Development of Integrated Bridge with Geosynthetic-Reinforced Soils

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1. Introduction

Bridges composed of conventional girders and abutments, with their backfill embankments constructed after the abutments have been completed, are prone to (1) displacement/settlement of abutments when track supporting embankments are extended and (2) corrosion of supports/settlement of abutment backfill embankments after the bridges have been completed and put in service. Additionally, when subjected to earthquakes, abutment backfill embankments tend to sink or cause damage on the supports, which may lead to a bridge fall accident.

Thus, two versions of a new bridge have been developed in recent years: one is a bridge having reinforcing soil retaining-walls (hereinafter referred to simply as a retaining-wall bridge) and another one is called an integral bridge (Fig.1). The former has retaining walls for the reinforcing soil in back of the abutments to help solve the problems caused by the settlement of backfill embankments, while the latter has eliminated supports to avoid the problems related thereto. However, some problems still remain unsolved with these new bridges, such as (1) corrosion/damage on supports with the retaining-wall bridge and (2) settlement of backfill embankments/cracking of the bridge skeleton due to thermal elongation/contraction of floor slabs with the integral bridge.

To develop a suitable integral bridge that solves the aforementioned problems of conventional bridges, the Railway Technical Research Institute (RTRI) has developed a technique to construct reinforcing soil blocks in the backfill embankments of integral bridges. The method uses a cement-mixed gravel approach block and a reinforcing material (geo-textile) to make the bridge and backfill embankments an integrated structure (Fig. 1). A bridge constructed to this design is called " Bridge Integrated with Geosynthetic-Reinforced Soils" . Loading tests of a life-size bridge specimen of this type are described below.

2. Alternating horizontal loading tests of a life-size test bridge

To investigate the behavior and damage conditions of the reinforcing embankment integrated bridge at a L2 level earthquake, RTRI implemented alternating horizontal loading tests. The test set up is shown in Fig. 2. The load was increased at increments of 250kN up to 2,000kN, while repeating loading three times at each loading step, and implemented monotonic loading in each direction thereafter up to the maximum load withstanding capacity.

As shown in Fig. 3, the horizontal displacement toward the cement-mixed gravel approach block was 19mm on the back side at +2,200kN (at approximately 1.0 seismic intensity) , which is equivalent to the seismic motion of a L2 level earthquake and 16mm on the front side at -2,200kN. It was also verified that the residual displacement was extremely small after application of the maximum load: 4mm on the back side at +2,300kN and 8mm on the front side at -2,600kN.

As the integral bridge has a reinforcing soil block in the back, the above phenomenon reflects the fact that the reinforcing material resists the active side displacement against the horizontal force at earthquakes, while the backside reinforcing soil block resists the passive side displacement. Thus the test demonstrated the high level earthquake resisting performance of this structure. Furthermore, the residual settlement of backfill embankments was 4mm or less due to the reinforcing soil block on the back side, with only minor cracks observed at the sidewall-haunch construction joints.

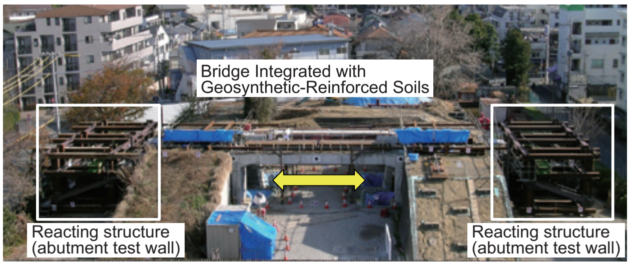

Fig. 2 Alternating horizontal loading test set up

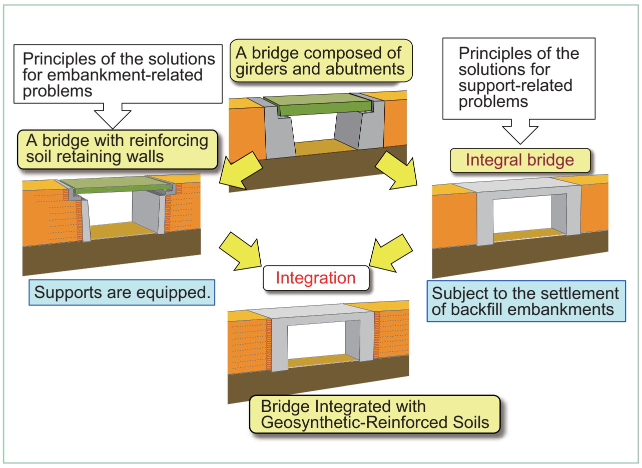

Fig. 1 Development of Integrated Bridge with Geosynthetic-Reinforced Soils

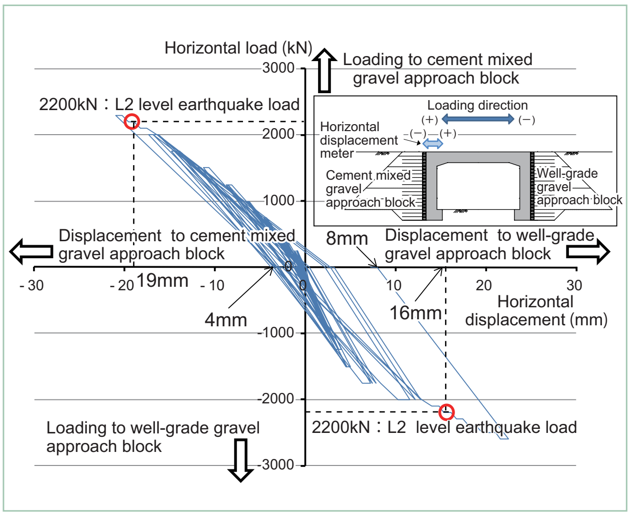

Fig. 3 Horizontal load versus displacement at the crown on the cement-mixed gravel approach block side