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The effect of fabrics on pavement strength - Plate bearing tests in the laboratory
L'effet de portance des textiles - Essais de plaque en laboratoire

RÉSUMÉ

Le Laboratoire de Recherche Routier en Norvège a fait une étude pour analyser l'effet des textiles en portance d'une structure de la chaussée. Les structures qui était composé d'une couche sol de fondation et une couche de gravier, était construit dans le laboratoire et sont chargé d'un essai de plaque. Trois différentes sols de fondation a fait un test avec trois différentes grosseurs de gravier, toutes modelès à la fois avec textile et sans textile. Les essais de plaque ne pouvaient pas constater que le textile ont quelqu'un influence à la portance, mais il a constaté que le textile, en certaines conditiones, pouvait retenir le developement des deformationes à charge de rupture. La conclusion des recherches est que l'effet armature du textile est au moindre importance d'une structure de la chaussée. C'est la propriété d'anticontamination que doit être la cause essentiel du succes du textile en construction des chaussées.

INTRODUCTION

Fabrics was used for road-construction purposes for the first time in Norway in 1972. It was mainly used for access roads and temporary roads and the experience has been rather good. The general opinion seemed to be that the use of fabric resulted in an increase of the load bearing capasity. This conclusion initiated the Norwegian Road Research Laboratory (NRRL) to put up a test program in 1973 to investigate the effect of fabric being used in this respect.

GENERAL ARRANGEMENT OF THE EXPERIMENTS

The experiments were carried out on structures with surface areas 1,6 x 1,6 m squared. The pavement structures were made as simple as possible, consisting of one layer of subgrade material and one layer of subbase material only, see fig. 1. Three different types of subgrade were tested with three different subbase thicknesses each. All constructions were built up twice, one with fabric placed between the two layers and one without.

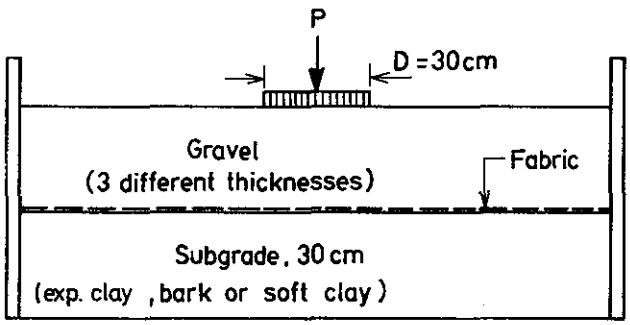

Fig. 1. Principle of testing constructions

All constructions were loaded staticly on the surface with a circular steel plate, diameter 30 cm. The applied force was inserted in steps and deformation measured at each step. From these measurements the modulus of elasticity were calculated using the formula

$$E = \frac{3}{4} \frac{\Delta P}{\Delta S} \cdot D$$

where ΔP is the interval of load (in kp/cm^2) and ΔS is the corresponding difference in

deformation (in cm). D is the diameter of the steel plate.

The tests on the expanded clay constructions were carried out following the standard procedure of plate bearing tests, but the load bearing capacity of the bark and soft clay constructions were so low that the standard procedure had to be deviated. The deformations were permanent and therefore the calculation of the modulus of elasticity is of minor importance.

The subgrade materials were not compacted directly but indirectly through the compaction of the overlying gravel layer.

When one plate bearing test was terminated, the gravel thickness was measured after excavating some gravel. It was noticed up to 1 cm difference between the similar constructions with and without fabric. The degree of compaction was with two exceptions (similar constructions) between 101 and 105% of Standard Proctor at optimum moisture content (max.dry density: 2,04 kp/dm^3 at 9% moisture content). The moisture content of the gravel was all the time less than the Standard Proctor optimum. The gravel had a CBR value of 40%. Sieve analysis showed that 10% of the material had a grain size less than 0,2 mm and 60% less than 2,0 mm.

The fabric being used was a Fibertex S170.

In the constructions without fabric there were used a very thin plasticfoil (0,025mm) to avoid mixing of the gravel and subgrade. If the plasticfoil had not been used there would have been contamination of the two adjacent materials and hence they would have to be replaced for each test without fabric. The tensile strenght of the plastic foil is below 10% of the fabric being used and was therefore supposed to have negligible influence on the load bearing capacity. For each construction a new piece of fabric or plasticfoil was taken in use.

RESULTS

Subgrade of non kohesive material

In the first test series the subgrade was a 30 cm thick layer of expanded clay (Leca) with mainly ball-shaped particles with a grain size of 10-20 mm. This particular material was chosen as it is less sensitive to variations in moisture content than a uniformly graded soil. The subbase thicknesses used in these tests were 15, 25 and 38 cm respectively.

