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Influence of Direction of Coring on Insitu Concrete Core Strength Results with Respect to Pouring Direction of Concrete

[1]**Dr Abdullah Ahmed Laskar**, *Sr Manager (Civil & Structural), BHEL-PSER, Kolkata, WB, India*
[2]**Anupam Sarkar**, *Dy Engineer (Civil-QA/QC), BHEL-PSER, Kolkata, WB, India.*

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Abstract - *The core test of in situ concrete is one of the important check to know the integrity of the RCC structure in case any nonconformity observed in concrete cube specimens test results than design specified strength of concrete. In addition to that core test is also plays an important role to evaluate the concrete strength of old RCC structure for rehabilitation or retrofitting of the structure. Considering the importance of the test the factors which can influence the test results are also equally important. As per the available standard guide lines of ACI214.4R-10, ASTM C-42/C-42M and IS-516, there is no correction factor has been given any of the standard for direction of coring just like correction factors mentioned for L/D ratio, even the direction of coring with respect to direction of pouring plays an important role in evaluation of concrete strength due to ITZ. Considering the importance of the core strength results & also the influence of the direction of coring on strength of core with respect to direction of pouring an experimental studies were conducted on 9 different concrete cubes of 150 mm size specimen by taking two core of 44 mm diameter both in parallel and perpendicular direction of pouring. Based on the studies it has been observed that core taking parallel to the direction of pouring is almost 13-21% higher than the core taking perpendicular to the direction of pouring. Thus such a large extent of variation in strength of core with respect to direction of coring is due to the weak interfacial transition zone (ITZ) around the aggregate surface due to accumulated bleed water which will make the plane weak.*

Key Words: Core strength, ITZ, L/D ratio, Coarse Aggregate, ASTM, ACI, IS.

1. INTRODUCTION

The importance of the core test of in situ concrete is one of the important check to evaluate the integrity of the structures by measuring the actual strength of insitu concrete. In practice core test of concrete is a very common type of check in any RCC structure whenever the sample concrete specimens are found unsatisfactory with respect to design strength requirement or any old RCC structure whose health assessment is required for evaluation of residual life of the structure. Considering the importance of the test and also the various factors which may further influence the test results are equally important with regards to importance of the core test results, which may govern the integrity of the structure and also prediction of residual service life. Although the available standard guide lines of ACI214.4R-10, ASTM C-42/C-42M and IS-516, there is no correction factor has been suggested for direction of coring as like the strength correction factors mentioned for L/D ratio. However the direction of coring is influencing the core strength in a large scale due to weak ITZ around the coarse aggregate because of accumulation of bleeding water around the aggregate and thus weaken the plane. Considering the importance of the core strength results & also the influence of the direction of coring on strength of core with respect to direction of pouring a research experiment were conducted on 9 different concrete cubes of 150 mm size & from each cube specimens two core of 44 mm diameter were collected for testing from both parallel and perpendicular to the direction of pouring. Based on the research studies it has been observed that core taking parallel to the direction of pouring is almost 13-21% higher than the core taking perpendicular to the direction of pouring.

