



Automated Excel-Based Mix Proportioning Framework for High-Strength Concrete (M70) Using IS 10262:2019

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Abstract. According to IS 10262:2019, designing a concrete mix includes complicated calculations that can easily go wrong, especially for high-strength concrete mixes. This document discusses the creation and testing of an automated framework for proportioning concrete mixes using Microsoft Excel that completely meets the requirements of IS 10262:2019. This framework works with all grades of concrete mix, from M10 to M100. It includes statistical target strength calculation, water-cement ratio calculation, supplementary cementitious material compensation, volumetric yield correction, and IS 456:2000 durability constraint satisfaction in one tool. We tested this framework by using it on a detailed example of an M70 grade high-strength concrete mix using UltraTech OPC 53 grade cement, a 10% silica fume replacement, and a PCE-based superplasticizer at a dose of 1.20%. Nine cube specimens were tested for compressive strength as part of the experimental validation. The average compressive strength was 45.82 MPa at 7 days, 48.74 MPa at 14 days, and 78.94 MPa at 28 days, which is much higher than the goal strength for the M70 grade mix, which is 77 MPa. This tool cuts down on the time it takes to develop a mix and makes a quality control batch sheet that is ready to use on site.

Keywords: IS 10262:2019, M70 High-Strength Concrete, Excel Automation, Mix Proportioning, Silica Fume, Superplasticizer, Compressive Strength.

1 Introduction

The selection of materials and their proportioning are important aspects for meeting the performance requirements for concrete. This process is regulated through IS 10262 by the Bureau of Indian Standards (BIS). IS 10262 was revised in 2019 and can be considered a major revision for updating the framework for covering high-strength grades ranging from M10 to M100 along with mass concrete and self-compacting concrete. Today's concrete mix may consist of a multi-component cement-based material with complex interrelations between fly ash, GGBS, silica fume, and chemical admixtures. In order to avoid any computation error, especially while calculating the water-cement ratio and while verifying the constraint for strength against durability, the Excel-based framework has been proposed. This paper proposes a computationally systematic procedure for calculating the mix proportioning using the Microsoft Excel framework.

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Concrete is an essential building element for modern infrastructure. But regular concrete could not hold up well when there are large structural loads or harsh chemicals. Because of this, some engineering qualities of concrete need to be improved to achieve high performance standards. High-strength concrete (HSC) has better compressive strength because it uses high-quality materials and mixes them in the right amounts. Crushed rock aggregates are the best way to make HSC. The maximum nominal aggregate size should be between 10 mm and 12.5 mm, and it shouldn't be too sharp or lengthy. Smaller aggregates are better because they have stronger bonds between their surfaces than bigger aggregates. The water-cement (w/c) ratio is another important factor in making HSC. It is inversely related to compressive strength and directly related to workability. Raising the w/c ratio makes workability better but strength worse. Lowering the w/c ratio makes strength better but workability worse. So, a low w/c ratio is quite important when designing HSC mixes. Because of the low w/c ratio and the addition of supplemental cementitious materials (SCMs), a superplasticizer must be used to keep the workability. Superplasticizers made from polycarboxylate ether (PCE) can cut down on water use by as much as 30%. But systematic trial mixtures are needed to find the best dose.

1.1 Objectives of the Study

The objectives of this study are:

- To develop an automated Excel-based tool for IS 10262:2019 mix proportioning applicable from M10 to M100.
- To demonstrate the framework through a detailed M70 grade HSC case study.
- To validate the mix design experimentally through compressive strength testing.

2 Literature Review

2.1 Silica Fume in High-Strength Concrete

Silica fume is one of the materials that is known for being very reactive as a pozzolan material and improves the strength of high-strength concrete. The research has indicated that the use of silica fume in concrete enhances the compressive strength owing to its role as a micro-filler and pozzolan [1] conducted research on different types of cementitious systems such as binary and ternary mixes. The researchers found that a mixture of cement, fly ash, and silica fume produced the best compressive strength when the silica fume made up 6% of the total. Similarly, Singh and Kumar [2] studied different replacement levels of 5%, 10%, and 15% and found that a replacement of 5–10% was best for achieving the highest strength. In addition, the study by [6] indicated that the increase in silica fume content increases the early-age strength and rigidity but makes the mix less workable.

