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STUDY ON CONCRETE COMPRESSIVE STRENGTH BASED ON SPECIMEN SIZE AND MATERIAL

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ABSTRACT

Concrete is widely used as a construction material all over the world for a long time by virtue of its excellent compressive strength. For the stability of the structure, quality control, design of concrete; the compressive strength of concrete is the primary property generally specified in the construction industry. The coarse aggregates are the main ingredients used in concrete. This study is conducted by changing the proportion of coarse aggregate and the proportion of cement and sand were remained unchanged. This study consists of two geometric shapes of concrete entitled 6 inch cube and cylinder of 6 inch diameter and 12 inch height. In this study 60 cylinders and cube concrete specimens are casted and exposed to water for 28 days for curing. Then the specimens are tested. The main objective of this research was to make comparison of strength between cube and cylinder using bolder stone chips as coarse aggregate. Three mix ratios were arbitrarily chosen for performing the research, they were 1:1.5:2; 1:1.5:2.5and 1:1.5:3. Cylinder strength was found to be approximately 94 to 95.5 percent of cube strength after the analysis of test results. The rich concrete shows maximum strength at early stage for both shape of concrete. Cubical specimen gives higher strength as compare to the cylinder for all stages.

Key words: Compressive strength, concrete, mix ratio, recycled aggregate concrete

INTRODUCTION

Most concrete structural members experience combined loading conditions composed of compression, tension, moment, and shear. Compressive strength of concrete is commonly considered its most valuable property. In order to determine the compressive strength of hardened concrete, compressive strength test is one of the most important experiment nowadays. According to Neville (2002), during this test, the results can be affected by various factors, like, specimen size, their shapes, moulds used for casting, curing methods, and rate of application of load etc. M.A. Rashid and M.A. Mansur (2009) found that, the use of quality materials, smaller water-binder ratio, larger ratio of coarse aggregate (CA) to fine aggregate (FA), smaller size of coarse aggregate, and suitable admixtures with their optimum dosages are necessary to produce high strength concrete (HSC). It is well known about the size effect that the strength of a member tends to decrease when its size increases. Therefore, in view of recent increased interest in the size effect of concrete compressive strength. Locally, the compressive strength is usually measured based on 6″ cubes. But in design practice, the design compressive strength is usually based on the standard 6″ x 12″ cylinders. A comparison of the compressive strength between 6″ x 6″ cubes, and 6″ x 12″ cylinders are performed. These sizes are chosen because these are most commonly used in the construction industry and research.Gonnerman (1925) experimentally showed that the ratio of the compressive failure stress to the compressive strength decreases as the specimen size increases.

The compressive strength is measured by breaking cylindrical or cubical concrete specimen in a compression testing machine. The compressive strength is calculated from the failure load divided by the cross-sectional area resisting the load and reported in unit pound per square inch (psi) or Megapascals (MPa). Concrete compressive strength requirements can vary from 2500 psi (17 MPa) to 4000 psi (28 MPa) for residential concrete and 10000 psi (70 MPa) or exceeding 10000 psi for higher in commercial structure.

Various researches have been conducted previously, to understand and clarify the so-called size and shape effect of concrete specimens on the compressive strength test results. Malaikah (2005) experimentally showed that the ratio of the compressive strength of high strength concrete of 6″ x 12″ cylinders to 6″cubes was 0.80. Aziz (1973) stated that the cube tests give much greater values of crushing strength usually 20 to 30 percent more than those given by cylinders. According to Bažant and Planas (1998), size effect can be seen when by altering the size of a

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concrete member, its nominal strength also gets changed, even though their shape is similar to each other. The same definition can be proposed for shape effect as well, when nominal strength of concrete members is dependent on their shape.

One of the first investigations about size effect was carried out in 1925 by Gonnerman, using standard cubes of 6″ and 8″ and different sizes of cylinders. Testing different specimens at different ages, the average cylinder/cube ratio of 0.85 to 0.88 was obtained by Gonnerman, 1925; Elwet and Fu, 1995. According to Bažant and Planas (1998), size effect can be seen when by altering the size of a concrete member, its nominal strength also gets changed, even though their shape is similar to each other. Different curing condition's effect on conversion factors (cylinder/cubes) was investigated by Plowman et al. (1974).

Shape and size effect has been also investigated about high-strength concrete, showing that size effect is stronger in cubes than cylinders. There is also a difference between cube's and cylinder's fracture patterns. The main fracture surface of cylinder is nucleated, on the other hand, in cubes lateral sides get broken and that there is destruction which occurred due to crushing. Del Visoet. all (2008), noticed this shape effect in σ–ε curves. Compressive strength test results are primarily used to determine that the concrete mixture as delivered meets the requirements of the specified strength, f′c, in the job specification. Strength test results from cast cylinders may be used for quality control, acceptance of concrete, or for estimating scheduling construction operations such as form removal or for evaluating the adequacy of curing and protection afforded to the structure. This study was done to observe the variation in compressive strength of concrete for different mix ratio of cement, sand and aggregate.

