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Technical Paper

Utilization and effect of specimen shape and size on the strength properties of concrete

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Abstract: High strength concrete is currently a common construction material and its compressive strength is most basic and important material property in structural design. In this paper, we investigate the influence of the shape and of the size of the specimens on the compressive strength of high-strength concrete. We used cylinder sand cubes of different sizes for performingd stable stress-strain tests. This value was kept constant throughout the experimental program. Our results show that the post- peak behavior of the cubes is milder than that of the cylinders, which results in a strong energy consumption after the peak. This is constant with the observation of the crack pattern: the extent of micro-cracking throughout the specimen is denser in the cubes than in the cylinders. Indeed, a main inclined fracture surface is nucleated in cylinders, whereas in cubes we find that lateral sides get spalled and that there is a dense columnar cracking in the bulk of the specimen. Finally, we investigate the relationship between the compressive strength given by both types of specimen for several specimen sizes. The influence of specimen size and shape on the measured compressive strength was investigated for different high strength concrete mixes. Also the compressive strength can also be determined to be in significantly affected by changing l/d as the strength of concrete increases. After testing of specimens at 7and 28 days, the results show that the cube specimen is generally stronger than the cylinder specimen and this effect will be gradually decreased when the concrete strength increased. For the effect of the specimen size the results show that the compressive strength increases as the specimen size decreases. This size effect might be ignored as the relationships showed that the effect is relatively small as compared to specimen shape effect.

Keywords: Microbial corrosion, Binder, Corrosion rate, EPMA, Deterioration process.

1. Introduction

1.1. General

The paper discusses the importance of testing practices for high-strength concrete (HSC) in various construction applications, such as high-rise buildings, long-span structures, bridges, and repair projects. It emphasizes the significance of the 28-day compressive strength test, which is universally accepted as a key indicator of concrete strength. Two main specimen shapes, cubes and cylinders, are commonly used for testing concrete strength, with variations in size and shape preferences across different countries. -While cubes are prevalent in the UK, Germany, and many European countries, cylinders are favoured in the US, Canada, France, and Australia. However, some countries, like Thailand, use both cube and cylinder specimens. In Saudi Arabia, where concrete is extensively used in construction, there's a growing trend towards employing HSC in major projects.

Local testing practices typically involve measuring characteristic compressive strength based on 150 mm cubes, while design compressive strength is based on standard Ø150×300mm cylinders. However, smaller

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Ø100×200mm cylinders are gaining acceptance due to equipment capacity limitations. The paper highlights the importance of the compressive strength test due to its simplicity and cost-effectiveness. It discusses the shape effect on compression strength and the emergence of HSC as a new construction material. It also addresses the size effect on compressive strength, noting that the behaviour of specimens is more complex than previously assumed.Researchers have compared strengths obtained from different specimen sizes, particularly focusing on cylindrical specimens of Ø150×300mm and Ø100×200mm. Findings have varied, with some studies reporting no significant difference in strength ratios between these sizes, while others indicate variations in strength levels. Overall, the paper underscores the need for a comprehensive understanding of specimen size and shape effects on compressive strength, especially with the increasing demand for accurate testing methodologies in the construction industry.

1.2. Objectives

- To investigate compressive strength and splitting tensile strength across various specimen sizes and shapes.
- To compare compressive strengths and splitting tensile strengths obtained from different concrete mixes using varying specimen sizes and shapes.
- To propose factors for converting compressive strength results from different specimen types to standard Ø150×300mm cylinders and 150mm cubes.

1.3. Scope of Research

- Focus on axial compressive strength and splitting tensile strength of test specimens at 7 and 28 days, with limited variables in specimen type and concrete strength levels.
- Test specimens include cylinders of Ø150×300mm and cubes of 150mm, with expected compressive strengths and splitting tensile strengths ranging between 550 and 1000 kg/cm2 (standard cylindrical strength at 28 days). Testing involves applying uniaxial loads until reaching ultimate load capacity.

2. Literature Review

Testing the compressive strength of hardened concrete is a fundamental and essential experiment in construction research. High Strength Concrete (HSC) has been extensively studied and utilized as a viable construction material for several decades. In the United States, HSC was first employed in major prestressed girders in 1949, with the Walnut Lane Bridge in Philadelphia being the inaugural reported project to incorporate HSC in its design and construction (Russell, 1997). This bridge, featuring a 160-feet centre main span and two 74-feet side spans, boasted a strength of 37MPa within 14 to 17 days of construction. Zollman (1951) reported that the compressive strength at 28 days typically reached around 65MPa. Notably, concrete with a compressive strength of 34MPa was deemed HSC in the 1950s, although the introduction of prestress design methods overshadowed this development. Advancements in material technology, particularly the development of high-range water reducing ad-mixtures in the 1960s, further propelled the production of HSC in the construction industry.

The most prevalent experimental method involves casting concrete samples and subjecting them to compression tests using relevant testing machines. However, the outcomes of such experiments can be influenced by various factors, including specimen sizes, shapes, moulds used for casting, curing conditions, and the rate of load application (Neville, 2002). Across different nations, cubes and cylinders are the two primary types of specimens used for testing hardened concrete, each with varying dimensions. Cylindrical specimens of Ø150mm×300mm are predominantly used in several countries, while cube specimens of Ø150mm×100mm are more common in European nations (Elwet& Fu, 1995).One notable distinction between cylinder and cube specimens is the necessity for capping cylindrical specimens before loading, whereas cubes do not require such capping. Cubes generally exhibit higher compressive strength, necessitating higher capacity testing machines, while cylinders are tested in the direction of casting, which is considered advantageous (Elwet and Fu, 1995). Several previous research endeavors have aimed to elucidate the size and shape effect of concrete specimens on compressive strength test results. Size effect refers to changes in the nominal strength of concrete members due to alterations in their size, while shape effect suggests that the nominal strength depends on the shape of the members. Other properties, such as cracking or fracture patterns and stress-strain curve trends, may also differ based on the shapes and sizes of specimens used. Initial investigations into size effect date back to 1925, with Gonnerman's study using standard cubes and cylinders of different sizes. Various studies have explored curing conditions' effect on conversion factors between cylinders and cubes. Furthermore, research on shape and size effect on the compressive strength of high-strength concrete has proposed different conversion factors for different specimen dimensions. Mix design parameters have also been found to influence the strength ratio of cylinders to cubes (Malaikah, 2009).

