**Hamburg Wheel Test**

**Introduction**

In the past three or four years there have been essentially no reports of rutting or stripping throughout the state, whereas, rutting and stripping was commonly reported as a failure mode in the past. These improvements may be partially accredited to the implementation of the Hamburg wheel test as a screening tool for hot mix asphalt (HMA).

Several significant issues have been raised since TxDOT fully implemented the Hamburg wheel test on all HMA projects. There are presently two issues regarding the Hamburg test that concern both TxDOT and the HMA paving industry: 1) appropriateness of the Hamburg specification limits for HMA mixes with softer binders such as PG 64-xx and PG 70-xx and 2) the variability of test results from using the Hamburg test procedure. The intent of this bulletin is to provide guidance on how to address these two issues.

**Initial Hamburg Specification Values**

In 2000, the Hamburg wheel test was initially implemented in Texas for “heavy duty” type mixes that were designed to be used on high traffic volume roadways. A specification value < 12.5 mm of rutting at 20,000 passes when run at 50°C was established for these heavy duty mixes. Most of these mixes utilized PG 76-xx as the binder. The Flexible Pavements Branch established a Hamburg database in 2000 in order to track the Hamburg test results of various HMA mixtures. Analysis of the database in 2002 showed that 90% or more of all mixes tested with PG 76-xx passed the Hamburg specification requirement listed above.

While developing the TxDOT 2004 Standard Specification book, it was determined that the Hamburg wheel test would be used on all future jobs in lieu of Hveem Stability and Lottman testing. TxDOT districts were encouraged to send in samples of all of their HMA mixes for Hamburg testing. The purpose of this request was to develop specification limits for each grade of PG binder. Some districts sent in numerous samples and some did not send in any samples for evaluation. The Hamburg Wheel test results were compiled and entered into the Hamburg database.

Based on the Hamburg data available in 2002, the decision was made to require 20,000, 15,000 and 10,000 passes for PG 76-xx, PG 70-xx and PG 64-xx, respectively. The database had several hundred results from mixes containing PG 64-xx and PG 70-xx binder; however, most of the 1,000+ Hamburg test results in the database were from mixes containing PG 76-xx binder. The 15,000 pass requirement for mixes with PG 70-xx and 10,000 passes for mixes with PG 64-xx was derived from the database that showed that 80% or more of the mixes would pass these specification values.

During the 2004 specification rewrite process, there were discussions on establishing a requirement of 10,000 passes for mixes with PG 70-xx and 5,000 passes for mixes with PG 64-xx, based on the logic that PG 70-xx is half as stiff as PG 76-xx and PG 64-xx is half as stiff as PG 70-xx and the established value for PG 76-xx was already set at 20,000 passes. However, these values would have been too low based on the data available at the time.

**Current Hamburg Results and Trends**

Over 3,700 Hamburg test results have been compiled and some observed trends may justify modifying specification requirements. Recent analysis of all HMA mixes statewide with PG 64-xx shows that almost 50% do not meet the 10,000 pass requirement. On
mixes with PG 70-xx, approximately 30% of all samples tested do not meet the 15,000 pass requirement; for mixes with PG 76-xx, approximately 15% of all mixes tested do not meet the 20,000 pass requirement.

It is apparent that the results for HMA with PG 64-xx and 70-xx are much different than those originally analyzed when the 2004 Hamburg specifications were developed. It is worth noting that had the original specification requirement been set at 10,000 passes for mixes with PG 70-xx and 5,000 passes for mixes with PG 64-xx, then the failure rate for all three PG binder grades would have been approximately 15%. It is not likely that the quality of hot mix has worsened but rather that there is now more data in the Hamburg database that is representative of the mixes used in Texas.

One consistent trend observed is HMA mixes with softer binders (such as PG 64-xx) or softer aggregate (such as limestone) and contain no additive (such as hydrated lime or liquid antistrip) have a relatively low probability of passing the Hamburg specification limits.

**Contractor Options to Improve Hamburg Results**

There are a number of options a Contractor can choose to significantly improve their Hamburg results. Provided below is a list of options to significantly improve Hamburg wheel test results:

- Use a good antistripping agent such as hydrated lime or liquid antistrip
- Use higher quality aggregates (more durable)
- Use aggregate that is cleaner (thoroughly washed)
- Incorporate the use of recycled asphalt pavement (RAP requires less asphalt and the original asphalt is harder)
- Use a PG binder from a different source (better or more compatible)
- Use a higher PG binder grade.

The options listed above have proven to be effective, but, in some cases, impractical such as using a higher grade of PG binder. For example: on a job that specifies the use of PG 64-xx, a Contractor could easily meet the Hamburg specification by supplying a PG 76-xx binder in lieu of the PG 64-xx. This would easily meet the Hamburg criteria of 10,000 required for the job. However, if increasing the binder grade is the only way that a Contractor could meet the Hamburg specification, the cost to do so would eventually be passed on to TxDOT. Designers typically do not intend for a Contractor to have to use a higher binder grade than what is specified.