2.2 Combined Use of Supplementary Cementitious Materials (SCMs)

Combination use of supplementary cementitious materials like fly ash, silica fume, and GGBFS plays an important role in increasing the strength and durability of high-performance concrete. [1] mentioned that silica fume was responsible for early gains in strength, whereas fly ash helped to gain high strength over the period. According to [14], the best strength is achieved by using a mixture of 20-30% GGBFS and 10% silica fume, which lowers the porosity and provides high durability. Similarly, Authors of [4] also pointed out that cement can be replaced partially (10-20%) with supplementary cementitious materials, but workability will be affected based upon the nature of materials used.

2.3 Effect of Silica Fume and SCMs on Workability and Setting Time

The addition of silica fume and mineral admixtures causes a noticeable impact on the fresh properties of concrete, such as workability and setting time. It found in [4] that the lower values of the ratio between water and cement improve strength but decrease workability, which could be improved through the use of polycarboxylate ether superplasticisers. According to [5], the addition of silica fume, metakaolin, fly ash, and GGBS results in retardation of setting time in the case of high-strength concrete, the higher being the amount of replacement of materials. Especially in the case of GGBS, when amounts exceed 40%, setting time is notably increased.

2.4 Aggregate Gradation and Mix Design Optimization

Aggregates grading is one of the key factors in producing dense and strong concrete. According to [3], aggregate grading has a significant effect on concrete, and a mixture of fine aggregate (4.75-10 mm) with a 40% proportion and coarse aggregate (10-20 mm) with a 60% proportion would reduce void space and increase density. Another important suggestion by the authors was that Zone II sand should be used to fill void spaces [7], [13]. Furthermore, rapid curing was observed to positively impact compressive strength.

2.5 Strength Prediction and Optimization Techniques

The application of sophisticated methods for analysis and statistical predictions is becoming more popular to determine and maximize the characteristics of high-strength concrete mixes. For example, [13] used an RSM technique based on IS 10262:2019 guidelines and established that use of 8–12% silica fume leads to compression strengths higher than 70 MPa. In addition, [15] employed the application of machine learning algorithms such as decision tree regression, support vector regression, and artificial neural network techniques to estimate the mix characteristics [15], [17]. The study revealed that the best result is achieved by the decision tree regression algorithm, and the use of plasticizers plays a crucial role in mix proportions.

2.6 Research Gap

Although there have been extensive studies on HSC materials and mix design, there is a significant gap identified as far as available IS 10262:2019 compliant automated tools for calculating statistical target strength, including durability requirements, SCM, and volumetric yield correction within one package. Although there have been studies on the application of machine learning and computational models for mix design optimisation [16], these models tend to be complex and require programming expertise. A simple, transparent, and compliant tool available in Excel format, which is useful for practicing engineers, is of significant importance. This paper aims to bridge that gap.

3 REGULATORY EVOLUTION AND STATISTICAL PARAMETERS

3.1 The 2019 Model Shift

IS 10262:2019 has changed the way mix design is done in a big way by breaking it down into steps that are easier to understand. It has also changed the target mean strength equation in a big way such that there is a statistical confidence level that the results of in-place tests will reach or surpass the required characteristic strength. This new standard now applies to grades M10 to M100, which means it can be used directly for high-strength and ultra-high-strength concrete for infrastructure projects.

3.2 Statistical Target Strength Logic

The target mean compressive strength (f^*_{ck}) is computed as the higher of two criteria specified in IS 10262:2019:

$$f^*_{ck} = f_{ck} + 1.65 S \quad \text{or} \quad f^*_{ck} = f_{ck} + X \quad (\text{whichever is higher})$$

Where S is the standard deviation (MPa) corresponding to the degree of quality control, and X is a grade-dependent factor for grades above M55. For M70 grade with good quality control, $S = 5$ MPa and $X = 6.5$ MPa, resulting in a target mean strength $f^*_{ck} = 70 + 6.5 = 76.5$ MPa ≈ 77 MPa.

3.3 Key Design Parameters

IS 10262:2019 says that you need to find out the following: (i) the maximum free water-cement ratio based on durability exposure, (ii) the minimum cement content, (iii) the maximum aggregate size, (iv) the workability requirement, and (v) the SCM adjustment parameters. The maximum w/c ratio for M70 grade in very harsh conditions.