The wall effect, attributed to differences in aggregates grading, has been extensively investigated. This effect, illustrated in Figure 2.1, indicates that the amount of mortar required to fill the space between aggregates and the mould's wall differs from the amount needed to fill the space between aggregates alone. This discrepancy leads to an increase in compressive strength, particularly in specimens with larger surface/volume ratios, thereby affecting the cylinder/cube conversion factor (Elwet and Fu, 1995; Tokyay and Ozdemir, 1997).Research by Zheng and Li (2002) proposed a three-dimensional model to simulate aggregate density inside concrete specimens, shedding light on the distribution of aggregates within the specimens. Efforts to eliminate the influence of the wall effect have included sawing concrete specimens from casted specimens, with studies indicating that the size effect is more pronounced in concrete samples of higher compressive strengths (Turkel and Ozkul, 2010).Given the increasing use of High Strength Concrete (HSC), it is crucial to ensure confidence in the suitability and applicability of current testing practices. While factors influencing compression test results for normal strength concrete (NSC) have been extensively studied, there is a paucity of investigations concerning these aspects for HSC. Imam et al. (1995) investigated the factors affecting compressive testing results of high-strength concrete, concluding that the compressive strength decreases about 5% for each 50 mm increase in cube size. Conversion factors between different specimen types have also been proposed to standardize strength assessment (Inam et al., 1995).Subsequent studies by Mansur and Islam (2002), Tokyay and Özdemir (1997), and Felekoglu and Turkel (2005) have further explored the effects of specimen size and shape on compressive strength, proposing transformation coefficients and correction factors to facilitate comparisons between different specimen types. Additionally, research by Yazıcı and Sezer (2007) investigated the influence of size and capping type of cylindrical specimens on compressive strength, highlighting the importance of specimen characteristics in accurately assessing concrete strength.

3. Experimental Procedure

3.1. Materials

The use of locally available materials from different sources was emphasized in this study. For the cases where locally available materials were not attainable, commercially available materials were used. Following are the details of materials used.

3.1.1. Ordinary Portland Cement

Cement is a crucial component of concrete mixtures, responsible for binding sand and stone particles together and filling voids to create a compact mass. Portland cement, particularly Ordinary Portland Cement (OPC), is the primary type used, with grades such as 33 Grade, 43 Grade, and 53 Grade based on strength. Upgraded cement qualities result from factors like high-quality limestone, modern equipment, precise particle size distribution, fine grinding, and improved packing. For this investigation, 43 Grade OPC from JK Cement, freshly sourced without lumps, was consistently used. Its physical properties, including initial and final setting time, specific gravity, fineness, and compressive strength, adhered to Indian Standard IS: 8112:1989. Proper storage methods prevented moisture-related deterioration.

3.1.2. Fine Aggregates

Fine aggregates, which primarily pass through a 4.75mm IS Sieve, consist of materials like Natural Sand, Crushed Stone Sand, and Crushed Gravel sand. These aggregates are categorized based on size into coarse, medium, and fine sands. Grading zones, ranging from Grade 1 to Grade 4 as per IS: 383-1970, define the particle size distribution, with finer zones progressing from 1 to 4. The sand used in this experimental program was locally sourced and adhered to IS: 383-1970 standards. It underwent sieving through a 4.75mm sieve to eliminate particles larger than 4.75mm, ensuring compliance with the grading zone requirement.

3.1.3. Coarse Aggregates

The use of superplasticizer (high range water reducer) has become a quite common practice. This class of water reducers was originally developed in Japan and Germany in the early 1960's; they were introduced in the United States in the mid 1970's. In this experimental study, Superplasticizer (SP 905) is used which is a super plastizing concrete admixture based on synthetic polymer. It has advantage of producing high early strength and higher workability concrete.

3.1.4. Silica Fume

Silica fume is the name given to the very fine-grained dust given off as a by-product of high temperature furnaces which reduce silica to silicon or silicon alloys. It is essentially amorphous silica, with small amounts of quartz,cristobalite and other phases. Commercially available powder silica fume was used in the study. 3.1.6 Water- Potable water, typically used for drinking, is generally acceptable for concrete mixing and curing. Water from natural sources like lakes and streams, free from contaminants, is also suitable. However, caution is advised when using water suspected of contamination from sewage, industrial waste, or mining activities.

3.2. Concrete

This experimental study utilized four different high-strength concrete mixtures with expected cylinder compressive strengths of 550, 700, 850, and 1000 kg/cm². The mixes were designed using Portland cement type I, natural river sand, crushed limestone as fine and coarse aggregates respectively, and silica fume as a mineral admixture. Superplasticizer was added in aqueous solution form to achieve workable mixes with desired quality and strength. Six trial mixtures were conducted with four different water-binder ratios (w/b) to gather sufficient data for final mix proportion design. Each trial mix was aimed to produce a range of strengths covering the target strengths. After testing three cylinders per trial mixture at 7 days, adjustments were made to the high-strength concrete mix proportions assuming 80% of the strength at 7 days corresponds to the strength at 28 days. Adjustments were made to the w/b ratio, water, and superplasticizer contents to achieve the expected strength and improve workability.The mix proportions for the high-strength concrete are detailed in Table 3.6, with varying amounts of cement, silica fume, water, superplasticizer, coarse aggregate, and fine aggregate for each target strength. The w/b ratios ranged from 0.25 to 0.38, and the maximum size of coarse aggregate was 20 mm with cleaned and saturated surface dry conditions. The fineness modulus of the fine aggregate (sand) was approximately 3.0 with an oven dry status.

