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The use of fabrics in road pavements constructed on peat
L'emploi des textiles dans les remblais construits sur un terrain tourbeux

Résumé

Trois séries d'essais de chargement sur plaque d'appui furent conduits pour examiner l'emploi des textiles sous les remblais construits sur un terrain tourbeux. Dans la première série d'essais les charges furent appliquées directement sur le terrain naturel. Les résultats démontrent que la couche supérieure composée de racines et fibres végétales forme un tissu naturel capable de transférer les contraintes de tension. Ce transfert des contraintes exerce une influence considérable sur la capacité portante de la tourbe. Dans la deuxième série d'essais les charges furent appliquées directement sur quatre toiles de textile placées sur le terrain et fixées dans ses abords par 30 cm de sol. Les résultats indiquent que la capacité portante limite accroît en proportion à la résistance à la traction du matériel utilisé. Avant la rupture, le matériel le plus rigide et le moins extensible produisit toujours des tassements moindres pour toute charge. Dans la troisième série d'essais les charges furent appliquées sur des remblais de gravier, chaque remblais comportant trois sections. Dans deux sections seulement des toiles de textile possédant différentes caractéristiques de résistance et d'élasticité furent placées à l'interface sol-matériaux d'apport. Des essais furent conduits sur les trois sections, l'épaisseur uniforme du remblai variant de 15 cm à 56 cm. Les résultats prouvent que pour de faibles déplacements de la plaque d'appui, comme requis dans la majorité des projets de route, les textiles n'importe peu. Pour des déplacements prononcés les textiles exerce une influence marquée sur le tassement, les textiles les plus rigides réduisant le tassement.

Les résultats de ces trois séries d'essais permettent d'isoler les éléments affectant le comportement des chaussées construites sur la muskeg et d'étudier leur importance. Incontestablement les textiles accroissent la force portante limite. Cependant les tassements qui doivent prendre place avant que l'influence des textiles entre en jeu sont plus grands que ceux permis par les critères qui régissent la conception des chaussées.

Introduction

The construction of roads across organic terrain (peatlands) represents a formidable problem. It has been shown practically that the use of fabric as a separation membrane between a pavement fill and a soft subgrade soil is beneficial in preventing mixing of the fill and subgrade. On such weak soils as peats it was considered possible that fabrics may also act as a reinforcing element in the pavement construction. To ascertain the value and preferred properties of such a fabric a series of plate bearing tests have been performed on all the elements of a peat-fabric-fill system.

Test Site and Peat Properties

The test site is part of a marsh bordering the Cataraqui River at Kingston. The surface cover consists of reeds and grasses with a classification of CF in the Radforth Muskeg Classification system, MacFarlane (1969). The peat varies from 1.5m to 2.0m in depth and it overlies a stiff grey clay. The fibrous surface mat of the peat formed from recent vegetation and roots is about 0.2m deep with a classification of $H_4 B_4 F_1 R_3 V_0$ on the Von Post system, Flaate (1966). The underlying peat has very little fibrous or rooty material and has a much higher degree of decomposition with a typical classification being $H_6 B_4 F_0 R_1 V_1$. Moisture contents in the peat vary between 600 and 800 percent and the water table in the marsh varies from 0.75m above the ground surface at maximum in Spring to just below the surface as a minimum.

Testing Apparatus

Reaction for the plate bearing tests was provided by a specially constructed, hand portable, triangular truss, Lee (1976). The truss was anchored to provide the reaction by a series of helical earth augers passing through the peat into the stiff clay. The load was applied to the plates by hydraulic jacks acting on a stiff spring. The spring was calibrated for load and also provided a buffer against the rapid load fluctuations likely to occur in a very rigid loading system acting on a compressible soil. Various measurements of plate and soil deformations were made together with pore water pressure readings.