4 Excel Framework Development

4.1 Objective and Structure

The Excel framework automates the IS 10262:2019 mix design process, so the user only has to put in a little bit of effort. There are four sheets in the workbook that are linked to each other: (i) an Input Sheet for material properties and design requirements; (ii) a Calculations Sheet that uses cell formulas to do all of the IS 10262:2019 step-by-step calculations; (iii) a Mix Proportions & QC Sheet that shows the final mix proportions, batch weights, and compressive strength results; and (iv) a Batch Sheet that shows the corrected batch weights that are ready for the site, taking into account surface moisture and water absorption.

4.2 Key Automated Calculations

The framework executes the following automated calculations in sequence:

- Target mean strength (f'_{ck}) based on grade and quality control level
- Water-cement ratio selection from IS 10262:2019 Figure 1, subject to IS 456 maximum.
- Water content estimation based on workability (slump) and nominal maximum aggregate size
- Cement and SCM content with volumetric adjustment for silica fume
- Absolute volume calculation for all constituents
- Fine and coarse aggregate split by zone and grading (IS 10262:2019 Table 3)
- Admixture dosage as percentage of cementitious content
- Batch weight correction for surface moisture and water absorption

4.3 Design Flowchart

The mix proportioning process follows the logical sequence defined in IS 10262:2019: Design Stipulations (Exposure, Grade, w/c limit) → Target Mean Strength → w/c Ratio → Water Content → Cementitious Content → SCM Substitution → Admixture Dosage → Absolute Volume → Aggregate Split → Volumetric Yield Check → IS 456 Durability Compliance → Batch Sheet Output. Each step is linked through cell references, ensuring that a change in any input parameter automatically propagates through the entire calculation chain as shown in Fig. 1.

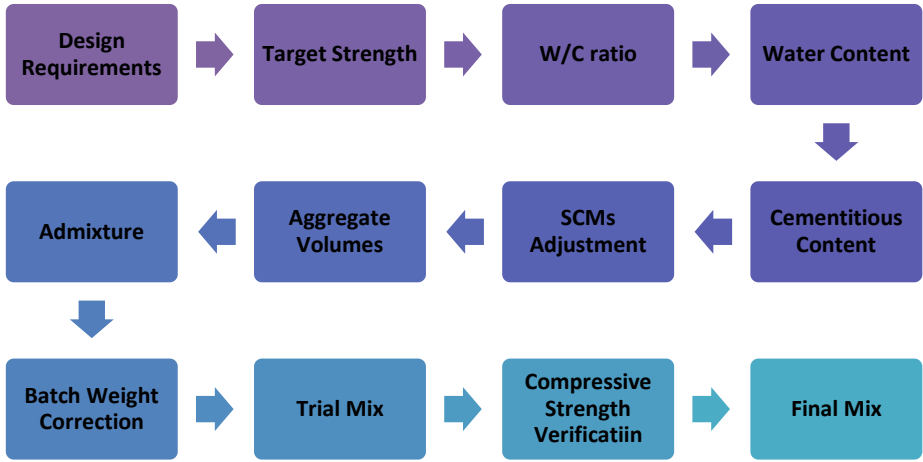


Fig 1. The mix proportioning process sequence

4.4 Advantages of the Framework

- Cuts the time it takes to design a mix from hours to less than five minutes
- Takes out mistakes made by hand when interpolating IS 10262:2019 figures and tables
- Works with any grade from M10 to M100 by altering the input parameters
- Automatically marks violations of IS 456:2000 durability limits with PASS/FAIL signs
- Makes a quality control batch sheet that is ready to use on site, with water added to rectify the moisture in the aggregate

5 Methodology

5.1 Stipulations for Proportioning

The following Table 1 shows the design stipulations were adopted for the M70 HSC mix design in accordance with IS 10262:2019 and IS 456:2000:

Table 1. Design Stipulations for M70 HSC Mix (IS 10262:2019 / IS 456:2000)

Ref.	Item	Parameter	Value
[1]	Grade Designation	Characteristic compressive strength	M70
[2]	Type of Cement	Cement type	OPC 53 Grade

[3]	Maximum nominal size of aggregate	NMC Aggregate	20 mm
[4]	Minimum cement content	IS 456:2000 – Severe exposure	360 kg/m ³
[5]	Maximum free w/c ratio	IS 456:2000 – Severe exposure	0.33
[6]	Degree of workability	Slump	85 mm
[7]	Type of exposure	Exposure condition	Severe
[8]	Method of concrete placing	Placement method	Non-pumpable
[9]	Degree of quality control	Quality control level	Good
[10]	Type of aggregate	Aggregate shape	Crushed angular
[11]	Maximum cement content	Upper limit	450 kg/m ³
[12]	Chemical admixture	Admixture type	Super Plasticizer (PCE)

5.2 Material Properties

The following materials were used in the M70 mix design:

Table 2. Material Properties Used in M70 Mix Design.

