Estimation of tsunami wave force by damage simulation of a highway bridge

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1.Introduction

Damage to a large number of bridges by the 2011 Tohoku tsunami, especially flow out of superstructures, caused harmful effects on the disaster area. Japanese design specifications for highway bridges were revised on February 2012 and structural planning taking account of tsunami effects was newly prescribed. Design tsunami load, however, was not described although it is required for bridge design when the tsunami effects are inevitable.

As a part of the research project towards formulation of design tsunami load for highway bridges, tsunami wave force acted on Koizumi Ohashi Bridge, of which superstructure and a pier (P3) were washed out, was estimated by a continuous earthquake-tsunami damage simulation[1)] as shown in Figure 1.

2.Earthquake –tsunami damage simulation

Since the mainshock motion had not been obtained at the site, aftershock observation was conducted from November 2011 to March 2012. The mainshock motion was estimated using an aftershock record with the site response characteristics and then applied to an earthquake response analysis. Seismic force acted on the bearings was found to exceed their yield strength while no pier was seriously damaged by the seismic action.

Time histories of tsunami height and flow velocity at the site were calculated by tsunami propagation and run-up simulation. Horizontal and vertical forces acted on the superstructure due to the simulated tsunami were analyzed by the numerical wave tank as shown in Figure 2. Finally, the analytical wave forces were applied to a tsunami response analysis assuming the seismic damage

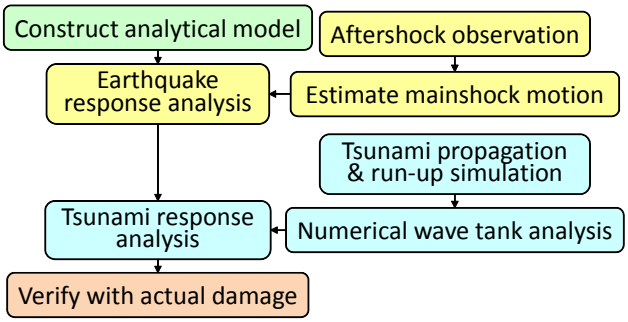

Figure 1 Flow of the earthquake-tsunami damage simulation

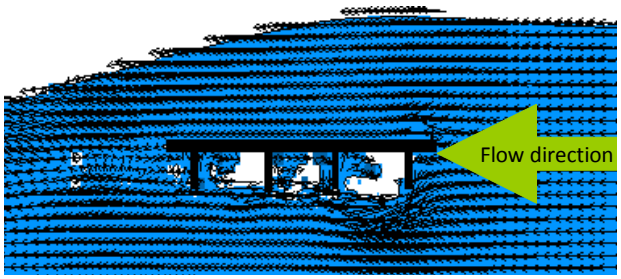

Figure 2 Example of numerical wave tank analysis

remained. The tsunami action was found not only surpass the strength of bearings but shear strength of P3; the result coincides with the actual damage to the bridge.

The peak horizontal wave force acted on the 90.9m-long superstructure was about 6MN, which is smaller than half of the wave force estimated by an existing formula.

3.Ongoing and future actions

Further research has been conducted towards reliable formulation of tsunami load for design practice based on the fact experienced during the Tohoku tsunami.

[Sources]

1) Earthquake-tsunami damage simulation of a highway bridge of which superstructure and a pier were washed out, Proc. JSCE A1, Vol. 69, No. 4, 2013(in press).