

INTERNATIONAL SOCIETY FOR SOIL MECHANICS AND GEOTECHNICAL ENGINEERING



This paper was downloaded from the Online Library of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE). The library is available here:

<https://www.issmge.org/publications/online-library>

This is an open-access database that archives thousands of papers published under the Auspices of the ISSMGE and maintained by the Innovation and Development Committee of ISSMGE.

Load Bearing Capacity of a Base Course

Force portante des couches de base

by H. TAKESHITA, Public Works Research Institute, Ministry of Construction, Tokyo, Japan

Summary

The author gives the results of investigations carried out on the load bearing capacity of a base course. He employs a new method to determine the strength of base materials and subgrade soils, using a special test tube for loading tests in the laboratory.

The results of his investigations are summarized in a diagram which may be used to determine the thickness of the base course.

Sommaire

L'auteur expose les résultats de ses recherches sur la force portante des couches de base.

Une nouvelle méthode est utilisée pour mesurer les caractéristiques de résistance des matériaux de couches de base et des sols de fondation. Il a employé à cet effet un tube spécial pour les essais de charge en laboratoire.

Les résultats de ces recherches sont résumés sur un diagramme, joint à la communication, qui comporte des courbes pour divers compactages. Ce diagramme peut être utilisé pour calculer l'épaisseur à donner à la couche de base.

Introduction

The design of road pavements in Japan is based on the plate bearing test using a plate of 30 cm diameter, in which the following criteria must be satisfied :

Flexible pavements : $K_{30} > 28$ kg per sq. cm per cm ;

Rigid pavements : $K_{30} > 15$ kg per sq. cm per cm.

No definite solution has yet been found to the problem of what kind of material must be placed in what thickness to meet these criteria. The answer depends upon the load bearing capacity of layered soils.

In the case of two-layer soils, the strength of base course and subgrade is represented by the moduli of deformations C_1 and C_2 respectively. In the elastic theory, however, the moduli of elasticity are indicated by E_1 and E_2 assuming the Poisson's ratio as 0.5 in base materials as well as in subgrade soils. The effect of the base course to increase the load bearing capacity may be shown in the form of K_1/K_2 , providing the moduli of base and subgrade reactions shown by K_1 and K_2 respectively.

New Method to Determine the Modulus of Deformation

Triaxial compression tests are widely used to determine the modulus of deformation of the material, such as the Kansas method. However, the following defects are found in triaxial tests, as follows :

1. The lateral pressure corresponding to field conditions is unknown ;

2. The lateral pressure varies with different soil types, and the vertical pressure changes according to field conditions ;

3. The shear stress is zero at the side of specimens in a triaxial compression test, but this condition may not apply to a mass of soil in the field.

The author therefore developed the apparatus shown in Fig. 1. The specimen is 5 cm in diameter and 10 cm high ; it is compressed longitudinally and is confined laterally. The confining effect of the container is of the same order

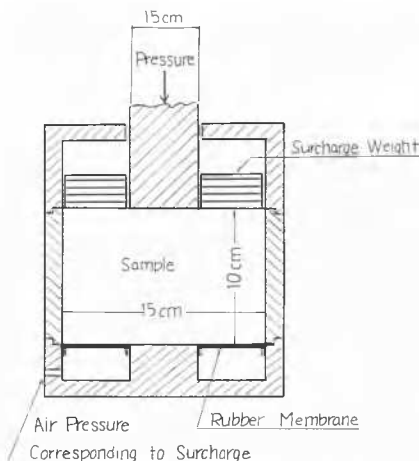


Fig. 1 Schematic diagram of equipment to determine the Modulus of Deformation.

Schéma de l'appareillage de mesure du module de déformation.

as in the CBR test. The result of a test on Kanto loam revealed that to obtain the same moduli of deformation, the lateral pressure in a triaxial compression test is about 1.0 kg per sq. cm.

Surcharge weight may be added to the surface of the specimen as in the case of the CBR test. This pressure may be added to the specimen at the base by compressed air, as shown in Fig. 1.

The modulus of deformation is obtained from the following expression :

$$C = \frac{P}{\epsilon} = \frac{P \text{ kg/cm}^2}{\frac{0.25 \text{ cm}}{10 \text{ cm}}} = \frac{P}{0.025} \text{ kg/cm}^2$$

where :

P : unit load applied by plunger, in kg per sq. cm ;
 ϵ : strain.

Test Tube and Loading Tests

A test tube 150 cm in diameter and 120 cm in height was used to study the load bearing capacity of the base course as shown in Fig. 2.



Fig. 2 Loading test.
Essai de charge.

Generally speaking, it is difficult to construct a model test of a hard base course on a soft base course. The base materials were therefore compacted first, and then the soft subgrade soils were put on the compacted base course in the test tube. The test tube was turned over so that the base course would come to the surface in order to obtain a two-layer model. As the result of experiments with pressure cells buried near the test tube, it was known that the confining effect of the test tube and its base was practically negligible if a loading plate not exceeding 30 cm in diameter was used.

The loading tests using the test tube and the testing of the mechanical properties of the materials were conducted as follows :

1. Various base materials were compacted at various moisture contents and under different loads to give the required thickness. Various subgrade soils having different moisture contents were then loaded and put on the base courses.

2. The test tube was turned over so that base course came to the surface. After the loading test on the base course, the subgrade soil was exposed by removal of the base materials and the loading test was conducted again on the subgrade soil. The same loading plate and similar displacements were used both on the base courses and on the subgrade soils. The moduli of subgrade reactions investigated ranged from 0.5 kg per sq. cm per cm to 20 kg per sq. cm per cm.

