RECYCLED CONCRETE MATERIALS REPORT

OHIO DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT
1600 WEST BROAD STREET
COLUMBUS, OHIO 43223

Testing performed by Aggregate Section and Cement and Concrete Section

Report prepared by Sean Mulligan, PE

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INTRODUCTION

The Ohio Department of Transportation (ODOT) is investigating the use of recycled concrete materials (RCM) in roadway applications. One of the potential uses for RCM is as an aggregate base in roadway construction or re-construction. Past problems encountered by ODOT with using RCM as an aggregate base include alkaline run-off (high pH of water flowing through RCM aggregate in sub-base) and tufa formation (calcium deposits) clogging drains and filter fabrics. Another concern of ODOT's when using RCM is the soundness of the material and the unreliability of using the Sodium-Sulfate Test on recycled concrete materials.

PURPOSE

ODOT began laboratory testing of RCM in January of 2002. The purpose of this testing was to:

1) Determine pH of water that has been in contact with RCM and compare these results to the pH of water that has been in contact with virgin aggregates under the same conditions;

2) Determine if tufa formations readily occur in drainage pipes and filter fabric exposed to water that has been in contact with RCM; and

3) Determine the soundness of RCM using methods other than the Sodium-Sulfate Test and compare these results to the soundness of virgin aggregates tested in the same manner.

PROCEDURES

ODOT performed four (4) separate tests regarding RCM. Individual reports for each of these tests are included. The tests performed include the Bucket Test, Box Test, Soundness Test by Freeze/Thaw, and Soundness by LA Abrasion.

The *Bucket Test* consisted of soaking various aggregates in water. Water samples were taken periodically and pH values were measured. Several trials were conducted where each trial had a different variation. The variations included size or gradation of material, the mixing of materials together at different ratios, and whether refreshing (periodically changing) the water as opposed to leaving the water stagnant had any impact on pH values.

The *Box Test* consisted of simulating an aggregate road base complete with drainage hoses and filter fabric, and percolating water through the aggregate, hoses, and filter fabric. Water samples were taken periodically and pH values were measured. The water was recycled through the simulated base numerous times, and when the test was complete, the drainage hoses and filter fabrics were inspected for tufa.

The *Soundness Test by Freeze/Thaw* consisted of exposing aggregates of known, uniform, particle sizes to repeated freezing and thawing occurrences. Samples were periodically re-sieved and losses due to particles fracturing and becoming smaller in size were recorded.

The *Soundness Test by LA Abrasion* consisted of exposing aggregates of known gradations to abrasion, impact, and grinding actions. Samples were sieved afterward and losses due to particle abrasion were recorded.

CONCLUSIONS

pH

The acceptable pH limit for run-off water is 9 according to EPA regulations. Results from both the *Bucket Test* and *Box Test* indicate pH values from run-off water in contact with RCM will be at least 10 which exceeds the EPA limit. However, results from the *Bucket Test* indicate that mixing limestone with RCM at a ratio of 60% (or more) limestone to 40% (or less) RCM will result in run-off water with a pH less than 9 which is acceptable.

Tufa

The results of the *Box Test* did not show signs of tufa formation. However, the procedure did not involve exposing run-off water to carbon dioxide or temperatures decreases which are both linked to tufa formation.

Soundness

With respect to the *Soundness Test by Freeze/Thaw*, RCM is not nearly as sound or durable as virgin aggregates (limestone and gravel) for particle sizes $\geq$ to the #4 sieve. This test was performed for 160 cycles but the majority of the losses occurred early (in the first 54 cycles). Results from the *Soundness Test by Freeze/Thaw* indicate that when compared to virgin aggregates (limestone and gravel) at 54 cycles, RCM will have losses 10% to 33% more (or 500 to 1500% higher) for 1" sized particles, 9% to 28% more (or 200 to 700% higher) for 3/4" sized particles, and 1% to 12% more (20 to 50% higher) loss for #4 sieve sized particles. For particle sizes < #4 sieve, RCM will have losses 8% to 23% greater than gravel but roughly but RCM losses will be roughly equivalent to limestone. The poor soundness and early loss for particle sizes $\geq$ #4 sieve is most likely attributed to chunks of mortar in the RCM fracturing and de-bonding from the aggregate. With particle sizes < #4 sieve, there are no mortar chunks adhering to the aggregate and therefore these smaller sized particles had losses similar to limestone.

With respect to the *Soundness Test by LA Abrasion*, RCM is not as sound or durable as virgin aggregates (limestone and gravel). The virgin aggregates tested exhibited losses of 21% (gravel) and 36%. RCM exhibited losses of 40% (R1), 42% (R2), and 37% (R3).