the traditional vessels are the keel length L_K and the displacement D. Since, from the hydrodynamic point of view, the waterline length L_{WL} is much more meaningful than the keel length, it would be very useful if total resistance R_T and residual resistance R_R could be expressed in terms of L_{WL} and D. This is enabled by the definition of the following modified non-dimensional coefficients C_{TL} and C_{RL} (Petrakos, 1991) :

$$C_{TL} = \frac{1/2\ L_{WL}\ WS}{\nabla}\ C_t \quad \text{... (4)}$$

$$C_{RL} = \frac{1/2\ L_{WL}\ WS}{\nabla}\ C_R \quad \text{... (5)}$$

where

∇ = the volume of the displacement

= $D/\rho g$ ... (6)

g = gravity acceleration.

Using definitions (4), (5) and (6), R_T and R_R can be expressed in terms of D and L_{WL} by the following equations :

$$R_T = C_{TL}\ \nabla\rho/L_{WL}\ V_S^2 = C_{TL}\ D/(gL_{WL})\ V_S^2 \quad \text{... (7)}$$

$$R_R = C_{RL}\ \nabla\rho/L_{WL}\ V_S^2 = C_{RL}\ D/(gL_{WL})\ V_S^2 \quad \text{... (8)}$$

where C_{TL} and C_{RL} are trim-dependent functions.

The experimental results have been plotted in a non-dimensional form, in terms of C_{RL} vs Fn, in Figs. 4 to 12. As it can be deduced by a simple inspection of these figures, C_{RL} curves do not differ significantly for the whole range of displacements tested at the same trim. Thus, a best fit C_{RL} curve can be deduced for each type of boat and trim. These C_{RL} curves, which have been plotted in Figs. 13 to 15, are useful for all practical cases of estimating the resistance of a traditional vessel. These curves are 4th-degree polynomials of the form :

$$C_0 + C_1\ Fn + C_2\ Fn^2 + C_3\ Fn^3 + C_4\ Fn^4$$

The coefficients C_i for each vessel type and trim are given in Table 4.

Using the graphs for a specific type of traditional vessels, one can easily apply relation (8) to estimate R_R for a given displacement, waterline length and trim. The ITTC 57 friction curve (3) is used for the estimation of the frictional resistance R_F and the total resistance R_T is calculated using relation (1). Finally, the Effective Horse Power (EHP) is calculated by the following relation (in metric units) :

$$EHP = \frac{R_T\ V_S}{75} \quad \text{... (9)}$$

4. Discussion and Conclusions

In order to demonstrate the applicability of the experimental results presented in this paper, these results have been used to estimate the Effective Horse Power (EHP) of a traditional vessel with a waterline length L_{WL} = 18.84 m and displacement D = 76.00 mt, at a trim of 3° by stern. The particulars of this vessel are given in Table 5. The respective results are presented in Fig. 16.

According to Fig. 16, the karavoskaro type possesses better performance characteristics in the higher speed range than the perama type. This is due to the fuller stern shape of the karavoskaro type, which is similar to the conventional cruiser stern vessels, and reduces the dynamic trim. On the other hand, the EHP requirements of the trechantiri type are higher than the other two types, because of the lower L/B ratio of this model.

Furthermore, the experimental results were compared with the Doust et al (FAO, 1967) and the Antoniou (1969) prediction methods. Both of these methods are based on regression analysis of large amount of existing data. The former method has taken into account fishing boats from all over the world, while the latter is relatively based on data for vessels similar to Greek type boats.

The comparison of Doust's method with the experiments is satisfactory in the cases of the trechantiri and the perama types. However, Doust's predictions underpredict significantly the experimentally determined EHP values for the karavoskaro type. A major problem of this method is that the karavoskaro and the trechantiri type fall outside the proposed range of the hull form parameters.

On the other hand, Antoniou (1969) method compares well with the experimental results only for the perama type. The discrepancies between Antoniou method and tests are higher in the case of the karavoskaro type of vessel.

In Figs. 17 to 19 the EHP curves based on the Doust et al (FAO, 1967) and the Antoniou (1969) methods have been plotted against the respective predictions of this paper for the three types of traditional vessels under investigation.

Acknowledgment

The authors would like to thank Professor T.A. LOUKAKIS for his interest and continuous encouragement during the present study.

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TABLE 1 : TRECHANTIRI MODEL PARTICULARS

Model displacement (Kp)	trim	L_{WL} (m)	B_{WL} (m)	T (m)	LCB (m)	Wetted Surface(m^2)
59.021	even keel	1.641	0.585	0.189	0.0498	0.922
73.915	even keel	1.665	0.630	0.211	0.0518	1.013
89.759	even keel	1.722	0.668	0.233	0.0527	1.104
59.021	1.5° by stern	1.635	0.585	0.191	0.0129	0.923
73.915	1.5° by stern	1.697	0.630	0.212	0.0179	1.014
89.759	1.5° by stern	1.720	0.668	0.235	0.0214	1.107
59.021	3° by stern	1.672	0.585	0.192	-0.024	0.925
73.915	3° by stern	1.697	0.630	0.235	-0.0156	1.017
89.759	3° by stern	1.717	0.668	0.236	-0.0097	1.107

TABLE 2 : KARAVOSKARO MODEL PARTICULARS

Model displacement (kp)	trim	L_{WL} (m)	B_{WL} (m)	T (m)	LCB (m)	Wetted Surface(m^2)
64.317	even keel	1.900	0.513	0.202	0.0800	1.12
70.339	even keel	1.902	0.522	0.210	0.0796	1.16
76.542	even keel	1.910	0.531	0.218	0.0788	1.20
64.317	1.5° by stern	1.900	0.513	0.203	0.0186	1.12
70.339	1.5° by stern	1.902	0.522	0.211	0.0204	1.16
76.542	1.5° by stern	1.910	0.531	0.219	0.0219	1.20
64.317	3 ° by stern	1.900	0.513	0.204	-0.044	1.12
70.339	3 ° by stern	1.902	0.522	0.212	-0.0397	1.16
76.542	3 ° by stern	1.910	0.531	0.220	-0.0364	1.20

TABLE 3 : PERAMA MODEL PARTICULARS

Model displacement (kp)	trim	L_{WL}(m)	B_{WL}(m)	T (m)	LCB(m)	Wetted Surface(m^2)
59.054	even keel	1.868	0.500	0.165	0.0208	1.005
73.940	even keel	1.884	0.584	0.185	0.0201	1.098
89.762	even keel	1.902	0.602	0.205	0.0197	1.187
59.054	1.5° by stern	1.868	0.500	0.165	-0.0358	0.998
73.940	1.5° by stern	1.884	0.584	0.185	-0.0298	1.092
89.762	1.5° by stern	1.902	0.602	0.205	-0.0253	1.185
59.054	3 ° by stern	1.868	0.500	0.165	-0.0911	0.995
73.940	3 ° by stern	1.884	0.506	0.285	-0.0795	1.088
89.762	3 ° by stern	1.902	0.506	0.205	-0.0701	1.180

TABLE 4 : POLYNOMIAL COEFFICIENTS OF C_{RL} CURVES

Type	trim	C_0	C_1	C_2	C_3	C_4
PERAMA	even keel	-0.04528	1.00106	-5.3902	11.5276	-2.43065
	1.5° by stern	0.05909	-1.07249	9.06074	-29.3443	37.198
	3° by stern	0.03645	-0.6769	7.6044	-29.1131	40.5403
TRECHA-NTIRI	even keel	0.1055	-1.8930	14.0741	-44.0701	54.3751
	1.5° by stern	0.0924	-1.18618	9.4862	-34.1016	47.3937
	3° by stern	-0.0182	-0.0684	5.4642	-27.3071	42.9909
KARAVO SKARO	even keel	-0.0109	0.4560	-4.5176	18.9656	-17.8913
	1.5° by stern	0.2300	-3.7770	22.061	-50.5720	45.4370
	3° by stern	0.1748	-3.231	21.895	-57.92	57.808

TABLE 5

SHIP CHARACTERISTICS	PERAMA type	KARAVOSKARO type	TRECHANTIRI type
L_{WL} (m)	18.84	18.84	18.84
B (m)	5.84	5.28	6.598
T (m)	1.597	1.829	1.44
L/B	3.226	3.568	2.85
B/T	3.65	2.887	4.581
LCB (%)	-4.24	-5.95	-1.2
de/2 (deg)	25	32	34.5
dr/2 (deg)	40	85	32
dbs (deg)	34	42.5	33
trim	3 ° by stern		
keel dimensions (breadth x height)	0.20 x 0.25	0.20 x 0.36	0.34 x 0.34
C_m	0.63	0.567	0.700
C_P	0.66	0.70	0.568
keel surf./max. transv.sec.	0.008	0.013	0.0169
Wetted Surface (m^2)	108.8	118.3	111
Displacement (t)	76		
Wet.Surf./(Displ.vol.) $^{2/3}$	6.088	6.621	6.199

