TEXAS TRANSPORTATION INSTITUTE
THE TEXAS A&M UNIVERSITY SYSTEM

Project Summary Report 0-4047-S

Project 0-4047: Analysis and Development of Asphalt Quality Assurance Procedures

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PROJECT SUMMARY REPORT

TxDOT Binder Quality Assurance Program: Assessment and Improvement

Most state departments of transportation (DOTs) maintain asphalt binder quality assurance (QA) programs to ensure materials used in road construction meet specifications for each project based on local environmental and traffic conditions. Currently, the Texas Department of Transportation (TxDOT) samples and approves asphalt materials at the source. These materials are then utilized in highway projects without consideration of possible changes in properties that may occur between production and use during construction.

Historic concern and limited recent data indicate that binder properties do change, after production contributing to construction and operation difficulties as well as poor performance. In this project, the current TxDOT QA program for binders was evaluated and recommended revisions toward improving quality were made.

What We Did ...

Information Search and Review

A literature search and review and an extensive survey accomplished the following goals:

- obtain general definitions of and recommendations for QA programs,
- identify prospective binder properties related to performance that can be measured in a timely manner for use in a QA system,
- identify performance models that relate changes in binder properties to field performance and associated costs,
- identify factors that may cause changes in binder properties prior to use,
- define the current binder QA program in Texas and its impact on TxDOT districts, and
- define the state-of-the-practice in binder QA programs in Texas and other selected states.

Analysis of Existing Data

In addition to the survey that provided a qualitative comparison of binder QA programs, cluster analysis or classification and regression trees (CART) evaluated existing binder data from Colorado, Oregon, and Texas quantitatively and statistically.

Field and Laboratory Simulation Experiments

The initial strategy for evaluating the TxDOT binder QA program was to validate and further examine differences in properties between corresponding supplier and field samples and identify factors responsible for these changes. Difficulties in obtaining corresponding samples due to poor sample identification and lack of an easily accessible database resulted in an alternative approach, and an extensive laboratory experiment utilizing supplier samples and simulation of storage conditions and contamination was designed. Table 1 shows specific factors and representative levels for each factor that were selected for the simulation experiment. Supplier was also introduced as a block factor.

This experiment identified factors with the most impact on percent relative change in a Dynamic Shear Rheometer property measured after short-term aging in the Rolling Thin Film Oven Test (RTFO-DSR) from samples for each factor-level combination to corresponding control samples. Two replicate samples (with two replicate measurements per sample) for each factor-level combination were tested. The RTFO-DSR property was selected due to its:

- direct relationship with performance in terms of resistance to rutting,
- frequent use as a QA parameter by other state DOTs, and
- equipment availability in TxDOT districts.

Fourier Transform Infrared Spectroscopy (FTIR) testing was also included in the experiment to better understand and explain changes in RTFO-DSR. Exploratory statistical analyses and Analysis of Variance (ANOVA) were conducted for the RTFO-

DSR results to identify outliers and estimate all main effects and two-way interactions.

Recommendations and Resource Requirements

Resources required to introduce field sampling and RTFO-DSR testing into the current TxDOT binder QA program were estimated, and a set of recommendations was produced based on the information found in the search and review, the analysis of existing data, and the results from the simulation experiment. These recommendations are intended to improve the TxDOT binder QA program.

What We Found ...

Analysis of Existing Programs and Data

- The current binder QA data storage system is inadequate to assess and/or address any potential problems associated with changes in binder properties from production to use. A new and greatly improved system was introduced by TxDOT toward the end of this project.
- Other states are successfully utilizing field samples in their binder QA systems. Although they are not analyzing binder QA data to full potential, they are collecting useful data and storing data in a readily accessible format.
- Researchers demonstrated the use of cluster analysis or CART as a methodology to analyze binder data to identify suppliers with a historical record of specification compliance or noncompliance by product. This type of analysis shows promise for estimating field sampling frequencies by supplier/product combination to reduce resource requirements to a reasonable level within current budget limits.

