The Ohio Department of Transportation Office of Research & Development Executive Summary Report

Larger Sized Coarse Aggregates in Portland Cement Concrete Pavements and Structures

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Problem

ODOT is continually searching for ways to improve the cost efficiency of Portland cement concrete without sacrificing concrete strength and stiffness. Because Portland cement is easily the most costly material used in normal concrete, limiting the amount of cement used is the quickest way to achieve cost effectiveness. In addition, limiting the cement content will also help to prevent dimensional instabilities in concrete such as shrinkage and creep. The use of larger sized coarse aggregates may be useful in limiting cement content, yet larger sized coarse aggregates may also decrease concrete strength by weakening the aggregate-cement paste bond. In many transportation structures, such as pavements, concrete strength is not critical, as dimensional stability, porosity, and durability play a more important role. It is possible, therefore, that larger sized coarse aggregates can reduce the cement content and improve these properties.
Laboratory research is needed to determine if larger sized coarse aggregates can improve cement efficiency without reducing concrete strength.

Objectives

This project seeks to assess the effects of aggregate type and size on the mechanical properties of concrete, viz., on the compressive and flexural strengths, and on the modulus of elasticity. The research goal is to examine if the cement efficiency of standard Ohio Department of Transportation (ODOT) concrete mixes for pavements and other transportation structures can be improved by the use

of larger sized coarse aggregates.

Description

A literature survey was conducted concerning the methods in which coarse aggregate properties (such as size, shape, strength, and surface texture) affect the physical, mechanical, and environmental properties of Portland cement concrete.
Aggregate testing was performed to determine properties (such as unit weight, specific gravity, and absorption) that were then used to create a series of mix designs. Two types of coarse aggregate (natural and crushed), along with three coarse aggregate gradations (No. 57, No. 467, and No. 357) were used to produce six different concrete mixes. Blending was used in creating the No. 467 and No. 357 aggregate gradations.
Concrete specimens were tested for compressive strength, modulus of elasticity, and modulus of rupture. For each test, two specimens were tested on each of five dates: 3, 7, 28, 56, and 90 days.

Conclusions & Recommendations

For the most part, different coarse aggregate properties did not impact significantly the mechanical properties of concrete examined. When significant differences were observed, these were confounded by variability issues related to the testing protocols themselves, and by mineralogical distinctions among the various aggregate blends. It is, therefore, concluded that coarse aggregate gradation had little effect on the mechanical properties of concrete. These results indicate that larger sized coarse aggregates can be used for pavements and highway structures without significantly compromising the mechanical properties of the concrete, and afford concrete producers more flexibility in creating cost-effective and cement-efficient mixes. In view of the natural variability of concrete test results, further research is highly desirable. It is recommended that the number of specimens tested be increased to five or six, in order to improve the confidence level. Conversely, the number of testing dates can be considerably curtailed without compromising the quality of the data obtained, since it was found that strength development in the first 90 days presents few surprises.

Implementation Potential

The recommendations above can be implemented immediately by any ODOT District including larger sized aggregates in its concrete mix design. The main benefits from this research will derive from the increased cement efficiency and economy expected to be associated with the use of larger sized aggregates, of appropriate mineralogical composition, if such use is also justified based on the results from other, more specific and extensive, studies. Another benefit will derive from the observations made regarding the natural variability of concrete and of the testing protocols followed, as well as the methodology for interpreting the data collected. The latter supplements the traditional statistical approach with a series of engineering considerations. It is anticipated that there may be a hesitation to innovate by using larger sized aggregates in pavement and bridge construction. It is suggested that ODOT make more stringent its mineralogical composition requirements when

envisaging the use of such aggregates, in order to ensure that material is obtained from reliable suppliers alone, whose declarations of suitability may be accepted with confidence. The possibility of bonding the manufacturer to the performance of the pavement or bridge concerned may also be considered.