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INFLUENCE OF RECYCLED COARSE AGGREGATE ON THE CONCRETE'S STRENGTH BEHAVIOR

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ABSTRACT

Within the last decade, the volume of building trash has expanded substantially, resulting in rising social and environmental concerns about waste recycling. Among the construction wastes, discarded concrete is particularly important. Recycling construction materials is critical in today's rapidly industrialized world to preserve natural resources.The goal of this study was to determine the physical parameters of concrete made using recycled coarse material like brick chips. Concrete waste from a demolished structure was gathered for this study.Demolished coarse aggregate about 2.5%, 5%, 7.5% and 10% was used to replace fresh coarse aggregate. From resulting of specimens, compressive strength (28 days) 21.53 MPa (fresh concrete), 21.32 MPa (2.5%), 20.67 MPa (5%), 19.15 MPa (7.5%), 17.63 MPa (10%) and also Tensile strength (28 days) 2.13 MPa (fresh concrete), 2.12 MPa (2.5%), 2.08 MPa (5%), 1.8 MPa (7.5%), 1.6 MPa (10%).Upto 5% usage of recycle aggregate the strength variation was found minimal which was 11% in compressive and 4% in tensile strength in comparison with fresh concrete. However, from this study it was found that using a combination of normal coarse aggregate and recycled aggregate at a lower percentage produces compressive strength that is comparable to that of new concrete which helps to minimize CO_2 emissions from the production of materials and it also reduces the adverse environmental impact of waste.

Keywords: *Recycled Aggregate Concrete (RAC); Recycled Coarse Aggregate (RCA), Compressive strength; Tensile strength; CO_2 emissions; waste.*

1. INTRODUCTION

1.1 General

Concrete is one of the most frequently utilized building materials on the planet, because to its mechanical qualities, durability, affordability, and accessibility. In recent years, worldwide consumption of concrete is estimated at 20 billion tonnes. To produce such a huge volume of concrete, we need 14 billion tonnes of natural aggregate. To supply aggregate, it is necessary to cut a huge volume of mountains or dig aggregate quarries. On the other hand, we are demolishing concrete structures due to deterioration as well as replacement of low-rise buildings by high-rise buildings Bangladesh has seen a huge number of infrastructure demolitions in the name of urbanization. It is clear that additional concrete waste will be generated by the time. Due to scarcity of natural sources of stone aggregates, bricks are widely used as coarse aggregate in concrete. Conventionally, bricks are produced by burning clay at a temperature of more than 1100°C which causes enormous environmental pollution. Around 17.2 billion clay burnt bricks are produced every year through

around 5,000 brick kilns across the country. During production of these bricks, about 10 million tonnes of carbon dioxide are emitted to the atmosphere. The brick industry is also responsible for about 40 percent of fine particles in the air of Dhaka city. The demand for waste concrete recycling and reuse is both urgent and vital. It has long been acknowledged that the use of recycled concrete is a cost-effective method for recycling leftover concrete and is particularly beneficial to the construction industry's long-term sustainability.

The oldest evidence of the use of recycled aggregate materials in construction dates back to the 1920s in Holland, when destroyed rubble and slag were processed as aggregates in the so-called gravel concrete used in the construction of residential buildings. The rubble was utilized as a base material and as aggregate for concrete and asphalt in the Netherlands at the end of World war II (WWII). Furthermore, Germany used 123 million m3 of masonry aggregates in concrete applications between 1945 and 1955. On the other side, in the Netherlands in the 1970s, the importance placed on quarry extractions caused problems, resulting in several demonstrations based on landscape preservation and the concern of disrupting the biosphere.