3.3. Equipment

- Standard Moulds - Cube 100 mm, Cube 150 mm, Cylinder Ø100×200mm, Cylinder Ø150×300mm
- Weighing Scales
- Concrete Vibrator
- Compression Testing Machine

3.4. Experimental Methods

The uniaxial compression tests were performed on specimens cast from 3 different high strength concrete mixtures. In order to determine shape and size effects, 4 different specimen types with the dimensions shown in figure are used.All specimens were tested at 2 ages, i.e. 7 and 28 days. The determination of the strength for each concrete mixture, specimen age and specimen type are based on the average of 6 specimens.

3.4.1. Specimen Preparation

Concrete mixing and casting procedures were standardized as follows:

- Batching of concrete mixtures was done using a pan mixer, dividing each mixture into four batches due to mixer limitations. Cement, silica fume, and aggregates were dry-mixed for approximately 1 minute to ensure uniformity. Mixing water and superplasticizer were gradually added and mixed mechanically for 2 minutes. The consistency of the fresh concrete was assessed using the conventional slump test.

- Seventy-two specimens were cast from each concrete mixture, with concrete consolidation achieved using an internal vibrator during placement to ensure full compaction.
- After 24 hours, all test specimens were demoulded and subjected to continuous curing in a water pond until specimen preparation and testing.

3.4.2. Testing

After the specimens have been cured for 7 and 28 days, the uniaxial testing is performed with the test procedures. The concrete specimens were tested for cylindrical compressive strength and splitting tensile strength in accordance with ASTM C39, while cubical compressive strength and splitting tensile strength in accordance with BS EN 12390-3.

4. Experimental Work

4.1. Introduction

The main goal of this study is to find out the effect of different factors, on conversion ratios for different concrete specimens' compressive strength. During theexperimental study, different concrete specimens of different concrete mix designs were tested at different ages, with different curing conditions.For casting concrete specimens, OPC cement was used. Crushed limestone aggregates (both fine and coarse), potable water and for one concrete mix design, superplasticizerwas also utilized.

Before beginning of casting, sieve analysis was done and moisture conditions for all the aggregates were determined.

Table 1 – Sieve analysis of aggregate with 20 mm maximum size

Sieve (mm)	Weight (kg)	% Retained	Cumulative % retained	Cumulative % passing
28	0.00	0.00	0.00	100.00
20	0.75	19.04	19.04	80.96
14	2.69	68.27	87.31	12.69
10	0.40	10.15	97.46	2.54
6.3	0.10	2.54	100.00	0.00
5	0.00	0.00	100.00	0.00
3.35	0.00	0.00	100.00	0.00
Pan	0.00	0.00	100.00	0.00
	3.94			

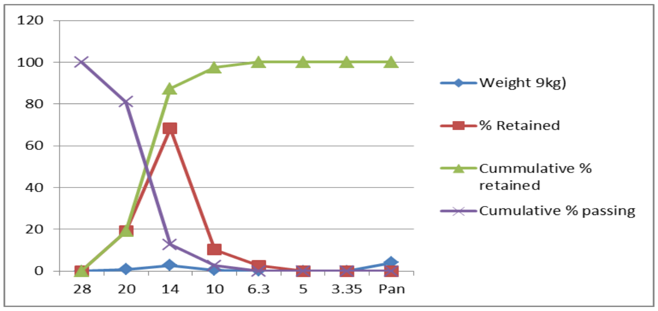


Fig. 1 – Sieve analysis of aggregate with 20 mm maximum size

Table 2 – Sieve analysis of aggregate with 14 mm maximum size

Sieve (mm)	Weight (kg)	% Retained	Cumulative % retained	Cumulative % passing
28	0.00	0.00	0.00	100.00
20	0.05	1.26	1.26	98.74
14	0.30	7.57	8.83	91.17
10	2.39	60.15	68.98	31.02
6.3	1.17	29.51	98.49	1.51
5	0.04	0.88	99.37	0.63
3.35	0.03	0.63	100.00	0.00
Pan	0.00	0.00	100.00	0.00
	3.97			

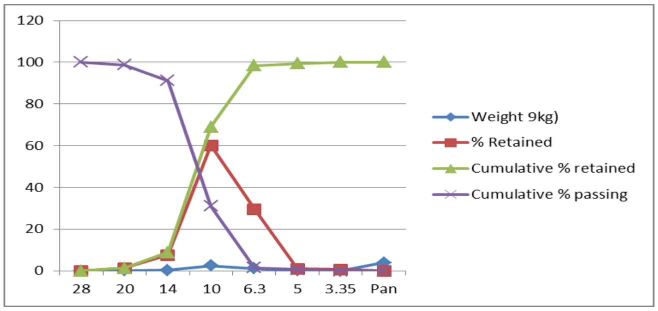


Fig. 2 – Sieve analysis of aggregate with 14 mm maximum size

Table 3 – Sieve analysis of aggregate with 10 mm maximum size

Sieve (mm)	Weight (kg)	% Retained	Cumulative % retained	Cumulative % passing
28	0.00	0.00	0.00	100.00
10	0.00	0.00	0.00	100.00
14	0.00	0.00	0.00	100.00
10	0.05	2.01	2.01	97.99
6.3	1.17	47.08	49.09	50.91
5	0.54	21.53	70.62	29.38
3.35	0.49	19.72	90.34	9.66
Pan	0.24	9.66	100.00	0.00
	2.49			

