GENERAL DISCUSSION

MR. NORMAN W. MCLEOD.[1]—This symposium on the specific gravity of bituminous coated aggregates is very timely. The various papers and discussions that have been presented should help to clarify this topic.

I would like to comment briefly on our own approach to bituminous paving mixture design, and on our reasons for using the ASTM bulk specific gravity of the aggregate for this purpose.

The ASTM bulk specific gravity of the aggregate was preferred because it gives the correct volume of the solid framework for a bituminous paving mixture that is provided by the aggregate. The ASTM apparent specific gravity and the "effective" specific gravity both indicate the volume occupied by the aggregate to be less than it actually is.

The principal objection usually raised against use of the ASTM bulk specific gravity of the aggregate is that it can result in negative air voids for the compacted paving mixture as a whole. However, this result can only occur where there has been failure to take absorption of asphalt into the aggregate particles into account. Consequently, it is important to separate the total asphalt content into absorbed and non-absorbed asphalt.

A serious error that is usually made when designing bituminous paving mixtures on the basis of either ASTM apparent specific gravity or "effective" specific gravity for the aggregate is the assumption that the total bitumen content is available to function normally as a binder. Only the portion of the bitumen that is not absorbed into the water-permeable porosity of the aggregate particles can function in this manner.

We are in agreement with those who feel that only the air spaces between the coated aggregate particles should be considered as part of the air voids of a compacted paving mixture. No portion of the water-permeable porosity of the individual aggregate particles should be included when the "per cent air voids" for a compacted paving mixture is being computed.

In addition to their value for determining the theoretical densities of paving mixtures, we believe that the gas pressure methods and those described by Mr. Rice[2] and by Mr. Serafin[3] should be employed as an indirect procedure for determining the amount of bitumen that has been absorbed into the water-permeable porosity of the aggregate particles in a compacted paving mixture. These indirect values can be compared with directly measured values of bitumen absorption given by the method described by Ricketts, Sprague, Tabb and McRae in 1954.[4]

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[2] See p. 43.

[3] See p. 25.

[4] W. C. Ricketts, John C. Sprague, D. D. Tabb, and J. L. McRae, "An Evaluation of the Specific Gravity of Aggregates for Use in Bituminous Mixtures," *Proceedings*, Am. Soc. Testing Mats., Vol. 54, p. 1246 (1954).

MR. C. A. CARPENTER.[5]—Mr. McLeod's remarks—unintentionally I am sure—implied that the people who have presented the papers of this symposium are unaware of the point that was brought out by him.

Actually, the fundamental concern today was with the voids that remain between the particles of aggregate, and the test methods that have been presented are not presented with the idea of analyzing technically and exactly all phases of the situation within the mixture. They are simply means to an end to minimize manpower requirements or, to put it another way, to make better use of the manpower in the laboratories.

Today, the big problem all over the country is the lack of manpower to make all of the scientific studies that seem desirable, unless sometimes short-cuts can be utilized or empirical methods used that will give the answers in the routine work with a minimum expenditure of man hours. As Mr. McLeod said, these things should be done with one's eyes open knowing what the actual scientific implications are but, in fairness to the authors, it is necessary to emphasize that their advocacy of the time-saving methods described does not imply that the scientific aspects of the matter so ably discussed by Mr. McLeod have been overlooked by them.

MR. J. L. MCRAE.[6]—Mr. McLeod's approach of using the bulk specific gravity is very thought-provoking and interesting, but it should be considered as just another interim solution similar to the bulk impregnated specific gravity since it is based on the premise that the air within the open pores of the aggregates can be ignored even though these air pockets interconnect with the remainder of the three-phase system of aggregate, asphalt, and air.

Expedient methods are certainly needed to help use existing voids criteria until better methods are developed. However, further research by the U. S. Corps of Engineers' Flexible Pavement Laboratory at Vicksburg, Miss., has indicated conclusively that the critical air content of a bituminous pavement is a variable, being not only a function of aggregate porosity but also aggregate gradation. Therefore, if some specific gravity method could be found to handle the variations in porosity, there would still be the problem that the critical air content varies with variations in aggregate gradation. It is certainly highly desirable to develop an entirely new approach to bituminous pavement design that is independent of voids criteria. This is what has been attempted with the kneading-compaction test discussed in the paper presented earlier in this Symposium.[7]

In addition to the above considerations, to reach an ultimately satisfactory solution the air to be measured should be defined as all the air in a pavement that is free to expand and contract with changes in temperature and pressure. This volume of air should be measured quantitatively the same as the asphalt. (To do this, ASTM apparent specific gravity methods[8] can be used for all practical purposes.) It cannot be expected that all mixes should have the same critical bitumen content. Why should it be implied that they all have the same critical air content? The critical air content should be looked at

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[7] See p. 62.

[8] Method of Test for Specific Gravity and Absorption of Coarse Aggregate (C 127 – 42), and Method of Test for Specific Gravity and Absorption of Fine Aggregate (C 128 – 42), 1955 Book of ASTM Standards, Part 3, pp. 1231 and 1233, respectively.

as a variable that characterizes each particular type of pavement. For instance, a slag pavement has a high critical air content and this type of pavement is characterized by its ability to carry a high bitumen content without flushing. On the other hand, a densely graded, nonporous limestone aggregate has a low critical air content, and this type of pavement characteristically requires a lower bitumen content.

MR. J. ROGERS MARTIN.[9]—It is possible to get in the position of not seeing the forest for the trees. It should be remembered that considerable emphasis has been placed on air voids in the design of mixtures for the past few years as an outgrowth of Clifford Richardson's work which was carried out over fifty years ago, when no stability tests were available.

Dependable stability tests are now being developed. Therefore, it should be less and less necessary to be dependent on air voids as criteria for this design.

After all, the object is to design a pavement that will have adequate stability. If an adequate stability curve is obtained and if an adequate stability test is devised, which can be completely dependable, what does it matter what the voids are?

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