For general awareness of recycling demolished building waste, public projects were made with recycled aggregate in many countries like Germany, USA, Japan, etc. The same policy can be adopted in Bangladesh as well. Recycling of demolished concrete waste will help in achieving several Sustainable Development Goals (SDGs) set by the United Nations (UN), such as SDG 9 (Industry, Innovation, and Infrastructure); SDG 11 (Sustainable Cities and Communities); SDG 12 (Responsible Consumption and Production); and SDG 13 (Climate Action). Considering sustainability of construction materials as well as sustainability of our environment, every particle of construction waste is expected to be recycled properly thorough the innovative ideas of our engineers keeping in mind that demolished concrete is not waste but a resource. Attached mortar and cement paste are frequently found in RCA. Depending on the qualities of the parent concrete and the manufacturing procedure, the volume percentage of old mortar might range from 20% to 30%. The distinction between recycled coarse aggregate (RCA) and natural coarse aggregate is primarily due to the associated mortar and cement paste on RCA.

1.2 Literature review

In general, the mix design technique for RAC is similar to that for ordinary concrete. Due to the high water absorption of RCA, more water is necessary to achieve same workability. The water for RAC should be divided into two parts: the first part is determined according to the mix procedure for conventional concrete (of similar strength); the second part is determined according to the RCA's water absorption capacity (usually the 10 minute one), which is used to compensate for the loss of slump in RAC. The two portions of water are combined in actual mixing. This strategy has gained widespread acceptance. (Zhang et al.2008)

1) Saturated-surface-dry (SSD) and bulk density are both low. RCA has a bulk density of 1290–1470 kg/m3. RCA's SSD density ranges between 2310 and 2620 kg/m3. 2) Absorbs a lot of water. The absorptions of RCA are approximately 8.34 percent (10 min), 8.82 percent (30 min), and 9.25 percent (24 h), which are significantly higher than those of natural coarse aggregates and may be considered the most essential feature. 3) There is a lot of porosity. Because of the high mortar/cement paste concentration, RCA has a porosity of approximately 23.3 percent. 4) Crushing index is high. RCA has a crushing index ranging from 9.2 percent to 23.1 percent. 5) Clay content is high. RCA has a clay content of roughly 4.08 percent. The absorption of RCA is roughly 8.34%. (Xiao et al., 2010)

The decreased strength of the recycled concretes matched the findings of strength reductions of 10–20 percent for RA replacement ratios of 25 and 50 percent, respectively. Furthermore, due to a probable interaction between the additive employed and the fines in the trash, the drop was steeper in recycled concrete containing super plasticizer. (Martínez-Lage et al. 2012)

The w/c ratio and the degree of RA substitution improve the absorption coefficient. In terms of the CC, absorption of 100 percent RAC with w/c = 0.65 goes from 6.2 percent to 8.4 percent. This implies a 35 percent gain. Although there are no variations in concretes built with varied recycled fine aggregates content, RAC concretes absorb 15 percent more water than CC concretes. As a result, the coarse aggregate has a far higher impact on this characteristic (Zega et al. 2011).

The effective w/c ratio is correlated with the tensile splitting strength of the RAC and CC of the three experimental phases with 28 (a), 180 (b), and 365 (c) days of age. There is a wide range of findings for all of the ages studied. The likelihood of fitting regression parameters is minimal. The tensile splitting strength of the RAC, on the other hand, tends to be lower than the CC strength. The tensile strength of RAC is mostly determined by the degree of replacement. With 20 percent, 50 percent, and 100 percent RA, the relative values are roughly 90 percent, 85 percent, and 80 percent, respectively. RAC has 100 percent RA values of 65 percent and 79 percent of the tensile splitting strength of CC, respectively (Cheng et al. 2011).

1.3 Objective

Construction and demolition trash can roughly be divided into two categories: soft materials and hard inert materials. Typically, they are made up of rocks and shattered concrete. These hard, inert materials are ideal for recycling and can be utilized as aggregates in concrete production or other applications with adequate sorting and testing. Construction and demolition of waste materials must be sorted and processed before they can be recycled and reused; one popular processing method is crushing the materials in recycling plants. The materials are broken down into various sizes, sorted, and chosen for their intended usage during this procedure. In the process, the materials are broken into different sizes, sorted and selected for their target uses. The study was carried out with the following objectives;

- Finding the strength of recycled concrete by using recycled coarse aggregate.
- Comparing the recycled concrete strength with the fresh concrete strength.
- Reducing the impact of concrete waste on environment.

