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Effect of Cube Size on the Compressive Strength of Concrete

[1]Misba Gul,
[1]Assistant Professor
[1]Department of Civil Engineering
[1]Islamic University of Science & Technology, Awantipora, India.

***Abstract* - In this paper the influence of the size of the cube specimens on the compressive strength of concrete has been investigated. Cube specimens of two different sizes 100 mm and 150mm were used for casting of concrete. The compression tests were performed on all the cube samples using Compression Testing Machine. The mix proportion was kept same in all the samples of concrete. Compression tests were conducted at the age of 7 days, 14 days and 28 days on 100mm & 150mm cube samples. Finally, the influence of cube size on the compressive strength of concrete was determined. The test results show that the compressive strengths of 100 mm cube samples was higher than that of 150mm cube samples.**

***Index Terms* - Compressive strength, Cube Size.**

I. INTRODUCTION

Compressive strength test is the most common test carried out on concrete. The main reason is that this kind of test is easy and relatively inexpensive to carry out (Mindess et al., 2003). Compressive strength of concrete can be determined using different shapes of specimens. Most commonly used specimens are cylinders and cubes. In United States compressive strength of concrete is determined by applying compressive force on cylindrical specimens of size 150 mm diameter and 300mm height.. While in Britain and Europe, the standard specimen for testing the compressive strength is a cube specimen of concrete by size 150 × 150 × 150 mm (Kim and Seong-Tae, 2002). The cubes are smaller compared with the cylinder specimen of concrete, and the advantages of cylinders do not depend on the quality and condition of the moulds and that their density can be more readily and accurately established by weighing and measuring (Day, 2006). Effect of shape of the specimen on the compressive strength of concrete has been widely studied and different relationships have been proposed between the cube compressive strength and cylinder strength.

As per Indian Standards 150mm cubes are used for determining the compressive strength of concrete. Use of I00 mm cubes has its advantages. The 100mm cubes are easier to handle and will result in saving of materials, curing space, storage and labor. The overall savings can be significant in financial terms. However, engineers and architects are reluctant in using 100mm cubes for determining the compressive strength because of the perceived greater variability in their compressive strength over that of the 150mm cubes. Also, there is a lack of compliance criteria for the 100mm cubes as the General Specification provides acceptance criteria based on 150mm cube strengths only. In this experimental study the effect of cube size on the compressive strength of concrete has been investigated so that a relationship can be developed between the compressive strength of 100mm cubes and 150mm cubes.

II. LITERATURE REVIEW

It has been well known that given the same mix, the strength of a concrete specimen is mainly influenced by the following factors:

a. the ratio of the size of the specimens to the maximum size of the aggregates;
b. the rate of application of the load;
c. the rnoisture condition of the specimen;
d. the end restraint due to the platens of the compression machine;
e. the slenderness ratio of the specimens (i.e. the length to diameter ratio); and
f. the size of specimen.

For concrete cubes cast, cured and tested under same conditions the influence of the factors mentioned in items (a) to (d) above on the concrete strength is kept to a minimum. As the slenderness ratios of 100mm and 150 mm concrete cubes are both equal to unity, the only factor that can significantly affect the concrete strength is the specimen size.

Since concrete is composed of elements of variable strength, it is reasonable to assume that the larger the volume of the concrete, the more likely it is to contain an element of weaker strength. As a result, for a concrete specimen of the same batch, it is reasonable to expect that its strength and its variability will decrease as the specimen size increases. Since the size effect

is a result of the inhomogeneity of the concrete, it follows that the more homogeneous the concrete the smaller will be the size effect.

There are few publications available on the strength comparison of 100mm and 150mrn cubes. The published data were mostly on the comparison of the strength of concrete cylinders of different sizes. Lessard (1990) found that the compressive strength of cylinders of 150mm diameter by 300mm was about 94% that of cylinders of 100mm dia. by 200mm height. Baalbaki et al (1992) repeated the experiment on a total of 126 cylinders and found that the strength of the cylinders of I50mm diameter was 93% that of cylinders of 100mrn dia.. Neville (1977) suggested that the strength of the 100mm cubes was about 104% that of the 150mrn cubes. Apart from the small difference in strength between the 100mm and 150mm cubes, a slightly higher standard deviation in strength is also reported for the smaller specimens. Neville (I977) reported that the standard deviation in strength of tile 70rnrn cubes was between 50% to I00% higher than that of the 150mm cubes. From the results of Baalbaki et al (1992), it can be stipulated that the standard deviation in strength of the 100mrn cylinders was on average 73% higher than that of the 150mrn cylinders.

