Strength Variation of Concrete Between Cylindrical and Cubical Specimen Due to Various Proportion of Ingredients

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Abstract

The objective of this research was to determine the relationship between compressive strength of cubes and cylinders that were produced and cured in Laboratory of Sonargaon University. The study is based on the comparison of experimental results between M-10, M-15 and M-20 grade concrete made with stone chips. Theoretical study was done on factors that affect the workability and gaining of strength of concrete. General slump test was done for each of these three grades of concrete mix to determine workability of concrete. Cylinder and cube specimens were moulded in laboratory and cured at preferred temperature and condition, and then cubes and cylinders were tested at different ages to determine their compressive strength. The cylinder-to-cube strength ratio was found to be a value of 0.80 and is slightly lower than the average ratio of 0.87 obtained by researchers in other countries (Rong, W.H., 2012). It is also found that, in average, the strength of Cube specimen is 1.25 times stronger than Cylinder specimen. According to determined results further recommendations and limitations are also assorted.

Keywords: *Concrete, Compressive Strength, Strength Ratio, Different ratio of ingredients, Slump test.*

1.0. Introduction

The compressive strength applying most important role in durability of structure. The design parameters depend upon various influencing factors such as specimen size and shape, application of loading, matrix porosity and transition zone porosity [1]. Compressive strength of concrete is important because the main properties of concrete, such as elastic modulus and tensile strength, are qualitatively and quantitatively related to this property. It is also important in structural design, because load-bearing capacity of structures is related to the concrete compressive strength. Concrete strength in structures is typically estimated by casting smaller specimens from the same concrete and crushing them in the laboratory. Most countries have their own standards for concrete compression testing, which differ in many ways but probably most significantly in type of specimen used. Cylindrical specimens — 150 mm (6-in.) in diameter by 300 mm (12-in.) in height — are used in

Australia, Canada, France, New Zealand and the United States. Bangladesh also follows this specification for testing. Cube specimens (150 or 100 mm) are used throughout much of Europe, including Great Britain and Germany. This study surveys the literature and test on the relationship between cylinders and cube-shaped specimens of concrete, covering the areas- testing standards and procedures, factors affecting the cylinder strength/cube strength & comparing the strength test result of both specimens. The aim of this study was to get a specific idea about the gaining of strength of concrete with change of time and difference in strength due to shape of cylinder and cube. Laboratory tests were carried out to get the compressive strength of concrete.

2.0. Literature review

From the very beginning of civilization remarkably used construction material is concrete. Concrete has been used as building material for epochs. It is by far the most extensively used construction material today. We can hardly find any aspect of our daily lives that does not depend directly or indirectly on concrete [2]. As the use of concrete has become a common practice in various applications for many decades, especially for high rise buildings, long span, bridges and repair and rehabilitation works. It is important to have confidence in the suitable and applicability of current testing practices. The 28 days compressive strength of concrete determined by a standard uniaxial compression test is accepted universally as a general index of concrete strength. The two of the most significant parameters that effect the result of concrete compressive strength due to its rupture features are size and shape of test samples [3][4].

To determine the compressive strength of concrete two standard methods are renowned all over the world. These are the testing to failure of cylinder and cube specimens. In the application of uniaxial compressive strength test, which is usually employed for the quality control process of concrete, the type and dimensions of the specimens considerably affect the test results. Due to the size effect, the relative strength of specimens varies at different dimensions [5]. National codes and specifications in North America, France, Japan, Australia, and New Zealand define the cylinder as the standard specimen. In Great Britain, Germany and other European countries, cube specimens of 100 mm and 150 mm are used.[1] [4][6][7][8][9]. For normal concrete and HSC, the concrete compressive strength test results from cube specimens are generally higher than cylinders specimens [10][11]. As states in BS 1881, the compressive strength of concrete gained by cylinder specimens is equal to 0.8 times of the compressive strength gained by cube specimens. However, in fact, this ratio is not always precise in the applications [1][10].

