Factors Influencing the Strength Relationship of Concrete Cube and Standard Cylinder

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Abstract- This paper report an experimental study carried out to investigate to influence of addition of different size aggregate and w/c ratio on the mechanical properties of controlled concrete. The standard size cube and cylinder specimens are prepared and cured for period of 7 and 28 days. At the end of each curing period the compressive strength of each specimen are determined. The result indicate that the cement content in mix are increasing, the ratio of cylinder to cube strength is in case of 10mm aggregate than the 20mm aggregate are also increasing. The results also show there is no unique relationship between the strength of cube and strength of cylinder.

Index Terms— Aggregate size, Compressive strength, Cube and Cylinder specimen, w/c ratio,

I. 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.

Generally the BS 1881: Part 120:1983 specifies that, the strength of cylinder is equal to 0.8 times of the strength of cubes but, in reality; there is no unique relationship among the cube and cylinder made with different proportion.

The interrelation varies also with age factors; the compressive strength of core concrete is affected by many parameters. These parameters are; the magnitude of core compressive strength itself, core diameter, core diameter over height ratio, coring orientation, core moisture condition at the time of testing and presence of reinforcement within the concrete core.

II. LITERTUTRE REVIEW

Two types of compression test specimens are used: cubes and cylinders. Cubes are used in Great Britain, Germany and Europe. Cylinders are the standard specimens in the United States, France, Canada Australia and New Zealand. The use of both type of specimen in given country is so ingrained that the European standard ENV 206:1992. [1]

The restraining effect of the platens of the testing machine extends over the entire height of a cube but leaves unaffected a part of a test cylinder. According to the expression converting the strength of cores into the strength of equivalent cubes in BS 1881: Part 120:1983, the strength of cylinder is equal to 0.8 times of the strength of cubes but, in reality, there is no simple relation between the strengths of the specimens of the two shapes.[1]

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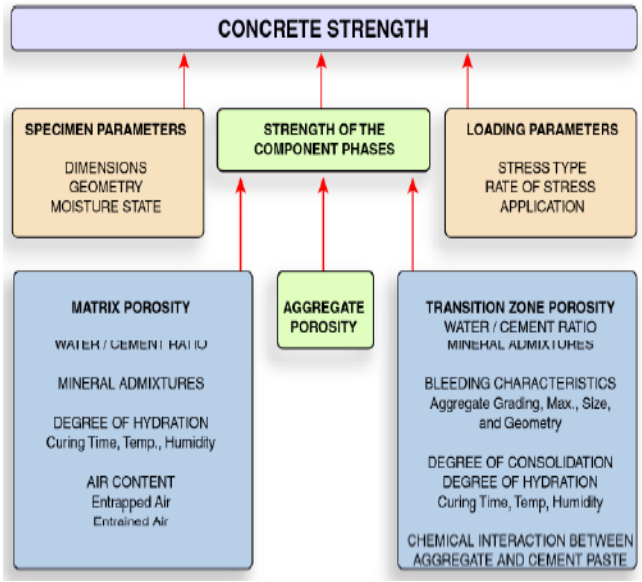
Cylinders are believed to give a grater uniformity of results for nominally similar specimens because their failure is less affected by the end restraint of the specimen, their strength is influenced by the properties of the coarse aggregate used in the mix , and the stress distribution on horizontal planes in a cylinder is more uniform than on a cube specimen.

III. FACTORS INFLUENCING THE STRENGTH RESULTS

The relation between compressive strength of concrete cube and cylinder is complex. The flow chart shows review the main parameters controlling the strength development of concrete structures:-



*[**Ref**:-CE 241 Advanced Concrete Technology]*

1. Effects of concrete cube / cylinder casting, curing and testing procedures:

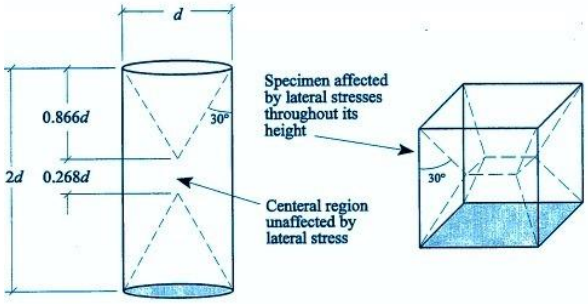
The use of rigid and non-rigid moulds affects their strength. In case of identical concrete, dry cubes give higher strength than wet cubes. Dry cube may have undergo drying shrinkage which will ultimately caused some amount of drying shrinkage cracks and bond failures

