STUDY ON PARAMETERS TO EVALUATE IMPACT PROBABILITY OF TSUNAMI SHIP DEBRIS ON SEAWALLS

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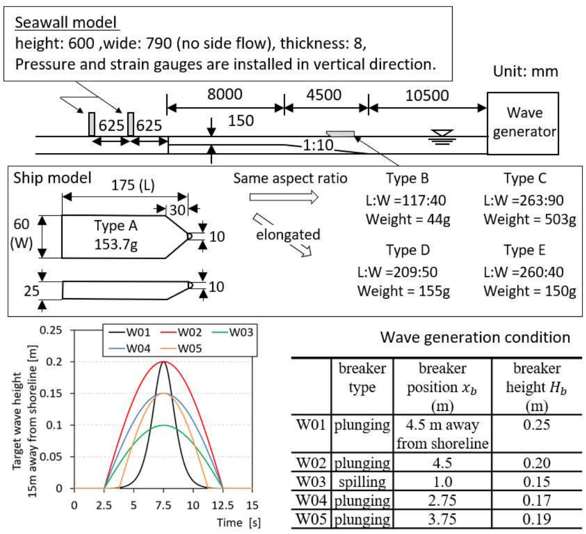
INTRODUCTION

A seawall is an important structure to protect nuclear power stations against tsunamis. To ensure its structural integrity, the tsunami debris impact possibility and force should be evaluated. Since there is uncertainty in motion of the tsunami debris object, the parameters to evaluate the possibility of debris impact should be clear. The purpose of this study is to identify one of the parameters affecting the debris impact probability. In this study, the situations that the debris floats offshore and is transported by riding on the leading wave edge and collides with the onshore seawall were targeted.

THE PREVIOUS TESTS

The outline of the model tests (Taisei Corporation, 2019 and 2020) is shown Figure 1. The initial location of debris was changed in about 0.5m increments. The tests were repeated 15 times for each condition. Oda et al. (2020) examined the relationship between initial location of debris away from shoreline and impact probabilities, and it was demonstrated that the impact probability of type A debris became a low value when the debris floated in the region 1.5m away from the wave breaking position on the shoreside (Figure 2). It is demonstrated that the debris that floated near wave breaking tended to be submerged.



	breaker type	breaker position x_b (m)	breaker height H_b (m)
W01	plunging	4.5 m away from shoreline	0.25
W02	plunging	4.5	0.20
W03	spilling	1.0	0.15
W04	plunging	2.75	0.17
W05	plunging	3.75	0.19

Figure 1 - Outline of the previous tests

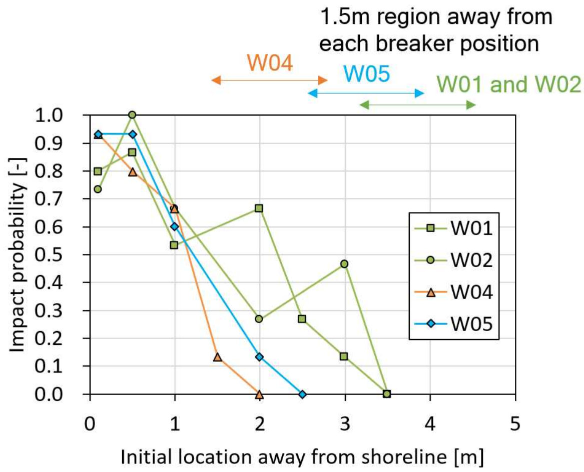


Figure 2 - Relationship between initial location and impact probability (type A)

DISCUSSION

The parameter that is the region 1.5m away from the breaker position on the shoreside could be the parameter to evaluate the possibility of debris impact, however, this is dependent on the experimental scale. A parameter independent of the scale should be considered.

Galvin (1969) identified four points through which the plunging wave passes. (1) The point where the wave initially becomes irreversibly unstable; (2) the observed breaking position, defined as the location where some segment of the front face of the wave initially becomes vertical; (3) the crest touchdown point where the wave crest touches down at the base of the wave; and, usually, (4) the splash touchdown point as shown in Figure 3. The plunge distance between (2) and (3) can be nondimensionalized by the breaker height. It is also demonstrated that the dimensionless plunge distance becomes four under the condition of bed slope zero.