In case of normal concrete, cube specimens produce 20-25% higher concrete compressive strength, with a decrease difference either at higher or increase compressive strength is generally assumed [4].

3.0. Methodology

Laboratory work procedure is initiated after a good literary study on this similar work done previously. The following steps are followed for this research.

- Study of previous work.
- Collection of materials.
- Specimen making in laboratory.
- Slump test of concrete mix.
- Curing of specimen & Data collection.
- Calculation and result analysis.

During laboratory work, three separate mixes of concrete prepared for M10, M15 and M20 grade with stone chips, sand, cement and water. W/C ratio was fixed at 0.45 for all three mixes. Dimension of mould for cylinder specimen was 8"deep x 4" diameter [**Fig. 1**] and for cube specimen was four square inches (4"x4") [**Fig. 2**]. After making concrete mix, slump test of each grade has been performed. After 24 to 36 hours of casting, the molds were removed and the specimens were cured in water at room temperature.

Fig.1. Dimension of cylindrical specimen mold.

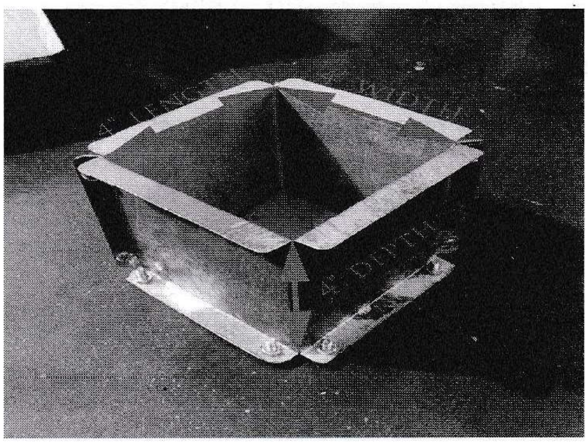

Fig.2. Dimension of cubical specimen mold

The standard allowable slump is needed to ensure the workability. However, the allowable slump data is shown in **Table.1.** It was much needed in this case because if the concrete is not workable the test results will be faulty and almost impossible to compare. Hence, the slump test results of different grades of concrete are given in **Table.2**.

Table.1: Allowable slump value chart

Allowable slump in Inch	Workability
0-1	Very Low
1-2	Low
2-4	Medium
More then 4	High

Table.2: Slump test result of different grade of concrete

Grade of concrete	Water/cement ratio	Slump test result in inches	Workability
M20 (1:1.5:3)	0.45	2.8	Medium
M15 (1:2:4)	0.45	3.4	Medium
M10 (1:3:6)	0.45	4.2	High

