# Experimental Study Of Core Diameter Varing H/D Ratio On Concrete Core Strength

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**ABSTRACT**

In this paper an effort has been made to find the effect of H/D ratio on the strength characteristics of the core. Cubes of 150mm x 150mm x 150mm were casted and cured for 28 days, desired core samples having diameter 50mm and 75 mm have been prepared from these cubes having different H/D ratios of 1, 1.25, 1.5, 1.75 and 2 respectively. The core samples were tested on compression testing machine. It was found that with the increase in the H/D ratio and decrease in the diameter of the core, compressive strength of the core increase. It has also been observed that the strength of core samples was less than those of the standard cubes.

## 1. INTRODUCTION

The compressive strength of these specimens is generally tested at the age of 7 days and 28 days. However 28 days strength is generally taken as compressive strength of concrete.
But this 28 days strength of standard specimen is not always the actual strength of concrete because:

i) It depends upon curing and compaction of concrete
ii) It is not possible to prepare and test standard specimens at a later stage, if the current strength of structure is to be determined to check whether or not strength and durability of concrete is adequate.

To overcome this problem one of the method is core testing of suspected structural elements. In this method cores are drilled from the structure as per **IS: 1199-1959**[15] and tested for compressive strength. As per **BS: 1881: part 4, 1970(2)**[5], the need for compressive strength of cores to yield an estimate of strength of suspected concrete is well established. This code also contains recommendation for core testing of concrete. Also more detailed and comprehensive recommendations for core testing is provided by **Concrete society technical report no.11 of 1976**[7].This report gives detailed procedure for testing and interpretation of results of core testing. Both BS:1881 and the report of concrete society recommends the diameter of cores as 150mm and 100mm. However is not always possible to obtain cores of this diameter, with required minimum H/D ratio of 1.0.This may be due to limitation of dimensions of the member or critical reinforcement location. To overcome this problem **CSTR 11,1976**[7] has allowed the use of 50mm and 75mm diameter cores.**BS:1881, part (120) 1983**[3], and **ASTMC 42-90,1994**[2]**,** allows a minimum core diameter of 102mm, provided that diameter of core is at least 3times greater than maximum aggregate size of concrete mix. As per **Bartlett F.M. et.al 1994**[4], the diameter of core affects the compressive strength of cores. **Arioz , O. et.al, 2006**[1]**,** concluded through his research that though , smaller diameter cores should give higher average strength than larger diameter cores for the same H/D ratio, due to size effect, but is not always true , since the concrete is susceptible to micro cracking during drilling operation.
From the above discussion it is evident that core strength is dependent of H/D ratio and diameter of the core specimen.**IS:1199-1959**[15] recommends the H/D ratio of core as 2, and **IS: 516-1959**[14], gives the correction factor to be applied , if the H/D ratio is less than 2.0.But this relation does not give particular values of different core diameter. In this paper the effect of age and H/D ratio ranging between 1.0 and 2.0 on cores of diameter of 50mm and 75mm has been analyzed. To find the in situ strength of concrete, generally core strength test is used. In this method cores are drilled from the structure, and are tested for compressive strength. Compressive strength of the core is then converted into equivalent cube strength. Though it seems to be a simple procedure, it is not easy to interpret the results. The following are some of the factors which affect the accuracy of results:

1. Height to Diameter Ratio (H/D) ratio.
2. Moisture condition at the time of testing.
3. Age of concrete.
4. Strength level of concrete.
5. Disturbance during drilling operation of cores.

Also the condition of placing, compacting and curing may not be the same at site which were used for preparing standard specimens. **J.H. Nevile et.al.(1956)** [17]**,** suggested that measured core strength increases with the decrease of core size. The

