State of Nevada
Department of Transportation
Materials Division

METHOD OF TEST FOR DETERMINING OPTIMUM BITUMEN RATIO OF BITUMINOUS PAVING MIXTURES

SCOPE

This method covers the procedure for the design of bituminous mixtures, which includes the determination of optimum bitumen ratio.

PROCEDURE

The purpose of this method is not to teach someone how to perform a mix design, but rather to aid the experienced bituminous engineer in the development of a durable long lasting bituminous concrete mix. Nevada has a wide variation in environment, traffic and aggregate quality that must be considered when designing flexible pavements. The task of the bituminous engineer is not to select a value from a rigid or limited system, but rather base his/her recommendation on an evaluation of all relative factors pertinent to a specific project.

To identify an optimum binder content for a particular mixture, a successive series of steps are employed. The optimum value is the one that will produce a mix that will meet the projected structural strength needs, and at the same time give the durability necessary to resist adverse environmental effects for the design life of the project.

APPARATUS

The apparatus required for this test method is outlined in each of the individual test methods.

METHOD

1. Check transmittal for required information. (Test Method Nev. T200)

2. Split down aggregate stockpile samples. (Test Method Nev. T203)

3. Perform wash test and sieve analysis to obtain gradations, on individual stockpile aggregates. (Test Method Nev. T206)

4. Perform sodium sulfate soundness, on combined aggregates. (AASHTO T 104)

5. Perform L.A.R., abrasion % loss, on combined aggregates. (AASHTO T 96)

6. Perform LL, PL tests and calculate PI, on individual stockpile aggregates. (Test Method Nev. T210, T211 and T212)

7. Perform sand equivalent, on combined aggregates. (Test Method Nev. T227)

8. Perform kerosene specific gravity, on combined aggregates. (Test Method Nev.T224)

9. Perform specific gravity of fine aggregate, on combined aggregates. (AASHTO T 84)

10. Perform specific gravity of coarse aggregate, on combined aggregates. (AASHTO T 85)

11. Perform absorption of coarse aggregate, on individual stockpile aggregates. (AASHTO T 85)

12. Determine percent fractured faces, on individual stockpile aggregates. (Test Method Nev. T230)

13. Combine, batch and lime aggregates. (Test Method Nev. T303)

14. Mix aggregate with asphalt, compact and perform stability tests. (Test Method Nev. T303)

15. Obtain bulk specific gravity and bulk density of compacted samples. (Test Method Nev. T333)

16. Calculate percent air voids of compacted bituminous mixtures. (Test Method Nev. T321)

17. Obtain theoretical maximum specific gravity of bituminous mixture. (AASHTO T 209)

18. Obtain percent air voids using maximum theoretical gravity. (AASHTO T 269)

19. Determine the original tensile strength, percent retained strength and visual stripping (Lottman tests) using compacted samples prepared at the estimated optimum bitumen ratio. (Test Method Nev. 341 and T342)

20. Calculate VMA at optimum bitumen ratio. (Test Method Nev. T338)

In practice, the first step is to test the proposed aggregate. The aggregate must be shown to meet or exceed all source acceptance and project specification requirements. These requirements must be met before proceeding with subsequent testing.

With respect to materials, aggregate quality has the greatest influence on long term durability. Water absorption, surface texture, particle shape, particle size distribution and specific gravity must be taken into consideration. It should be noted that this does not guarantee a good final product. Mix designs will be rejected due to tenderness and instability, while the aggregate met all other design criteria.

Asphalt type and grade, with or without modification, along with all of the above mentioned factors must be taken into consideration. Prior to starting a mix design, a sample of the asphalt cement from the supplier (refinery sample or hotplant tank sample) shall be submitted for testing. This sample, after it has passed all test requirements, is used to perform the mixture design. The asphalt cement must meet all specification requirements before performing the mix design. Construction type is a very important consideration relative to location, traffic and aggregate quality. For rehabilitation projects, the type, severity and extent of pavement distress influences the selection of type and grade of asphalt cement.

Samples are batched having a range of bitumen ratios that will give data points on both the lean side and the rich of optimum. This range of bitumen ratios is commonly known as the "curve".

After the curve has been run, the resulting data is evaluated to determine if there are sufficient data points on either side of optimum. If not, additional samples must be batched and run to fill in the necessary data.

In identifying optimum for a particular mix, first determine which samples meet both air void and stability requirements. At this point consider the environmental area where this material is to be used and the type and amount of traffic to be carried. Then, from review of test results of the qualifying samples, plotted data points, and giving consideration for environment and traffic levels, select an estimate of optimum.

At the estimated optimum bitumen ratio, prepare samples for maximum theoretical specific gravity (Rice) determination and Lottman testing.

From the result of the maximum theoretical specific gravity (Rice) determination, adjust the air void percentage of each point on the curve. This gives a more accurate representation of air voids than only a calculated theoretical value.

From the data determined from testing, the following values are calculated with which to apply the required criteria.

VMA, Voids in Mineral Aggregate.

VFA, Voids Filled with Asphalt.

Film Thickness

Apply the project specification requirements to test determinations and calculated values to assure that all project specification requirements have been met. After specification requirements are met, project criteria is applied to further identify the optimum bitumen ratio.

CRITERIA

1. Film Thickness:

The thickness of the asphalt cement coating surrounding the aggregate particles. This is a theoretical value given as an average film thickness derived as follows:

$$T_F = \frac{V_{asp}}{SA \times W} (304800)$$

Where: T_F = Average film thickness in microns.

V_{asp} = Effective volume of asphalt cement in cubic feet.

SA = Aggregate surface area in ft^2 per lb of aggregate.

W = Weight of aggregate in pounds.

Film Thickness shall be 8 microns minimum for projects north of US 6 and 6 microns minimum for projects south of US 6.

2. Voids Filled with Asphalt (VFA):

The percent of the volume of the Voids in Mineral Aggregate (VMA) that are filled with asphalt cement.

The VFA is derived as follows:

$$VFA = \frac{V_{EAC}}{V_{EAC} + Vv} \times 100$$

Where: VFA = Voids filled with asphalt cement.

V_{EAC} = Volume of effective asphalt cement.

Vv = Volume of air voids.

The VFA shall be in the range of 70 percent to 80 percent.

3. Visual Stripping:

The amount of asphalt stripped from the aggregate after Lottman conditioning (Test Method Nev. 341).

a. Lime will be required for those mix designs performed without hydrated lime, if any visual stripping is noted.

b. For those mix designs performed with hydrated lime, and visual stripping is still noted, marination (48 hour wet-cure) with hydrated lime shall be required.

c. Lime is added at a rate of 1.5% by dry weight of aggregate. If necessary to control stripping, the rate may be increased to 2.5% maximum.

d. If, after the addition of lime and wet cure, there is 30 percent or greater stripping, the mix shall not be approved for use.