2. METHODOLOGY

Natural resources in Bangladesh are limited but anticipated rapidity of infrastructure development is quite fast. The changed development scenario of the country further indicates towards maximizing the land use through demolishing old low-rise structures with the high-rise ones. Recycling of demolish concrete can save the environment further by efficient and cost effective management of generate solid wastes.

Table 1: Properties of recycled coarse aggregates.

Materials	Properties	Unit	Value
Recycled coarse aggregates.	Void	%	28.90
	Absorption	%	17.80
	Unit Weight	Kg/m^3	1235
	Fineness modulus		5.10

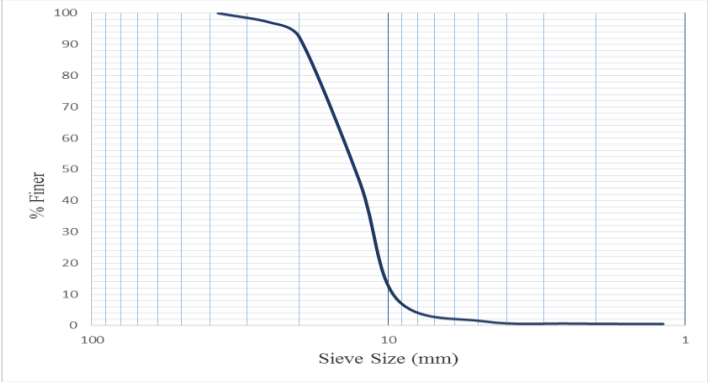


Figure 1: Grain size distribution curve of recycled aggregate

Natural fine aggregate used is Sylhet sand and RCA used from demolished concrete waste from which physical test such as specific gravity, absorption and sieve analysis are carried out.

Figure 2: Recycled Coarse Aggregate

Total 75 (8"x 4") Cylinders are cast for this research. where fifteen are used for tensile strength test. Using recycled coarse aggregate with fresh aggregate in several proportions, cylinders are performed for compressive and tensile strength of concrete. Five categories (fresh, 2.5%, 5%, 7.5%, 10%) of concrete mixture have been used and testing period of cylinders is respectably 3, 7, 14 and 28 days. The engineering properties of the RCA were also compared to those of the reference concrete. The Concrete mixing ratio is 1:2:4, FM of Coarse Aggregate is 7.47 and Water cement ratio (w/c) is 0.55.

a. Mixing of Concrete

b. Curing of Cylinder

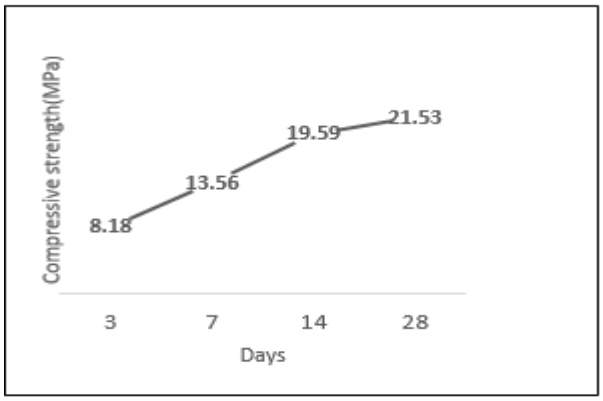
Figure 3: Preparation of Concrete Cylinder

