Development of Earthquake Resistant Bridge Abutment (Reinforced with Cement-Mixed Earth)

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INTRODUCTION

Since embankments have voids, they tend to settle when shaken at earthquakes, to a large degree in particular behind a bridge abutment added with the settlement due to the deformation caused by its forward inclination (Fig. 1), which has been pointed out for long to compromise the stability of train running.

Figure 2 shows the settlement behind a bridge abutment seen after the Hyogoken-Nambu Earthquake that attacked the southern part of Hyogo Prefecture, Japan, when large degrees of settlement were observed along the entire routes in the area. Under the circumstances, thorough measures have been required to effect sufficient earthquake resistance at earthquakes of such a large magnitude. In conjunction with the Japan Railway Construction Corporation and the University of Tokyo, therefore, we performed vibration tests of various brigde abutment types, based on which we proposed a new reasonable abutment structure with earthquake resistance high enough to keep the structure stable.

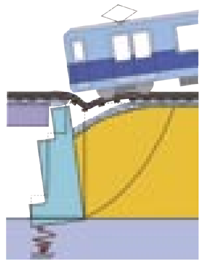

Figure 1. Image of the damaged bridge abutment at earthquake.

Figure 2. A damaged bridge abutment at Hyogoken-Nambu Earthquake (January 17, 1995).

BASIC CONCEPT OF REINFORCING WORK

There are two types of settlement behind a bridge abutment in general. One is the "rocking settlement" that occurs when voids are crashed by the earthquake motion, and the other the "difference in level" generated when soil and ballast fall on account of the forward inclination of the bridge abutment. To materialize such sufficient resistance against large-scale earthquakes, it is required that measures be taken for both types of settlement.

Figure 3 shows the proposed bridge abutment that uses geotextle to connect the abutment structure and cement-mixed earth that effectively prevents rocking settlement. This design features a slim structure and footing, and prevents not only rocking settlement, but also the difference in level due to the connection between the abutment and cement-mixed earth, to significantly improve the earthquake resistance. We call this type "the bridge abutment reinforced with cement-mixed earth."

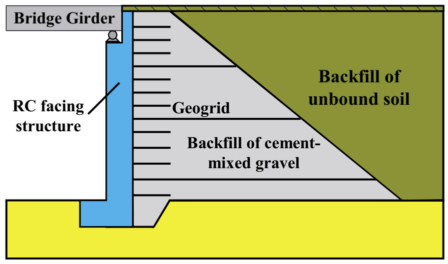

Figure 3. Typical close-section of proposed bridge abutment.

VERIFICATION OF THE EARTHQUAKE RESISTANCE OF PROPOSED BRIDGE ABUTMENT

To check the earthquake resistance of the bridge abutment reinforced with cement-mixed earth, we performed a series of vibration tests of a model and a bridge beam at the scale ratio λ =1/10, by using the medium-scale vibration table of the Railway Technical Research Institute (RTRI), for about 40 cases of different measures and exciting waveforms. Figure 4 shows the model abutment after excited under an irregular wave at 1,400 gal. It virtually did not deform in this high-frequency vibration test, but exhibited extremely high earthquake resistance even when compared with the case where the conventional measure was applied and tested under the same condition.

Figure 4. Deformation of the model abutment after a shaking test.

DISCUSSION FOR PRACTICAL USE

We proposed a designing method for this bridge abutment and applied to the test site under construction for Kyushu Shinkansen.

Figure 5 shows the cross-section of the bridge abutment. Despite the design for large-scale earthquakes, the cross-section is smaller than that of the conventional structure to prove its reasonable and economical features.

We performed a lateral loading test of the bridge abutment by applying 4,000 kN or the design load for large-scale earthquakes to prove that it has extremely high-level earthquake resistance, in that the displacement is as small as 15 mm. See Fig. 6 for a test scene. This bridge abutment will be used for projected Shinkansen lines as the standard structure.

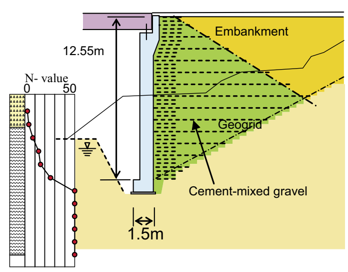

Figure 5. Close-section of Kyushu-Shinkansen abutment.

Figure 6. View of the lateral loading test in Kyushu.