Highway Materials

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12-8 MARSHALL METHOD OF MIX DESIGN

Perhaps the most widely used method of bituminous-mix design is the Marshall or U.S. Army Corps of Engineers method. Developed by the Corps of Engineers during World War II, the test is a relatively simple one and uses equipment that can be set up easily in a portable laboratory.

In this procedure, a sample specimen 4 in. in diameter by $2\frac{1}{2}$ in. high is prepared by compacting in a mold with a compaction hammer that weighs 10 lb and has a free fall of 18 in. Depending upon the design traffic, either 35, 50, or 75 blows of the hammer are applied to each side of the specimen. After overnight curing, the density and voids are determined and the specimen is heated to 140°F for the Marshall stability and flow tests. The specimen is placed in a cylindrically shaped split

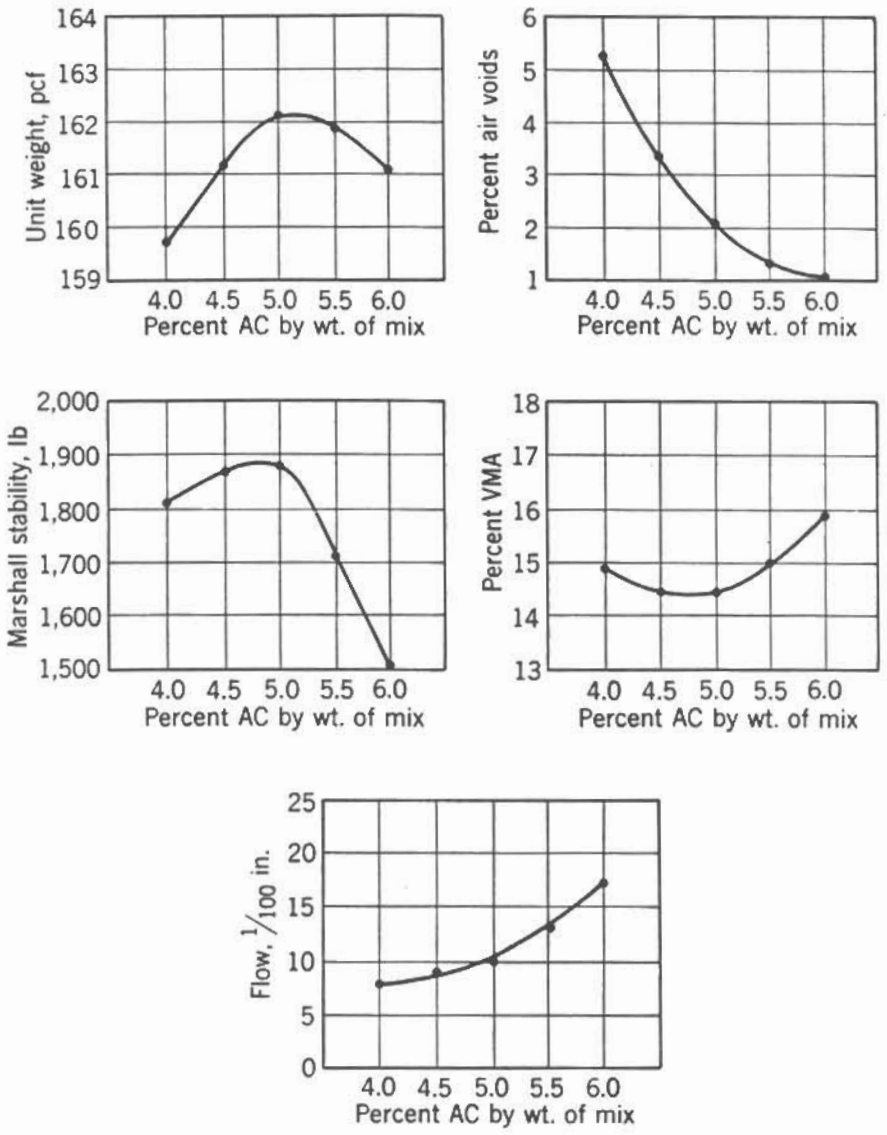

Fig. 12-3 Test-property curves for hot-mix-design data by the Marshall method. (*From Asphalt Institute* [2].)

breaking head and is loaded at a rate of 2 in./min. The maximum load registered during the test, in pounds, is designated as the *Marshall stability* of the specimen. The amount of movement, or strain, occurring between no load and the maximum load, in units of 0.01 in., is the flow value of the specimen. As with the Hubbard-Field test, specimens are prepared at a range of asphalt contents.

