International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Evaluation of Mechanical Strength and Non-Destructive Characteristics of Self Compacted Concrete Incorporating Coir Pith Ash

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Submitted:07/08/2025 **Revised**: 28/09/2025 **Accepted**: 12/10/2025

Abstract: Self Compacted Concrete (SCC) has emerged as foremost effective advancements in concrete technology, primarily due to its ability to achieve full compaction without the need for external vibration. Its high paste content, optimized flow behavior, and controlled aggregate gradation make it distinct from conventional concrete. However, these same characteristics can influence how non-destructive testing (NDT) methods perform when used to estimate mechanical strength. In the present study, SCC was produced using Ordinary Portland cement (OPC 53 grade) blended with ground granulated blast furnace slag (GGBS), FA, and coir pith ash as supplementary cementitious materials. A polycarboxylate-based superplasticizer was added to achieve the required self-compaction. The concrete's strength development was evaluated using ultrasonic pulse velocity (UPV) testing, while splitting tensile behavior was studied through prism testing to establish correlations with UPV readings. All specimens were cast from a single batch and cured under standard conditions. The compressive strength values ranged between 48.32 MPa and 91.56 MPa, while the UPV values varied from 4.12 km/s to 5.08 km/s. The statistical analysis showed a strong correlation (R^2 = 0.97) between UPV and compressive strength, confirming the reliability of UPV for predicting the mechanical performance of SCC. Overall, the study demonstrates that UPV testing can be effectively used to estimate the in-situ strength of SCC containing sustainable pozzolanic materials, offering a practical, non-destructive alternative for strength evaluation and quality assurance in modern concrete construction.

Keywords: *SCC; ND test methods; compressive strength; UPV test; splitting tensile failure mode; testing of prism; coir pith ash; sustainable materials*

1. Introduction

Concrete has remained the backbone of modern infrastructure for more than a century, continually evolving to satisfy the structural and durability requirements of contemporary construction. Its combination of strength, versatility, and cost-efficiency has made it indispensable in the creation of buildings, bridges, pavements, and a wide variety of civil engineering projects. Continuous innovation in materials science and mix design has led to the development of specialized concretes that cater to diverse performance demands and application contexts [1].

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Among these innovations, (SCC) represents a major technological advancement. Unlike conventional vibrated concrete. This self-consolidating property eliminates the need for mechanical vibration, thereby improving construction quality and reducing labor requirements. [2] Moreover, SCC yields exceptionally smooth and defect-free surfaces, which makes it highly desirable in architectural applications where the appearance of exposed concrete plays a significant role.

As the expected lifespan of infrastructure continues to increase, the accurate evaluation, maintenance, and rehabilitation of existing concrete elements have become critical for ensuring safety, extending service life, and optimizing maintenance costs. A key aspect of this evaluation process is determining the in-situ strength of concrete, which governs decisions related to structural assessment, prestressing, formwork removal, and the transfer of loads in precast elements [3].

Although destructive testing methods provide direct and reliable measures of concrete strength, they are often unsuitable for existing structures because of their intrusive nature, cost implications, and the potential for permanent damage. Consequently, non-destructive testing (NDT) techniques have emerged as practical alternatives for assessing the mechanical properties of concrete without affecting its integrity. Among these, the UPV(UPV) test has gained significant recognition for its ability to evaluate the uniformity, density, and estimated strength of concrete through wave propagation analysis [4].

However, most existing calibration models for UPV were developed based on Normal Vibrated Concrete (NVC). Applying these models directly to SCC may lead to inaccurate results because SCC differs from NVC in several fundamental ways—it contains a higher proportion of paste, reduced coarse aggregate volume, and enhanced workability [5]. These differences influence the internal structure and, consequently, the transmission of ultrasonic waves through the concrete matrix. Given these limitations, there is a growing need to establish mix-specific correlations between UPV values and the mechanical performance of SCC. Developing such relationships is vital for accurate estimation of compressive and tensile strength, ensuring that NDT-based evaluations can be reliably applied in both laboratory and field settings. A polycarboxylate-based superplasticizer was introduced to enhance flow and self-compacting characteristics [6]. The performance of the developed SCC was assessed through UPVtesting, alongside mechanical testing of prism specimens, which enabled a comprehensive evaluation of its strength development under controlled curing conditions.

2. Experimental Program

The experimental work for this research was carried out in three main phases. Each phase was designed to ensure that the developed SSC(SCC) mix satisfied both the fresh and hardened property requirements for high-performance concrete applications.

2.1. Phase I – Mix Design and Characterization

In the first phase, an SCC mix was proportioned and refined to achieve excellent flow characteristics while maintaining sufficient strength. The mix incorporated OPC(OPC, 53 grade) as the main binder, combined with (GGBS), FA, and coir pith ash as supplementary cementitious materials. These mineral additives were selected to improve workability, reduce cement content, and enhance long-term performance.

Natural fine aggregates and crushed granite coarse aggregates were used according to relevant Indian Standard specifications. To attain the required self-compaction and flowability, a polycarboxylate-based superplasticizer was added to the mix.