The strength of cube specimen cannot be same as that of the member because of the differences with respect to the degree of compaction, curing standard, uniformity of concrete, evaporation and loss of mixing water etc

2. Effects of geometry of specimen:-

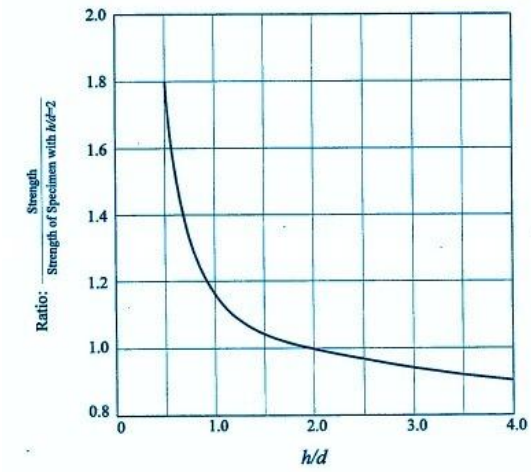
Geometric factors such as volume of concrete shape of concrete and h/d ratio (height to lateral dimension) of specimen affects the concrete cube and cylinder strength ratio. The following figure shows the effect of

height/diameter ratio to concrete strength ratio.



3. Effect of concrete strength level:-

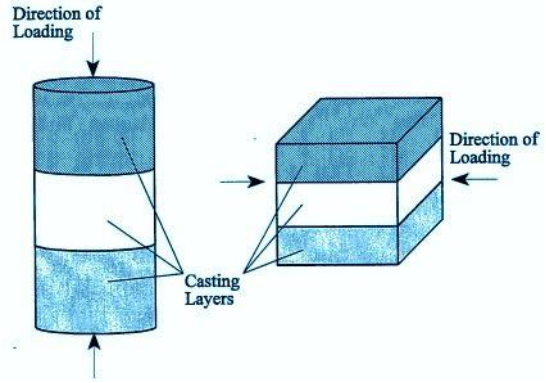
Nominal strength of concrete has been shown to affect the concrete cube and cylinder strength ratio. Research by Evans indicates that this ratio decreases with increasing concrete strength. Cylinder to cube strength ratio ranges from 0.77 to 0.96 depending on concrete strength level.



4. Direction of loading and machine characteristics:-

Concrete cubes may be loaded in the direction perpendicular to casting while cylinders are always loaded in the direction of casting. Since these concrete cubes and cylinders are casted in multiple layers, their strength will differ based on direction of loading.

Lower the rate of application of load, the lower will be the recorded strength; the reason for this is probably the effect of creep. If the load is applied slowly, or if the there is some time lag, the specimen will undergo certain amount of creep which will increase the strain due to creep will be responsible for failure of sample.



5. Grading of aggregates:-

The effect of compression test on concrete specimens is large due to relative size of aggregate particles to specimen dimensions. Most standards set limits for the ratio of diameter or size of specimen to maximum nominal size of aggregates. Typically this allowable minimum is around 3 to 4. ***[Ref:** - The constructor civil engineering home*]

IV. SCOPE OF WORK

This study only deals with axial compressive strength from cube specimen of the size 150x150x150mm and cylinder specimen of 150mm diameter and 300mm height (standard cylinder) at 7 and 28 days with limited variables such as different aggregate size and variation of mix proportion.

To suggest the size and shape factors to convert the compressive strength of concrete determined from cube specimen to standard Ø150x300 cylinder strength.

This result is useful for calibration of actual core strength of cylindrical specimen obtained from existing structure with respect to equivalent cube strength of identical concrete.

