Experimental Investigation of Floating Debris Impact Loading on Structures During Extreme Waves Like Tsunami

Harish, S. 1*, Sriram, V. 2*, Sundar, V. 3* Sannasiraj, S. A. 4* and Didenkulova, I. 5†

ABSTRACT

Debris generated during extreme events like the tsunami can impose substantial impact loading on structures closer in the coastal zone. Majority of design codes do not quantify the impact forces close to reality owing to uncertainties in defining the wave characteristics and a lack of knowledge in understanding the underlying physical processes. The present study focuses on the measurement of forces which a coastal structure would encounter due to the impact of debris in motion during such an extreme event. The study herein focuses the motion of the debris due to undular bores. 1:20 scaled model of structure and the debris were used. Experiments were conducted in a wave flume 72.5 m long and 2 m wide. A beach slope of 1:30 is laid to replicate the coastal zone. By varying the wave heights and time periods, different types of waves such as elongated single pulse waves, symmetrical N waves and unsymmetrical N waves were generated replicating the characteristics of a tsunami as close as possible. The impact tests were conducted using box shaped smart devices as debris of weight 4.62 kg, 5.82 kg and 7.02 kg. The debris is attached with an accelerometer for measuring the impact acceleration. In order to have a better understanding of the behavior of debris during the impact, a camera at a speed of 120 fps is operated. The force acting on the structure is measured with a load cell. The forces due to the velocity of the debris and the mass is compared with the force measured using load cell. The details of the testing facility, model parameters, test set-up, test procedure, analysis of results and discussion are presented in the paper.

KEY WORDS: Extreme waves; Floating debris; Tsunami; Structures; Impact acceleration.

INTRODUCTION

Debris generated during a tsunami or any coastal floods can strike the residential buildings, commercial or any other structures in the coastal zone. The debris generated during such process on striking the structure induces large impact loading on the structure. The magnitude of the force may be large enough causing local or global failure of the structure. The maximum force acting on the structure due to this tsunami driven debris is difficult to estimate as the impact of the debris on the structure is influenced by the mass, velocity, draft and the orientation of the debris with respect to structure.

The study on the impact of debris on structure has received considerable consideration, after the studies on impact of debris on the structure (Haehnel and Daly, 2004, Nouri et al., 2010, Riggins et al., 2013). Their study reported that debris driven during tsunami induces large impact loading on the structure compared to that due to the impact of tsunami alone. Further, the contact duration of the debris with the structure is less. ASCE/SEI 7-05 suggests contact duration of 0.03s between the structure and debris for estimating the impact force. Few guidelines for the design of structure around the globe have included the impact of debris driven during floods and tsunami on the structure (ASCE/SEI 7-05(2005), FEMA55 (2011), FEMA P-646(2012) etc.). These guidelines provide rational formulae for estimating the loads acting on the structure during a tsunami.

Previous studies on the tsunami interaction with structure mostly dealt with the breaking bore generated with a dam break event (Al-Faesly et al.,(2011), Shafiei et al.,(2016)) as the incoming surge of the tsunami towards the coast resembles the bore. The correctness of tsunami to be considered as a hydraulic bore generated with the dam break event was justified by Chanson (2005, 2006). However, the incoming tsunami bore can be a non-breaking bore, breaking bore or an Undular bore depends on the intensity of tsunami wave, Origin point of tsunami, Bathymetry of the shore, (Bryant (2014)). Ramsden (1996) studied the force and over turning moment on a vertical wall due to tsunami waves like solitary waves, turbulent bores, undular bores and surges. Arnson et al., (2009) stated that during the propagation of a tsunami, second and third waves often strike the exposed stretch of the coast and in fact the impact could be much larger compared to the one affected by the first wave. Recently, Ko et al., (2015) carried out experiments on the