Engineering Structures 33 (2011) 344–356

Contents lists available at ScienceDirect

Engineering Structures

journal homepage: www.elsevier.com/locate/engstruct

Experimental evaluation of the dynamic properties of a wharf structure

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ARTICLE INFO

Article history:
Received 23 January 2008
Received in revised form
9 October 2010
Accepted 11 October 2010
Available online 16 November 2010

Keywords:
Damping
Wharf
Health monitoring
Pull-Back test

ABSTRACT

This paper presents the results from a series of experimental tests carried out to determine the damping characteristics of a section of a 375 m long pile-supported wharf structure under forced excitation. The test program was designed with two primary objectives: (1) to identify the fundamental damping of the structure by using structural microvibration signals produced by tides, wind and microtremors, and (2) to evaluate the variation of the dynamic properties as a function of response amplitude by applying initial displacements of varying amplitude to the deck using a pull mechanism.

Although the wharf was designed as a series of independent deck sections, the study revealed that the non-structural frames and piping supported on top of the wharf tie adjacent sections together and have a significant influence on the dynamic behaviour, particularly in the longitudinal direction. Care must be taken in to provide sliding connections for wharf supported structures or to include the influence of these elements in the original design. From our review of the properties identified under the different excitation levels, it was determined that the wharf has relatively linear behaviour with an equivalent viscous damping of about 3%. This is a good reference damping value to be used for the analysis of the pile-supported wharf structures under operational loads and low magnitude seismic events

1. Introduction

A fundamental aspect in the seismic design process of structures is the correct estimation of their dynamic properties as a function of the expected response and level of damage. Information obtained from low level vibration testing of the existing structures can be used to improve the structural models and our understanding of their response to gravitational, operational and seismic loads.

The verification and validation of modelling recommendations for many common types of building structures has been very extensive. In contrast, much less has been done in this area regarding marine wharves. Although wharves typically have simple structural systems, their dynamic behaviour is complex due to the soil–structure interaction, the interaction between wharf segments, and the interaction between the wharf structure and the supported equipment and systems. As a result, it is difficult to define unique models for the various load states and performance levels for wharves and even more complex to correctly select the energy dissipation capabilities for the different damage states of these structures.

In the case of limited damage or operating conditions of wharves with piles, researchers have used energy dissipation values that are based on results obtained in other types of structures such as bridges and buildings, but with very limited experimental information on wharves.

For the analysis of wharves subjected to operating loads or seismic loads, where there is little or no damage, different authors and design criteria recommend the use of a reference value of about 5% of the critical damping ratio for energy dissipation [1,2]. Benzoni and Priestley [1] used a critical damping ratio between 5% and 7.5% for moderate or medium response levels, which is increased to 10%–20% in cases of extreme demand and high damage levels. Donahue et al. [3] has used a similar value of 10% in cases of extreme demand and energy dissipation levels. However, some authors consider damping values of about 5% for damage situations (e.g. [4]) when nonlinear elements are added in the analytical model with intrinsic energy dissipation. In general, it is accepted that for modelling purposes, values higher than 5% should be used when there is extensive damage [5]. The International Navigation Association recommends equivalent damping values derived from hysteretic damage models and, up to a certain level, discarding the base viscous contribution [6]. Taking this into account, equivalent values between 10% and 20% of critical damping ratios are considered.

Although the values mentioned above are commonly accepted by professionals, they must be experimentally validated. Due to

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doi:10.1016/j.engstruct.2010.10.014