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## A Testing and Evaluation Protocol to Assess Seal Coat Binder-Aggregate Compatibility

Highway agencies such as TxDOT have comprehensive quality and contract management systems that control the quality of materials that are used in the highways under its purview. For a process such as seal coats, it is important for agencies to move from the concept of separately controlling the quality of individual constitutive materials to an approach based on the 'systems' concept. For seal coats, this calls for an effective testing protocol that is able to measure the performance of an aggregate-binder system in the laboratory, and use the data to predict how the material combination will perform in the field. This requires a performance-based test protocol that gives due consideration to the 'practical'

aspects of seal coat construction and performance. The purpose of this research project was to develop a new testing and evaluation protocol to assess aggregate-binder compatibility for seal coats and surface treatments. The testing protocol has to be technically sound, practical, and economical for the intended applications. In addition to studying materials-related factors, the researchers had to place a heavy emphasis on experimental parameters that represent construction and performance conditions of seal coats.

### What We Did...

Two test protocols were developed in this research. The

primary test protocol was the performance-based seal coat aggregate-binder compatibility test which can be used for all types of materials, and the other was the modified net adsorption to be used for non-precoated aggregate and hot asphalt binders to determine the affinity of aggregate to the asphalt and its resistance to stripping.

Development of a new testing protocol is a challenging task. The researchers first began a study of the existing technical literature to obtain an understanding of the extent of the aggregate-binder compatibility problem. It was quickly observed that the topic of seal coat aggregate-binder bonding had not received much attention from researchers in the past. A couple of studies had



Figure 1. Seal Coat Construction



developed test methods to evaluate aggregate-binder bonding, but none of them had been accepted widely enough for mainstream use by highway agencies. After a close look at these test methods, combined with a study of the seal coat process, the researchers came to the conclusion that only a performance-based testing protocol could effectively predict the performance of seal coat aggregate-binder combinations in the laboratory, and none of the existing test methods appeared to meet this criterion.

Practitioners often refer to seal coating as an ‘art’ that can be perfected only through years of experience. An engineer’s first reaction to this notion would be to discount it based on the fact that all civil engineering processes are governed by the principle of physical sciences. However, the reference to seal coat as an art form has some validity to it. Even though a seal coat process is a simple and highly repetitive process, construction of a successful seal coat is often a complex process due to the interaction of a number of factors that are related to the design, materials used, construction process, climatic conditions during construction, contractor’s

professional competence and – last but not least, the conditions under which the seal coat has to provide its intended service. The highway agencies manage this process through creative use of materials and construction specifications, general plan notes and contract management techniques. A performance-based test method for seal coats can make the job easier for those managing a seal coat program through accurate prediction of material performance under various field conditions.

Therefore, the researchers studied the seal coat process from the perspective of materials (i.e., aggregate and binder), and then looked at other factors that influence the bond between the two materials that is so critical to the success of a seal coat. The research team leveraged their findings from a previous study they conducted on seal coat constructability review (project 0-1787) and also talked to more than half of the TxDOT districts to tap into their knowledge base. The researchers also studied the construction activities of 15 projects and collected data, sampled materials, and observed the construction process. At the end of this process, a list of factors was prepared to be incorporated into the testing protocol being developed.

Then, the researchers moved to the laboratory and began conducting a series of experiments with the idea of coming up with a testing protocol that can effectively predict the performance of aggregate-binder bond. This phase of experimental trials took almost one year, and the researchers developed a prototype of the testing protocol for further testing.

The testing protocol incorporated a specimen preparation procedure, a specimen conditioning procedure, and a testing procedure. Specimens were prepared on 60-inch square aluminum plates (1/8 in. thick) by spreading a uniform asphalt film thickness that corresponded