III. MATERIAL USED

Materials used for making concrete (cement ,sand and aggregate) were tested for their respective properties according to the respective IS codes.

a. **Cement**: Ordinary Portland Cement (OPC) 43 Grade (JK Cement) was used for this experimental investigation.
Fineness test was done using 90 micron sieve. The average value of weight of residue left on 90 micron sieve was 2.3% .
The standard consistency of cement = 28%
Initial setting time = 1 hour 53 minutes
Final setting setting time = 5 hour 9 minutes.
Average value of expansion in Le-Chatelier's soundness test =1.67mm.
The average compressive compressive strength at the age of 28 days =45.47 N/mm^2.

b. Course Aggregates: Course aggregates were obtained from a local crusher. Two nominal sizes 10mm and 20mm were used. Sieve analysis was carried out for both the sizes.
Fineness modulus for 10mm aggregates=5.9562
Fineness modulus for 20mm aggregates=8.1868

c. Fine aggregates: Local river sand was used as fine aggregates. Sieve analysis was carried out for sand.
Fineness modulus of sand=3.992 (Grading Zone =II)

IV. METHODOLOGY

In this experimental investigation nine castings were done, one casting per week. In each casting nine cubes each of 100 mm and 150mm size were cast in order to minimize the strength variability. In each lot of cubes three were tested at the age of 7 days, three at the age of 14 days and remaining three at the age of 28 days. The cubes were cast, cured and tested in accordance with Indian Standards.

V. RESULTS & DISCUSSIONS

On all the cube samples compression test was done using Compression Testing Machine. The test results obtained are shown in the following table:

Table 1:Test results

Casting No.	Compressive Strength (N/mm^2)					
	100 mm Cubes			150 mm Cubes		
	7 days	14 days	28 days	7 days	14 days	28 days
1	14.4	21.5	25.8	14.8	21.28	24.31
2	13.1	19.3	22	13.27	18.44	20.84
3	17.9	24.5	26.9	15.64	22.66	24.66
4	12	19.6	21.8	13	18.177	20.14
5	14.1	21.0	24.0	13.97	19.64	23.51
6	16.7	23.5	25.7	15.55	21.51	24.57
7	19.5	25.4	26.7	17.77	23.16	25.51
8	18.8	24.7	26.5	16.35	23.26	25.06
9	19.7	26.4	27.1	18.83	25.2	25.77

