Transportation Consortium of South-Central States (Tran-SET)

Use of Rice Hull Ash (RHA) as a Sustainable Source of Construction Material

Highlight | Feb. 2018

Project No. 17CASU02

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POP: May 2017 – November 2019

Testing the feasibility of rice husk ash as a suitable supplementary cementitious material

This study focuses on the use of rice husk ash (RHA) as an alternative supplementary cementitious material (SCM) to be added with ordinary Portland cement (OPC) concrete. Pozzolans, or alternative supplementary cementitious materials, are silicate-based materials which in finely powdered form and in the presence of water will react with the calcium hydroxide generated by hydrating cement to form additional cementitious material.

RHA has been used with OPC in different portions to investigate the chemical, physical and strength properties of modified concrete. In this study, three different sizes of RHA (600 µm, 150 µm, and 44 µm) in two different portions (10% and 20%) were used as a partial replacement of Type-I OPC. Two other SCM materials, namely, C fly ash (CFA) and silica fume (SF), in the same percentages are also being evaluated in this project work to have comparative analyses with RHA-modified concrete. Different types of laboratory tests were done to determine the properties of the fresh concrete mix as well as the mechanical properties of hardened concrete. The durability of concrete under adverse conditions was tested for alkali-silica reaction (ASR) and deicing chemicals tests. With the detailed study, it was concluded that finer RHA is more advantageous than coarse RHA, and a 10% dose of RHA was found to be the optimum for use in concrete. Results of this study are expected to help in assessing the feasibility of utilization of RHA as supplementary cementing materials.

Problem Statement

In the present world, the most amount of natural products such as sand, gravel, crushed rock and fresh water are consumed by the concrete industry. Annually, 1.6 billion tons of Portland cement are being used as a binder material. Different cost-effective technologies such as blended Portland cement, and modified concrete have been used to reduce the environmental impacts. Rice husk is a by-product of the rice industry, which is obtained during the process of milling rice. According to the AASHTO M321, RHA is a highly reactive pozzolan material because of its high silica content, but its performance as a construction material has been investigated very little. Moreover, RHA can be used as an alternative modifier to enhance the performance of asphalt binder under the heavy traffic loads. The results of this study are expected to be more informative in the direction of use of RHA in the field of ecological and economical construction.

Summary

A comprehensive literature review on RHA in concrete from past research publications published by different agencies (ASCE, TRB, FHWA, DOTs, ASTM) was done. Coarse aggregates and fine aggregates were obtained from a local ready mix concrete plant. Three different types of RHA (RHA-I: 600 µm, RHA-II: 150 µm, and RHA-III: 44 µm) were collected from Riceland and other producers, as shown in Figure 1. The physical and chemical data of the provided RHA has also been collected from the source provider. Laboratory tests were conducted on modified concrete cylinders, beams, and mortar bars. Initially, modified concrete mixes were tested for slump, air content, and unit weight according to ASTM C143 (25), ASTM C231 (26), and ASTM C138 (19), respectively. The American Concrete Institute (ACI) recommended "Absolute Volume Method" was followed to design concrete mixes with a water to cement ratio of 0.45.

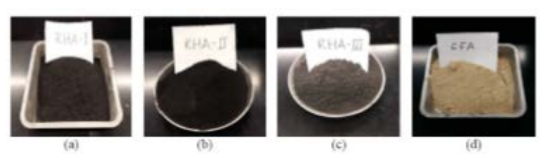

Figure 1. Different Test Samples: (a) RHA-I, (b) RHA-II, (c) RHA-III, and (d) CFA.

The mechanical properties such as compressive, tensile, flexural strength, modulus of elasticity, and Poisson's ratio of hardened concrete were determined by following appropriate ASTM standards. Concrete cylinders of 150 mm by 300 mm were used for determining the compressive and tensile strength of the modified concrete. Compressive strengths were determined at 7, 14, 21, and 28 days according to ASTM C39 (27). To observe the alkali-silica reactivity (ASR), the test method outlined in ASTM C1260 was conducted. The effects of deicing chemicals were evaluated by testing mortar bars according to ASTM C672. BET analyses using a NOVA 2200e analyzer have been conducted to get the surface area of the RHA, CFA, and SF .

Findings

The properties of fresh concrete mixes (CR, RHA-1, RHA-2, RHA-3, CFA, SF) are shown in Table.1. From the Table.1, it is observed that finer RHA particle shows less slump value and require more water to have consistency. For the 28-day compressive strength test results, it was observed that the specimen groups RHA-I and RHA-II had significantly less strength than the Control specimens. On the other hand, RHA-III exhibits an increase in compressive strength. Figure 2 presents the effects of alkali-silica reaction (ASR) in mortar bars.

Table 1. Mix Properties of Fresh Concrete.

Type of RHA/Fly Ash	Replacement (%)	Slump (mm)	Air Content (%)	Unit Weight (kg/m^3)
Control	0%	90	1.3	2435
RHA-I	10%	90	2.1	2259
	20%	115	3.2	2179
RHA-II	10%	25	3.4	2323
	20%	25	3.5	2275
RHA-III	10%	40	1.4	2371
	20%	50	2.3	2323
CFA	10%	130	5.5	2355
	20%	130	5.8	2355
SF	10%	114	5.0	2387
	20%	76.5	5.5	2291

Figure 2. Effect of ASR expansion on RHA, CFA and SF modified concrete.

Impacts

This study is expected to give a road map for using agricultural waste as a construction material. The outcomes of this project are expected to reduce the cost of concrete and asphalt mixes significantly and make local farmers economically sustainable. The sustainable use of RHA in producing concrete will be a significant cost saving for ARDOT. It will also enhance the learning opportunities for students involved in this project. Upon their graduations, they are expected to enter into transportation workforce.

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

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