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EFFECT OF PARENT CONCRETE STRENGTH ON THE STRENGTH OF RECYCLED AGGREGATE CONCRETE

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ABSTRACT

Recycled aggregates play an important role in the strength of second generation or recycled aggregate concrete. So, it is necessary to study the composition of parent concrete which provides the necessary compressive strength of recycled aggregate concrete. A substantial amount of relatively soft cement mortar paste is always bonded with recycled aggregate particles which makes these aggregates more porous and less resistant to mechanical attacks. This article discusses the compressive strength of recycled aggregate concrete derived from parent concrete of different strengths, each of them made with 33.33 % of recycled aggregates obtaining from its parent concrete and 1:2:4 (Cement: Sand: Coarse aggregate) proportion is maintained as concrete mix design. By obtaining different recycled aggregates from parent concrete of different ages the recycled aggregate concrete specimens were made and studied. A comparative analysis of the experimental results of the strength properties of concrete with a single replacement ratio for conventional aggregate with recycled aggregate is presented in this paper. The un-hydrated cement particles of parent concrete have a significant effect to increase the strength of recycled aggregate concrete. The parent concrete of higher strength have more adhered mortar which represent more bond between mortar and aggregate and this have a detrimental effect on the strength of recycled aggregate concrete.

Key words: Adhered mortar, coarse aggregate, compressive strength, parent concrete, recycled aggregate concrete

INTRODUCTION

The protection of the environment should be promoted by the recovery (reuse or recycling) of waste materials. In many cases, recycled materials must compete with low-cost products. However, when the properties of the waste make its use possible in specific, high added value applications, these products can successfully compete with products made from primary materials, and reduce the environmental costs of waste disposal. Demolition of old and deteriorated buildings and traffic infrastructure and their substitution with new ones, is a frequent phenomenon today in a large part of the world. The main reasons for this situation are changes of purpose, structural deterioration, rearrangement of a city, expansion of traffic directions and increasing traffic load, natural disasters (earthquake, fire and flood), etc. (Rahman*et al*. 2012).

Recycled Aggregate (RA) is defined as the aggregates resulting from the reprocessing of inorganic material previously used in construction and Recycled Concrete Aggregate (RCA) is defined as the aggregates comprising the crushed concretes. The concrete from which recycled aggregates are collected for making recycled concrete is called parent concrete of this recycled aggregate concrete. The containing coarse aggregates in parent concrete are completely fresh.

Various research works carried out on recycled aggregates have pointed the some parameters to be addressed to achieve the required strength. These parameters are adhered mortar, water absorption, Los Angeles abrasion, size of aggregates, strength of parent concrete, age of curing, interfacial transition zone, ratio of replacement, moisture state, impurities present and conntrolled environmental condition (Yadav and Pathak 2009).

It seems to be a general consensus amongst most researchers that the replacement of natural aggregate with RCA affects the performance of recycled aggregate concrete. The characteristics of the RCA which is most influencing to the performance of recycled aggregate concrete seems to be the porosity of the mortar adhering to the RCA which is responsible for high water absorption and low crushing values (Guan 2011).

In Bangladesh, the volume of demolished concrete is increasing due to the deterioration of concrete structures as well as the replacement of many low-

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rise buildings by relatively high rise buildings due to the booming of real estate business. Disposal of the demolished concrete is becoming a great concern to the building developers. If the demolished concrete can be recycled and used for new constructions, their disposal problem will be minimized. Additionally the demand for new aggregates will be reduced and finally consumption of the natural resources for making aggregate will be reduced. It was also found in some project sites that a portion of the demolished concrete can be used as aggregate (after breaking into aggregate) in foundation works without any research on the recycled aggregates. In most of the old buildings, brick chips were used as coarse aggregate of concrete in Bangladesh. Studies related to the recycling of demolished concrete are generally found for stone chips made concrete (Alan 1977, Ravindrajah*et al.* 1988). Therefore, investigations on the strength of demolished parent concrete with brick chips as coarse aggregate are necessary. With this background, this study was carried out.

MATERIALS AND METHODS

Concrete attains strength with time. Ordinary cement concrete (with ordinary Portland cement) gains 70 to 75% of its final strength within 28 days and about 90 to 95% in the course of one year (Aziz 1973). With a view to the above needs and consideration, the present study is aimed to determine the strength properties of recycled aggregate concrete depending on the strength of parent concrete, and to compare them to the properties of concrete made with conventional aggregate i.e. brick chips. For investigation, parent concrete cylinder (150 mm diameter and 300 mm height) were made and tested for their compressive strength and then demolished concrete blocks were collected and broken into pieces as aggregate as shown in Figure 1. Before making concrete, the aggregates were investigated for unit weight and specific gravity. Standard grading of the aggregates were maintained. Description of constituents materials used for concrete mix is described as:

Cement: The whole project was performed with commercially available Portland cement. At present the Portland cement is widely used for constructional purpose.