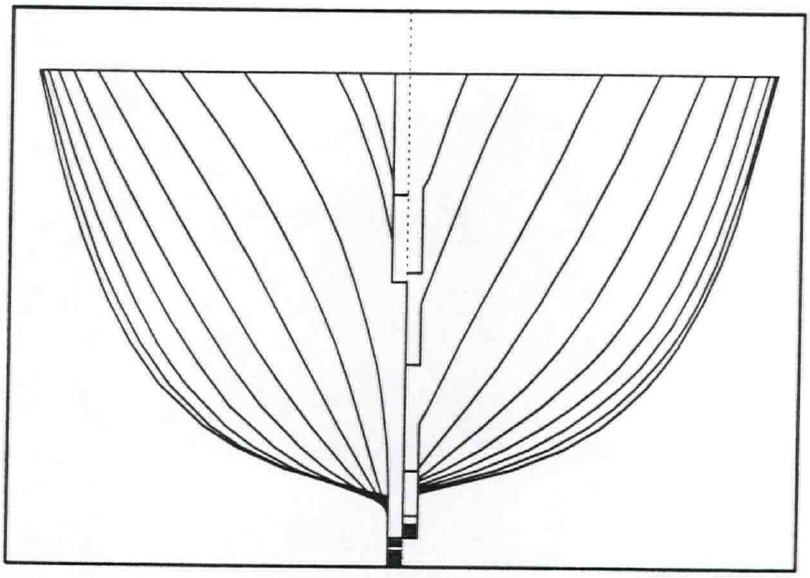

Fig. 1 : BODY PLAN OF TRECHANTIRI

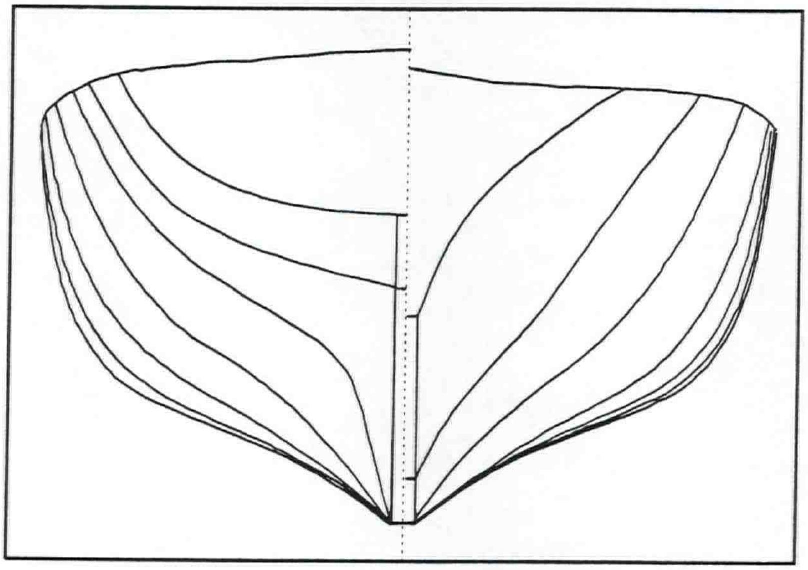

Fig. 2 : BODY PLAN OF KARAVOSKARO

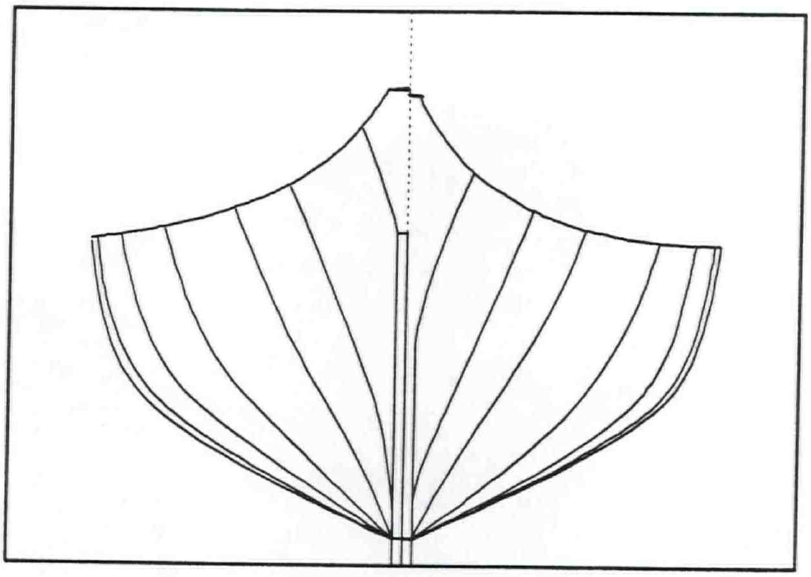

Fig.3: BODY PLAN OF PERAMA

