ABSTRACT

This paper summarizes the results of a series of experiments on the insulation structure from the NO96 membrane containment system. The experiments assessed the static and dynamic loading of the insulation structure and its materials. The dynamic loading assessment included a “dry-drop test” which was followed by a series of corresponding non-linear dynamic structural finite element analyses. These were conducted to grasp the dynamic structural response and strength. The structural FEM analyses well represented the dynamic structural response of the insulation structure after the effect of the boundary conditions and material properties were investigated.

KEY WORDS: Membrane LNG Carrier; Insulation box; Plywood; Perlite; Dynamic strength

INTRODUCTION

Strength assessment of LNG cargo tanks against sloshing forces is crucial in the estimation of membrane LNG carriers’ structural integrity. Due to no internal structural members, violent fluid motion in partially filled LNG cargo tanks can occasionally cause large permanent damage (T. Gavory et al., ISOPE2009). Currently partial filling is restricted; but recently with the application of membrane systems to offshore structures, the growth in ship size and loading-and-unloading at offshore terminals; partial filling is much more likely to occur. As of which the importance of a reliable sloshing assessment is larger than ever. However, due to the non-linear, localized, physical phenomena of sloshing, a reliable assessment is not straightforward to undertake. Classification societies and companies, including a membrane concept designer, have been actively working to develop a suitable solution for the assessment of sloshing. A realistic sloshing load and a corresponding dynamic structural response of the insulation structure are critical in the accuracy of the strength assessment of sloshing in a membrane LNG tank. However, the dynamic effect of the loading and the structural response is still not clear, despite all the recent developments in the industry. This paper summarizes the results of a series of experiments on the insulation box of the NO96 membrane LNG carrier, which are aimed to grasp and understand the dynamic structural response and strength of the membrane tanks.

Initially a strength test of the materials used in the insulation box was carried out to obtain their structural characteristics. Then a static load test and a corresponding structural FEM analysis of the insulation box were prepared. The purpose of this is to evaluate the global static strength characteristic of the insulation box and investigate the material properties of the FEM. Finally, a dry-drop test and a corresponding transient structural FEM analysis was made to evaluate the dynamic structural characteristic of the insulation box.

DESCRIPTION OF THE INSULATION BOX

The insulation box of the NO96 membrane containment system is used as a high performance thermal-insulator. The specification of the insulation box is regulated by GTT, a membrane concept designer. It is well known that there are two main types of insulation boxes used in NO96 membrane containment systems, the ordinary and reinforced type. Both of which are assessed in this report. The insulation box comprises of the insulator perlite, and a plywood strength casing. The plywood casing of the insulation box is assembled using staples.

STRENGTH TEST ON THE COMPOSED MATERIAL

For the overall strength assessment of the NO96 membrane, the strength characteristic of both the plywood and perlite is required. A tension test of the plywood and a compression test of the perlite are subsequently carried out.

Tension Test of Plywood

A specimen of plywood from the insulation box casing is used for the tension test assessment. The specimen and the test specifications are done in accordance with ASTM D3500 A. Figure 1 shows the specimen characteristics for the tension test piece. The following strength characteristics were studied in this test.

- Tensile strength of plywood
- Effect of the grain direction on the strength of plywood
- Effect of the test-velocity (strain rate) on the strength of plywood

Table 1 shows a list of test specimens. Figures 2-3 show the cut points of the test specimens on the insulation box. The tension test was carried out using an Instron tension/compression tester, shown in Figure 4.