Features of tsunami action on highway bridges by the Great East Japan Earthquake

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1.Introduction

Damage to many bridges by the 2011 Tohoku tsunami, especially the flow out of superstructures, caused harmful effects in the disaster area. As a part of a research project to formulate design tsunami action for highway bridges, a tsunami numerical simulation was performed to investigate features of tsunami action on highway bridges. The simulation result is examined by comparing estimated wave force acting on superstructures and their loading capacities[1].

2. Features of tsunami acting on highway bridges

Propagation and run-up of the 2011 Tohoku tsunami were simulated using 2-D FDM, based on the nonlinear long wave theory, in order to evaluate time histories of wave height and flow velocity at 10 bridge sites. Horizontal and uplift forces acting on the superstructures due to the simulated tsunami were then analyzed using the numerical wave flume[1], i.e. a numerical analysis model used to conduct hydraulic model experiments by numerical simulations.

Figure 1 shows the ratios of horizontal force to horizontal capacity and vertical force to vertical capacity of superstructures of highway bridges. The capacities were estimated from the ultimate capacity of bearings and weight of superstructures. We can see that at least one of the horizontal and vertical wave force-capacity ratios of the superstructures that were washed out are larger than 1, except for the Koizumi-ohashi Bridge, while both the horizontal and vertical ratios of the superstructures that survived are smaller than 1. As for the Koizumi-ohashi Bridge, the process of its superstructure washout was reproduced by a detailed earthquake-tsunami damage simulation, taking account of effects of strong motion and rupturing sequence of its bearings.

Since the wave force-capacity ratios account for the damage status as described above, the simulated tsunami at the bridge sites are considered to be reliable. Figure 2 shows time histories of tsunami inundation height at the bridge sites. The speed the water surface rose is around 1 to 5 m a minute at these sites; the tsunami is not likely to be a bore-type one but one that gradual raises the water surface.

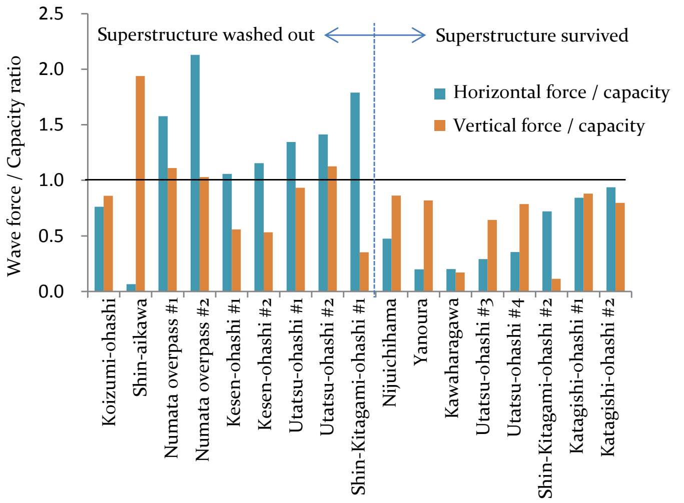

Figure 1 Wave force/capacity ratio of superstructures

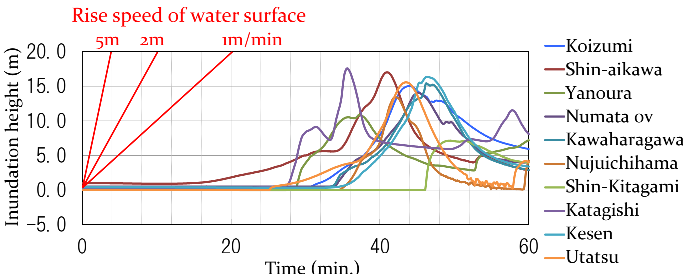

Figure 2 Time histories of inundation height at bridge sites

Peak flow velocity of the simulated tsunami is around 6 to 8 m/s, which coincides with the average subaerial flow velocity, about 6m/s, estimated from debris movement recorded in video shots.

3.Ongoing and future actions

Further research has been conducted to reliably formulate tsunami action for design practice based on the features of the tsunami from the Tohoku event as well as anticipated future giant earthquakes.

[Sources]

1) Estimation of wave force acting on bridge superstructures due to the 2011 Tohoku tsunami, Journal of Disaster Research, Vol. 8, No. 4, pp. 605-611, 2013.8.