



US Army Corps
of Engineers

CERC LIBRARY

TECHNICAL REPORT CERC-91-12

LOS ANGELES AND LONG BEACH HARBORS MODEL ENHANCEMENT PROGRAM

MEASURED RESPONSE OF MOORED SHIPS TO LONG-PERIOD WAVES

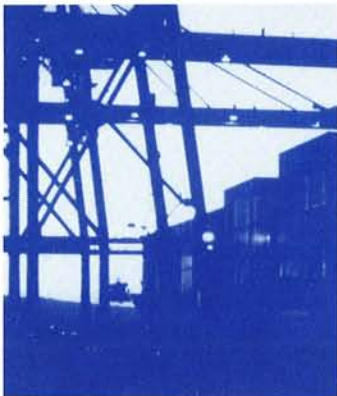
by

David D. McGehee

Coastal Engineering Research Center

DEPARTMENT OF THE ARMY

Waterways Experiment Station, Corps of Engineers
3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199



September 1991

Final Report

Approved For Public Release; Distribution Unlimited

Prepared for US Army Engineer District, Los Angeles
Los Angeles, California 90053-2325

Port of Los Angeles
San Pedro, California 90733-0151

and

Port of Long Beach
Long Beach, California 90801-0570



Destroy this report when no longer needed. Do not return
it to the originator.

The findings in this report are not to be construed as an official
Department of the Army position unless so designated
by other authorized documents.

The contents of this report are not to be used for
advertising, publication, or promotional purposes.
Citation of trade names does not constitute an
official endorsement or approval of the use of
such commercial products.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE September 1991	3. REPORT TYPE AND DATES COVERED Final report	
4. TITLE AND SUBTITLE Los Angeles and Long Beach Harbors Model Enhancement Program, Measured Response of Moored Ships to Long-Period Waves		5. FUNDING NUMBERS	
6. AUTHOR(S) David D. McGehee			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) USAE Waterways Experiment Station Coastal Engineering Research Center 3909 Halls Ferry Road Vicksburg, MS 39180-6199		8. PERFORMING ORGANIZATION REPORT NUMBER Technical Report CERC-91-12	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) See reverse.		10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.			
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited		12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) A monitoring system was designed and operated at a coal terminal in Los Angeles Harbor and at a container terminal in Long Beach Harbor. The objective was to obtain the complete six degree-of-freedom response of vessels, as well as the mooring line and fender reactions, to measured long-period waves. A unique data set was collected on five separate ships. The data will be used to calibrate and verify a numerical, moored ship-motion model. The system design and sample data results are presented. Spectral analysis is used to illustrate relationships between waves and ship response.			
14. SUBJECT TERMS Harbor Monitoring Mooring		Motion Vessels Waves	15. NUMBER OF PAGES 133
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

9. SPONSORING/MONITORING AGENCY NAMES AND ADDRESSES (Continued):

USAED, Los Angeles
Los Angeles, CA 90053-2325

Port of Los Angeles
San Pedro, CA 90733-0151

Port of Long Beach
Long Beach, CA 90801-0570

PREFACE

This report was prepared by the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES), and is a product of the Los Angeles and Long Beach Harbors Model Enhancement (HME) Program. The HME Program has been conducted jointly by the Ports of Los Angeles and Long Beach (LA/LB); US Army Engineer District, Los Angeles (SPL); and WES. The purpose of the HME Program has been to provide state-of-the-art engineering tools to aid in port development. In response to the expansion of ocean-borne world commerce, the LA/LB are conducting planning studies for harbor development in coordination with SPL. Ports are a natural resource, and enhanced port capacity is vital to the Nation's economic well-being. In a feasibility study being conducted by SPL, the LA/LB are proposing a well-defined and necessary expansion to accommodate predicted needs in the near future. The US Army Corps of Engineers (CE) will be charged with the responsibility for providing deeper channels and determining effects of this construction on the local environment.

This report documents the Ship Motion Data Collection and Analysis subtask of the HME Program. Vessels were monitored in both harbors in February and March 1989 to provide validation data for numerical models. Mr. David D. McGehee of the Prototype Measurement and Analysis Branch (PMAB), Engineering Development Division (EDD), CERC, provided planning and management of the effort and conceptual design of the measurement system. Detailed design implementation of the data collection system was performed under contract to Evans-Hamilton, Inc. (EHI), of Houston, TX.

Integration of an intensive measurement study into the routine operations of one of the world's busiest ports could not be contemplated without the indulgence and assistance of scores of professionals that conduct the business of LA/LB. Mr. Daniel Zuliani of the National Lines Bureau coordinated the efforts by the members of International Longshoreman and Warehouseman Union, Local 13, who provided technical advice and willing hands that resulted in faultless installation of the tension monitoring hardware. Mr. Jim Holland of Kaiser International Corporation and Mr. Bruce Wargo of Stevedoring Services of America arranged access to the Kaiser Coal Terminal and the Pacific Container Terminal, respectively, as well as provided valuable technical data. Assistance was provided by the operations directors,

wharfingers, and shipping agents in both ports. In particular, respectful appreciation is extended to the captains of the monitored vessels, who carry the responsibility for their crew, vessel, and cargo, for permitting the participation of their ships in the study.

Mr. Robert C. Hamilton, President, EHI, prepared the comprehensive contractor's report that provided the basis for this technical report. An extraordinary level of effort was maintained by Mr. Nicholas G. Carter, Ronald W. Nance, Lloyd Stahl, Keith A. Kurrus, and Barbara Allen, EHI, during the construction, execution, and documentation phases to maintain schedules and budgets.