The mix design followed a modified volumetric method based on the procedure, where the relationship among paste, aggregate, and water volumes was optimized experimentally. The key ratios considered during the mix design process included:

- .(w/b): 0.35
- Powder-to-fine aggregate volume ratio (Vp/Vs): 0.80
- Water-to-powder ratio (Vw/Vp): 0.77
- Superplasticizer dosage (Sp/p%): 0.75% by binder weight

To enhance the sustainability aspect, 30% of cement was replaced with a ternary blend consisting of 15% GGBS, 10% FA, and 5% coir pith ash. The fine aggregate portion was composed of equal proportions of 0–2 mm river sand and 0–4 mm natural sand, providing a balanced grading curve. For the coarse aggregate phase, 65% 10 mm and 35% 20 mm crushed granite aggregates were used to ensure adequate packing density and passing ability.

2.2. Phase II – Casting of Specimens

Seven batches of concrete were mixed and labeled according to their testing ages: 1, 2, 3, 7, 14, 28, and 94 days. All specimens were cast on the same day using a single concrete batch to maintain uniformity across tests.

Fresh SCC was placed directly into molds without mechanical vibration, utilizing its inherent flowability. Each batch included:

- One 200 mm cube for installing five pull-out inserts and a temperature-monitoring probe, and
- Four 150 mm cubes for compressive strength(UPV), and surface hardness testing.

Minor temperature and humidity variations were recorded during curing, but they remained within acceptable limits for proper hydration [7].

2.3. Phase III – Testing Procedures

After the designated curing periods, both non-destructive and destructive tests were conducted to evaluate the mechanical behavior of the SCC.

- Non-destructive testing included the UPV(UPV) and Surface Hardness (Schmidt Rebound Hammer) tests [7].
- Destructive testing involved compressive strength tests and splitting tensile failure evaluation on prism specimens.

Each test was carried out according to relevant standards, and all readings were recorded with care to ensure repeatability and accuracy

The physical properties of the binders were as follows: OPC with a density of 3150 kg/m³, GGBS with 2850 kg/m³, FA with 2400 kg/m³, and CPA with 2100 kg/m³.

Fine aggregate specific gravity of 2.62 and a fineness modulus of 2.70. Coarse aggregate specific gravity of 2.70, and a fineness modulus of 6.80, conforming to IS 383:2016 specifications.

3 Mix Design of SCC

The SCC mix design was mixed using a modified volumetric method [8]. This procedure emphasizes the proportional relationships between the mortar components, allowing effective control over flowability, cohesiveness, and segregation protects it from.

The major mix design parameters included:

- the volumetric ratio of individual fine aggregate fractions $(s_1, s_2, \ldots, s_n)$within the total fine aggregate volume (V_s),
- the replacement percentage of cement with supplementary cementitious materials,
- the ratio of powder to fine aggregate volumes (V_p/V_s),
- the water-to-powder volume ratio (V_w/V_p), and
- the mass ratio of superplasticizer to powder $(Sp/p\%)$.

A (w/b) of 0.35 was chosen based on the target compressive strength and the performance of the selected binders. The $(V_p/V_s)$was fixed at 0.80 to provide sufficient viscosity and stability [9].

To promote sustainability, 30% of the cement was replaced by a ternary blend consisting of 15% GGBS, 10% FA, and 5% coir pith ash (by binder weight). The experimentally FINDd ratios of $V_w/V_p = 0.77$and $Sp/p\% = 0.75$produced the best results in terms of self-compactability, cover the area, and protects it from to segregation.

The fine aggregate blend consisted of equal portions of river sand (0–2 mm) and natural sand (0–4 mm), based on preliminary optimization. The coarse aggregate phase was proportioned considering the volumetric share of each fraction $(g_1, g_2, \ldots, g_n)$within the total coarse aggregate volume (V_g), with a void ratio $(V_v = 0.03m^3)$and a mortar-to-coarse aggregate volume ratio (V_m/V_g) of 2.25 to ensure both adequate flow and passing ability [10].

The final combination of coarse aggregates consisted of 65% of 10 mm and 35% of 20 mm crushed granite, achieving a balanced packing density and flow behavior.

The optimized Dosage of SCC per cubic meter are presented in Table 1.

Table 1. Dosage of SCC (contents per cubic meter).

Constituent Material	Quantity
OPC(OPC 53 grade)	455 kg
GGBS	68 kg
FA	45 kg
Coir pith ash	23 kg
Water	205 liters
Superplasticizer (Polycarboxylate ether-based)	4.5 liters
Fine aggregate (0/2 mm)	365 kg
Fine aggregate (0/4 mm)	365 kg
Coarse aggregate (10 mm)	520 kg
Coarse aggregate (20 mm)	

3.1 Fresh Properties of SCC

In the slump-flow test (Figure 1), the spread diameter (Dm) was measured immediately after lifting the slump cone. The V-funnel test (Figure 2) was used to FIND the flow time (t), representing the viscosity of the SCC [11].

The obtained results are presented in Table 2 and indicate that the mix achieved the required workability and stability criteria for self-compacting concrete. Visual inspection confirmed a uniform spread with homogeneous aggregate distribution and no signs of segregation or bleeding (Figure 1c).

