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EVALUATION OF TRIMARAN BOW SHAPES IN HEAD SEAS TOWING TANK TESTS AND RESULTS

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ABSTRACT

The future of naval architecture looks at improved ship designs which can operate in extreme weather while capable of achieving missions either commercial or naval. This demand for new and improved capabilities stipulates for research in this area. The concept of wave piercing bows for trimaran ships was investigated at UCL in the past, and this study aims to supply further information to past research regarding seakeeping behaviour. The contribution of two different wave piercing bow shapes, in terms of sea keeping for a well-known trimaran destroyer design produced in the past by UCL, is assessed through tank model testing for an available range of frequencies and wave amplitudes. Due to limited facilities and time, the report only analyses heave and pitch motions in head seas. Essentially, the focus is directed towards assessing the impact of a wall-sided and a flared bow shape on trimaran performances, following any changes in heave and pitch equations of motion that they generate (such as differences in damping and stiffness). Finally, the project also describes the whole procedure from model design, model manufacture, model testing, to the understanding and presentation of any valuable findings.

Keywords: trimaran, head seas, towing tank experimental tests

1. EXPERIMENTAL PROCEDURE

1.1. CoG Experiment Procedure

The model's centre of gravity, especially the VCG had to be determined in order to set a correct GM for the model. The author could not rely anymore on information received from Paramarine because of several reasons such as:

a. Use of different materials to finish the model (carbon fibre, foam filler, paint, glue, expanded foam)
b. Use of different foam densities for box structure and immerse bodies
c. Use of different foam densities for box structure (front flared section made from the same foam as the main and side hulls and the rest main from different foam)
d. Carving access pockets inside the main hull for ballasting the model to the right draught.

CoG Experiment

The centre of gravity was determined experimentally using gravity suspending the model from the LCG position in order to avoid any longitudinal inclination. The accuracy of this measurement is not extremely precise, but proved to be quick and very useful (Fig.1.1). The angle of inclination was determined geometrically in the absence of an inclinometer (Fig.1.1).

Fig.1.1

The experiment was repeated for both models. Values obtained for the position of CoG in both cases was as high as expected given the presence of the box structure which increases the value of the VCG.

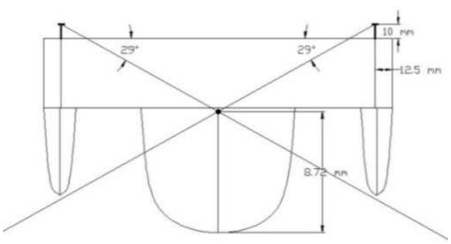

Fig.1.2

1.2. Ballasting and Trimming Procedure

The models were weighed before adding extra ballast to achieve the right draught.

Note. The ballasting and the trimming procedure were performed for each model with the towing arm already attached, to avoid any source of error caused by a future attachment of the towing arm.

The amount of ballast required was calculated according to the ship deep displacement (Paramarine model), but it was found that the models did not sink enough to achieve the right draught.

Due to this problem the model ended up heavier than previously anticipated due to:

- The manufacture procedure, as the models were glued with expanded foam which determined added buoyancy in the model by increasing the centre hull and side hull beam.
- The use of carbon sheets and foam filler in the bow region (main hull), and bow and stern regions (side hulls) contributed to the increase in buoyancy.

The correct draught was achieved by adding rectangular weights in the available space in the central hull (ballasting pockets).

Table 1. Added Ballast

AXE BOW	X BOW	AXE BOW	X BOW
3.024kg	3.2kg	2kg	1.86kg

1.3. Inclining Experiment Procedure

After determining the position of the centre of gravity, due to differences between Paramarine model and reality, an inclining experiment was required in order to determine the GM of the model.

The inclining experiment setup involved the use of a pendulum and a square aluminium weight to transversely incline the model by moving the weight from starboard to portside.

In an inclining experiment is desired to incline the vessel with an angle between -5 and 5 degrees just to keep a linear variation between the change of G and the angle of inclination.

The experiment was performed in both cases and the results are presented in Table 2.

Table 2. Inclining Experiment Results

	X Bow	Axe Bow
MODEL MASS	1.86 kg	2 kg
BALLAST	3.2 kg	3.024 kg
DISPLACEMENT	5.06 kg	5.024 kg
WEIGHT MOVED	0.063 kg	0.063 kg
GM corrected	0.0028 m	**0.0028 m**

Note. The experiment is not highly accurate due to the rather old equipment (the angle reading from the pendulum lacks in high precision).

The model is setup by moving weights transversely at a certain distance.

