INVESTIGATIONS OF ASPHALTIC PAVING MIXTURES RELATIVE TO DEFORMATION OF SURFACES UNDER TRAFFIC

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Considerable advance is being made in the study of factors influencing the behavior of asphaltic paving mixtures Widespread interest is apparent in the work of the several organizations engaged in research dealing directly with the service behavior of asphaltic pavements, and although this interest is accompanied by an eagerness to apply in a practical way the results of laboratory studies, it is not surprising that in meetings where the subject is discussed there is introduced a cautionary note on too broad application of the indications of test data and of proposed theories of mixture design Investigators realize that there are qualities of a pavement to be controlled other than its resistance to displacement, and that a thorough investigation involves consideration of a multiplicity of factors, among which quantity and consistency of asphalt, percentage and type of mineral filler, size and grading of mineral aggregate, degree of compaction of the total aggregate and mixture, range of temperature of the pavement and the character of traffic upon it, are a few of major importance Moreover, pavement construction details, particularly as to obtaining the best practicable compression of the mixture and uniformity of contour are to be emphasized, as indicated by these studies, as of importance equal to the evolution of a theory of design in insuring entirely satisfactory service of a bituminous pavement.

A review of papers presented during the past year, however, indicates that a large amount of work has been done and that very definite advances in knowledge of bituminous mixture behavior have been made References to these discussions are appended to this report and supplement lists previously published in the Proceedings of the Highway Research Board

METHODS OF TESTING STABILITY

In general, the methods of testing stability outlined in the 1925 Report of the Committee have been adhered to Hubbard and Field (4)[1] have modified their method of preparing specimens from direct pressure to a method of controlled tamping followed by compression Abson (6) has described a shear test for stability

[1] Numbers refer to list of references on page 249.

measuring the force required to shear off a free section of a compressed cylindrical specimen. Emmons (5) describes a machine being developed by the Bureau of Public Roads which attempts to simulate the action of traffic on a pavement Essentially this machine consists of a series of steel rolls mounted between and near the periphery of two parallel steel discs which are rotated by a motor. The rolls resting on and passing over a rectangular specimen tend to deform it longitudinally The number of passages of the rolls necessary to produce an extension in the length of the specimen of 0 5 inch is taken as a measure of its resistance to displacement

LABORATORY STUDIES OF MIXTURES

Some data have been developed in the correlation of stability and characteristics of the asphalt cement Hubbard and Field (4) show increasing resistance to displacement with decreasing penetration and increasing softening point of the asphalt. The latter relation particularly appears to be modified by differing type of asphalt They did not establish a direct relation between stability and ductility of the asphalt To quote from a paper they conclude in reference to consistency of asphalt

"Of the physical characteristics of asphalt, which are usually determined, penetration at 70° F appears to exert the most direct and definite effect upon stability of the mixture at all temperatures and a general increase in stability, produced with a given mineral aggregate, accompanies decreases in penetration of the asphalt"

Nicholson (8) has studied the effect of the sharpness of sand particles on the resistance to displacement of sheet asphalt mixtures by the Hubbard and Field method of testing He notes a decided gain in strength with increased angularity of grain

The degree of compaction of sheet asphalt aggregates as indicated by voids tests, has received much attention The lack of a generally accepted and standardized voids test, as well as the existing uncertainty regarding the relative significance of voids determinations made in the presence of bitumen or in a dry condition, have contributed to the confusion on this subject Skidmore (1) and Abson (6) employ a measure of total aggregate voids with certain reservations as an approximate measure of the bitumen carrying capacity of the mixture Hubbard and Field (4), however, point out that under their method of preparing specimens an aggregate compacts to a degree varying with the percentage of bitumen present. Moreover, these authors assert that in any voids test the aggregate particles are not in absolute contact, no matter how thoroughly compacted, but are separated by air or liquid films

Their deductions on this phase of the subject and its influence upon pavement stability are as follows

"Closeness of packing or reduction of voids by compression of the mineral aggregate exerts a much greater stabilizing effect than the mere reduction of voids in the entire mixture Specific gravity or density of the mixture itself is therefore not always a direct indication of either degree of compression or stability

"Asphalt films surrounding the particles of compressed mineral aggregates may be thinner than the air or liquid films which exist in the usual methods of determining voids Therefore any attempt to proportion asphalt in a mixture with the idea of completely filling the voids as determined in the mineral aggregate may result in the use of too much asphalt with a marked reduction in stability

