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RESONANCE TESTS ON GLASS REINFORCED PLASTIC COMPOSITE PANELS.(U)
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Structures Technical Memorandum 329

RESONANCE TESTS ON GLASS REINFORCED PLASTIC COMPOSITE PANELS

A. GOLDMAN and B. QUINN

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SUMMARY

Resonance tests have been undertaken on four panels of glass reinforced plastic (GRP) and foam sandwich construction to determine their natural frequencies and mode shapes up to 100 hertz.

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16. ABSTRACT:

Resonance tests have been undertaken on four panels of glass reinforced plastic and foam sandwich construction to determine their natural frequencies and mode shapes up to 100 hertz.

CONTENTS

1. INTRODUCTION

As part of a project to construct a catamaran minehunter vessel having a hull made of glass reinforced plastic (GRP) sandwich panels, sample panels were constructed to test some of the manufacturing options available.

Aeronautical Research Laboratories were requested to carry out resonance tests on four panels, all of similar construction, to ascertain whether slight differences in manufacture had any significant effect on the natural frequencies of vibration.

2. PANEL CONSTRUCTION

Two panels were constructed by Ramsay Fibreglass Australasia, and two by Vickers-Cockatoo Island Dockyard. All panels were constructed from slabs of Klegecell H130 modified PVC foam, of density 130 kilograms per cubic metre, held in a timber frame, and sandwiched between two sheets of GRP, each consisting of several alternate layers of glass-fibre woven roving and glass-fibre chopped strand mat. BP Cellobond A2785-CV resin was used to bond the glass fibre layers to the foam.

A rib was constructed from a foam slab with eight layers of 600 grams per square metre woven roving, and six layers of 300 grams per square metre chopped strand mat, laid alternately.

Construction was generally as shown in Fig. 1 where it can be seen that the slab layout is not symmetric. The joints between foam slabs were filled with putty.

The differences between the panels were the number of layers of glass fibre used on each side, the density of the woven roving used, and the manufacturing technique used. These differences are listed in Table 1.

All panels used chopped strand mat of density 300 grams per square metre, and the overall mass of each panel was approximately 500 kilograms.

3. TEST CONDITIONS

Panel No. 1 was tested in open sunlight with an ambient shade air temperature which varied from 20°C to 27°C. Panels Nos. 2, 3 and 4 were tested in the loading bay of a building where the ambient air temperatures fluctuated between 25°C to 35°C over the period of the tests.

4. TEST PROCEDURE

Each panel in turn was set up generally as shown in Fig. 2. The four springs were selected to provide a low frequency support system. The natural frequency of the whole rig, in vertical translation, was 4.5 Hz. The input force was provided by an electromagnetic vibrator, carrying a mass of 4.5 kilograms, being glued to the surface of the panel using a weak epoxy resin adhesive. The total mass of the vibrator and load was approximately 30 kilograms. The vibrator was located off-centre to ensure that as many modes as possible would be excited from the one position. The vibrator was driven by a high impedance amplifier and a variable oscillator.

An accelerometer was fixed at each corner of the panel using adhesive at three locations and a suction cup at the fourth location. This fourth accelerometer was used to traverse the panel to determine the mode shape.

The outputs of the accelerometers were observed as Lissajous figures on a four-channel oscilloscope by displaying them against a signal displaced 90 degrees from the forcing current. This ensured that the figures closed to a straight line at resonance, as an aid in tuning. The phase relationship between different parts of the structure was determined by the slope of the Lissajou figure.

At each frequency at which all four accelerometers were indicating resonance, measurements were taken at 15 points on Panel 1 and 25 points on Panels 2, 3 and 4. The increase in points in the later tests was made to improve definition. The 15 point measurements were considered to be the minimum required to obtain satisfactory results within the limited time available for Panel 1 tests. The measurements were made using a digital multimeter for modulus and the slope of the Lissajou figure to indicate positive or negative phase relationship.

5. RESULTS

The frequencies at which whole panel resonances occurred are listed in Table 2.

Figures 3 to 12 show the mode shapes at the frequencies indicated. As all four panels appeared to be similar, several modes were not plotted for Panels Nos. 2, 3 and 4. The amplitudes of vibration were generally very small, the largest measured being 0.1 mm peak to peak.

