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Lateral Loading Tests for Buried Bend with Light-Weight Thrust Restraint in Liquefaction

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ABSTRACT

In bends, unbalanced force, which is called thrust force, is generated. A concrete block is usually installed at the bend to provide the lateral resistance. However, the heavy concrete block is week point in an earthquake. In our previous study, a lightweight thrust restraint using geogrids was suggested. In this study, shaking table tests for buried bends were conducted to verify the safety of the lightweight thrust restraint in liquefied ground. From the results of the tests, it was revealed that the proposed method with geogrids was superior to the concrete block.

KEY WORDS: Earthquake; Buried bend; liquefaction; Shaking table test; Lateral loading test; Geogrid; Light-weight:

INTRODUCTION

Unbalanced force, which is called thrust force, acts on bend of pipeline depending on the magnitude of internal pressure and the bending angle. Thrust force acts on the bend outward and tend to move the bend. Generally passive earth pressure acting on the bend resists thrust force. If thrust force is larger than passive force, thrust restraint is required. Currently, concrete block is usually installed at bend.

However, it was reported that the concrete block was week point in earthquakes. In the Hokkaido-Nansei-Oki earthquake in Japan in 1993, the concrete block at a bend was largely moved in liquefied ground due to thrust force and a adjacent pipe was slipped out as shown in Fig. 1. (Mohri et al, 1995).

In our previous study, a lightweight thrust restraint using geogrids was suggested (Kawabata et al, 2005). In order to verify the effectiveness of the proposed method as thrust restraint, laboratory model tests and large-scale tests (Sawada et al, 2008) were carried out. From these results, it was found that the lateral resistance increased and the lateral displacement was reduced in the proposed method

However it is unknown whether the proposed method is stable in liquefied ground. In this study, shaking table tests for buried bends were conducted at National Institute for Rural Engineering in Japan to verify the safety of the lightweight thrust restraint in liquefied ground.

SHAKING TABLE TEST

Test Equipment

Fig. 1 Damage to buried bend in the 1995 Hokkaido-Nansei-Oki Earthquake

The shaking table used for the test has plane dimensions of 6 m × 4 m, with the maximum loading capacity of 50 tf. Its excitation system is a electro-hydraulic servo. The test pit (5.6 m length, 3.6 m width, and 1.4 m) was installed on the shaking table. Load cells, displacement transducers, pore water pressure transducers and accelerometers for observing the behavior of the pipelines and the surrounding ground were laid out as shown in Fig. 2. In addition, strain gauges were attached on both faces of geogrids to measure axial strain of geogrids.

Model Ground

Kasumigaura-sand and gravel were used as the backfill materials. The properties of Kasumigaura-sand are presented in Table 1. The grain size distribution of Kasumigaura-sand and the gravel are indicated in Fig. 3. The ground was compacted every 0.1 m and relative density (*Dr*) of the ground was 45 %.

Test Conditions

The test conditions are indicated in Fig. 2. Four model pipelines (CASE A~D) having a diameter of 200 mm were buried at a depth of 0.4m. Pipelines consisted of a bend having an angle of 30º and short pipes. In CASE A, a concrete block was installed at the bend. In CASE B, C and D, geogrid having a width of 200 mm was connected with the bend. In CASE C, the gravel was used as the backfill material around geogrid. In CASE D, the gravel was used around geogrid and the bend. Fig. 4 shows the results of the tensile tests of