Sand: Coarse sand usually named as the “Domar” sand was used in this project work.

Fresh Coarse Aggregate: Brick chips, broken stones, gravels, clinkers etc of size 3/16 inch to 2 inch are commonly used as coarse aggregate in Bangladesh. In this research, brick chips were used and maximum size of ¾ inch was allowed.

Water: Water fit for drinking is generally considered fit for making concrete. Water used for this project work was fresh tap water supplied from water treatment plant of University (RUET).

Recycled Coarse Aggregate: For test purpose recycled aggregates were obtained from parent concrete with ages of 14, 40 and 90 days.

RESULTS AND DISCUSSION

Specific Gravity of different Materials

The specific gravity of different constituent materials was determined according to the code ASTM C127. The specific gravity of the constituent materials is given in Table 1.

Gradation of Coarse Aggregate

Standard procedure described in ASTM C136M-14 was followed for gradation of coarse aggregates. A known quantity of dry aggregate (5 Kg) was taken and sieved through a consecutive order of standard sieves; i.e. sieves with opening size $\frac{3}{2}$ inch, $\frac{3}{4}$ inch, $\frac{3}{8}$ inch, sieve no. 4, no.8, no.16, no.30, no.50 and no.100. The percentages of the respective retained quantities were added and divided the sum by 100 to obtain a figure termed as “Fineness Modulus” of the sample. The fineness modulus of fresh and recycled coarse aggregate is shown in Table 2.

Fineness Modulus of fresh coarse aggregate = $\frac{680.7}{100} = 6.81$

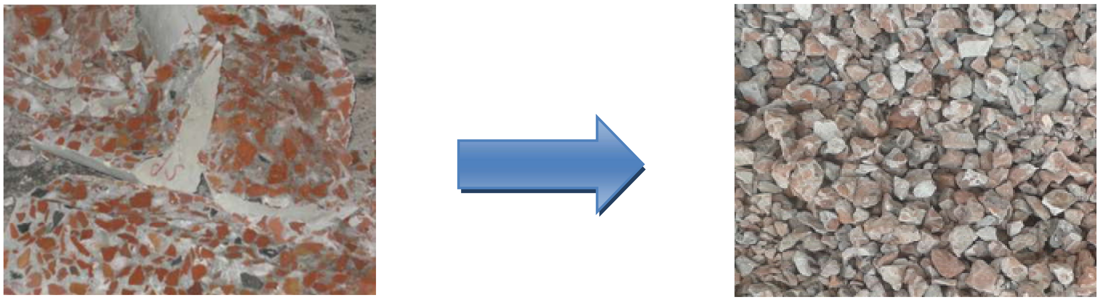
Fineness Modulus of recycled coarse aggregate = $\frac{693.04}{100} = 6.93$

Particle size distribution curves for FCA and RCA are shown in Figure 2.

Unit weight of Coarse Aggregate: The unit weight of fresh aggregate and recycled coarse aggregate were determined according to the procedure described in standard code ASTM C29. The unit weight of FCA was 79.8 lb/ft^3 and for RCA was 81.6 lb/ft^3.

Compressive strength test of Concrete: Compressive strength tests for moist cured specimens were carried out after removing them from the curing bath. The compressive strength tests of cylindrical concrete specimens were performed according to the code ASTM C39. In this project three types of parent concrete of age 14 (Type 1), 40 (Type 2) and 90 (Type 3) days were used with three water-cement ratio (w/c) 0.40, 0.45 and 0.50 for each type. By using 33.33% RCA with fresh coarse aggregate (FCA) at same specification of its parent concrete, the compressive strength was obtained from universal testing machine. The recycled aggregate concrete was crushed after 28 days curing for every case. The bearing faces of the test specimen were wiped clear and the test specimen were placed on the lower bearing plate. The axis of specimen was carefully aligned with the center of the upper bearing plate as shown in Figure 3.

