On the Ultimate Strength of Cylinders with U-Type Longitudinal Stiffeners

Setsuo Iwata, Masayuki Tanigawa, Naohiro Yoneda and Toshiaki Makihata
Hitachi Zosen Corporation
Osaka, Japan

Abstract

Results from an experimental and theoretical study of the cylinder with U type longitudinal stiffeners on buckling and ultimate strength are reported.

In the experimental investigation, combined loading (axial, moment and shear) tests were conducted on longitudinally stiffened cylinders with sixty U-type stiffeners.

In the theoretical investigation, FEM analyses by use of the computer program MSC/DYTRAN for the ultimate strength of the stiffened cylinder were conducted. From the parametric FEM analyses, it was clarified that the thickness of the cylinder and the stiffener exert decisive influences upon the buckling and ultimate strength.

Keyword: offshore structure, stiffened cylindrical shell, buckling stress, ultimate strength DNV recommendation, inclined loading test, FEM

1 Introduction

The utilization of a huge diameter stiffened cylinder for offshore structures which is shown in Fig.1 gives the advantages of large stiffness, light weight and big buoyancy.

Many projects using the stiffened cylinder are in various stages of design for offshore structures such as semi-submerged platform.

Based on these necessity, Det Norske Veritas (DNV) investigated the buckling strength to issue regularly design code and recommendations "Buckling Strength Analysis, Classification Notes" for structural design.[1][2]

In this paper, the authors carried out investigations into the buckling and ultimate strength of the stiffened cylinder. The ratio of diameter to thickness was D/t=2083.

The U type longitudinal stiffeners (U stiffener) and H type circumferential ring stiffeners (H stiffener) were furnished on the cylinder by welding.

The research program is composed of experiments and FEM simulation analyses. Experiment includes a series of static tests under combined compression, shear and bending. For FEM analysis, six models were employed to investigate the effects of the thickness of the panel, and one model was employed to simulate the buckling and ultimate strength of test model. Quite good agreements are observed between the experimental results and calculated FEM analysis.

2 Model Test and Results

2.1 Test Models

Two test models of 2500 mm diameter and 1.2 mm thickness employed U stiffeners and H stiffeners as shown in Fig.1(b). The dimensions of the models are given in Table 1 and Fig.2.

Two kind of U stiffeners were furnished on the external surface of the cylindrical shell. The height of U stiffener for the model A was 33 mm which was intended the shell buckling mode. For the model B, U stiffener whose height was 13 mm was intended the panel stiffener buckling mode.

Fig. 1 Stiffened circular cylindrical shell

2.2 Procedure

Fig.3 shows the longitudinal stiffened model ready for testing. The test models were loaded to the slant direction whose angle was 42.2 degree by using the 200 tf jack on the test frame.

Circularity of the both sides of the cylinder were maintained during the tests by the use of the loading ring block which was held in place by fixed with the bolts. The lower end was fastened to the test frame with the bolts.