2. LITERATURE REVIEW

Sullivan (1991) defines the use of non-destructive tests to check for anomalies in cores in advance the compressive strength tests are showed. The examination and understanding of core strength data are difficult by the large scatter typically perceived in the test results. Detailed descriptions of these statistical techniques can be found in most statistical references, such as Ang and Tang (1975) or Benjamin and Cornell (1970). The length-to-diameter ratio l/d was documented in the 1927 edition of ASTM C 42/ C 42M as a factor that influences the dignified compressive strength of a core, and minor dissimilarities of the original l/d strength correction factors have been suggested in successive editions. Specimens with small l/d fail at greater loads because the steel loading platens of the testing machine restrain lateral enlargement during the length of the specimen more efficiently and so deliver limitation (Newman and Lachance 1964; Ottosen 1984). Bartlett and MacGregor (1994b) account that the necessary strength correction is slightly less for high-strength concrete and soaked cores, but they endorse strength correction factor values that are similar to those in ASTM C 42/C 42M. They also perceived that the strength correction factors are less precise as the extent of the necessary correction increases for cores with smaller l/d. Thus, modified core strength values do not have the same degree of inevitability as strength obtained from specimens having l/d of 2. There is contradictory investigational indication regarding the strength of cores with dissimilar diameters. While there is an agreement that modifications between 100 and 150 mm (4 and 6 in.) diameter specimens are negligible (Concrete Society 1987), there is less arrangement regarding 50 mm (2 in.) diameter specimens. In one study connecting cores from 12 different concrete mixtures, the ratio of the average strength of five 50 mm (2 in.) diameter cores to the average strength of three 100 mm (4 in.) diameter cores ranged from 0.63 to 1.53 (Yip and Tam 1988). An analysis of strength data from 1080 cores tested by various investigators indicated that the strength of a 50 mm (2 in.) diameter core was on average 6% less than the strength of a 100 mm (4 in.) diameter core (Bartlett and MacGregor 1994d). The inconsistency of the in-place strength within the element being cored, however, also inflates the variability of the strength of small-volume specimens. Cores drilled vertically through the thickness of slabs can be particularly vulnerable to this effect (Lewis 1976). Different moisture-conditioning behaviours have a substantial effect on the dignified strengths. Air-dried cores are on average 10 to 14% (Neville 1981; Bartlett and MacGregor 1994a) stronger than soaked cores, although the actual ratio for cores from a specific concrete can differ significantly from these average values. Soaking causes the concrete at the surface of the specimen to swell, and restraint of this swelling by the interior region causes self-equilibrated stresses that reduce the measured compressive strength (Popovics 1986). Conversely, drying the surface causes shrinkage that, when restrained, creates a favorable residual stress distribution that increases the measured strengths. In both cases the changes in moisture condition are initially very rapid (Bartlett and MacGregor 1994c, based on data reported by Bloem 1965). If cores are not given standardized moisture conditioning before testing, or if the duration of the period between the end of the moisture treatment and the performance of the test varies, then additional variability of the measured strengths can be introduced. The percentage of strength loss caused by soaking the core depends on several factors. Concrete that is less permeable exhibits a smaller strength loss. Bartlett and MacGregor (1994a) observed a more severe strength loss in 50 mm (2 in.) diameter cores compared with 100 mm (4 in.) diameter cores from the same element. Extending the soaking period beyond 40 h duration can cause further reduction of the core strength. The difference between strengths of soaked and air-dried cores may be smaller for structural lightweight aggregate concrete (Bloem 1965). Cores drilled in the direction of placement and compaction (which would be loaded in a direction perpendicular to the horizontal plane of concrete as placed, according to ASTM C 42/C 42M) can be stronger than cores drilled normal to this direction because bleed water can collect underneath coarse aggregate, which will weaken the ITZ around the coarse aggregate. In practice, it is often easier to drill horizontally into a column, wall, or beam in a direction perpendicular to the direction of placement and compaction. The influence of coring direction can be more pronounced near the upper surface of members where bleed water is concentrated.

3. TESTING METHOD

The core specimens were tested as per standard guide lines of ACI214.4R-10, ASTM C-42/C-42M and IS-516.

4. MATERIAL AND SAMPLE CONDITIONING.

The grade of concrete used for the research work was C-30/37 grade concrete with Portland cement CEM-I, 52.5N class cement as per BSEN-197, Part-1 with w/c ratio 0.4 and coarse aggregate used for the experiment is crushed basalt rock. The experiment was conducted by taking two 44 mm diameter core from each cube specimen after 28-days of curing. The core specimens were collected from both parallel & perpendicular to the direction to direction of pouring direction of the cube samples. The core specimens were air dried till the weight of the core specimens were remain unchanged before the same were allowed for testing. The specimens were also weighted and measured the length & diameter of the core specimens before it was allowed for compressive strength test of core specimens. The mix proportion of C-30/37 grade concrete used for the experiment is shown in Table-1.

Table-1
Mix proportion of reference mix (M0) C-30/37

Name of the ingredient	UOM	Quantity	Remarks
Cement	Kg/m3	438	Portland cement CEM-I,52.5N class cement is used
Mixing water	Kg/m3	175	The water content is after SSD condition of aggregate
Fine Aggregate	Kg/m3	685	The type of fine aggregate is river sand & the weight is SSD condition
Coarse Aggregate	Kg/m3	1142	The type of aggregate is crushed basalt & the weight is SSD condition
Superplasticizer	Kg/m3	3.5	Superplasticiser [Master polyheed 8650] @ 0.8% weight of cement

Table-2
Sample details of concrete core with respect to direction of coring & direction of pouring.