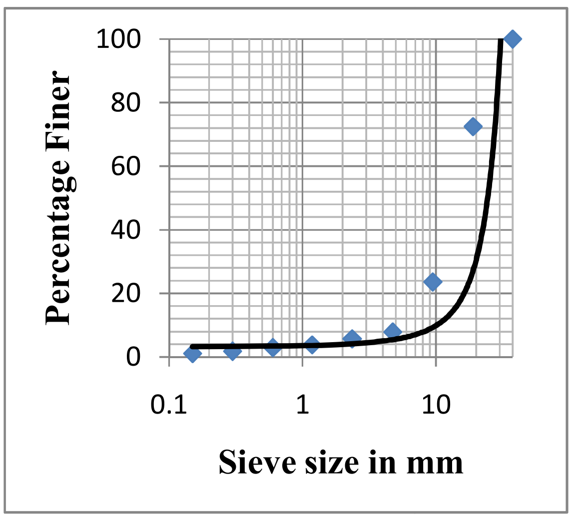
The Compressive strength was calculated by dividing the maximum load applied to the cross sectional area



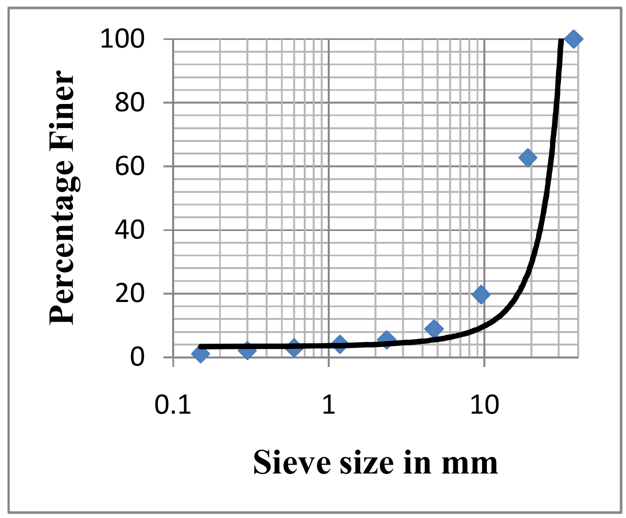
Demolished parent concrete blocks
(Collected from demolished parent concrete cylinder)

Recycled coarse aggregate
(After crushing concrete blocks)

Figure 1. Demolished concrete block and recycled coarse aggregates



Fresh coarse aggregate (FCA)



Recycled coarse aggregate (RCA)

Figure 2. Particle size distribution curves for FCA and RCA

Figure 3. Compressive strength test of cylindrical specimen

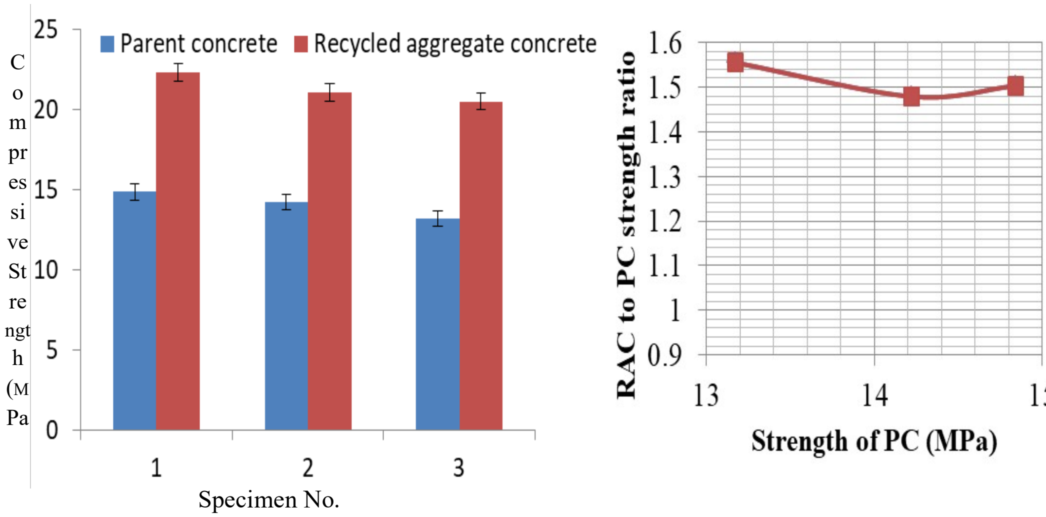


Figure 4. Comparison of compressive strength of RAC with PC (Type -1)