smaller size cores give more variable results. **Mcintyre.et. al(1990)** [20]through their studies concluded that with the decrease in diameter, the homogeneity of the material in test specimen diminishes, thereby affecting the internal failure mechanisms of the specimen. **IndelicatoF.et.al(1993)** [9], showed that with the decrease in diameter, the assessment of correct results become hard. The core strength obtained by converting these to standard cube or cylinder may not give true value. **Neville.et.al (1995)** [21] , showed that as the core diameter decreases, the volume the specimen also decreases significantly for a given H/D ratio. Hence the strength of specimen decreases with the increase in its size. **BungeyJ.H. Et.al (1996)** [6] **,** showed that the properties of insitu concrete will vary with in a member , due to difference in compaction and curing as well as non uniformity of material. The effects of drilling are more pronounced for small diameter cores, as suggested by **Barlet F.M. et al.(1997)** [4]They showed that is because damaged parts of the core have a constant thickness independent of core diameter. They used 102mm diameter and 204mm height of the cores as standard specimen and concluded that a factor of 0.98 and 1.06 has to be applied for cores of 152mm and 51mm respectively. **IndelicatoF.et.al(1997)** [10]through their tests on cores , showed that choice of smaller diameter of cores is motivated by the need to reduce costs and minimize the damage to the structure, and by possibility of drilling out samples more easily by means of smaller tools for these reasons concrete society has recommended the ise of 50mm and 75 mm diameter cores.**Indelicato F.et.al (1998 and 1999)** [11,12]**,** concluded that potential strength of concrete is related to quality of material used and is an estimate of standard test specimen. However in situ strength of the concrete as it exists in construction is the end result of quality of concrete used in the construction. **Erdogan T.Y. et. al(2003)** [8] , indicate that variability of strength of small diameter cores is greater than that of large diameter cores , even when strength are very close to each other . **JeeNamyong .et.al(2004**) [18] in their study presented a regression equation for predicting compressive strength of in-situ concrete based upon mix proportions and concluded that , water cement ratio, cement contents, cement aggregate ratio are the main influential factors for reliability prediction of compressive strength. **Tuncanet.al(2006)** [22] has shown that concrete strength is a further factor which may influence the behavior of a core, and it is possible that this also may affect the relative behavior of small and large cores. The complexity of these problems contributed to the decision to confine the investigation to a single small core size .**M.Yaqub.et.al (2006)** [19] in their research established the relation between core compressive strength and cube compressive strength of hardened concrete in existing structures, and concluded that core strength of 75mm cores is 69% of compressive strength of 150mmX150mmX150mm cubes. **I. M. Nikbin et.al (2009)** [16] revealed that the age of the concrete was found to be an effective factor in the interpretation of the core strength results. Test results also revealed that the H/D ratio of the specimen is more effective for small diameter cores. The coefficient of variation of strength values was noticed to be somewhat higher for 50 mm diameter cores.

## 2. Materials and Methods

In this work, Experimental study of core diameter varying H/D ratio on concrete core strength is investigated by:

- Using a same type of aggregate and a same type of cement for standard and core specimens.
- Curing the standard cubes specimens and the testing core specimens in the same conditions.
- Taking cores from the cubes.
- Using regression analysis to define the correction factor curves.

**Testing equipment** :The equipment used are those available in the structural laboratory of NITTR, CHANDIGARH.

**Core drilling machine:** The Cores of 75mm and 50mm were drilled out this machine.

**Measurement of compressive strength :**For cubes and core drilled are tested at various rates of loading with a compression machine with a maximum capacity of 3000 KN.

**Materials:** Locally available Ordinary Portland Cement (OPC) and sand was used in this study and locally available crushed coarse aggregate with a nominal maximum aggregate size of 20.0 mm was used.

**Figure 1. Core drilling machine**

**igure 2. Compression Testing Machine**

**Concrete Mix Proportions**
Nominal mix concrete of M25 grade was used.
**Specimens**
**Testing procedure**The compressive strength of the standard specimens and the cores was determined by Compression testing machine. The compressive strength test results were taken as the average of four specimens. A total of 4 standard and 40 core specimens were tested in this investigation.

In all 44 numbers of 150X150X150 mm (were casted and cured in the laboratory condition.50 and 75 mm diameter cores were cut from the cubes by using a diamond- tipped core-cutter and trimmed to give over- all H/D ratios between 1.0 and 2.0. The H/D ratios of capped core specimens were 2.0, 1.5, 1.25 and 1.0. Fig.1 shows core drilling operation
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. **RESULTS AND DISCUSSION**

In this study for each mix the average values of measured core strength, were compared for each different value of H/D and expressed in terms of a core with H/D = 2.0. Based on the results obtained for H/D ratios an over-at least-squares regression was performed.

