STATIC AND DYNAMIC BEHAVIOUR OF MARINE RISER

by

SUHAIL AHMAD

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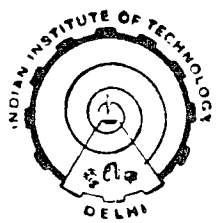
in Fulfilment of Requirement
For the Degree of

DOCTOR OF PHILOSOPHY



Department of Civil Engineering
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DEDICATED TO MY PARENTS

CERTIFICATE

This is to certify that the thesis entitled, "STATIC AND DYNAMIC BEHAVIOUR OF MARINE RISER", being submitted by Mr. SUHAIL AHMAD, to the Indian Institute of Technology, New Delhi, for the award of the Degree of 'DOCTOR OF PHILOSOPHY' in Civil Engineering is a record of the bonafide research work carried out by him under my supervision and guidance. He has fulfilled the requirements for submission of this thesis, which to the best of my knowledge, has reached the requisite standard.

The material contained in this thesis has not been submitted in part or full to any other University or Institute for the award of any degree or diploma.

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SUMMARY

Static and dynamic responses of marine risers are investigated in the present study. Static response of the riser is obtained for its self weight (under the static offset), quasi-static wave force, current and quasi-static vessel motion at the top. Dynamic response of the riser is determined for regular and random wave forces, long drift and instantaneous (to random sea) vessel motions and earthquake forces. A general 2-D analysis is performed using a finite beam element formulation to determine both static and dynamic responses. Riser behaviour under different conditions is investigated by parametric studies.

The static response behaviour is concerned with the study of the effects of geometric nonlinearity, quasi-static vessel motion, tension level, end conditions of the riser, wave height, wave period and probabilistic characteristics of random waves on the static/quasi-static response of the riser. For investigating the last effect, a method for determining the probabilistic quasi-static response of the riser to random waves is described. Some of the important results of the study may be summarized as (i) the potential geometric nonlinearity may significantly influence the riser's response if the top end of the riser is prevented from vertical displacement; (ii) the pitch motion of the vessel introduces more stresses in the riser than the surge motion and vessel motions, in general, are more important for long risers in comparison to wave and current forces; (iii) the level of tension

in the riser is an extremely important parameter that decides riser's response and may be optimized with respect to static response criterion and (iv) the probabilistic quasi-static response of the riser to random waves may be adequately described by Peirson-Holmes distribution.

The dynamic response of the riser is determined, in time domain, for both regular and random waves using a time integration method. For random waves, short term sea states are simulated by wave superposition technique. An iterative frequency domain method is presented, as an alternative to time domain solution, to take into account the relative velocity squared drag nonlinearity in the solution. In addition, the proposed frequency domain method can also consider the forces induced by the instantaneous motion of the top vessel. The method is found to be computationally more efficient than the time domain solution. Using the above methods of solution, parametric and numerical studies are conducted to show the influence of a number of important factors on the responce of the riser. These factors include drag induced nonlinearity, long drift vessel motion, instantaneous vessel motion to random sea, presence of current velocity and riser length. They are shown to have considerable effect on the responce of the riser.

Finally, seismic response of marine riser to random ground motion is obtained by a spectral analysis. The method is based on the principle of random vibration in which the seismic excitation is assumed to be a broad band stationary process. Using

this assumption, the mean peak response of the riser is obtained from the acceleration response spectrum of the earthquake process. A parametric study is conducted to investigate the relative importance of the seismic stresses in comparison to the stresses induced by wave and current forces. The results of the study show that the seismic stresses may assume importance for riser having high level of tension.

CONTENTS