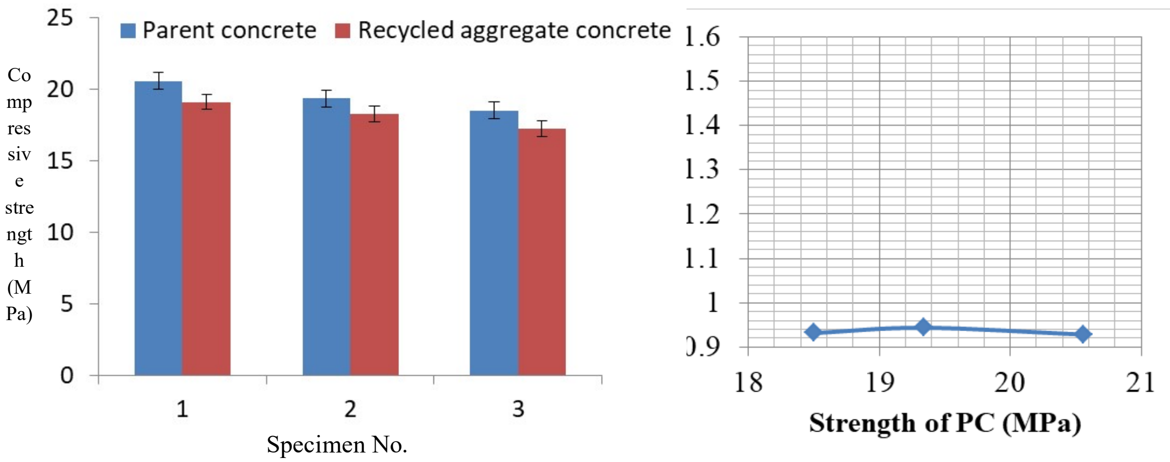


Figure 5. Comparison of compressive strength of RAC with PC (Type -2)

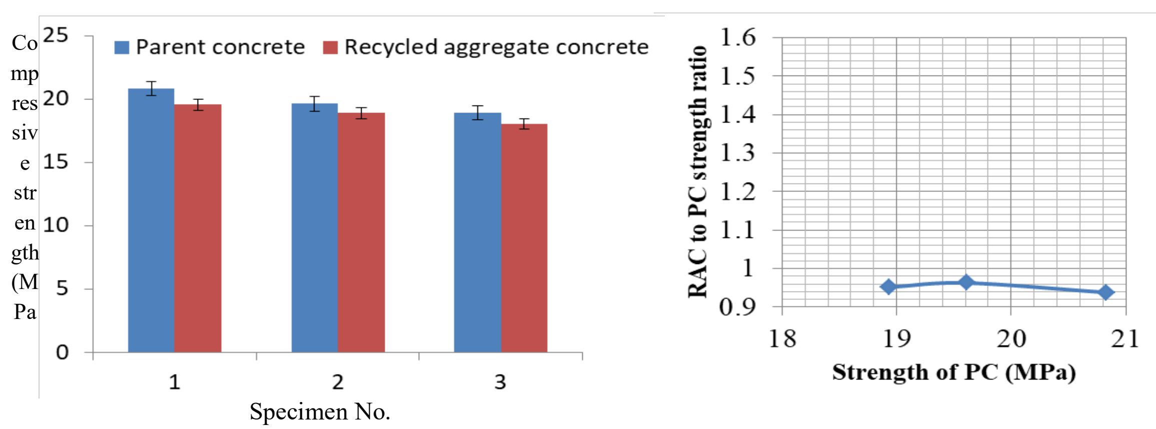


Figure 6. Comparison of compressive strength of RAC with PC (Type -3)

of the Cylindrical specimen. The formula used for finding the Compressive strength is, $C = \frac{P}{A}$
Where, P = Maximum load applied on the specimen, A = Cross sectional area of the specimen.

The compressive strength of concrete for various cases is shown in Table 3. The compressive strength of recycled aggregate concrete with the variation of the strength of the parent concrete is shown in Figure 4, Figure 5 and Figure 6.

From Figure 5 (Type 1), it is observed that the compressive strength of recycled concrete is higher than that of the parent concrete. This happens because the parent concrete was tested after 14 days of curing, whereas the recycled aggregate concrete was tested after 28 days of curing. Recycled aggregate particles are always attached with substantial amount of relatively un-hydrated cement mortar paste. In this case a large amount of un-hydrated cement was present in recycled aggregates which influence largely the strength of recycled aggregate concrete.