Asphalt Cements

Figure 1 shows that almost all asphalt cement results indicated a practically significant change in binder properties greater than 100 percent. This threshold was considered practically significant because it represents the change due to RTFO short-term aging that causes an approximate shift by one binder grade. Statistically significant interaction effects from the ANOVA analysis included Modifier*Contamination, Contamination*Storage Time, Contamination*Storage Temperature, and Storage Time*Storage Temperature at the level $\alpha=0.05$. Therefore, the main effects were assessed only conditionally with the exception of the block factor Supplier. The conclusions for asphalt cements are as follows:

- Uncontaminated or contaminated samples that contained more modified binder (PG76-22) generally resulted in a smaller change in binder properties compared to samples that contained more unmodified binder (PG64-22). Modification appears to improve susceptibility to aging.
- The largest and significantly different changes in binder properties occurred for a Storage Time of 2 months at the largest level of Contamination.
- No Contamination effect was shown for a Storage Temperature of 375˚F.
- The material response to Storage Temperature was statistically significant only for Storage Times of 1 week and 1 month.
- One supplier exhibited a greater relative change in the response variable compared to the other supplier.

In addition to RTFO-DSR, FTIR testing conducted on short-term aged asphalt cement samples identified peak regions of the spectra that could predict the relative change in RTFO-DSR. The resulting peak region confirmed that an oxidation process causes the observed relative changes. Hypothetically this process formed chemical radicals within the binder structure available for reaction and combination with oxygen when the sample was exposed during the RTFO test.

Emulsions

Almost all emulsion residue results indicated a substantially smaller and practically insignificant change in binder properties of less than 20 percent. This

Table 1. Factors and Levels in the Laboratory Simulation Experiment.

Material	Factors	Levels
Asphalt Cement	Modifier	Modified PG76-22 Unmodified PG64-22
	Contamination	No Contamination Transport Truck Contamination (100 of 6000 gallons) Contractor Tank Contamination (500 of 20,000 gallons)
	Storage Time	1 week 1 month 2 months
	Storage Temperature	335°F 375°F
Emulsion	Modifier	Modified CRS-2P Unmodified CRS-2
	Contamination	No Contamination Transport Truck Contamination (100 of 6000 gallons)
	Storage Time	2 days 1 week 1 month
	Storage Temperature	150°F 180°F

threshold was considered practically significant because it corresponds conservatively to the difference in penetration required for an emulsion residue to obtain an "h" designation. Samples from one of the suppliers yielded a number of negative results that were also considered insignificant. The emulsion data were analyzed separately for each Supplier, but the relative changes are practically insignificant in terms of performance.

FTIR testing produced several distinctive peak regions that correlated with the changes in RTFO-DSR emulsions. None of the peaks corresponded with oxidation indicators. This reaffirms that the relatively small negative or positive observed changes do not represent a critical change in material properties for the conditions considered.

