ABSTRACT

Offshore platforms serve as artificial bases, supporting drilling and production facilities above the elevation of waves. The most popular structures for shallow water depth are the 'jacket' platforms, which are fabricated mainly using cylindrical steel tubular sections. The interface created between two intersecting member surfaces in the structure is called a tubular joint. While joints without reinforcements are called unstiffened joints, those reinforced with internal annular rings are called internally ring stiffened joints.

Offshore structures have to serve in harsh environments and hence are likely to be damaged by a variety of causes. The damage must be properly assessed and the structures repaired so that they may continue to serve their intended function for their specified design life. The research works carried out in this thesis pertain to the assessment and rehabilitation of fatigue damaged internally ring stiffened tubular joints.

Two undamaged joints, stiffened internally with three rings, were tested under axial brace compression loading to evaluate their strengths and to create a bench mark. The chord and brace diameters of these tested joints were 324 mm and 219 mm respectively. Their thicknesses were 12 mm and 8 mm respectively. Compared with the largest joints in the platforms of Bombay High field, the actual test joints are approximately quarter size. The fabrication procedures used represented exactly that employed offshore. Therefore, the tested joints can be considered to be representative for a large number of platforms built in the
Bombay High in a water depth of up to 80 m as well as similar other environments elsewhere in the world.

A tri-linear stress-strain model, which considers the strain hardening characteristics of the material, has been developed to predict the strength of the undamaged joints. This model has been validated with experimental results. Two unstiffened joints of the same dimensions were also tested. The strengths of the internally ring stiffened joints were almost twice that of the unstiffened joints of the same dimensions.

Eight fatigue damaged internally ring stiffened joints of the same dimensions as stated above were tested under axial brace compression loading to evaluate their residual strengths. The degree of damage of the tested joints varied from 35 to 50 per cent. One stiffened joint was also tested under axial brace tension loading. In a damaged condition, these joints possessed an in-built load-transfer mechanism.

A bi-linear stress-strain model has been developed to predict the residual strengths of the damaged joints. This model considered the strain hardening effect. The residual strengths of the fatigue damaged stiffened joints tested under axial brace tension loading was less than one-fourth of that tested under compression loading.

An innovative technique, to rehabilitate fatigue damaged tubular joints, has been evolved in this investigation. A proposal for patenting this innovative technique is under the active consideration of the competent authorities. The proposed repair technique has made use of the ferrocement jackets and epoxy based high performance grout specially developed for this purpose. This grout has ensured an adhesively bonded repaired joint which is free from the defects associated with the stress concentration effects. Excellent bond with the tubular member could be
achieved without any additional effort such as welding of shear connectors. The proposed technique is cost effective, simple, and easy-to-execute and has several advantages over conventional techniques.

Three repaired stiffened joints were tested to check the efficacy of the proposed repair technique. An analytical model to predict the strengths of the repaired joints has been developed in this investigation considering the strain compatibility and force equilibrium based on the principle of reinforced concrete theory. It has been validated with experimental results. The bond strength of the high performance grout was evaluated by conducting push-out test on pipe-to-pipe connection. This was found to be almost three times greater than that of the conventional cement grout.

FE analysis using NISA II package was performed to predict the behaviours of both undamaged and damaged stiffened joints. Based on the equations derived in these investigations, computer programmes in FORTRAN were developed to calculate various loads both for damaged and repaired stiffened joints.