

## Numerical and Experimental Study on Wave Deformation and Overtopping around Vertical Seawall in Coral Reef Sea Area

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### ABSTRACT

The main purpose of this study is to investigate wave deformation over a coral reef and wave overtopping characteristics around a vertical seawall by carrying out hydraulic model experiments and numerical computations with a two-dimensional numerical wave flume based on a VOF method ‘CADMAS-SURF’. The comparison of the numerical and experimental results reveals that the CADMAS-SURF can reproduce well the experimental results regarding wave deformation and wave overtopping rate. The results also indicate that the mean water level increases due to successive wave breaking over the reef and wave set-up takes place remarkably. The wave overtopping rate for the reef topography is found to be much larger than one on the mild slope.

**KEY WORDS:** Wave overtopping; wave deformation; coral reef; VOF method; numerical computation; hydraulic model experiment; vertical seawall

### INTRODUCTION

The passage of tropical cyclones such as tropical storms and typhoons causes sea level rise around coastlines due to atmospheric pressure depression and strong wind, resulting in high waves, storm surges and wave overtopping. Especially, violent wave overtopping over road revetments induces not only human and property damages but also traffic accidents in low visibility conditions and the isolation of interregional transportation networks.

Photo 1 exemplifies wave overtopping of road revetment in Okinawa Main Island, which is one of the typhoon prone areas in Japan. Wave overtopping characteristics in Okinawa Islands are said to be complicated since the sea areas have wide coral reefs with very shallow water depth and waves propagate with the repeat of wave breaking over the reef. However, countermeasures against wave overtopping have not been sufficiently taken yet. It is, thus, of extremely importance to fully comprehend wave overtopping characteristics of coastal revetments to prevent wave overtopping-induced disasters.

A number of experimental and numerical studies on wave overtopping have ever been done in order to estimate wave overtopping rate and take a countermeasure for the protection of human and property damages by wave overtopping.

The experimental studies on wave overtopping have led to some empirical formulae of wave overtopping rate in relationship to wave condition, bottom topography, the configuration of revetment and so on. Goda et al. (1975) developed the design diagrams of dimensionless wave overtopping rate to estimate wave overtopping rates for vertical and wave-dissipating concrete blocks mound seawalls on the basis of hydraulic model experiments using a two-dimensional wave flume under irregular wave conditions. Takayama et al. (1982), furthermore, proposed the approximate equations of wave overtopping rate so that wave overtopping rate can be easily calculated without reading off the diagrams by Goda et al. (1975). The Goda’s diagrams and Takayama’s approximate equation for estimating wave overtopping rate are the most famous in Japan and have been used as standard for the design of seawalls without and with wave-dissipation blocks. However, the diagrams and the approximate equation have some limitations for bottom topography and the shape of a seawall. These would be, therefore, difficult to precisely estimate the wave overtopping rate of a unique shaped-revetment over a complicated bathymetric feature, such as a reef topography with rapid change in depth.

Over the past few decades, a lot of studies on wave deformation over a



Photo 1. Wave overtopping under storm surge in Okinawa