Test Series 1

The fibrous surface mat of a peat deposit forms in effect a natural fabric at the peat surface. Many roads have been "floated" across peat deposits using the tensile strength of the surface mat as the main supporting medium. A series of plate bearing tests were made by Lee (1976) to assess the influence of the surface mat on bearing capacity. Plates nominally of 7.5, 15, 30, and 60cm diameter were tested both with the surface mat intact and with it cut around the perimeter of the plate thus preventing tensile stress transfer. An example of the results of these tests for the 15cm diameter plate is given in Figure 1.

The two curves shown are the average results from a number of tests. At failure the surface mat ruptured and the plate punched down into the peat in such a manner that the load level could not be sustained. It is obvious from the differences between the two types of test that the tensile strength of the surface mat is a significant factor in the bearing capacity .

To compare the results obtained with predictions of behaviour from measured soil properties, the tensile strength and shear strength of the peat were measured. The tensile strength of the fibrous surface mat was measured using a direct tensile testing apparatus, Jarrett (1975). An average value of tensile strength from all the tests made was 28 kN/m^2. The shear strength of the underlying peat was obtained from the vane shear test and was found to be 10 kN/m^2. To calculate an ultimate bearing capacity for the tests with the surface mat cut, only the shear strength of the underlying peat was used in a normal bearing capacity analysis. For the ultimate bearing capacity of the tests with the surface mat intact a term directly dependent on the tensile strength of the surface mat and the plate size was added to the previous value for the underlying peat. A good agreement was obtained between the calculated and measured values of bearing capacity for all plate sizes, Lee (1976). At stress levels below the ultimate, the effect of the tensile stiffness of the surface mat was to reduce settlement at any particular value of stress.

Test Series 2

In this series, 15 cm diameter plate bearing tests were performed directly on 4 different fabrics placed on the surface of the peat and

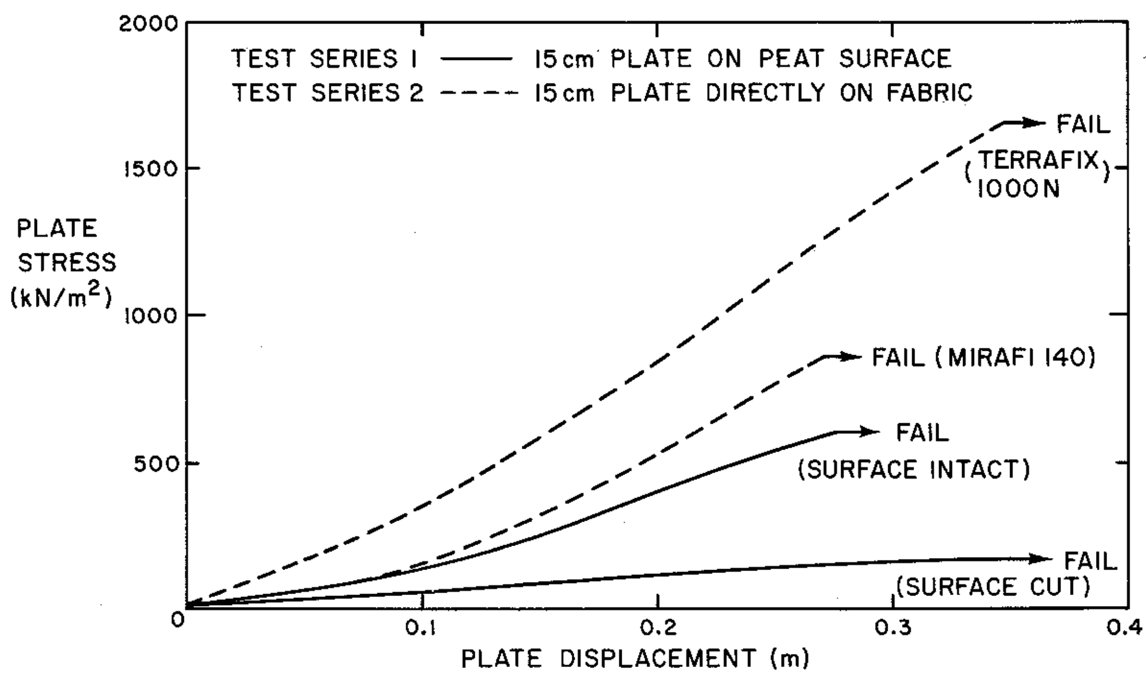

Figure 1. Plate bearing test results on peat surface and on fabrics.