Material	Property	Value	Unit
Cement (OPC 53)	Specific gravity	3.16	—
Cement (OPC 53)	Fineness	268	m ² /kg
Silica Fume	Specific gravity	2.23	—
Silica Fume	Replacement of cement	10	%
River Sand (FA-I)	Specific gravity	2.54	—
River Sand (FA-I)	Water absorption	2.88	%
River Sand (FA-I)	Grading zone	Zone	—
		II	
Crushed Sand (FA-II)	Specific gravity	2.73	—
Crushed Sand (FA-II)	Water absorption	2.92	%
CA-I (20 mm)	Specific gravity	2.88	—
CA-I (20 mm)	Water absorption	0.84	%
CA-II (10 mm)	Specific gravity	2.83	—
CA-II (10 mm)	Water absorption	1.65	%
Admixture (Fosroc PCE)	Specific gravity	1.10	—
Admixture (Fosroc PCE)	Dosage	1.20	% of cementitious

5.3 Step-by-Step Mix Design Calculations

Step 1 — Target Mean Compressive Strength: For M70 grade with good quality control ($S = 5$ MPa, $X = 6.5$ MPa): $f'_{ck} = \max(70 + 1.65 \times 5, 70 + 6.5) = \max(78.25, 76.5) = 78.25$ MPa ≈ 77 MPa (adopted).

Step 2 — Free Water-Cement Ratio: From IS 10262:2019 Figure 1, the w/c ratio corresponding to the target mean strength of 77 MPa is approximately 0.33. This satisfies the IS 456:2000 maximum w/c ratio of 0.33 for severe exposure. Adopted w/c = 0.33.

Step 3 — Water Content: From IS 10262:2019, Table 2, the base water content for 20 mm crushed angular aggregate with a 50 mm slump is 186 kg/m³. Correction for target slump of 85 mm: +3% per 25 mm above 50 mm = +4.46 kg/m³. Reduction for 10% silica fume: -3% = -5.58 kg/m³. Net free water content $W = 186 + 4.46 - 5.58 = 184.88 \approx 185$ kg/m³.

Step 4 — Cementitious Content: Total cementitious content, $C_t = W / (w/c) = 185 / 0.33 = 550$ kg/m³. Silica fume content (10%): $SF = 550 \times 0.10 = 55$ kg/m³. Cement content, $C = 550 - 55 = 495$ kg/m³. Check: $360 \leq 495 \leq 450$ — PASS (cement within limits).

Step 5 — Admixture Dosage: Admixture = $C_t \times \text{dosage}\% = 550 \times 1.20/100 = 6.60$ kg/m³ (Fosroc Auramix 300, PCE-based, Sp. Gr. 1.10). Adopted dosage in batch: 5.50 kg/m³ (adjusted per trial) [19].

Step 6 — Absolute Volume: Volume fractions: Entrapped air = 0.015 m³; cement = $495/(3160) = 0.1566$ m³; silica fume = $55/(2230) = 0.0247$ m³; water = $185/1000 = 0.185$ m³; admixture = $5.50/(1100) = 0.005$ m³. Total aggregate volume $V_{agg} = 1 - 0.015 - 0.1566 - 0.0247 - 0.185 - 0.005 = 0.6137$ m³.

Step 7 — Fine/Coarse Aggregate Split: Fine aggregate fraction (IS 10262 Table 3, 20 mm, Zone II, w/c ≈ 0.33) = 36%. Volume FA = $0.6137 \times 0.36 = 0.2209$ m³; Volume CA = 0.3928 m³. The river sand fraction of FA is 60%; the CA-20 mm fraction of CA is 60%. Resulting masses: River sand = 644.51 kg/m³; Crushed sand = 0 kg/m³; CA-20 mm = 693.70 kg/m³; CA-10 mm = 454.44 kg/m³.