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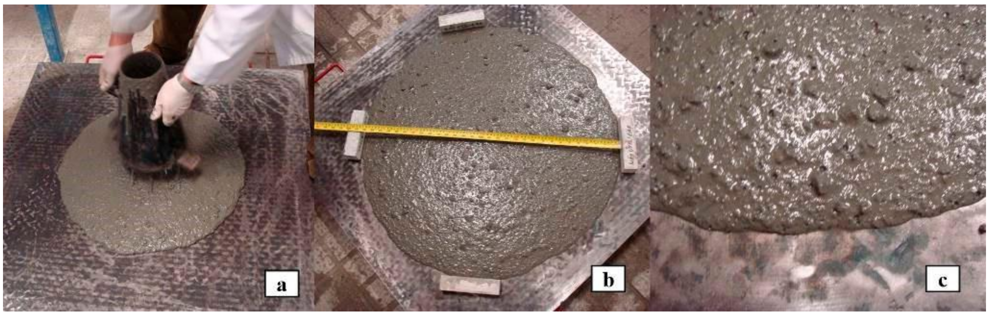

Figure 1. Slump test: (a) beginning of test, (b) diameter, (c) no segregation or bleeding.

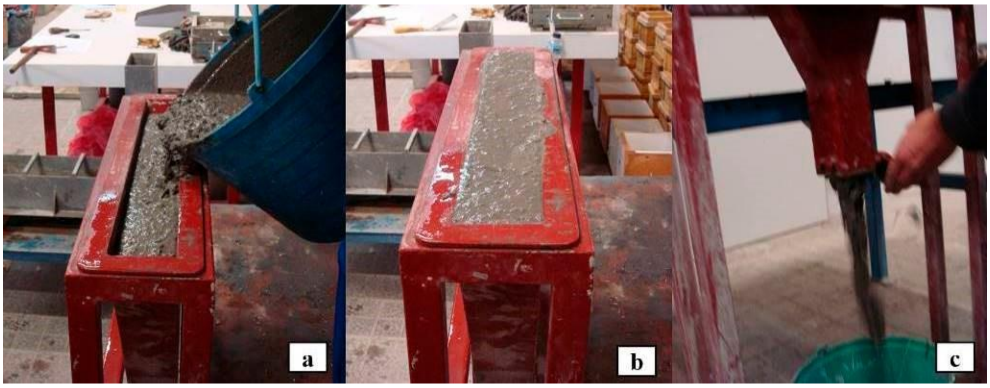

Figure 2. V-funnel test: (a) filling, (b) ready, (c) flow.

Table 2. Fresh properties of SCC.

Test	Parameter	Result	Typical Range (EFNARC 2005)
Slump-flow	Dm (mm)	780	650–800
V-funnel	t (s)	15.6	6–20

3.2 Production of Specimens for Testing

A total of seven sets of SCC specimens were mixed, all cast on the same day using a single batch of concrete to maintain consistency across the tests. The fresh concrete was poured directly into the molds without any vibration, taking advantage of its self-compacting nature (Figure 4).

Each set included one cube of 200 mm and four cubes of 150 mm.

- The 200 mm cube was used for installing five pull-out probes (one on each exposed face) and for embedding a maturity sensor to monitor temperature development during curing (Figure 5).
- The 150 mm cubes were reserved for the UPV(UPV), surface hardness, and compressive strength tests.

After casting, all specimens were covered with a plastic sheet to minimize moisture evaporation and kept at room temperature for the first 24 hours (Figure 6a). Once demolded (Figure 6b), the samples were transferred to a controlled curing chamber maintained at a temperature of around 20 °C and relative humidity of about 95%, following the guidelines of EN 12390-2:2000 [22] for preparing and curing strength specimens.

Throughout the curing period, slight variations in environmental conditions were recorded — the temperature ranged between 18 °C and 20 °C, while the humidity fluctuated between 90% and 95%, which were still within the acceptable limits for proper concrete hydration.

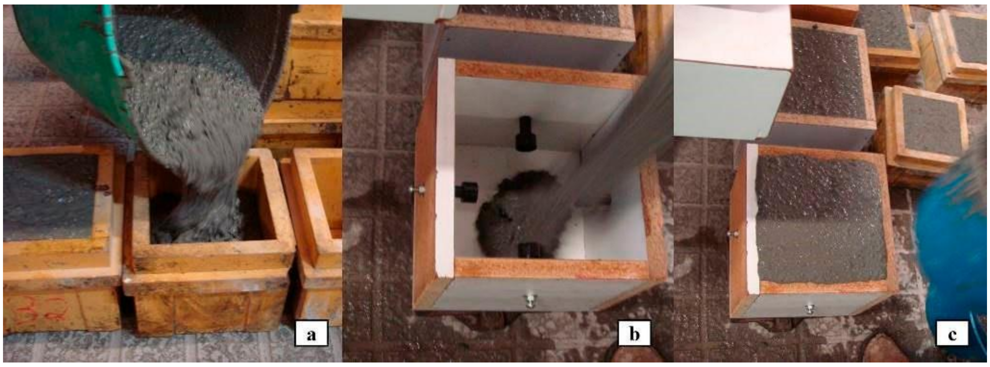

Figure 4. Casting of SCC specimens: (a) 150 mm cubes, (b) 200 mm cube for instrumentation, (c) placement of fresh concrete.