Other CERC personnel involved in the data collection were Messrs. William E. Grogg and William M. Kucharski, Equipment Specialists, and Mr. Jay Rosati, Hydraulic Engineer, all of PMAB. Data analysis was performed by Mr. James P. McKinney, PMAB, and Mr. Francis E. Sargent, Wave Processes Branch (WPB), Wave Dynamics Division (WDD), CERC, with the assistance of Ms. Deborah Shafer, PMAB. Mr. William C. Seabergh, WPB, served as principal investigator for the HME Program and coordinator for the various subtasks of the HME. The WPB personnel were under the direction of Mr. C. E. Chatham, Jr., Chief, WDD, and Mr. Dennis G. Markle, Chief, WPB. The PMAB personnel were under the direction of Mr. Thomas W. Richardson, Chief, EDD, and Mr. William L. Preslan, Chief, PMAB. This study was under the general supervision of Mr. Charles C. Calhoun, Jr., Assistant Chief, CERC, and Dr. James R. Houston, Chief, CERC.

During the course of the study, liaison was maintained between WES, SPL, and LA/LB. Mr. Dan Muslin, followed by Mr. Angel P. Fuertes, was SPL point of contact. Mr. John Warwar and Ms. Lillian Kawasaki, Port of Los Angeles, and Mr. Michael Burke, Mr. Rich Weeks, and Dr. Geraldine Knatz, Port of Long Beach, were LA/LB points of contact and provided invaluable assistance.

COL Larry B. Fulton, EN, was Commander and Director of WES during the publication of this report. Dr. Robert W. Whalin was Technical Director.

CONTENTS

	<u>Page</u>
PREFACE.....	1
LIST OF FIGURES.....	4
CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT.....	5
PART I: INTRODUCTION.....	6
Problem Statement.....	6
Background.....	8
PART II: FUNCTIONAL CONSTRAINTS.....	11
Model Properties.....	11
Operations.....	11
Logistics.....	12
PART III: SYSTEM DESIGN.....	13
Forcing Functions.....	13
Ship Motions.....	13
Reaction Forces.....	15
Signal Processing.....	16
PART IV: SYSTEM OPERATION.....	18
PART V: RESULTS.....	19
PART VI: DISCUSSION.....	23
PART VII: CONCLUSIONS.....	33
REFERENCES.....	34
PLATES 1-95	

LIST OF FIGURES

<u>No.</u>		<u>Page</u>
1	LA/LB Harbor Complex and positions of wave gages.....	7
2	Schematic of system design and signal processing/data capture plan.....	14
3	Tension link mounted in-line between ship and bollard.....	16
4	Time series of incident energy from platform "Edith".....	24
5	Tension link reaction time series from "Hui He," 22 March 1989....	25
6	Ship motion time series from "Hui He," 22 March 1989.....	26
7	Mooring line geometry for "Hui He," 22 March 1989.....	27
8	Energy spectra of tension links for "Hui He," 22 March 1989.....	28
9	Energy spectra of ship motions of "Hui He," 22 March 1989.....	29
10	Energy spectra of waves in basin and resulting motions of "Hui He," 22 March 1989.....	31

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement can be converted to SI (metric) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
degrees (angle)	0.01745329	radians
feet	0.3048	metres
kips (mass)	453.5924	kilograms

LOS ANGELES AND LONG BEACH HARBORS MODEL ENHANCEMENT PROGRAM
MEASURED RESPONSE OF MOORED SHIPS TO LONG-PERIOD WAVES

PART I: INTRODUCTION

Problem Statement

1. The Ports of Los Angeles and Long Beach (LA/LB), California, are conducting planning studies for a major expansion known as the 2020 Plan. This plan calls for reclamation of nearly 10 sq km of new landfill, construction of 38 new terminals, and the dredging or deepening of over 11 km of deep-draft channels. Systems of rail and highway connectors and intermodal container transfer facilities are included in the various configurations under evaluation.

2. The US Army Corps of Engineers (CE) is responsible for providing the deeper channels and determining the effects of this construction on the local environment. The development will affect the tidal circulation pattern in the harbor and the harbor resonance characteristics. To upgrade the CE's capability to estimate these effects based on state-of-the-art modeling technology, the US Army Engineer Waterways Experiment Station (WES) is executing the Los Angeles/Long Beach Harbors Model Enhancement (HME) Program.

3. Adequate circulation is necessary to ensure harbor flushing and acceptable water quality. Resonant oscillations caused by long-period waves (15 to 400 sec) entering the harbor may cause ship mooring and/or cargo handling problems. Long-period energy, or surge, has been observed in the LA/LB Harbors since at least the 1940's (Knapp and Vanoni 1945). The WES made model investigations of the Naval Base (Department of the Army (DOA) 1947a, 1947b), but studies of the entire harbor complex, with a long-term tidal circulation, harbor resonance, and ship-motion study, began in the 1970's. One year's worth of visual observations of moored ship response identified the East Channel in Los Angeles Harbor and Southeast Basin in Long Beach Harbor (Figure 1) as the most active areas (Durham et al. 1976).

4. By the 1980's, modeling and measurement techniques had advanced sufficiently to warrant upgrading these capabilities for application to the 2020 Plan. The HME Program was designed to obtain data for improving the