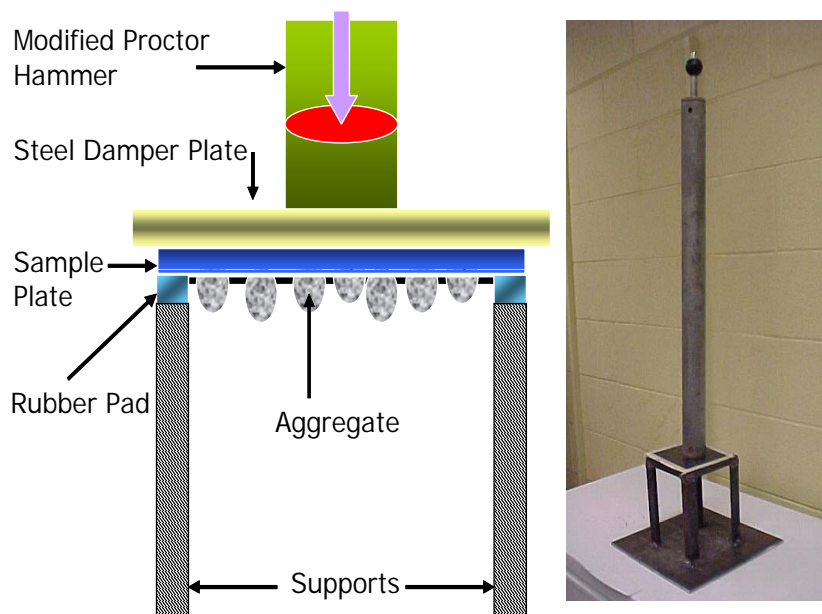
to the asphalt application rate, followed by the spreading of aggregate on it and rolling. Aggregate was spread using an automated aggregate spreader developed at Texas Tech University. (See Figure 2) Rolling was done by a ballasted tennis court roller which was padded with rubber to provide the contact pressure and the feel of a lightweight pneumatic roller. The specimens were kept in the laboratory for 30 hours and then subjected to an environmental conditioning regime. This involved three cycles of a freeze-soak regimen which was followed by a 48-hour soaking under room temperature. Each freeze-soak cycle involved a 16-hour soaking period (at room temperature) followed by eight hours of freezing at -25°C. The test protocol was designed in such a way that districts could subject specimens to the lowest temperature typically experienced in that district. Once the conditioning regime was completed, the specimens were kept in the laboratory for three days before the Impact Hammer Test was conducted on them. (See Figure 3) This involved the dropping of the Modified Proctor Hammer (MPH) used in the soil compaction test. This method was selected because the equipment is already available in the TxDOT district laboratories. The MPH is dropped three times on the specimen mounted on the Impact Test Pedestal, and the percent aggregate particles lost from the specimen, is calculated.

When samples are prepared, several experimental factors that simulate the field conditions are considered. These experimental factors varied somewhat between hot asphalt seals, emulsified asphalt seals, and seal coats that use precoated aggregates. For hot asphalt that does not use precoated aggregate, these experimental factors include the aggregate dust level (if non-precoated aggregate is used), percent embedment of aggregate in asphalt, surface tem-



**Figure 2.** TechMRT Automated Seal Coat Aggregate Spreader





**Figure 3.** Impact Loading Apparatus for Performance-Based Seal Coat Aggregate-Binder Compatibility Test

perature when aggregate is spread, and the delay between aggregate spread and rolling. The aggregate dust level simulated the dust generation during normal handling of non-precoated aggregate in the field. In the laboratory, dust was generated by sending the aggregate sample through the Micro-Deval drum without the steel charge for 2 minutes (medium dust) and for 5 minutes (high dust).

For emulsified asphalt seals, the experimental factors included the timing of aggregate spread (before or after breaking of emulsion) and the aggregate moisture content (air-dry and SSD). For seals where precoated aggregate is used, the percent coverage by the precoating binder on the aggregate was considered at two levels (50% and 90%).

Approximately 300 tests were conducted using this performance-based test protocol. But before these tests were conducted, seal coat specimens brought in from the 15 seal coat projects visited during the first year of the study were tested using the protocol to assess the accuracy with which it predicts field

performance. The field performance in these sections and the test results for field specimens collected from the same test sections using the new test protocol compared very well.

In addition to this performance-based test protocol, a second test protocol was recommended by researchers to evaluate the bond between non-precoated aggregate and hot asphalt binders under ideal field conditions. The second protocol recommended is the modified Net Adsorption Test (NAT) developed by the SHRP program and later modified by the National Roads Authority of Ireland to evaluate the bond between seal coat aggregates and binders. This test method provides a good assessment of the affinity of an aggregate to a particular asphalt and also the resistance of that aggregate-binder combination to stripping. This test was conducted for five binder grades and five aggregates that are commonly used by TxDOT, and NAT test results generally agreed with the experience of TxDOT with its seal coats. This test protocol requires an investment of approximately \$5000 for

a spectrophotometer, a mechanical shaker, and glassware.

## What We Found...

Based on a large number of tests conducted on several seal coat material combinations, the researchers found the following:

- Both test protocols proved to be very effective in predicting the field performance of aggregate-binder combinations for seal coats.
- The performance-based seal coat aggregate-binder compatibility test showed very good promise for prediction of field performance under a variety of field conditions. The test protocol was able to distinguish between the ‘good’ and ‘poor’ material combinations classified as such based on years of field performance.
- The performance-based seal coat aggregate-binder compatibility test also showed sensitivity to all key experimental parameters investigated for hot asphalt, emulsified asphalt, and precoated aggregates.

## The Researchers Recommend...

The researchers recommend that the two testing protocols developed from this research, the performance-based aggregate-binder compatibility test and the modified net adsorption test, be implemented on a limited basis, first to collect additional data on more aggregate-binder combinations and their field performance, and then to refine the acceptance criteria recommended by the researchers.



### *For More Details...*

The research is documented in the following report:

Report No. - 0-4362-1: A Testing and Evaluation Protocol to Assess Seal Coat Binder-Aggregate Compatibility

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