It was not expected that the fabric would improve the load bearing capacity of constructions with this subgrade, and the test results do not show any improvement due to the fabric. The expanded clay was quite well compacted indirectly through the compaction of the gravel. Plate bearing test directly on the expanded clay gave a modulus of elasticity of E = 150 kp/cm^2.

For plate bearing tests on the constructions, the load was applied 6 times increasing from 0 to 6,0 kp/cm^2 (only up to 5,0 kp/cm^2 on the construction with 15 cm gavel to avoid cracking of the expanded clay).

The reason for this test-procedure was to find a possible indication of the dependence on the number of load-cycles. The test results did not show any difference in the bearing capacity (modulus of elasticity) according to the presence of the fabric. The differences in the similar tests are put down to differences in the degree of compaction or gravel thickness.

Results from the tests are given in figure 2.

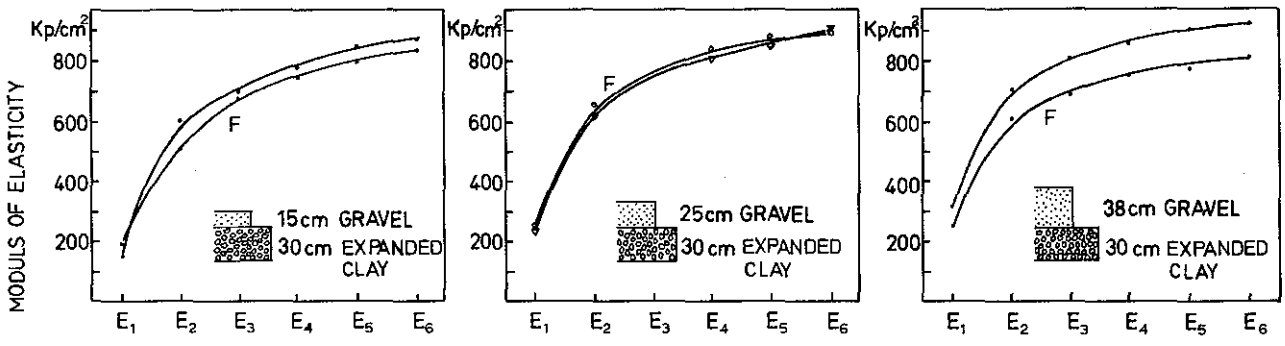

Fig. 2. Modulus of elasticity from the plate bearing tests on constructions with expanded clay subgrade. The index on the "E"'s correspond to the number of load cycles. Constructions with fabric are marked with "F".

Subgrade of bark

For the second test series a 30 cm layer of bark was used as subgrade and the subbase thicknesses were 15, 25 and 38 cm.

Bark is used as a frost-protecting material in Norway, but the main reason for using bark in these tests was that bark is a rather soft material and was expected to give large deformations. The bark was characterized as rather fresh. Its modulus of elasticity was found to vary from 6 to 15 kp/cm^2 at a pressure varying from 0 to 3 kp/cm^2.

The standard procedure of the plate bearing test had to be deviated. Pneumatic loading was used to secure a constant pressure on the plate during the deformation. The pressure was increased up to 5,0 kp/cm^2 in steps of 0,5 kp/cm^2 and deformations were measured 10 minutes after the increase in pressure.

During the test the steel plate was squeezed into the construction and at a pressure of 5,0 kp/cm^2 the deformation was between 80 and 120 mm depending on the gravel thickness, see fig. 3. Due to these large deformations the constructions were loaded only once. For the same reason the calculation of the modulus of elasticity is of minor importance.

In spite of the great deformations the tests did not prove that the fabric had any influence on the degree of or the developement of the deformations, see fig. 3. The differences between similar constructions is probably mainly due to differences in testing conditions.

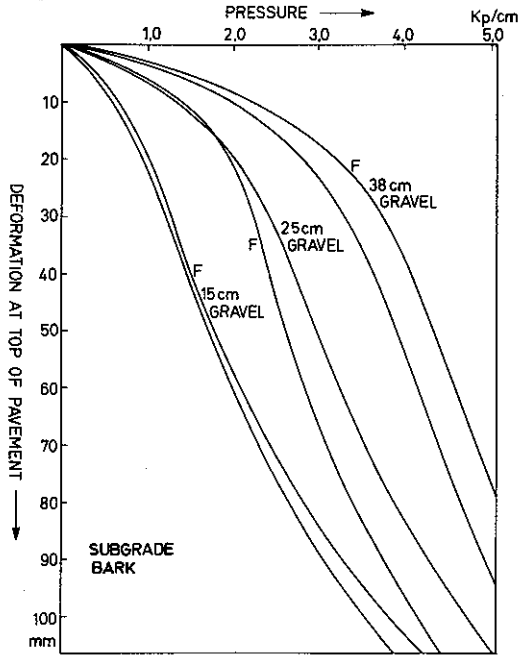

Fig. 3. Results from plate bearing tests on constructions with bark subgrade. The constructions with fabric are marked with "F".

