J. Build. Mater. Struct. (2026) 13: 53-58 ***Short Communication***
DOI : 10.34118/jbms.v13i1.4569

Evaluating the Compressive Strength of Concrete Different Water - Cement Ratio

Abiodun Joseph Kilani*, Rasheed Abdulwahab and Bolanle Deborah Ikotun

Department of Civil & Environmental Engineering and Building Science, College of Science, Engineering and Technology, University of South Africa, Florida Science Campus, Roodepoort, Johannesburg, South Africa
* Corresponding Author: 20994680@mylife.uniza.ac.za

Received: 17-04-2026 **Accepted: 08-06-2026**

Abstract. The performance of concrete is greatly influenced by the proportion of its constituting materials. Despite concrete having rightful content of binder and mineral fillers, the amount of water used for its production has significant effects on its characteristics. The standard concrete mix design influences the characteristics performance of concrete and plays significant roles in the development of quality and sustainable concrete. This study evaluates the effect of different water - cement ratios (0.6 and 0.43) on the density, workability, and compressive strength of concrete. In the experiment, concrete mix of 1:2:3 with 0.6 and 0.43 water – cement ratios were used. The workability was assessed through slump test in accordance with SANS5862-1:2006, while the compressive strength test was done on 100 x 100 x100 concrete cubes in accordance with SANS5863: 2006. The densities were measured before the compressive strength tests were performed. The slump values obtained from the concrete with 0.6 and 0.43 water – cement (w/c) ratios were 80 mm and 70 mm respectively. The concrete with 0.6 and 0.43 w/c ratios have density range of 2310 – 2434.5 kg/m^3 and 2332.5 – 2398.5 kg/m^3, respectively. The concrete's compressive strengths with 0.43 w/c ratio exceeds that of 0.6 by 59.09, 30.54 and 29.66 % at 3, 7 and 28 days, accordingly. In conclusion, concrete with 0.43 w/c ratio gave better compressive strength and is recommended for the construction of high-rise buildings and infrastructures.

Key words: Compressive Strength, Sustainable Concrete, Water – Cement Ratio, Infrastructures.

1. Introduction

One of the major sources of concrete deformation that does not make it structurally sustainable is the use of high quantity of water for its production. The fact remains that, concrete produced with high water-cement (w/c) ratio developed several problems such as segregation, structural deflection, creeping of concrete structural members, shearing of the buildings' beam members, cracks and formation of large pores within the concrete matrix. These defects have been affecting the sustainability capacity of concrete structures in the global communities. Thus, resulting in demolition of many multimillion dollars concrete projects without fulfilling their initial purposes of construction. The previous reports on concrete mix proportion show that water is one of concrete production materials that require accurate proportioning during mix design formulation (Aïtcin, P.-C., 2016; Ejiogu et al., 2018).

According to Ejiogu et al. (2018), the use of high w/c ratio such as 0.8 and 0.9 w/c ratio in concrete developed into formation of lowest flexural, tensile and compressive strengths compared to concrete with less w/c ratio such as 0.5. In addition, Ayanlere et al. (2023) reported that concrete's bond and compressive strengths decreased up to 25.4% and 30.8% by increasing the concrete's w/c ratio from 0.4 to 0.6.

Without adequate solutions on regulating the concept of w/c ratio in concrete, the negative impacts of high w/c ratio in concrete such as formation of low bond, high bleeding, voids, sudden deformation of concrete structural members will not cease. Thus, this research worked on controlling the negative impacts of high w/c ratio on concrete's strengths, most especially, compressive strength. The research aims at increasing the concrete strength properties using low w/c ratio. This aim is accomplished by characterizing concrete's aggregates; determining consistency, setting times and workability of concrete using different w/c ratio; evaluating the influence of different w/c ratio on concrete's hardened properties such as density and compressive strength, and discovering the suitable w/c ratio good for high strength concrete production for sustainable concrete infrastructures construction.