Pendulum indicates no heeling angle at datum position (no weight attached).

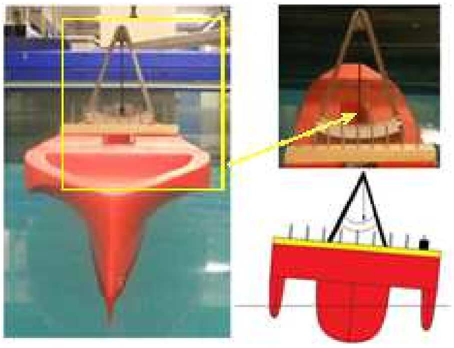

Fig.1.3 Inclining Experiment Setup

1.4. Instrumentation and constraints setup

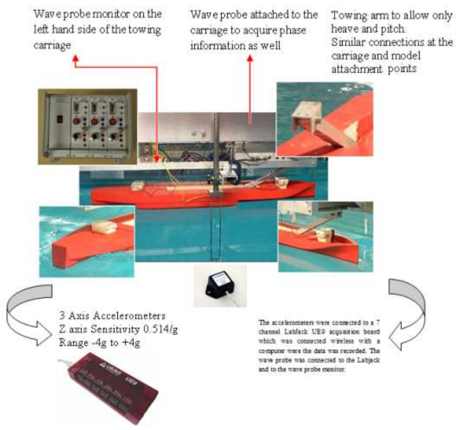

Fig.1.4 Experimental Setup Presentation

2. PRESENTATION OF RESULTS

2.1. Trimaran motion in regular waves

The seakeeping experiments were conducted in the UCL Ocean Towing Tank, which has a length of 20 m and a minimum calibration depth for the wave makers of 1 m (Fone, 2009).

Both models were tested statically and in towed position as follows:

a. range of frequencies from 0.5 to 1.5 Hz (range permitted by UCL Ocean Towing Tank Wave maker Software) (Fone, 2009) see Fig.3.

b. wave amplitude from 1.5 cm to 2.5 cm

c. model speed 0 and 0.7 m/s

d. heading: 180 degrees (head seas)

X BOW-49 runs

AXE BOW-45 runs

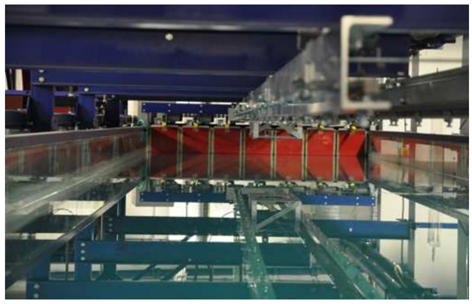

Fig.2.1

2.2. Data files interpretation

The signal acquired from the LabJack had to be analysed and post processed. The post processing part was carried out using the software MatLab.

2.3. Results –Forward Speed 0m/s

In this section the seakeeping experiment results for 0 m/s forward speed are presented.