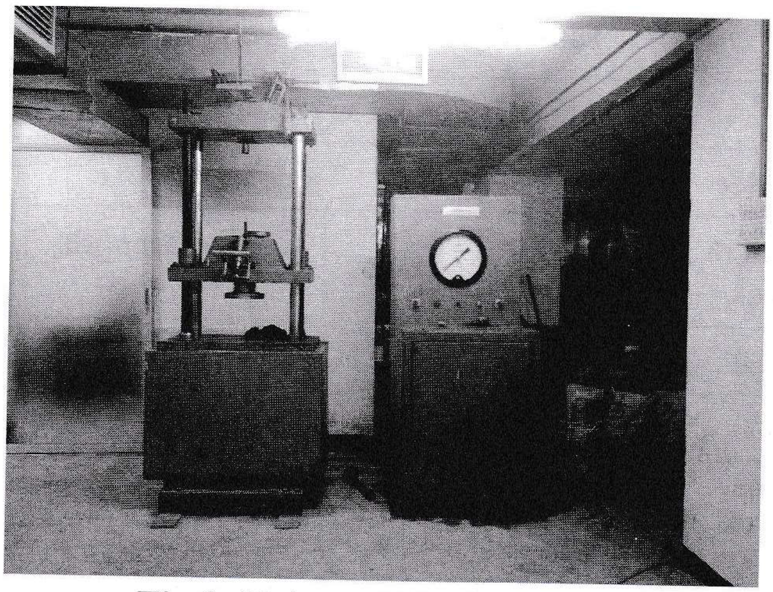

Fig.3: Universal Testing Machine

Each set of specimens contains 2 cylinders and 2 cubes of each ratio. Total 36 specimens were made. Compressive strength test of concrete using Universal Testing Machine [**Fig. 3**] was done at 7days, 14 days and 28 days' time interval of specimen casting date. 12 specimens for each M20, M15, and M10 grade of which, 2 cylinders and 2 cubes of each ratio were tested after 7 days of casting. Same procedure followed for 14 days and 28 days strength test. All results are noted to the following chart. Compressive strength test results of M20, M15 and M10 grade from the experiment are shown in **Table.3, Table.4** and **Table.5** respectively.

Table.3: M20 strength variation

Grade M20 (1:1.5:3)								
Cylinder				**Cube**				**Cylinder/ Cube Ratio**
Days	**SL.**	**Strength (Psi)**	**Avg. Strength**	**Days**	**SL.**	**Strength (Psi)**	**Avg. Strength**	
7 Days	1	2500	2400	7 Days	1	2300	2600	0.92
	2	2300			2	3000		
14 Days	1	2700	2700	14 Days	1	3800	3200	0.84
	2	2800			2	2600		
28 days	1	2600	2800	28 days	1	3700	3400	0.82
	2	3100			2	3100		

Table.4: M15 strength variation

Grade M15 (1:2:4)								
Cylinder				**Cube**				**Cylinder/ Cube Ratio**
Days	**SL.**	**Strength (psi)**	**Avg. Strength**	**Days**	**SL.**	**Strength (psi)**	**Avg. Strength**	
7 Days	1	1700	1700	7 Days	1	1900	1900	0.89
	2	1800			2	2000		
14 Days	1	2300	2100	14 Days	1	2900	2700	0.78
	2	2000			2	2600		
28 days	1	2300	2400	28 days	1	2700	2800	0.86
	2	2500			2	2900		

Table.5: M10 strength variation

Grade M10 (1:3:6)								
Cylinder				Cube				Cylinder/ Cube Ratio
Days	SL.	Strength (Psi)	Avg. Strength	Days	SL.	Strength (Psi)	Avg. Strength	
7 Days	1	1000	900	7 Days	1	1300	1300	0.69
	2	900			2	1300		
14 Days	1	1100	1100	14 Days	1	1600	1600	0.68
	2	1200			2	1600		
28 days	1	1300	1300	28 days	1	1900	1800	0.72
	2	1400			2	1800		

4.0. Results and discussions

Graphs were drawn to express the relationship of compressive strength of concrete and time which have been shown in [**Fig. 4**] for M20, [**Fig. 5**] for M15 and [**Fig. 6**] for M10 grade.