The images of high-speed camera obtained in the previous study by Taisei Corporation (2019 and 2020) are shown in Figure 4. The images which the debris was located between (2) and (3) characterized by the Galvin (1969) were selected. If the debris is located between this region, the downward wave force submerges the debris. Thereby the debris floats behind the leading wave edge. Due to the reflected wave near the seawall, the debris velocity abruptly decreases. For this reason, it is considered that the impact probability becomes a low value, when the debris floats between (2) and (3).

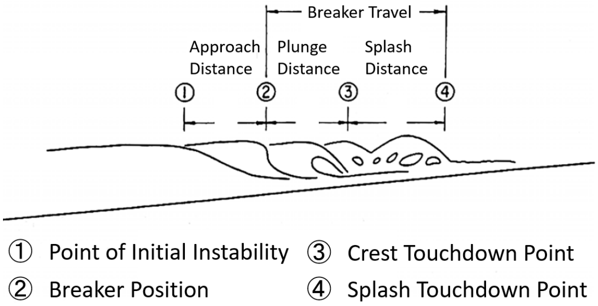


Figure 3 - Travel of plunging wave in Galvin (1969)

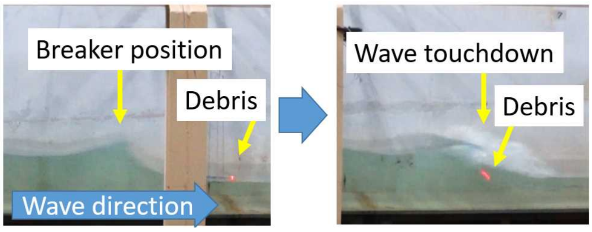


Figure 4 - Images of debris located between (2) and (3)

A part of the model test results is nondimensionalized by applying the dimensionless distance shown in Galvin (1969). Figure 5 shows the relationship between dimensionless distance and impact probability. The waves (W01, W02, W04 and W05) whose breaker types were plunging waves were used. Other type debris as shown in Figure 1 was used under the wave conditions of W02 and W05 as well. The dimensionless distance x' is defined as Eq.1, where x is the initial location of debris away from the shoreline, x_b is the breaking position away from the shoreline and H_b is the breaker height. This equation represents a dimensionless distance shown in Galvin (1969) starting from the breaking position. As shown in Figure 5, the impact probability of type A debris becomes a low value between 0 and 5 of dimensionless distance. The region where the dimensionless distance is between 0 and 4 is included in the 1.5m region from the breaking position shown in the previous study. On the other hand, the impact probability of type D and E debris did not become a low value even between 0 and 4 of the dimensionless distance. Since these types were elongated shape compared to type A, the downward wave force could not submerge them. It can be said the impact probability of the elongated shape debris does not become a low value even if it is located between 0 and 4 of dimensionless distance.

$$x' = (x_b - x)/H_b \qquad (1)$$

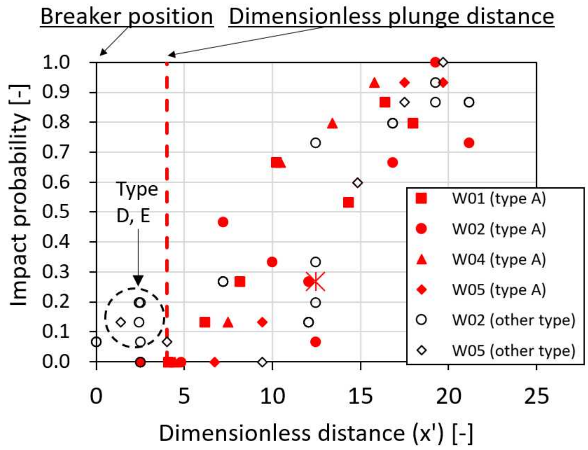


Figure 5 - Relationship between dimensionless distance and impact probability

CONCLUSION

In this study, the dimensionless distance defined as the distance away from the breaking position on the shoreside nondimensionalized by breaker height is identified as the parameter to evaluate the possibility of debris impact. It is demonstrated that the impact probability becomes low value when the debris located between 0 and 4 of dimensionless distance. This distance is included in the 1.5m region from the breaker position shown in the previous study (Oda et al. (2020)). On the other hand, the impact probability of elongated shape debris does not become a low value even under such conditions. The challenge is to evaluate the aspect ratio conditions of debris that is not submerged by plunging wave.

ACKNOWLEDGEMENTS

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