Development of a Treatment Technique to Reduce the Water Absorption Capacity of Recycled Aggregates

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Abstract: This study was to find a treatment technique to reduce the water absorption of Recycled Aggregates (RA) which involved preparing a coating to reduce the water penetration. The materials considered for the preparation of coating was Termite Mound Soil (TMS) and ordinary Portland cement. The objective was to find their optimum proportions and the slurry thickness for a coating that gives the lowest absorption. TMS was tested for pozzolanic properties. Chemical composition was tested using Atomic Absorption Spectroscopy and other analytical techniques. Water absorption, particle size distribution, AIV, LAAV of RA was tested to ensure the suitability for construction purposes. Slurries were prepared using cement replacement levels of 0, 20, 40, 60 and 80% of TMS. Three sets of coatings were prepared with water to solid ratios of 1, 1.25 and 1.5. Slurries were prepared in a concrete mixture in which the aggregates were coated for 10 minutes at a speed of 30rpm. After air drying, coated aggregates were tested for the absorption after 14 days. The absorption of treated aggregates was compared with those of natural and untreated recycled aggregates. Aggregates Coated using 50% cement and 50% TMS showed a significant reduction in the water absorption up to 38.44%.

Keywords: Coating; Recycled aggregates; Termite mound soil; Water absorption.

1. Introduction

With the increasing growth of global construction industry, concrete has become an indispensable material which has made high rise buildings, roads, dams and many other constructions possible. Concrete is a mixture of several major constituents, namely cement, water, fine and coarse aggregates and in some cases, special additives. Out of these constituents, fine and coarse aggregates play a major role in concrete by providing less expensive filler, by providing strength to withstand applied loads, abrasion, effect of weather etc, and by helping to reduce the volume changes happening during the concrete setting process. Natural rocks, sands or gravel are used as aggregates which take up to about 70%-80% of concrete volume (Parek and Modhera, 2011).

There is a considerable environmental impact associated in the production of aggregates. According to recent studies annual global aggregate demand has exceeded 26 billion tonnes by year 2011(Otoko, 2014). Further, construction and demolition waste from concrete has become a major source of industrial wastes in the past years (Fucale et al. 2009).

To give a solution to both above problems recycling of demolished concrete waste by producing Recycled Aggregates (RA) and utilizing for the preparation of new concrete is becoming popular. Many studies have proved that concrete made with RA can have mechanical properties similar to those of conventional concrete after some modifications. (Rahal 2007; Limbachiya et al. 2004; Malešev et al. 2010)

However, there are several drawbacks in RA. Higher water absorption can be considered as the most significant drawback which can directly affect the strength of concrete. This can further change the workability and uniformity of concrete mixtures (Pelufo et al. 2009). Investigations have revealed such high absorption is due to excessive attached mortar and micro cracks generated in the process (Zaharieva 2003).

To overcome this drawback several treatment methods are implemented by researchers, namely heating and rubbing of RA to remove adhered motar (Parekh and Modhera 2011), treating the aggregates with mineral oil (Tsujino and Noguchi 2006), treating with several different types of pozzolanic materials and silica fume impregnation by surface adsorption (Kim and Youn 2005)

In this research, termite mound soil (TMS) along with Standard Portland cement was used to treat RA. TMS is analytically proven to have pozzolanic properties (Ikponmwosa et al. 2009). Several studies have proved that addition of TMS to concrete can improve the properties of concrete (Ikponmwosa et al. 2009; Orie and Anyata. 2012).

TMS is obtained from termite mounds which are made of clay whose properties have further been improved by the excrement and saliva from the termites while being used in building the mound (Mijinyewa et al. 2007).

This study aims on finding the optimum combination of cement and TMS, and the most effective water to solid ratio for preparing a durable coating in order to reducing the water absorption of RA by filling the micro cracks within the aggregates and reducing the porosity of attached motar.

2. Materials and Methods

A bulk sample of Recycled concrete aggregate was collected from the COWAM centre recycling site in Galle. Standard Portland cement was used and a sufficient amount of TMS was collected from a termite mound in Kottawa area, Colombo.

Methodology comprised of several steps. Initially recycled aggregates were tested for the physical properties to identify and analyze the major drawbacks. Physical and chemical properties of Termite Mound Soil were studied to ensure the suitability for the preparation of strong, durable, abrasive resistant coating along with cement.Then the aggregates were treated using several TMS and Portland cement proportions under several water/solid ratios. Finally Water absorption was tested after the surface treatment of RA.

2.1 Initial Physical and chemical tests

Chemical analysis of TMS was conducted in accordance with BS: 4550: part 2: 1978: testing cement. Atomic Absorption Spectrophotometric method and titrametric procedures were followed. Physical properties were tested accordance with ASTM D 845.
Aggregate properties were tested in accordance with BS 812: part 2 and IS 2386. Testing was carried out for both natural aggregates and RA.

