



PUTTING RESEARCH TO WORK

BRIEF

Flow Number as a Discriminating HMA Mixture Property

The flow number test is used to measure the rutting potential of asphalt concrete mixtures. It is a variation of the repeated load, permanent deformation test that has been used by researchers since the 1970s. The flow number is one of three tests that were identified in National Cooperative Highway Research Program (NCHRP) Project 9-19 as simple performance tests related to the rutting resistance of hot mix asphalt (HMA) mixtures; the others are dynamic modulus and flow time. Flow number is defined as the number of load pulses when the minimum rate of change in permanent strain occurs during the repeated load test and is determined by differentiation of the permanent strain versus number of load cycle curve. In NCHRP Project 9-33, tentative flow number criteria for mixture design were developed based on evaluation of a limited number of mixtures. These tentative criteria were included in the Mix Design Manual that was developed in that project.

What is the Problem?

The flow number criteria developed in NCHRP Project 9-33 were based on traffic moving at normal highway speeds. However, mixtures placed at intersections are subjected to the effects of slow or standing traffic resulting in greater potential for rutting. Current mixture design methods provide designers considerable freedom in selecting the composition of a mixture. With limited information available on the effects of mixture composition on the flow number, it may be difficult to develop mixtures that meet the flow number criteria. Additionally, acceptance criteria permit deviation from the design job mix formula during construction, which may result in a change in the flow number and rutting resistance of the mixture. There is a need to investigate the effect of changes in mixture composition on the flow number and rutting resistance of hot mix asphalt (HMA) and to develop flow number criteria for mixtures used at intersections.

Research Objective

This research was aimed to:

- investigate the effect of changes in mixture composition on the flow number and rutting resistance of HMA mixtures from Wisconsin.
- evaluate the rutting resistance of mixtures used at intersections.
- recommend improved criteria for the design and acceptance of HMA mixtures.

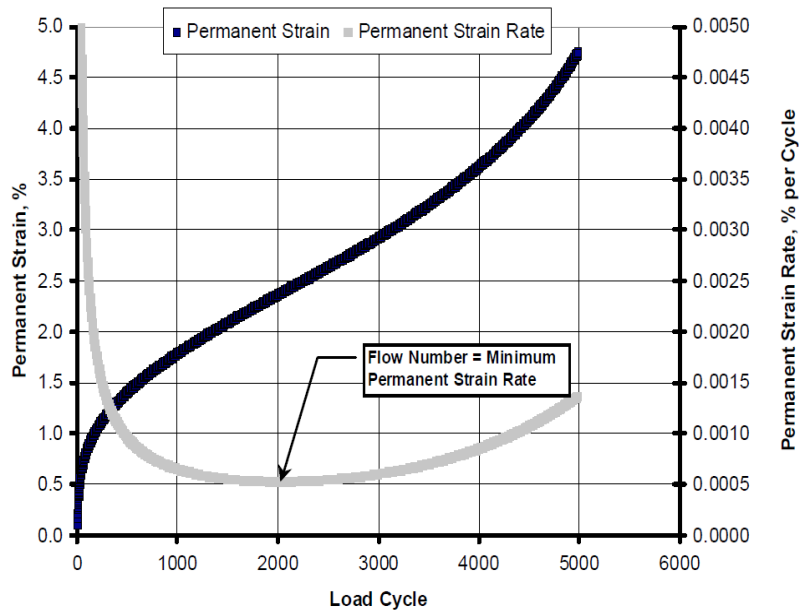
Methodology

The project started with a review of completed research concerning the flow number and the effect of mixture composition on rutting resistance. Based on this review two laboratory experiments were designed. The first experiment, called the primary flow number experiment, was designed to evaluate the effect of changes in asphalt content and filler content on the flow number. A total of 180 flow number tests were conducted on a variation of six mixtures. The second experiment, called the intersection flow number experiment, was designed to evaluate differences in flow numbers for mixtures with good and poor performance at intersections. Eight different mixtures were evaluated in this experiment. The results of the two experiments and estimates of rutting resistance from a model developed in NCHRP Projects 9-25, 9-31, and 9-33 relating rutting resistance to mixture composition were used to evaluate current Wisconsin Department of Transportation (WisDOT) criteria for mixture design and acceptance, and to establish recommended flow number criteria for use in mixture design and acceptance.

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Typical permanent axial strain response and the computation of flow number

Results

Data from the primary flow number experiment confirmed that deviations in binder content and filler content significantly affect the rutting resistance of asphalt mixtures as measured by the flow number. Flow numbers consistently decreased with increasing binder content for all mixtures tested; however, the effect was mixture specific. At the WisDOT high warning limit of 0.3 percent, the range of the decrease in flow number was 10 to 30 percent of the flow number at the optimum binder content. For the more sensitive mixtures, this decrease is large enough to reduce the rutting resistance of the mixture one design traffic level based on relationships between flow number and allowable traffic developed in WHRP Projects 0092-08-06 and 0092-09-01. The effect of filler content was mixed. Increasing the filler content above the design value generally improved rutting resistance, but for approximately one-half of the mixtures tested the rutting resistance also increased when the filler content was decreased.

Mixtures in the intersection exhibiting good performance had flow numbers that were 4 to 26 times greater than those exhibiting poor performance. Based on evaluation of this data, the researchers determined that intersection mixtures should have flow numbers six times greater than those for normal traffic speed, 40 mph (64.4 km/hr). The criteria for the slow speed, 20 mph (32.2 km/hr), and intersection mixtures are three and six times that required for highway speed traffic. A significant issue in flow number testing is an appropriate level of short-term oven conditioning for flow number specimens. Two hours at the compaction temperature results in flow numbers that are approximately one-half of those measured using four hours of short-term conditioning at 135°C.

Benefits and Implementation

The primary application of flow number testing is during asphalt mixture design to ensure adequate rutting resistance. This testing would normally be performed by the producer and the results would be submitted as part of the mixture design submittal. The findings of this study provide guidance to mix designers for meeting specified levels of rutting resistance. They also provide WisDOT information on appropriate flow number values for mixtures used in highway sections and intersections, and provide relationships to evaluate current mixture acceptance criteria and modify them if necessary. To account for the detrimental effect of increasing binder content on the flow number, testing during mixture design should be conducted on specimens prepared at the high warning limit for asphalt content.

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*This brief summarizes Project 0092-09-01,
"Evaluation of Flow Number (Fn) as a Discriminating HMA Mixture Property."*

Wisconsin Highway Research Program (WHRP) <http://wisdotresearch.wi.gov/whrp>

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