Experimental Study on Size Effect of Specimen In Concrete

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Abstract - *Concrete is a heterogeneous material. Past research has established the effect of its primary constituents namely water, cement, aggregates on the behavior at the micro level as well as the macro level. In particular, several researchers have investigated the role of aggregates on the behavior of the concrete mix, the goal being to design aggregate gradations which results in higher concrete quality. The goal of this is to study the effect of specimen size on strength in unconfined concrete.*

An experimental program to determine the compressive strength of a set of unconfined concrete cylinders of varying size (100mm, 150mm, 190mm diameter) and slenderness ratio of 2 is adopted. However, while studying the effect of meso-structure on strength and size effect, care has to be taken to ensure similar levels of workability and compaction in all specimens, since otherwise no meaningful conclusions can be drawn from the test results.

Average strength of specimen is taken and It is concluded from the experimental study that with increase in size of specimen its compressive strength is observed decreased.

Key words: compressive strength Test, size effect, meso geometry

1. INTRODUCTION

Size effect on the structural strength of concrete is deviation, due to structure size, of actual load capacity predicted from plastic limit analysis. Laboratory tests are carried out on small sized samples and the results obtained are used to predict the properties of actual structural member. Therefore, for accurate interpretation of laboratory test data, understanding of the structural size effect is very important. Size effect in concrete can be classified into two major types, energetic size effect and statistical size effect. Two types of energetic size effect can be distinguished: Type-I energetic size effect, and Type II energetic size effect. Energetic size effect is due to the release of stored energy of the structure into the fracture front. It is caused by the fact that the energy released into a propagating crack front increases roughly in proportion to the volume of the structure, while the energy dissipated in doing fracture work increases roughly in proportion to the cross-section area. Consequently, as the size of the structure increases, the stored elastic energy available to drive crack growth increases faster than the energy necessary to create new fracture surfaces (the fracture energy). As a result, crack growth occurs faster in larger structures than in smaller structures, thereby leading to smaller nominal strengths for larger structures as compared to smaller structures, and hence giving rise to a size effect.[1]

Size effect becomes critical in the design of large structures such as dams, nuclear power plants, bridges, etc. This is because laboratory tests are performed on small scale structures and the results are extrapolated to predict the properties of large structures. Hence proper techniques for extrapolation of these results are necessary. Therefore, a proper understanding of the size effect is vital to predict the strength of large structures.[4],[5]

2. SYSTEM DEVELOPMENT

2.1. Materials

2.1.1 Cement

In this experimental work, UltraTech cement (PPC) was used for preparation of all concrete mixes. Cement was fresh and without any lumps. It was tested for its physical properties in accordance with Indian standard specifications. The physical properties obtained are given in Table 1

TABLE - 1: Properties of Cement

Sr. No.	Property	Test result	IS limits
1	Fineness (sieve analysis)	3%	<10%
2	Setting time		
	Initial	113 min.	>30 min.
	Final	185 min.	<600 min.
3	Soundness	3 mm	< 10 mm
4	Compressive strength (MPa)		
	a) 7 days	26.66	Not less than 22
	b) 28 days	41.77	Not less than 33

2.1.2 Superplasticizer

Conplast SP430 was used as superplasticizer in the concrete mixture. It is brown liquid which is instantly dispersible in water and it complies with IS: 9103: 1999 [9] as a high range water reducer. It can be used for high water reduction up to 25% without compromising the workability and strength. It also helps to produce high quality concrete with reduced permeability. Properties of superplasticizer are obtained from manufacturer are given below in Table 2.

Table - 2: Properties of Superplasticizer

Sr. No.	Property	Results
1	Specific gravity	1.20 to 1.21 at 30^{o} C
2	Chloride content	Nil.
3	Air entrainment	Approx... 1.5%

2.1.3 Coarse aggregate

In this work, locally available angular aggregates were used as coarse aggregates having maximum no of 20mm. Tests on aggregates were conducted for its properties as per IS 383 [10] in the laboratory. The test results of C.A. are shown in the Table 3 and is observed within permissible limit according to IS code.

Table - 3: Physical properties of Coarse aggregate

Sr. No.	Property	Results
1	Particle shape	Angular
2	Size	20 mm max.
3	Specific gravity	2.744
4	Water absorption	1.3%

2.1.4 Fine aggregate

Locally available natural sand confirming to zone II as per sieve analysis was used as fine aggregate. Sand was sieved through 4.75mm sieve before using for concrete mixture. Various test to evaluate the physical properties of sand were conducted in the concrete lab such as specific gravity, silt content etc. according to IS 383 [10]. The test result for FA is shown in the Table 4 and is observed within permissible limit according to IS code.