held down by a gravel fill, 30 cm high and 180 cm in diameter. The central area of the fill, to a radius of 10 cm, was kept clear to allow the plate to rest directly on the fabrics. The fabrics used had a wide range of properties and were in ascending order of grab tensile strength, Mirafi 140 (low strength fabric), Terrafix 300N, Mirafi 280, and Terrafix 1000 N (high strength fabric). The results obtained for the lowest and highest strength fabrics are presented in Figure 1. Failure in these cases occurred when the fabric ruptured and the plate punched into the peat. Results for the two fabrics of intermediate strength are not presented in Figure 1 to maintain clarity and because only the two extreme fabrics were used in Test Series 3. The intermediate fabrics did however fail at stresses consistent with their respective tensile strengths. In terms of plate stress against displacement their behaviour was very similar to the low strength fabric until close to failure when the curves separated somewhat. In addition to the tests on fabrics a plate test on the peat surface with the gravel fill surrounding it was performed. This test behaved identically to the Series 1 surface intact test, shown in Figure 1. The inference is that the fill had negligible effect on the bearing capacity and that the bearing capacity increase noted for Series 2 over the Series 1 result is a function of the fabric strength.

In calculating the ultimate bearing capacity of the Series 2 tests, the peat bearing capacity was calculated exactly as for Series 1. The influence of the fabric was calculated based on the circumference of the plate and the grab tensile strength of a 10 cm wide sample of fabric. In all cases the calculated bearing capacity was less than the measured bearing capacity indicating that the ultimate strength of the fabrics was being underestimated. In the case of the strongest fabric the difference was 33 per cent and in the other three cases 10 per cent. These tests have shown that the ultimate bearing capacity of a deposit may be increased by the use of a membrane. It was also shown that below the ultimate bearing capacity, the stiffer less extensible fabrics did slightly reduce the settlement at any particular level of plate stress. Even with this reduction however, large vertical movements were still necessary to utilise the available strength.

Test Series 3

The final series of plate bearing tests were made using a 30 cm diameter plate on top of two compacted gravel fills placed on the peat. The fills each covered a plan area of 2.25 m by 6.75 m and were divided longitudinally into 3 equal test sections. One section of each fill had no fabric at the peat-fill interface, one section had the previously mentioned low strength fabric and one section the high strength fabric at the interface. A number of plate tests were then carried out on each section as the gravel thickness was increased in a series of steps. One fill was tested with gravel thicknesses of 15 cm, 30 cm, 45 cm and 56 cm with the fill being taken to failure at the 56 cm thickness. The second fill was tested at thicknesses of 15 cm and 23 cm with the 23 cm test being taken to failure.

The test procedure in this series was designed to assess the fill as a pavement structure. The procedure used was similar to that of McLeod (1947) from whose work most Canadian pavement design methods were developed. Each test involved performing load repetitions at pre-determined displacements. Six repetitions of load were made after 0.25, 0.76, 1.52 and 2.54 cm of plate displacement. The testing was stopped after a displacement of 3.8 cm was reached. The two tests taken to failure followed the same procedure but loading was continued beyond the 3.8 cm displacement until a failure condition was reached. Failure in both instances occurred by the plate punching into the gravel. At this point however the fabrics were not ruptured and it is possible that with further displacement some increase in plate stress may have developed. In terms of pavement utility however such large deformations would be impractical.

The results obtained of plate stress against plate displacement for the tests taken to failure are presented in Figure 2. It may be observed that at the higher displacements the fabrics were having a very slight effect on behaviour. Unfortunately by this stage of testing a pavement would be in a state of unserviceability if the plate were representing a wheel load. One possibly useful factor is that the fabric may well limit the extent and consequences of a failure on a very soft soil.

