EVALUATION FOR OUTFLOW OF GIRDER DUE TO TSUNAMI

Graduate School of Kyushu Institute of Technology Student Member ○Yulong ZHENG
Kyushu Institute of Technology Member Kenji KOSA
Graduate School of Kyushu Institute of Technology Student Member Li FU

1. INTRODUCTION

The 2011 Tohoku earthquake, known as the 2011 Great East Japan Earthquake, with a magnitude 9.0, occurred at 14:46 (JST) on 11 March 2011. Due to the great triggered tsunami, areas along eastern Japan suffered tremendous destructions.

In this paper, firstly, the authors will introduce the damage conditions for bridges due to the tsunami. Secondly, the tsunami velocities for general Tohoku area will be estimated. Thus, based on the velocity data, the evaluation and re-evaluation for reasonability of using β ratio (ratio between girder resistance and tsunami impact force) to judge outflow of girder will be conducted.

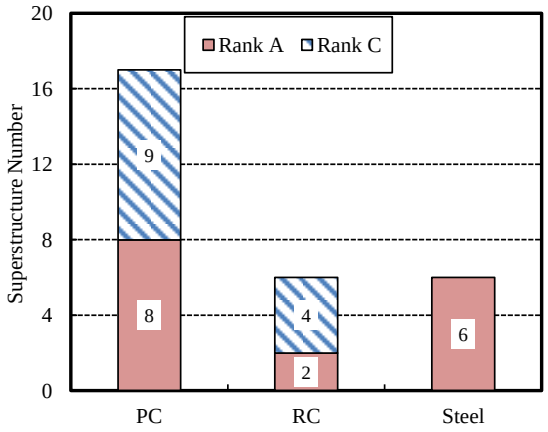

Fig.1 Damage for Evaluated Bridge Girders

2. DAMAGE CONDITION TO BRIDGES

During the great tsunami, the outflow of girder occurred to more than 324 bridges in Eastern Japan. Furthermore, as to the 29 evaluated bridge girders for which the detailed drawings are possessed, the damage extent of them is shown in Fig. 1. Focusing on the outflow condition, it is found that the bridges constructed by steel suffered more serious damage than concrete bridges. About half of PC girders belong to Rank A while it is 1/3 for RC girders.

3. TSUNAMI VELOCITY AND EVALUATION OF GIRDER OUTFLOW

From recorded videos, velocity can be calculated by checking the floating distance of debris and the time. Tsunami velocities in five typical areas (Shizugawa, Otsuchi, Rikuzentakata, Shinkitakami and Wakabayashi) have been estimated. The velocity of each measure position and the maximum, minimum and average velocities in each area are presented in Fig. 2. The overall average is 6.1m/s. The average velocities in Shizugawa,

