GEOTECHNICAL TOPICS FOR RAIL TRACKS

PROPOS GEOTECHNIQUES DES PLATE-FORMES FERROVIAIRES

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SYNOPSIS: Maintenance work reduction of existing lines has keenly been requested because of labor shortage, refinement of transportation service and so on. So, the research and development concerning roadbed and ballast, which are considered relatively critical for the realization of the reduction has been carried out. This paper describes the outline of the situation of roadbed:mud-pumping, improvement by soil-cement columns and application of geocell are reported.
To elucidate mud pumping phenomenon and to develop its countermeasures, nation-wide in-situ investigations and small/large scale model tests have been realized. The process of mud pumping are verified with subsidence of ballast due to inadequate strength of roadbed soil, remolding of soil by repetitive stress and pumping up of the soil through the ballast and the practical countermeasures against mud pumping are proposed.Soil-cement columns have been applied successfully to the actual lines where frequent maintenance work had been done because of weak embankment. The application of the columns realized the reduction of vertical displacement of roadbed.Geocell of polyethylene honeycomb structures have been examined through compaction test and large scale cyclic loading tests. The geocell will have the effect to increase roadbed stiffness and disperse train load and this structure may be expected as the practical reinforcing method of roadbed of relatively low strength.

ELUCIDATION OF MUD PUMPING AND DEVELOPMENT OF ITS COUNTERMEASURES

Mud pumping, which will result in increase of maintenance work and clogging ballast to reduce its drainage effect, may be caused mainly by remolding of roadbed soil. The phenomenon is influenced by the soil conditions of roadbed including its bearing capacity, drainage condition and train load.According to the field investigations and laboratory tests, the following three processes can be considered for the appearance of mud pumping(Ito, 1984).
(1)Subsidence of ballast due to inadequate strength of roadbed soil
(2)Remolding of soil by repetitive stress
(3)Pumping up of roadbed soil through the ballast

The effective countermeasures against mud pumpimg will be the increase of ballast thickness, improvement of drainage capacity, roadbed covering, groundwater level lowering and roadbed replacement. The field test of the countermeasures has shown the following.
(1)The increase of ballast depth up to 35 cm or higher is effective.
(2)The drainage layer of about 10 cm deep sand should be accompanied with the roadbed covering method.

IMPROVEMENT OF EXISTING ROADBED BY SOIL-CEMENT COLUMNS

Fig.1 shows a profile of about 6 m high embankment where ballast often flowed due to the relatively large roadbed displacement during rapid service train passage and consequently frequent maintenance work had been done. As shown in the figure, the top part of the embankment is ballast-soil mixed area and relatively stiff with 7 of N-value formed by ballast penetrating during train passage and weak silty layer followed with 2 to 4 of N-value. Soil cement column method shown in the figure was adopted, because the depth to be improved exceeded the possible depth for replacement method:the improvement execution work had to be done making use of short headway at midnight and the outline of such improvement method is presented by Tarumi(1985). The soil-cement mixing work was executed by inserting a mixing apparatus with rods spreading in the ground from between

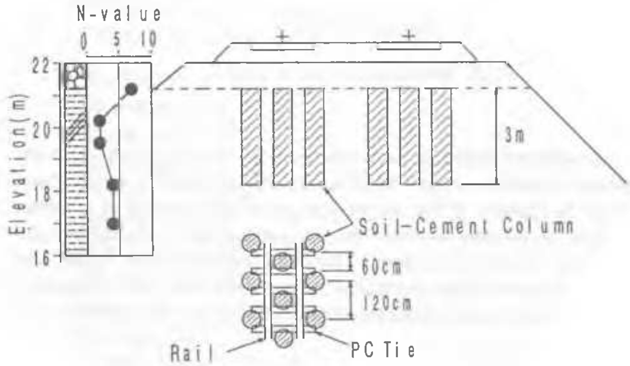

Fig.1 Improved cross section

ties and the 7 day strength of the columns was about 2 MPa. After the application of the method, the vertical displacement at the shoulder of embankment was reduced to about 70 % of the displacement before roadbed improvement and the ballast flowing disappeared.

APPLICATION OF GEOTEXTILE

Geotextiles have recently applied to the improvement of roadbed and compaction tests and loading tests of large scale model were carried out to examine the mechanical properties of geocell placed as shown in Fig.2:the geocell of 1.2 mm thick polyethylene sheets with tensile strength of 18 MPa and elasticity modulus of 1220 MPa has cells 20 cm long, 24 cm wide and 20 cm high(Sekine and Muramoto, 1992).