V. EXPERIMENTAL RESULTS

Design Stipulation:-

- Characteristic Compressive Strength At 28 Days :-20mpa
- Maximum Size of Aggregate :-20mm
- Minimum Size of Aggregate:-10mm
- Degree of Quality Control:- Good
- Type of Exposure :- Mild

Test Data for Materials:-

- Specific Gravity of Cement:- 3.15
- Specific Gravity of Coarse Aggregate:-2.6
- Specific Gravity of Fine Aggregate:-2.6
- Water Absorption:- Coarse Aggregate:- 0.50%
- Fine Aggregate :- 0.50%
- Surface Moisture:- Nil

Table 1: Content of ingredients in various proportions

Batch	Specimen	Proportion	Cement content (kg/m^3)	Water content (Lit.)
A	Cube	1:2.59:3.89	300	22.5
	Cylinder	1:2.59:3.89	300	22.5
B	Cube	1:2.11:3.17	350	22.5
	Cylinder	1:2.11:3.17	350	22.5
C	Cube	1:1.75:2.62	400	22.5
	Cylinder	1:1.75:2.62	400	22.5
D	Cube	1:1.46:2.2	450	22.5
	Cylinder	1:1.46:2.2	450	22.5

Table 2 : - Compressive strength test results on specimen for 7 days of 20mm and 10mm size aggregate (W/C ratio =0.45)

Batch	Specimen	Test results for 7 days	
		Average Compressive strength (N/mm^2)	
		20mm size aggregate	10mm size aggregate
A	Cube	7.33	7.68
	Cylinder	5.04	6.05
B	Cube	9.86	9.05
	Cylinder	8.14	7.18

C	Cube	14.44	15.17
	Cylinder	13.02	14.56
D	Cube	20.65	21.06
	Cylinder	19.12	20.12

Table 3 : - Compressive strength test results on specimen for 28 days of 20mm and 10mm size aggregate (W/C ratio =0.45)

Batch	Specimen	Test results for 28 days	
		Average Compressive strength (N/mm^2)	
		20mm size aggregate	10mm size aggregate
A	Cube	25.78	26.0
	Cylinder	23.68	24.12
B	Cube	33.14	33.79
	Cylinder	31.11	32.01
C	Cube	40.11	41.65
	Cylinder	38.64	39.89
D	Cube	48.62	49.49
	Cylinder	46.12	47.95

Table: 4:- Relative strength of specimen

Time period	Agg. size	Batch	Ratio= cylinder /cube	Factor = correlation between cube and cylinder
7 days	20mm	A	0.687	1.45
		B	0.825	1.21
		C	0.901	1.11
		D	0.925	1.08
	10mm	A	0.787	1.27
		B	0.793	1.26
		C	0.959	1.04
		D	0.989	1.01
28 days	20mm	A	0.92	1.08
		B	0.938	1.06
		C	0.963	1.04
		D	0.969	1.03
	10mm	A	0.927	1.07
		B	0.947	1.05
		C	0.957	1.04
		D	0.969	1.03