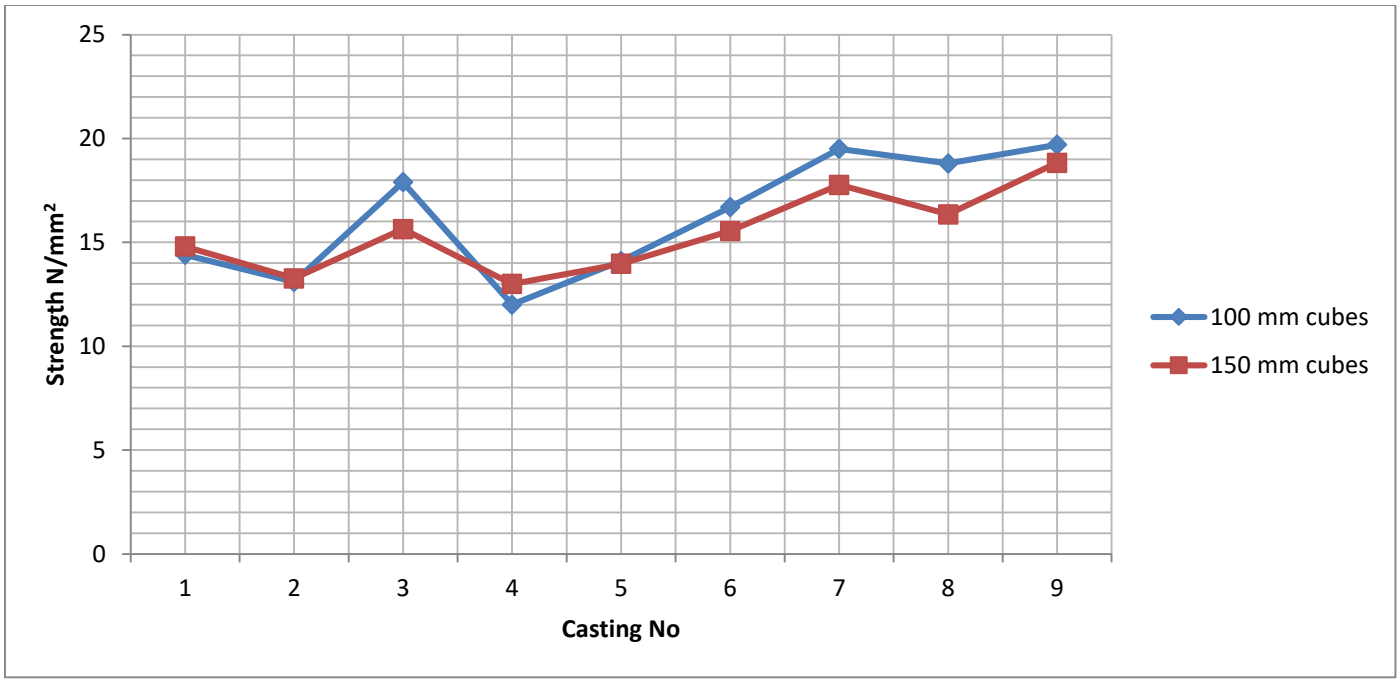

Figure 1: Comparative study of 7 days compressive strength of 100 m and 150 mm cubes.

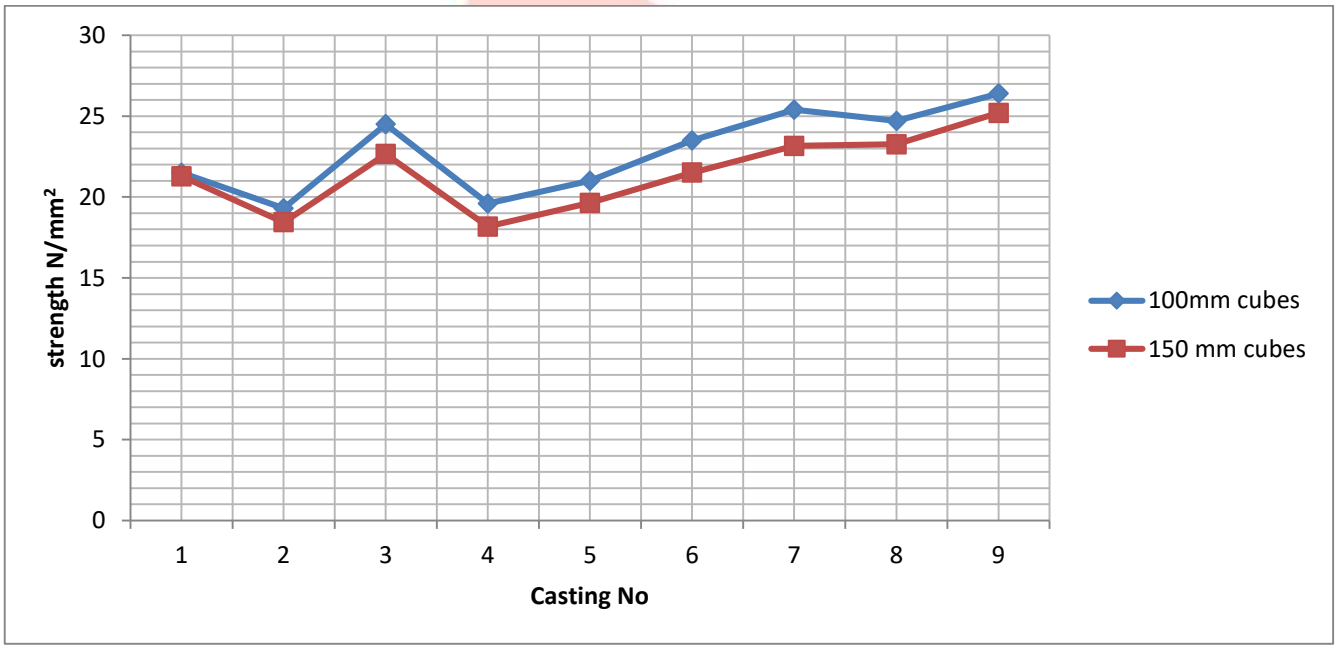

Figure 2: Comparative study of 14 days compressive strength of 100 m and 150 mm cubes.

