A Report On The Effect Of Compaction And Curing On The Strength Of Core Concrete

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I) Introduction

Concrete is the most widely used construction material in today's world. The process of making concrete and placing needs close supervision to achieve the targeted design parameters. Once the concrete of required strength and workability is designed, the placing of concrete plays an important role. The difference between good and bad concrete can also be attributed to the quality control, provided all other factors are essentially maintained in the process of concrete making. Quality control refers to proper compaction, form working and curing. Compressive strength of concrete cast in structures is generally determined by core cylinder tests. This requires concrete cores to be taken out of structures and to be tested for compressive strength. This result will be indicative of the concrete quality from making to placing. **However, these standard tests conducted on specimens represent the potential quality of concrete only when they are subjected to full compaction.**

1.1) Core strength of concrete

The core strength of concrete is conducted to establish the actual strength of concrete at site. **It is generally practiced if the cast cubes at field during casting fail to satisfy the characteristic strength**. As an integral part of concrete is removed in the core test, it becomes important to follow certain specifications as the shape and size of concrete is known to impact on the strength value. The various Codal provisions to be followed for the core strength test at field as per IS 516 [1] are briefed below:

(i) Diameter d should be greater than 3 times max. aggregate size
(It has been noted that **smaller size of cores generate high variability in results**, hence SP 24 of IS 456 suggests correction factors for cores less than 100mm as given in Figure 1 below. This is because proportion of the drilled and potentially damaged surface to the volume of the core is significantly higher in small cores than larger ones, resulting in non-representative sample of concrete [2] [3])

Standard diameter of core is 150 mm; however cores of 100 mm diameter may also be used and the strength assessed from both cores will be about the same. The length of core should be at least 95 percent of the core diameter. The equivalent cube strength (on 150 mm cubes) may be obtained in the following manner:

a) Strength of core = f_0 (on 100 mm diameter core)

b) Apply correction for diameter: if diameter is less than 100 mm, correction factor = 1.08

Figure 1: Correction factor for the diameter of core

[In the core tested at site, the diameters have been all maintained at 68 mm which is not the appropriate diameter to be chosen for reliable results]

(ii) h/d > 0.95 before capping, if not satisfied not to be tested

(iii) h/d >1.0 after capping, if not satisfied not to be tested

(iv) Material used for capping should have a strength greater than that of the concrete

(v) At least three specimens should be tested (It has been noted that the representative sampling nos. have not been taken for the core tests at site)

(vi) h/d = 2 preferred and if not should incorporate the below correction factor for the equivalent strength

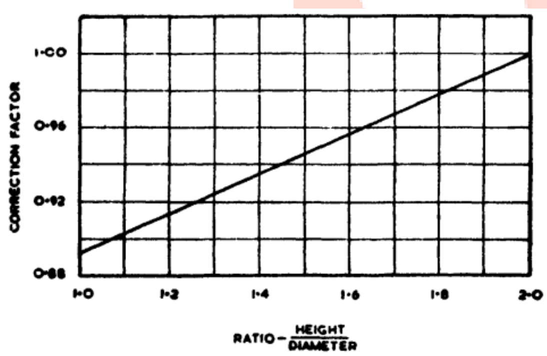

FIG 1 CORRECTION FACTOR FOR HEIGHT/DIAMETER RATIO OF A CORE

1.2) Importance of Compaction on the Strength of Concrete

In the process of mixing, transporting and placing concrete, air gets entrapped inside concrete. Compaction is the process, which expels entrapped air from freshly placed concrete, and packs the aggregates together so as to increase the density of concrete. If this air is not removed totally, the strength of concrete will be considerably reduced. **Neville reports that 5% air voids reduce the compressive strength by 30%, and 10% voids reduce the compressive strength by 50%** [2, 3]. The density of concrete is found to depend largely on the compaction along with the cement content and maximum size and type of aggregate used [4].