2. Materials and Methods

2.1. Materials

The materials used for this research were Ordinary Portland Cement (OPC) of grade 52.5 N, crusher sand (fine aggregate), granite (coarse aggregate) of 20 mm maximum size, optima 206 superplasticizer, and potable water.

2.1.1 Materials Collection and Treatments

The crusher sand and granite used in this experiment comprise of particles with less than 10 mm diameter for sand and maximum of 20 mm diameter for granite. The fine and coarse aggregates and cement were supplied by AfriSam, South Africa. Aggregates were washed with clean water to remove the purities such as dust and clay from the granite and sand. The washed samples were dried in the oven for 24 hours at 110°C. Thereafter, samples were allowed to cool and sieve to determine their fineness modulus (FM). The optima 206 superplasticizer was applied to the concrete mix (most especially water) to improve workability of 0.43 w/c ratio – concrete. Both the cement and superplasticizer were produced in accordance with South African Bureau of Standards-SANS 50197 (2013) and South African Bureau of Standards-SANS 50934 (2011), making them suitable for research work.

2.1.2 Materials' Characterization

Fine & Coarse Aggregates (Crusher Sand & Granite) and Cement Paste

The characterizations of sand and granite were determined through the sieve analysis of their aggregates (Figure 1a) using 10.00 to 0.075 mm and 26.50 mm to 1.0 mm sieve sizes respectively in accordance with South African Bureau of Standards-SANS 3001 (2011) standards.

The percentage of water required to form the consistency and setting times of cement paste were determined to and recorded according to South African Bureau of Standards- SANS 50196 (2006).

2.3. Concrete Mix Design

Two mix designs were used to produce concrete with two different w/c ratios (0.6 and 0.43) as presented in Table 1.

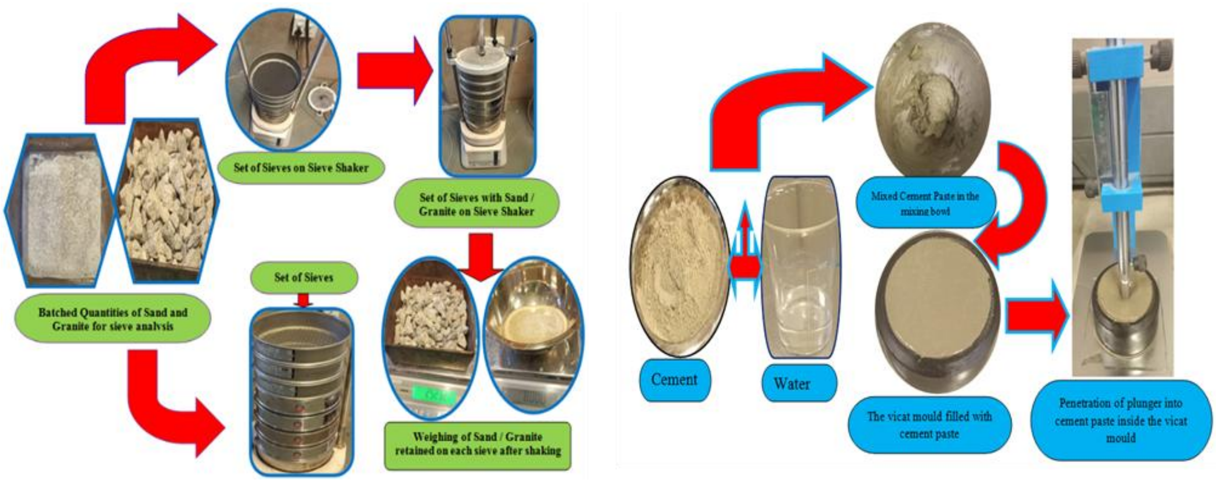

Fig. 1. (a) steps of determining the sand and granite particles' sizes through Sieve analysis (b) steps of determining the Consistency of Cement Paste

Table 1. Concrete mix designs for 0.43 & 0.6 w/c ratio – Concrete Production

Sample	Cement (g)	Sand (g)	Granite (g)	Water (g)	Superplasticizer	W / C ratio
Concrete produced with 0.43 w/c ratio and 1:2:3 mix proportion	342.90	685.70	1371.40	205.74	3.43	0.43
Concrete produced with 0.6 w/c ratio 1:2:3 mix proportion	342.90	685.70	1371.40	205.74	-	0.6