3. RESULTS AND DISCUSSIONS

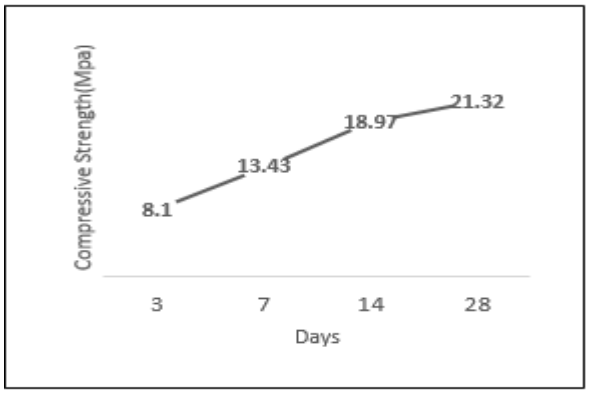
The Compressive Strength of RCA, whether it would gain the Ultimate Strength like Normal Strength Concrete or not. For this test, concrete waste from a demolished structure was obtained, and the percentage of RCA is 2.5 %, 5%, 7.5%, and 10% respectably to produce concrete. Compressive strength (28 days) 21.53 MPa (fresh concrete), 21.32 MPa (2.5 %), 20.67 MPa (5 %), 19.15 MPa (7.5 %), 17.73 MPa (10 %) and tensile strength (28 days) 2.13 MPa (fresh concrete), 2.12 MPa (2.5 %), 2.08 MPa (5 %), 1.8 MPa (7.5 %), 1.6 MPa (10 %) were acquired from the specimens. When up to 5% recycled aggregate is utilized, the strength variance is low compared to fresh concrete, which has a compressive strength of less than 11% and a tensile strength of less than 4%.