Figure: 1 Ratio of cylinder to cube strength vs. cement content for 7 days

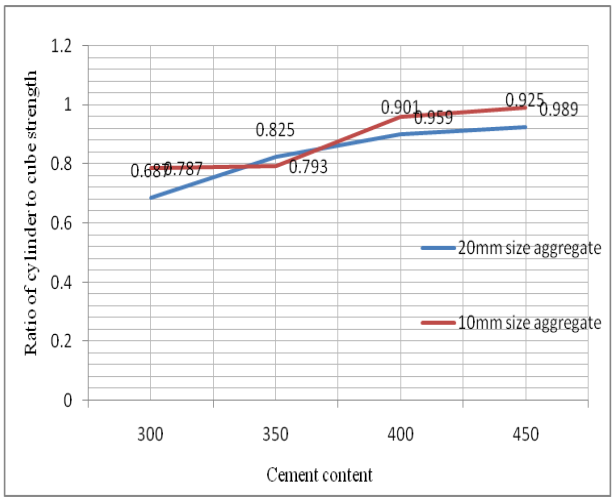


Figure: 2: Ratio of cylinder to cube strength vs. cement content for 28 days

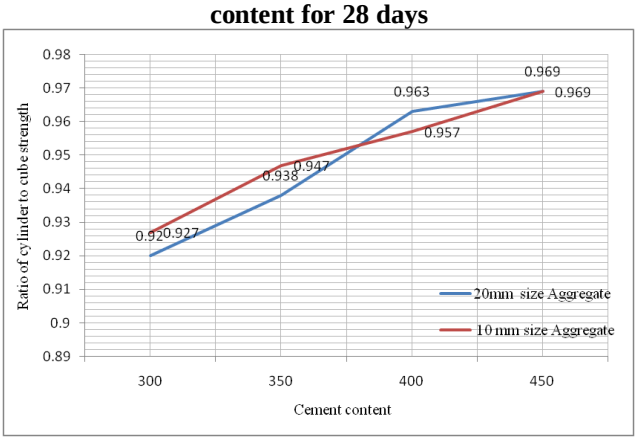
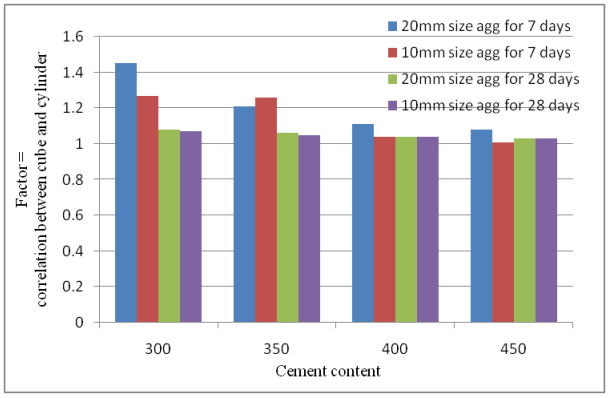


Figure: 3: Correlation between cube and cylinder vs cement content



VI. FINDINGS

[1] The cube strength at 7 days is in between 7 to 21 N/mm^2, and cylinder strength is also in between 5 to 20 N/mm^2, for 20mm aggregate size and 0.45 water/cement ratio for different proportions.

[2] The cube strength at 28 days is in between 7 to 22 N/mm^2, and cylinder strength is also in between 6 to 21 N/mm^2, for 10 mm aggregate size and 0.45 water/cement ratio for different proportions.

[3] Difference of strength in cube and cylinder is greater (2.3 to 1.65) in cement content 300kg/m^3 and its decreasing at increasing cement content up to 400 kg/m^3 is lesser (1.53 to 0.24).

[4] The result Shown in

table no.03 indicate that:-

a) The cylinder to cube strength of batch D at 7 days is 0.74 times than batch A for 20mm aggregate size and W/C ratio 0.45.
b) The cylinder to cube strength of batch D at 28 days is 0.95 times than batch A for 20mm aggregate size and W/C ratio 0.45.

VII. CONCLUSION

[1] After studied all experimental data the cement content in mix are increasing, the ratio of cylinder to cube strength is in case of 10mm aggregate than the 20mm aggregate are also increasing.

[2] It was seen that the strength relation varies with the level of the strength of concrete. For higher strength, the difference between the strength of cube and cylinder is becoming narrow, for higher strength it is nearly 1.00.

[3] The **IS- 516-1979** specified that the strength of cube of controlled concrete specimen will be different from the standard strength of cylinder. Normally strength of cylinder is taken as 0.8 times the strength of cube, but experiment results in this study have shown that there is no unique relationship between the strength of cube and strength of cylinder.

[4] After studied all experimental data of relation between cube and cylinder , stated that the cylinder strength of hardened concrete is not constant value 0.8 times than the cube strength , because it varies depend upon all factors like cement content, W/C ratio aggregate size, and time period. So in case of core strength for longer period is at the time of determination of equivalent strength is not considered only factor 0.8 but its depend upon all relevant data from structure and calibration graphs showing the core (standard cylinder) and equivalent cube strength of concrete specimen.

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