MATERIALS AND METHODS

The use of locally available materials from different sources of Bangladesh was emphasized in this study. For the cases where locally available materials were not attainable, commercially available materials were used. Relatively higher strength concrete with a low permeability is commonly used for construction. The whole study was conducted in Engineering Materials Laboratory of Southern University Bangladesh, Chittagong, started from July-2015 and ended in June-2016. A brief description of the constituent materials as used in the present investigation is given below:

Coarse aggregate: Basalt, granite, quartzite, rocks are generally used as raw materials for coarse aggregate in construction due to their imperviousness, high strength and weather resisting characteristics. Bolder stone chips were used as coarse aggregate in this test. The size of coarse aggregate was ¾″ down grade.

Fine aggregate: Sand is commonly used as fine aggregate. Sylhet sand was used in the experimental concrete mix. It was free from clay, organic matter and salts.

Water/cement ratio: For mixing maximum water/cement ratio 0.43 was used.

Aggregate/cement ratio: "Aggregate/cement ratio"-obviously this ratio is not primary factor in strength development of concrete. But for a particular water/cement ratio, higher strength is produced by a leaner mix. It was found that a gradual decrease in compressive strength is associated with increasing volume of aggregate

Water: The available (Potable) supply water was used for mixing of concrete.

Cement: Portland composite cement is used for concrete construction in Bangladesh. Portland composite cement was used throughout the experiment. The selected cement brand was "Ruby Cement".

The method of finding the compressive strength of concrete was "compressive strength test".

Moulds: Cylindrical and cubical in form, made of non-absorbent material, and substantial enough to hold their form during the molding of test specimens are used. We use standard cylindrical molds size 150 mm in diameter and 300 mm in length and cubical molds size 150 mm in breath and height and 150 mm in length. Molds are water tight and the base plate or bottom at right angles to the axis of the cylinder.

Tamping Rod: A round straight steel rod 5/8 in. diameter and 24 in. length. One end was a hemisphere 5/8 in. diameter.

Experimental Program: The size of the cylindrical specimen was 6″ diameter with 12″ height and the cubical specimens are 6″ cube. Concrete was prepared by three different mix ratios of 1:1.5:2; 1:1.5:2.5; and 1:15:3.

Curing: Specimens were removed from the molds after 24 hours of casting. Then all the specimens were marked with suitable number to keep proper record. Finally the specimens were placed in natural water. According to Aziz (1973), ordinary Portland cement attains above 70 to 75% of its final strength within 28 days and about 90 to 95% in the course of one year. The casted concrete specimens were immersed in water for 28 days and after that they were tested.

RESULTS AND DISCUSSION

Compressive strength: 28 days compressive strength of cylinder for ratio 1:1.5:2; 1:1.5:2.5 and 1:1.5:3 are obtained as 3651 psi (25.18 MPa), 3619

Table 1. Compressive Strength of Concrete in Different Mix Ratio for Cube and Cylinder Specimens.

Mix Ratio		1:1.5:2		1:1.5:2.5		1:1.5:3	
Specimen Type		Cube	Cylinder	Cube	Cylinder	Cube	Cylinder
Strength	MPa	26.74	25.18	26.40	24.96	26.07	24.89
	psi	3877	3651	3828	3619	3780	3609
Comparison of Strength		Cube strength is 1.062 times cylinder strength		Cube strength is 1.057 times cylinder strength		Cube strength is 1.047 times cylinder strength	
Curing period		28 days		28 days		28 days	

(a) (b)

(c) (d)

Figure 1. a) 6″x12″ cylinder molds, b) Cylindrical Specimens c) 6″ cube molds, and d) Cubical specimens.

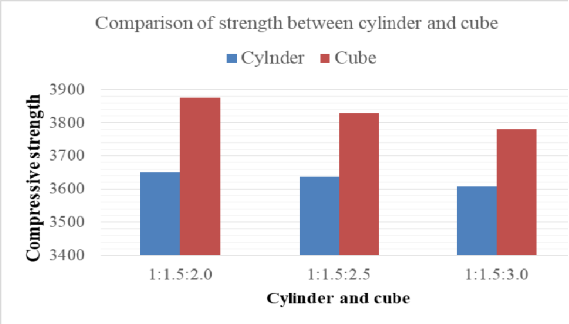

Figure 2. Comparison between cylinder and cube strength

psi (24.96 MPa), and 3609 psi (24.89 MPa) respectively. Again, the compressive Strength test results of cube for ratio 1:1.5:2; 1:1.5:2.5 and 1:1.5:3 are obtained as 3877 psi (26.74 MPa), 3828 psi (26.40 MPa), and 3780 psi (26.07 MPa) respectively after 28 days of curing period. These results are shown in Table 1. From figure 2 it was observed that the strength of concrete decreases as the ratio of coarse aggregate/cement increases for both cylinder and cube specimen. Again, the cube specimen gives more strength than that of cylindrical specimen for same mix ratio. Cubical strength was approximately 1.054 times the cylinder strength. For a constant water/cement

ratio, compressive strength increases with the decrease of aggregate/cement ratio. A gradual decrease in compressive strength is related with increasing volume of aggregate was also noticed from Table 1.

CONCLUSIONS

Based on the experimental results, it can be concluded that the concrete compressive strength depends on several factors like mix ratio, size of aggregates, method of compaction etc. Mix ratio 1:1.5:2 gives higher compressive strength than others. A slight change in strength is found with the reduction of coarse aggregate.

To know about the behavior of concrete in different environmental conditions it is recommended that the study can be carried out for wide range of w/c ratio and using brick chips or recycled aggregates.

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