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TECHNICAL SUMMARY 87-1B

Summary of Report Number 226

INVESTIGATION OF NUCLEAR ASPHALT CONTENT GAUGE

INTRODUCTION

The introduction of new aggregate sources to Louisiana since the mid 1980s has presented problems in asphaltic concrete mix design and construction. Absorptive aggregates such as reclaimed portland cement concrete and some stones which are now being used in asphaltic concrete have made asphalt content determination a critical aspect of mix control. Current test procedures take several hours to determine asphalt content. It has been established that a nuclear gauge once calibrated, can determine asphalt content within 16 minutes or less. The nuclear asphalt content gauge would provide a faster indication of the need for a correction of asphalt content at the hot mix plant. It would also eliminate the problem of hazardous solvent storage, handling and disposal at the plant site, since the use of solvents for asphalt cement extraction would be terminated.

Currently, hot mix is sampled for asphalt content twice in each lot, normally one day of production. Using the centrifuge extraction method, testing takes approximately two hours, in which time 400-600 tons of mix may be produced. If asphalt content is not within job mix formula tolerances, corrections are made to the plant. However, the mix produced before corrections are made has already been placed on the roadway. Using the nuclear asphalt content gauge, with a testing time of approximately 20 minutes, only 60-80 tons of mix will have been produced before corrections are made.

Use of the nuclear gauge will provide another benefit. It will eliminate the problem of storage, handling and disposal of solvents. 1,1,1 - trichloroethane (ethane) is the solvent most often used in testing for asphalt cement content. The vapors generated by the testing process can produce irritation causing dermatitis, blotches, or blisters. If solvent is splashed in the eye, it will cause irritation and pain. While basic safety precautions can prevent harmful contact, the possibility of accidents cannot be eliminated. With increased restrictions against indiscriminate dumping, disposal of the dirty solvents is becoming more of a problem. Contractors could become required to store the waste for disposal by an approved hazardous waste facility. Producers of hazardous waste are classified by the amount of waste produced. If a contractor does not reclaim his solvent, it is possible he would produce as much as 100 kg (about 1/2 drum) per month, which is the criterion for classification as a "small quantity generator, 100 - 1000 kg/mo". When a contractor is so classified, he is required to obtain an EPA identification number and comply with EPA and DOT regulations for storage, shipping and disposal. The waste generated must be offered only to transportation and disposal facilities with an EPA identification number. Further complicating this situation, production of 1,1,1 trichloroethane has been docketed by EPA for termination. Other more potent solvents would have to be substituted which pose additional handling and disposal risks.

Moisture content of the asphalt concrete was another area requiring further investigation before the nuclear asphalt content gauge could be introduced to the contractors. Louisiana's aggregates are normally high in moisture content. The nuclear asphalt content gauge uses a neutron count to determine the amount of hydrogen in the mix such that the total hydrogen content must be corrected for the amount of water to accurately determine asphalt content.

Another area requiring investigation deals with gradation testing. Maintaining aggregate gradation is necessary to insure a mix which can be placed and compacted properly. Currently, the aggregate from which asphalt is extracted is used for acceptance testing for gradation. Use of the nuclear gage in lieu of the current extraction testing would necessitate a change in the sampling location and method of aggregate gradation testing.

OBJECTIVES AND SCOPE

The major objective of this study was to determine the variation in asphalt cement content found with the nuclear asphalt content gauge during normal plant production. Secondary issues which needed to be resolved for implementation were moisture content determinations for the correction of nuclear readings and the variation associated with changing the sampling location for gradation from extracted mix to cold feed operations.

The scope of the study included asphalt content determination using the nuclear asphalt content gauge and the centrifuge and reflux extraction tests at three drum and three batch plants. One week's production was sampled at each plant. Simultaneously, cold feed samples were taken for gradation analysis. Moisture contents were determined at the plant using the ASTM D1461 and microwave methods.

Accuracy testing was added to the test factorial after widely varying results were found during testing at the first plant. Three asphalt contents for each of two mix types were found during testing at the first plant. Three asphalt contents for each of two mix types were investigated. Additionally, the effect of mix temperature on the calibration curve and change in sample size versus calibration sample size were evaluated. Also, the loss of an aggregate feed at an asphalt plant was simulated by reducing the fine aggregate feed to determine sensitivity of the nuclear gauge.

RESEARCH APPROACH

Accuracy Testing

This test phase was added to the study after finding widely varying results at a field plant from the first set of test data. After consultation with the equipment manufacturer, modifications were made to the sample preparation and test procedures. These modifications included the sweetening of the mixing spoon, bowl and pans prior to calibration, defining a technique for achieving consistent volume, and using background counts. These procedures were implemented for the accuracy testing. The data from the first field project were discarded and another field project was selected.

Two mix types, a low stability gravel mix and a high stability stone mix, were investigated with the nuclear gauge to determine the accuracy of the device with regard to known samples prepared in the laboratory. For each mix type, samples of 4.6, 5.1 and 5.6 percent asphalt cement were prepared. Each sample was subjected to three tests: nuclear gauge, centrifuge extraction and reflux extraction. The centrifuge samples were corrected for ash content.