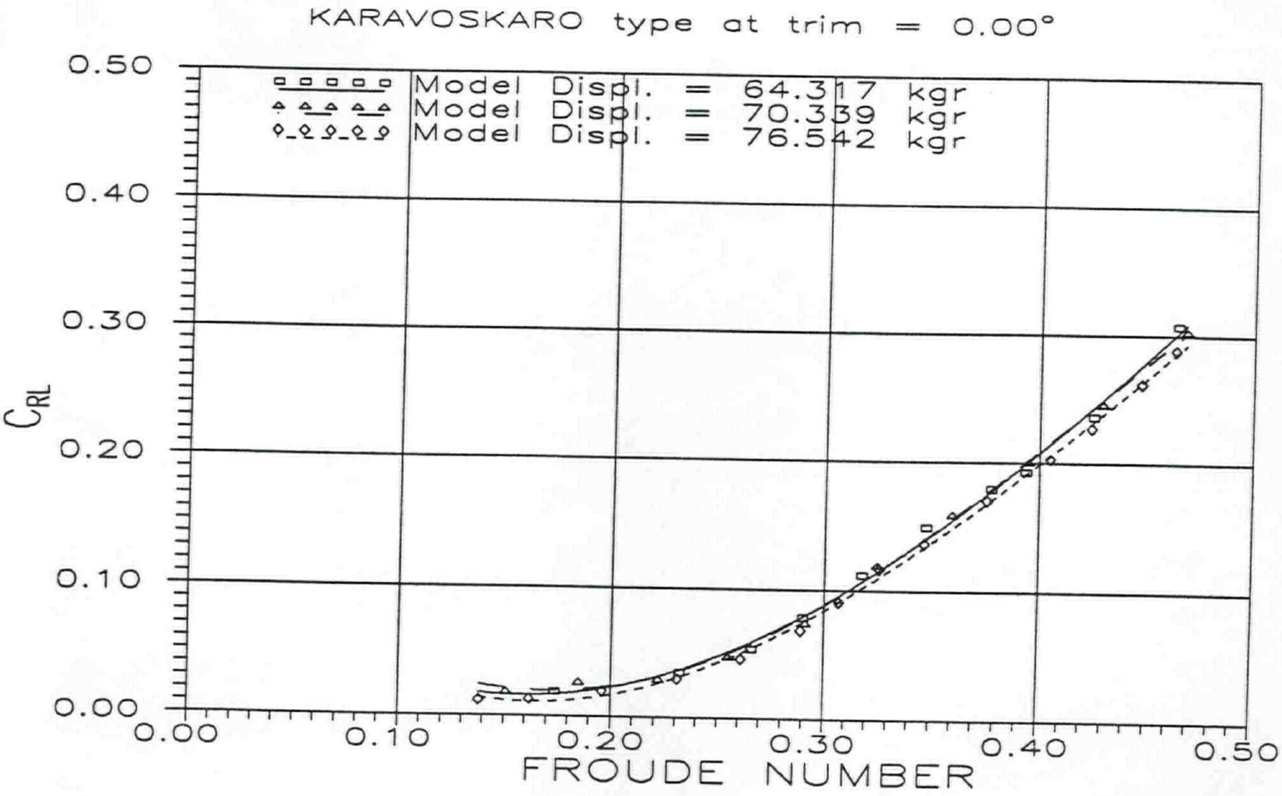

Fig. 4 : C_{RL} CURVES

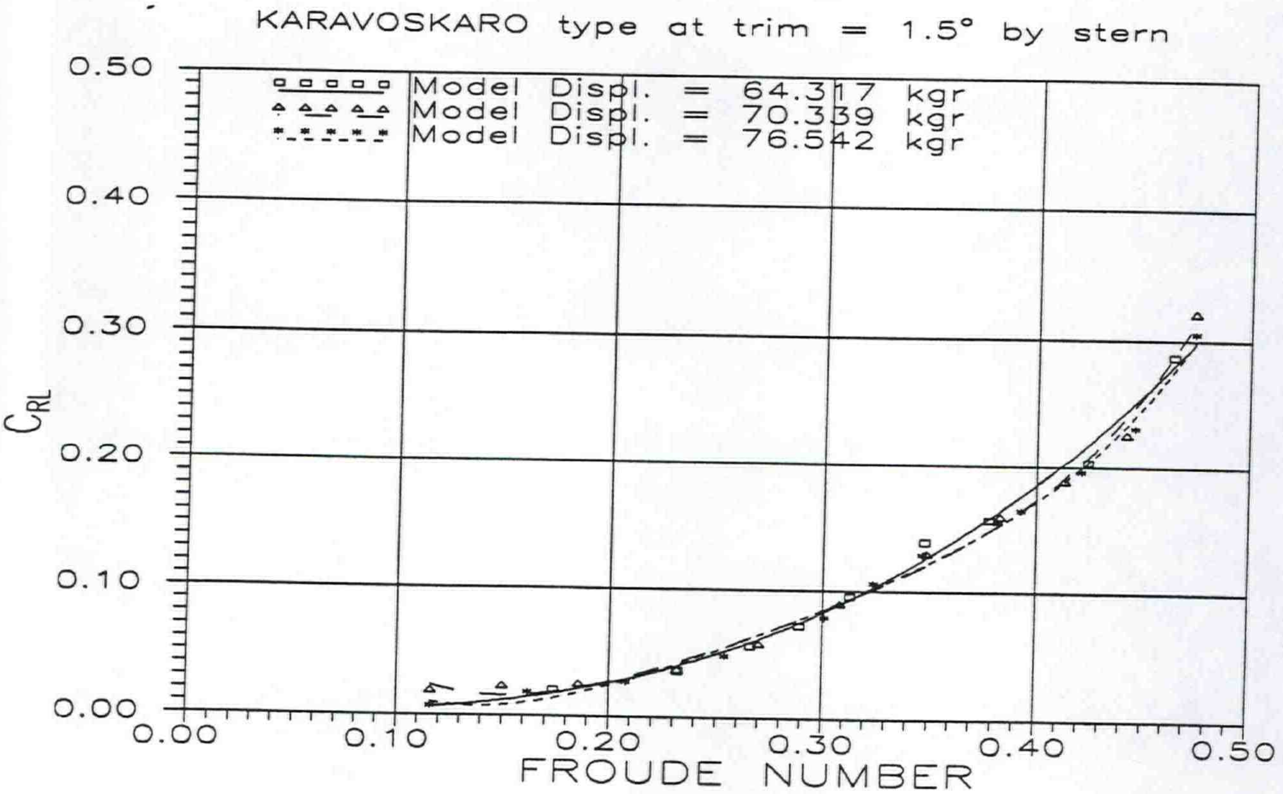

Fig. 5 : C_{RL} CURVES

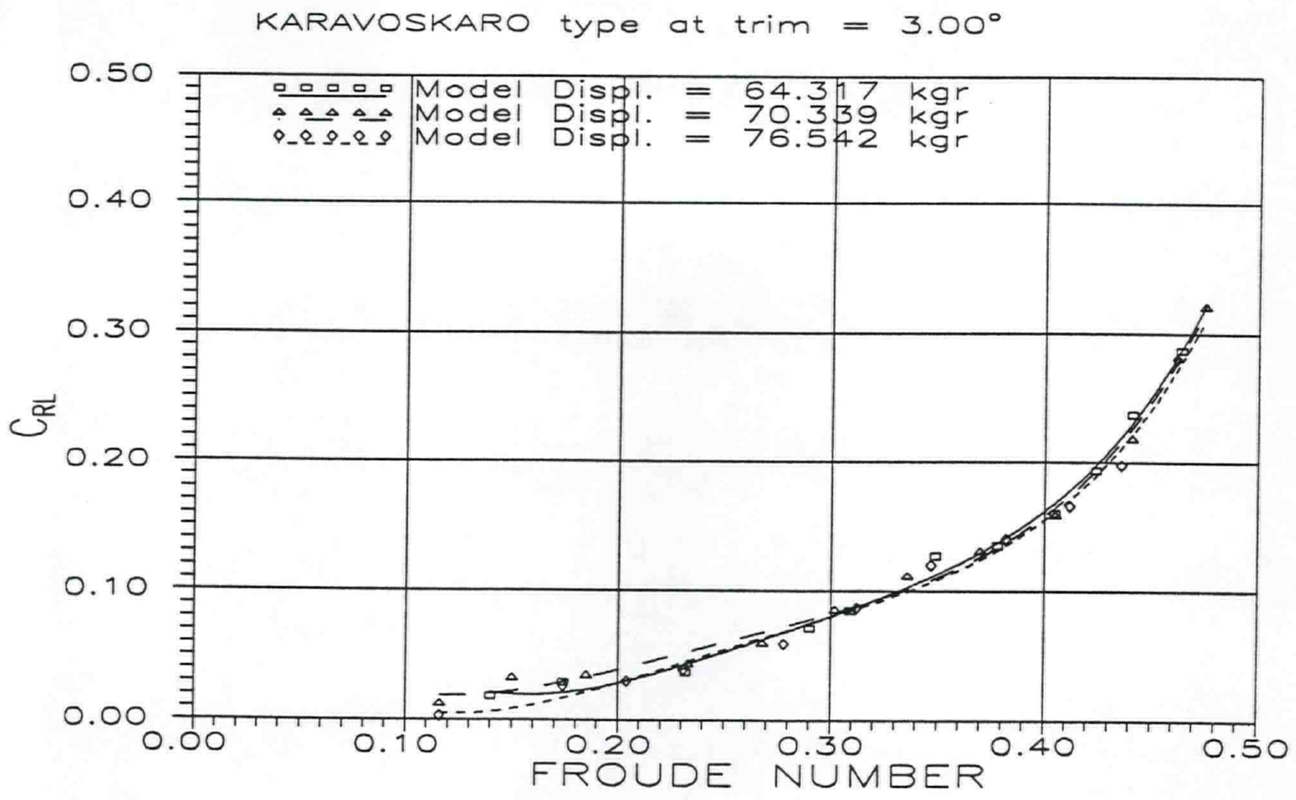

Fig. 6 : C_{RL} CURVES

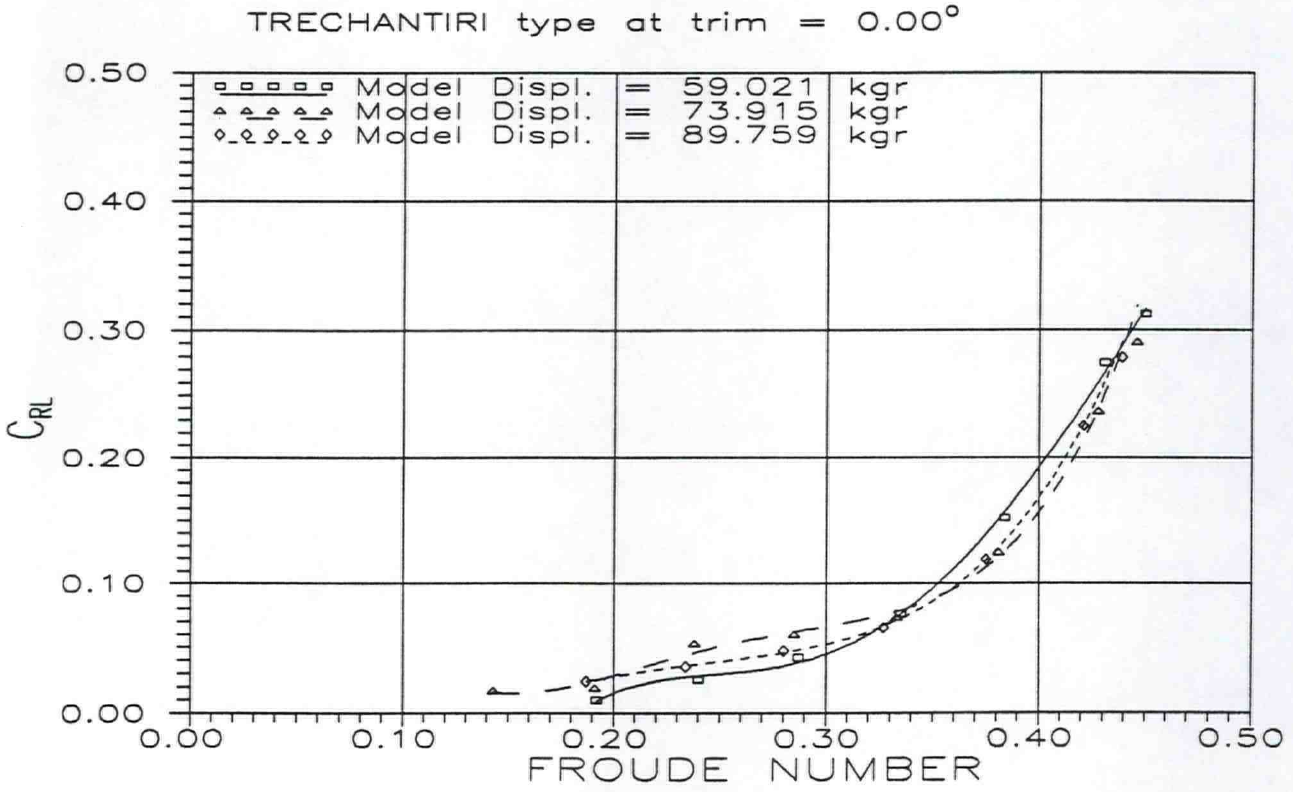

Fig. 7 : C_{RL} CURVES