a. Compressive test b. Tensile Test

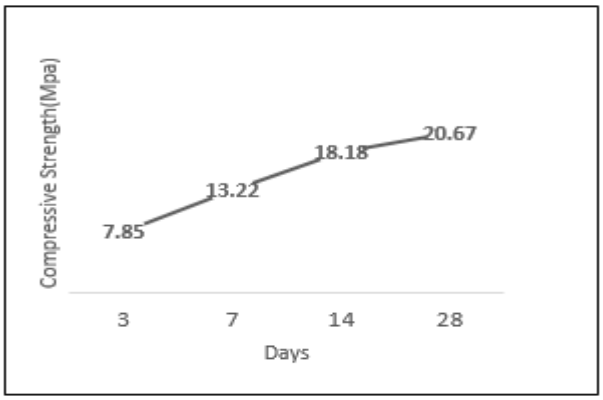
Figure 4: Specimens test



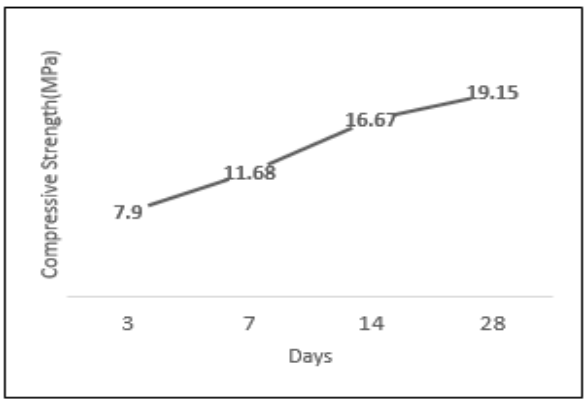
a. Fresh Aggregate



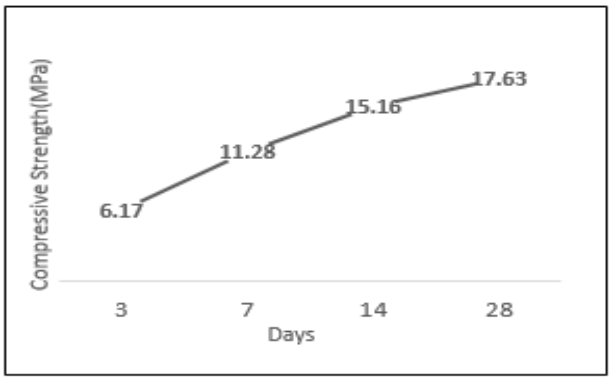
b. Fresh Aggregate and 2.5 % RCA



c. Fresh Aggregate and 5 % RCA



d. Fresh Aggregate and 7.5 % RCA



e. Fresh Aggregate and 10 % RCA

Figure 4: Compressive Strength with mixing RCA

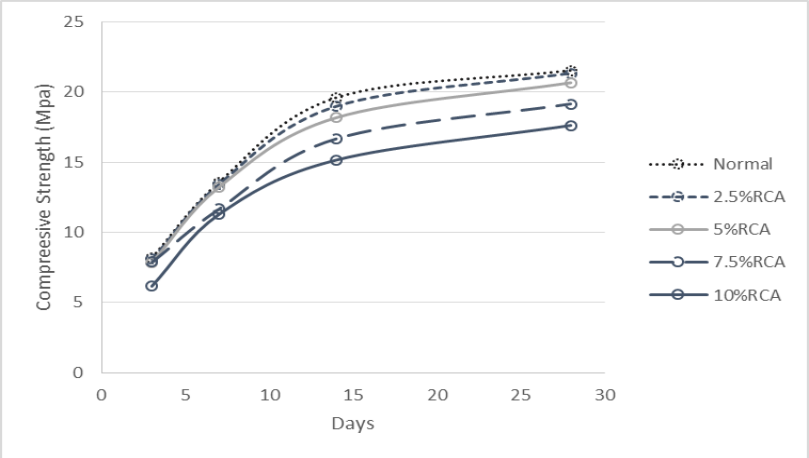
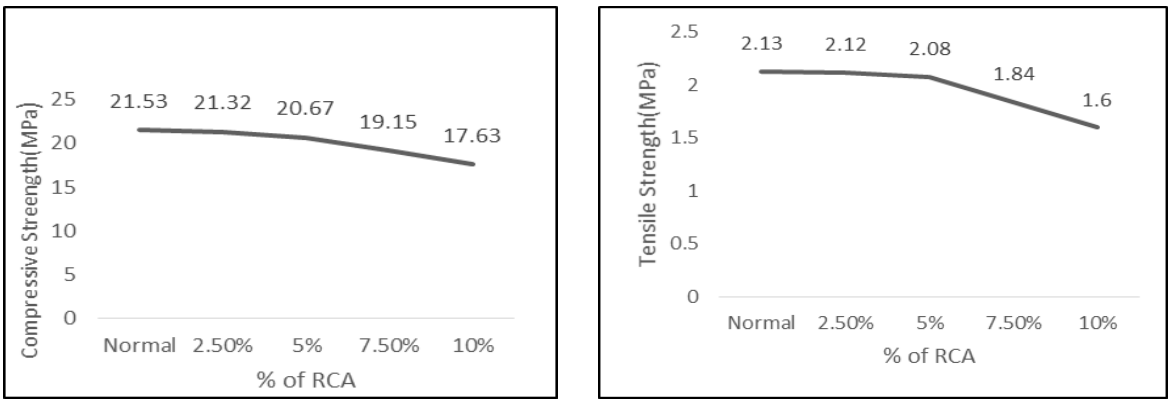


Figure 5: Comparison of Compressive Strength of RCA

Comparing to fresh concrete, the loss of compressive strength for RCA (2.5%, 5%, 7.5%, 10%) are 0.98%, 3.99%, 11.05% and 18.11% respectively where total curing period was 28 days. By increasing the percentage of RCA, tensile strength also varied. For conventional concrete the tensile strength is 2.13 MPa and after using 10% of RCA it decreased to 1.60 MPa.



a. Compressive strength

b. Tensile strength

Figure 6: Comparison of Strength with RCA (28 days)

Table 2: Compressive Strength various mixing with RCA

Days	Compressive Strength (Mpa)				
	Normal	**2.5% RCA**	**5% RCA**	**7.5% RCA**	**10% RCA**
3	8.18	8.10	7.85	7.90	6.17
7	13.56	13.43	13.22	11.68	11.28
14	19.59	18.97	18.18	16.67	15.16
28	21.53	21.32	20.67	19.15	17.63

4. CONCLUSIONS

At times, the rapid development of construction and industrial works in recent years, it is very much inevitable for the world and as a result a lot of solid concrete are producing. From the viewpoint of environmental and sustainable development, it is more likely to reuse the RCA concrete for making new concrete development and thereby it is also cost-effective too. For making more and more employment opportunities in RCA industries it is very usable for the world and rather RCA decreases compressive strength of concrete 10-30% which is not much variable rather than new concrete.

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