2.3. Research Methodology

2.3.1. Workability, Density and Compressive Strengths

The fresh and hardened properties of concrete with 0.6 and 0.43 w/c ratios were determined through the evaluation of workability, density and compressive strength. The workability of concrete was determined through its slump test in accordance with South African Bureau of Standards- SANS 5862 (2006) while the compressive strength was determined by subjecting 100 x 100 x 100 mm concrete cubes produced with different w/c ratio (0.6 and 0.43) to compressive load in accordance with South African Bureau of Standards- SANS 5863 (2006). Density of each sample was measured prior to the compressive strength test.

3. Results and Discussions

3.1. Results of Materials' Characterization

The fineness modulus (FM) of crusher sand and granite aggregates were determined to be 3.2 and 4.5 respectively and these values complied with Bureau of Indian Standards (1963) and ASTM International (1980) standards. Also, the consistency of cement paste was determined to be 31.5% while the setting times of cement paste was determined to be 93.21 - 169.17 minutes. These values complied with Bureau of Indian Standards (1991) and Bureau of Indian Standards (1975) standards.

3.2. Results of Fresh and Hardened Properties of Concrete

3.2.1 Workability and Density of Concrete

The concrete produced with 0.6 & 0.43 w/c ratio had the slump value of 80 and 70 mm respectively which were referred to as true slump. Also, the density of concrete with 0.6 & 0.43 w/c ratio ranged from 2310 – 2434.5 kg/m^3 and 2332.5 – 2398.5 kg/m^3, respectively (Figures 2a - b) indicating good potential for light – normal weight concrete production

