ESC Aggregate In HMA

This paving application has not been used in many years, but here is an opinion and product comparison that lightweight aggregate can still be an option

By Kevin King, TXI

TXI's plant in Streetman produces lightweight expanded shale and clay (ESC) aggregate of the type used for these tests.

Lightweight expanded shale and clay (ESC) aggregate has long been used in applications that require strength without excessive weight, such as in high-rise buildings and bridge decks. Blended lightweight/stone mixes that were used for roadway paving in the late 1970s and throughout the 1980s continue to provide excellent service today. Although 300,000 cubic yards of ESC aggregate is used each year in Texas in seal coat and surface treatment applications, the material has seemingly fallen out of favor in hot mix asphalt roadway paving applications today.

Expanded shale and clay is a ceramic lightweight aggregate prepared by expanding select minerals in a rotary kiln at temperatures over 1000° Celsius. The production and raw material selection processes are strictly controlled to ensure a uniform, high quality product that is structurally efficient, durable and inert, yet up to 50 percent lighter than stone.

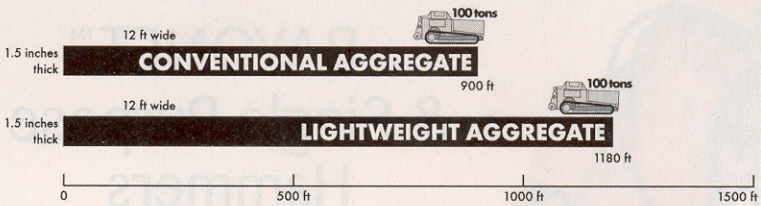
The result is a material which has the highest polish value of any material used in the state of Texas, based on TxDOT's Bituminous Rated Source Quality Catalog (BRSQC). A polish value is a measurement of readings on a test specimen of aggregate after nine hours of polishing in an accelerated polishing machine. It measures the ability of an aggregate to withstand the polishing effects of traffic wear. Simply put, the material maintains its "roughness" and excellent wet weather skid characteristics even after years of traffic wear.

Oscar H. Rodriguez, P.E., an expert in the field of asphalt and concrete materials and paving, spent the first 10 years of his career working in TxDOT's Materials and Tests Division and the Austin District Laboratory, and the past 11 years as the principal at Rodriguez Engineering Laboratories. He has worked on Hot Mix Asphalt Concrete (HMAC) designs for the Texas Motor Speedway in Fort Worth, and test tracks throughout Texas for Goodyear, Cooper Tire and General Tire. He currently serves as a director for the Texas Hot Mix Asphalt Paving Association.

Rodriguez explains the benefit of lightweight aggregate by comparing it to a sponge: "If you cut a sponge in half, you expose its cells inside, each with tiny edges formed by air bubbles. As you wear through the shell of lightweight aggregate, you expose one of its best characteristics — its abrasive texture formed by its cells makes it highly resistant to polishing and stripping."

A recent study by an independent lab commissioned by TXI tested the performance of a hot mix design using TXI Streetman lightweight aggregate compared with a conventional design. The study, conducted by Gary W. Dolph Company, a hot mix asphalt concrete research and development firm, ran a series of tests on two hot mix designs used for roadway overlays.

Conventional Coarse Aggregate
Versus
Lightweight Aggregate
In Hot Mix Applications



Left: Lightweight aggregate weighs 50 percent less than stone, so that a ton of ESC aggregate is a larger pile than a ton of limestone.

Right: Chart 1. The end result is that a greater volume of hot mix — approximately 30 percent more, measured in cubic yards, not tons — is produced to use on the roadway.

The conventional design consisted of:

26% Type C (Crushed Limestone)
32% Type D (Crushed Limestone)
36% Screenings (Crushed Limestone)
5% Field Sand
4.3% Asphalt (Lion Oil PG 76-22)
1% Hydrated Lime

The test design substituted TXI Streetman ESC aggregate for the Type D coarse aggregate:

32% Type C (Crushed Limestone)
20% Type D (TXI Streetman Lightweight)
42% Screenings (Crushed Limestone)
6% Field Sand
5.5% Asphalt (Lion Oil PG 76-22)
1% Hydrated Lime

The two samples were subjected to a battery of lab tests to measure strength, stability, environmental durability and wear characteristics. In every test, the lightweight test design performed at a level that met or exceeded TxDOT specifications set by the Manual of Testing Procedures, and bettered the conventional design in one test: the Hamburg Wheel tracking test, which measures rutting, a danger to motorists.

The Hamburg test is a relatively new test method being used by TxDOT on some recent overlay projects to determine the susceptibility of bituminous (asphalt) mixtures to moisture damage. The test involves running a steel wheel with a 158-pound load over a specimen 50 times a minute and measuring the rutting that occurs.

The Dolph study conducted the Hamburg test on both the conventional design and the test design, with the TxDOT required specification of less than 12 mm rut depth after a minimum of 20,000 wheel passes. The conventional design failed to meet TxDOT specifications after only 19,000 passes, with a rut depth of 12.5 mm. The test design easily met specifications with a rut depth of 9.8 mm after 20,000 passes.

While this test does not mean that another limestone mix couldn't pass the Hamburg test, it does show that a mix using lightweight aggregate can be stable enough to meet TxDOT specifications. "The abrasive nature of lightweight aggregate makes it more resistant to stripping than conventional stone," said Rodriguez. "In the case of this particular mix, my opinion is that the aggregate's abrasiveness contributed to a very stable mix that is more resistant to rutting."

The systemic problem is that hot mix is typically measured by the ton, unlike concrete, which is measured by the cubic yard. This inherently penalizes the ESC aggregate's lightweight properties. Since lightweight aggregate weighs 50 percent less than stone, a ton of ESC aggregate is greater volumetrically than a ton of limestone, accounting for its higher cost. If hot mix using ESC lightweight aggregate were measured and sold by the cubic yard, it would be on a level playing field with conventional stone hot mix.

The problem is compounded by the misconception that since ESC aggregate is porous, it "absorbs" more asphalt in the hot mix. This appears to be so because approximately two percent more asphalt is required to coat the larger surface area of the ESC aggregate. This is the calculation that also makes bidding ESC more difficult, according to TxDOT sources.

"As with any new or unfamiliar material, there's a learning curve associated with its unique characteristics and proper installation," said Rodriguez. "With the proper handling, lightweight aggregate performs just as well as other types of aggregate and offers many benefits over conventional stone."

The end result is that a greater volume of hot mix — approximately 30 percent more, measured in cubic yards, not tons — is produced to use on the roadway. (Chart 1) Based on performance, there's no reason why ESC lightweight aggregate shouldn't at least be considered in hot mix projects to deliver a safer, longer-lasting roadway surface for the traveling public. ❑

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