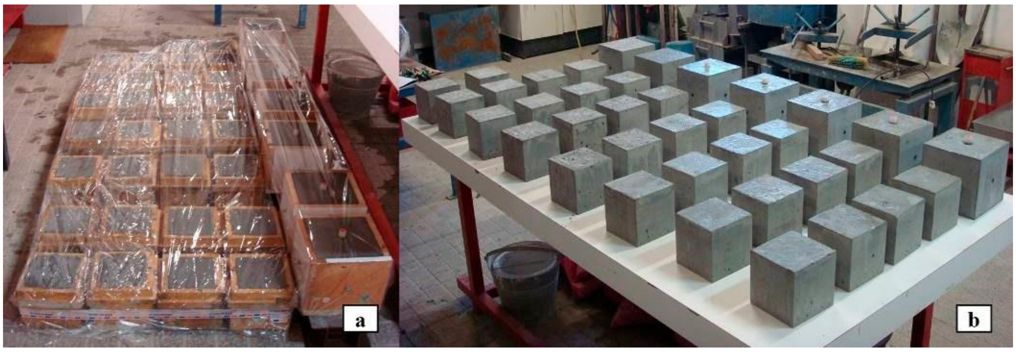

Figure 5. Concrete test specimens: (a) protection, (b) demolding.

3.3 Hardened Properties of SCC

The hardened behavior of the SSC(SCC) mix was examined through compressive strength and density evaluations at various curing ages [12]. The mean compressive strength results (f_{cm}) obtained from specimens cured under standard laboratory conditions are summarized in Table 3.

At 28 days, the concrete achieved a density of around 2320 kg/m³, confirming the mix's uniform compaction and good internal consistency. The trend of compressive strength development is depicted in Figure 7, which shows a steady and continuous strength gain with age—a response typically observed in mixtures containing supplementary cementitious materials (SCMs) such as FA, GGBS, and coir pith ash.

After 28 days of curing, the average compressive strength (f_{cm}) reached 87.24 MPa, with a standard deviation (S_d) of 1.42 MPa and a coefficient of variation (C_v) of 1.63%. Based on a normal strength distribution and applying a margin factor of 1.64, the characteristic compressive strength (f_{ck}) was estimated to be 85.9 MPa.

In line with the classification defined in NP EN 206-9:2010 [21], the SCC produced in this work falls under the C70/85 strength class, which qualifies it as high-strength self-compacting concrete.

Table 3. Hardened properties of SCC.

Series	Age (days)	(f_{cm}) (MPa)	(S_d) (MPa)	(C_v) (%)
P1	1	48.32	1.46	3.02
P2	2	55.64	1.87	3.36

P3	3	61.85	2.04	3.30
P7	7	70.12	2.65	3.78
P14	14	79.41	3.85	4.85
P28	28	87.24	1.42	1.63
P94	94	91.56	1.73	1.89

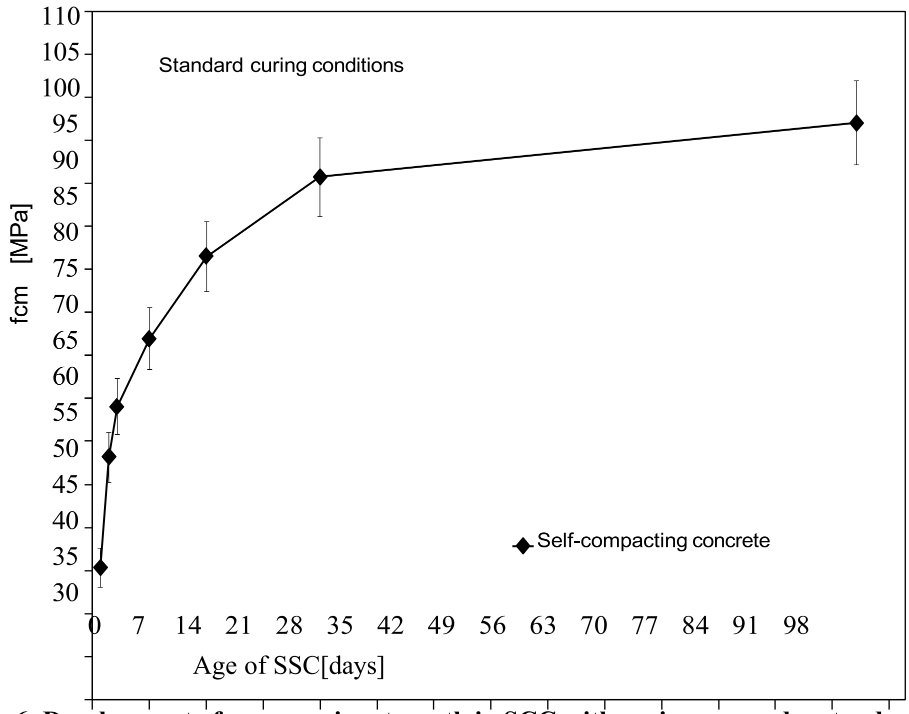

Figure 6. Development of compressive strength in SCC with curing age under standard conditions.

3.4 Non-Destructive Tests

All non-destructive testing (NDT) [13] procedures and corresponding correlation methods were conducted in accordance with the recommendations of BS 1881-201:1986 [23]. Among the available techniques, the UPV(UPV) test was chosen for its ability to assess internal concrete quality without causing surface damage. This method is especially suitable for evaluating the strength development and uniformity of self-compacting concrete.[23].