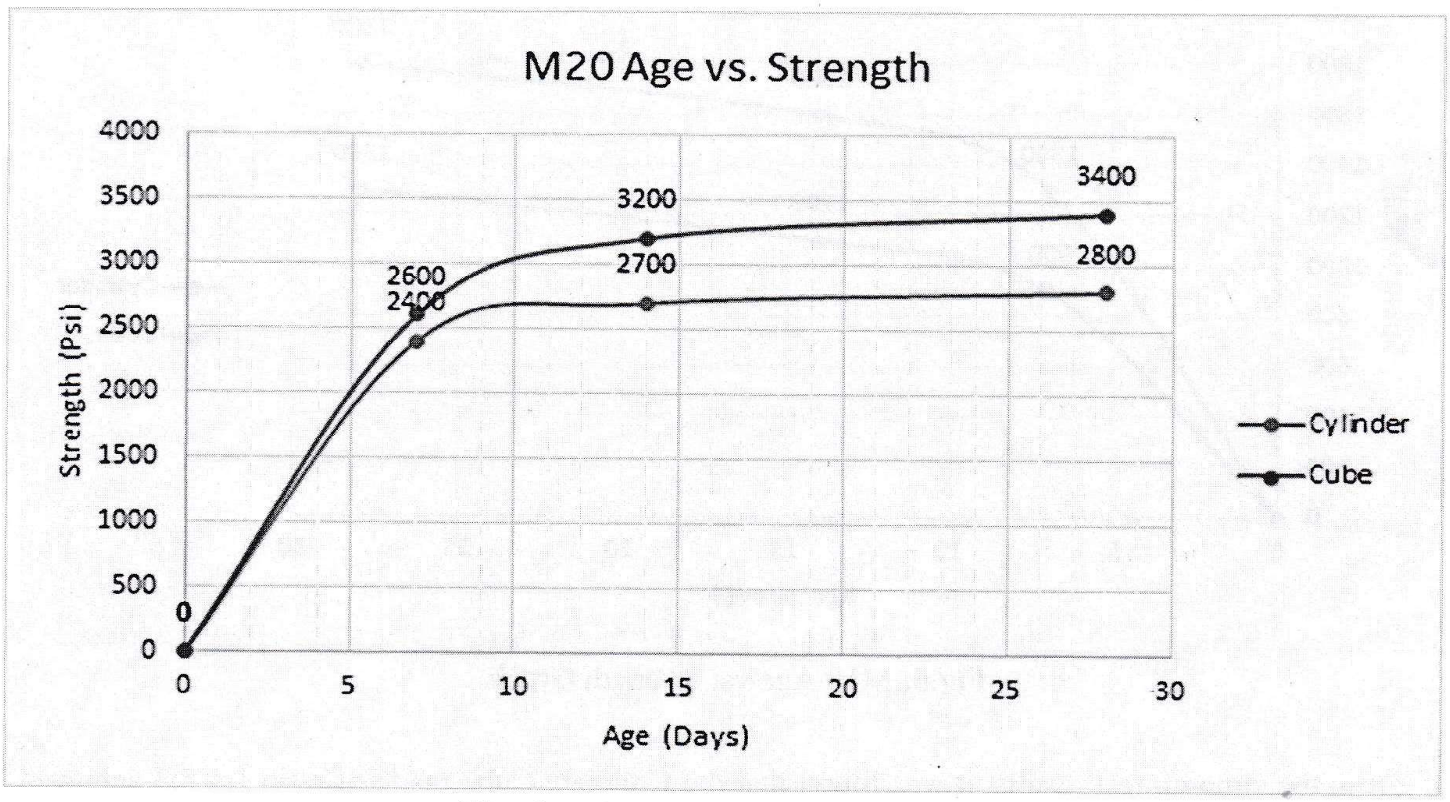

Fig. 4: M20 Age vs. Strength graph

Since, at first concrete sets, hardens and then gains strength with time, concrete strength has assumed zero for zero age. Strength variation of cylinder and cube is clearly notified from the following graphs. These graphs have also been shown that concrete strength is gradually increasing with time.