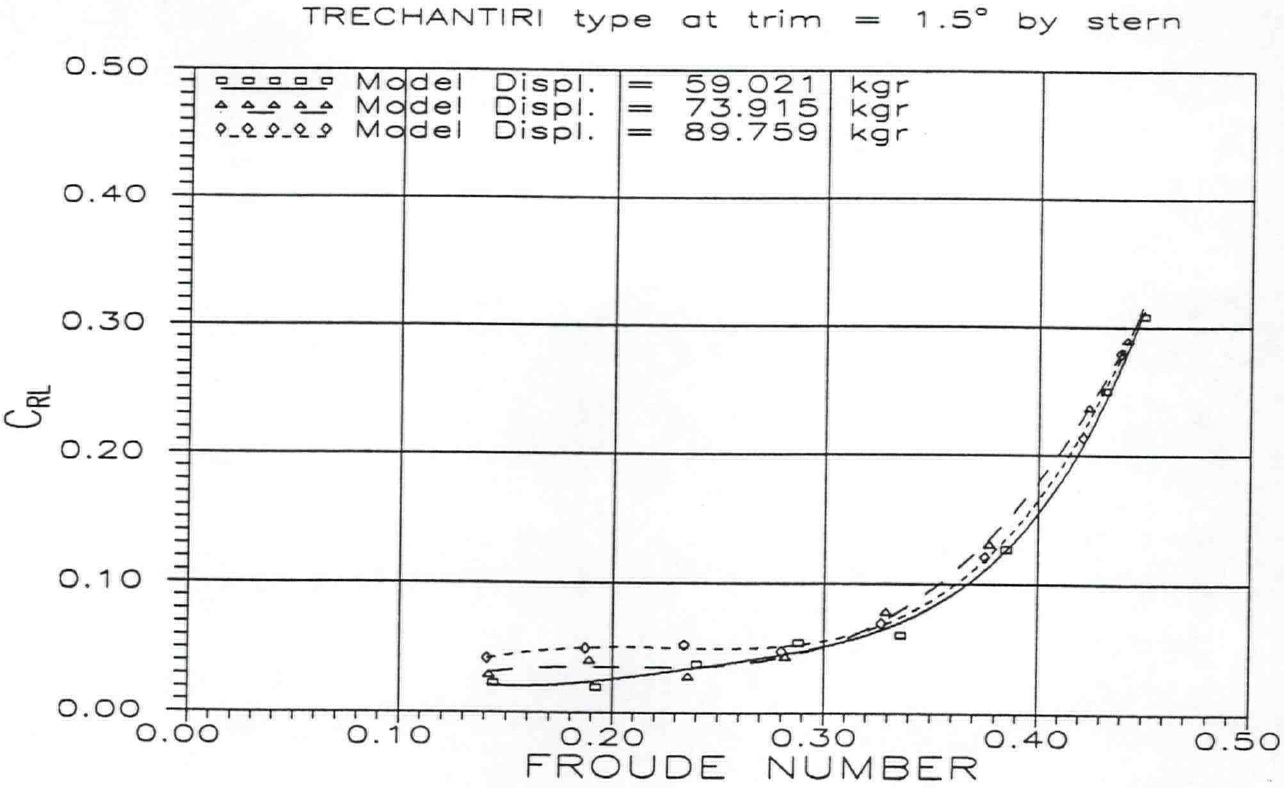

Fig. 8 : C_{RL} CURVES

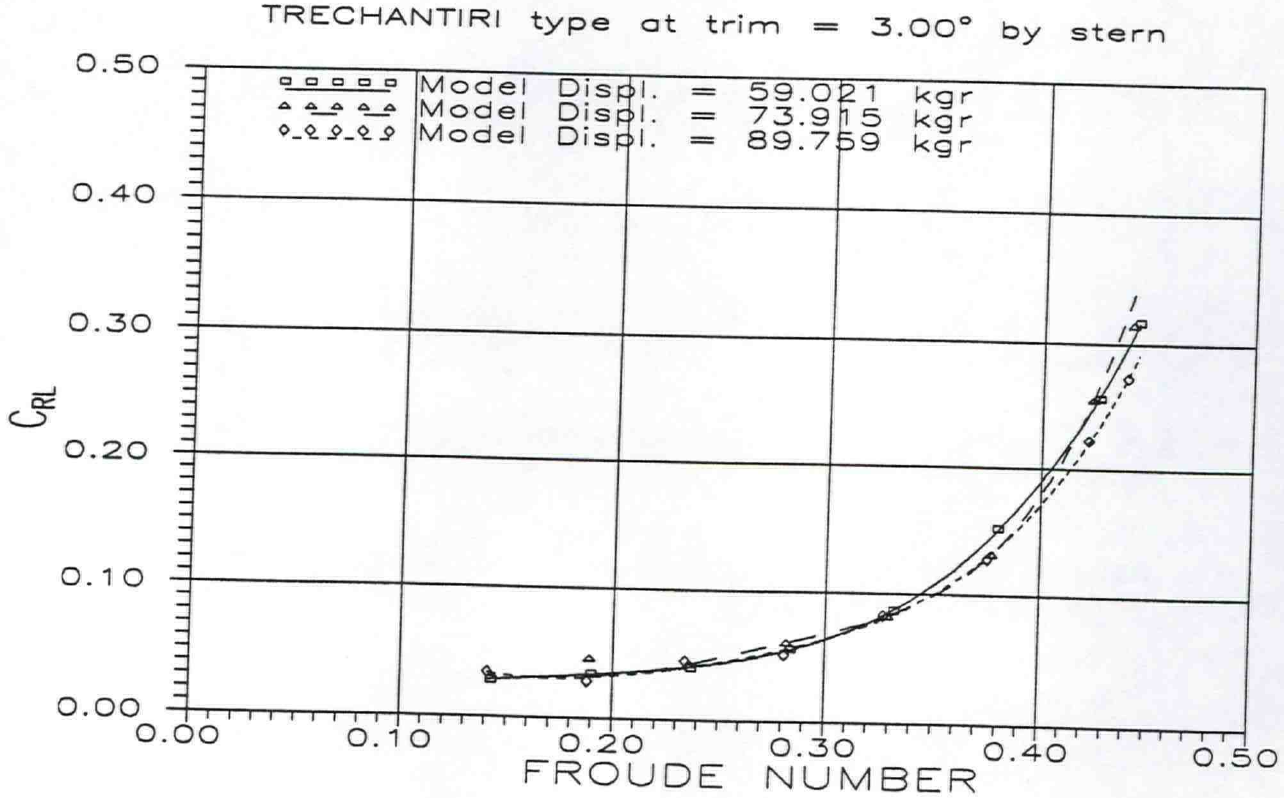

Fig. 9 : C_{RL} CURVES

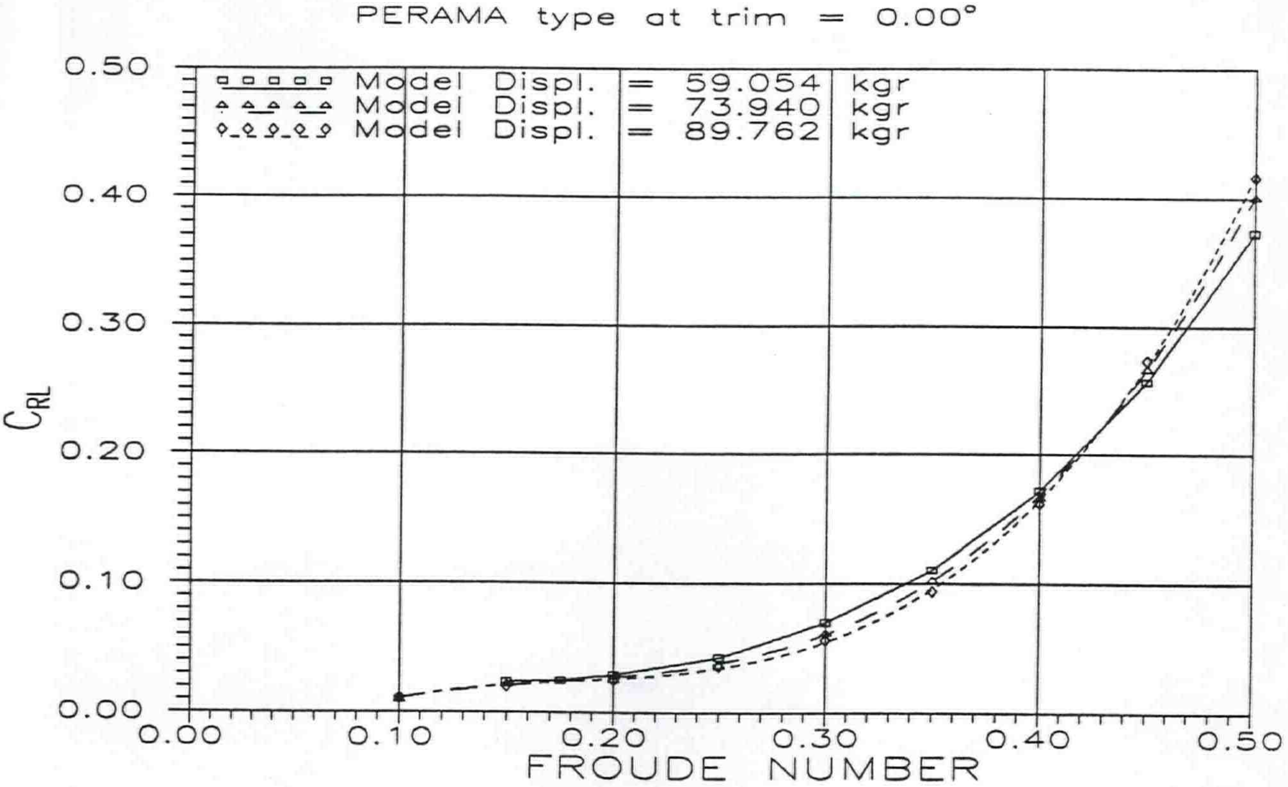

Fig. 10 : C_{RL} CURVES

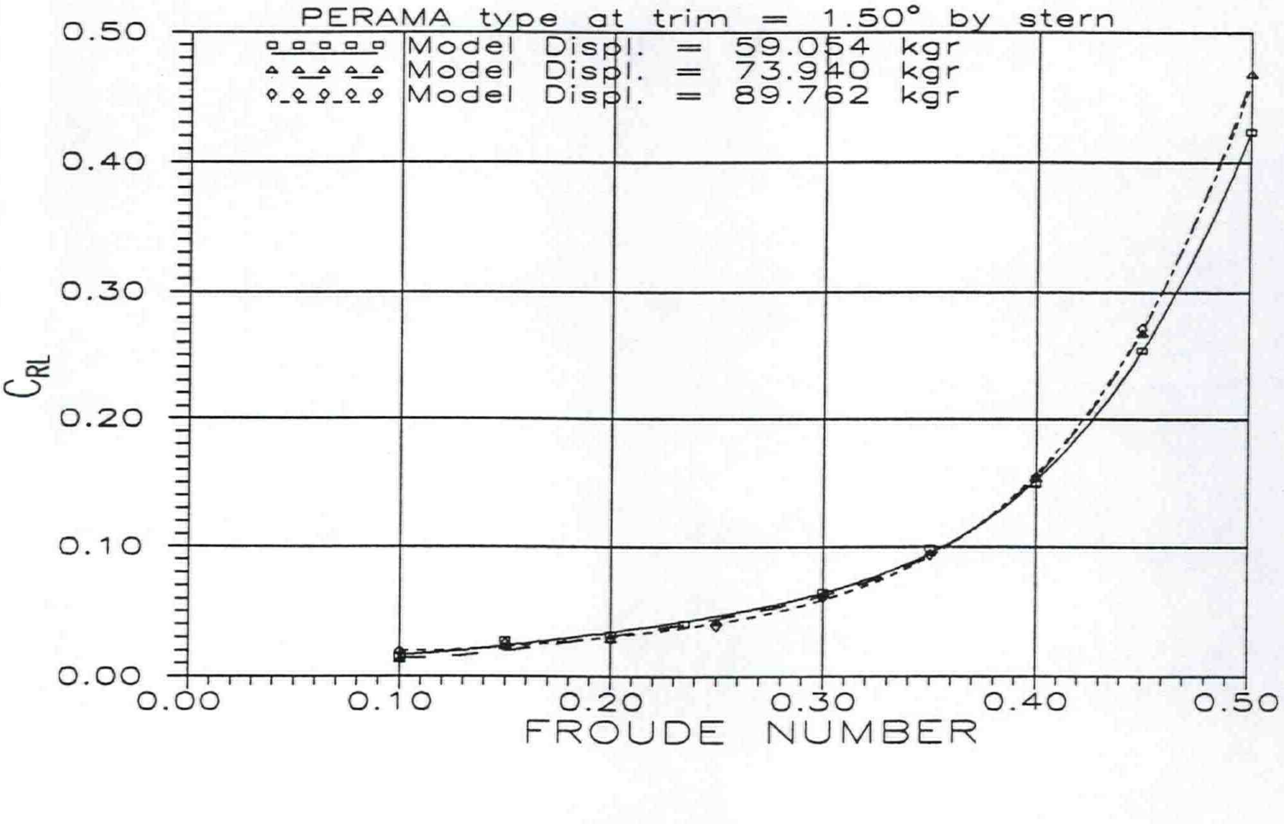

