CHAPTER 2

OBJECTIVE AND SCOPE OF THE INVESTIGATIONS

It has become clear from the review of the literature presented in Chapter 1 that internally ring stiffened tubular joints have certain distinct advantages over the unstiffened joints. Information on unstiffened joints are very well documented. As for internally ring stiffened tubular joints are concerned, limited study to the extent of the determination of stress distribution around the welded intersection and thereby estimation of stress concentration factor has been carried out. However, little effort has been made to understand thoroughly the behaviour of internally ring stiffened joints under different types of loadings. Similarly, methods to evaluate their strengths in intact conditions are also lacking. As stated in Chapter 1, since internally ring stiffened tubular joints are used in the construction of offshore structures, there is, therefore, a greater need to carry out detailed investigations to understand the behaviour of internally ring stiffened joints and develop methods to assess their strength in a rational manner. This is essentially required to create a benchmark.

Of all the causes of damages to offshore structures, fatigue constitute the single largest cause (Table 1.1) and hence the most important factor to be considered seriously in the damage assessment of offshore structures. Environmental corrosion weakens the structure and jeopardizes its integrity. As stated in section 1.1 of Chapter 1 above, corrosion in conjunction with fatigue forms a serious threat to the integrity and safety of the offshore structures and can cause extensive damage to
them. Corrosion fatigue reduces the life of the structure to half of that in air. As internally ring stiffened joints are also likely to be damaged by ocean wave loading as well as environmental corrosion, it is, therefore, imperative to study in detail the behaviour of internally ring stiffened corrosion fatigue damaged joints and also evolve a methodology to estimate their residual strengths. By comparing the strength and stiffness of the damaged joints with that of the original undamaged joints, the reduction in strength and degradation in stiffness of the damaged joints are to be evaluated.

As such, knowledge on the internally ring stiffened joints in their intact and damaged conditions is not well advanced. Therefore there is a need to chalk out a programme of both experimental and analytical investigations to carry out a systematic study to understand the behaviour of the internally ring stiffened joints in their entirety.

As has been stated in Chapter 1, offshore structures all over the world have been damaged in service and subsequently repaired using a variety of techniques. All techniques, however, have certain limitations in terms of applicability. These techniques are case-specific and have been handled according to the situation on hand. Most of the currently available techniques are based on mechanical engineering discipline. At present a number of civil engineering repair materials are available. The advantages of these materials and the available techniques can be combined to evolve a generic, cost-effective, efficient and easy-to-execute solution for the repair of damaged offshore structures. While repaired dented tubular members have been studied extensively test results on repaired tubular joints are lacking. Therefore there is all the more reason to carry out tests on repaired joints to have basic understanding of the effectiveness of the repair and the capacity of the joint after repair.
Based on the consideration of different factors stated above and careful analysis of the existing information on the damage and repair scenario of offshore structures, the scope and objectives of the present thesis work have been formulated and are stated below:

1. To study the behaviour of the undamaged internally ring stiffened tubular joints under axial brace compression loading, determine experimentally their intact strengths, and develop an analytical model to evaluate their ultimate strengths in order to create a benchmark problem for the purposes of comparison. Also validate the analytical model with the experimental results. To compare the behaviour of the internally ring stiffened joints with that of the well-established unstiffened joints.

2. To carry out experimental investigations to study the behaviour of corrosion fatigue damaged internally ring stiffened tubular joints and determine their reserve capacities. To develop a methodology to assess the reserve capacity of damaged internally ring stiffened tubular joints. To validate the proposed analytical model with the experimental results. By comparing the strengths and stiffnesses of the damaged joints with that of the original intact joints, to determine the reduction in strengths and degradation in stiffnesses of the damaged joints.

3. To devise an efficient, cost effective, and generalized repair scheme based on the available civil engineering materials and good structural engineering practice to rehabilitate fatigue damaged tubular joints. To test the repaired joints to determine the efficacy of the proposed repair scheme and thus evaluate the strength of the repaired joints.

4. To develop an analytical model to assess the strength of the repaired internally ring stiffened joints and validate the theoretical values with the experimental results.
According to these scope and objectives stated above certain experimental and analytical works have been contemplated. Details of these experimental investigations and development of the analytical models envisaged are given below in brief.

It has been planned to carry out experimental investigations on internally ring stiffened joints in their intact conditions. Static tests under axial brace compression loading are to be carried out on two internally ring stiffened joints and two unstiffened joints to measure experimentally their ultimate loads. The programme envisages the proposal of an appropriate stress-strain model for the development of an analytical method to predict the ultimate strengths of the internally ring stiffened joints in their intact conditions. Necessary equations to compute the moment capacity have to be derived. Predicted and measured loads are to be compared to validate the proposed model. Finite element analysis using NISA II Software package is to be performed to predict the behaviour of the undamaged internally ring stiffened joints under axial brace compression loading. It is also proposed to carry out monotonic load test on two unstiffened joints for the purposes of comparison of behaviours of both internally ring stiffened and unstiffened joints.

Experimental investigations are to be carried out on corrosion fatigue damaged internally ring stiffened joints. Eight internally ring stiffened joints have been planned to be tested under axial brace compression loading to determine their residual strengths experimentally. One fatigue damaged internally ring stiffened joint has been planned to be tested under tensile loading and study its behaviour under such loading. To propose a suitable stress-strain model in order to develop an analytical model to predict the residual strength of damaged joints. Based on the proposed model necessary equations to calculate the moment capacity of the damaged joints are to be derived. To predict the behaviour of the
damaged joints numerical analysis using NISA II Software Package is to be performed.

It has been planned to cast ferrocement jackets and develop epoxy based high performance grout. Tests are planned to be carried out to evaluate the mechanical properties of the grout. To evaluate the strengths of the ferrocement jackets alone static load tests are to be conducted. Method of repairing the fatigue damaged internally ring stiffened joints is to be indicated. Experimental investigations are to be carried out on repaired joints to check the efficacy of the repair technique and also measure the strength of the repaired joints. It has been planned to test three repaired T joints. To compute the moment capacity of the repaired joints, based on the equilibrium of forces, necessary equations are to be derived. It is also planned to evaluate the bond stress of the high performance grout by casting and testing of pipe-to-pipe connections using this grout and compare the results with a companion specimen to be cast using cement mortar.