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Effect of Chemrite SP-303 Superplasticizer on the Strength of Concrete

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Abstract: This study investigates the effect of Chemrite SP-303 superplasticizer on the strength of concrete, focusing on its impact on compressive and tensile strengths. Basic concrete constituents, including crushed angular coarse aggregates (maximum size 9.5 mm), natural river sand, Ordinary Portland Cement (grade 42.5), tap water, and Chemrite SP-303, were utilized in the experimental work. Four concrete mixes were prepared with varying dosages of Chemrite SP-303, ranging from 0.4% to 2% of the cement mass, using the method, termed RGW, which involved replacing gauging water with the superplasticizer. A control mix, designed for a 28-day compressive strength of 25 N/mm², contained no superplasticizer, while the other mixes incorporated the superplasticizer at increments of 0.5% up to 1.5%. The workability of the fresh concrete was evaluated using the slump test, after which the concrete was cast into standard 6" x 12" cylinders. 48 cylinders were subjected to curing periods of 7, 14, and 28 days, and then tested for compressive and split tensile strengths. Results indicated that superplasticizer addition generally improved compressive strength, with the most significant gains observed at dosages ranging from 0.5% to 1.5%. Beyond this range, the strength tended to decrease. The study also highlighted that water reduction of up to 22.93% was achieved with superplasticizer use, contributing to strength improvements. For optimal results, superplasticizers should be used at the manufacturer-recommended dosage, balancing between improved workability and strength. This research underscores the importance of precise superplasticizer dosing in enhancing concrete performance while maintaining workability. Recommendations include thorough testing of cement properties for each replacement percentage and careful handling of superplasticizers to achieve desired concrete strength and workability.

Keywords: Superplasticizer, Chemrite, High Strength Concrete.

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1. Introduction

1.1 General

The word "concrete" originates from the Latin term "concretus," meaning compact or condensed, derived from "concrescere" (to grow together), combining "con" (together) and "crescere" (to grow). Concrete consists of cement, water, fine and coarse aggregates (like gravel or crushed stones), air, and chemical admixtures. In this mixture, cement and water undergo hydration to bind the aggregates, which primarily remain inert. When dry Portland cement, water, and aggregates are mixed, they form a fluid slurry that can be molded into any shape. As the mixture hardens, the cement reacts with the water and other components, creating a durable, stone-like material suitable for various applications. The properties of the concrete, including strength and durability, depend on the ingredients, mix proportions, and methods of transportation, compaction, placement, and curing. High-quality concrete must fulfill performance standards in both its fresh and hardened forms. In the fresh state, it should exhibit good workability without segregation or bleeding. In the hardened state, it must demonstrate strength, durability, and impermeability. Several factors influence concrete strength, like water-cement ratio, aggregate-cement ratio, aggregate size and shape, moisture content, age, and curing. Compressive strength is considered the key indicator of concrete quality, and proper curing is essential for attaining maximum strength Kovler & Roussel, [1].

Portland cement is classified as hydraulic cement because it undergoes a chemical reaction and hardens when mixed with water. The production process involves blending rock, limestone, clay, and iron ore, which are heated to temperatures ranging from 1200 to 1500°C. The resulting clinker is finely ground, and gypsum is added to regulate the setting time. This study used ordinary Portland Maple Leaf Cement, Grade-43. To maintain its quality and usability, cement must be stored properly, shielding it from rain, wind, and moisture to avoid deterioration. As the most commonly used type of cement, Portland cement is a crucial element in concrete, mortar, and plaster. It was patented by Joseph Aspdin, an English masonry worker, in 1824 and was named for its resemblance in color to Portland limestone, commonly used in London architecture. The composition of Portland cement includes oxides of calcium, silicon, and aluminum Ali [2].

Coarse aggregates are materials like gravel or crushed stone with particle sizes larger than sand, typically exceeding 4.00 mm. They consist of irregularly shaped broken stones or naturally rounded gravel. Coarse aggregates are essential in various construction applications, either used independently, such as in granular bases under slabs or pavements, or as components in mixtures like asphalt or concrete Maslehuddin [3].

Fine aggregates, commonly referred to as sand, can be sourced naturally or produced by crushing stone. Sand particles are smaller than 4.00 mm and are essentially a finer form of coarse aggregate. They play a crucial role in concrete by filling the voids between coarse aggregates and cement, thereby enhancing the concrete's strength, as filling these voids contributes to a more solid and durable mix of Gonçalves [4]. Water used in concrete must adhere to specific standards: it should be free from excessive soils, acids, alkalis, or any organic and inorganic impurities. It must also be devoid of iron, vegetable matter, or other substances that could adversely affect the concrete or its reinforcement. The water should be of potable quality, and suitable for drinking.

