Experimental Modeling Of Debris Advection Driven By The Tsunami: Application For Non-Uniform Density Groups Of Debris With Obstacles

Hyoungsu Park, University of Hawaii, hpark9@hawaii.edu
Myung-Jin Koh, University of Hawaii, myungj@hawaii.edu
Daniel T. Cox, Oregon State University, dan.cox@oregonstate.edu
Mohammad Shafiqual Alam, alammo@oregonstate.edu
Sungwon Shin, Hanyang University, sungwshin@hanyang.ac.kr

IMPORTANCE

Extreme coastal events like hurricanes and tsunamis often generate and transport debris, resulting in severe damage to civil infrastructure and often adversely affecting communities' resilience and recovery process. In particular, water-borne debris transported over the land often decreases critical facilities' functionality and block access for initial rescue and recovery. It is also reported that the hurricane-driven coastal debris removal could account for approximately 27% of the total disaster recovery cost in the USA. A better understanding of water-driven debris transport is essential to predict damages and losses on coastal communities and develop a mitigation plan to minimize those losses and improve the resilience against future extreme coastal events. In this paper, an experimental study of tsunami-driven debris advection over a flat testbed was conducted considering different density conditions of debris elements.

EXPERIMENTAL SETUP AND RESULTS

The physical experiments were performed in the Directional Wave Basin at Oregon State University, where the wave basin has 48.8 m long (*x*-direction), 26.5 m wide (*y*-direction), and 2.1 m deep (*z*-direction). To measure hydro-kinematics and debris transportation, in total, 17 wave gages, five ADVs and four recording cameras were installed. Each camera angle covered a quarter of the debris testbed, and four rectified images were merged and trimmed into a single image to cover the test region, as shown in Fig. 1. We utilize two types of debris elements, which have the same shape but different material (wood, HDPE) to create debris of different density. We considered variations in the grouping of debris (wood only, mixed wood and HDPE, and HDPE only), parameterized by the mean specific gravity (*SGg*), ranging from 0.65 (wood only) to 0.99 (HDPE only). Fig. 1e shows the example result with a mix of debris (10 HDPE and 10 Wood, SGg = 0.82). In total, there were 45 trials conducted for varied SGg and w/ and w/o obstacles.

Fig. 2 shows the mean longitudinal distance and the 95% confidence interval for HDPE and wood debris for the five *SGg* conditions from *SGg* = 0.65 (wood only) to *SGg* = 0.99 (HDPE only). For comparison, we plot defined as the mean longitudinal distance normalized by the mean longitudinal distance of *SGg* = 0.82 (equal number of HDPE and wood elements), which was repeated seven times. The values used for normalization were = 4.51 m for HDPE and = 6.99 m for wood. The higher density debris (HDPE, red) is nearly constant (~ 0.8), while for the lower density debris (wood, yellow) decreases linearly as *SGg* increases. This linear decrease would extrapolate to approximately the same value for the HDPE only case. The variation in indicated by the 95% confidence limits (c.l.) are relatively uniform across all values of *SGg* for HDPE, indicating that the presence of the lighter debris has little to no influence of the heavier debris. Moreover, the 95% c.l. is several times smaller than for the wood debris. On the other hand, the 95% c.l. for the wood debris increases as *SGg* decreases, indicating that the presence of the more massive debris affects the variability in the final position of the lighter debris. Even a relatively small amount of more massive debris (25%) causes the variation in the lighter debris for *SGg* = 0.73 cases to be larger than the cases where only the lighter debris was present (*SGg* = 0.65).

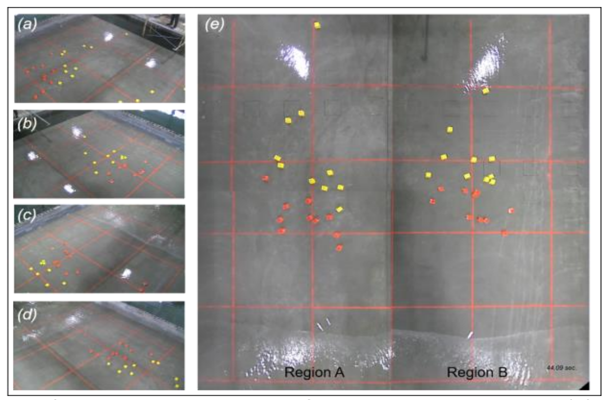

Fig.1: Example snapshots of recorded video images (a) to (d) A raw video images. (e) A rectified and merged image.

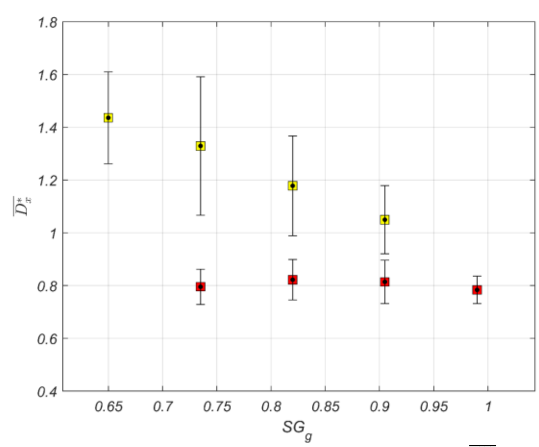

Fig 2: Normalized mean longitudinal distance, $\overline{D_x^*}$ of HDPE and wood and debris as a function of SG_g. Vertical bars indicated a 95% confidence limits (c.l).