SELECTION OF TEST EQUIPMENT

by JOHN M. GRIFFITH*

The first phase of the general project "Investigation of the Design and Control of Asphalt Paving Mixtures" *(1)* was the selection or development of a simple method of asphalt pavement design and control which would utilize easily portable testing apparatus that could be used in the field. It was particularly desired that the apparatus be adaptable to the California Bearing Ratio (CBR) testing equipment which was available to Corps of Engineers troops. This paper covers the primary aspects of the investigation made to select a method of design and control which would fit these requirements.

TULSA REPORT

Prior to the initiation of the investigation described in this symposium, the Tulsa District, Corps of Engineers, conducted a comprehensive laboratory investigation which is summarized in an unpublished report prepared by that office and titled "Comparative Laboratory Tests on Rock Asphalts and Hot-Mix Asphaltic Concrete Surfacing Materials." *(2)* Included in this report was a comparative study of the relative merits of four test methods which were most widely in use at that time. Comparative tests indicated that the Hubbard-Field test was the most satisfactory method of the four for general utility.

SELECTION OF MARSHALL EQUIPMENT

The results of the Tulsa investigation were studied, and their conclusions appeared to be reasonable based on their data. However, other factors had to be considered in the selection of test equipment to meet the requirements of the Corps of Engineers. In addition to selecting or devising a test method which was reliable and sensitive to the various factors entering into the design of asphalt pavements, it was also considered that the test equipment should be adaptable to the CBR test apparatus and that it should be easily portable. The available test equipment most nearly conforming to these latter requirements was that which had been devised by Bruce G. Marshall while working with the Mississippi State Highway Department. The Marshall stability equipment, however, had not been included in the Tulsa investigation previously referenced. In order to determine the over-all adequacy of the Marshall equipment in the design of asphaltic pavements the decision was made to conduct a series of comparative tests using both the Marshall and the Hubbard-Field equipment. The Hubbard-Field equipment was chosen for these comparative tests on the basis of the data contained in the Tulsa report and because it was one of the most widely used methods of asphalt pavement design at that time.

A detailed description of the Hubbard-Field method and apparatus may be found in a publication by the Asphalt Institute titled "The Rational Design of Asphalt Paving Mixtures." *(3)*

The test apparatus required for the Marshall test is relatively simple and compact. Figure 1 shows a view of the testing machine and the Marshall test head as developed at the start of the investigation by the Flexible Pavement Laboratory of the Waterways Experiment Station. Figure 2 shows the original adaptation of the Marshall test apparatus to the CBR testing frame furnished to troops.

*Engineer, Chief, Bituminous Section, Flexible Pavement Branch, Waterways Experiment Station, CE, Vicksburg, Miss.

The sample of asphaltic mixture to be tested by the Marshall method was prepared by a standard compaction procedure in a 4-in. diameter mold to a height of 2½ in. This procedure consisted of compacting the specimens on one side only by 15 blows of a 10-lb. hammer falling 18 in. on a 2-in. diameter foot, followed by a 5000-lb. static leveling load applied over the surface of the specimen. The prepared sample is inserted into the Marshall test head (see Figure 3) after being heated in a hot water bath to 140 F., and the load is applied to the peripheral area of the specimen. The stability of a specimen is the maximum load in pounds which the compacted specimen will withstand. Load is applied to the test head by means of a mechanical jack at a rate of 2 in. per minute. The load is measured by means of a calibrated proving ring.

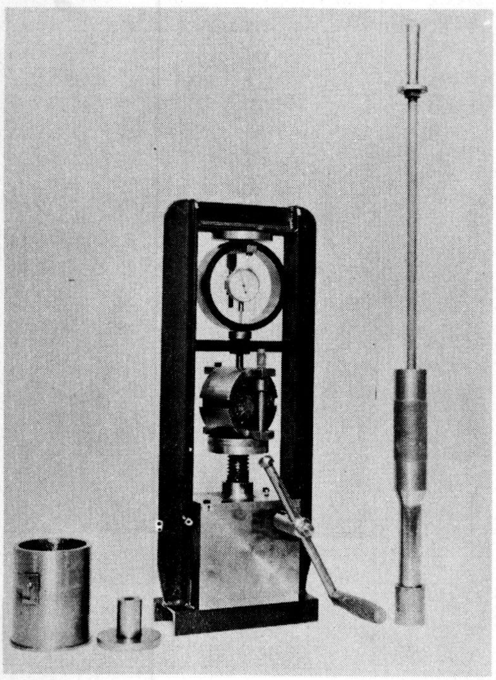


Figure 1. Marshall Testing Machine and Compaction Equipment Available in Field CBR Testing Kits

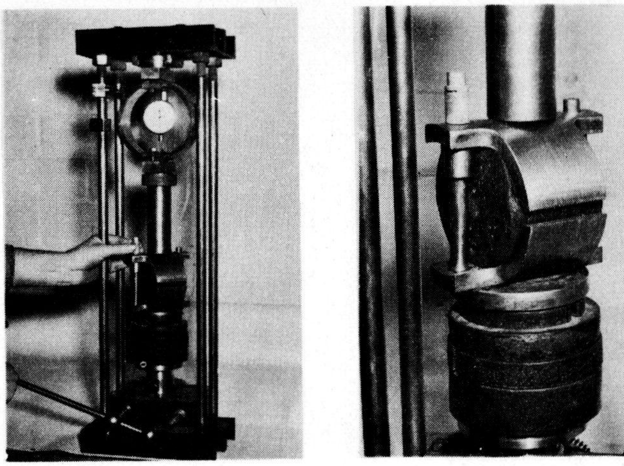
DEVELOPMENT OF FLOW METER

Prior to the initiation of the comparative laboratory test series using the Marshall and Hubbard-Field equipment it was recognized that some device for the measurement of strain of the test specimen would probably be a valuable addition to the Marshall stability test. Accordingly, a device named the "flow meter" was originated. The flow meter measures the total amount of movement between the two halves of the compression ring, or Marshall test head, as the specimen is failed. The operating principle of the flow meter may be observed by reference to Figure 3. The flow meter is a device consisting of a sleeve within which there is a cylinder graduated vertically on its side in units of one-hundredth of an inch. The internal cylinder fits snugly into the sleeve so that slight pressure is required to move the cylinder with respect to the sleeve. By means of the flow meter the strain occurring within the test specimen between no load and maximum load (Marshall stability) is determined.