**Table 1: Correction factor for 75mm diameter core:**

| No. | Diameter (mm) | H/D Ratio | Core Compressive Strength(Mpa) | Correction Factor |
|---|---|---|---|---|
| 1. | 50 | 1 | 24.16 | 0.85 |
| 2. | 50 | 1.25 | 25.93 | 0.91 |
| 3. | 50 | 1.5 | 26.66 | 0.93 |
| 4. | 50 | 1.75 | 27.6 | 0.97 |
| 5. | 50 | 2 | 28.54 | 1.00 |

**Table 2: Correction factor for 50mm diameter core:**

| No. | Diameter (mm) | H/D Ratio | Core Compressive Strength(Mpa) | Correction Factor |
|---|---|---|---|---|
| 1. | 75 | 1 | 24.08 | 0.86 |
| 2. | 75 | 1.25 | 24.94 | 0.89 |
| 3. | 75 | 1.5 | 25.82 | 0.92 |
| 4. | 75 | 1.75 | 27.13 | 0.96 |
| 5. | 75 | 2 | 28.15 | 1.00 |

The following graphs are obtained between the Correction factors and different Height/Diameter ratio , for 50mm and 75mm diameter cores

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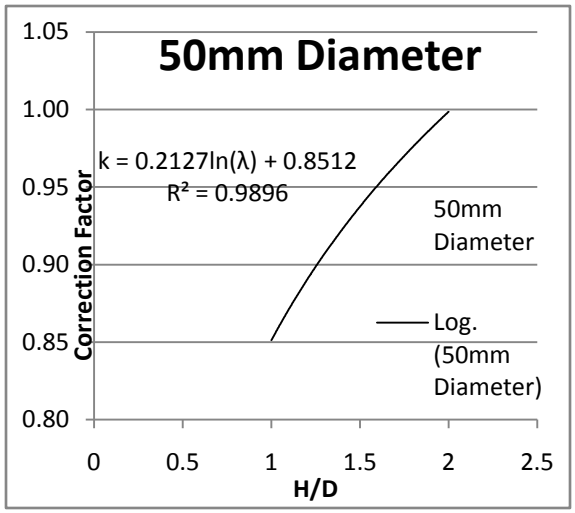


**Fig. 5.1: Correction factor for H/D ratio of core dia. 50 mm**

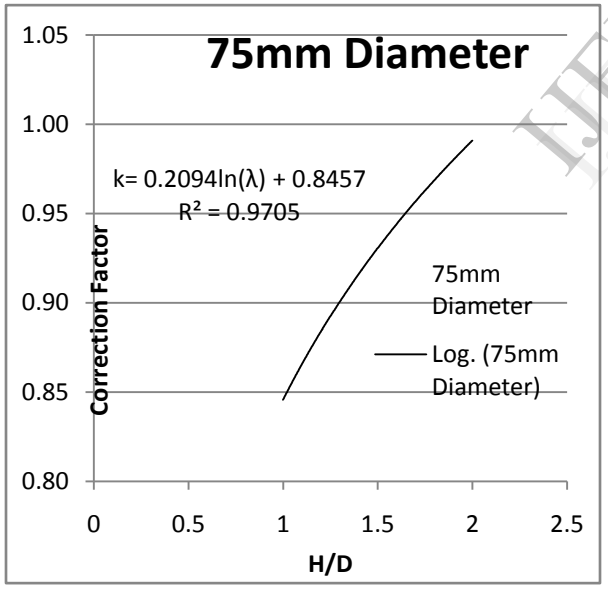


**Fig. 5.2: Correction factor for H/D ratio of core dia. 75 mm**

The numerical formula for 50mm core and 75 mm cores is given in equation no.1&2 respectively.

**k = 0.2127ln (λ) + 0.8512 (1)**
**k= 0.2094ln (λ) + 0.8457 (2)**

Where k is the correction factor of core strength for a core with H/D = λ

## 4..SUMMARY AND CONCLUSION

For small cores of 50 and 75 mm diameters, the following conclusion may be drawn:
1 The compressive strength of cores increased with the decrease in H/D ratio of the core.
2 The effect of H/D ratio was more pronounced for 50 mm diameter cores.
3 The strength of cubes is generally higher than that of cores drilled of the same concrete mix.

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