Subgrade of soft clay

For the third test series a 30 cm layer of soft clay was used as subgrade and the gravel thicknesses were 23, 30 and 33 cm.

The clay had a shear strength of about 1 ton/m^2 and a moisture content of about 34% by dry weight. The clay was very plastic but not sensitive (39% particles less than 0,002 mm).

The standard procedure of the plate bearing test had to be slightly deviated to fit the low bearing capacity of the clay. The pressure on the steel plate was increased in steps of 0,25 kp/cm^2. Even so failure in the constructions developed suddenly and for some of the tests the steel plate sank more than 100 mm in a few seconds.

Failure occured at the same pressure for comparable constructions with and without fabric. The failure pressure was 0,5, 1,0 and 1,5 kp/cm^2 at gravel thicknesses 23, 30 and 38 cm respectively. Constructions with fabric showed deformations somewhat less before failure compared with the corresponding constructions without fabric. The difference was, however, negligible, see fig. 4. Of greater importance was the fact that the fabric in the constructions with 23 and 30 cm gravel managed to prevent the developement of the deformations at failure pressure. The deformations were about 40 and 120 mm respectively, see fig. 4 For the construction with the 23 cm gravel layer the fabric caused the deformation to stop when the pressure was increased above failure pressure (0,5 kp/cm^2) up to 0,75 kp/cm^2. The reason for this is probably that the deformation put up tensile stresses in the fabric due to the elongation in it. The stresses have a vertical, upward directed component to be added to the bearing capacity of the subgrade, and there is a force balance between the steel plate and the construction.

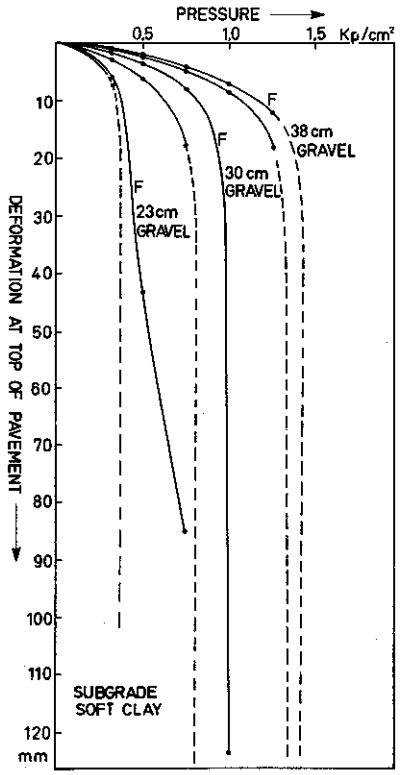

Fig. 4. Results from plate bearing tests on constructions with soft clay subgrade. The constructions with fabric are marked with "F". The dotted lines indicate that the deformations did not stop until the pneumatic cylinder stopped.

For the tests with the 38 cm gravel layer, the fabric did not stop the development of the deformations at failure pressure in spite of the fact that the steel plate went more than 150 mm into the construction. The reason might be that the deformation, to cause a certain elongation of the fabric, is increasing with an increase of the gravel thickness. For this test the deformation may not have been large enough in relation to the gravel thickness.

CONCLUSION

The experiments carried out with the plate bearing tests on similar constructions with and without fabric, did not show any significant difference in bearing capacity. The question to be answered is whether the so-called reinforcement effect of the fabric is of any importance for the design of pavement structures.

However, it was noticed that the fabric, under certain conditions, caused the deformations to stop at failure pressure. The loads in the tests were small in relation to traffic loads and it is not proved that the fabric has a similar effect when the loads are larger and the gravel layer thicker. In any case, the utilization of this effect will be dependent on large deformations and the advantage of it seems to be rather limited to most roads where deflections are very small.

However, there might be an advantage of the fabric when there are very local weaknesses of the subgrade. Even on ordinary roads, designed to meet specifications depending on the traffic, subgrade conditions etc., there will always be local spots where the subgrade strenght is inferior to the design subgrade. In such places the fabric might be of a certain advantage compared with a conventional filter layer of sand.

The explanation of the great success of the fabric used in access roads and temporary roads is probably that the fabric prevents contamination of the subbase and thereby conserves the initial conditions. For ordinary roads contamination is prevented by a filter course, but such a course is very seldomly used in temporary roads. Consequently the subbase is often mixed with the subgrade. As the fabric prevents contamination the necessary maintenance of the temporary road is often reduced. This effect has been discovered by contractors and others. When fabric is used it is possible that the thickness of the subbase layer could be just somewhat reduced without getting an increase in maintenance costs compared with an ordinary, temporary road without fabric. The answer to that can, however, not be taken from these experiments.