Step 8 — Volumetric Yield Check: Sum of all absolute volumes = 1.000 m³ — PASS (within ± 0.002 tolerance).

5.4 Final Mix Proportions

The final design mix proportions per 1 m³ and batch quantities for a 0.04 m³ trial mix are summarised in Table 3.

Table 3. Final Mix Proportions for M70 HSC (IS 10262:2019)

Ingredient	kg/m ³	m ³ /m ³	Ratio to Cement	Batch 0.04 m ³ (kg)	Remarks
Cement (OPC 53)	495.0	0.1566	1.00	19.800	Base cementitious
Silica Fume (10%)	55.0	0.0247	0.11	2.200	SCM replacement
Water	185.0	0.1850	0.37	7.400	Net free water

Admixture (PCE)	5.50	0.0050	0.011	0.220	Fosroc Auramix 300
River Sand (FA-I)	644.51	0.2537	1.30	25.780	Zone II graded
Crushed Sand (FA-II)	0.00	0.0000	0.00	0.000	Not used
CA 20 mm	693.70	0.2409	1.40	27.748	60% of CA
CA 10 mm	454.44	0.1607	0.92	18.178	40% of CA
TOTAL	2533.15	1.000	—	101.326	Yield \approx 1.000 m ³

5.5 Quality Control Batch Sheet

Table 4 presents the batch weight correction sheet incorporating water absorption of aggregates. Net Moisture Content (NMC) values are entered from site measurements. A negative water correction indicates that the aggregate requires absorption of water from the mix.

Table 4. Quality Control Batch Sheet — M70 HSC (IS 10262:2019)

Ingredient	Design kg/m ³	NMC %	WA %	Water Correction (kg)	Corrected kg/m ³	For 0.04 m ³ (kg)
Cement	495.00	0.00	0.00	0.00	495.00	19.800
Silica Fume	55.00	0.00	0.00	0.00	55.00	2.200
Water	185.00	—	—	+0.32	185.32	7.413
CA 20 mm	693.70	0.00	0.84	-0.06	693.64	27.746
CA 10 mm	454.44	0.00	1.65	-0.07	454.36	18.175
River Sand	644.51	0.00	2.88	-0.19	644.32	25.773
Crushed Sand	0.00	0.00	2.92	0.00	0.00	0.000
Admixture	5.50	—	—	0.00	5.50	0.220
Total	\approx 2348	—	—	-0.32	\approx 2348	—

6 Results and Discussion

The compressive strength test results are presented in Table 5. Nine cube specimens (150 mm \times 150 mm \times 150 mm) were cast and cured under standard conditions. Compressive strength was evaluated at 7, 14, and 28 days of curing in accordance with IS 516:1959 [18].

Table 5. Compressive Strength Test Results

Obs. No.	Curing (days)	Weight of Cube (g)	Load at Failure (kN)	Compressive Strength (MPa)	Average Compressive Strength (MPa)
1	7	9035	939.2	41.74	45.82
2		9023	1088.55	48.38	
3		8769	1065.4	47.35	

4	14	9283	1030	45.77	
5		8907	1065	47.33	48.74
6		8961	1196.2	53.13	
7	28	8753	1863.3	82.81	
8		9240	1739.8	77.32	78.94
9		8678	1793.02	79.69	