3. The base material was compacted in two layers as shown in Fig. 1 under different loads. The modulus of deformation of the base material was determined at the dry density of the base course in the test tube by interpolation.

4. Undisturbed samples from the subgrade were taken and tested to determine the moduli of deformation of the

subgrade soil. The ranges of the ratios of the moduli of deformations of base courses and sub grade soils tested were from 2 to 70.

Some results of those tests are shown in Fig. 3, in which the curves after Burmister's theory are also indicated. Burmister's curves correspond closely to those obtained from test results, so that the theory may be used to calculate the increase of the load bearing capacity of the base course provided that C_1/C_2 is used instead of E_1/E_2 in Burmister's theory.

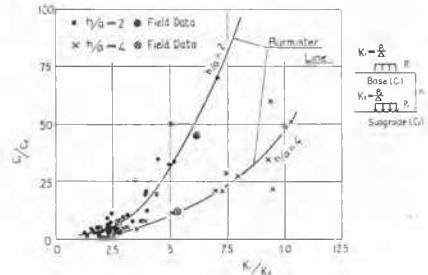


Fig. 3 Relationship between C_1/C_2 and K_1/K_2 obtained from large scale model tests.

Quelques relations entre C_1/C_2 et K_1/K_2 obtenues par essai sur modèle à grande échelle.

Fig. 4 is derived from test results, in which the increase of the load bearing capacity of the base course is indicated in the ordinate in the form of K_1/K_2 , and the thickness of base course is shown in the abscissa so as to be applicable to a test plate of 30 cm diameter. Burmister's lines are shown in dotted lines indicating the values of C_1/C_2 .

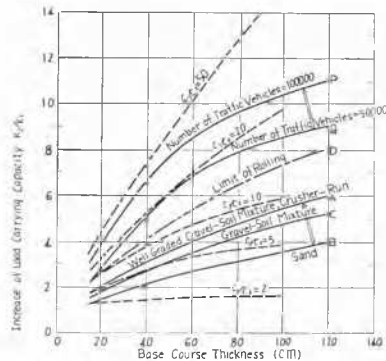


Fig. 4 Increase of load bearing capacity with base course thickness (in case of using 30 cm diameter rigid plate).

Accroissement de la force portante en fonction de l'épaisseur de la couche (dans le cas où l'on emploie des plateaux de chargement de 30 cm de diamètre).

Results of Field Tests

Many loading tests were performed in the field for several years all over Japan ; the results were plotted and boundary lines were drawn as shown in Fig. 5.

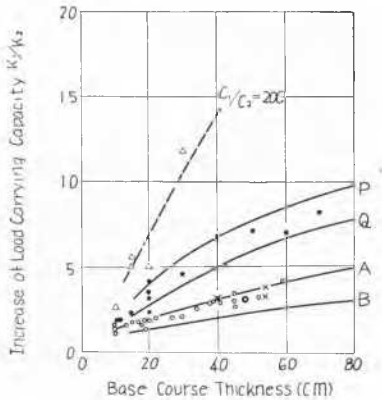


Fig. 5 Plate bearing test data in 1958: ○ (Newly constructed gravel bases); × (newly constructed crushed rock bases); ● (data obtained from gravel roads); △ (Soil cement bases, after 7 days curing).

Matériaux essayés en 1958, provenant d'une couche de base : ○ (route neuve en gravier); × (route neuve pierre cassée); ● (route ancienne en gravier); △ (sol stabilisé au ciment, après 7 jours de conservation).

The specifications in this country generally require that a 10-ton roller shall make from six to eight passes when rolling a base course. Curves *A* and *B* show the boundary lines of various base materials compacted by a 10-ton roller with six to eight passes.

Curve *A* indicates the increase of load bearing capacities of crusher-run bases or bases of soil-aggregate mixtures which follow the AASHO grading requirements, and curve *B* shows that of a poor sand base. Most data fall within the boundary ranges between curves *A* and *B*, and most base materials commonly used show that the increases of load bearing capacities are approximately shown by the curve *C*.

In Fig. 4, most base materials which are compacted with six to eight passes of a 10 ton-roller have values for C_1/C_2 of 3 to 8. Curve *D* shows the limit of rolling with various rollers and numbers of passes.

Curves *P* and *Q* show the increases of load bearing capacity of gravel roads which were opened to traffic after construction. These curves show that the passing vehicles number approximately 100 000 and 50 000 respectively. In Fig. 4, the effects of traffic bond bases may be over 20 for the values of C_1/C_2 . However, the effects of traffic bond bases may not be expected to be above the curve *P*, in case more than 100 000 vehicles pass over the bases.

The plate bearing test results conducted in 1958 are plotted in Fig. 5, which show the data fall within these limiting ranges stated above.

How to make use of Fig. 4

Fig. 4 may be used for the design of base courses when using a bearing plate of 30 cm diameter; it may also be applicable to a three-layer system. For example, the increase of the load bearing capacity of 30 cm sand subbase can be shown by curve *B*, and the effect of a 40 cm thickness of gravel base upon the sand subbase is shown parallel to curve *C* to the total depth of 70 cm. Then the increase of load bearing capacity may be approximately 3.4; that of 70 cm gravel base will be 3.9.

Acknowledgement

The author gratefully acknowledges the assistance of Messrs. T. Odagiri, J. Tanaka, Y. Iwashita and F. Endo in conducting many of those tests referred herein for many years.

References

- [1] KANSAS STATE HIGHWAY COMMISSION (1947). Design of Flexible Pavements Using the triaxial compression tests. H.R.B. *Bulletin No. 8*.
- [2] BURMISTER, D. M. (1943). The Theory of Stresses and Displacements in Layered Systems and Application to the Design of Airport Runways. *Proc., H. R. B.*