3.4.1 UPV Test

The UPV test was performed following [14], using a Portable Ultrasonic Non-Destructive Digital Indicating Tester (PUNDIT) manufactured by ELE International. The system was equipped with a pair of electro-acoustic transducers operating at a frequency of 54 kHz.

Before initiating each test series, the equipment was calibrated using a standard reference bar to ensure accuracy (Figure 8). For every age group, four readings were recorded on each 150 mm cube specimen. Measurements were taken between two parallel faces oriented perpendicular to the casting direction to minimize anisotropy effects.

The average pulse velocity (V) for each series was computed from the four individual readings and is summarized in Table 4. The measured velocities were later correlated with the corresponding compressive strength results to establish predictive relationships for the SCC mixes [15].

Figure 7. Calibration of the PUNDIT apparatus.

Table 4. UPVtest results.

Series	Age (days)	V (km/s)	Sd (km/s)	Cv (%)
P1	1	4.12	0.040	0.97
P2	2	4.28	0.028	0.65
P3	3	4.43	0.032	0.72
P7	7	4.56	0.036	0.79
P14	14	4.71	0.052	1.10
P28	28	4.83	0.024	0.50
P94	94	4.87	0.018	0.37

3.4.2 Surface Hardness Test

The surface hardness of the SSC(SCC) specimens was evaluated using the Schmidt rebound hammer (Type N), following the procedure outlined [16]. The hammer, with an impact energy of 2.207 Nm, was supplied by ELE International.

Before carrying out the rebound tests, and after completing the UPV(UPV) measurements, the average compressive strength of the mix was established from three out of four cubes (150 mm) in each testing series. The fourth specimen from every group was then used for the rebound hammer test.

To minimize unwanted movement during testing, each specimen was preloaded under a compressive stress equal to one-tenth of its mean compressive strength. This setup—achieved by confining the cube between steel loading plates in the compression testing frame (Figure 8b)—helped simulate field-like loading conditions and reduced the excessive bounce typically observed when testing freely supported samples.

During testing, the hammer was operated horizontally, and nine rebound impacts were taken on a molded surface perpendicular to the casting direction (Figure 8c). The device was calibrated before each test to ensure reliable measurements (Figure 8a).

The average rebound value (R), calculated from nine individual readings, was used to represent the surface hardness of each specimen. The complete set of results is summarized in Table 5.

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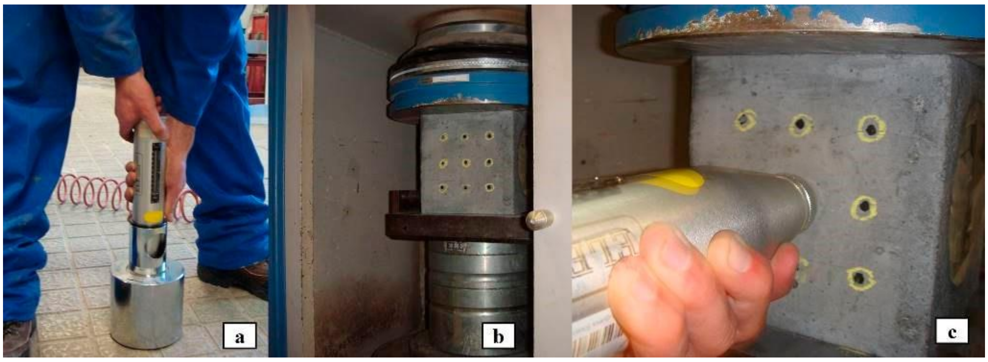

Figure 8. Surface hardness testing setup — (a) Calibration of the rebound hammer, (b)

Specimen confinement between steel plates, (c) Horizontal testing on molded surface.

Table 5. Surface hardness test results.

Series	Age (days)	R	Sd	Cv (%)
P1	1	34.25	0.72	2.10
P2	2	37.68	0.95	2.52
P3	3	40.12	1.05	2.62
P7	7	42.86	1.18	2.75
P14	14	45.73	1.64	3.58
P28	28	47.95	1.22	2.55
P94	94	49.88	0.78	1.56

4 Presentation and Discussion of the Results

4.1 UPV Test

Figure 15 shows the experimentally obtained relationship between the average UPV(V, km·s^{-1}) and the average compressive strength (f_m, MPa) for the SCC series. An exponential model was used to fit the data because it provides a physically plausible growth trend for strength with increasing pulse velocity. The fitted equation (obtained by least-squares fitting of an exponential form) is:

$$f_{cm} = 1.684 \times e^{0.8159\,V}$$

where $f_{cm}$is in MPa and $V$is in km·s^{-1}. The goodness-of-fit is high: the model yields $R^2 = 0.993$(Pearson correlation coefficient $r \approx 0.997$), indicating that the exponential curve explains about 99.3% of the variance in the measured compressive strength for the tested SCC mixture and ages.

