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Recycling and reuse of reclaimed Portland cement concrete aggregate

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Abstract— the purpose of this research was to study the behaviour of RPCC aggregates in Portland cement concrete and embankment. For the first case, several batches of concrete were prepared with RPCC aggregate, natural aggregate, different water cement ratio (WCR) and different maximum size of the aggregate. Standard tests were performed on RPCC and natural aggregates, concrete made with recycled and natural aggregate, including specific gravity and absorption, slump and compression tests. For the second case, shear tests were performed on RPCC aggregate to obtain the failure envelope and the friction angle. RPCC material can develop a high friction angle at failure, making this material highly recommended for use in embankments. Moreover, RPCC aggregate can be mixed with a material of lower quality, making its use more economically attractive.

Keywords— Reclaimed, landfills, Penetrability, Demolished wastes, workability, compressive strength, recycled concrete, coarse aggregate.

I. INTRODUCTION

The construction of infrastructures related to bridges, highways, water systems, and buildings has been increasing from the beginning of the past century, especially in areas where population density is high. Infrastructures need to be repaired with the pass of the time. In some cases, constructions need to be replaced, because their service life is reached or their original design no longer satisfy the new requirements (population, traffic, or weather). These facts have generated two important issues: first, a growing demand for construction aggregates, and second an increasing production of construction material waste.

The construction waste only, on the other hand, produced from building demolition is estimated to be 124 million tons per year. Historically, the most common method of managing this material has been through disposal in landfills. It is estimated that 50 percent of concrete debris and 20 percent of all asphalt pavements end up in landfills. As cost, environmental regulations, and land policies of landfill arise, the concern to seek alternative uses of the waste material also increases.

II. MATERIALS AND METHODOLOGYP

The research was addressed to the study of the incorporation of Reclaimed Portland cement concrete (RPCC) in Portland cement concrete pavement and embankments. For Portland cement concrete, slump and compression tests were performed with the purpose of studying and comparing the properties of freshly mixed and hardened Portland cement concrete made with RPCC as well as natural aggregate, using the same mixture design and specifications. For the second case, the use of recycled concrete in embankment, shear tests were performed with the objective of determining the shear capacity of this material, i.e. calculating its failure envelope and its angle of friction at failure. The present research, including material description, aggregate properties, material preparation, and testing procedures.

MATERIAL DESCRIPTION.

RECLAIMED PORTLAND CEMENT CONCRETE COARSE AGGREGATE.

An aggregate producer in Maryland donated the RPCC aggregate used in this research. The recycled aggregate was identified as RC-57 (Reclaimed concrete #57) and it met the requirements for size #57 specified in ASTM C33 (14). Table 1.1 contains the material properties of RPCC. Specific gravity and absorption were determined in laboratory and they were included. From visual observation as shown in Figure 3.1, the material was highly angular in shape. The recycled aggregate was sieved, separated, and stored by individual sizes. All the contaminated particles were removed through sieving and washing processes. RPCC aggregate was recombined later according to the necessities of the mixture design and following the grading proportion specified in Table 1.2.

TABLE 1.1. CRUSHED CONCRETE RECYCLED AGGREGATE PHYSICAL AND MECHANICAL PROPERTIES.

Property	Value
Plastic index	Non-Plastic
Loss Angeles Abrasion Loss	35.9%
Soundness. (By use of sodium Sulphate. ASTM C88)	6.6%

TABLE 1.2. SIEVE ANALYSIS OF THE CRUSHED CONCRETE RECYCLED AGGREGATE.

Sieve Size		Crushed Concrete recycled Material	ASTMC33 Requirements (14)
in	mm	% passing by weight	% passing by weight
1 ½"	37.5	100	100
1"	25.0	96	95-100
½"	12.5	27	25-60
#4	4.75	5	0-10
#8	2.36	2	0-5

Figure 3.1. RPCC Aggregate.

III. **RESULTS.**

In this section, physical properties (specific gravity and absorption) of the RPCC aggregate and natural aggregate were determined with the objective of using them in the mixture design process.

Specific Gravity and Absorption

The test methods for specific gravity and absorption were applied to two samples: a RPCC and a natural coarse aggregate samples, each one with a saturated surface- dry weight of 9.20 lb (4.17 kg.). The results are summarized in Table 1.3. The specific gravity value for RPCC aggregate was a 7.9% lower than that of natural aggregate. On the other hand, the absorption for RPCC material was 3.6 times the value obtained for natural aggregate.

TABLE 1.3. SPECIFIC GRAVITY AND ABSORPTION RESULTS.

	RPCC aggregate	Natural aggregate
OVEN DRY WEIGHT (A), LB (KG).	8.85	9.10
Saturated-surface-dry weight (B), lb (kg).	9.20	9.20
Saturated weight in water (C), lb (kg).	5.40	5.60
Bulk Specific Gravity	2.33	2.53
Bulk Specific Gravity (saturated-surface-dry), (SSD)	2.42	2.56
Apparent Specific Gravity	2.57	2.60
Absorption, %	4.00	1.10

Note: Bulk specific gravity = AI (B-C).
Bulk specific gravity (SSD) =B/ (B-C).
Apparent specific gravity =A/ (A-C).
Absorption = [(B-A)/A]*100.

IV. CONCLUSIONS

The purpose of this research was to study the behavior of RPCC aggregates in Portland cement concrete and embankment. For the first case, several batches of concrete were prepared with RPCC aggregate as well as natural aggregate. Several parameters were varied from batch to batch to understand their influence, including water cement ratio and maximum size of the aggregate. The design method and specifications used were the same for all batches prepared. Absorption and specific gravity test were performed on recycled and natural coarse aggregate, since these values play an essential role in concrete mixture design. Standard tests used to certify the quality of freshly mixed and hardened concrete with natural aggregate were performed on concrete with recycled and natural aggregate, including slump test and compressive tests. For the second case, shear tests were performed on RPCC aggregate with the objective of obtaining the failure envelope and the friction angle.

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