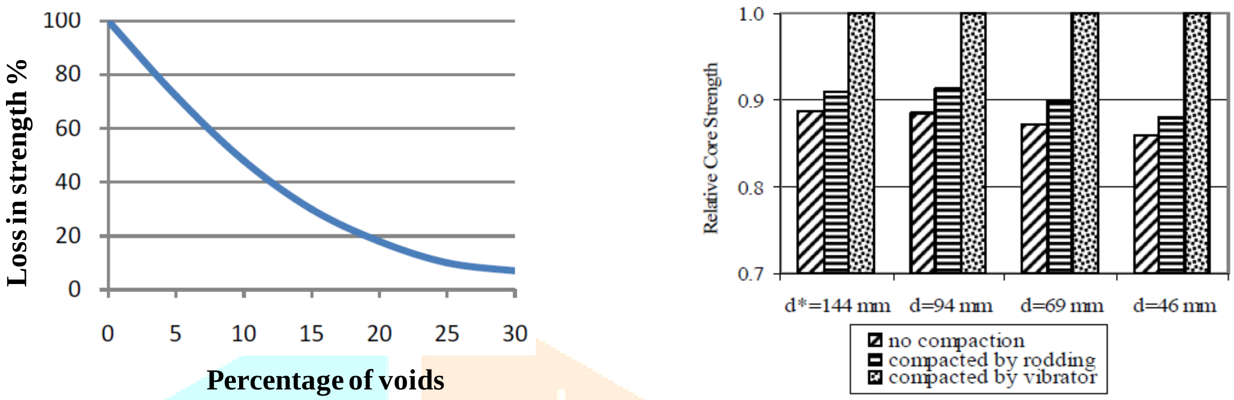

Figure 2: Loss of strength of concrete due to incomplete compaction

Similar research by Omer et.al where effects of various compaction methods were studied, a considerate difference was reported in the concrete quality when subjected to no compaction, compaction by rodding and compaction by vibration methods (Figure 2).

1.3) Importance of curing on the compressive strength of concrete

Curing is without a doubt the most crucial step in the concrete manufacturing process. This is due to the fact that a properly designed concrete can achieve its full design parameters if the design water content is present in the system for cement hydration and not lost by evaporation, which necessitates curing. Mehta & Monterio establishes that strength of a continuously moist cured concrete is three times the strength of continuously air cured concrete [5]. If concrete is not cured for the first three days after casting, it loses 30% of its strength [6]. Within the first seven days after casting, the concrete should have ideally developed 50-70 percent of its desired strength. The probability of inadequate curing cannot be ruled out in this case because several of the core strengths were as low as 40% of their target strength.

II) CORE TEST RESULTS CONDUCTED

		Cubes from TM tested for the respective pour		Field cores	
Date of casting	**Grade**	**Cube Strength (MPa)**	**Cube Density (kg/m^3)**	**Core Strength (MPa)**	**Core density (kg/m^3)**
8/5/2017	M30	34.24	2511	31.45	2119
				24.97	2144
5/6/2017	M30	35.01	2495	36.93	2147
				11.24	2081
14/6/2017	M35	43.02	2488	24.97	2062
				26.9	2112
				22.49	2162

				24.7	2090
				17.1	-
				27.8	2152
				23.49	2064
				43.79	2276
17/7/2017	M35	52	2490	30.3	2138
				14.5	2088
11/8/2017	M30	39.61		12.87	2111
12/9/2017	M35	43.66	2518	23.5	2059
				24.05	2259
17/10/2017	M35	50.58	2471	43.5	2317
				21.7	2092
				17.3	-
				18.3	1984
				32.3	2137
				25.8	2197
				32.9	2270
21/11/2017	M35	44.68	2497	15.04	1995
				29.31	2268
				16.7	-
23/02/2018	M30	34.65	2482	13.47	2055
				12.87	2111
				22.08	2223

From the core results, it is to be noticed that the **variability of strength** is very high in the core tests done from the same pour (indicated by the highlight). This indicates poor compaction yielding lower strengths. Moreover, the density of tested core is noted to be always lesser than the cube density which requires investigation on the addition of any additional water at site for ease in workability. The large strength loss of the core also necessitates enquiry on the adequacy of curing done, particularly during the first three to seven days of concrete placement.

III) INFERENCES

(i) In-situ strength of core concrete largely depends on the method of placing of concrete along with the concrete quality.

(ii) Compaction is essential to remove air voids from concrete as it severely affects the concrete strength.

(iii) Core strength test of concrete represent the quality of concrete only when subjected to full compaction.

(iv) The high variability in core strength results can be an indication of improper compaction.

(v) As the field cube strength and density of concrete has satisfied design parameter which was also approved by the client, the decreased density of core mostly indicate improper compaction and poor curing practices, hence the reduced strength.

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