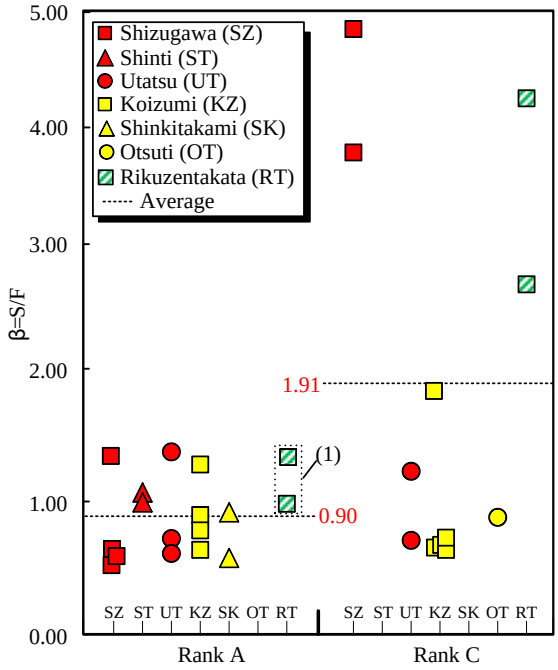

Fig. 3 β Ratios for Tohoku Area

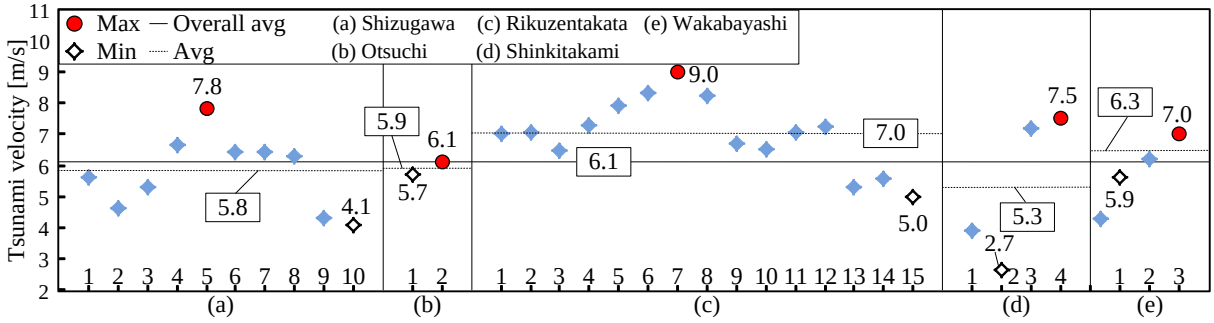

Fig. 2 Estimation Results of Velocities for Tohoku Area

Keywords: Tsunami damage, bridge girder, outflow, β Ratio
Address: 〒804-8550 Graduate School of Kyushu Institute of Technology, 1-1 Sensui, Tobata, Kitakyushu, 093-884-3123

Otsuchi and Wakabayashi have the same level (about 6.0m/s) and are close to the overall average. The average velocity in Rikuzentakata is 7.0m/s being greater than the overall average.

Authors define the indicator β to evaluate outflow of girders. If β ratio is smaller (greater) than 1.0, resistance of girder is smaller (greater) than tsunami impact force, which means the girder is easy (difficult) to flow out. To check the reasonability of β ratio, the following two steps are conducted:

Firstly, average velocity as about 6.0m/s is used as a constant to all bridges for only concentrating on the relationship between damage ranks with impact force. Fig. 3 illustrates β ratios for 29 bridge girders in Tohoku area. Average β ratio of Rank A girders with girders flowed out is 0.90. Average β ratio of Rank C girders with girders survived is 1.91 (2.12 times of Rank A).

Secondly, considering the velocity in each area is not same to be 6.0m/s, the average velocity in each area (refer to Fig. 2) is used for re-calculation of β. Fig. 4 shows the re-calculation results. Compared with Fig. 3, average of β for Rank C girders changed to be 1.81 (2.01 times of Rank A). β ratios of Rank A for Rikuzentakata area ((1) region in Fig. 4) become to be all smaller than 1.0, further inferring the smaller resistances of girder. As the average velocity in each area is not greatly different with 6.0m/s, the trend of β ratios has not changed greatly from Fig.3. In addition, as shown in Fig. 4, average β ratio of Rank A for Koizumi area is 0.90, same with that of Rank C. Difference is not occurred. If deleting the β ratios of Koizumi area, the re-calculation results are shown in Fig.5. The average of β for Rank C changed to be 2.46 as 2.73 times of Rank A (0.90), which becomes greater than the 2.01 times of the results shown in Fig. 4. Greater difference occurred between Rank A and Rank C.

Further, for Koizumi (Fig. 6), bridges in A area suffered smaller damages compared with bridges along Tsutanigawa (B area). Considering the tsunami along Tsutanigawa is the main flow and tsunami toward A area is the sub-flow, the tsunami velocity in these two areas will probably be different. Thus, assuming the same velocity for Koizumi, β ratios become not coinciding with the damage ranks.

