SOME FACTORS AFFECTING THE STABILITY OF BITUMINOUS-AGGREGATE BASE COURSES

A. H. Layman, Research Assistant,
Joint Highway Research Project, Purdue University

This discussion deals with some of the factors affecting the stability of a bituminous-aggregate base course. Most methods for the determination of the stability of bituminous-aggregate mixtures involve some measure of their shearing resistance. Therefore, it was decided to approach this study of factors affecting the stability of bituminous-aggregate base courses through an investigation of their shearing resistance in unconfined compression.

In this study only one type of bituminous material and one aggregate were employed. (See Table 1.) The bituminous material was a soft asphaltic cement conforming to Indiana State Highway Specifications for OH-2. The aggregate was Mitchell limestone, a hard, angular aggregate with an absorption of 1%. With only one type of bituminous material and one aggregate, there still remained several variables which exerted a profound effect upon the stability of such a base. Chief among these were the variables of gradation and percentage admixture.

TABLE I

PHYSICAL CHARACTERISTICS OF BITUMINOUS MATERIALS

Specific Gravity (at 25°C.)	0.997
Total bitumen (soluble in CCL_4)	99.51%
Penetration (50 gms. at 25°C.)	196
Flash Point	640°F.
Spot Test	Negative

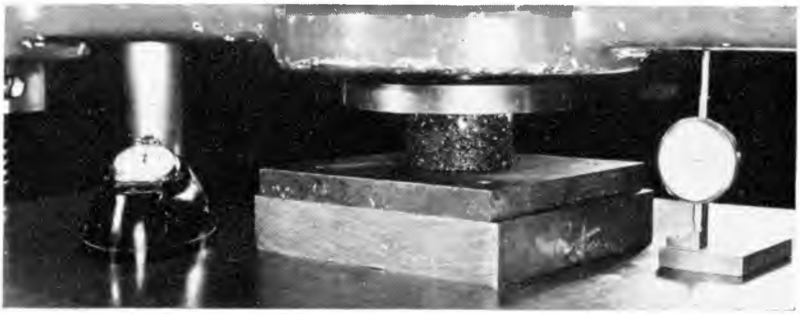

Fig. 1. Specimen ready for test.

Fig. 2. Tested and untested specimens.

Acting upon the recommendations of early investigators, cylindrical specimens 3 inches in diameter and 1½ inches in height were employed. Several hundred were mixed, molded, and cured. These specimens were tested in unconfined compression at a head speed of 0.04 inches per minute and a temperature of 77° F.±3° F. (See Figs. 1 and 2.) The results and conclusions presented in this paper apply only to the materials and testing procedure employed.

TABLE 2

AGGREGATE GRADATIONS

Sieve Size	Percentage Between Sieves		
	Dense	Semi-Open	Open
½-⅜	8	10	14
⅜-4	35	33	36
4-8	11	17	30
8-16	13	16	20
16-30	11	14	..
30-50	10	10	..
50-100	8		..
100-200	3		..
200-	1		..

The first variable investigated was that of percentage admixture. A series of specimens was made which contained the hard limestone aggregate graded to conform to Indiana State Highway Specifications for hot mix, Type B. (See Table 2.) To this densely-graded aggregate were added increasing amounts of the soft asphaltic cement. The resulting mixtures were compacted to the maximum unit-weight obtainable and tested in unconfined compression. (See Fig. 3.)

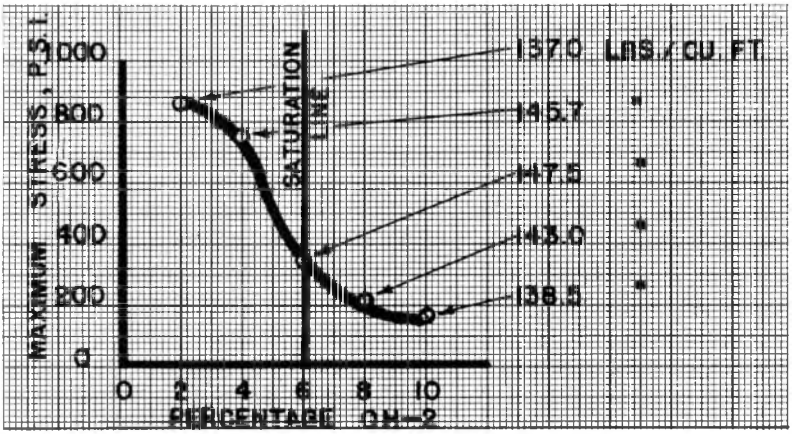

Fig. 3. Effect of bituminous admixtures upon the shearing resistance of dense-graded mixtures compacted to maximum obtainable unit-weight.