2. Literature Review

2.1 History of Concrete

Cement and concrete have a rich history that dates back over 5,000 years, beginning with the construction of the Egyptian Pyramids and evolving into today's advanced decorative concrete applications. Throughout history, concrete has played a vital role in various aspects of construction, including architectural wonders and essential infrastructure.

2.1.1 Ancient Times

Mayan concrete at the Uxmal ruins, as noted by John L. Stephens in *Incidents of Travel in the Yucatán*, featured flat roofs and cement floors that have largely remained solid but are now deteriorating due to exposure. The walls, made of large stones bound with mortar, were nearly rock-hard. Similarly, the Nabateans, who controlled areas of southern Syria and northern Jordan from the 4th century BC, were early producers of small-scale concrete-like materials. By 700 BC, they identified the self-cementing properties of hydraulic lime and used it as mortar in rubble masonry, concrete flooring, and waterproof cisterns. These cisterns, crucial for desert survival, were kept secret, and many of their structures still stand today Seymour [5].

2.1.2 Classical Era

During the Ancient Egyptian and Roman eras, builders discovered that incorporating volcanic ash into concrete enabled it to set underwater. By 1400–1200 BC, concrete floors had already been employed in the royal palace of Tiryns, Greece. The Romans made extensive use of concrete from 300 BC to 476 AD, creating a mix known as opus caementicium, composed of quicklime, pozzolana, and pumice as aggregate. This innovation led to a Roman architectural revolution, allowing for remarkable structures such as the Colosseum and the Pantheon, which holds the record for the largest unreinforced concrete dome globally. The use of volcanic rock and ash in Roman concrete contributed to its durability, enhancing its resistance to fractures and seawater erosion. Following the Roman Empire's decline, the use of concrete diminished until its revival in the mid-18th century. Currently, concrete is used globally in greater tonnage than steel Moropoulou [6].

2.1.3 Middle Ages

After the fall of the Roman Empire, the utilization of burned lime and pozzolana decreased, leading to a decline in the quality of concrete and mortar. This decline was attributed to low kiln temperatures, the absence of pozzolana, and inadequate mixing techniques. However, the resurgence of stone construction in churches and castles during the 11th century led to an increased demand for mortar. By the 12th century, improvements in grinding and sieving enhanced the quality of mortar. During the medieval period, lime mortars were non-hydraulic and were mainly used for binding masonry, rubble cores, and foundations. In 1240, Bartholomaeus Anglicus described the mortar-making process, noting that a mixture of lime, sand, and water produced cement. Although mortar quality continued to improve by the 14th century, it was not until the 17th century that pozzolana was commonly reintroduced into the mixtures Gotti [7].

2.1.4 Industrial Era

The Eddystone Lighthouse was an early example of using hydraulic lime in concrete, incorporating pebbles and powdered brick as aggregates. In 1824, Joseph Aspdin developed and patented Portland cement in England, inspired by the resemblance of its color to Portland stone from Dorset. His son William refined the formula in the 1840s, which became the basis of modern Portland cement. In 1849, Joseph Monier invented reinforced concrete, and François Coignet built the first reinforced concrete house in 1853. William B. Wilkinson then constructed the first reinforced concrete building, a servant's cottage with iron-reinforced floors and roof, in 1854. Monier also designed the first reinforced concrete bridge in 1875. The concept of ready-mix concrete began with its first delivery in Baltimore, Maryland, and the first concrete pump patent followed, greatly enhancing the transportation and on-site mixing of concrete in Jackson [8].

2.2 Types of Concrete

Concrete can be classified by its material composition and compressive strength. Concrete can be categorized into two main types based on material composition: Plain Cement Concrete (PCC) and Reinforced Cement Concrete (RCC). PCC, consisting of cement, fine aggregate, and coarse aggregate, lacks reinforcement and is often used to prevent direct contact between reinforcement and elements like soil or water. RCC, on the other hand, includes steel reinforcement, enhancing the concrete's tensile strength and ductility. Concrete is classified based on compressive strength into three categories: Normal Strength Concrete (NSC), High Strength Concrete (HSC), and Ultra High Strength Concrete (UHSC). NSC typically has a density of 140-150 lb/ft^3, compressive strength between 3000 to 6000 psi, and flexural strength ranging from 400 to 700 psi. HSC offers compressive strength between 6000 to 17000 psi, while UHSC boasts strengths exceeding 17000 psi Bazli [9].