Compaction test

Four kinds of granular materials shown in Fig.3 were used to compare the compacting properties. A vibraring compacting machine weighing 6.5 kN

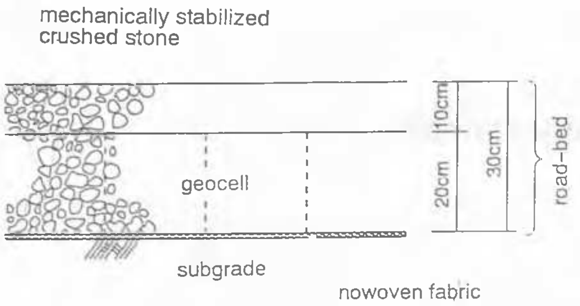

Fig.2 Roadbed with geocell

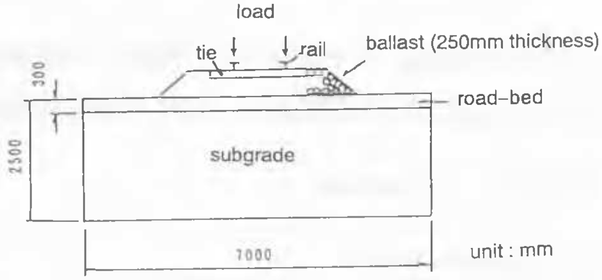

Fig.4 Cross section of cyclic loading test

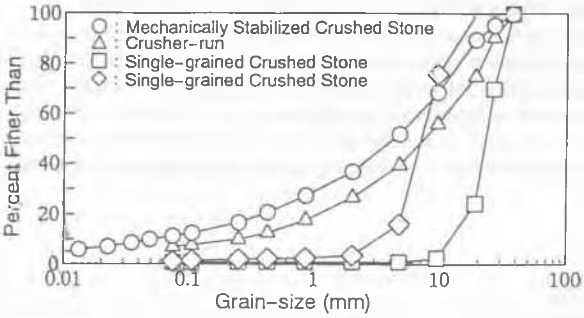

Fig.3 Grain size distribution curves

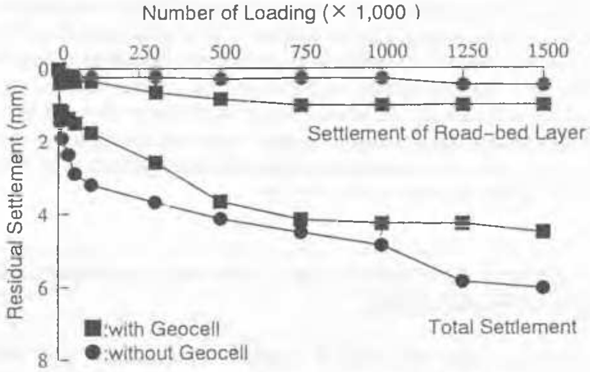

Fig.5 Residual settlement at cyclic loading

was used and the compacting work was continued 15 times to almost stable condition of roadbed surface. The settlements ranged from 2 to 4 mm, whose about 60 % appeared at the second passage of the comapacting machine. Density of the granular materials after compaction were measured by sand replacement method in the upper 10 cm thick layer and water replacement method in the lower 20 cm thick layer, or inside the cells. The mecanically stabilized crushed stone showed the relatively low degree of compaction.

Cyclic loading test

A large scale loading tests was performed for the model shown in Fig.4:dynamic load of 11 Hz sine wave was 10 kN for the minimum and 90 kN for the maximum and the mechanically stabilized crushed stone was used for the roadbed and ordinary sand for the subgrade with reaction modulus of 0.4 MPa. Fig.5 shows the relation between the residual settlement and the number of loading for the roadbed and the total layer. The settlement of roadbed was about 80 % of the final one less than 1 mm at one third loading process of the final loading. The roadbed settlement was smaller for the roadbed without geocell than for the roadbed with geocell, which will be due to the above mentioned compacting properties. The total settlement of geocell-reinforced case, on the other hand, was 70 % of the case without geocell where the settlement curve showed the increasing tendency at the final loading process. This situation may be attributed to the imoprovement of roadbed stiffness by the geocell and its load-dispersing effect which may be considered the effect of geocell. Fig.6 shows the vertical and lateral strain distributions in the geocell which were measured by strain gauges during cyclically loading. They are the values par 1 kN. The measured results show the vertical strains are larger under the tie end than under the tie center and the lateral ones are the largest under the tie center. As the maximum cyclic load is 90 kN, the muximum vertical and lateral strains are about 900 x 10^{-6} and 400 x 10^{-6} respectively.

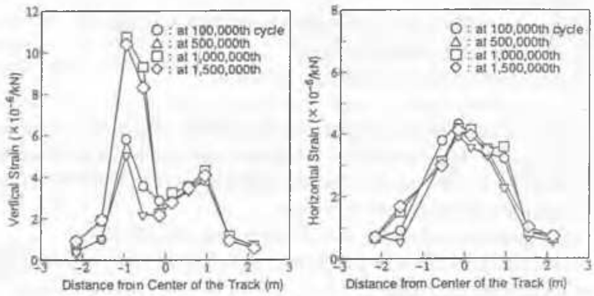

Fig.6 Dynamic strain of geocell

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