Evaluation of Recycled Brick as an Aggregate Material for Shoulder Base Courses

What Was the Need?
Sustainability is a growing concern in nearly all facets of transportation, and a central component is the conservation and reuse of materials. MnDOT is already a leader in using recycled aggregate materials, including asphalt pavement, concrete aggregate and glass. More than half of aggregate material in metro area shoulders and pavement base is recycled.

Each year an estimated 88,000 tons of brick enter Minnesota’s waste stream. A contractor inquired if this material would be suitable for use as aggregate, which could divert a significant amount of material from landfills. Using waste material as aggregate could also significantly reduce costs and conserve natural stone aggregate.

What Was Our Goal?
This project sought to evaluate whether recycled brick is suitable for use in aggregate for road construction.

What Did We Do?
There are three broad categories of brick: structural brick used in building construction; pavers used in driveways and sidewalks; and refractory brick used in lining furnaces, kilns and fireplaces. Researchers collected 16 clay brick samples from all three types for testing. Half of these samples were 8-month-old brick obtained from brick plants or distributors, while half were used brick up to 130 years old that came from site demolitions or construction and demolition debris stockpiles.

Researchers crushed the brick into aggregate and conducted three tests on each of the 16 brick samples. The first test measured specific gravity and absorption. Absorption can vary widely (from less than 1 percent for granite to 30 percent for lightweight shale), and different limits for absorption may be acceptable depending on the application. A high absorption, however, may indicate poor freeze-thaw capabilities or abrasion resistance.

Researchers then conducted the Los Angeles Rattler test to determine mass loss due to abrasion. Aggregates must be able to withstand crushing and disintegration to perform adequately; MnDOT specifications for virgin aggregates permit no more than 40 percent mass loss in this test or 35 percent mass loss for Class 6 aggregate. (In general, this specification is most important for carbonate quarry aggregate; most other types meet the standard easily.)

In the third procedure, researchers tested samples for resistance to weathering with the magnesium sulfate soundness test. This test simulates the effects of annual freeze-thaw cycles in a short time. MnDOT specifications for mass loss vary by aggregate size from 14 to 23 percent.
What Did We Learn?

Most of the bricks met or nearly met MnDOT specifications for virgin aggregate. Absorption for the brick aggregate averaged 7.7 percent. The eight samples from demolitions or stockpiles had a higher average absorption (8.7 percent) and higher variability. The two refractory bricks had exceptionally high absorptions—more than twice the standard deviation greater than the average.

Mass loss in the LA abrasion test averaged 41.6 percent, near to the MnDOT specification for virgin aggregate. The two refractory bricks performed notably poorly, with one losing an average of 78 percent of its mass over three separate test runs. Among the other samples, nine met MnDOT’s 40 percent standard, while five failed by a small margin.

Most of the samples easily met MnDOT specifications in the magnesium sulfate soundness test, although two demolition samples—one refractory brick and one structural brick—failed.

While most of the brick samples performed well in these tests, refractory brick performed notably poorly. It is impractical to simply specify the exclusion of these bricks, however; there is no simple test to identify refractory brick and no way to ensure that aggregate recycler stockpiles will not include it.

What’s Next?

Based on the collected data, researchers recommend that a maximum of 10 percent brick aggregate by mass be permitted for shouldering applications, which they considered a conservative value that will meet the 35 percent LAR limit for Class 6 aggregate at the 98th percentile. Shouldering consumes about 800,000 tons of aggregate in Minnesota every year; using 10 percent recycled brick aggregate would consume almost all of the waste brick generated in the state annually.

MnDOT’s approach is more cautious, however, because if recycled brick does not perform adequately the negative consequences are potentially severe. Moreover, most aggregate recycling companies do not manage separate stockpiles for shoulders and for pavements, where recycled brick aggregate will not be permitted. While keeping recycled aggregate piles completely free of poor aggregate material is impossible, MnDOT has changed its specification to permit up to 1 percent recycled brick in shouldering aggregate.