"The greatest stability for a given mineral aggregate has not been obtained with that proportion of asphalt which would produce the lowest percentage of voids in the compressed mixture The fact that further reduction of voids in the mineral aggregate is likely to occur under traffic after a pavement has been laid, due both to additional compression and internal wear, indicates that from the standpoint of stability mixtures should be designed so as not to be completely voidless even after thorough compression during construction Cases have been noted where pavements have been quite stable for a number of years following construction and have afterwards suddenly become unstable with no sudden change in traffic It is believed that in such cases while the proportion of asphalt was originally satisfactory for the degree of compaction of the mineral aggregate, a further reduction in its voids under traffic made the quantity of asphalt excessive"

Skidmore (1) and Abson (6) using a determination of voids in the aggregate as a basis of design, with limitations which they emphatically point out, proportion the amount of asphalt so as almost to fill the voids Skidmore states·

"If, then, the problem of producing greater stability of mixture resided alone in the reduction of film thickness, stability could be controlled at will in any mixture by simply reducing or increasing the amount of asphalt. That this would be dangerous practice, however, is immediately apparent, because, unless reduction in cementing medium is accompanied by a reduction of voids in the aggregate the mixture is immediately weakened in structure, and likewise because of increased porosity is weakened in its natural resistance to the attack of moisture. Hence, if structural soundness is to be preserved, the voids must be reduced before the bitumen is reduced Strange as it may seem, the more both are reduced the stronger the mixture becomes, provided two things are also done First, the bitumen must be maintained at a percentage as will almost fill the voids (or will fill them at, say, 350° F) and the mixture must be capable of compression to within, say 98% of maximum density"

It should be noted that they stress the workability of the mixture so designed as a limiting factor in the proportioning and give striking examples of unsufficiently plastic low aggregate-voidage and low asphalt mixtures

Although investigators differ in some respects in their method of applying determinations of voidage in the aggregate and in the compressed mixture to the study of stability, it will be seen that they point out that voidage has a direct bearing on pavement characteristics The voidage question, therefore, will continue to receive exhaustive consideration In order to clarify this situation, the voidage in aggregates and compressed specimens of mixtures as related to pavement voidage should be thoroughly studied As a step toward this, the Bureau of Public Roads is attempting to develop a machine acting on a vibratory principle for the compaction of aggregates, which has been described by Emmons (5) The same agency is investigating the voids existing in the aggregate of pavements which have been subjected to long periods of service

The extreme importance and close interrelationship of bitumen content and filler is emphasized by virtually all investigators, who furthermore indicate the greater sensitiveness of high filler mixtures to change in percentage of asphalt as affecting their plasticity Hubbard and Field (4) express this as follows.

"In order to secure maximum stability in paving practice the percentage of asphalt must be controlled within much narrower limits for high filler low void aggregates than for relatively low filler high void aggregates

"Next to closeness of packing of the mineral aggregate, percentage of filler appears to be the greatest stabilizing factor in paving mixtures and provided the proper proportion of asphalt is used increased stability is invariably produced by increase in filler at least to the extent that such addition decreases voids in the mineral aggregate If, however, the proper proportion of asphalt is not used an increase in filler may result in decrease in stability "

Correlation of service behavior of pavements with laboratory test results is well under way. Of possibly equal importance with their composition, the conditions of use influence pavement behavior, Emmons and Anderton (2) show that mixtures of very unstable character may satisfactorily withstand heavy traffic at low temperatures Studying the relation of temperature and the results of their laboratory stability test, Hubbard and Field (4) draw the following conclusion.

"The stability of a given compressed mixture appears to be directly proportional to its temperature but the proportion varies for different mixtures so that of two mixtures which show the same stability at 140° F one may be much harder and more likely to crack at low temperatures than the other."

In the study of actual pavement behavior Hubbard and Field (7) found that mixtures of the same laboratory test values might either prove satisfactory or fail depending upon the character of the traffic to which they are exposed

In concluding, it may be remarked that as a result of several years active work investigators of bituminous mixtures have not only brought out many facts of extreme importance leading to a scientific combination of aggregates, mineral filler and asphalt to produce pavements of high resistance to deformation, but at the same time have been defining this problem and its relation to others involved in the most successful construction of asphalt pavements The application of research data to practical construction generally will undoubtedly be possible within a short time, and is, in fact, already being rapidly developed.

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