2.3 High Strength Concrete

HSC is essential in various applications, such as early-age service requirements (e.g., opening pavements within three days), constructing high-rise buildings by reducing column sizes to increase usable space and building long-span superstructures like bridges that demand enhanced durability. HSC is also crucial for specialized applications requiring high compressive strength, flexural strength, durability, and modulus of elasticity, such as dams, marine foundations, parking garages, and heavy-duty floors. By efficiently carrying loads, HSC reduces the total material used, thereby lowering the overall cost of the structure while increasing strength per unit cost, weight, and volume Li [10].

Designing an optimal HSC mixture involves selecting locally available materials to meet specific properties and conditions, ensuring the concrete is placeable and finishable according to the designer's needs. Key factors include using strong and durable aggregates of regular and small sizes to ensure proper binding, maintaining a low water-cementitious ratio, and adhering to appropriate cementitious material content, typically around 700-1100 lbs/yd^3. Proper mix design ratios are critical for achieving HSC, and the addition of admixtures is often employed to enhance concrete strength Adjoudj [11].

Admixtures, which are extra components added to concrete besides cement, water, and fine, and coarse aggregates, are essential for High Strength Concrete (HSC). High Range Water Reducing Admixtures (HRWRAs) are particularly significant as they reduce the amount of water needed for a given consistency by 12% or more, according to ASTM C 494-C 494M. This reduction helps in maintaining flowability, lowering water-cementitious ratios, and preserving slump while decreasing the amount of cementitious material required. HRWRAs include various types such as sulfonated melamine-formaldehyde, sulfonated naphthalene-formaldehyde, modified lignosulfonates, and polycarboxylate derivatives. These admixtures enhance concrete strength and allow for reductions in the cross-sectional areas of compression members, optimizing cost, weight, and volume Huang [12].

Specifically, naphthalene-based superplasticizers (SNF), a type of HRWRA, have been in use since the 1930s and continue to be refined for improved performance. They effectively reduce water-cement ratios by 20% or more, achieving a slump of at least 200 mm without segregation, reducing thermal peaks, and maintaining workability, durability, and impermeability. SNFs are compatible with all cement types, including sulfate-resistant cement, and improve the permeability, trowel ability, and surface finish of concrete. They also extend the initial setting time, making them suitable for complex concrete placements or grouting, and help prevent cold joint formation and reduce permeability by minimizing the honeycombing effects of Tayfur [13].

2.4 Research Work Related to High-Strength Concrete

The theoretical foundation for producing high-strength concrete originated in ceramic materials research in the late 1950s and early 1960s. According to Griffith’s Theory, reducing particle size increases material strength by decreasing pores. The availability of ultra-fine condensed silica fume significantly advanced high-strength concrete (HSC) production. Naphthalene-based superplasticizers (SNF), derived from naphthalene through sulfonation, play a crucial role in reducing water-cement (w/c) ratios in concrete mixes, improving workability, and enhancing compressive strength. ASTM C494 and EN 934-2 standards highlight superplasticizers' capacity for up to 35% water reduction, leading to significant strength improvements Toledano-Prados [14].

Research has shown that using SNF in concrete can yield compressive strength gains of up to 26.69%, with a 27% increase recorded at 1.5% dosage for C25/30-grade concrete. Studies on SNF (Rebuild 1125) reported a 29% water reduction in 20N/mm2 and 40N/mm2 grade concrete, with compressive strength losses of 15% and 5.33% respectively Prakash Mishra [15]. The water-reduction effect of superplasticizers depends on factors like initial slump and dosage. While SNF's water reduction ability is notable, it is generally lower than that of polycarboxylate-based superplasticizers. This study investigates the effect of a new naphthalene-based superplasticizer on compressive strength and water reduction in C20/25-grade concrete, offering recommendations for local construction industries on the effective use of superplasticizers. Phan & Carino [16].

2.4.1 High Strength Concrete (HSC) and Its Constituents

The evolution of high-strength concrete (HSC) has been marked by extensive research on mix proportions, aggregate types, and the influence of admixtures. Farooq [17] explored mix designs using ASTM Type-I cement, locally sourced sand with a fineness modulus of 2.80, 10 mm crushed granite, and potable water. Admixtures included condensed silica fume and DARACEM-100, a superplasticizer. Dancygier & Yankelevsky [18] tested concrete mixes with compressive strengths between 8,700 and 9,300 psi, finding that lower cement pastes content and larger aggregate reduced creep, while high-range water reducers did not significantly affect creep.

