

ABSTRACT

Kho Pin Verian. M.S.C.E., Purdue University, May 2012. Using Recycled Concrete as Coarse Aggregate in Pavement Concrete. Major Professor: Jan Olek

The objectives of this study was to evaluate the effects of using aggregate produced from recycled concrete as a replacement for natural (virgin) coarse aggregate in pavement mixtures. All mixtures containing the recycled concrete aggregate (RCA) were designed to meet the requirements of Indiana Department of Transportation (INDOT) specifications. The scope of the study included evaluation and comparison of several properties of RCA and natural aggregates, evaluation and analysis of the effects of RCA on concrete properties, and modification of aggregate gradations and mixture composition in an attempt to improve the properties of RCA concrete.

A total of ten different concrete mixture types were produced in the course of this study. These included four different RCA replacement levels (0%, 30%, 50% and 100% by weight of the natural coarse aggregate) and two different cementitious systems (*plain system* – Type I portland cement only and *fly ash system* – 80% of Type I portland cement and 20% of ASTM C 618 Class C fly ash). All ten mixtures were first produced in the laboratory (trial batches) and subsequently reproduced in the commercial ready mixed concrete plant. Each mixture produced in the ready mixed plant was used to prepare several types of specimens for laboratory testing. The tests performed on fresh concrete included determination of slump and entrained air content. The mechanical properties of the hardened concrete were assessed by conducting compressive strength, flexural strength, modulus of elasticity and Poisson's ratio tests. The durability of concrete was assessed using wide array of measurements, including: rapid chloride permeability (RCP), rapid chloride migration (RCM), electrical

impedance spectroscopy (EIS), surface resistivity, free shrinkage, water absorption test, freeze-thaw resistance and scaling resistance.

The test results indicated that the properties of plain (no fly ash) concrete mixtures with 30% RCA as coarse aggregate were very comparable (in some cases even better) than those of the control concrete (0% RCA). Although mixtures with 50% RCA showed up to 36% reduction in durability and mechanical properties, the test results still met INDOT's specifications requirements. However, the mechanical properties of plain concretes made with 100% RCA were measurably lower (16- 25%) than those of the control concrete. It should be pointed out, however, that these properties were still above the minimum required by INDOT's specification, the only exception being the w/cm value that needed to be elevated to 0.47 from the maximum recommended of 0.45.

The use of fly ash improved the quality of RCA concrete, especially at later ages. In particular, the properties of concrete with 50% of RCA were similar to the properties of control concrete. Similarly, the properties of mixture with 100% RCA improved when compared to the same mixture without fly ash and the concrete met minimum requirements imposed by INDOT's specifications. However, when compared to the fly ash concrete with 100% virgin aggregate the mechanical properties of the 100% RCA concrete were up to 19% lower.

The results of all tests performed during this study were used to develop several statistical models which can be used to predict selected properties of the RCA concrete, thus reducing the number of laboratory test required to be performed on the actual mixtures. The developed models can be used to predict the following properties: slump, 7-day flexural strength and 56-day bulk resistance. These models were successfully verified using results from several independent (not used in the original model development) mixtures.

Once the testing of the original ten types of concrete mixtures was completed, six additional concrete mixtures were produced, each with modified (with respect to original mixtures) gradation of aggregate. These mixtures were

used to study if the virgin and RCA aggregates can be combined in different proportions to produce the “optimized blend” which will improve one (or more) concrete characteristics. The test results obtained from the six additional mixtures indicated that modifying the aggregate gradation did not have beneficial effects with respect to either compressive or flexural strength values.

Considering limited scope of this study (only one source of RCA aggregate was used) it is recommended that the amount of RCA in plain concrete be limited to 30% and that in the fly ash concrete be limited to 50% to ensure the adequate quality of the pavement concrete.

Key words: recycled concrete aggregate (RCA), pavement concrete, mechanical properties, durability properties, rapid chloride permeability, electrical impedance spectroscopy, shrinkage, plain concrete, fly ash concrete.