# EXPERIMENTAL STUDY ON BORE WAVE PRESSURE ACTING ON STORAGE TANK

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## INTRODUCTION

Storage tanks located in coastal areas can be damaged by tsunami. The damage can lead a spill of gas or oil, which cause an extensive fire. Another huge tsunami triggered by earthquake is predicted to strike Japan in the near future. Therefore, tsunami wave load acting on storage tanks has to be investigated. The authors have investigated the characteristics of tsunami wave load acting on a storage tank (Araki et al., 2017a; 2017b). In this study, bore wave pressure acting on a cylindrical storage tank was measured. The characteristic of the pressure was discussed.

## EXPERIMENTAL SETUP

The hydraulic experiment was conducted in a wave flume. Bore waves are generated using a gate and a reservoir at an end of the flume. A model cylindrical storage tank made of acrylic plastic was placed on a storage site. Bore wave pressures acting on the side and bottom of the storage tank were measured at points P1 to P12 shown in Figure 1. Bore wave loads acting on the storage tank were also measured by force transducer. The cylindrical tank was fixed to the surface of the model storage site when the pressure acting on the side (from P1 to P6) was measured. The cylindrical tank was fixed 1.0 cm above the storage site when the pressure acting on the bottom (from P7 to P12). The water surface elevation and the inundation depth on the storage site were measured.

## RESULTS & DISCUSSION

The inundation depth around the cylindrical storage tank was approximately distributed according to an existing equation. Figure 2 shows the distribution of the measured inundation depth when the horizontal bore wave load reached the maximum in three cases. Each of the cases has a different magnitude of bore wave. The black solid line shows an equation in the procedure that

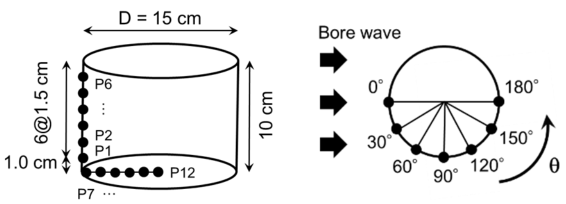


Figure 1 Pressure Measuring Points on Cylindrical Tank

Fire and Disaster Management Agency of Japan (FDMA) proposed for estimating the maximum tsunami wave load. The vertical and horizontal axes show the ratio of $\eta(\theta)_{Fxmax}$ to $\eta_{max}$ and the rotational coordinate along the arc shown in Figure 1, respectively. $\eta(\theta)_{Fxmax}$ is the inundation depth around the cylindrical tank when the horizontal bore wave load reaches the maximum. $\eta_{max}$ is the maximum inundation depth under the condition of no tank. The measured inundation depth was approximately estimated by FDMA equation on average.

The bore wave pressure on the side of the cylindrical tank was not necessarily hydrostatic. Figure 3 shows the vertical distribution of the pressure measured on the side of the tank (from P1 to P6) when the horizontal bore wave load reached the maximum. The vertical and horizontal axes show the normalized vertical position of pressure measurement from the bottom and the pressure normalized by hydrostatic pressure $\rho g \eta_{max}$. The pressure at $\theta = 0^\circ$ where bore waves acted head on was not distributed hydrostatically, especially near the bottom. It seems that this resulted from the flow velocity of the bore wave. The pressures at $\theta = 60^\circ$-$180^\circ$ were small.

The bore wave pressure on the bottom of the tank was also not necessarily hydrostatic. Figure 4 shows the distribution of the pressure measured on the bottom along the line between $\theta = 0^\circ$ and $180^\circ$. The vertical and horizontal axes show the normalized pressure and the distance from the center of the cylinder r normalized by half diameter D/2. The measured pressure (red) was smaller than hydrostatic pressure calculated from the inundation depth measured around the tank (blue). This may also result from the influence flow velocity

## CONCLUSION

The pressure on the side and bottom of cylindrical tank was not necessarily estimated by hydrostatic pressure.

## REFERENCES

Araki, Kunimatsu, Nishiyama, Furuse, Aoki, Kotake (2017a): Experimental study on tsunami wave load acting on storage tank in coastal area, Journal of Loss Prevention in the Process Industries, Elsevier, Vol. 50, pp. 347-354.

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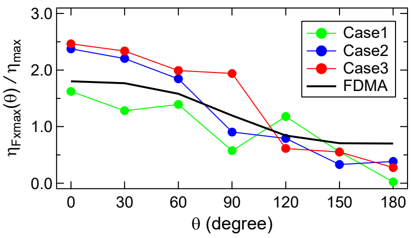


Figure 2 Inundation Depth around Tank

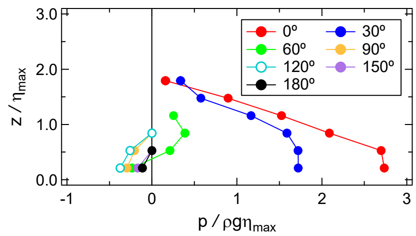


Figure 3 Pressure on Side of Tank

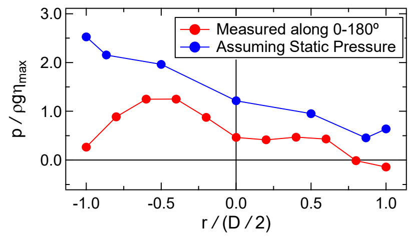


Figure 4 Pressure on Bottom of Tank