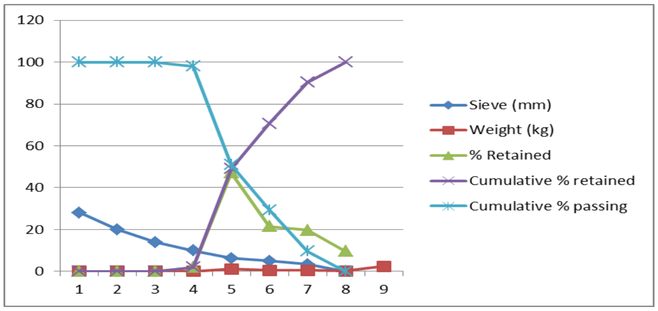


Fig. 3 – Sieve analysis of aggregate with 10 mm maximum size

Table 4 – Sieve analysis of fine aggregates

Sieve (mm)	Weight (kg)	% Retained	Cumulative % retained	Cumulative % passing
4.75	0.00	0.00	0.00	100.00
2.36	140	14.00	14.00	86.00
1.19	310	30.50	44.50	55.50
.059	220	21.50	66.00	34.00
0.297	130	12.50	78.50	21.50
0.149	90	8.50	87.00	13.00
Pan	130	13.00	100.00	0.00
	1000			

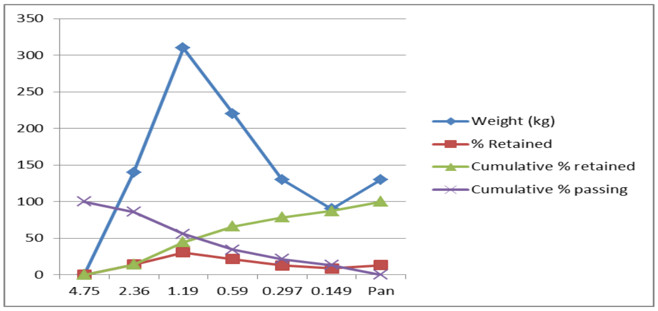


Fig. 4 – Sieve analysis of fine aggregates

Three mix designs were chosen for this study. The mix designs were decided to be different in water/cement ratio and superplasticizer percentage respectively.

For each mix design, before casting, trial mix-designs were done in order to make sure that each mix satisfies the requirements. Table show the proportioning of materials and results of trial mixes for each concrete mix.

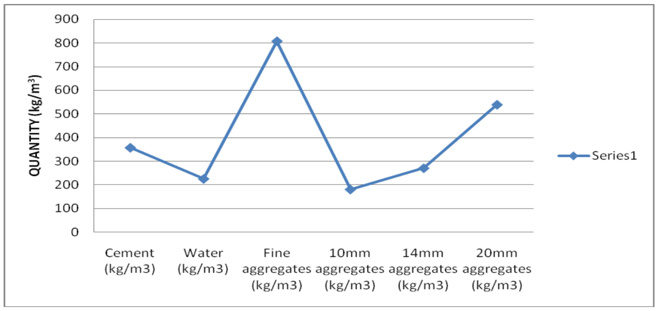


Fig. 5 – Mix design values for mix A

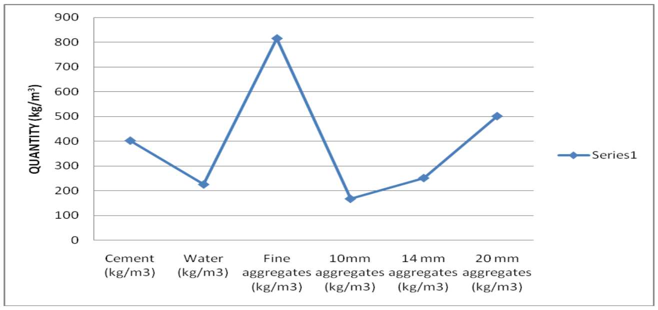


Fig. 6 – Mix design values for mix B

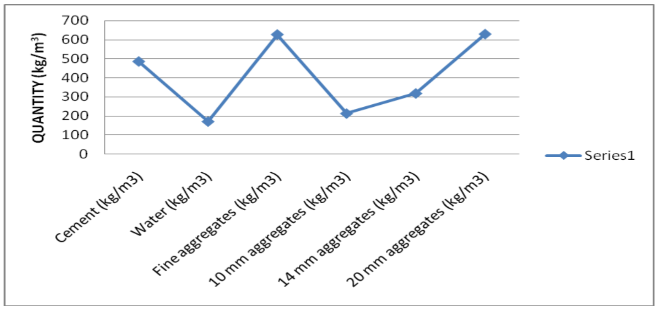


Fig. 7 – Mix design values for mix C

Water to cement ratio of mix design A, B and C are kept constant to be equal to 0.63, 0.56 and 0.35, respectively. On fresh concrete, for each mix design, test of workability and on hardened concrete, compressive strength tests and splitting tensile strength test were performed. Also, non-destructive tests, including rebound hammer tests, were executed. Two types of curing conditions (water and air) and testing ages (7 and 28 days) were considered for the test specimens.

4.2. Materials used

4.2.1. Cement

For casting all the specimens, OPC cement was used. Both coarse and fine aggregates used for this study were crushed limestone. Prior to casting, tests were done to determine the aggregates properties.