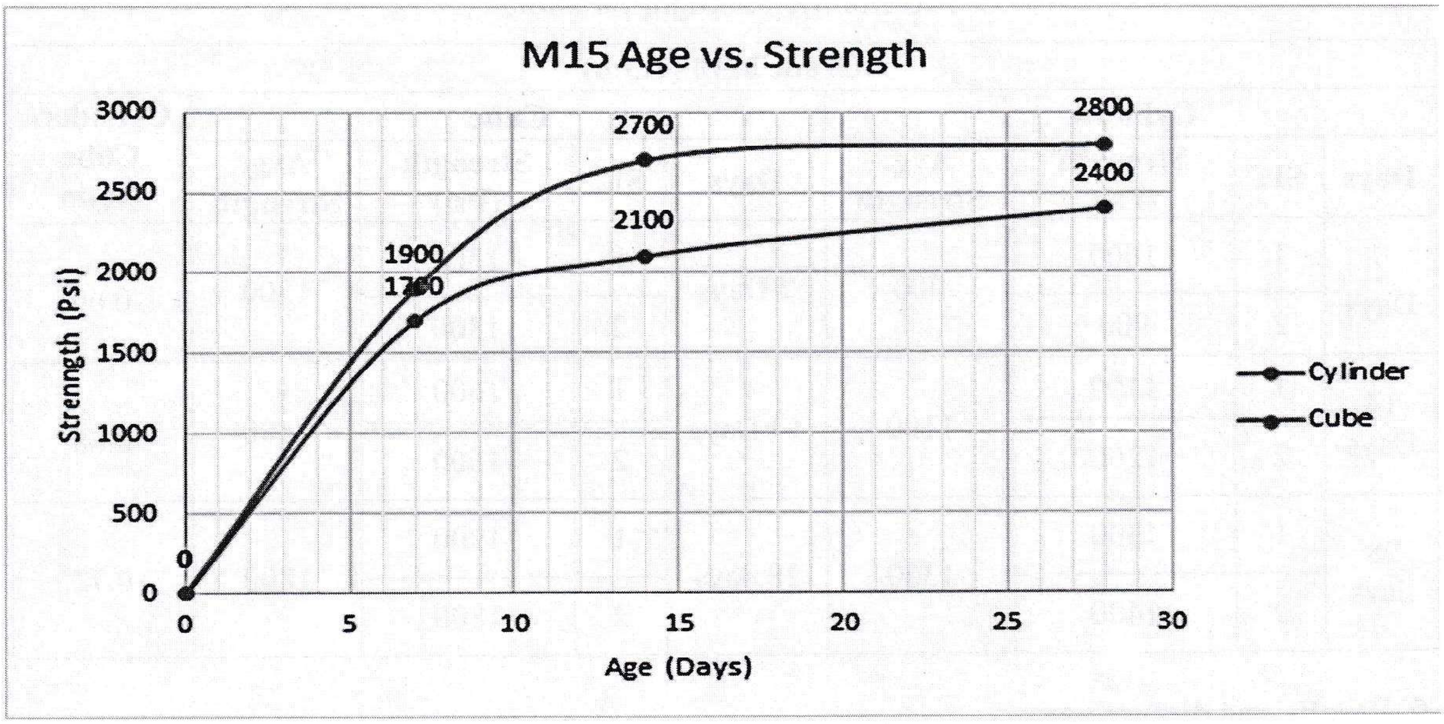

Fig. 5: M15 Age vs. Strength graph

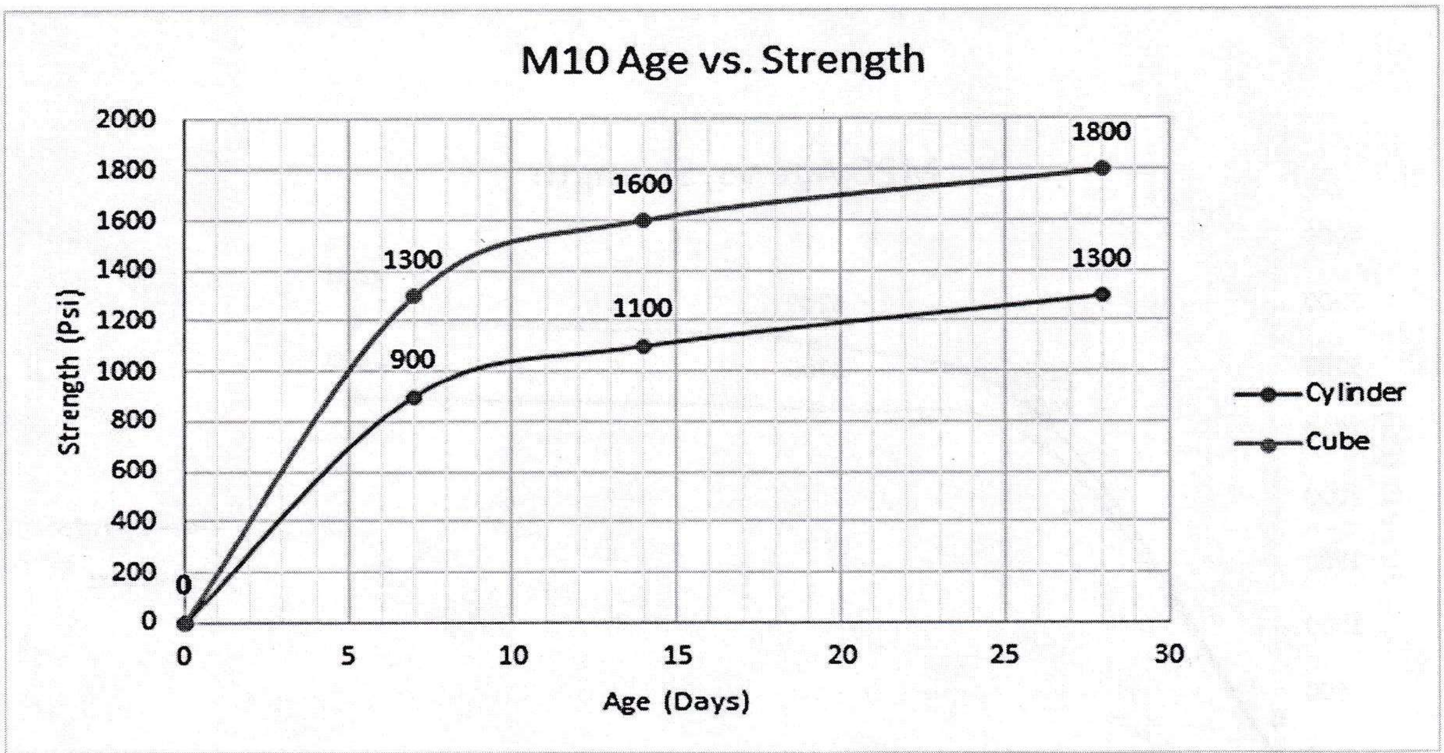

Fig.6: M10 Age vs. Strength Graph

From the strength test results, it was found that the Concrete Cube made of ratio 1:1.5:3 achieved the highest strength of 3400 psi by 28 days. It was also found that the Concrete Cylinder made of ratio 1:1.5:3 achieved the second highest strength of 2800 psi by 28 days. It is also found that, in average, the strength of Cube specimen is 1.25 times stronger than Cylinder specimen. Accepting the experimental variations and procedural errors from the standard, it may be assumed that achieving the design strength within 28 days, indicating its suitability of successful using in actual construction work. But it is also observed that, though M20 is good in strength, but all three grades are also good in strength according to non-workable strength category. Also, all of three are good in strength and workability from the point of view of where the concrete is to be used. In this study, only three most widely used grade of plain concrete i.e. M20, M10 and M15 were used. For better understanding of this study other grade of concrete should be used. In this study, w/c ratio was taken as a fixed value, it is recommended to use different w/c ratio for better understanding of the compressive strength of concrete.

5.0. Conclusions

From the above discussion, it is clear that M20 concrete has achieved maximum compressive strength among three mix proportions in both cube and cylinder test. The average cylinder to cube strength ratio was found 0.8 which is slightly lower than the average ratio 0.87 reported by Neville. It is also found that the strength of cube specimen is 1.25 times stronger than cylinder specimen.

6.0. Acknowledgments

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7.0. References

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