An admixture of 2% or less resulted in the greatest shearing resistance, 865 lbs. per sq. in. It is emphasized that this small percentage represents the optimum amount of bituminous material for maximum shearing resistance and does not necessarily result in the best mixture when evaluated on any other basis. It is interesting to note that the specimens of maximum unit-weight were not the specimens with the maximum shearing resistance.

The same dense gradation was employed again with increasing amounts of the soft asphaltic cement. However, in this

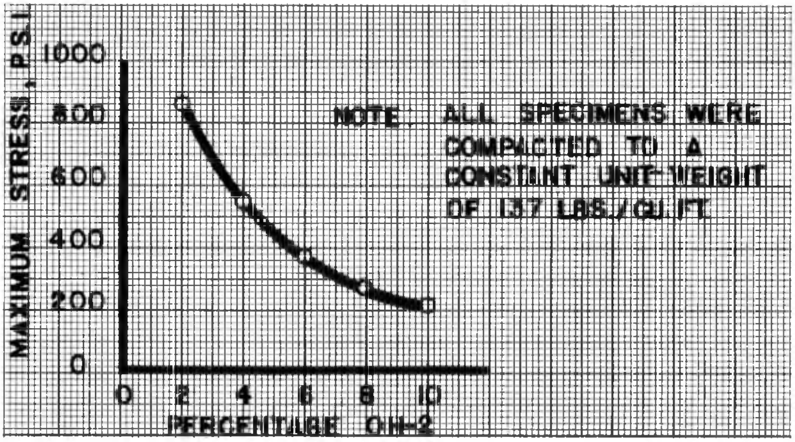

Fig. 4. Effect of bituminous admixtures upon the shearing resistance of dense-graded mixtures compacted to constant unit-weight.

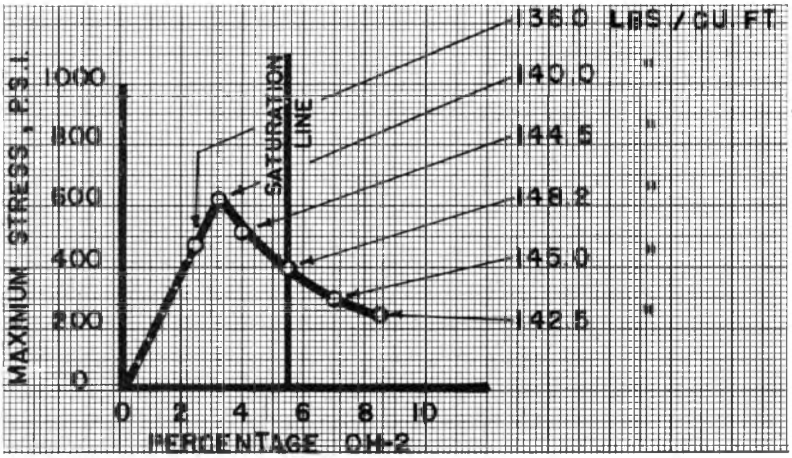

Fig. 5. Effect of bituminous admixtures upon the shearing resistance of semi-open graded mixtures compacted to maximum obtainable unit-weight.

series the mixtures were compacted to constant unit-weight and tested in unconfined compression. (See Fig. 4.) Once more an admixture of 2% or less resulted in a maximum shearing resistance of 865 lbs. per sq. in.

To investigate the effect of aggregate gradation upon the stability of bituminous-aggregate base courses, a more open gradation of aggregate was employed. (See Table 2.) To this semi-open grading, increasing amounts of bituminous

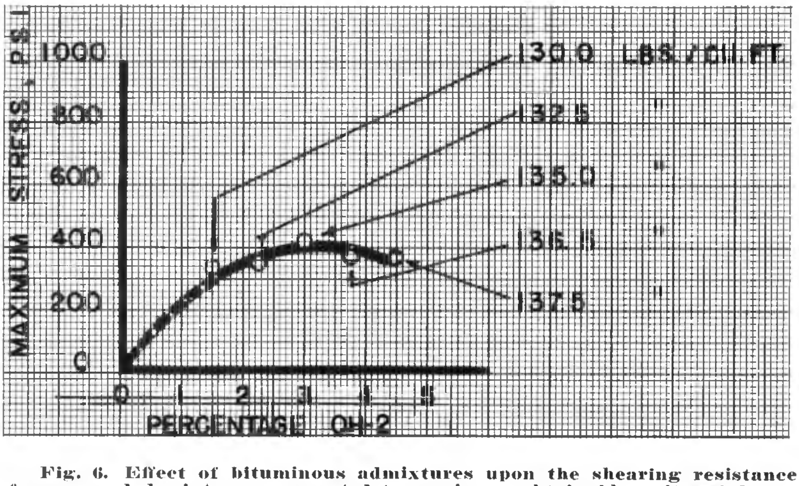

Fig. 6. Effect of bituminous admixtures upon the shearing resistance of open-graded mixtures compacted to maximum obtainable unit-weight.

material were added. The resulting mixtures were compacted to the maximum unit-weight obtainable and tested in unconfined compression. (See Fig. 5.)