The UPV readings and corresponding statistics used to obtain this correlation are summarized in Table 4. For the seven age groups the measured average velocities ranged from 4.12 km·s^{-1} (P1, 1 day) to 4.87 km·s^{-1} (P94, 94 days). The standard deviation (S_n) of velocity for each group varied between 0.018 and 0.052 km·s^{-1}, with a mean standard deviation of 0.0329 km·s^{-1}. The coefficient of variation (Cv) of the UPV readings ranged from 0.37% to 1.10%, with a mean Cv of 0.73%. These low Cv values indicate good repeatability of the UPV measurements within each series.

A few careful observations and practical cautions:

- Trend and plateau behavior. The UPV–strength relationship shows a steady increase up to about 4.8 km·s^{-1}. Beyond this region (near the highest velocities observed), the rate of strength increase per increment of velocity becomes smaller — i.e., the curve flattens somewhat. In this data set the flattening is slight (4.83 → 4.87 km·s^{-1} corresponds to a modest strength gain), but it does suggest reduced sensitivity of UPV for incremental strength prediction at very high velocities. Avoid extrapolating the correlation far outside the measured velocity range.
- Material specificity. The correlation above is mix-specific: it applies to the SCC produced with your binder composition (OPC + GGBS + FA + coir pith ash) and the aggregate grading, casting, curing, and test procedures used in this study. Applying the same equation to other SCC mixes, different aggregate sizes, reinforcement configurations, or different curing regimes will likely produce larger errors.
- Repeatability and uncertainty. The within-series standard deviations and Cv values show good repeatability for the performed measurements. Still, when using the UPV-based prediction for in-situ strength assessment, consider an uncertainty band around the predicted mean (e.g., ±10–20% depending on local calibration and purpose) and corroborate with at least some destructive tests or alternative inspections for critical decisions.
- Reinforcement and boundary effects. Note that UPV readings can be affected by reinforcement, specimen geometry, moisture condition, and coupling quality. In this laboratory program measurements were taken on unreinforced 150 mm cubes between parallel faces perpendicular to casting direction to minimize anisotropy and reinforcement effects.

Summary (numeric highlights):

- UPV range (averages): 4.12 → 4.87 km·s^{-1} (P1 → P94)
- Compressive strength range (used for fit): 48.32 → 91.56 MPa

- Exponential fit: $f_{cm} = 1.684\, e^{0.8159V}$(MPa, V in km·s⁻¹)
- Fit quality: $R^2 = 0.993$(very high fit for the tested dataset)
- UPV variability across repeats: S̄d ≈ 0.0329 km·s⁻¹, Cv̄ ≈ 0.73%

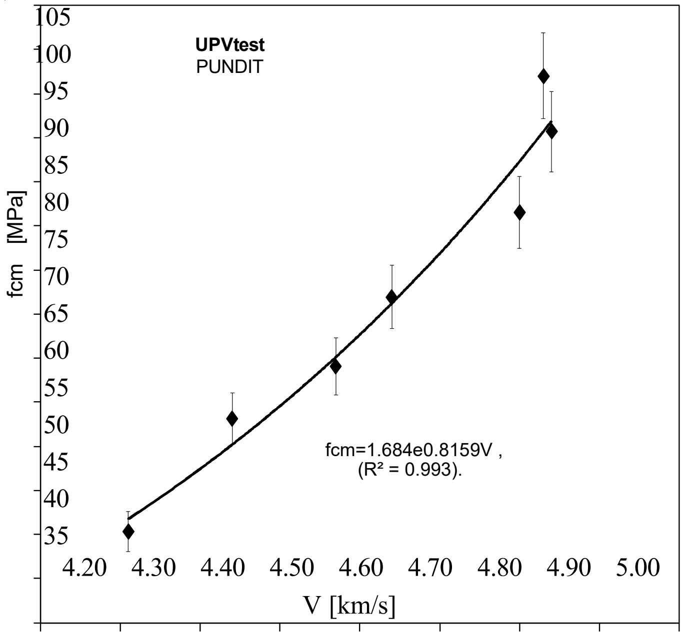

Figure 15. UPV v/s average compressive strength.

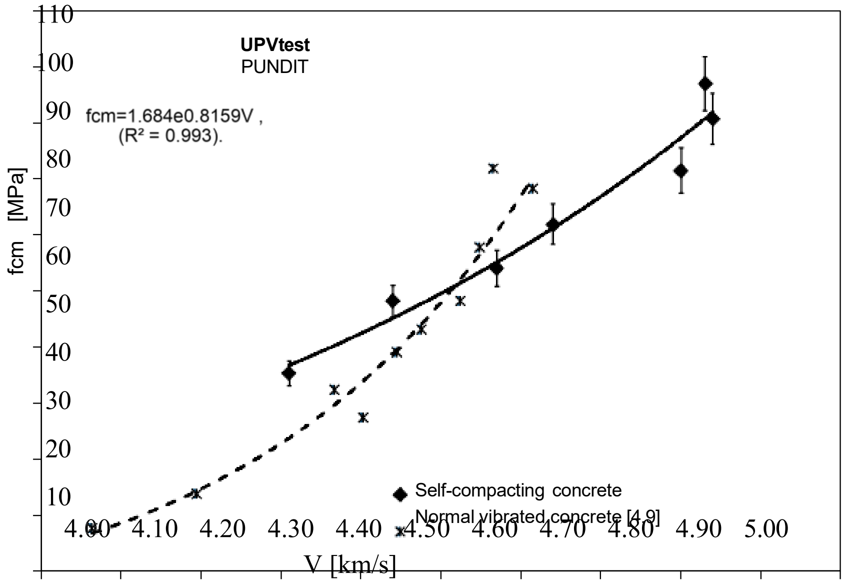

Figure 16. SCC V/S NVC using UPV.

