Form 2

Dissertation Abstract

Report no.	(Course-based) No.1077	Name	HO MANH HUNG

Dissertation title	Confined-Reinforced Subgrade to Reduce Differential Settlement of Road Pavement (道路舗装の不同沈下を軽減するための拘束補強路床)

Abstract

※The abstract should be in keeping with the structure of the dissertation (objective, statement of problem, investigation, conclusion) and should convey the substance of the dissertation.

Earthquakes often induce differential settlement between bridge abutments and their approaches due to slope movement or grainslip. Consequently, vehicles cannot pass the stepwise settlement created by the earthquakes. Because of its high seismic resistance, geosynthetic reinforced soil has been widely used to mitigate such damage from earthquakes. Furthermore, one important aspect of reinforced-soil is its potential to reduce differential settlement. The confined-reinforced earth (CRE) method, has been proposed to make it possible for vehicle, especially emergency vehicles to pass road surfaces roughened caused by earthquakes. The CRE method employs geogrid layers, prestressed steel tie rods, and granular soil applied to subgrade layers under pavements of roads. In this study, a physical model, which can simulate a large-scale model of CRE but with smaller its size of the apparatus, was proposed to carry out tests in laboratories. Effect of tie rods and boundary conditions on the CRE, including geogrid length, ground anchors at the end of the geogrids, and overburden, on the behavior of the CRE subjected to differential settlement and cyclic load were performed.

In this study, four geogrids layers (G1-4) and three sand layers were used. The total thickness of the CRE was 30 cm. They were laid on a fixed plate simulating an abutment of a bridge and a moveable plate which simulated settlement of an embankment by jacking down it. Studying the effect of geogrid length, instead of increasing the length of a soil box, which is used for the CRE test, and the geogrid, an embedded geogrid was simulated by its pullout resistance. This resistance was applied at the boundary of the soil box with the dimensions of 1.2 x 0.4 x 0.8 m = length x width x height. As an embedded geogrid changed, the pullout resistance was changed corresponding to the embedded geogrid length outside the soil box. By using this physical model, a large-scale model test can be done in a laboratory where the space is often limited.

The effect of confining tie rods on behavior of the CRE subjected to differential settlement, and then cyclic load, with different confining tie rod spacing and preload in tie rods were performed. The confining tie rod spacing was 40 cm, 80 cm and no tie rod which simulates very large tie rod spacing. Preload in the tie rods of 0 and 3 kN was compared and analyzed. The results showed that surface settlement of the CRE decreased with a decrease in tie rod spacing and an increase in preload in tie rods. Large shear strain zone occurred between the tie rods with larger tie rod spacing. Large width of shear zone causing more surface deformation. Reinforced soil became an integrated structure with close confining tie rods while the geogrids and soil seemed to be separated with large tie rod spacing. Tensile strain in the geogrids increased due to the cyclic

loading. The increment of the lower layers was larger than those in the upper layers in cases with the close confining tie rods spacing.

The effect of geogrid length was investigated with different embedded geogrid length (resistance length) outside the soil box. The embedded geogrid lengths in a series tests were 0, 0.29, 0.54, 0.81, 1.01, 1.26 and very long geogrid. When the embedded geogrid length is zero, the right end of the geogrid was laterally free. Infinitely long geogrid was simulated by laterally fixed condition at the right boundary of the soil box. It had large pullout resistance so that the geogrids were not pulled out. It was found that the surface settlement decreased with an increase in embedded geogrid length (increase in pullout resistance). It also showed that with a certain settlement, S_v, geogrid length on an embankment, L_E, was greater than 18 times settlement, S_v, the slope surface changed slightly or remained unchanged, otherwise it changed significantly. This geogrid length consisted of the geogrid on the movable plate of the soil box and embedded geogrid (the embedded geogrids were out of the soil box). For example, with settlement, S_v, of 9.0 cm, when the length of geogrid on an embankment, $L \geq 18*9.0 = 162.0$ cm, the slope surface changes very small. In shear zone of the CRE, which was between the first and the second tie rods, on the moveable plate and near the fixed plate, shear strain in the case with short embedded geogrid (0, 0.29 m) was larger than that in long embedded geogrid (0.54-1.26 m) case. In the shear zone, shear strain was concentrated. Tensile strain in the geogrids increased with an increase in embedded geogrid length. In the cases of short embedded geogrid, tensile strain at the bottom geogrids, near to a structure showed compression or small tension. This is because the CRE deformed like a mattress folded in a Z shape. However, in the cases of long embedded geogrid, all strain showed tension and the peak tensile strain shifts from the left to right with depth as the CRE behaved like a beam. Tensile strain increased under the cyclic loading and the increase of tensile strain in the lower geogrids (G3, 4) was larger than that in the upper geogrids (G1, 2). The force in tie rods decreased with the differential settlement in general, then decreased significantly with the cyclic loading.

Use of ground anchors at the end of the geogrids was considered to improve pullout resistance of the geogrids for better performance of the CRE. Ground anchors were used with three embedded geogrid length of 0.29, 0.54, and 0.81 m. When the anchors were used, surface settlement were smaller than those of the CRE without the ground anchors. However, the effect of anchors was negligible in the case with long embedded geogrids (0.81 m) due to the larger pullout resistance of the embedded geogrids. Tensile strain in the geogrids were larger in the cases with the ground anchors than in the cases without ground anchors. However, the increment in tensile strain due to the use of the anchors was small in the cases with long embedded geogrids. The force in the tie rods decreased in general.

Overburden of 1, 2, and 4 kPa simulating the thickness of a pavement on the CRE, was applied to the surface of the CRE. It showed that the surface settlement increased with the overburden. Similarly, tensile strain in the geogrids also increased with the overburden. In the case with long embedded geogrid (0.81 m), the tensile train increased linearly with the overburden. Furthermore, the tensile strain also increased linearly with the settlement.