Sl No	Sample Identification	Direction of coring with respect to direction of pouring	Specimen ID	Diameter of the core specimen in mm	Length of the core specimen in mm
1	C-1	Parallel to pouring direction	C-1V	44 mm	88 mm
		Perpendicular to pouring direction	C-1H	44 mm	88 mm
2	C-2	Parallel to pouring direction	C-2V	44 mm	88 mm
		Perpendicular to pouring direction	C-2H	44 mm	88 mm
3	C-3	Parallel to pouring direction	C-3V	44 mm	88 mm
		Perpendicular to pouring direction	C-3H	44 mm	88 mm
4	C-4	Parallel to pouring direction	C-4V	44 mm	88 mm
		Perpendicular to pouring direction	C-4H	44 mm	88 mm
5	C-5	Parallel to pouring direction	C-5V	44 mm	88 mm
		Perpendicular to pouring direction	C-5H	44 mm	88 mm
6	C-6	Parallel to pouring direction	C-6V	44 mm	88 mm
		Perpendicular to pouring direction	C-6H	44 mm	88 mm
7	C-7	Parallel to pouring direction	C-7V	44 mm	88 mm
		Perpendicular to pouring direction	C-7H	44 mm	88 mm
8	C-8	Parallel to pouring direction	C-8V	44 mm	88 mm
		Perpendicular to pouring direction	C-8H	44 mm	88 mm
9	C-9	Parallel to pouring direction	C-9V	44 mm	88 mm
		Perpendicular to pouring direction	C-9H	44 mm	88 mm

5. EXPERIMENT AND METHOD.

The experiment was on 9 no's150mm sizes cube specimens of C-30/37 grade concrete after 28-days of curing & subsequent drying of the specimens. The core specimens of 44 mm diameter were extracted from each cube specimens from both parallel & perpendicular to the direction of pouring, and subsequently the specimens were prepared as per ASTM C-42. All the core specimens' length were maintained in such a way, so that L/D ratio is 2. Each core specimens were measured for its diameter, length and weight before it was allowed for compressive strength test.

Fig-1: Extraction of core specimens from cube samples.

Fig-2: Extracted core specimens & measuring weight of the specimens.

Fig-3: Testing of core specimens for evaluation of compressive strength of concrete core specimens.

6. RESULTS AND DISCUSSIONS

Table-3
Concrete core strength assessment with respect to direction of coring & direction of pouring.

Sl No	Sample Identification	Direction of coring with respect to direction of pouring	Specimen ID	Diameter (D) of the core specimen in mm	Length (L) of the core specimen in mm	L/D Ratio	Unit Weight of concrete in Kg/cum	Core Strength in Mpa	% of higher strength observed in core taken parallel than core taken perpendicular to direction of pouring.
1	C-1	Parallel to pouring direction	C-1V	44	88	2	2429.53	16.64	21.45%
		Perpendicular to pouring direction	C-1H	44	88	2	2427.42	13.7	
2	C-2	Parallel to pouring direction	C-2V	44	88	2	2426.76	16.34	14.90%
		Perpendicular to pouring direction	C-2H	44	88	2	2429.54	14.22	
3	C-3	Parallel to pouring direction	C-3V	44	88	2	2416.62	15.88	12.14%
		Perpendicular to pouring direction	C-3H	44	88	2	2420.52	14.16	
4	C-4	Parallel to pouring direction	C-4V	44	88	2	2422.56	16.52	20.76%
		Perpendicular to pouring direction	C-4H	44	88	2	2421.32	13.68	
5	C-5	Parallel to pouring direction	C-5V	44	88	2	2418.64	17.12	20.90%
		Perpendicular to pouring direction	C-5H	44	88	2	2420.32	14.16	
6	C-6	Parallel to pouring direction	C-6V	44	88	2	2425.62	16.72	16.59%
		Perpendicular to pouring direction	C-6H	44	88	2	2423.42	14.34	
7	C-7	Parallel to pouring direction	C-7V	44	88	2	2420.76	17.34	13.77%
		Perpendicular to pouring direction	C-7H	44	88	2	2418.58	15.24	
8	C-8	Parallel to pouring direction	C-8V	44	88	2	2423.22	16.66	20.20%
		Perpendicular to pouring direction	C-8H	44	88	2	2421.67	13.86	
9	C-9	Parallel to pouring direction	C-9V	44	88	2	2424.68	16.84	18.34%
		Perpendicular to pouring direction	C-9H	44	88	2	2423.42	14.23	