4.2 Surface Hardness Test

Figure 17 illustrates the correlation established between the rebound number (R) and the average compressive strength (f_m) for the SSC(SCC). The best-fit linear relationship, shown as a continuous line, exhibits a strong correlation coefficient of 0.96, confirming that rebound number readings can be used as a reliable indicator of surface strength for the tested SCC mixtures.

As presented in Figure 18, the correlation derived for SCC in this study was compared to that reported by Nepomuceno and Lopes [4, 9] for normal vibrated concrete (NVC) of similar compressive strength. Noticeable differences are observed between both correlations, primarily attributed to the variation in mortar-to-coarse aggregate ratios and the maximum aggregate size used in SCC compared to NVC. Furthermore, the absence of external vibration during SCC placement and its higher paste content contribute to a more homogeneous but less densified surface layer, which may result in slightly lower rebound numbers for similar compressive strength levels.In general, NVC tends to display higher surface hardness values for equivalent compressive strengths, possibly due to the compaction energy imparted during vibration, enhancing the near-surface density.From the results shown in Table 5, the standard deviation (Sd) for SCC varied between 0.65 and 2.22, with an average of 1.23. These findings are consistent with the NVC studies [4, 9], where Sd ranged from 0.66 to 1.93, averaging 1.11. Similarly, the coefficient of variation (Cv) for SCC ranged from 1.3% to 4.8%, averaging 2.8%, which aligns closely with the NVC results where Cv ranged between 1.3% and 5.0%, averaging 3.0%.According to Bungey [24], typical Cv values around 4% are expected when performing rebound hammer tests on different points of a single specimen, confirming that the present results are within acceptable repeatability limits.The statistical analysis indicates that Sd remains nearly constant across strength levels, while Cv slightly decreases as compressive strength increases, suggesting that Sd is the more stable parameter for evaluating the repeatability of rebound hammer results in SCC.

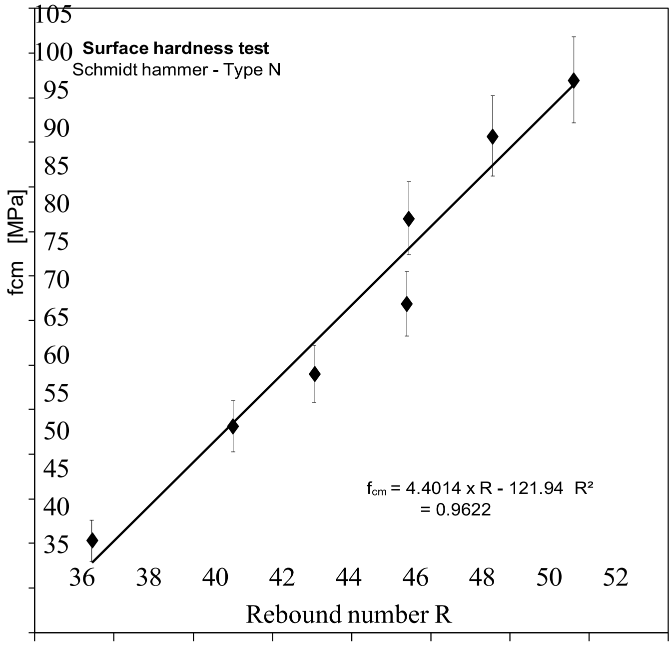

Figure 17. Rebound number V/S average compressive strength.

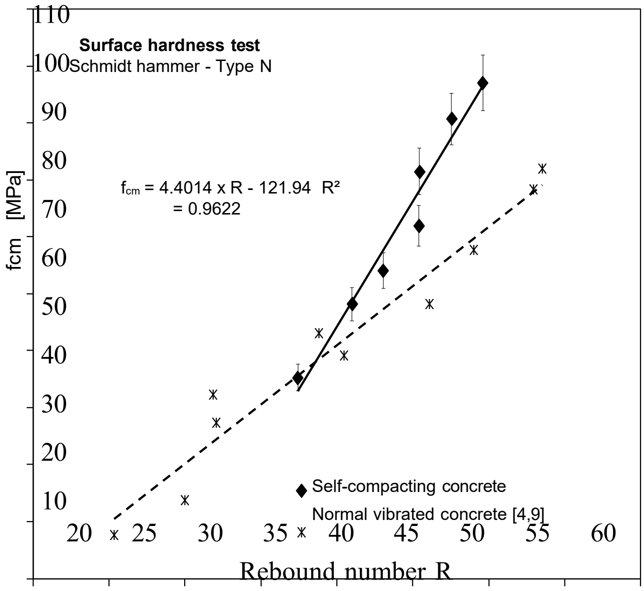

Figure 18. SCC V/S NVC using surface hardness test.