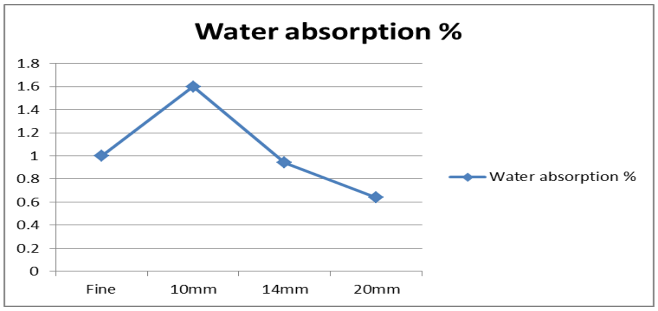


Fig. 8 – Water absorption percentage for different size aggregates

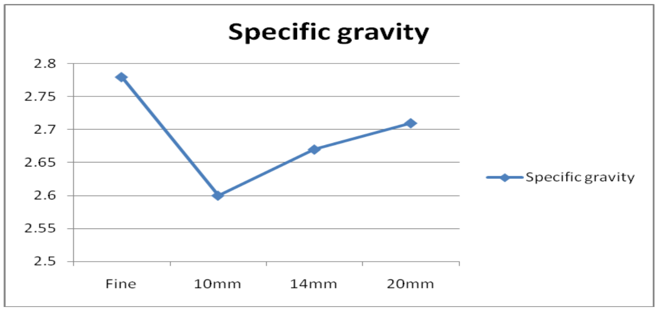
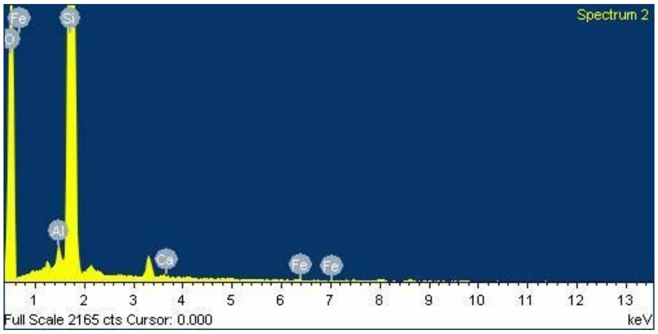


Fig. 9 – Specific gravity results for different size aggregates

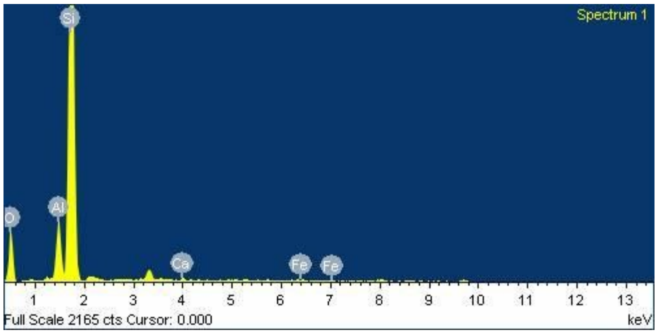
4.2.2. Silica Fume

For casting all the specimens, OPC cement was used with admixture(silica fume) and super plasticizer. Chemical compositions and physical properties of silica fume are shown in previous chapter. Prior to casting, XRD and SEM tests were done to determine the silica fume properties.

Chemical composition for Spectrum 1:



Chemical Composition for Spectrum 2:



4.3. Casting Concrete

The concrete casting process involved manual batching, weighing, and mixing of materials. Aggregates and cement were first mixed in a plate mixer for 30 seconds, followed by the addition of water and further mixing for a few minutes. Samples for tests on fresh concrete were taken before pouring the concrete back into the source for homogenization. Finally, the concrete was poured into moulds according to BS 1881: Part 125: 1986, 2009 standards.

4.4. Compacting and Curing

After casting and compacting, concrete specimens were transferred to a curing room with over 90% humidity and a temperature of 21°C. After approximately 24 hours, specimens were moved to either a water tank or an air room, depending on their specified curing conditions. They remained there until reaching the required testing age. Two types of vibration tables were used: an ordinary vibrating table and one where concrete mould could be fixed.

4.5. Tests onFresh Concrete

4.5.1. Workability test

Slump tests were the only tests conducted on new concrete mixtures. A straightforward and popular technique for determining the consistency or workability of fresh concrete is the slump test. The process involves pouring concrete into a shortened cone-shaped mold and compacting it in layers. The amount that the concrete slumps (or settles) is measured after the mold is raised vertically. The concrete's fluidity and workability are indicated by this slump value, which is typically expressed in millimeters. A low slump denotes a drier, stiffer concrete, whereas a high slump denotes a wetter, more fluid mixture. By confirming that the concrete mix has the workability required for a given construction task, the slump test can help avoid problems like segregation or inadequate compaction. The test is less useful for very dry or very wet mixes, though, and is only appropriate for concrete with a slump range of 25 to 175 mm.

4.6. Tests on Hardened Concrete

4.6.1. Compressive Strength Test

In this research, concrete specimens of different sizes and shapes for compressive strength tests. 4.6.2 Splitting Tensile Strength Test- Splitting test was also carried out on both cubes and cylinders at the age of 28 days. At the time of testing, specimens were removed from curing tank and a line was drawn on specimens to make sure that load was axially applied.

4.6.2. Rebound Hammer TestRebound Hammer Test

The Rebound Hammer Test, also known as the Schmidt hammer test, assesses surface hardness to estimate concrete compressive strength. Ten impacts are applied to the specimen's surface during the test, with each specimen tested about ten times on the same side. Results may be influenced by factors like moisture conditions and cement type. To calculate the true number of rebound hammer readings, the average of all ten results is first determined. Any readings differing by more than six units from the average are discarded. The average of the remaining readings is then calculated and reported as the specimen's rebound number.

5. Results and Discussion

5.1. Introduction

The experiments carried out were slump test, rebound hammer test, compressive strength and splitting tensile strength. For each test, results will be presented and discussed.

5.2. Test on Fresh Concrete (Slump Test)

The results show that by decreasing water to cement ratio of mix designs, there is a decrease for slump. Despite the fact that for mix design C, super-plasticizer was used, the level of workability was still low, which was caused by low water/cement ratio.i.e. 0.35. For the mix design A, high slump value is in fact due to high water/cement ratio. This was probably as a result of the utilized cement's strength grade.