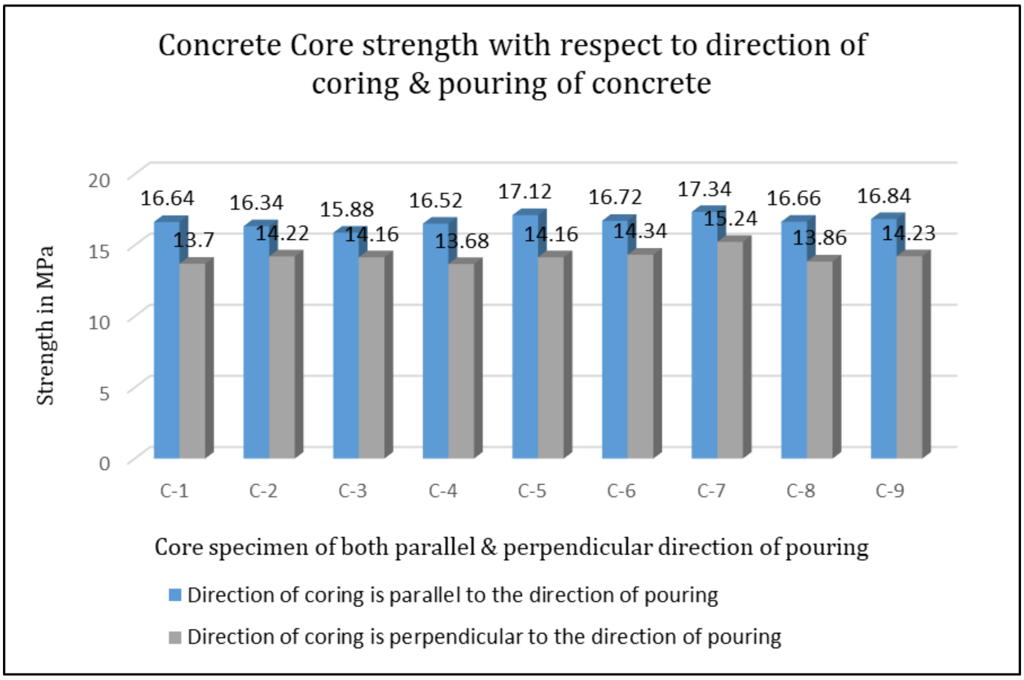

Fig-4: Concrete core strength with respect to direction of coring and direction of pouring.

