A SYMPOSIUM ON RESEARCH FEATURES OF FLEXIBLE-TYPE BITUMINOUS ROADS

INTRODUCTION

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In this introduction to the discussion of flexible-type bituminous roads it would be well to define first what is meant by the word "flexible" As applied to road surfaces, it is a term which is quite generally used, without much regard to its exact meaning, to designate those types which have little or no flexural strength, as contrasted with the truly rigid types which have high flexural strength Thus, a flexible-type surface may not be flexible in the true sense of the word but all surfaces of this type have the common characteristics of low beam-strength Also they have the ability, in varying degree, to adjust themselves to minor settlements without structural failure

The function of a bituminous road surface of the flexible type is to carry the wheel loads of vehicles without failure of the bituminous wearing course, the base course or the subgrade These three component parts of a flexible-type bituminous road are interdependent and the characteristics of each affect the performance of the whole

SUBGRADES

During recent years great progress has been made in increasing our knowledge of soils and their use as subgrade materials We have learned to differentiate with some precision, between good subgrade soils and poor ones, we have learned something regarding frost action and the means for eliminating its detrimental effects, we are increasing our knowledge of the consolidation of fill materials, and, finally, we have learned much regarding the stabilization of soils, particularly by means of suitable combinations of soil materials But soil science is still in its infancy and, in the larger sense, the research which is needed is barely under way Particularly promising are the possibilities of stabilization with admixtures of chemicals or bituminous materials

BASE COURSES

What has been said with respect to subgrades is also generally applicable to base courses Our knowledge of bases of the macadam type, which depend primarily on internal friction for stability, is largely the result of experience But soil science, coupled with experience, has greatly extended our knowledge of the essential characteristics of such base-course materials as sand-clay, gravel, limerock and caliche. Here, also, the possibilities of stabilization with other than soil materials merit careful investigation.

BITUMINOUS WEARING COURSES

In bituminous wearing courses, as in subgrades and base courses, stability or resistance to lateral displacement is an essential characteristic. But here we have a part of the road structure in which other qualities become of increasing importance The wearing course is subjected to the direct action of traffic and weather. Adequate strength and durability of the mineral aggregate and durability of the bituminous binder are necessary.

Numerous investigations have developed valuable information regarding stability as affected by character and grading of mineral aggregate and character and quantity of bituminous binder Further research along this line is needed The development of a test for stability, preferably a simple one, which would simulate the action of a paving mixture under actual wheel loads, would go far toward solving some of the questions which now confront the engineer

With respect to mineral aggregates, much has already been learned regarding strength characteristics and durability but further work along these lines remains to be done The relative affinity of aggregates for water and for bitumen is a characteristic which has not yet received the attention it deserves

The present question of pressing importance in the field of bituminous surfacing has to do with the durability of the bituminous material itself The great programs of highway construction, particularly of the low-cost type, have focused attention on a problem which previously had not been of great concern

It is known that some bituminous materials lack durability or resistance to weathering. In the road surface they soon lose their cementing properties and the friable mixture which results may fail rapidly under traffic In the absence of a definite method of differentiating between good and poor materials, specification writers are now requiring compliance with test requirements which are primarily for the identification of source While these requirements may exclude certain poor materials, they are so little a measure of quality that they may also exclude materials which are known to be satisfactory. What appears to be needed is an accelerated weathering test capable of completion in a few hours. Research along this line is under way and should be continued.

It should not be inferred that bituminous materials lacking in weather resistance are necessarily entirely lacking in value With a full realization of their limitations, economic considerations may sometimes dictate their use in preference to more expensive materials Also, it may be possible to use them advantageously in mixtures which are protected by weather resistant wearing courses However, it is necessary to have some means for identifying them so that they may not be used improperly

THE ROAD STRUCTURE

We have learned much, both from practical experience and from research, regarding the design of the component parts of the flexible-type road Concerning the design of the road structure as a whole we know very little except what has been taught us by experience. For roads of the rigid type the analyses of Westergaard, supplemented by research, have given us the basis for a rational theory of design applicable to concrete pavements For roads of the flexible type no rational method of design exists and rule-of-thumb methods still govern Attempts have been made to develop a rational theory but these are based on questionable assumptions of such far-reaching importance that they can scarcely be accepted without verification

From the structural standpoint, the function of a pavement of the flexible type is to distribute the wheel load to the subgrade in such manner that the intensity of pressure will cause neither permanent nor elastic deformations of the soil of sufficient magnitude to produce failure of the pavement surface The rational design of a pavement to perform this function requires a knowledge of the mechanics of load support The characteristics of the applied loads, the magnitude and distribution of the forces of subgrade reaction, and the physical behavior of the pavement under these two sets of forces must be determined

This problem is of outstanding importance Its complicated nature is indicated by the following brief analysis of some of its details.