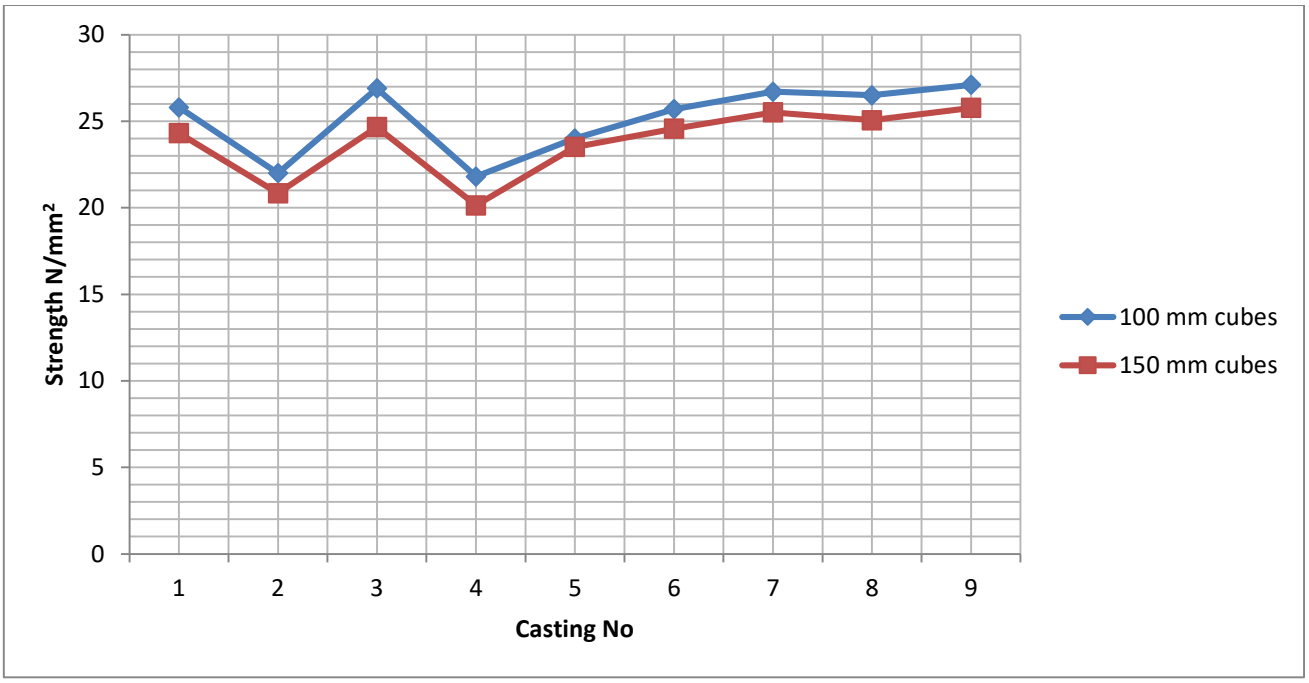

Figure 3: Comparative study of 28 days compressive strength of 100 m and 150 mm cubes.

From the above graphs it is clear that the strength obtained on 100mm cubes is higher than 150mm cubes and the variation in the values of compressive strength of concrete ranges between 5 to 6 %., Since concrete is composed of elements of variable strength, it is reasonable to assume that the larger the volume of the concrete, the more likely it is to contain an element of weaker strength. As a result, for a concrete specimen of the same batch, it is reasonable to expect that its strength and its variability will decrease as the specimen size increases. Since the size effect is a result of the inhomogeneity of the concrete, it follows that the more homogeneous the concrete the smaller will be the size effect.

VI. Conclusion & Recommendations

The variation in values of compressive strengths of concrete when testing is done on two different sizes of cubes (100 mm and 150mm) ranges between 5 % to 6 % the strength obtained on smaller size cubes being higher.

In case 100 mm cubes are tested for determination of compressive strength of concrete, the values obtained should be reduced by about 5 to 6 % to achieve the actual characteristic strength.

References

[1] Z.P. Bazayt and Y.W. Kwon "Failure of slender and stocky reinforced concretecolumns: tests of size effect", Materials and structures, 1994,pp 27,79-90.

[2] H.G. Gonnerman "Effect of size and shape of test specimen on compressive strength of concrete".Proc., ASTM, West Conshohocken, 1925, pp, 237-250.

[3] Cusatis, G. and Z.P. Bazant "Size effect on compression fracture of concrete with or without V-notches: a numerical meso-mechanical study, Computational Moedelling of Concrete Structures" -Meschke,de Borst, Mang & Bicanic (eds), Taylor & Francis Group, London. 2006