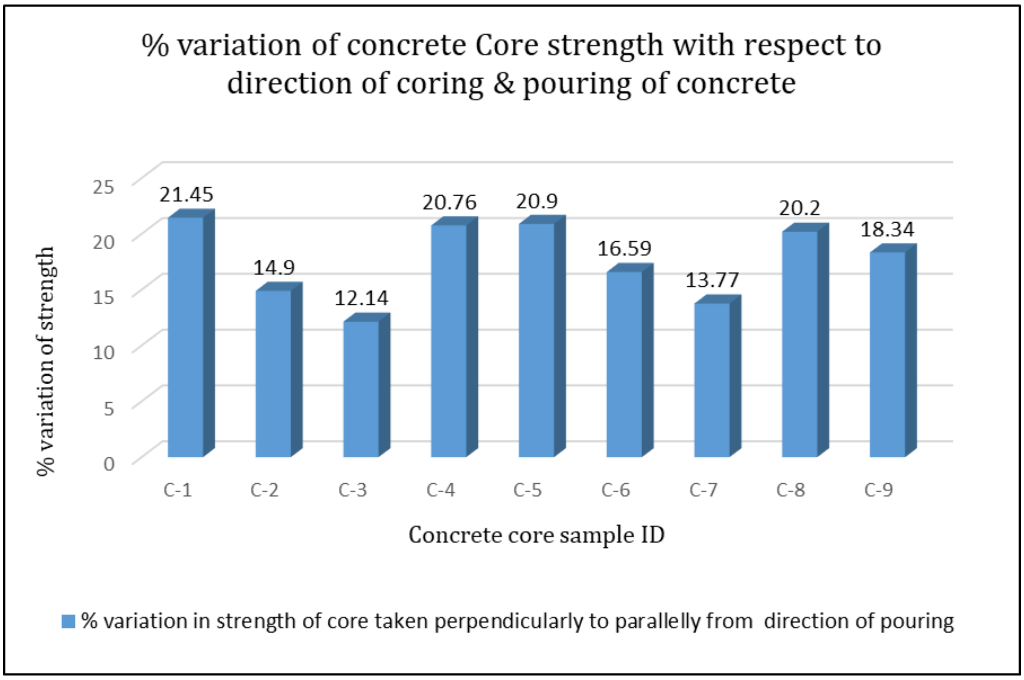

Fig-5: % Increase of strength of core extracted parallelly and perpendicular to the direction of pouring.

The experimental results shows that concrete core which are extracted parallel to the direction of pouring shows higher compressive strength than the core extracted perpendicular to the direction of pouring of concrete. The variation of strength of core extracted parallelly is minimum 12.14% & maximum 21.45% higher than the core extracted perpendicular to the direction of pouring. The extent of such variation is due to weak interfacial transition zone around the coarse aggregate as per the Fig-6 shown below. The accumulation of bleeding water around the aggregate is a very common phenomenon in concrete & thus this will weaken the ITZ around the coarse aggregate and causes failure through this plane. Weak ITZ will encounter while core will be extracted perpendicular to the direction of concrete pouring

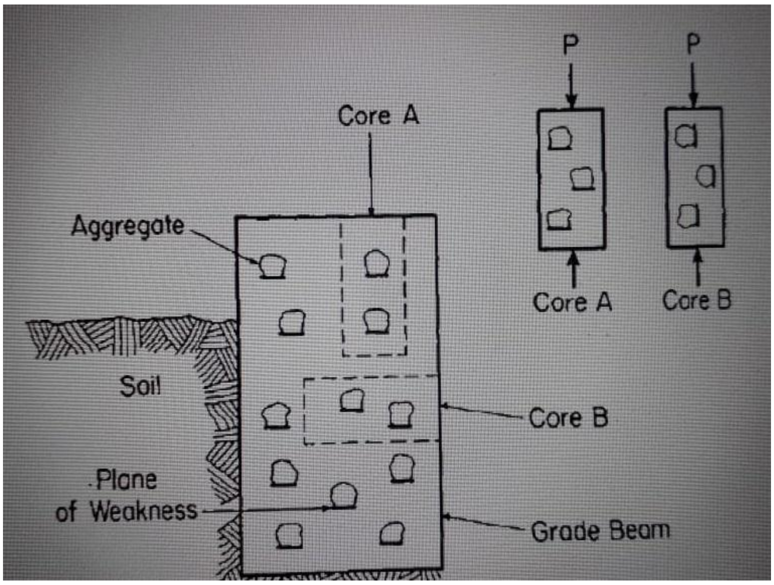

Fig-6: Weak ITZ around the coarse aggregate based on the direction of coring with respect to direction of pouring of concrete.

7. CONCLUSIONS

The core strength of concrete samples extracted parallel to the direction of pouring is approx. 12-21% higher than the core samples extracted perpendicular to the direction of pouring direction. This is because of the weak ITZ around the coarse aggregate due to accumulation of bleeding water surrounding the aggregate weaken the ITZ. When the core is extracted parallel to the direction of pouring the direction of applied force is perpendicular to the weak ITZ, while the core is extracted perpendicular to the direction of pouring then the weak ITZ is parallel to the direction of applied force & thus early failure of the specimen is possible. Thus the experimental studies concluded that core sample extracted perpendicular to the direction is pouring shows almost 12-21% lower strength than the core extracted parallel to the direction of pouring from same concrete member.

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BIOGRAPHIES

Dr Abdullah Ahmed Laskar, Sr Manager (Civil/Structural-QA/QC), BHEL-Power Sector Eastern Region, Kolkata, WB, India.

Anupam Sarkar, Dy Engineer (Civil-QA/QC), BHEL-Power Sector Eastern Region, Kolkata, WB, India.