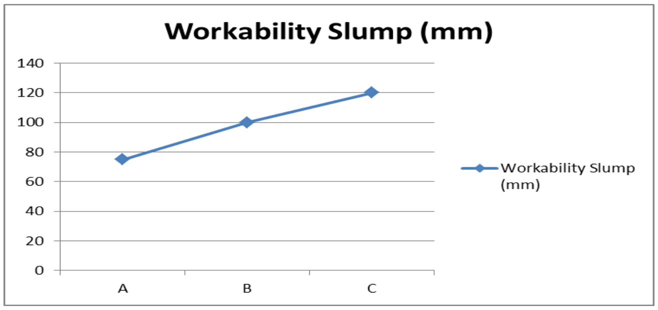


Fig. 10 – Slump test results

5.3. Testson Hardened Concrete

5.3.1. Compressive Strength

On each mix design, hardened concrete density test was performed according to BS EN 12390-7, 2009.

Table 5 – The average hardened density of HSC mix A for each experiment's condition.

Specimen Type	Compressive Strength (MPa)							
	100mm cube		150mm cube		Cylinder 100×200mm		Cylinder 150×300mm	
Sr. No.	7 Days	28 Days	7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
1	59.6	68.4	61.8	70.9	47.5	59.5	50.6	55.5
2	68.9	72.7	62.0	71.1	49.1	57.8	46.7	58.7
3	66.3	73.3	65.1	71.5	50.8	61.7	49.0	57.5
4	71.9	73.7	64.7	75.2	48.5	63.0	50.1	56.9
5	64.7	73.7	64.3	68.9	51.5	65.9	47.5	61.5
6	69.1	80.2	64.5	76.6	51.7	63.8	48.2	60.3
Average	66.75	73.7	63.7	72.4	49.9	62.0	48.6	58.4

Table 6 – The average hardened density of HSC mix B for each experiment's condition.

Specimen Type	Compressive Strength (MPa)							
	100mm cube		150mm cube		Cylinder 100×200mm		Cylinder 150×300mm	
Sr. No.	7 Days	28 Days	7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
1	79.7	89.8	75.3	88.7	68.2	74.5	60.7	67.0
2	76.3	88.5	67.5	87.3	67.6	75.6	65.5	69.9
3	74.2	87.5	73.7	86.1	68.9	73.7	65.4	72.3
4	78.2	88.1	74.7	90.7	70.7	76.2	65.7	71.5
5	73.3	89.6	76.7	85.1	71.5	73.4	61.9	71.0
6	74.7	91.2	68.1	84.6	70.2	74.8	66.2	70.4
Average	76.0	89.1	72.7	87.0	69.5	74.7	64.2	70.3

Table 7 – The average hardened density of HSC mix C for each experiment's condition.

Specimen Type	Compressive Strength (MPa)							
	100mm cube		150mm cube		Cylinder 100×200mm		Cylinder 150×300mm	
Sr. No.	7 Days	28 Days	7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
1	93.6	97.3	86.4	104.0	78.5	86.2	76.6	86.3
2	89.0	99.8	85.8	98.4	85.3	90.6	82.3	87.9
3	95.9	95.0	85.3	99.3	84.5	88.7	79.7	85.6
4	98.8	115.5	87.6	100.8	85.9	84.3	82.9	88.2
5	100.7	110.2	92.5	101.0	78.2	93.1	74.1	89.0
6	103.8	107.4	89.3	103.9	79.0	93.8	81.3	92.2
Average	97.0	104.2	87.6	101.2	81.9	89.4	79.5	88.2

5.3.2. Specimen Size Effect on Compressive Strength

Linear regression analysis is used to examine the relationship between concrete strength values obtained from specimens of different sizes. Tables and figures illustrate the average compressive strengths. Generally, larger specimens exhibit lower compressive strength compared to smaller ones from the same concrete mix. This discrepancy is attributed to the higher likelihood of large defects like voids and cracks in larger specimens. Consequently, smaller specimens tend to yield higher strength, and adjustments may be necessary for interpreting test results from smaller specimens.

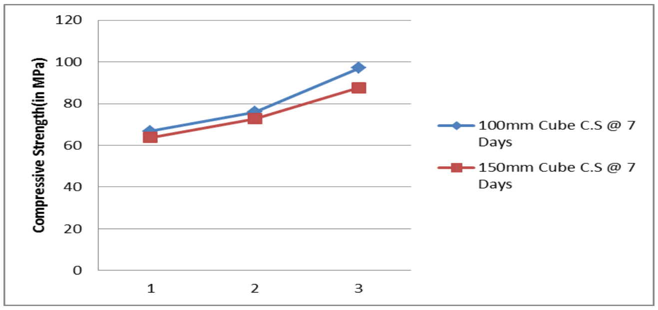


Fig. 11 – Comparison between compressive strength (average) at 7 days of 100 mm cube and 150 mm cube

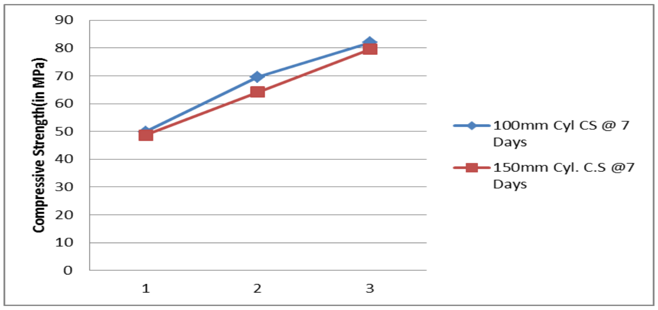


Fig. 12 – Comparison between compressive strength (average) at 7 days of Ø100×200mm cylinder and Ø150×300mm cylinder