2.4.2 Importance of Aggregate Type

Hernández-Olivares & Barluenga [19] emphasized the significance of the matrix-aggregate bond, noting that some aggregates are limited by "ceiling strength" constraints, which prevent them from achieving the full-strength potential of concrete. Rao & Prasad [20] found a strong correlation between aggregate compressive strength and concrete properties, suggesting a maximum aggregate size of 9.5 mm for optimal compressive strength, especially with high cement content and a low water/binder (w/b) ratio.

2.4.3 Admixtures and Supplementary Cementitious Materials

Song & Hwang [21] investigated high-performance concretes with substantial fly ash content, finding that these mixtures exhibited excellent mechanical properties and minimal creep deformation. Le [22] evaluated different types of aggregates, such as crushed granite, marine marl, and rounded gravel, in high-strength concretes with compressive strengths greater than 10,000 psi. The study observed that creep strains ranged from 20% to 50% of those in ordinary concrete, with marine marl aggregates showing higher specific creep. Russo [23] examined the impact of aggregate characteristics on creep, concluding that maximum aggregate size and grading have minimal effect on creep as long as full compaction is achieved. Jamalaldin [24] analyzed the effects of admixtures and supplementary cementitious materials on deformation, comparing these with control concretes of the same mix proportions. The findings indicated no significant differences in creep strain among various plasticizers and superplasticizers, although a general increase in creep of about 20% was noted, potentially due to air entrainment weakening the hardened cement paste.

2.4.4 Impact of Supplementary Cementitious Materials

Blast furnace slag (BFS) and fly ash were studied for their impact on creep and shrinkage. BFS was found to reduce ultimate creep as cement replacement increased, while fly ash continued to develop strength over a long hydration process, also reducing creep. Silica fume (SF) showed mixed results, with low replacement levels reducing creep but higher levels (over 16%) increasing it. Chen & Liu [25] summarized findings on creep deformation related to different admixtures and supplementary materials, noting that water reducers had varied effects, ranging from 34% to 166% of creep strain compared to a reference mix.

2.4.5 Variability in Creep Deformation

No consistent trend was observed in concrete creep with changes in cement paste content, aggregate type, or cement composition. Lignosulphonate admixtures led to higher basic creep than carboxylic acid admixtures, while superplasticizers generally increased mean creep deformation. GGBFS tended to decrease total creep at low w/c ratios, but this trend reversed at higher ratios. Fly ash reduced basic creep, while silica fume increased it at higher contents. Autoclaved concrete with high silica fume content showed a significant reduction in creep, with equations provided to estimate creep based on the percentage of cement replaced by supplementary materials Shoaib Ismail & Waliuddint [26].

2.4.6 Recent Studies on HSC

Megat Johari [27] examined how different aggregate size distributions affect the fracture parameters of high-strength concrete (HSC) with compressive strengths ranging from 50 to 89 MPa, using aggregate sizes of 10 mm, 15 mm, and 20 mm. Phan (n.d.) investigated the effect of SF on HSC, finding that a 15% SF replacement produced the highest compressive strength, with optimal results at 72 MPa for 425 kg/m^3 cement and 75 kg/m^3 SF, and 80.5 MPa for 595 kg/m^3 cement and 105 kg/m^3 SF.

2.4.7 Aggregate Type and HSC Performance

Rashid & Mansur [28] explored how different aggregate types—calcareous, dolomitic, quartzitic limestone, and steel slag—affect the compressive and tensile strength of high-strength concrete (HSC). The study found that steel slag aggregate resulted in the highest compressive and tensile strengths, whereas calcareous limestone produced the lowest. Similarly, Lee [29]evaluated various aggregates in HSC containing 15% silica fume (SF) and discovered that gabbro provided the highest compressive strength and abrasion resistance, while sandstone exhibited the lowest performance.

2.4.8 Shrinkage and Creep in HSC

Yang [30] examined drying shrinkage in high-strength concrete (HSC) with silica fume (SF) replacements of 0%, 6%, 10%, and 15%, finding that autogenous shrinkage increased as SF content rose. Mohammad Hassani [31] assessed shrinkage in HSC with 10% SF or fly ash and observed that shrinkage strains were higher (6% to 10%) compared to neat cement, with granite aggregate showing slightly less shrinkage than sandstone.

