Low-Cost and Environment-Friendly Asphalt-Treated Mixtures

Louisiana Tests Designs

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Asphalt cement materials are costly, and asphalt mixtures have environmental impacts. Alternatives are needed to reduce the cost and to decrease the emissions generated in production and construction without compromising performance. Asphalt-treated mixtures (ATMs) offer one alternative.

ATMs are hot-mix asphalt (HMA) from crushed rock or natural gravel with paving-grade asphalt cement in low percentages—2.5 to 4.5 percent (*1*). Because the mixtures can be produced with less expensive aggregates and with lower percentages of asphalt cement binder, the cost is less than for typical HMA mixtures.

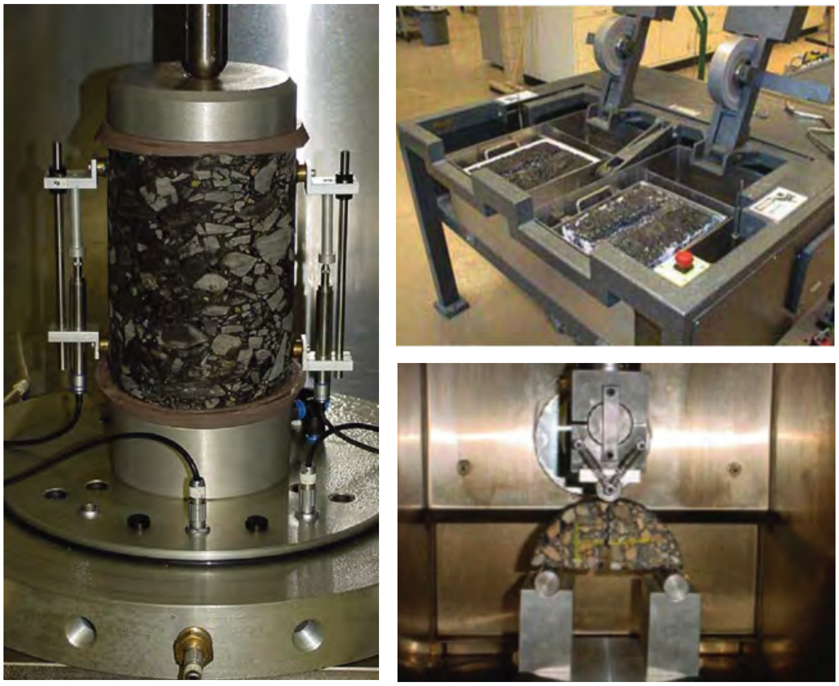
Problem

ATMs can be used in the construction of a pavement's asphalt layer. State agencies' specifications for ATMs, however, are similar to those for conventional asphalt mixtures with an asphalt content of 4.5 to 5.5 percent in the binder and in the wearing course layers. These specifications adversely affect the economic competitiveness of ATMs and limit their use in pavement construction.

(a) (b) (c) (d)

PHOTOS: LOUISIANA DOTD

Construction of asphalt-treated mixture (ATM) layers in Louisiana.



Photos: Louisiana Transportation Research Center

Comprehensive laboratory tests were conducted to evaluate a variety of ATMs.

Research

The Louisiana Department of Transportation and Development (DOTD) initiated research to develop a design methodology for ATMs that would be durable, stable, cost-effective, and environment friendly. Researchers examined eight aggregate sources and two types of asphalt binders and conducted comprehensive laboratory tests to characterize the behavior of the mixture designs.

Results

The research findings contributed to the development of a guideline for designing low-cost ATMs. The guideline recommends a maximum aggregate absorption of 2 percent and micro-Deval loss values of 18 percent. In addition, the power coefficient that describes the gradation curve of the aggregate blend should be at least 0.2; the aggregate blend should be 75 percent 1.5-inch crushed-run aggregate material and 25 percent coarse sand. Also recommended are a maximum rut depth of 0.48 inches on the Hamburg loading wheel test (LWT), a minimum indirect tensile strength (ITS) of 150 psi, and a minimum toughness index value of 0.65.

The results of the LWT, ITS, and flow number tests showed that the ATMs designed with the methodology developed for this project had a laboratory performance similar to that of conventional base course HMA mixtures at high and intermediate temperatures. In addition, the asphalt-treated base mixtures demonstrated a several-fold improvement over unbound granular base materials in stiffness and in permanent deformation resistance. Replacing the unbound granular material with ATMs in a base layer reduced the total pavement rutting by more than 33 percent (2).