Table 1. Specific gravity of different materials used in this study

Material	Specific gravity
Cement	3.15
Sand	2.78
Fresh Coarse Aggregate	1.92
Recycled Coarse Aggregate	1.98

Table 2. Fineness Modulus of FCA and RCA

Sieve Opening mm	Fresh coarse aggregate (FCA)			Recycled coarse aggregate (RCA)		
	Cumulative retained in Kg	Cumulative percentage of retain	Percentage finer	Cumulative retained in Kg	Cumulative percentage of retain	Percentage finer
37.5	0	0	100	0	0	100
19	1.379	27.58	72.42	1.865	37.3	62.7
9.5	3.821	76.42	23.58	4.018	80.36	19.64
4.75	4.605	92.10	7.90	4.555	91.10	8.9
2.36	4.715	94.30	5.70	4.724	94.48	5.52
1.18	4.810	96.20	3.80	4.795	95.90	4.10
0.60	4.850	97.00	3.0	4.854	97.08	2.92
0.30	4.910	98.2	1.8	4.896	97.92	2.08
0.15	4.945	98.9	1.1	4.945	98.9	1.1
	Total cumulative percentage retained = 680.7			Total cumulative percentage retained = 693.04		

Table 3. Compressive strength of parent concrete and recycled aggregate concrete

Type	Specimen No.	Water cement ratio	Strength of parent concrete after 14/40/90 days for Type-1,2,3 respectively (MPa)	Strength of recycled aggregate concrete after 28 days (MPa)
1	1	0.40	14.84	22.30
	2	0.45	14.22	21.03
	3	0.50	13.17	20.48
2	1	0.40	20.56	19.09
	2	0.45	19.34	18.25
	3	0.50	18.5	17.24
3	1	0.40	20.83	19.54
	2	0.45	19.61	18.88
	3	0.50	18.94	18.03

Figure 6 (Type 2) and Figure 7 (Type 3) revealed that the compressive strength of recycled concrete is slightly less than that of the parent concrete and the compressive strength recycled aggregate concrete increases with the increase of the strength of parent concrete. But parent concrete with higher strength is not recommended to use in producing recycled aggregates as Sami and Akmal (2009) reported that parent concrete of higher strength contains more adhered mortar (bond between mortar and aggregate is more) and therefore, it has a detrimental effect on the strength of recycled aggregate concrete. It also can be noted that the influence of parent concrete of 40 and 90 days is so near on the strength of the recycled aggregate concrete.

CONCLUSIONS

Research on the effect of waste parent concrete materials is very important due to the gradual increasing with the increased of population and increasing of urban development. This study showed that when the parent concrete of 14 days old is used it gives high strength second generation concrete having a greater compressive strength. Another important observation of this project is that recycled concrete obtained from parent concrete of 40 and 90 days old exhibited the strength slightly less (maximum of 1.47 MPa) than the normal conventional concrete. This may happen due to the interfacial transition zone effect.Hence it is necessary to understand the percentage of adhered mortar which could be attached on recycled aggregates in making concrete and also it is important to calculate the percentage of replacement based on the percentage of adhered mortar.

REFERENCES

ASTM C29. 2017. Standard test method for bulk density ("unit weight") and voids in aggregate. ASTM International, West Conshohocken, PA.

ASTM C39.2017.Standard test method for compressive strength of cylindrical concrete specimens.ASTM International, West Conshohocken, PA.

ASTM C127-15. 2015. Standard test method for relative density (specific gravity) and absorption of coarse aggregate. ASTM International, West Conshohocken, PA.

ASTM C136M-14. 2014. Standard test method for sieve analysis of fine and coarse aggregates. ASTM International, West Conshohocken, PA.

Alan DB. 1977. Recycled concrete as a source of aggregate. ACI Journal, American Concrete Institute. Volume-74 Issue- 5: 212-219.

Aziz MA. 1973. A Text Book of Engineering Materials.Hafiz Book Centre, Dhaka, Bangladesh. pp.:122-124.

Guan JLL. 2011. Effects of recycled aggregates on concrete properties. Master of Engineering thesis, National University of Singapore, Singapore.

Rahman MS, Hossain MB and Ruksana R. 2012.Strength behaviour of recycled concrete with partial replacement of conventional aggregate.International Journal of Environment. 2(2): 80-86.

Ravindrajah RS, Loo YH and Tam CT. 1988.Strength evaluation of recycled aggregate concrete by in situ tests.Materials and Structures. 21: 289-295.

Sami WT and Akmal SA. 2009. Influence of recycled concrete aggregates on strength properties of concrete. Construction and Building Materials. 23: 1163–1167.

Yadav SR andPathak SR. 2009. Use of recycled concrete aggregate in making concrete- an overview. 34th Conference on OUR WORLD IN CONCRETE & STRUCTURES,Singapore.2-9.