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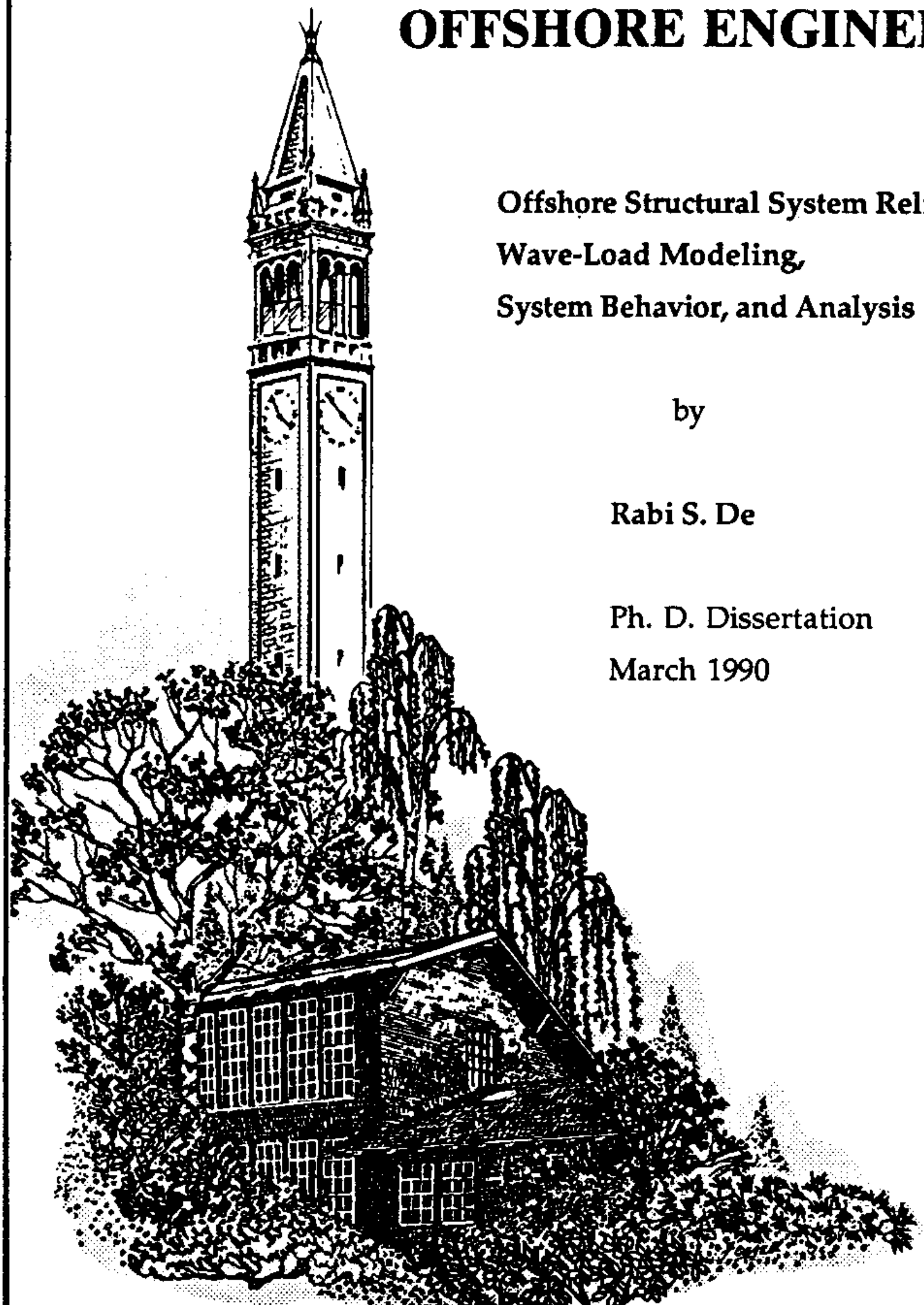

Offshore Structural System Reliability: Wave-Load Modeling, System Behavior, and Analysis

by

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ABSTRACT

The application of system reliability methodology for offshore structural problems is investigated. The emphasis is on wave-load modeling and its implications with respect to system reliability analysis of fixed offshore structures. In addition, probabilistic and deterministic measures of "system effects" are proposed.

The wave loading in system reliability analysis is usually modeled as a fixed spatial pattern of nodal forces scaled by a random intensity factor. In this work, the change of spatial pattern of the mean nodal wave forces with increasing wave height is accounted for by using the so-called "fragility approach" to systems analysis. The change of the relative importance of different member-failure sequences with wave loads corresponding to different wave heights is studied for a fixed offshore jacket in 140 feet of water. Results from simplified "fixed-pattern" analyses are calibrated against the "fragility" analysis.

The nodal wave forces are implicitly assumed to be fully correlated in both the "fixed pattern" and the "fragility" analysis. In response, a framework is developed that allows modeling of a general correlation structure of nodal wave forces. Using this framework the effects of less than perfect spatial correlation among nodal wave forces on the system reliability of a fixed offshore structure are investigated.

The reliability of near-ideal parallel structural systems is studied in order to understand and quantify the probabilistic and deterministic "system factors" influencing the overload capacity and redundancy of realistic statically indeterminate structures. Efficient use of reduced space Monte Carlo simulation techniques in system reliability analysis is

demonstrated. Application of these findings in accelerated system reliability assessment of a fixed offshore jacket structure under wave-loading is demonstrated.

In view of the importance of the load variability in system reliability assessment, a new model for short-term extreme (storm) sea-states for static structural reliability problems is presented. The model is based on a "multivariate" random variable characterization of the observed irregular process suitable for use in efficient reliability computation, e.g., FORM / SORM, and in general purpose methods such as Monte Carlo simulation. Although the model is restricted to at least semi-narrow banded time histories, it does not make any a priori assumption regarding the Gaussianity of the time series. Hence it is attractive for characterizing the skewed wave elevation processes observed in shallow water and / or in extreme (storm) sea-states. The application of the proposed model is demonstrated by analyzing a 34.13 min. long wave-elevation record collected during hurricane Camille. Calculation of response statistics such as the probability distribution of extreme base shear of a pile, the spatial correlation of sets of drag forces at different locations, etc., is demonstrated.

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