Applications

◆ *Roadway shoulders.* Louisiana DOTD implemented the research findings to design ATMs for four overlay rehabilitation projects. In each project, a 1-

TABLE 1 Properties for ATM Mixtures Used in the Field

Mixture Designation	ATM 1	ATM 2	ATM 3	ATM 4	Conventional HMA
Aggregate blend	75% LS 25% CS	75% LS 25% CS	75% NV 25% CS	60% LS 20% RAP 20% CS	44% #67 LS 16% #78 LS 31% #11 LS 9% CS
Binder type	PG 70-22M	PG 64-22	PG 70-22M	PG 70-22M	PG 70-22M
Binder content (%)	3.0	3.0	3.0	3.0	4.0
Design air void (%)	8.0	9.0	10.4	6.7	3.7
Film thickness (m)	3.39	6.15	1.02	3.73	8.2
Permeability (10^{-4} mm/s)	30	98	352	33	44
Tensile strength ratio (%)	84	52	76	100	83
Rut depth in LWT (mm), 50°C, wet	3.6	22	5.3	2.6	5.7
Dissipated strain creep energy (kJ/m^3)	1.48	1.34	0.2	0.84	2.52
LFWD modulus (ksi)	NA	114	86	107	105
PSPA modulus (ksi)	1936	1717	1688	1877	1862

Note: LS = limestone, CS = coarse sand, NV = navoculite, RAP = reclaimed asphalt pavement, LWT = loading wheel tester, LFWD = light falling weight deflectometer, NA = not available, PSPA = portable seismic pavement analyzer.

TABLE 2 Results of MEPDG Analysis

MEPDG Performance Parameter	Section 1 (ATM 1)	Section 2 (ATM 4)	Section 3 (HMA)
Rutting (mm)	1.05	1.12	1.15
Fatigue cracking (%)	0.9	1.1	1.1
International Roughness Index (in./mi)	140	139	143

mile section of the roadway lane shoulder was constructed with ATMs that were produced in the HMA plants and constructed in the field. The ATMs exhibited in situ moduli similar to those of conventional HMA base course mixtures, as shown in Table 1 (page 38). The implementation projects showed that the ATMs also have potential for use in the construction of HMA base course layers of pavement structures.

◆ *Low-volume roads*. The designed ATMs also were evaluated in low-volume roads with traffic of less than 1,000 vehicles per day. The results showed that the mechanistic properties and the performance of ATMs were similar to those of the asphalt mixtures typically used in low-volume roads.

Researchers used the *Mechanistic–Empirical Pavement Design Guide* (MEPDG) software to compare the performance of the low-volume pavement sections incorporating ATMs to those with a conventional HMA mixture. The mechanistic properties and the performance of the ATMs were similar to those of the low-volume pavement structures with conventional HMA mixtures (see Table 2, above).

Benefits

The results show that the ATMs designed in this research project perform comparably to conventional low-volume HMA mixtures. ATMs moreover have the following advantages:

◆ The materials cost of the designs developed for this project was approximately $7.20 less per ton than that of conventional low-volume HMA mixtures. This reduced the price of materials by 16 percent.

◆ The life-cycle assessment showed that in low-volume roads, the new generation of ATMs, compared with conventional HMA mixtures, reduces energy consumption by up to 29 percent, water consumption by 39 percent, and hazardous waste generation by 42 percent (see Table 3, below) (3).

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Suggestions for Research Pays Off topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, Keck 488, 500 Fifth Street, NW, Washington, DC 20001 (202-334-2952; gjayaprakash@nas.edu).

TABLE 3 Life-Cycle Cost Assessment Results for Low-Volume Sections

Environmental Variable	Section 1 (ATM 1) Total	Section 1 (ATM 1) Difference (%)	Section 2 (ATM 4) Total	Section 2 (ATM 4) Difference (%)	Section 3 (HMA) Total
Energy (MJ)	1,637,890	–29	1,879,443	–18	2,301,874
Water consumption (kg)	421	–39	508	–26	688
CO_2 (Mg)	92	–29	106	–18	130
RCRA hazardous waste generated (kg)	15,035	–42	18,450	–29	26,102

Note: RCRA = Resource Conservation and Recovery Act.