AXE BOW vs X BOW

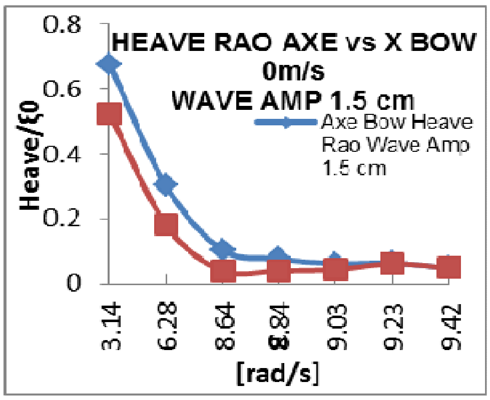

Fig.2.2

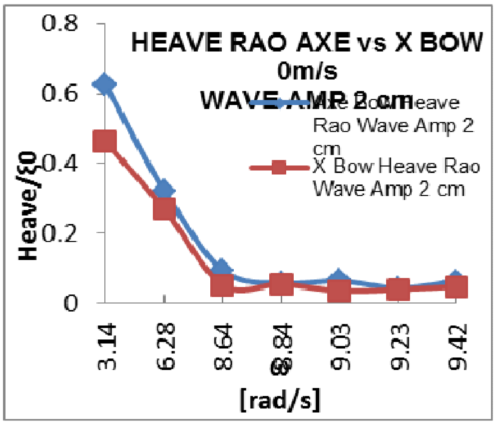

Fig.2.3

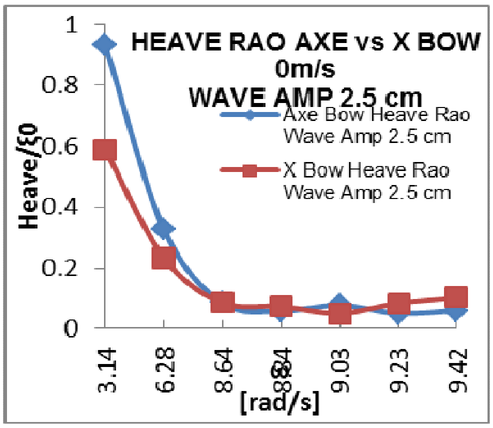

Fig.2.4

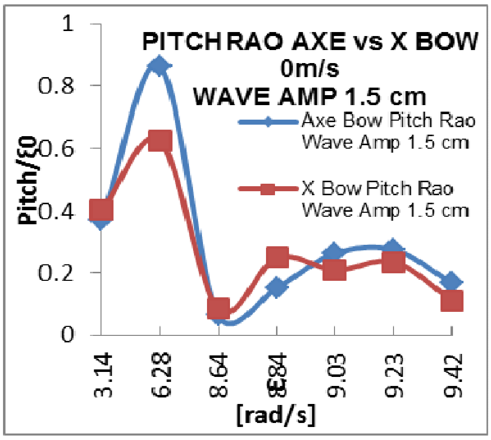

Fig.2.5

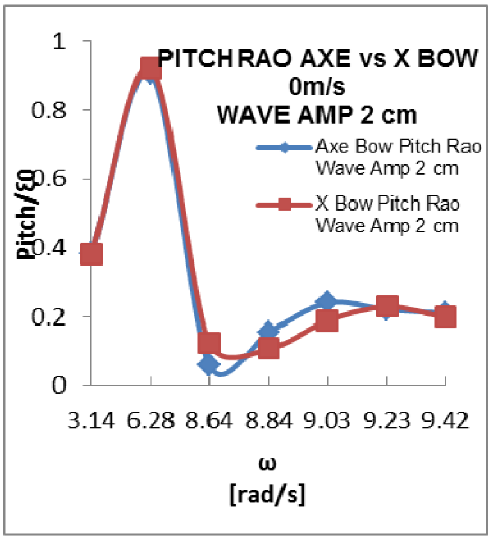

Fig.2.6

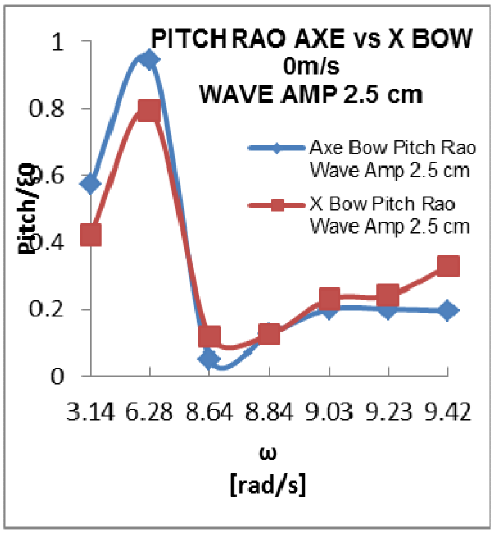

Fig.2.7

3. CONCLUSIONS

In this section conclusions related to every stage of the project are presented.

3.1 Design Procedure

The importance of previous experience in Ship Design was crucial for this project. Without the experience brought by the Ship Design Exercise, the task would have been almost impossible. The generation of solid bodies into Paramarine and drawings formatting in AutoCad in such a short timeframe, require a skilled software user. The use of three different pieces of software during the design procedure and of another one for the data analysis speaks for itself.

3.2 Manufacture Process

One of the most attractive parts of the project, the manufacture process, gave an insight into industry matters and quickly proved to be a reality check. Decisions had to be made quickly and consequences taken. Nevertheless, it was learned that it does not matter how well prepared the individual is, but it is the communication between individuals that drives people around and makes things happen.

3.3 Experimental Procedure

The experimental procedure was carefully planned ahead in order to make full use of the available time spent in the towing tank. During the scheduled towing tank time, it was found that the necessary time to undertake such as an experiment needs to last at least for two weeks in order to set everything properly and not to leave any room for errors.

3.4 Results

The author believes that the project achieved its initial aim. Clear results were presented, proving the advantage of the X Bow over the AXE Bow. However, more time would have been preferred and ideal in order to perform a better investigation into this matter and to allow for a better understanding of the equations of motions.

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