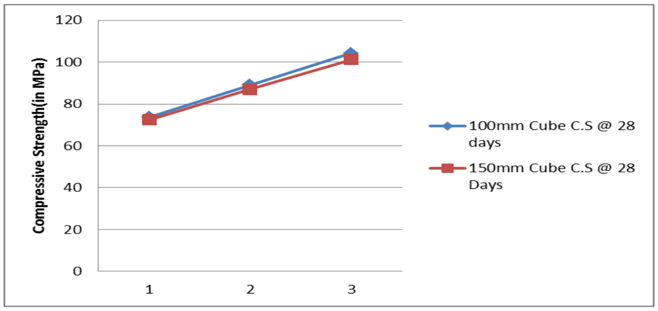


Fig. 13 – Comparison between compressive strength (average) at 28 days of 100 mm cube and 150 mm cube

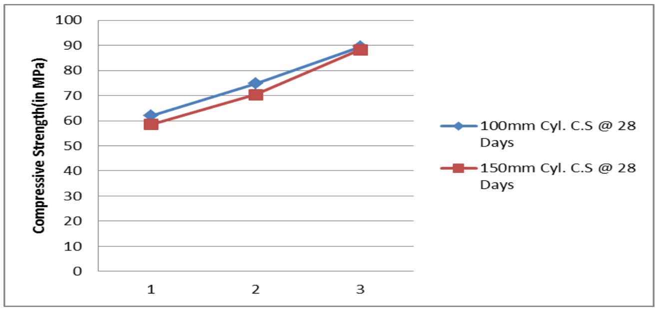


Fig. 14 – Comparison between compressive strength (average) at 28 days of Ø 100×200 mm cylinder and Ø150×300 mm cylinders

5.3.3. Specimen Shape Effect on Compressive Strength

Tables demonstrate that cube strengths consistently surpass corresponding cylinder strengths across the considered concrete strength range. The ratio of compressive strength for Ø150×300mm cylinders to 150 mm cubes varies from 0.78 to 0.86 for cylinder strengths of 550 to 1,000 kg/cm². According to the CEB-FIP (1990) Model Code, the transformation factor, based on this ratio, starts at 0.80 for cylinder strength of 40 MPa and increases to 0.89 for a strength of 80 MPa. Figures depict plots of cube against cylinder compressive strengths, with best-fit lines obtained from linear regression analysis. These relationships are also summarized in the tables for comparison with expressions from prior research.

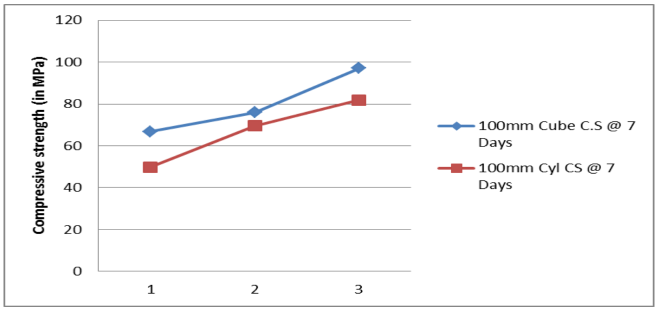


Fig. 15 – Comparison between compressive strength at 7 days of 100mm cube and Ø100x200mm cylinder

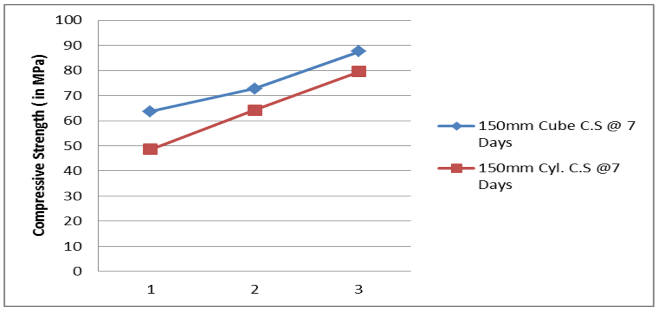


Fig. 16 – Comparison between compressive strength at 7 days of 150 mm cube and Ø150×300 mm cylinder

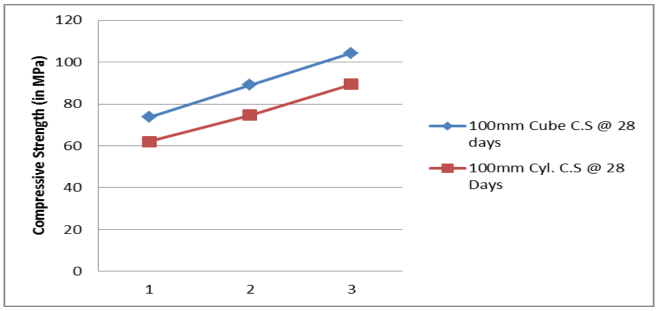


Fig. 17 – Comparison between compressive strength at 28 days of 100 mm cube and Ø100×200 mm cylinder

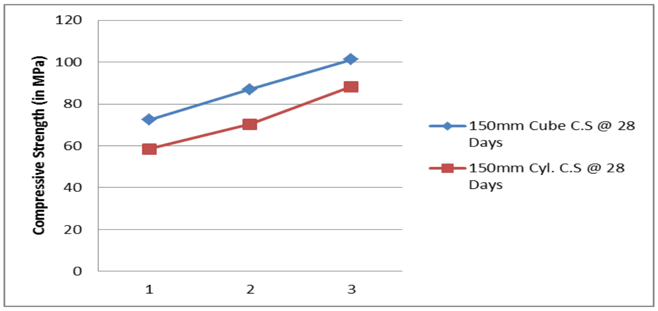


Fig. 18 – Comparison between compressive strength at 28 days of 150 mm cube and Ø150×300 mm cylinder

5.4. Splitting Tensile Strength

In this experiment, splitting tensile strength test was performed on both cubical and cylindrical specimens cured in water at the age of 28 days.

