THE PRACTICAL APPLICATION OF THE DESIGN METHOD OF ASPHALTIC MIXTURES TO PAVEMENT CONSTRUCTION

by
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The primary reason for the investigation which is the subject of this symposium was to provide methods for the solution of certain practical problems which are common to all asphalt paving projects. These problems may be listed as:

a. Are aggregate materials which are locally available suitable for use in asphalt pavements?

b. If two or more aggregates are to be blended, what are the desirable proportions for each?

c. What percent asphalt in the paving mixture should be used as a basis of estimate for total quantities required?

d. Is the asphalt mixture as produced and laid as a pavement of satisfactory quality, containing the proper amount of asphalt for the maximum intended service?

Items a, b, and c involve preliminary design work and should be completed well in advance of actual construction. Item d includes a final design based on materials actually taken from plant bins and includes constant sampling, testing, and analysis of the asphalt mixture as it is being produced.

With respect to items a, b, and c, the available aggregate may be restricted to a single source such as from a producer of commercial slag or a limestone rock quarry. In such cases the preliminary design may be limited to the preparation of a few mixes to determine the amount of filler and asphalt which might be required. In other cases a considerable choice of aggregate may be available, such as several local deposits of sand and gravel. In such cases it may be desirable to prepare a number of different trial mixes as a basis for selecting a final design which will provide for a satisfactory mix at the most economical price. For example, a local sand-gravel aggregate which is unsatisfactory by itself may be entirely satisfactory if blended with a very fine sand and a nominal percentage of a commercial filler. It is believed that the test procedures, the method of anaylsis, the test property criteria which have been outlined in previous papers provide adequate tools and a satisfactory method to solve the problems presented by items a, b, and c. Such preliminary studies take time and must be done well in advance of the construction period if the final plans and estimates are to reflect the results of the preliminary investigational work. The value of a reliable preliminary design, firm estimates as to quantities of material required, and prior approval of material for use is readily appreciated by responsible engineers familiar with the problem.

While the preliminary design and analytical work can probably be best accomplished in a central laboratory, the actual final pavement design used in the field and daily construction control tests (item d of first paragraph) must be done in a laboratory set up at the site of the mixing plant. With respect to a final mix design, it should be recognized that certain factors always are present which may cause modification of the preliminary design. Some of these factors include variation in gradation due to errors in sampling aggregate in the deposit or stock pile, changes made by crushing oversize material, and changes produced by drying the aggregate.

With respect to plant control during construction, samples of the mixture must

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be taken constantly, specimens prepared and tested, and the results, immediately analyzed if positive action to assure the production of a uniform mix of good quality is taken. Samples sent to a central laboratory for test are suitable only for record purposes and serve no other function. Also, the practical aspects of the construction control problem demand that the test procedure and equipment be simple to operate and enable test results to be obtained quickly. The test procedures which have been developed and presented in the preceding paper involve sampling of the hot asphalt mixture from trucks as they leave the plant, the compaction of several test specimens in molds, cooling to 140 F. for a brief period, and then testing for stability and flow. By this method results can be made available with in less than an hour after sampling. It is believed that the ability to obtain and test large numbers of test specimens with the results immediately available is of prime importance. Complicated procedures that limit the number of tests that can be secured and in which the results are long delayed have no place in the stress of a construction job. The method of design and control has been put to actual use during the construction of several paving projects at the Waterways Experiment Station. Satisfactory blends of local aggregates have been developed, optimum asphalt content determined, and the production of the asphalt plant closely controlled by a systematic sampling and testing schedule. The discussion presented in this paper is based on practical experience obtained during actual construction operations and not on theoretical hypotheses.