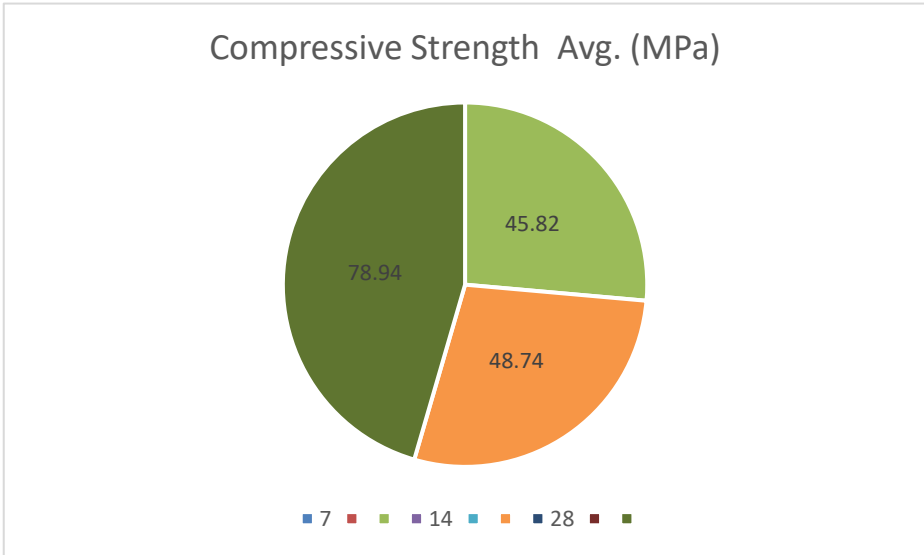


Fig. 2. Average Compressive Strength for 7, 14, and 28 days

From Fig. 2, the average 7-day compressive strength of 45.82 MPa indicates an increase of nearly 58% over the 28-day goal strength. This is consistent with what we would expect from OPC 53 grade cement to which silica fume is added. The increase is due to the reaction of silica fume with pozzolans. Silica fume reacts with calcium hydroxide, a by-product of the cement hydration reaction. The average compressive strength of 48.74 MPa over 14 days indicates an increase in strength from 7 to 14 days. It is increasing at a moderate rate. It indicates that 61.7% of the desired strength for 28 days has been achieved. The moderate increase from 7 to 14 days indicates that the main pozzolanic reaction of silica fume is complete by the end of the first week. This is consistent with the results reported by [6]. The results reported by [13] confirm the above results. They report similar characteristics of the increase in the strength of silica fume added to HSC at 8-12%.

The average compressive strength after 28 days is found to be 78.94 MPa, which is greater than the target strength of 77 MPa and characteristic strength of 70 MPa, i.e., M70 grade concrete. This again confirms that the design technique of IS 10262:2019 for mix design in the Excel framework is correct. Further, it can be observed that all the compressive strengths of nine specimens are greater than the target strength. This again confirms that the design technique of mix design is correct and that quality control is

effective during the casting of specimens. Further, it can be noted that the minimum compressive strength of 77.32 MPa, as observed in the case of Specimen 8, confirms that the design technique of mix design is correct in satisfying the characteristic strength of M70 grade concrete. Similar trends were also observed in [15], where they studied the properties of HSC with M65 to M75 grades using a combination of ground granulated blast furnace slag and silica fume.

From the study, it can be observed that the effect of SCM in HSC resulted in a synergistic effect of increasing the density of the interfacial transition zone.

The w/c ratio of 0.33, along with 10% substitution of silica fume and PCE-based superplasticizer at a 1.20% dosage, was found to be the critical combination that made the M70 performance possible. The superplasticizer was effective in maintaining sufficient workability at an 85 mm slump, even at such low levels of w/c ratio. This confirms that PCE-based superplasticizers are essential in the production of HSC at such high levels of strength. This is in accordance with the results obtained in the published literature [5], [6]. This validates the dosage of superplasticizers selected by the Excel framework. [2] and [4] have both recommended 10 to 20% levels of SCM substitution, which is in accordance with the 10% substitution of silica fume in the present study.

7 Conclusion

This study has presented a comprehensive, validated automated Excel-based framework for concrete mix proportioning fully compliant with IS 10262:2019. The following conclusions are drawn: The four-sheet Excel worksheet automates the entire mix proportioning process of the IS 10262:2019 specification for concrete mixes of any grade from M10 to M100. It reduces the time of calculation from hours to under five minutes. It eliminates errors due to human interpolation. The final mix proportions of the M70 mix design case study are: Cement: Silica Fume: Water: CA 20mm: CA 10mm: River Sand = 495: 55: 185: 693.70: 454.44: 644.51 kg/m³. The w/c ratio is 0.33. PCE superplasticizer is added at 1.20%. The average compressive strength of the concrete mix is 78.94 MPa. It is above the desired mean strength of 77 MPa and the characteristic strength of 70 MPa. It shows that the mix design process of the IS 10262:2019 specification is correct. A 10% silica fume substitution contributed to an increase in early strength due to pozzolanic reactivity, and a PCE-based superplasticizer was sufficient for workability at a low water content of 0.33. The proposed computational model reduces the cement content in concrete mixtures by incorporating SCM, thereby reducing the carbon footprint during construction.

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