Fig. 11: C_{RL} CURVES

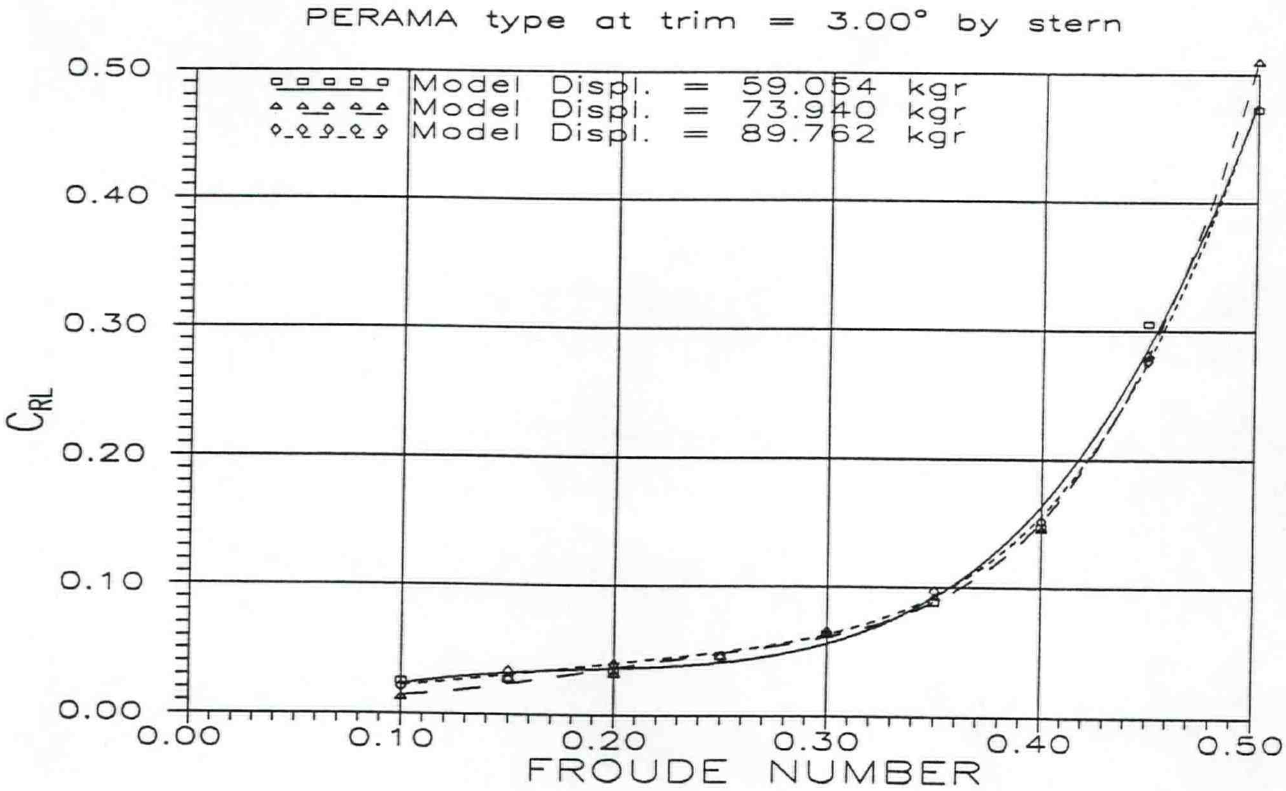

Fig. 12 : C_{RL} CURVES

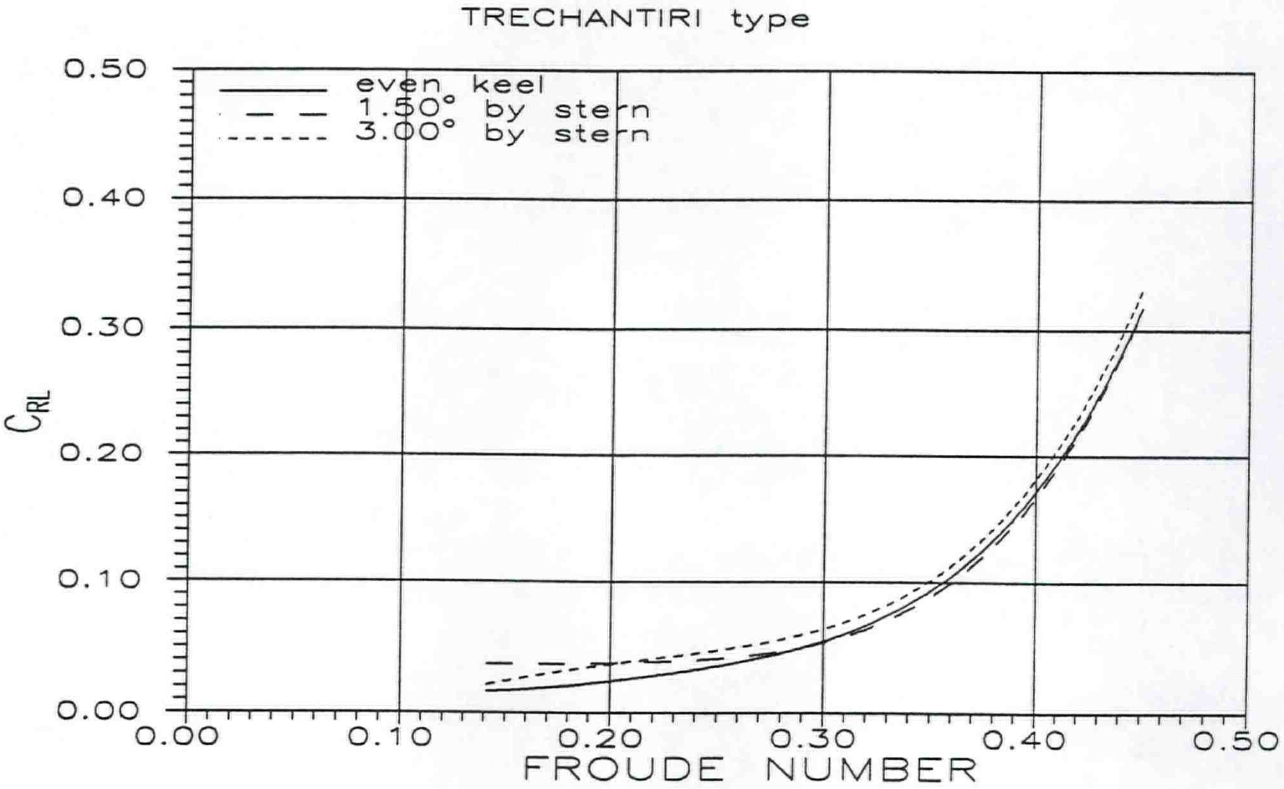

Fig. 13 : BEST FIT $C_{RL} = C_{RL}$ (trim) CURVES

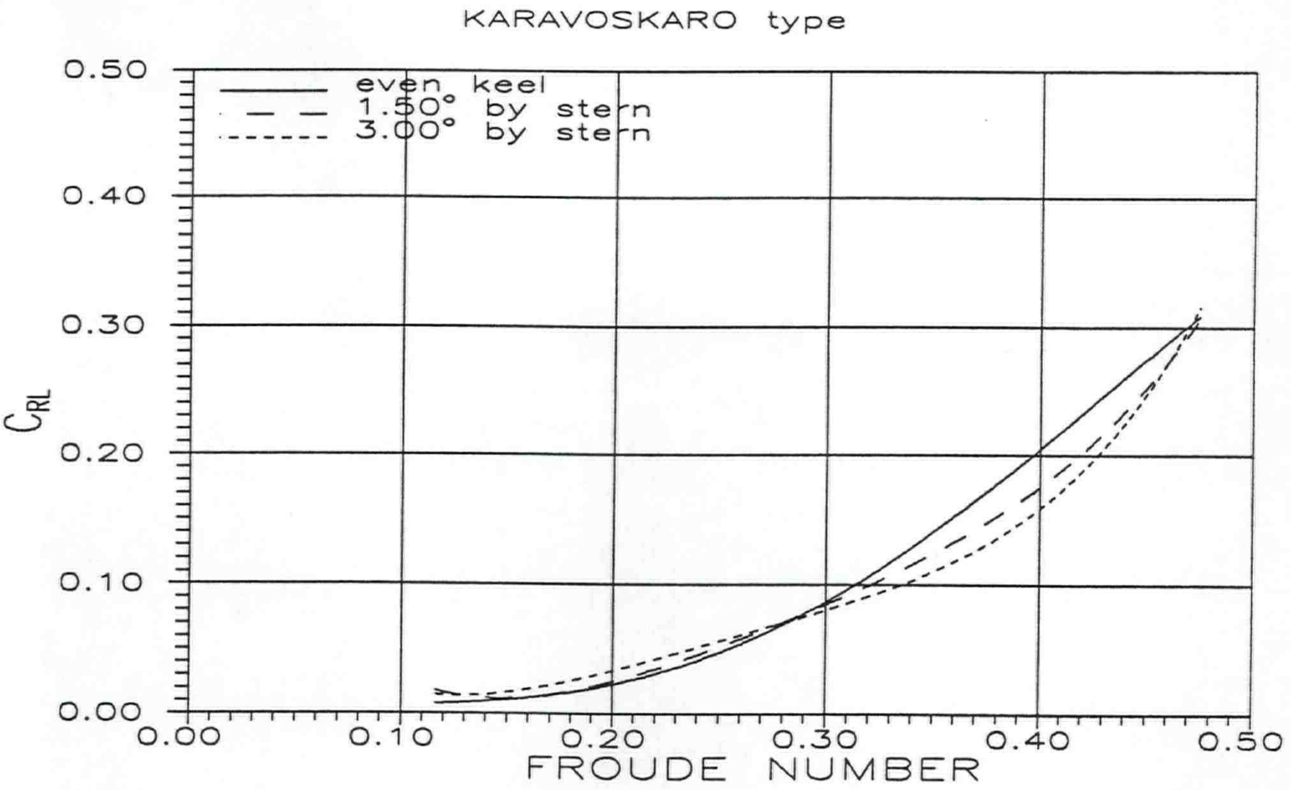