5 Conclusions

Concerning the main achievement in this article the following conclusions can be drawn:

- The results showed strong correlations between the SCC compressive strength and the NDT test readings. For UPV(UPV), the correlation coefficient was approximately 0.97, while for the surface hardness (rebound number) test, it was about 0.96. However, some deviations were observed when compared with the correlations obtained for NVC, particularly in the case of surface hardness. Hence, when applying general correlations to SCC, they should be used with caution.
- The surface hardness of SCC was slightly lower than that of NVC for the same level of compressive strength. This can be attributed to differences in mixture proportions and compaction methods. SCC, which consolidates under its own weight without external vibration, generally contains a higher paste volume and smaller maximum aggregate size, leading to a less dense near-surface zone. In contrast, external vibration used for NVC tends to densify the surface region, resulting in higher rebound numbers.
- The analysis of test variability revealed that for SCC, the standard deviation (Sd) and coefficient of variation (Cv) obtained from the UPV and surface hardness tests were consistent and within acceptable limits. For the surface hardness test, Sd ranged from 0.63 to 2.24 with an average of 1.21, and Cv ranged from 1.3 to 4.9% with an average of 2.7%. For the UPV test, Sd varied between 17.2 and 41.2 m/s (average 30.4 m/s), and Cv ranged from 0.2 to 0.7% (average 0.4%). These results indicate good repeatability and confirm that both NDT methods provide reliable and consistent readings for SCC.

6. References

[1] M. Abed and J. de Brito, "Evaluation of high-performance self-compacting concrete using alternative materials and exposed to elevated temperatures by non-destructive testing.," *Journal of Building Engineering,* vol. 32, p. 101720, 2020.

[2] R. H. Haddad, R. A. Odeh, H. A. Amawi and A. N. Ababneh, "Thermal performance of self-compacting concrete: destructive and nondestructive evaluation.," *Canadian Journal of Civil Engineering,* vol. 40(12), pp. 1205-1214, 2013.

[3] M. C. Nepomuceno and L. F. Bernardo, "Evaluation of self-compacting concrete strength with non-destructive tests for concrete structures.," *Applied Sciences,* vol. 9(23), p. 5109, 2019.

[4] D. Tripathi, R. Kumar, P. K. Mehta and A. Singh, "Evaluation of a sustainable self compacting concrete using destructive and non-destructive testing.," *Materials Today: Proceedings,* vol. 58, pp. 830-835, 2022.

[5] D. Rama Seshu and A. Pratusha, "Study on compressive strength behaviour of normal concrete and self-compacting concrete subjected to elevated temperatures.," *Magazine of concrete research,* vol. 65(7), pp. 415-421, 2013.

[6] A. Sadrmomtazi, S. H. Gashti and B. Tahmouresi, "Residual strength and microstructure of fiber reinforced self-compacting concrete exposed to high temperatures.," *Construction and Building Materials,* vol. 230, p. 116969, 2020.

[7] M. Karatas, M. Dener, A. Benli and M. Mohabbi, " High temperature effect on the mechanical behavior of steel fiber reinforced self-compacting concrete containing ground pumice powder.," *Structural Concrete,* vol. 20(5), pp. 1734-1749., 2019.

[8] I. 1.-1. 1992, "NON-DESTRUCTIVE TESTING OF CONCRETE -," *IS,* p. 14, 1992.

[9] A. F. Obaton, B. Butsch, E. Carcreff, N. Laroche, J. Tarr and A. Donmez, "Efficient volumetric non-destructive testing methods for additively manufactured parts," *2020,* Vols. 1417-1425, p. 64(8), Welding in the World.

[10] P. Müller, J. Novák and J. Holan, "Destructive and non-destructive experimental investigation of polypropylene fibre reinforced concrete

subjected to high temperature.," *Journal of Building Engineering, 26, 100906.*, vol. 26, p. 100906, 2019.

[11] O. Benjeddou, H. Y. Katman, M. Jedidi and N. Mashaan, "Experimental investigation of the high temperatures effects on self-compacting concrete properties.," *Buildings,* vol. 12(6), p. 729., 2022.

[12] M. Fenollera, J. L. Míguez, I. Goicoechea and J. Lorenzo, "Experimental study on thermal conductivity of self-compacting concrete with recycled aggregate.," *Materials,* vol. 8(7), pp. 4457-4478., 2015.

[13] A. M. Ashteyat and M. Ismeik, " Predicting residual compressive strength of self-compacted concrete under various temperatures and relative humidity conditions by artificial neural networks.," *Computers and Concrete,* vol. 21(1), pp. 47-54, 2018.

[14] A. M. Ashteyat, R. H. Haddad and M. Ismeik, "Prediction of mechanical properties of post-heated self-compacting concrete using non-destructive tests.," *European journal of environmental and civil engineering,* vol. 18(1), pp. 1-10., 2014.

[15] H. H. Y. Al-Radi, S. Dejian and H. K. Sultan, "Performance of fiber self compacting concrete at high temperatures," *Civil Engineering Journal,* vol. 7(12), pp. 2083-2098, 2021.

[16] S. Kazemifard, S. Motaghed and N. Eftekhari, " NDT prediction of self-compacting concrete strength based on maturity method.," *Multiscale and Multidisciplinary Modeling, Experiments and Design,*, vol. 7(2), pp. 1031-1043, 2024.

[17] I. 1. P.-2. 1992, "NON- DISTRUCTIVE TESTING REBOUND HAMMER TEST," *Indian Standards,* p. 12, 1992.