6. DISCUSSION

The variation in temperatures during the period of the four panel tests probably contributed as much toward the slight differences in frequency as would any of the changes in manufacture. The omission of the mode at 86 hertz on Panel 1 may have been due to a different location of the vibrator. The vibrator location on Panel 1 was close to grid position D2 whereas for the other three panels, a position close to D4 was used. The 86 hertz mode has a nodal line which runs closer to D2 than D4 and it is probable that for Panel 1 the vibrator was too close to the nodal line to excite that mode.

The lack of symmetry of the mode shapes at the higher frequencies was caused by the staggered layup of foam slabs during construction, as shown in Fig. 1. The changes in local stiffness at the joints between slabs were more noticeable at the higher frequencies. Above 86 hertz the mode shapes became less definite, and attempts to plot them using the simple technique described were unsatisfactory. A sweep through the frequency range 100 to 300 hertz revealed several frequencies at which one of the accelerometers at the corners produced an indication of resonance. However, these were localised vibrations and no attempt was made to measure any mode shape. A complete sweep through the frequency range from 20 hertz to 300 hertz, whilst observing the response of an accelerometer placed at the centre of the panel, revealed no resonant frequencies that had not been noted at the four corners.

Further tests may be carried out, on one panel, to determine mode shapes when treated as a built in panel. This simulates more closely the construction of a ship hull, and also allows investigation of the effects on resonant frequencies of controlled amounts of damage to the panel.

7. CONCLUSIONS

The four panels have been tested and found to possess sufficiently similar resonant frequencies, in the range 0 to 100 hertz, for them to be indistinguishable in this aspect.

ACKNOWLEDGEMENT

The assistance of Mr. D. Hall and Ms. K. Challis, of Materials Research Laboratories, in the conduct of the tests, and in particular in the supply of information regarding construction of the panels, is gratefully acknowledged.