2.1.1 Testing of Termite soil

Following tests were carried out to test the Pozzolanic property of TMS

- Total Silica analysis
- Chemical analysis for Al_2O_3, Fe_2O_3, MgO and CaO.
- Specific gravity

2.1.2 Testing of recycled coarse aggregates

Followings tests were carried out to test the properties of RA and natural coarse aggregates

- Sieve Analysis test
- Water Absorption test
- AIV test
- LAAV test

2.2 Preparation of materials for the coating process

TMS lumps were air dried for 7 days before they crushed into smaller particles manually using a hammer. Then the smaller soil lumps were introduced to the ball mill and milled for 20 minutes. Further crushed soil lumps were taken out of the mill and sieved manually using the 0.4mm IS sieve and the fine portion was obtained for the process.

Aggregates were air dried for 7 days and contaminants (polythene, plastic, wooden and glass pieces) were removed manually and sieved using 10mm sieve to remove smaller particles.

2.3 Coating of aggregates

Six scenarios were developed and slurries were prepared from each scenario under three water /solid ratios namely 1, 1.25 and 1.5. (Table 1)

Table 1: Mix proportions

scenario number	Cement %	Soil%
1	20	80
2	40	60
3	50	50
4	60	40
5	80	20
6	100	0

Material from each scenario was placed in the concrete mixer with respective amount of water and was mixed well with a trowel. Then consistent slurry was formed by mixing the materials with respective amount of water for 10 minutes inside the mixer. Then the Recycled Aggregates were introduced to the same and the mixing was carried out for another 10 minutes for each mix proportion at a speed of 30 rotations per minute. Then the coated aggregates were removed from the mixer.

2.4 Drying, Curing and Testing for water absorption

Treated aggregates were then allowed to air dry for 2 days on a steel mesh outside the laboratory and aggregates were sprinkled with water for 2 days and kept 14 days inside the laboratory for curing. After 14 days aggregates were kept in water for one day and water absorption was tested according to IS: 2386 (Part III) - 1963.

3 Results

3.1 Major constituents of termite mound soil

Table 2: Chemical composition

Constituent	Percentage (%)
CaO	0.283
SiO_2	49.6
Al_2O_3	25.2
Fe_2O_3	2.76
MgO	1.82

3.2 Physical properties of aggregates

Table 3: Physical properties of aggregates

Test	Natural aggregate value (%)	Recycled aggregate value (%)
LAAV	27	43.3
AIV	13	27.58
Water absorption	2.5	5.67

3.3 Water absorption of Recycled aggregates after treating.

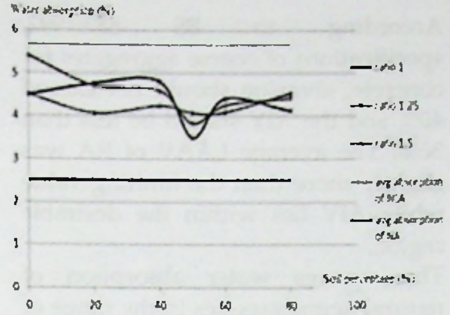

Figure 1: Water absorption variation of treated RA

Upper most line shows the average absorption of RA while lower most line shows the same of natural aggregates. The rest of the curves show the variation in water absorption with the soil content in the coating slurry of treated RA under specified water to solid ratios.

4. Discussion

4.1 Chemical composition of termite mound soil and specific gravity

Table 2 summarizes the percentage of major constituents of TMS. The combined percentage of SiO_2, Al_2O_3 and Fe_2O_3 in TMS was 77.50%, which satisfies the ASTM and BS requirement for pozzolanic materials of minimum of 70%. MgO composition was found to be 1.82% which is less than 4% maximum limit, while CaO composition is 0.283% within the recommended range of ASTM C618-78.

Specific gravity of TMS was found to be 2.4073 ± 0.01644. It is a significantly low specific gravity compared to that of Cement which is 3.15.

4.2 Physical properties of aggregates

According to BS 882:1992, specifications of coarse aggregates for concrete, abrasion should not exceed 40% and the AIV should be less than 30%. The average LAAV of RA was slightly more than the limiting value while AIV lies within the desirable region.
The average water absorption of natural aggregates lies in the range of 2% to 2.5% but for RA the value was close to 6%. Thus recycled aggregates have 55% higher absorption than the natural aggregates which is significantly higher than the specifications. (Table 3)

Aggregate grading was completely within the standard region. Thus the recycled concrete aggregates from the Cowam recycling center have several desirable characteristics.

4.3 Water absorption of Recycled aggregates after treating.

Based on the standard t test results all 3 sets of coatings (Under 3 water to solid ratios) have reduced the water absorption of recycled aggregates with a 99% level of significance compared to the water absorption value of recycled aggregates before treating. Further a significant reduction in absorption could be noticed in RA which were treated using 50% cement and 50% TMS mix proportion in all 3 water solid ratios compared to other mix proportions and the least absorption, 3.49% was achieved under the water solid ratio 1 as reflected in the figure 1.

5. Conclusions

From the results it is evident that coatings made using 50% cement with 50% Termite mound soil, at water/cement ratios of 1 can be used as a treatment method to reduce the water absorption of recycled aggregates up to around 38.44%.

From the research findings it can be concluded that termite mound clay can be used along with cement for treating recycled aggregates to reduce the water absorption of recycled aggregates.
Construction wastes must be properly sorted before processing and further researches are recommended on the effects of addition of TMS as an additive to concrete.

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