Specimens of this semi-open gradation containing 3¼% bituminous material showed the greatest shearing resistance. This was the first indication of an optimum bituminous material content for maximum shearing resistance. It will be recalled that the maximum shearing resistance of the densely-graded specimens was 865 lbs. per sq. in. The maximum shearing resistance of these semi-open-graded specimens was only 620 lbs. per sq. in. Again the specimens with the greatest shearing resistance were not the specimens of maximum unit-weight.

A still more open gradation of aggregate was used in the next series. (See Table 2.) These specimens were compacted to the maximum unit-weight obtainable and tested in unconfined compression. (See Fig. 6.) Specimens of this open gradation containing 3% bituminous material showed the greatest shearing resistance. It will be noted that this open gradation is much less critical in regard to the optimum amount of bituminous material. The maximum shearing resistance of this open-graded series was only 420 lbs. per sq. in. against 620 lbs. per sq. in. for the semi-open gradation and 865 lbs. per sq. in. for the dense gradation. Once more the specimens which showed the greatest shearing resistance were not the specimens of maximum unit-weight.

Densely-graded mixtures are not only stronger than open-graded mixtures, but they are also stiffer over a certain range of admixture. (See Fig. 7.) For percentages of admixture less than 5%, the densely-graded mixtures required greatest stress to produce a unit-strain.

To summarize briefly, the following results and conclusions, concerning the construction of base courses only, are presented:

(1) Densely-graded bituminous-aggregate mixtures which contain low percentages of bituminous material show the greatest shearing resistance in unconfined compression.

(2) Semi-open and open-graded mixtures show the greatest shearing resistance at one definite optimum amount of bituminous material for any given gradation, but this optimum becomes less critical as the gradation becomes more open.

(3) As the aggregate gradation becomes more open, the shearing resistance decreases sharply.

(4) For densely-graded mixtures or open-graded mixtures the percentage of bituminous material which results in maximum compacted unit-weight does not also result in maximum shearing resistance in this type of unconfined compression.

(5) Finally, over a certain range of admixture, the semi-open and open gradations are not as stiff as the dense gradation.

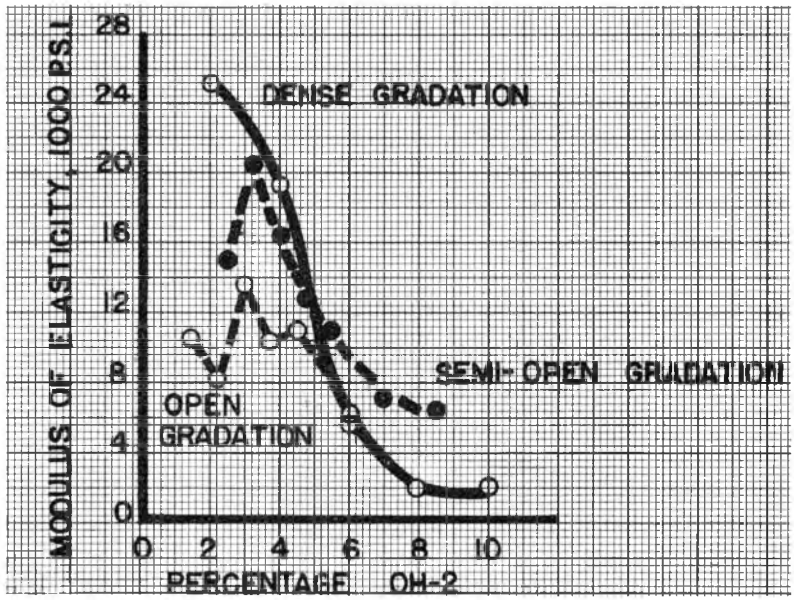

Fig. 7. Variation of modulus of elasticity with aggregate gradation and percentage admixture.

It is recognized that shearing resistance and stiffness are not the only criteria for a satisfactory bituminous-aggregate mixture. Adequate tensile strength, toughness, and weather resistance are also prime requisites in some instances. Although investigation of all of these factors has not been completed, the results to date suggest the possibility that maximum stability and minimum harmful base deflection would result from a lean, densely-graded, well-compacted base course and a richer, tougher riding surface of the same gradation.

THE USE OF AERIAL PHOTOGRAPHS IN IDENTIFYING GRANULAR DEPOSITS AND OTHER SOILS

J. E. Hittle, Research Engineer,
Joint Highway Research Project,
Purdue University

During the last two decades engineers have come to recognize the aerial photograph as a useful engineering tool. This