Fig. 14: BEST FIT $C_{RL} = C_{RL}$ (trim) CURVES

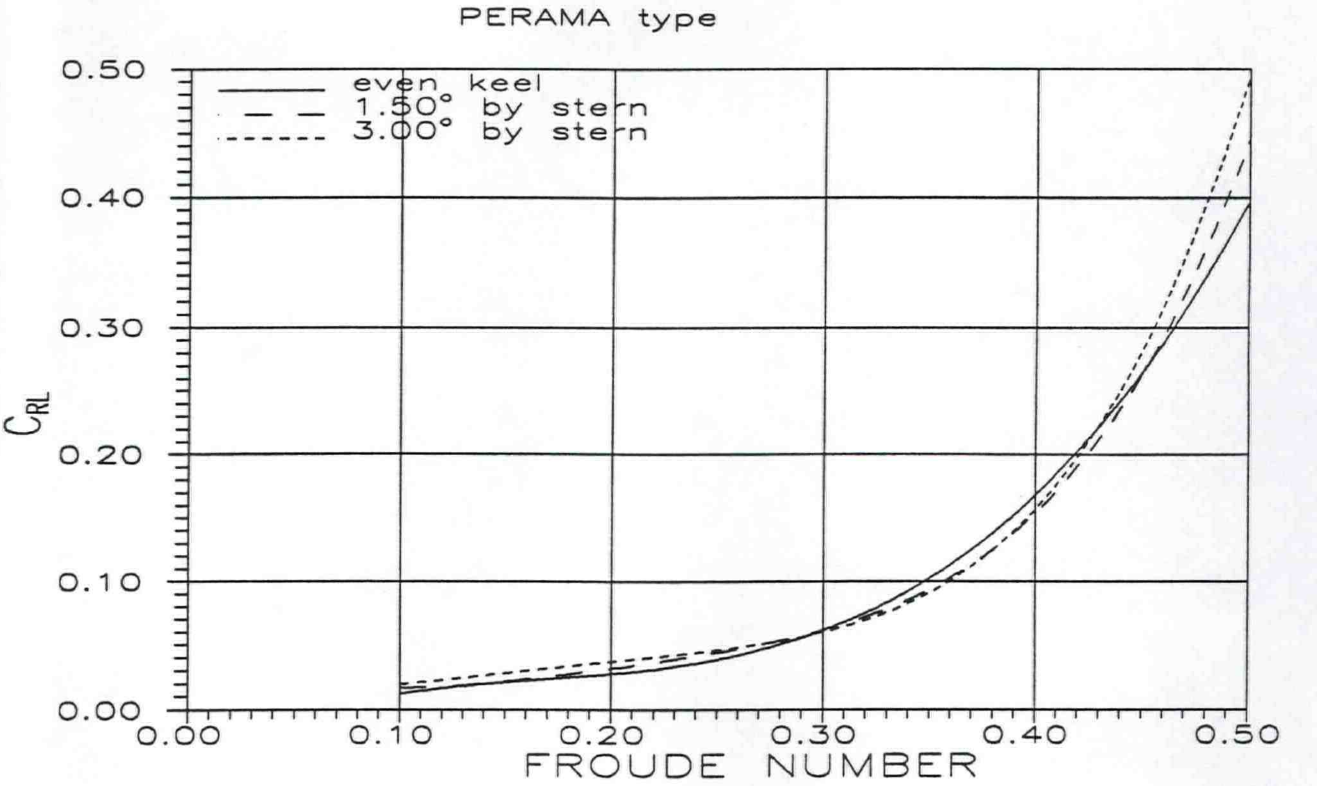

Fig. 15 : BEST FIT $C_{RL} = C_{RL}$ (trim) CURVES

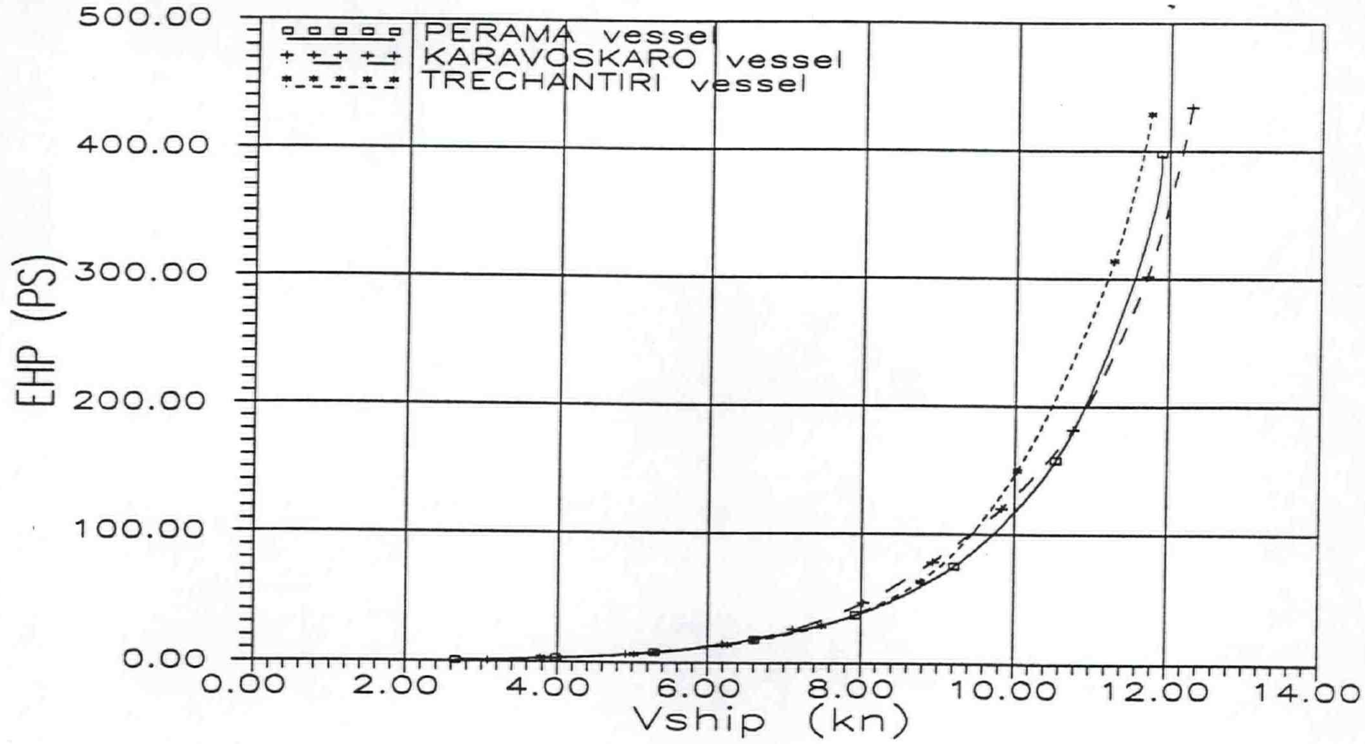

Fig. 16 : COMPARISON OF EHP - V_S CURVES AT L_{WL}=18.84 m AND DISPLACEMENT= 76 t