Table - 4: Physical properties of fine aggregate

Sr. No.	Property	Results
1	Particle shape	Natural
2	Size of aggregates	4.75mm
3	Specific gravity	2.70
4	Silt content	3.33%
5	Water absorption	1%

2.1.5 Water

Potable tap water without any deleterious material was used for concrete mix and curing of concrete.

2.2. Experimental Method

In this experimental work, concrete mix design for M30 grade was prepared by using IS 10262: 2019 **[11]**. Proportions of all the materials for each grade is given in Table 5.

Table - 5: Mix proportion for M30 grade

Sr. No.	Material	Quantity of material (NMSA 20 mm) (kg/m3)
1	Water	153
2	Cement	365
3	Fine aggregate	694.84
4	Coarse aggregate	1233.85
5	Superplasticizer	4.015

Total nine numbers of concrete cylinder specimens were cast of 100 mm, 150mm and 190mm diameter with slenderness ratio 2 for the determination of compressive strength of concrete for design mix of grade M30. M30 concrete mix was filled in the moulds layer wise, each layer being given 30 blows using the standard tamping rod at a rate of 2 blows/s by lifting the rod 5 cm above the surface of the mix. Cast specimens were de-moulded after 24 hours and placed immediately in the curing tank and continuous moist curing was done for large specimen by covering them with jute bags for 28 days.

After 28 days of curing, specimens were loaded under uniaxial compression up to failure in a universal testing machine (UTM) of capacity 600kN and 1000 kN as per IS: 516-1999 [12]. The specimen was centrally placed so that an axial load without any eccentricity could be achieved. The ultimate loads were recorded with an automatic data acquisition system.

3. RESULTS AND DISCUSSION

3.1. Compressive strength test results of cylinder:

Average compressive strength for M30 grade concrete was found and is shown in Table 6. And it shows that with increase in size of specimen, compressive strength of cylinder decreases.

Table - 6: Test results of average compressive strength of 100 mm, 150mm 190mm diameter cylinder

100mm Cylinder (MPa)	150mm Cylinder (MPa)	190mm Cylinder (MPa)
36.1	31.9	24.2

4. CONCLUSION

The average compressive strength of the concrete cylinder is found decreased with the increase in specimen size. Hence, the existence of size effect on compressive strength of concrete columns was verified.

REFERENCES

[1] Bazant ZP (1984) “Size effect in blunt fracture: concrete rock metal” J Eng Mech (ASCE) 110:518–535

[2] Blanks RF, Mcnamara CC (1935) “Mass concrete tests in large cylinders” J Am Concr Inst 31:280–303

[3] Carpinteri A, Chiaia B, Ferro G (1995) Size effects on nominal tensile strength of concrete structures: multifractality of material ligaments and dimensional transition from order to disorder. Mater Struct 28:311–317

[4] Carpinteri A, Ferro G, Monetto I (1999) “Scale effects in uniaxially compressed concrete specimens” Mag Concr Res 51:217–225

[5] Elsanadedy, H.M., Al-Salloum, Y.A., Alsayed, S.H. and Iqbal, R.A., 2012. “Experimental and numerical investigation of size effects in FRP-wrapped concrete columns” Construction and Building Materials, 29, pp.56-72.

[6] Kumutha R., Vaidyanathan R., Palanichamy M.S., "Behavior of reinforced concrete rectangular columns strengthened using GFRP", Elsevier Cement & Concrete Composites, volume 29, pp.609-615, (2007)

[7] Liang, M., Wu, Z.M., Ueda, T., Zheng, J.J. and Akogbe, R., 2012. “Experiment and modeling on axial behavior of carbon fiber reinforced polymer confined concrete cylinders with different sizes.” Journal of Reinforced Plastics and Composites, 31(6), pp.389-403

[8] Yuan-feng Wang., Han-liang Wu. “Size Effect of Concrete Short Columns Confined with Aramid FRP Jackets” American Society of Civil Engineers, Journal of Composites for Construction, July/August 2011, page no. 535-544

[9] IS: 9103 - 1999, Indian Standard CONCRETE ADMIXTURES - SPECIFICATION (First Revision)

[10] IS: 383, Specification for Coarse and Fine Aggregates from Natural Sources for Concrete (Second Revision)

[11] IS: 10262: 2019, Concrete Mix Proportioning — Guidelines (Second Revision)

[12] IS: 516-1999, Methods of Tests for Strength of Concrete