COMPARISON OF HUBBARD-FIELD AND MARSHALL TEST APPARATUS

In the comparative test series three primary variables were introduced into the specimens compacted and tested by the two methods under study. In one series of tests the gradation of the aggregate blends used was varied from mixtures containing only 30 percent of gravel (material coarser than No. 10 size) to mixtures containing 70 percent of gravel. In another series of tests two basic sand gradations were used and the filler content of the mixtures was varied. The third variable consisted of changing the asphalt content in the two test series outlined above. Specimens were prepared in quadruplicate for each condition of test in order to obtain good average data on which to base the comparison of the methods.

The test data obtained in this initial comparative series of tests and in other phases of this investigation are considered to be too voluminous for extensive presentation in this symposium; therefore, the findings in this comparative test series are discussed only in general terms,



General View Close-up

Figure 2. Adaptation of Marshall Stability Testing Head to Field CBR Testing Frame

and the detailed data are not presented herein.

Both the Marshall and the Hubbard-Field equipment were found to be sensitive to, and to detect by measurement, changes in gradation, variations in filler content, and changes in asphalt content. In either test the stability of the prepared samples increased with increasing asphalt content to some maximum value, after which the stability decreased. Both test methods indicated that a maximum stability was attained when the mixtures contained approximately 50 - 60 percent coarse aggregate in the particular blends used for these tests. Both test methods indicated that in sand-asphalt mixtures, where filler content was varied, the stability of the mixture increased with increasing filler content as indicated below. In the coarse-graded sand-asphalt mixtures, 15 percent filler produced maximum stability by both methods, and additional amounts of filler decreased the stability of the mixtures. In the fine-graded sand-asphalt mixtures, the stability by both test methods continued to increase with increasing filler content up to 20 percent, the maximum used in these tests. Results of the tests described above indicated that both test methods were sensitive in a comparable manner to changes in asphalt content and to changes in aggregate gradation and filler content.

Density determinations on specimens compacted as prescribed in the two test methods indicated that density of the compacted specimens increased with increments of asphalt cement to a maximum value, after which they decreased, For any given mix, however, the maximum unit weight, as determined by the high point of the curve, was greater in all cases for the Hubbard-Field than for the Marshall compaction procedure. A comparison with a very limited amount of field data available at that time indicated that compaction by the method used with the Marshall test more nearly duplicated densities obtained during normal construction than did compaction by the Hubbard-Field method.

In general, it was noted that the amount of asphalt required to produce maximum stability was roughly about 2 percent less in the Hubbard-Field than in the Marshall test. This difference is attributable to the greater densities obtained in samples compacted by the Hubbard-Field method. It was apparent that an optimum asphalt could be selected on the basis of

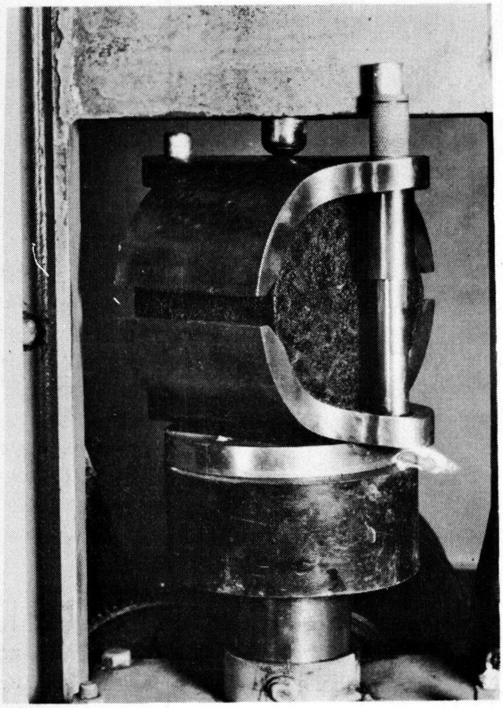


Figure 3. Marshall Specimen in Testing Position

stability by either test; the questionable factor being only the density to which the specimen need be compacted. The development of compaction technique was not considered pertinent to this phase of the study; however, subsequent laboratory work, described in a later paper, dealt very thoroughly with compaction procedures.

Comparative results on flow values were not possible in this investigation since the Hubbard-Field test did not include a comparable measurement. Flow values were measured, however, on the Marshall specimens, and it was noted that the flow value increased in a logical manner with increasing asphalt content. It was considered that when properly evaluated, the flow value would be a valuable measurement in the test procedure.

CONCLUSIONS

On the basis of the study briefly outlined above it was concluded that the Marshall equipment compared favorably with the recognized Hubbard-Field equipment as to measurement of stability, sensitivity to asphalt content, and reproduction of test results. Since the Marshall apparatus utilized equipment that could be readily incorporated into the CBR test apparatus and would be easily portable, it was decided to adopt the Marshall apparatus and to develop and perfect it for both design and control of bituminous pavements in the field.