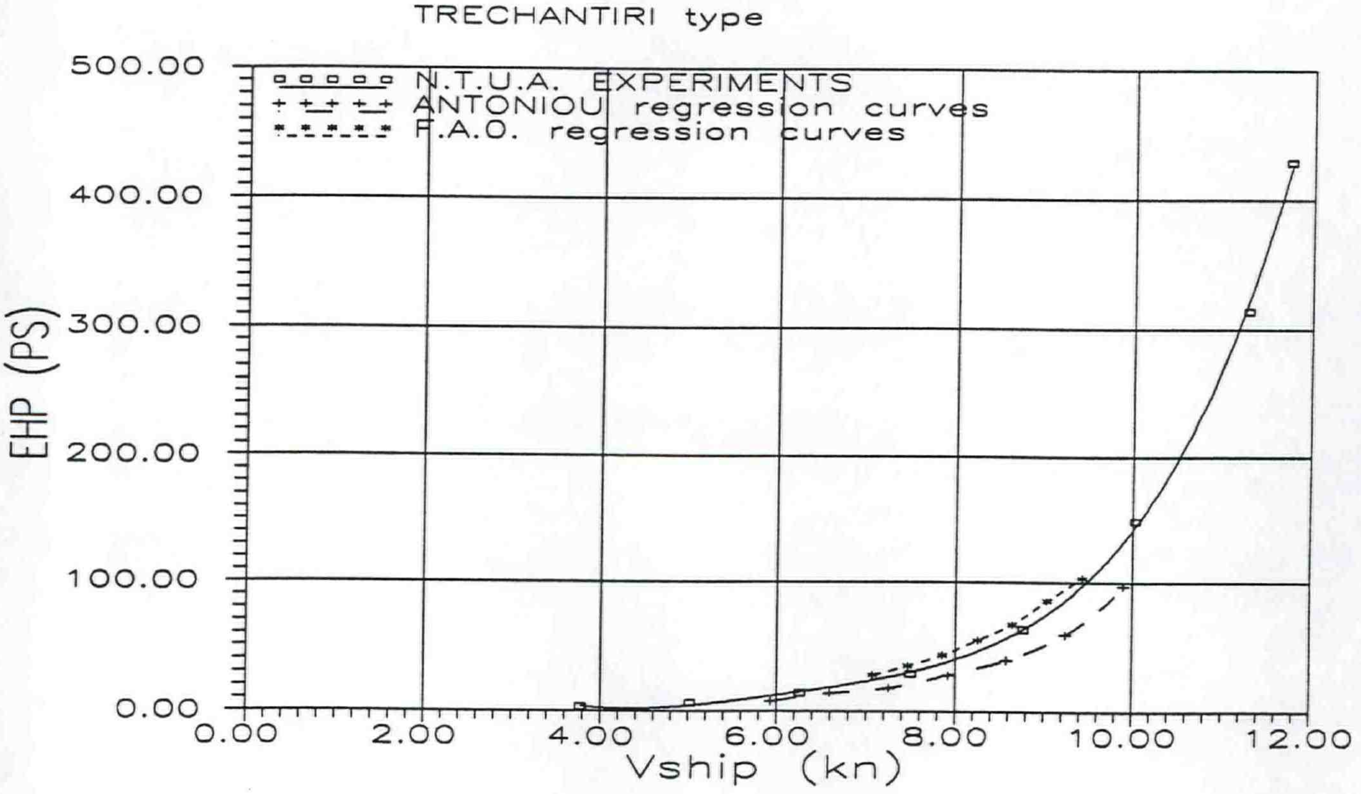

Fig. 17 : COMPARISON OF EHP -V_S CURVE AT DISPLACEMENT=76 t WITH ANTONIOU AND F.A.O. REGRESSION ANALYSIS

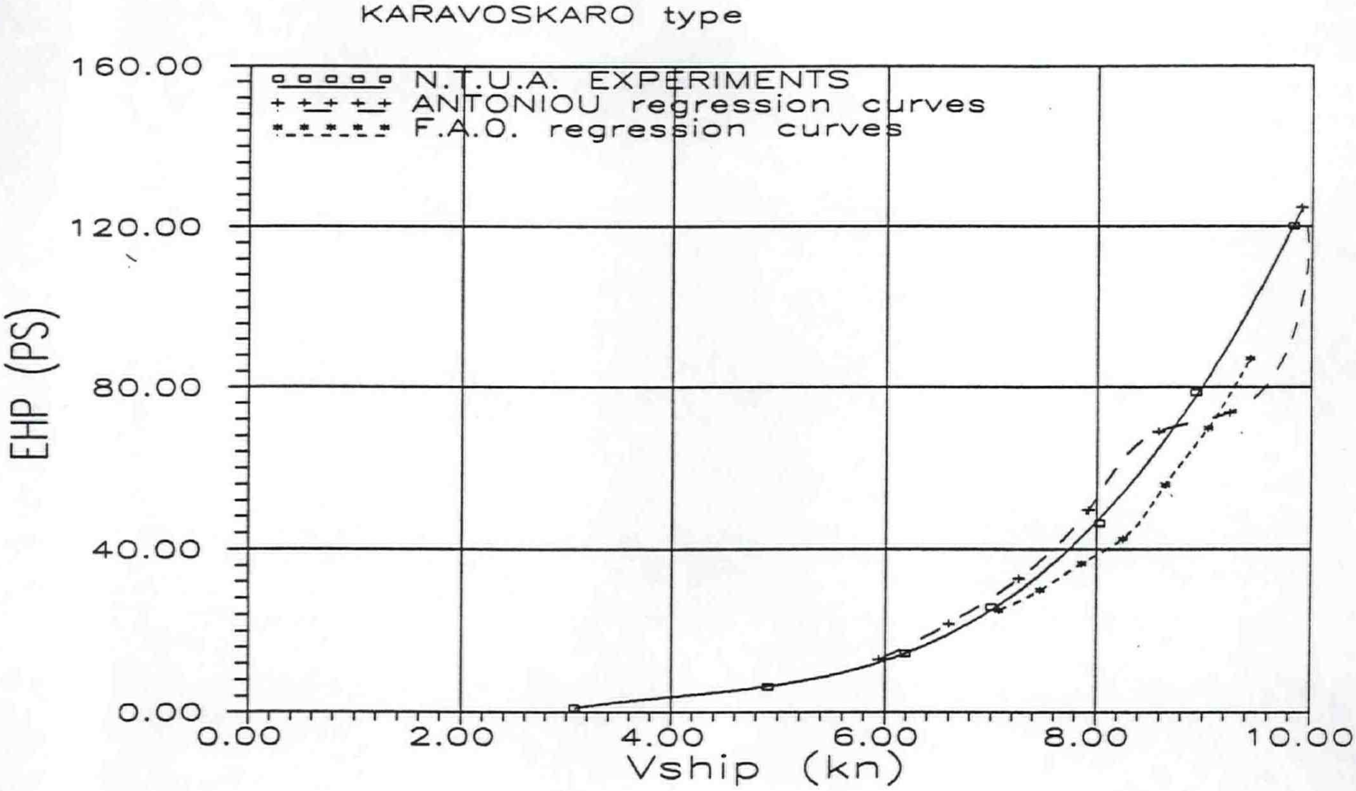