The two series of tests shown in Figure 2 are also typical of the behaviour of all the tests in the low displacement range from 0 to 0.038 m. In essence they show that at the small displacements allowable in a pavement structure the fabrics had little influence on performance. Far more significant variations in behaviour were produced by changes in gravel thickness and even by variations in peat properties than by the changes in fabric.

Conclusions

1. Based on static loading tests it could not be shown that the presence of fabrics had any significant influence on the behaviour of a compacted gravel fill at the levels of deformation likely to be significant in a road pavement.

2. It is probable that the utility of fabrics lies solely in the prevention of mixing of fill and subgrade due to dynamic effects. In this case fabrics of great strength should not be required.

3. It was shown that at large deformations the presence of fabrics could significantly increase the ultimate bearing capacity of a peat deposit. It is possible there-

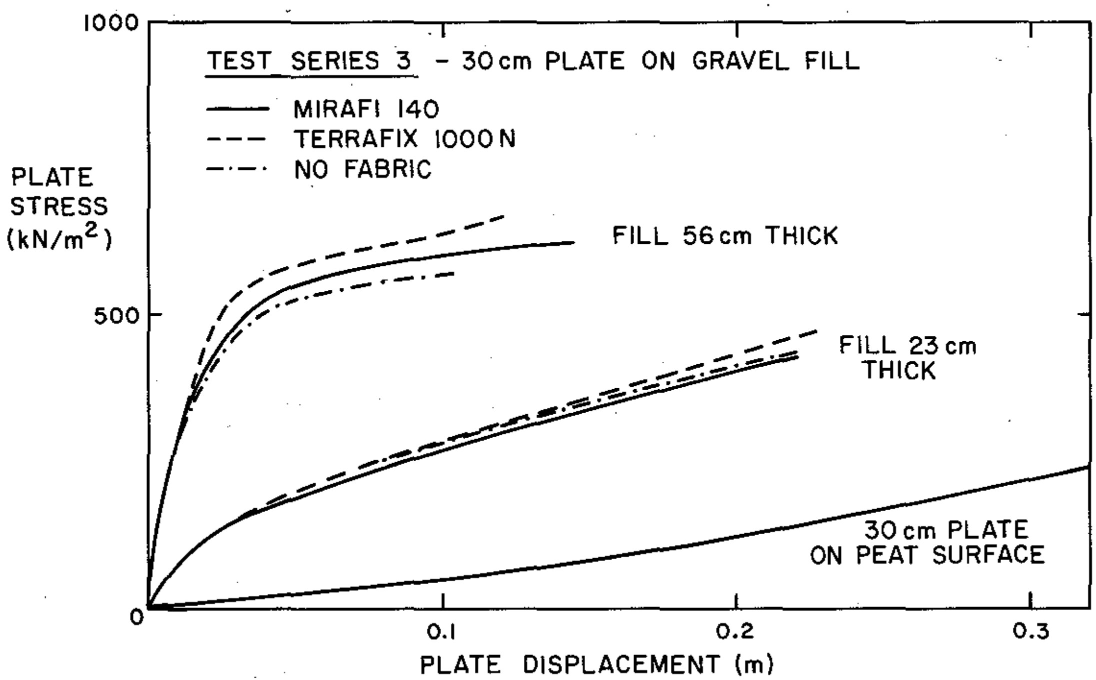

Figure 2. Plate bearing test results on gravel fills with fabric separation membranes.

fore that fabrics beneath pavement fills in very soft soils may assist in limiting the severity or consequences of a pavement failure.

Acknowledgements

The work presented in this paper was supported by the Defence Research Board of Canada under Grant No. 9511-88.

The authors gratefully acknowledge the assistance of summer students Tony Herritt, Lawrence Hwang and John Boadway during the testing. The provision of fabrics for this research by Kenross-Naue Canada Ltd. and Celanese Canada Ltd. is greatly appreciated.

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