As a result, for both the calculation and the re-calculation results, difference of β ratios between Rank C and Rank A bridge girders is obvious. Thus, β ratio is considered as an effective indicator to evaluate outflow of bridge girder.

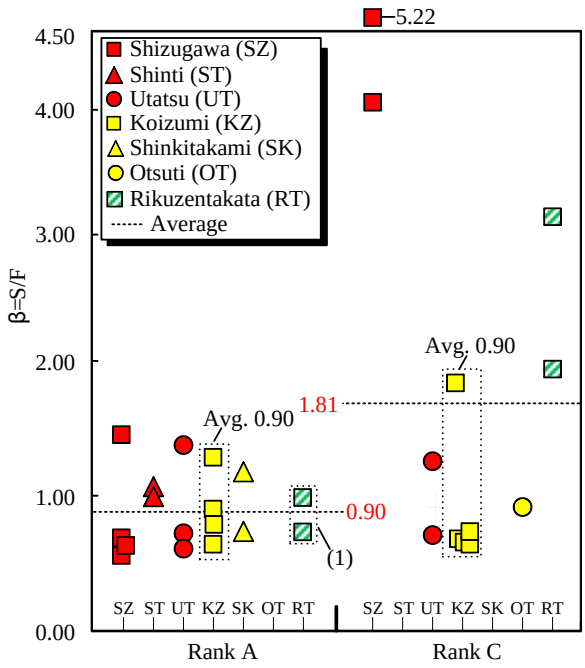

Fig. 4 Recalculation of β Ratios

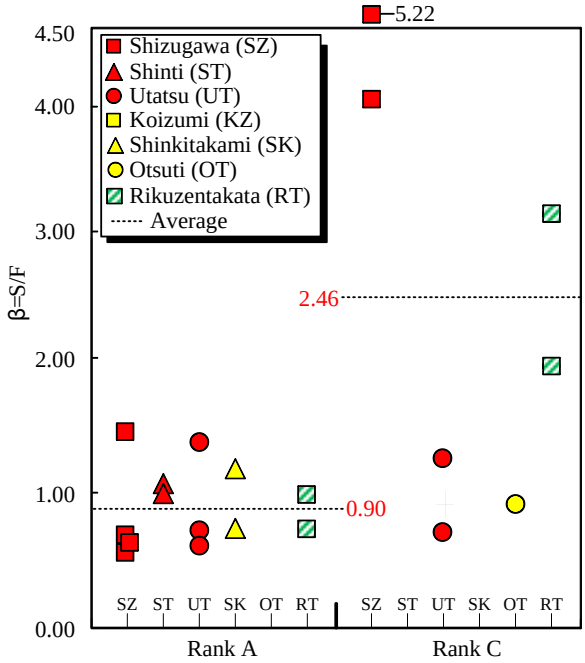

Fig. 5 Recalculation of β Ratios (without Koizumi Area)

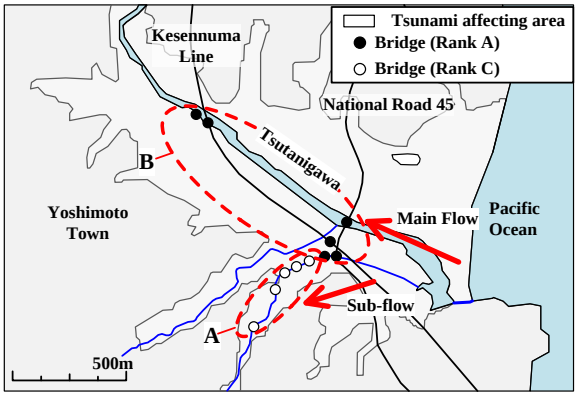

Fig. 6 Damages in Koizumi Area

4. CONCLUSIONS

(1) From both the calculation and the re-calculation, difference of β ratios between Rank C and Rank A girders is obvious. β ratio is considered to be an effective indicator to evaluate outflow of girder.

(2) As the velocity in each area is not greatly different with the overall average, trend of β ratios has not changed greatly after re-calculation.