The more important variables which must be considered are

1 The magnitude of the load
2 The position of the load on the pavement
3 The area of load application and the distribution of pressure over the loaded area
4 The time duration of loading
5 The thickness of the pavement (base course plus wearing course)
6 The internal stability of both base and wearing courses.
7. The distribution of pressure on the subgrade
8 The supporting power of the subgrade.

The vehicle load which is important in the design of any pavement is known to be the maximum wheel load Within reasonable limits the maximum wheel load which is likely to operate over a given road can be determined. This, of course, is the maximum static load and must be considered since heavy vehicles may stop on the highway surface for considerable periods of time. The impact forces produced by the wheels of moving vehicles must also be considered since these are greater than the forces due to static wheel loads and may exceed them many times. Researches extending back over the past fifteen years make it possible to predict, with a fair degree of accuracy, the magnitude and frequency of the impact reactions which may be expected for specific conditions of wheel load, tire equipment, vehicle speed and road roughness

The position of the applied load on the pavement is also a factor which must be considered A load applied near the free edge of the pavement will have a different effect than one applied in the interior portion where continuity exists Rational design requires that there be equal resistance to load in all parts of the structure and this can be obtained only by systematic study of the mechanics of pavement action

The area of load application and the distribution of pressure over the loaded area are two separate though related factors The effect of the area of load application has been quite thoroughly investigated with respect to the design of concrete pavement slabs It seems quite probable that the shape of the loaded area may be an even more important factor in relation to flexible pavements than its size. The effect of variations in intensity of pressure over the loaded area is also a detail which must be investigated

Between standing or static loads, slowly rolling loads, and suddenly applied impact forces there is a difference in time duration which is probably quite important in pavements of the flexible type For example, under certain conditions it is very probable that a standing vehicle of given wheel load may subject the pavement to a more severe condition than will the same vehicle moving at speed and producing impact reactions greatly exceeding the static wheel load Certainly the factor of time duration of the load application is one of the important details to be investigated in the development of a rational method of design

The ultimate object of the development of a theory of design is the determination of the required thickness of pavement The supporting power of the flexible-type pavement is intimately related to its thickness and researches designed to develop basic principles will necessarily include thickness as one of the variables of major importance

The stability of the base course and the bituminous wearing course have already been mentioned Stability in the wearing course is necessary to prevent such surface failures as shoving and rutting. Stability in the base course is necessary for the distribution of load to the subgrade. The combined stability of these two component parts of the road structure is another one of the major variables which will require intensive study One of the important problems to be solved will be the development of a suitable method for measuring this combined stability in actual road surfaces

The distribution of load to the subgrade is doubtless affected by all the variables which have been mentioned as well as by the elastic characteristics of the subgrade itself Only fragmentary information exists regarding load distribution and very comprehensive investigations will be required to evaluate the many variables which affect it

Assuming that research has solved all the problems which have been enumerated thus far, there still remains the supporting power of the subgrade to be determined The supporting power of a soil, or its resistance to distortion under load, is dependent on the resisting forces of internal friction and cohesion The relative importance of each and the net result of their combined action varies widely, depending upon conditions Subgrade research has already suggested means for increasing the ability of soils to carry loads What is needed in the development of methods of pavement design is some test which, when applied to a given subgrade, will determine the pressure intensity which can safely be imposed on the soil

Past investigations of the bearing capacity of soils have related primarily to the foundations of buildings or other structures in which the dead load is the principal burden Therefore, the theories which have been developed from these investigations may not be applicable to pavements where the conditions differ in two important respects Under a structure the load is practically constant while under a pavement the transient live load is the principal burden on the soil Furthermore, under buildings it is permissible to anticipate foundation settlements which, if they occurred under a wheel load, would cause pavement failure For these reasons, the requirements of a test to determine the safe bearing capacity of subgrades may be somewhat different from those of a test to determine the bearing capacity of soils in deep foundations

It is apparent that the flexible-type bituminous road offers a fertile field for future research The experience of the past few years justifies the expectation that further rapid progress will be made in advancing our knowledge of subgrades, bases and bituminous wearing courses The most urgent need is for researches aimed at the development of a rational method of design of the road structure as a whole