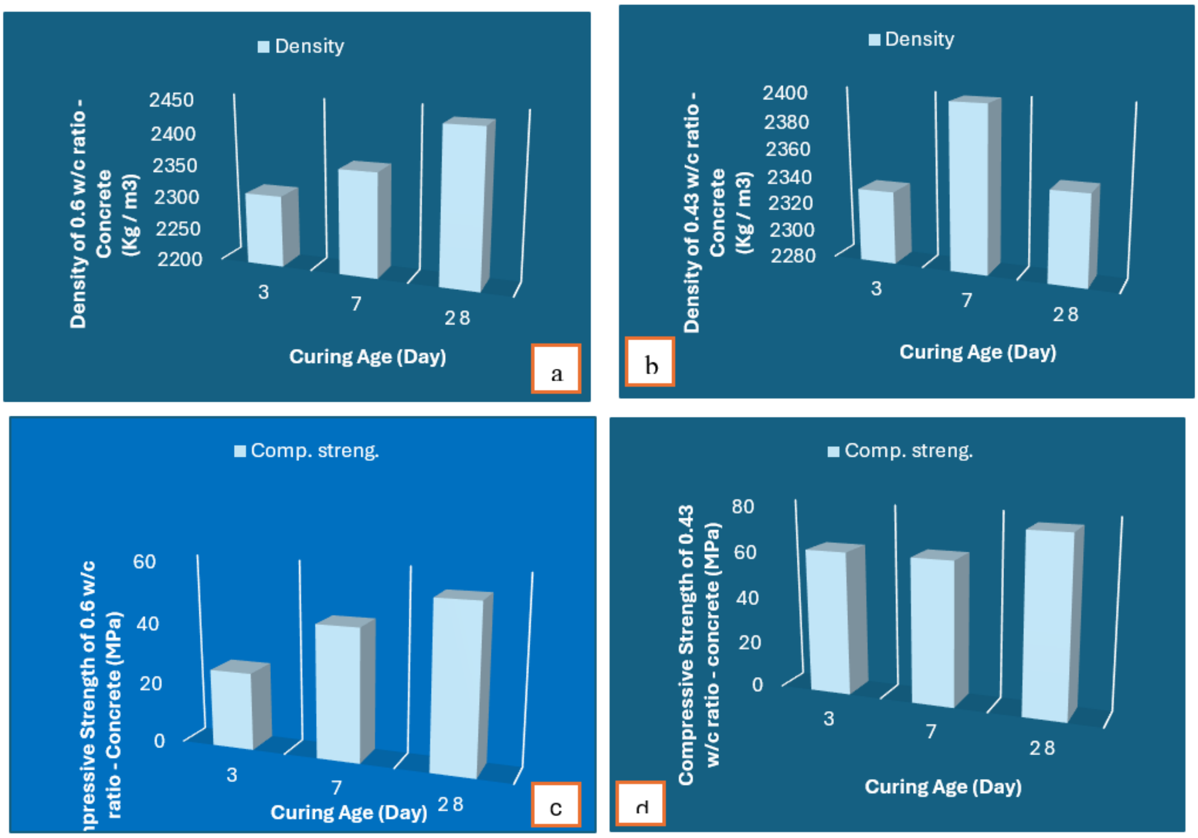

Fig. 2. (a - b) The Density of Concrete Produced with 0.6 and 0.43 w/c ratios respectively (c - d) The Compressive Strength of Concrete Produced with 0.6 and 0.43 w/c ratios respectively

3.2.2. Compressive Strength of Concrete

The compressive strength of concrete produced with 0.6 & 0.43 w/c ratios were found ranging from 25.43 - 53.59 MPa and 62.08 – 76.19 MPa at 3 - 28 days of curing respectively (Figures 2c – d). With critical consideration of results in Figures 2c-d, it was observed that concrete produced with 0.43 w/c ratio increased in compressive strengths by 59.09 %, 30.54 % and 29.66 % than that of relative concrete with 0.6 w/c ratio at 3, 7 and 28 days, respectively. These results prove that the use of high volume of water for concrete production contributes a negative impact on sustainability and durability on concrete structural performance in service. For deeper evaluation, the 28th day result of 0.43 w/c ratio – concrete's compressive strength shows that concrete strength can be increased up to 30% with the decrease in its w/c ratio up to 28.3%. Therefore, it is highly essential to review the volume of water use for concrete production through their mix design in the global concrete industries to prevent deficiencies in concrete properties such as segregation, cracks, deflection, shearing, creeping and shrinkage, thus, increasing its sustainability. The reports of Wei (2021) and Kilani et al. (2026) support the fact that up to 30% of concrete compressive strength will be increased by decreasing its w/c ratio 0.43 from 0.6.

3.3. Novelty of Research

Most concrete produced in the construction industries with low w/c ratio have the problem of workability and poor quality after hardening (UltraTech Cement; Vladimir, 2009). In this research, the application of Optima 206 superplasticizer into production of low w/c ratio (0.43) - concrete made the concrete workable, developed complex matrix bonds within the concrete's aggregates, show less pores formation and yield good strength for high strength infrastructures building. This is the novelty of this research.

4. Conclusions and Recommendations

4.1. Conclusions

Based on the experimental output, it is very evident that workable concrete with enhanced strength can be produced with 0.43 w/c ratio using superplasticizer. In conclusion, 0.43 w/c ratio is suitable to produce sustainable, durable and good strength concrete.

4.2. Recommendations

In accordance with experimental results obtained, 0.43 w/c ratio together with superplasticizer is recommended for the production of sustainable and good concrete strength in the globe. Likewise, low w/c (≤ 0.43) is recommended for the production of sustainable concrete in the current construction industries to reduce the issue of sudden structural failures and cracks. In order to increase the quality of concrete produce globally, it is highly essential to critically evaluate the ratio of w/c in usage for construction purposes. This will enhance the sustainability and durability of concrete structures in circulation.

Acknowledgements

The efforts of Chryso company limited are appreciated for giving out optima 206 superplasticizer free for this research

Funding

This research received no funds.

Conflict of Interest

No conflict of interest is associated with this research

Data Availability Statement

All the data used for this research are included in the manuscript

Clinical Trial Study

Not Applicable

Ethical Approval

There are no ethical issues with the publication of this manuscript.