Results are shown in the table given below.

Table 8 – The 28 Days Splitting Tensile Strength of Mix Design

Samples	Splitting Tensile Strength (MPa) Mix A	Splitting Tensile Strength (MPa) Mix B	Splitting Tensile Strength (MPa) Mix C
Cyl. 100X200mm(1)	4.28	4.41	6.04
Cyl. 100X200mm(2)	4.47	4.47	6.31
Cyl. 100X200mm(3)	3.95	3.81	6.91
Cyl. 150X300mm(1)	3.72	6.67	5.84
Cyl. 150X300mm(2)	3.83	6.60	5.60
Cyl. 150X300mm(3)	3.65	6.35	6.08
Cube 100mm (1)	3.75	1.69	1.59
Cube 100mm (2)	3.47	1.55	1.45
Cube 100mm (3)	3.53	1.60	2.09
Cube 150mm (1)	3.38	3.59	5.48
Cube 150mm (2)	3.15	3.59	5.48
Cube 150mm (3)	3.40	3.52	4.93

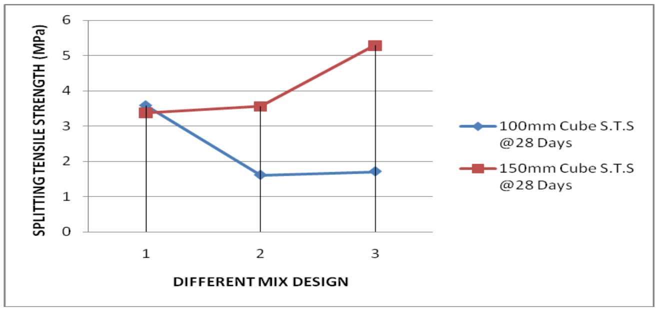


Fig. 19 – Comparison between splitting tensile strength (average) at 28 days of 100 mm cube and 150 mm cube

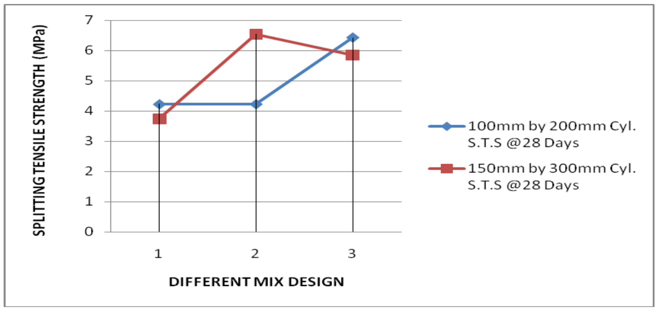


Fig. 20 – Comparison between splitting tensile strength (average) at 28 days of Ø 100×200 mm cylinder and Ø150×300 mm cylinder

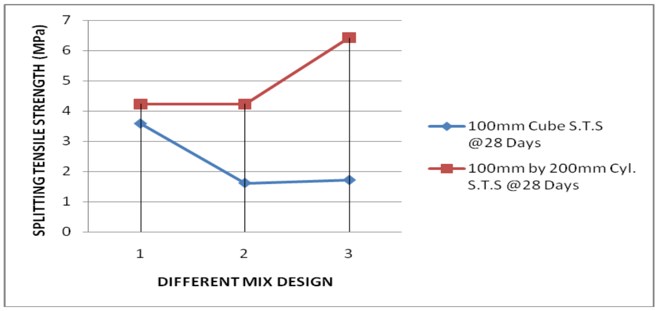


Fig. 21 – Comparison between splitting tensile strength at 28 days of 100 mm cube and Ø100×200 mm cylinder

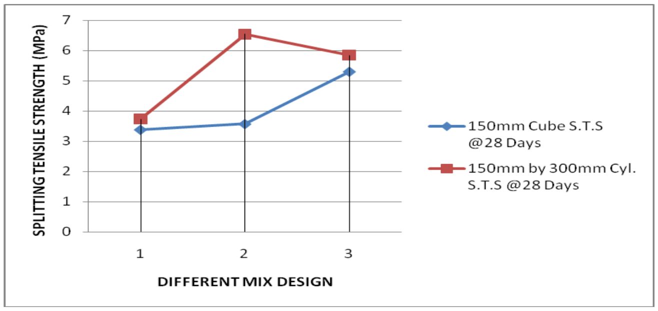


Fig. 22 – Comparison between splitting tensile strength at 28 days of 150 mm cube and Ø150×300 mm cylinder

6. Conclusion

Based on the findings of this review paper, several conclusions regarding the effects of specimen size and shape on concrete strength can be drawn:

- Specimen Size Effect: The study presents expressions detailing the size effect based on two different specimen sizes. Results indicate that compressive strength tends to increase as specimen size decreases, with ratios of 0.96 for 150 mm to 100 mm cube strength and 0.97 for Ø150×300 mm to Ø100×200 mm cylinder strength, as observed in the 28-day test results.
- Specimen Shape Effect: Expressions derived from cube and cylinder specimens demonstrate that cube compressive strength generally surpasses cylindrical strength. However, this effect diminishes as concrete strength increases, suggesting a trend toward convergence of strength values between cube and cylinder specimens.
- Splitting Tensile Strength: The review reveals that cylindrical specimens exhibit higher splitting

tensile strength compared to cube specimens, indicating a shape effect on tensile strength. Additionally, splitting tensile strength increases with increasing specimen size, highlighting a size effect in this context.

These conclusions shed light on the complex interplay between specimen size, shape, and concrete strength characteristics, providing valuable insights for researchers and practitioners in the field of concrete testing and structural design.

Acknowledgement

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