Fig. 18 : COMPARISON OF EHP -V_S CURVE AT DISPLACEMENT=76 t WITH ANTONIOU AND F.A.O. REGRESSION ANALYSIS

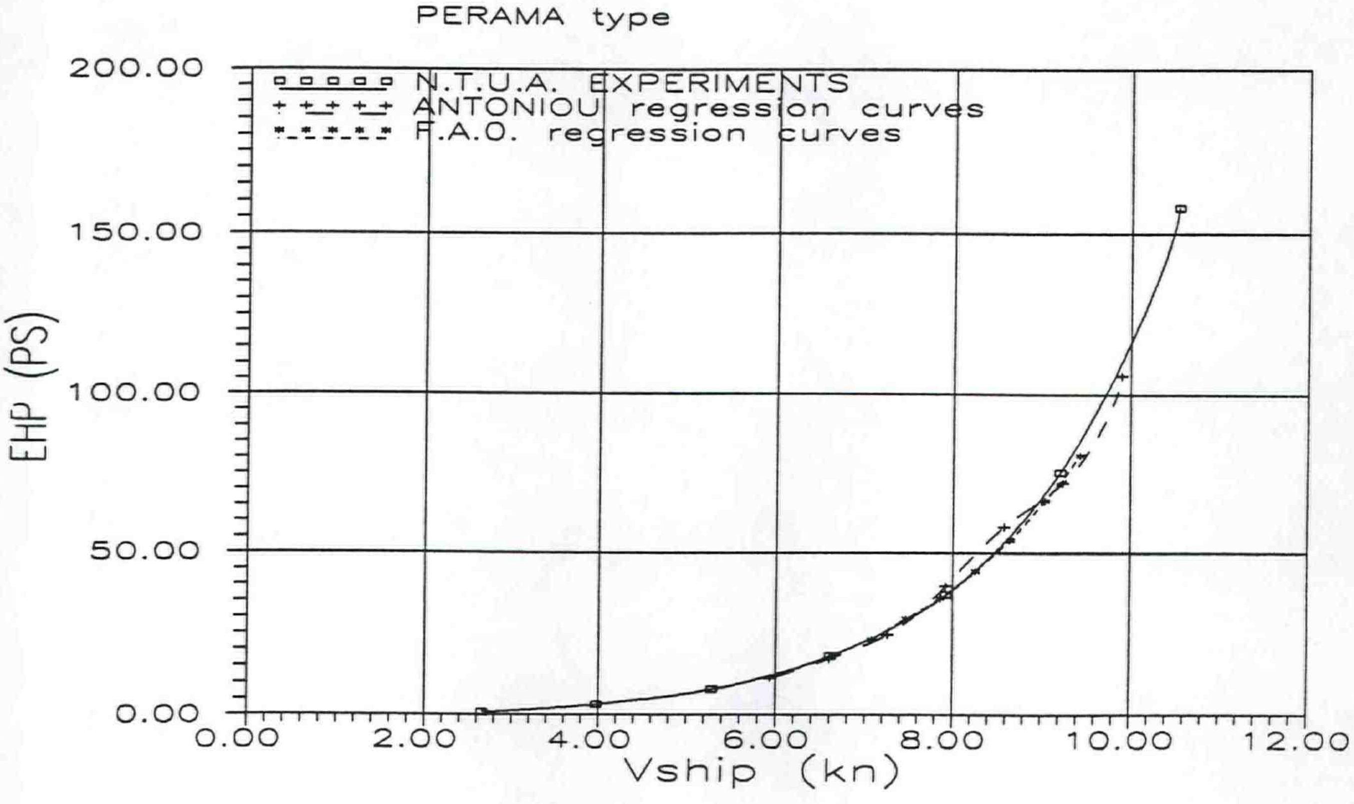

Fig. 19 : COMPARISON OF EHP -V_S CURVE AT DISPLACEMENT=76 t WITH ANTONIOU AND F.A.O. REGRESSION ANALYSIS