TABLE 1

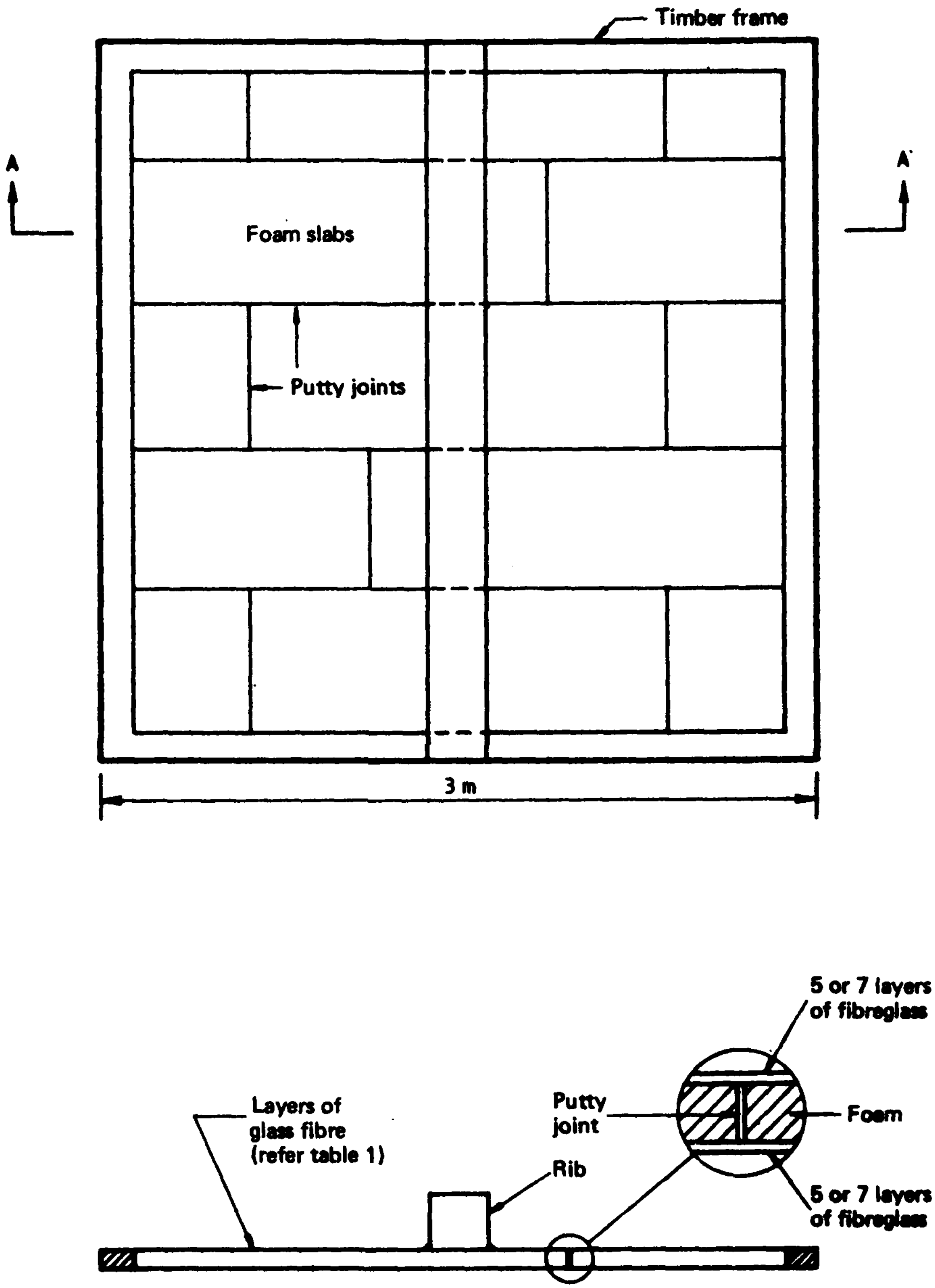
MANUFACTURING DIFFERENCES BETWEEN PANELS

	Panel 1	Panel 2	Panel 3	Panel 4
Manufacturer	Ramsay	Ramsay	Vickers	Vickers
Layers of glass fibre on each side of foam	7	5	5	7
Area density of woven roving used· gram/metre^2	600	800	800	600
Manufacturing technique	Hand laid	Hand laid	Vacuum bag	Hand laid

TABLE 2

RESONANT FREQUENCIES OF PANELS

Panel 1	Panel 2	Panel 3	Panel 4
21 Hz (Fig. 3)	22 Hz	21.6 Hz	22.2 Hz
31.4 Hz (Fig. 4)	32.56 Hz	32 Hz	32.4 Hz
42.5 Hz (Fig. 5)	43.6 Hz	43.1 Hz (Fig. 11)	43.4 Hz
44.4 Hz (Fig. 6)	46 Hz	46 Hz	45.8 Hz
50.06 Hz (Fig. 7)	51 Hz	51 Hz (Fig. 12)	51 Hz
75.1 Hz (Fig. 8)	77.3 Hz (Fig. 9)	75.8 Hz	77.2 Hz
	86 Hz (Fig. 10)	86.9 Hz	86.5 Hz



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Dimensions:	Length	3 metres
	Width	3 metres
	Thickness	80 millimetres
	Rib	250 x 250 millimetres