Engineers and designers must make a value decision when setting the specification limits for the Hamburg test. The goal is to ask for no more or no less than what is necessary to achieve the goal of preventing rutting and stripping.

There are two other ways to improve the Hamburg results: 1) reduce the asphalt content of the HMA and 2) make changes to the aggregate gradation. It usually takes a significant reduction in the asphalt content or large change in aggregate gradation to have much effect on the Hamburg results. This approach is usually not very practical and, therefore, it is not recommended as a general approach to improving Hamburg results. Reducing the asphalt content also tends to have a negative overall effect on the long term performance of the HMA.

**Hamburg Testing Variability**

Like many other HMA tests that are currently performed, the Hamburg wheel test has inherent variability. A number of issues have been raised as a result of testing variability on HMA mixtures that are borderline in terms of meeting the Hamburg specifications. Contractors are continually encouraged to design HMA that will safely meet the required Hamburg specifications and allow room for variability due to factors such as materials, sampling, testing and production variability. The Flexible Pavements Branch is currently performing extensive research to reduce the variability of the Hamburg wheel test; however, a certain degree of variability is a constant factor that must be compensated for in the Department’s specifications and the Contractor’s expectations for meeting those specifications. Note, that there are now 20 laboratories across the state approved to do Hamburg testing. Variability will increase when multiple laboratories are involved in testing.

Variability has also been observed between laboratory molded production samples as compared to field cores. Generally, field cores should only be tested if rutting is observed on the project. The original Hamburg database was developed using laboratory molded samples. There have been a number of cases when the field cores appear to correlate fairly well with the laboratory molded samples, but poor correlations have also been observed in some cases. Much of the variability may be
attributed to the fact that laboratory molded samples are molded to a specified density whereas field cores may or may not meet that criteria. Some value may be gained from testing field cores such as testing to verify the quality of HMA material in question; however, routine testing of field cores for specification compliance is not recommended at this time.

**Recommendations Regarding Hamburg Specification Values**

The Construction Division’s (CST) general recommendations regarding the Hamburg specifications are for the districts to analyze their district-wide results and determine whether or not the data justifies lowering the specifications. As mentioned earlier in the article, the Flexible Pavements Branch of CST maintains a Hamburg database that contains the results of over 3,700 Hamburg tests. The Flexible Pavements Branch staff is available to provide this data to the districts upon request and can assist in sorting and analyzing the data based on the district’s needs.

The overall goal is to set a Hamburg value that is practical, considering the locally available materials and projected traffic. One should consider past performance of pavements constructed with these materials and consider reducing the specified Hamburg value if the mix has performed well in the past and the pavements are not showing any significant rutting or stripping. Generally speaking, it is recommended that the Hamburg specification values be set in increments of 1,000 cycles (example: 5,000, 6,000, 7,000, etc). Ideally, adjacent districts that use similar materials should coordinate with their neighboring districts to establish a uniform Hamburg policy whenever possible.

**Softer Aggregates**

For districts that predominantly use softer aggregates (generally soft limestone) and do not require hydrated lime or liquid antistrip agents, it is recommended that the districts review test data for their mixes to determine if adjustments to the Hamburg specification values are needed. If an adjustment is made, the requirement of at least 5,000 passes for PG 64-xx and at least 10,000 passes for PG 70-xx is recommended.

**Addition of Hydrated Lime or Liquid Antistrip Agents**

In many cases, the addition of hydrated lime or liquid antistrip agents will enable a mixture to meet the current Hamburg specifications. In other cases, the antistrip agent may provide a significant benefit to the mix, yet the mix may still fall short of meeting the current Hamburg specifications.

If a district prefers to have hydrated lime or liquid antistrip agents in their mixes, CST does not recommend lowering the Hamburg value to a value that can be achieved without the antistrip agent. For example: if a Contractor can produce a PG 64-xx mix that averages 8,500 passes in the Hamburg test by using either hydrated lime or liquid antistrip, set the passing criteria at 7,000 or 8,000 passes rather than 5,000 passes which might possibly allow the Contractor to eliminate the use of the antistripping agent.

**Conclusions and Recommendations**

1. The Hamburg test is still believed to be the best available tool to prevent rutting and stripping. This is evidenced by the reduction in the number of premature failures and forensic studies related to rutting and stripping in recent years from an average of three or more per year to zero.
2. Recent data suggest that some districts should consider making adjustments to the Hamburg specification values.
3. When justified, districts should consider lowering the Hamburg specification to a value of not less than 5,000 passes for mixes with PG 64-xx and not less than 10,000 passes on mixes with PG 70-xx unless the district has convincing evidence that shows their mixes meet the current specifications. Evidence suggests that the Hamburg requirements for HMA with PG 64-xx or PG 70-xx can be lowered with low risk of premature failure provided the mixes are used in the appropriate applications.
4. The Hamburg test, like every other test, has inherent variability. This variability becomes more evident on borderline mixes, particularly those mixes with PG 64-xx and PG 70-xx binder. Testing variability was factored into the recommendation to lower the Hamburg specification when justified. Contractors should be aware of testing variability with the Hamburg test and avoid providing HMA mixes that are “borderline” passing.

**Contact Information**

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