Figure 12-3 shows typical test results plotted in routine form. As usual, measurements made on the specimens before testing for stability are used for the unit-weight and void calculations. The stability value obtained for each individual specimen is modified if the specimen thickness is greater or less than the nominal height of 2 in.

Table 12-2 Marshall design criteria

Traffic category	*Heavy and very heavy*		*Medium*		*Light*	
No. of compaction blows each end of specimen	75		50		35	
Test property	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
Stability, all mixtures	~~750~~ 1500		~~500~~ 750		500	
Flow, all mixtures	8	16	8	18	8	20
% air voids						
Surfacing or leveling	3	5	3	5	3	5
Sand or stone sheet	3	5	3	5	3	5
Sand asphalt	5	8	5	8	5	8
Binder or base	3	8	3	8	3	8
% Voids in mineral aggregate: See Fig. 12-4						

Table 12-2 shows Asphalt Institute Marshall design criteria [2]. These criteria are applied to the curves and a suitable asphalt percentage is determined. A common procedure for doing this is to take the most desirable asphalt percentages for stability, unit weight, and percent voids and average them. This average value should satisfy the required criteria and if it does not, it should be adjusted until a value is found that will satisfy all criteria. If no such asphalt percent exists, then a different aggregate gradation must be selected. Normally, the percent asphalt selected will produce a value for voids in mineral aggregate that will satisfy the chart shown in Fig. 12-4.

As with the Hubbard-Field method, if several aggregate gradations are used the mix showing the higher stability will generally be selected, provided that economic considerations are equal. However, it should be pointed out that high stability accompanied by abnormally low flow values is not desirable. Usually a flow value of less than 0.08 in. is considered undesirable. A pavement made with a mixture having this low a flow would be rather rigid and brittle and would have a tendency to crack early in its life. On the other hand, flow values of over 18 are also to be avoided, but usually such high flow values are accompanied by low stability values. Thus, the Marshall mix design takes into account three of the basic properties discussed earlier, i.e., stability, durability (by controlling percent air voids), and flexibility (as reflected in values of flow).

Because of the use of this method by the Corps of Engineers and many state highway departments, a large amount of field experience has been correlated with results obtained from laboratory specimens. For

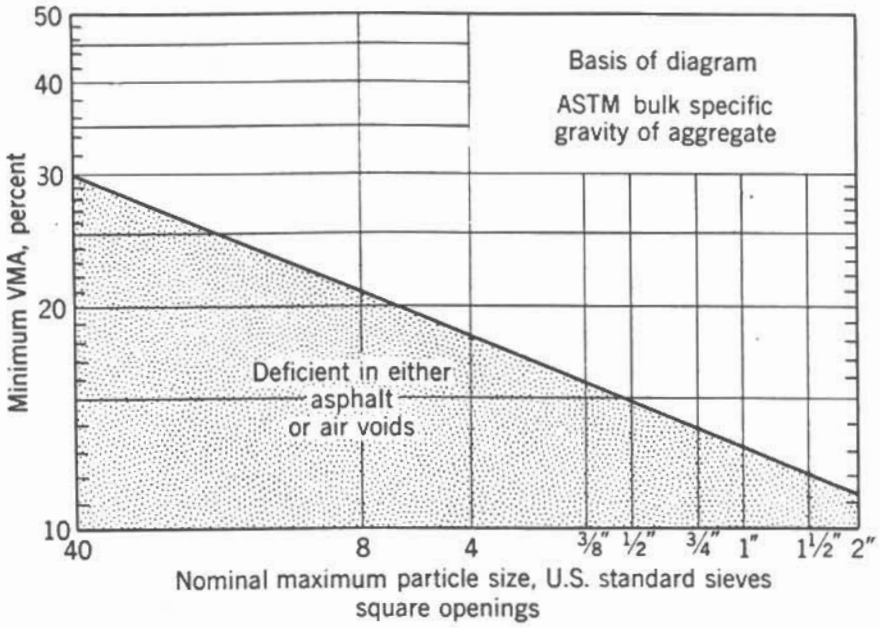

Fig. 12-4 Relationship between minimum allowable voids in mineral aggregate (VMA) and nominal maximum particle size of aggregate for compacted, dense-graded paving mixtures. (*From Asphalt Institute* [2].)

the design criteria that are used by various state highway agencies, the reader is directed to *Highway Res. Bd. Bull.* 160 [4].

The Marshall-test procedure is described by ASTM D 1559-65, Test for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus.