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COMPARISON OF STRENGTH PERFORMANCE OF CONCRETE WITH UNCRUSHED OR CRUSHED COARSE AGGREGATES

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ABSTRACT

This study focuses on the relative performance of uncrushed aggregates and crushed aggregates for concrete in strength gaining. The study was conducted for medium grade concrete (concrete having cube compressive strength at 28 days between 6 Mpa to 50 Mpa). There is a general belief that crushed aggregates contribute higher strength in concreting compared to uncrushed aggregates. Contrary to this belief, our study revealed: uncrushed aggregates perform better than crushed aggregates in gaining strength for medium grade concrete. From the laboratory test of strength determination it was explored that uncrushed aggregate provide more strength (22% at 28 days) than crushed aggregates for medium grade concrete. Similar results were found for low grade concrete (cube strength at 28 days up to 15 Mpa) in a previous study relevant to mention: uncrushed aggregate is cheaper than crushed aggregate in the market of Bangladesh. Consequently, concrete with uncrushed aggregates will be cheaper. It can be concluded that uncrushed aggregates are appropriate for medium grade concrete for better performance in terms of strength and economy. Future study is required on high-grade (cube strength at 28 days between 51 Mpa to 100 Mpa) and super high grade concrete in similar line.

Keywords: concrete, coarse aggregate, compression strength, water cement ratio.

INTRODUCTION

Concrete is a stone like material obtained by designing a carefully proportioned mixture of cement, sand, and gravel or other aggregates and water to harden in forms of the shape and dimensions of the desired structure. Aggregate is one of the important constituents in concrete, which has effect in strength development. Although strength depends upon many parameters such as water/concrete (w/c) ratio, aggregate gradation, aggregate size and shape, cement quality, mixing time, mix ratio, curing etc., but this study has concentrated only on the comparative performance of uncrushed aggregates and crushed aggregates available in Bangladesh in strength gaining of concrete.

Natural (uncrushed aggregates) and artificial (crushed aggregates) are two types of coarse aggregates normally found. 40mm-downgraded natural stones are designated as uncrushed aggregates and that above 63 mm is termed as boulders or gravels. Boulders or gravels are broken down below 40mm size to prepare crushed aggregates. Uncrushed aggregates are semi angular or rounded, but crushed aggregates are angular. Concrete strength depends upon the above-mentioned types of aggregates.

According to the compressive strength, concrete can be classified as follows: concrete having cube compressive strength at 28 days up to 15 Mpa is low grade concrete, between 16 Mpa to 50 Mpa is medium grade, between 51 Mpa to 100 Mpa is high grade and beyond 100 Mpa is ultra high strength concrete [2]. The main objective of the present study was to determine the relative performance of uncrushed aggregates to crushed aggregates for medium grade concrete in strength gaining keeping all other parameters same except w/c.

Some previous works related to shape of coarse aggregates in concreting:

Shape of the aggregates contributes to the strength value of concrete. Comparing the strength value between angular and smooth aggregates when slump is constant, there is no significant variation, as angular aggregates require more water than smooth aggregates. However, if w/c ratio and slump are kept constant with the use of admixture, there may be a reasonable increase in strength with the use angular aggregates [4].

From [1], it is seen that as the size of the aggregate increases, the requirement of the water decreases to obtain the same workability (Table-1). This is because, increase of size decreases surface area of the aggregates and less water is absorbed on the decreased surface, more is available for workability. From Table-1 it is also seen that water content of concrete with angular aggregate is always more than water content of concrete with rounded aggregate of same slump.

Table-1. Approximate water content for different slumps and maximum sizes of aggregates [1].

Maximum size of Aggregate in mm	Water content in liter per m^3					
	25—50 mm slump		75—100 mm slump		150—175 mm slump	
	Rounded Aggregate	Angular Aggregate	Rounded Aggregate	Angular Aggregate	Rounded Aggregate	Angular Aggregate
10	189	214	202	225	231	255
20	172	196	189	208	208	225
40	160	172	172	189	189	208
50	148	166	166	178	178	196
75	136	154	154	166	160	184

A study on the relative strength performance of uncrushed aggregate to crushed aggregate for low-grade concrete was conducted by Mohiuddin [4]. It reveals that 10% extra water is required for obtaining same workability or slump on design mix with crushed aggregates than that with uncrushed aggregates. It also shows that 6%-11% higher strength is attained for uncrushed aggregates than crushed when cement content and slump are kept constant. This study concludes that uncrushed aggregates perform better than crushed aggregates for low-grade concrete.

MATERIALS AND METHODS

The following steps were taken up for the study:

- Different laboratory tests such as grain size analysis, specific gravity test, absorption test etc. for different concrete materials, which were used in the study, were performed to determine their characteristics. Standard test method ASTM C127 was used for determination of specific gravity and absorption of coarse aggregates. Standard test method ASTM C128 was used for determination of specific gravity and absorption of fine aggregates. Standard test method ASTM C136 was used for sieve analysis of fine and coarse aggregates.
- Slump tests for concrete separately with uncrushed and crushed coarse aggregates with same slump (38 mm or 1.5 inch) were performed to determine the w/c ratio. For the convenience of manual concreting, such a low slump has been selected for the experiment. Standard test method ASTM C143 was used for the test.
- Mix design of concrete was performed by using the method offered by Kaushal Kishore (Article "Concrete mixed design simplified" [3] from ICI bulletin no. 56 July-September, 1996).
- Compressive strength of concrete (7 days, 14 days and 28 days) was determined using cube specimens as per British standard (BS-1881). Five specimens with uncrushed and five specimens with crushed aggregates were made.

RESULTS AND DISCUSSION

Slump test result is shown in Table-2. For constant slump (38 mm), it is seen that w/c ratio is higher for concrete with crushed aggregates than with uncrushed aggregates. For the same amount of cement, crushed aggregates need 10% more water than uncrushed aggregates to obtain same workability. This 10% extra water for the same slump negates the positive contribution due to the bond offered by the angular shape. On the hand, uncrushed aggregates are rounded in shape but this negative characteristic is compensated by reduced water/cement ratio.

Table-2. Slump test results.

Coarse aggregate type	Test condition	Slump (mm)	W/c Ratio
Un-crushed aggregate	**Cement type** = PFA **Mix ratio** = cement: fine aggregate: coarse aggregate = 1:1.6:3.4 **Fine aggregate** = river sand **Zone grading of fine aggregate** = zone 1 (one) **Maximum size of aggregate** = 40 mm down grade	38	0.4
Crushed aggregate			0.5

From the laboratory test of strength determination it was explored that uncrushed aggregates provide more strength (22% at 28 days) than crushed aggregates for medium grade concrete (Tables 3 and 4).

Table-3. Concrete compressive strength for crushed aggregates.

Sample No.	Compressive Strength (Mpa)		
	7	14	28
1	24.75	28.28	30.48
2	22.05	33.65	34.66
3	22.14	29.17	30.55
4	23.86	30.43	32.80
5	23.93	33.52	34.46
Average	23.34	31.01	32.59

Table-4. Concrete compressive strength for uncrushed aggregates.

Sample No.	Compressive Strength (Mpa)		
	7	14	28
1	27.43	33.45	34.40
2	33.56	42.21	45.39
3	30.70	38.09	39.19
4	33.59	41.43	43.76
5	27.03	33.57	36.62
Average	30.47	37.77	39.91

Figure-1 shows the relation between two types of concrete using uncrushed aggregates and crushed aggregates in gaining strength with time.

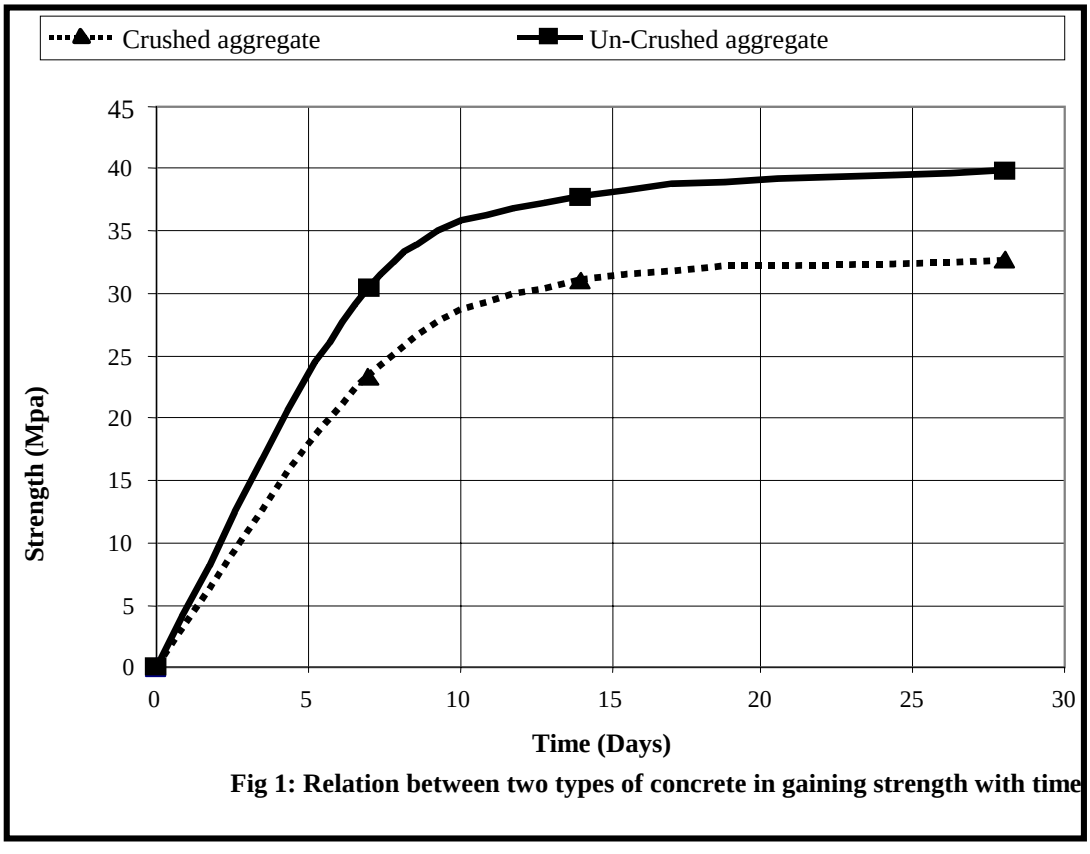

Fig 1: Relation between two types of concrete in gaining strength with time

CONCLUSION AND RECOMMENDATION

From the laboratory study, it was found that the uncrushed aggregates need lower w/c ratio than crushed aggregates and uncrushed aggregates cater higher strength in concrete of medium grade. Again uncrushed aggregates are cheaper than crushed aggregates in the market of Bangladesh. So from the study, it can be concluded that uncrushed aggregates are appropriate for medium grade concrete for better performance in terms of strength and economy. A previous study [4] has already confirmed similar finding for low-grade concrete.

Similar study can be conducted in future also for high-grade and super high-grade concrete.

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