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

Effect Of Larger Sized Coarse Aggregates And Of Microsilica
On Environmental Properties Of Portland Cement Concrete Pavements And Structures

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Problem

Addition of microsilica to a concrete mix usually results in significant improvements in strength, durability and permeability. American Society for Testing and Materials (ASTM) C 1240 requires wet-sieved microsilica to pass a No. 325 sieve with no more than 10% retained. Densified microsilica samples submitted to ODOT sometimes do not meet this specification as the sieving process may not be able to break the bonds formed due to the densification. At the other extreme of the concrete mix design gradation spectrum, 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. This study examines whether the addition of microsilica, or the use of aggregates with maximum size above 1.5 in., in concrete mixes prepared by the Ohio Department of Transportation (ODOT) for bridge decks and highway pavements can have adverse effects on the durability properties of such structures.

Objectives

The behavior of several series of concrete specimens has been monitored over a period exceeding a year, and numerous measurements have

been recorded. Such data are evaluated to determine if altering the standard ODOT concrete mix design on either end of the gradation spectrum can indeed lower the cement content and increase its cost effectiveness and efficiency.

Description

A literature survey was conducted pertaining to the effect of larger sized coarse aggregates and of microsilica on the durability of concrete. The emphasis of the information presented is on the various experimental methods of assessing the environmental properties of concrete mixes, many of which are used subsequently in this project. The bibliography examined covers primarily the period between 1990 and the present.

A number of testing procedures were adopted for the purpose of assessing the environmental properties of the concrete mixes prepared, while adhering to the specifications of ODOT, of the American Association of State Highway and Transportation Officials (AASHTO), and of the American Society for Testing and Materials (ASTM). Such procedures included tests for shrinkage, creep, freeze/thaw durability, abrasion resistance, and rapid chloride permeability.

Conclusions & Recommendations

Different coarse aggregate gradations did not impact significantly the environmental properties of concrete examined. Differences observed 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 environmental properties of concrete. These results indicate that larger sized coarse aggregates can be used for pavements and highway structures without significantly compromising the environmental properties of the concrete, and afford concrete producers more flexibility in creating cost-effective and cement-efficient mixes.

It was found earlier that the compressive and flexural strengths of abused microsilica did not differ much from that of densified microsilica. The abused microsilica was intended to represent the worst possible situation that might arise in the field. The clumps formed during the abusing process were evindently broken using a trowel; therefore, it was concluded that the clusters of microsilica that are formed in the field due to moisture can easily broken during the mixing process. This conclusion is brought into question, at least in the case of abused microsilica, by the rapid chloride permeability results obtained. Nonetheless, all values obtained are within the limits termed as low or moderate by the prevailing specifications. It is recommended that the microsilica should be stored for limited time only, in areas of low humidity at room temperatures, and that the mixing process should be careful and thorough, to limit the amount of densification at mixing, and to permit any bonds to be broken. 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 in order to improve the confidence level. The blends conforming to the No. 467 and the No. 357 gradations can be refined further through experimentation. The mineralogical characteristics of the aggregates should be

examined using appropriate procedures that were beyond the scope of this project, and should be controlled by exploring the most suitable sources of aggregates. The suitability of microsilica types, other than the undensified, must be explored by a larger series of tests focusing exclusively on the environmental properties of concrete mixes containing these materials.

Implementation Potential

The recommendations above can be implemented immediately by any ODOT District including microsilica or larger sized aggregates in its concrete mix design.

The main benefits from this research will derive from the use of densified microsilica from respected manufacturers in pavement and bridge construction, as well as the increased cement efficiency and economy expected to be associated with the use of larger sized aggregates of appropriate mineralogical composition, provided such practices are also justified based on the results from other, more specific and extensive, studies.

It is anticipated that there may be a hesitation to abandon what may currently be the only test conducted at the ODOT laboratory in order to assure the quality of densified microsilica, or to innovate by using larger sized aggregates in pavement and bridge construction. It is suggested that ODOT make more stringent its microsilica procurement process, in order to ensure that material is obtained from reliable manufacturers alone, whose declarations of suitability may be accepted with confidence. It is also suggested that ODOT make more stringent its mineralogical composition requirements when envisaging the use of larger size aggregates. The possibility of bonding the manufacturer to the performance of the pavement or bridge concerned may also be considered.