Consent to Participate

Not applicable

Consent to Publish declarations

Not applicable

5. References

Aïtcin, P.-C. (2016). The importance of the water–cement and water–binder ratios. In Science and technology of concrete admixtures (pp. 3–13). Woodhead Publishing. https://doi.org/10.1016/B978-0-08-100693-1.00001-1

ASTM International. (1980). Standard test method for sieve analysis of fine and coarse aggregates (ASTM C136-06). ASTM International.

Ayanlere, S. A., Ajamu, S. O., Odeyemi, S. O., Ajayi, O. E., & Kareem, M. A. (2023). Effects of water-cement ratio on bond strength of concrete. Materials Today: Proceedings, 86, 134–139. https://doi.org/10.1016/j.matpr.2023.04.686

Bureau of Indian Standards. (1975). Specification for ordinary Portland cement, 33 grade (2nd rev.) (IS 269:1975, reaffirmed 2015). BIS.

Bureau of Indian Standards. (1991). Specification for Portland pozzolana cement, Part 1: Fly ash based (IS 1489-1:1991). BIS.

Bureau of Indian Standards. (1963). Methods of test for aggregates for concrete, Part 3: Specific gravity, density, voids, absorption and bulking (IS 2386-3:1963). BIS. https://archive.org/details/gov.in.is.2386.3.1963

Ejiogu, I. K., Mamza, P. A. P., Nkeonye, P. O., & Yaro, S. A. (2018). Effects of water-cement ratio and cure days on the strength and workability of normal concrete blocks. International Journal of Innovative Scientific & Engineering Technologies Research, 6(2), 11–18. http://www.seahipaj.org

Kilani, A. J., Abdulwahab, R., & Ikotun, B. D. (2026). Modelling of structural performance and sustainability of concrete produced with different water–cement ratio and superplasticizer using multi-linear regression model. Chemistry of Inorganic Materials, 8, Article 100145. https://doi.org/10.1016/j.cinorg.2026.100145

South African Bureau of Standards. (2006). Concrete tests — Compressive strength of hardened concrete (SANS 5863:2006). SABS.

South African Bureau of Standards. (2006). Concrete tests — Consistence of freshly mixed concrete (SANS 5862-1:2006). SABS.

South African Bureau of Standards. (2006). Method of testing cement, Part 3 (SANS 50196-3:2006, Ed. 2). SABS. https://www.afrisam.co.za/wp-content/uploads/2021/10/2010277-AfriSam-Technical-Ref-Guide-update-2021.pdf

South African Bureau of Standards. (2011). Admixtures for concrete, mortar and grout, Part 2: Concrete admixtures — Definitions, requirements, conformity, marking and labelling (SANS 50934-2:2011). SABS. https://www.gpwonline.co.za

South African Bureau of Standards. (2011). Civil engineering test methods, Part AG20: Determination of the bulk density, apparent density and water absorption of aggregate particles retained on the 5 mm sieve for road construction material (SANS 3001-AG20:2011). SABS. https://www.sabs.co.za

South African Bureau of Standards. (2013). Cement, Part 1: Composition, specifications and conformity criteria for common cement (SANS 50197-1:2013). SABS. https://img.antpedia.com/standard/files/pdfs_ora/20210202/SANS%2050197-1-2013.pdf

UltraTech Cement (n.d.). Why the Right Water Cement Ratio is Crucial for Your Home? Retrieved (2021) from https://www.ultratechcement.com/for-homebuilders/home-building-explained--single/descriptive-articles/how-to-calculate-the-water-cement-ratio#

Vladimir, Ž. (2009). Effects of the very low water/cement ratio. Construction and Building Materials, 23(12), 3579–3582. https://doi.org/10.1016/j.conbuildmat.2009.03.014

Wei, L. (2021). Analysis of the influence of water-cement ratio on concrete strength. E3S Web of Conferences, 283, Article 01016. https://doi.org/10.1051/e3sconf/202128301016