# FATIGUE BEHAVIOUR
# OF
# OFFSHORE STEEL JACKET PLATFORMS

by
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TO

MY PARENTS

## CERTIFICATE

This is to certify that the thesis entitled **FATIGUE BEHAVIOUR OF OFFSHORE STEEL JACKET PLATFORMS** being submitted by **Mr. Ashok Gupta** to the Indian Institute of Technology, Delhi for the award of the degree of **Doctor of Philosophy** is a record of the bonafied research work carried out by him. Mr. Ashok Gupta has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis which to my knowledge has reached the requisite standard.

The thesis, or any part thereof, has not been submitted to any other University or Institute for the award of any degree or diploma.

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## ABSTRACT

The object of the present work is to characterize the significance of the various uncertainties in the estimation of the fatigue life of an offshore structure. The studies on fatigue damage behaviour are carried out on a plane frame version of a chosen symmetric steel jacket. Two types of structural model are used in the stress analysis. Whereas the members are rigidly connected with joints at their ends in case of first model, the members are taken as pin-ended for the second model. The structural properties associated with the frames in the orthogonal plane are taken into consideration.

The soil-pile-structure system is divided into two subsystems: (i) the soil-pile subsystem and (ii) the jacket subsystem. The soil-pile subsystem is appropriately modelled. In the present investigation a numerical technique based on transfer matrix approach is proposed to calculate the impedance functions of pile-head at its interface with the leg members of jacket platform. Variation of shear modulus of soil with depth and soil-pile separation near the mudline are also taken into account in the evaluation of pile-head impedance functions.

The random sea surface elevations are simulated by using the modified Pierson-Moskowitz spectrum. The long term sea environment is represented by fifteen sea states in terms of their significant wave heights and corresponding zero upcrossing time periods. The

velocities and accelerations of water particles are calculated by using the linear (Airy) wave theory; its validity is taken to extend upto the free water surface. The current velocity is added vectorially to the water particle velocity due to waves. The modified Morrison equation is used to calculate the hydrodynamic forces on the structure taking the variable submergence of structural members into account; the drag and inertia coefficients are taken to be constant. The distribution of fluid loading along the axis of a member is assumed to be linear.

The equations of motion for the jacket model are written in the generalized coordinates and their solutions are obtained in the frequency domain using mode acceleration method. The local stresses are found by making use of various stress concentration factors (SCF) as given by Visser, Kuang, et. al. and Kellog. The fatigue damages are evaluated by using AWS-X, AWS-X modified and BS-F S-N curves in conjuction with the Palmgren-Miner rule. The fatigue life is also computed by applying the fracture mechanics approach to the solution of fatigue-fracture problem.

The effects of various parameters associated with soil-pile subsystem on the impedance functions of pile-head have been studied. The influences of different soil-pile parameters, the current in addition to waves the variable submergence of structural members, the various SCF and S-N curves on the fatigue damage of welded joints are investigated and discussed in the present work. The fatigue damages at the joints of two different structuralmodels are compared with each

other to assess the errors involved in the results due to modelling of the complex offshore structure. The fatigue lives as obtained by S-N curve and fracture mechanics approach are also compared with each other to look into the difference in the fatigue life estimates.

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