A brief reference was made above to certain factors that tend to modify the preliminary design mix. No attempt should be made to prepare test specimens for use as the final design until the plant has been properly adjusted to produce the desired aggregate gradation. Since one or more of the aggregate sources may contain quantities of material that vary considerably in gradation, every effort should be made to improve the uniformity of the gradation of the material by proper construction methods. The careful placement of large aggregate stock piles at the site of the work which permit thorough mixing of material is desirable. If two or more aggregates are being used, the proportion of each to produce the desired blend must be adjusted carefully. Finally the efficiency of the screens which separate the material into the different bins must be determined so that the proper amount of aggregate can be taken from each to meet the desired job mix gradation curve and also maintain a proportionate balance in the different aggregate bins. This may be quite difficult if the screens tend to choke up or if there are marked differences in the moisture content of the aggregate from time to time. Obviously a job mix formula should utilize the entire amount of aggregate available if a satisfactory mix can be produced. Until these adjustments are completed a few specimens can be prepared and tested as an aid to selecting a tentative approximate asphalt content during the period of plant adjustment.

With the plant adjustments made with reasonable accuracy, several batches should be run through the plant at about four asphalt contents intended to bracket the optimum amount. A sample of each mixture should be taken and eight specimens should be prepared at each asphalt content. The test properties for each mix should be determined and the values for each plotted so that curves can be drawn through the plotted points. Optimum asphalt can be determined and the values for stability, flow, percent voids total mix, and percent voids filled with asphalt can be compared with the design criteria. Depending on the results of this analysis, certain decisions are made and may include only a revision of asphalt content or some slight adjustment in the bin proportions. At the time samples of the asphalt mixture are taken to determine the final design, samples should also be taken of the aggregates from the several plant bins for sieve analysis. From a sieve analysis of the material in each bin, and knowing the amount from each weighed into the hopper, a gradation curve for the combined aggregate can be computed. It is important to know the exact amounts of coarse and fine aggregate, since often they may be of different type and have different specific gravity values. Since values for specific gravity are used in the formulas to compute the density relationships, the exact proportion of each type aggregate used in the mix should be determined. Also, in the event that the trial mix proves unsatisfactory and fails to meet the design criteria, a study of the combined aggregate gradation curve will usually indicate the proper steps necessary to correct the aggregate to produce a satisfactory mix.

With the mix design established, check specimens should be made at regular intervals. These should be tested for stability and flow, and occasionally the unit weight and void relationships can be computed. Reasonable latitude should be tolerated in test results, as some variations in the values can be normally expected. However, if there is a definite trend for, say, the flow to be high, then a study of the aggregate gradation may give a clue as to the trouble. It is seldom necessary to rerun a complete curve of test properties versus asphalt content, even though considerable changes are subsequently made in aggregate gradation from the preliminary mix design. If at optimum asphalt the flow was 15 for a given aggregate gradation, minor changes in gradation may require a different amount of asphalt. At optimum, however, the flow still will be about 15. In this respect it should be noted that the design criteria indicate a maximum flow of 20 for a satisfactory mix. These criteria are based on the results of the traffic tests previously discussed. Practically every asphalt paving item with a flow value not exceeding 20 was satisfactory, and, in general, those with flow values in excess of 20 were unsatisfactory. It is believed that if for a given type and gradation of aggregate the flow value at optimum is, say, 15 and if subsequent tests indicate the flow value has increased to 20, it is probable that the mix would still be entirely stable. It is reasonable to assume, however, that optimum asphalt has been exceeded and the asphalt content probably should be reduced until the flow is again about 15. By the same method of reasoning it is possible that a mix which has a flow of 20 at optimum asphalt still may be satisfactory if occasionally the flow increases to 25.

Experience has indicated (as explained in Paper No. 5) that it is possible with good construction rolling to place the pavement at a density equal to 98 percent of that secured by the laboratory compaction effort (50 blows of a 10-lb. hammer with 3-7/8 in. face falling 18 in. applied to each face of the specimen). Thus, if test samples weigh 140 lbs. per cu. ft., the completed pavement should be compacted to a minimum density of 137 lbs.

It should be emphasized that good construction control can be secured only by providing proper facilities for making the required tests, competent and sufficient personnel to do the work, and prompt recording of the results to permit an early analysis to be made of the results obtained. A systematic laboratory program insures a high quality finished pavement and eliminates the necessity for "guesses" to be made by the engineer in charge.