Set-up of a sloshing laboratory at the University of Western Australia

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ABSTRACT

A university laboratory has been equipped for carrying out experiments on sloshing dynamics inside tanks. In a first series of runs the measurement of the sloshing pressure on the walls of a rectangular tank at various filling levels were carried out. For this activity the pressure time histories at some specific locations together with the instantaneous position of the tank were recorded. Furthermore, images of the sloshing events with a high speed video camera, have been acquired in synchronization with the other signals.

The design and operation of such a facility involved a number of foreseen activities but also mitigation of least anticipated road blocks. Many of these were resolved on the go. Since the entire activity was to be carried out in a university environment part of the equipment was developed in-house. This approach has the advantage of considerable flexibility but on the contrary unforeseen difficulties can arise.

This paper aims to report on the problems that were faced during the set-up and operation and suitable solutions that were adopted. Some of the topics reported here have to do with the technological aspects of the measuring chain while others are more related to the physics of the flow. The following issues, were of particular importance: 1) signal conditioning; 2) operation of the pressure transducers; 3) choice of the optimal sampling frequency; 4) synchronization of the signals and the images; 5) testing procedure and order of the operations; 6) data storage and test logging.

INTRODUCTION

Sloshing is one of the subjects that has raised significant interest in the scientific community in the past years. The industrial importance is related to the transport and storage of LNG at sea and in general to the transport of any liquid in containers. In civil engineering it is related to impacts on coasts and coastal structures. Furthermore it is a non trivial scientific problem that is still far from being completely understood. The last aspect is probably what makes it interesting and suitable for an experimental activity to be undertaken in a university environment.

Sloshing happens in a particularly extended range of lengths and time scales. Typically sloshing in enclosed containers involves lengths that range from the tank dimensions to the characteristic lengths of the smaller features like entrapped bubbles, small droplets of spray and the complex topology of the breaking free surface. In terms of duration it is important to consider periods that range from the frequency of oscillation of the container, typically of the order of seconds, to the short duration of the pressure impacts that last few milliseconds. Also the pressure ranges from the hydrostatic pressures that are proportional to the filling level height, to the hydrodynamic impact pressures that can be hundreds of time larger.

Presently commercial software and R&D codes still have difficulties in providing reliable results with reasonable computational costs. Data from experimental activity is still needed for tuning up codes and verifying theories. This situation opens the possibility for universities and research institutions to play a role.

This paper discusses the issues encountered during the set up of an experimental laboratory for the study of sloshing phenomena in enclosed containers within a relatively low budget. The results that have been obtained with such a facility during the first tests are encouraging and seem to be in line with the results that

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