FIG. 1 CONSTRUCTION OF PANELS

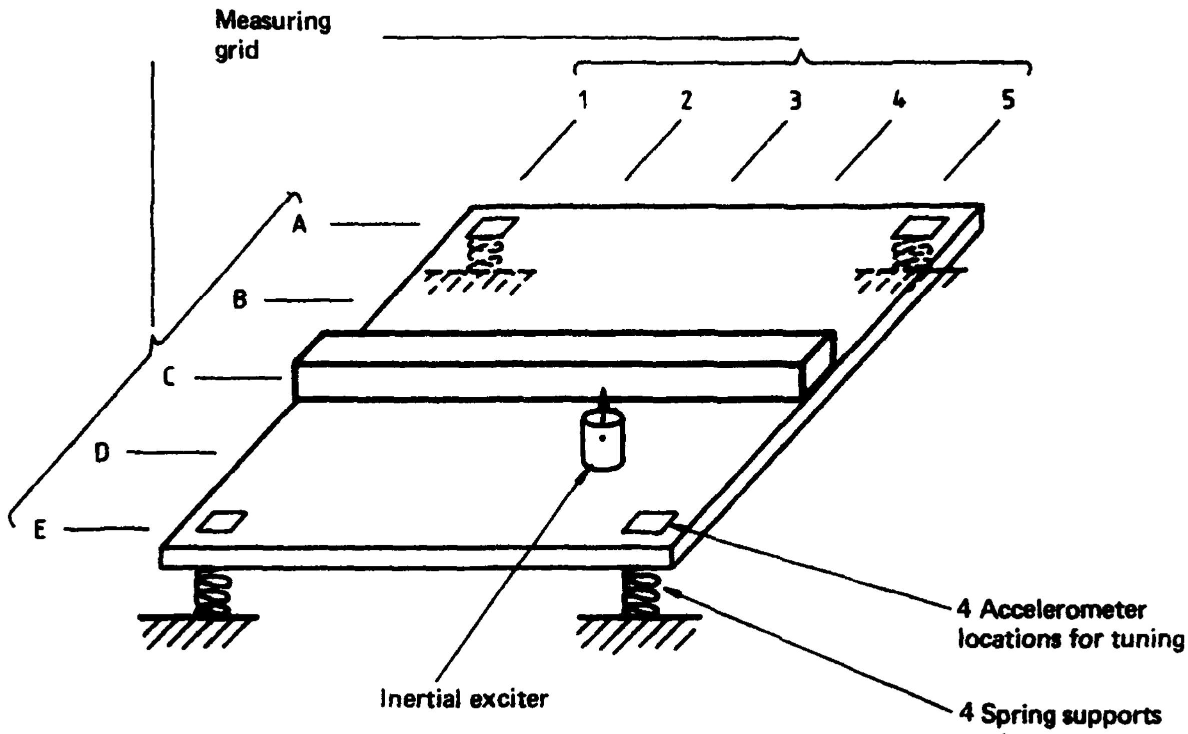

FIG. 2 TEST RIG SET UP

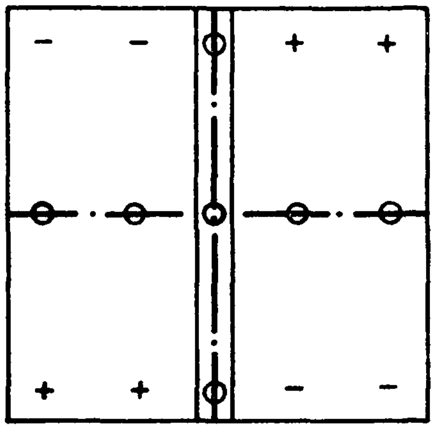

FIG. 3 PANEL 1 21 Hz

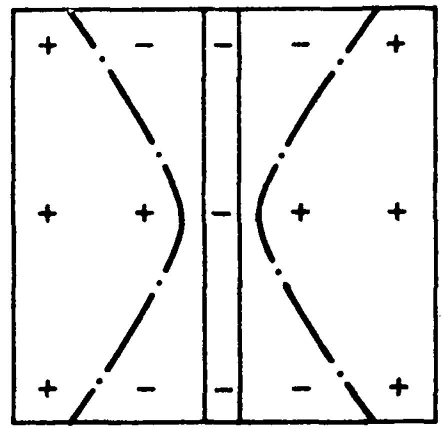

FIG. 4 PANEL 1 31.4 Hz

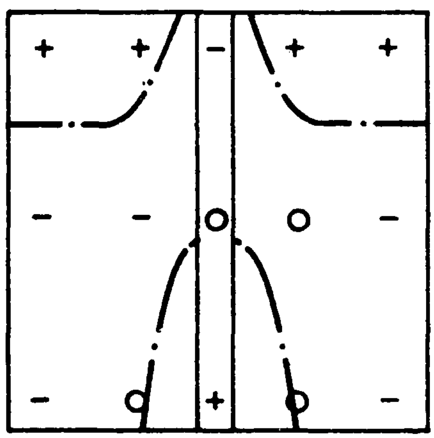

FIG. 5 PANEL 1 42.5 Hz

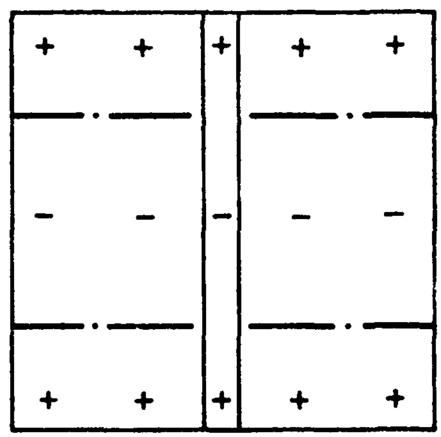

FIG. 6 PANEL 1 44.4 Hz

+ Indicates upwards motion

– Indicates downwards motion

O Indicates no motion or non Resonant motion

