Progress Report on
Large Grillage Structural Tests
- Ship Structures Committee Project SR1442

Prepared for:
Defense Research and Development Atlantic
Transport Canada

October, 2004

by:

Faculty of Engineering and Applied Science
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Table of Contents

1. Summary .........................................................................................................................1
2. Single Frame Tests .........................................................................................................1
3. Single Frame Experimental Results ............................................................................4
4. Grillage Tests ................................................................................................................6
5. Numerical Analysis .......................................................................................................7
6. Points of Concern .........................................................................................................8
7. Expenditure of Funds ......................................................................................................8
8. Schedule: ........................................................................................................................8
9. References ....................................................................................................................8
1. SUMMARY

The ship structures committee research project (SR1442) is progressing well on all aspects. The project is connected to and follows on from a research program that consists of a series of increasingly large experiments to investigate the plastic behavior of ship framing and grillages subject to lateral loads. The tests on the single frames have begun and will be completed during the next couple of weeks. A new technique for measuring the 3D distortions of the frame is being tried. In addition to the use of the micro-scribe for point measurements, a photographic system (PhotoModeler) offers the potential of attaining up to 1/50,000 measurement accuracy in 3D. The system will be far more practicable for the measurement of the distortions of the small and large grillages. The design of the support frame for the grillage tests is complete, the material has been received and fabrication is well underway. Final design of the large grillage tests is underway. Extensive ANSYS finite element analysis of single frames has been conducted, as well as initial analysis of grillages.

2. SINGLE FRAME TESTS

After two initial experiments with single frames, the test frame was re-designed and modified to increase its axial stiffness and moment connections. The new support frame ready and the remainder of the single frame tests will be completed in the next couple of weeks. Testing of five frames is completed, three more test with central load are to be done. The experimental program has been expanded from six to eight frames, to include a test of an L frame, with central and end load conditions. The 150,000 lb actuator, load-cell and new load pillow are ready to continue testing. Figure 1 shows the test set-up during final preparations. Figure 2 shows a distorted L section frame after the test. A test report for the single frame tests is in preparation and will be circulated before the end of 2004.

A new method of 3D coordinate measurement is being tried. We have purchased the program PhotoModeler 5 from EOS Systems, along with a calibrated 6.1 mega pixel Canon digital camera. (see http://www.photomodeler.com and Figure 3.) We anticipate that the photographic approach will enable us to make distortion measurements of the entire frame, and subsequently of the small and large grillages. Figure 4 shows the reconstruction of a failed frame based on PhotoModeler data.
Figure 1. Single Frame support frame (blue) and test frame (yellow) at final preparations for testing.

Figure 2. Single Frame test (L75 End) at completion of testing.
Figure 3. PhotoModeler software screen, digital camera and sketch of working concept.

Figure 4. Reconstructed Frame geometry, from PhotoModeler data (Rendered in Rhino).
3. **Single Frame Experimental Results**

The comprehensive results for the 8 single frame tests will be presented in a test report that is in preparation. It will be completed after all the tests are complete. Some initial results are presented below. Figures 5 and 6 show the experimental set up, frame under load and deflection measuring devices.

It can be seen from Figure 7 that the load deflections curves measured with the LVDT (attached on the frame below the line of points shown in Figure 6) match very well with the values measured with the micro-scribe (at the 6 points indicated in Figure 6). This adds credibility to the whole set of deflection measurements.

![Figure 5. Sketch of deflection measurements for the tee frame end load tests. The micro-scribe 3D digitizer is being operated by hand, while the LVDT is fixed under the frame.](image1)

![Figure 6. Sketch of load position and locations of measured deflections for the Flat Bar end load tests.](image2)
Figure 7. Comparison of seven load-deflection plots for the flat-bar-end-load tests.
4. **Grillage Tests**

The design of the support frame for the grillage tests is finalized. The support frame and test specimens have been ordered and fabrication of all components is underway. No problems are foreseen with this work. Figure 8 shows a Rhinoceros™ drawing of the central portion of the grillage support frame. Figure 9 shows a Rhinoceros™ drawing of a test grillage, with the boundary plates and frames shown. Figure 10 shows the grillage support frame in various stages of fabrication in the shop.

Figure 8. Grillage support frame (2 configurations).

Figure 9. Small Grillage structure with end and edge supports.
5. **Numerical Analysis**

A detailed finite element study of a variety of single frames has been completed and has been circulated [1]. The study found a number of interesting results and lead to a number of avenues for further study. The investigation indicates a number of interesting relationships between various buckling mechanisms (shear buckling, web compression buckling and tripping) and the overall plastic collapse. Some of these trends are quite different than what occur in elastic response (with small deflections). The large deflections, with the change in geometry, tend to change the typical relationships. For instance, larger flanges tend to enhance rather than restrict local web bucking, in some cases. The numerical side of the program will continue alongside the experimental tasks. Figure 11 shows a preliminary analysis of the Small Grillage under central loads.
6. **POINTS OF CONCERN**

Other than the normal concerns to keep the experimental work moving smoothly forward, we have no immediate concerns.

7. **EXPENDITURE OF FUNDS**

The project is on budget with no difficulties. Funds are being spent, as planned, on frame design, materials purchase, literature search, finite element analyses and support of graduate students and project engineer.

8. **SCHEDULE:**

The general schedule is shown below. We are currently right on schedule.

- Final Support Frame Design - July ’04
- Test Frame Design - Sept ’04
- Support Frame Constructed - Jan ’05
- Test Frames Ready - Jan ’05
- Grillage Experiments - Mar. ’05
- Experimental Analysis - May ’05
- Experimental Report - July ’05
- FE Analysis - Aug ’05
- FE Report - Sept. ’05
- Final Report - Nov. ’05

9. **REFERENCES**