A Laboratory Study of Submerged Multi-body Systems in Earthquakes

CUIMR-X-78-006 C. 2

CIRCULATING COPY
Sea Grant Depository

By

Gholam Reza Ansari

B.S. (University of Tehran) 1978

DISSERTATION

Submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Engineering

in the

GRADUATE DIVISION

OF THE

UNIVERSITY OF CALIFORNIA, BERKELEY

Approved: William C. Webster May 20, 1983
Date
Robert L. Wiegel 20 May 1983
Joseph Penzien 20 May 1983
Bruce A. Bolt 20 May 1983

COMPLIMENTS OF
CALIFORNIA
SEA GRANT COLLEGE PROGRAM

ABSTRACT

Through interactions with the surrounding water, the behavior of a submerged structure can be considerably affected by neighboring systems. In this thesis, a theoretical and laboratory study of such multi-body and fluid interactions, subject to a set of boundary conditions, constraints and excitations is presented.

In the theoretical section, the effects of simplifying assumptions on the results are discussed. The "scales of motion" along with various parameters found in the ocean environment are investigated. The behavior of ocean based systems subject to earthquake excitations is discussed.

A multi-variable feedback control system is developed to model the behavior of multibody fluid interactions. A direct application would be the control of ocean based structures, using active interaction concepts in the design.

In the study of multi-body and fluid interactions, the common solution techniques (Green's function method and finite-element alternatives) can be inefficient. A "successive Superposition Technique" is presented using "Efficiency Functions". With appropriate discretization or depth averaging, this method can be very useful.

In order to augment present theoretical knowledge, physical modeling criteria are developed. A laboratory study of the behavior of structures in water is carried out using a series of $\frac{1}{200}$ scale, geometrically similar and elastically distorted physical models. The instrumentation used in the experiments is discussed and evaluated.

Time scaled excitations are generated and applied to the models, using an earthquake simulator. The geometric configurations and inertia related properties are varied and various response parameters are measured. Three-dimensional motions of the subsystems, and surface effects along with the pressure distribution on the structures are recorded. The variations of the pressure distributions resulting from interactions are obtained.

A dynamic system identification method is developed to measure the "added mass" properties of the multi-structure system without constraining any of the degrees of freedom. The applications of various signal processing techniques such as Complex Demodulation to the experimental study of Fluid-structure systems are explained.

The importance of transient analysis is emphasized. The coupling of transverse and in-line degrees of freedom are measured. It is shown that the systems with well-spaced modes can behave similar to closely-spaced-mode systems, when placed in a fluid.

ACKNOWLEDGEMENT

I would like to express sincere gratitude to my advisor, Professor Robert L. Wiegel, for his support, encouragement, and interest in this research. I am indebted to Professor William C. Webster, whose guidance and insight were invaluable in this work. I wish to thank Professors Joseph Penzien and Bruce A. Bolt for their keen direction and many helpful discussions.

I appreciate the help and support of the staff of the Earthquake Engineering Research Center during my experiments. I would like to thank Messrs. H.R. Ansari and Wen Gen Liao who provided assistance in the course of the experimental procedures.

I am grateful to Mmes Joy Kono, Nora Lee and Connie Calica who typed the manuscript.

This work is a part of a long term research effort at the University of California, Berkeley on various aspects of the fluid and structure interactions of the ocean based systems in earthquakes. The program has been fully supported by NOAA, Office of Sea Grant, Department of Commerce, and by the State Resource Agency of California. Their financial support and traineeship assistance is sincerely appreciated. These were Projects R/OT-1-WGL-SD-09/83 and E/G-2-WIEGEL-09/82.

California Sea Grant College Program
University of California, A-032
La Jolla, California 92093
(619) 452-4444