One of the mix types was also tested for sample density effects on the nuclear gauge output. After a calibration sample was established, the sample weights were varied 100 and 200 grams on either side of the calibration weight.

An additional mix type was prepared with fine materials completely omitted from the mix composition and with 50 percent of the fine aggregate to simulate either the complete or partial loss of the fine aggregate cold feed. If the nuclear gauge is sensitive to these changes, the gauge could be used for process control at the plant providing enhanced quality control.

Finally, the effect of testing mix at temperatures other than the calibration temperature was studied.

Field Testing

One week's production from each of the three batch plants and three dryer-drum plants was evaluated. Testing included asphalt cement content by the nuclear method, centrifuge extractor and reflux extractor; moisture content by the distillation method and microwave drying; and aggregate gradation based on belt samples and dry hot-bin pull samples for dryer drum and batch plants, respectively.

Eight samples per day for five days were split for use. A comparison of the nuclear asphalt content with the centrifuge and reflux extractions was used to evaluate the variation of the three test methods. Four 4-minute counts were averaged for each nuclear gauge asphalt content determination. All centrifuge tests were corrected for ash content.

The effectiveness of microwave drying versus distillation by ASTM D1461 at the plant site to determine moisture content in the mix, and the variability thereof, was assessed by a comparison of test results on paired samples.

Aggregate samples from the composite cold feed belt at drum plants and from a dry batch at batch plants were collected at the time the hot mix was sampled for asphalt content testing. In this manner the gradation from the extracted hot mix could be compared to the cold feed/dry batch gradations. The number of cold feed/dry batch samples was reduced because of contractor opposition to plant shutdown in order to obtain the samples.

CONCLUSIONS

The following conclusions are drawn from the data generated in this study and, as such, are constrained by the number of projects examined:

- The nuclear asphalt content gauge produced results that were as accurate with less variation (more consistent) than the current centrifuge extraction method used for quality control testing. Because of the reduced test time for the nuclear method (20 minutes) versus the centrifuge method (2 hours), additional quality control tests could be required enhancing the process control operation. In addition, the use of the nuclear gauge would eliminate the use of a hazardous solvent at the asphalt plant.

- Moisture content testing using both the ASTM D1461 distillation method and a microwave method indicated negligible moisture contents in the mix tested for asphalt content. Moisture content determinations would only be necessary when abnormal asphalt contents were found. The distillation procedure was hazardous with several explosions and fires occurring during testing. Its use is not recommended. The microwave test would need further development to eliminate the aggregate explosions experienced during this study.
- Cold feed gradations were found to be as accurate with similar variation (as consistent) to the extracted hot mix gradations. Minor adjustments may be necessary to remove bias imposed by plant configuration, ie. the loss of fines in a wet scrubber system could be compensated at the cold feed.
- When compacted to a constant volume, a change in sample weight of up to 100 grams does not provide significant differences in asphalt content determined with the nuclear gauge.
- The nuclear gauge was able to detect the simulated loss of fine aggregate feed enhancing its use as a quality control tool. If quality control testing is increased because of the quicker test time of the nuclear gauge asphalt content determinations and cold feed gradations, plant malfunctions causing nonspecification mix can be found and corrected much sooner than currently feasible.
- The calibration temperature should be used during quality control testing. The calibration temperature should be the projected job mix temperature.
- The use of RAP in the hot mix did not affect the asphalt contents or cold feed gradations.

RECOMMENDATIONS

The use of the nuclear asphalt content gauge and cold feed gradation for quality control testing is recommended. The results obtained in this study demonstrate these methods to be as accurate and more consistent than the current centrifuge extraction method and can be conducted in much less time. This provides the advantage of conducting more control testing thereby decreasing the opportunity to send nonspecification mix to the roadway. While not tested during this study, the equipment manufacturer now has developed a nuclear gauge capable of testing Marshall specimens in addition to loose mix samples. Additional advantage can, therefore, be made by reducing sample preparation time for the nuclear gauge loose mix samples. Since Marshall testing is currently required four times per lot, such testing would immediately double the quantity of asphalt content control testing while eliminating two hours of sample preparation and test time for extraction and gradation testing. Additional quality control testing for asphalt content or cold feed gradations could be incorporated or the inspector could spend increased time in the plant observing plant operations. With the ability to detect aggregate feed problems and the ability to increase test frequency, a more uniform and higher quality mix should be produced. As an initial program until experience dictates refinement, the following specific recommendations for implementation are offered:

- Require all Marshall specimens be tested for asphalt content using the nuclear gauge prior to Marshall testing. Four additional asphalt contents should be obtained throughout the lot at random times using the nuclear gauge. This would provide a fourfold increase in quality control testing for asphalt content.
- Require cold feed gradation testing at least four times at random per lot providing a twofold increase in gradation quality control testing.
- Require moisture content testing as needed dependent on unexplained high asphalt content determinations that cannot be reconciled through Marshall or gradation results.
- Either eliminate gradation as an acceptance criteria or use the reflux extracted verification sample for acceptance purposes. This will totally eliminate the need for solvents at the plant, using them only in the more controlled laboratory environment.

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