—·— Nodal lines

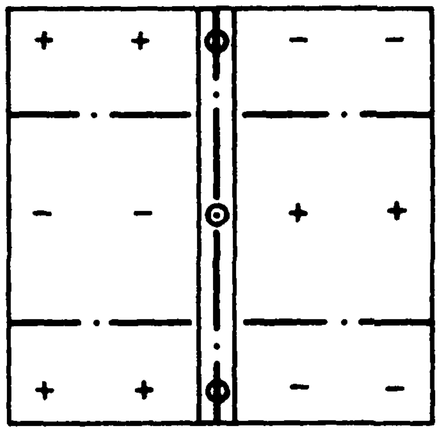

FIG. 7 PANEL 1 50.06 Hz

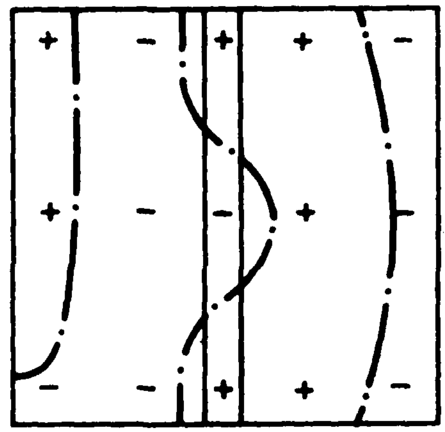

FIG. 8 PANEL 1 75.1 Hz

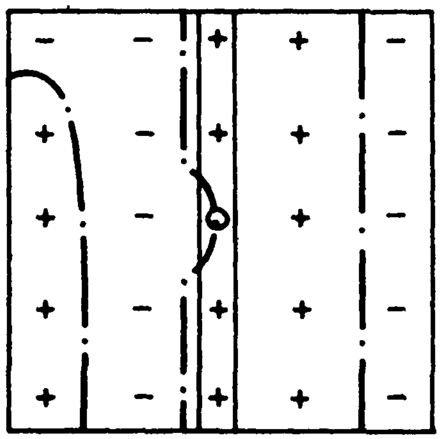

FIG. 9 PANEL 2 77.3 Hz

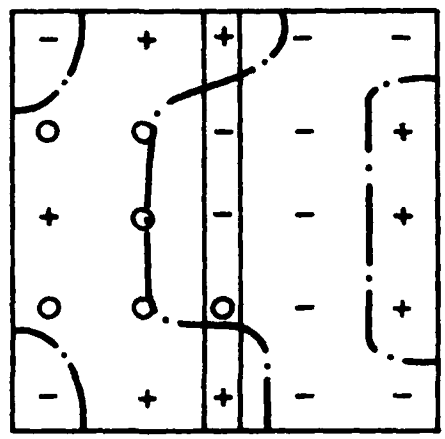

FIG. 10 PANEL 2 86 Hz

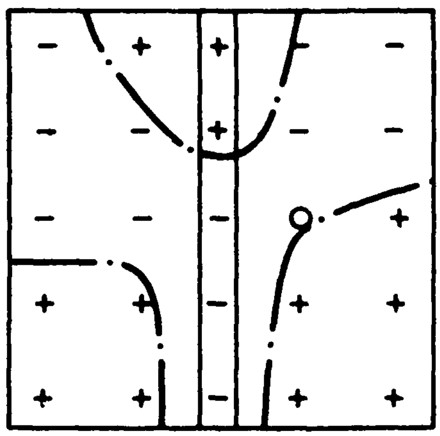

FIG. 11 PANEL 3 43.1 Hz

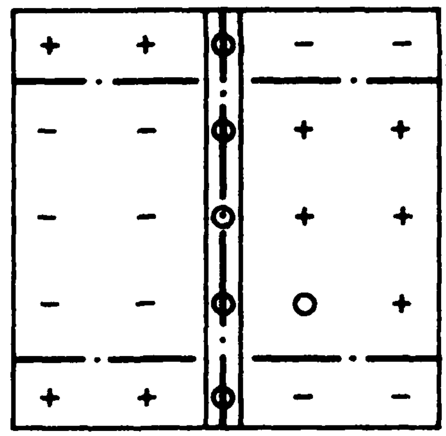

FIG. 12 PANEL 3 51 hz

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