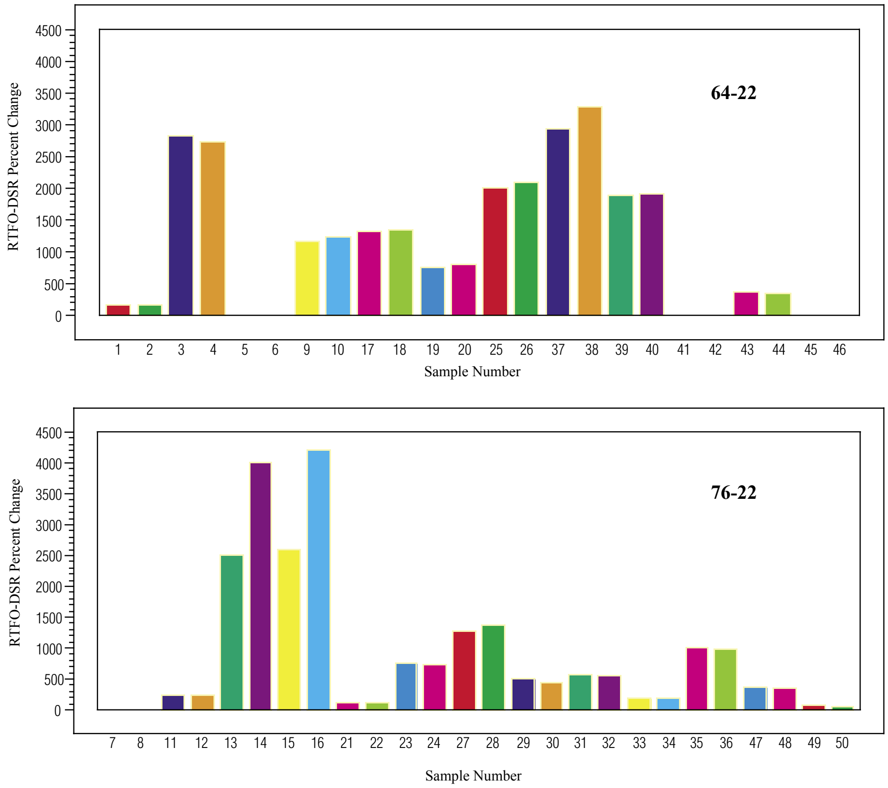

Figure 1. Percent Change in RTFO-DSR for Asphalt Cements by Modifier.

Resource Requirements

Resource requirement estimates indicated that implementation of an exclusive field sampling program in the TxDOT binder QA system is feasible. Specification verification for supplier samples can possibly be required of the supplier. In addition, more responsibility for checking the supplier samples can possibly be shifted to the contractor as part of a recommended and required quality control (QC) plan.

The Researchers Recommend . . .

Changes to Current Program

- Appoint a binder QA program manager and educate all employees on all aspects of the revised binder QA program to ensure maximum benefit at the least cost.
- Use the binder QA program established by TxDOT as only one tool in a system that also includes:
  - required QC plans for both binder suppliers and asphalt paving contractors,
  - training programs for all binder technicians and personnel responsible for taking samples, and
  - a round-robin program to establish the testing variability for selected binder QA parameters across multiple laboratories.
- Store data in a user-friendly database that can be accessed by TxDOT district personnel, and reduce the number of labels for data records to facilitate production of meaningful statistical results.
- Organize and analyze data frequently to detect problems, show historical specification compliance for different binders and suppliers, or establish field sampling rates by binder and supplier on an annual basis.
- Uniformly test asphalt cements and emulsion residues using a performance-related parameter.
- Use detailed labels and multiple records for binder samples that include the corresponding acceptance laboratory number based on the supplier sample, as well as storage times and temperatures for both the supplier and contractor locations.
- Include special handling requirements for asphalt cements in QC plans for both suppliers and contractors.
- Store relevant binder data in the same database as pavement performance data.

Future Research

The researchers recommend further study regarding:

- a comprehensive evaluation of the current TxDOT binder QA program,
- additional chemical engineering studies to better understand the reactions in asphalt cements and emulsions during prolonged storage at elevated temperatures,
- a significant national study to establish an upper limit on the RTFO-DSR binder parameter to preclude using material that has been stored for long periods of time or contaminated, and
- collection and analysis of historical binder data at the national level to establish field sampling frequencies by supplier/product combination.

For More Details . . .

The research is documented in:
Report 4047-1: *Initial Assessment of TxDOT Binder Quality Assurance Program*
Report 4047-2: *Assessment of the TxDOT Binder Quality Assurance Program*

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TxDOT Implementation Status
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The majority of the recommendations in relation to sample identification and data storage included in this PSR have been implemented by TxDOT. Since this research project did not quantify the quality of binders due to problems with sample identification, a new research project, 0-4681, is being started to develop a new binder quality assurance program.

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YOUR INVOLVEMENT IS WELCOME!

Disclaimer

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