3. Methodology

3.1 Materials

The experimental work involved using standard concrete components, including CA, FA, OPC, and SP-303, as depicted in Figure 1. The coarse aggregate was crushed and angular, with a maximum size of 9.5 mm, and its physical properties are listed in Table 1. Fine aggregates were sourced from river sand from the Okhuahe River in Edo State, with a sieve analysis performed according to ASTM: E-11 standards. Tap water from Bahauddin Zakariya University (BZU) in Multan City was utilized for all testing procedures. Ordinary Portland Cement of grade 42.5, adhering to BS 12:1991 and produced by Maple Leaf, was used as the cementitious material. A naphthalene-based superplasticizer, Chemrite SP-303, was incorporated, with its properties detailed in Table 2.

Table 1: Coarse Aggregate Properties

Sr. No.	Properties	Results
1	Water Absorption	1.13%
2	Specific Gravity	2.74
3	Aggregate Impact Value	20.50%
4	Aggregate Crushing Value	28.90%

Table 2: Chemrite SP-303 Properties

Sr. No.	Properties	Results
1	Consistency	Liquid
2	Color	Brown
3	Density	1.13~0.03
4	Chloride Contents	NIL
5	PH	5
6	Recommended Dosage	0.3~2
7	Solid Contents	30%

Figure 1: Materials for mix design (CA, FA, OPC, SP-303)

3.2 Concrete Mix Proportion and SNF Addition Process

Four concrete mixes were prepared with sulfonated naphthalene formaldehyde (SNF) added at 0.4% to 2% of the cement mass, based on the manufacturer's guidelines. This process, known as RGW, involved replacing an equivalent amount of gauging water with the superplasticizer (SP). The control mix, with no SP, was designed according to ASTM standards to achieve a 28-day compressive strength of 25 N/mm². The other mixes included SP at 0.5% to 1.5% of the cement mass, as detailed in Table 3. Consistency for each mix was assessed using the slump test per ASTM: E-11 standards. After consistency was verified, the concrete was poured into cast iron molds and compacted in three layers using an iron rod to ensure proper consolidation.

3.3 Mixing of specimen

Throughout the experimental work, a mixture machine was used shown in Figure 2. First, the cement was weighed separately and then added to the weighed sand, mixing thoroughly to achieve a uniform mixture. Next, the coarse aggregate was poured into the mixture machine, followed by the cement-sand mixture, and mixed to form a uniform matrix. Water was then added to the mixture and thoroughly combined to produce a uniform concrete mix (PCC). Subsequently, a series of new mixes were prepared by replacing cement by weight with superplasticizer (Chemrite-SP:303) at varying proportions: 0.5%, 1%, and 1.5%. Each mix was prepared sequentially, incorporating the specified percentages of superplasticizer.

Table 3: Concrete Mix Proportion Details

SP Dosage	Slump (mm)	OPC (kg/m^3)	F.A (kg/m^3)	C.A (kg/m^3)	W/C (ratio)
0%	25	105	211	423	0.65
0.5%	27	105	211	423	0.55
1%	32	105	211	423	0.45
1.5%	40	105	211	423	0.4

Figure 2: Mixture Machine

3.4 Tests on fresh concrete

ASTM standards outline specific procedures for field tests to assess the quality of freshly mixed concrete, focusing on consistency, strength, unit weight, air content, and temperature. Although some test specifics may seem minor, adherence to these standards ensures uniform testing methods. Consistent testing is essential for identifying changes in fresh concrete that might affect its performance. Deviations from these procedures can result in the acceptance of poor-quality concrete or the rejection of satisfactory concrete, impacting contractors, ready-mix producers, and owners. Understanding the scope, significance, and procedures of each test is crucial for accurate results. In mix design, the water-cement ratio is assumed to control the compressive strength of workable concrete. To evaluate workability, various tests are used, with the slump test being particularly valuable on-site. This test helps track daily or hourly variations in mixer materials, offering immediate feedback if the slump is outside the desired range, thus allowing for prompt adjustments. The slump readings using SP percentages are detailed in Table 4.

Table 4: Slump Readings

SP (%)	Slump (mm)
0	25
0.5	27
1	32
1.5	40

3.5 Casting and curing of specimen

For casting and curing, 48 cylinders were prepared using standard cast iron molds with dimensions of 6” diameter by 12” length, as shown in Figure 3. The molds were cleaned and coated with mineral oil before pouring the concrete. The thoroughly mixed concrete was placed in the molds in three layers of equal height, with each layer tamped down. Excess concrete was removed with a trowel, and the surface was smoothed. Curing was conducted to prevent moisture loss while maintaining the proper temperature. After casting, the specimens were kept in the laboratory at room temperature for 24 hours. They were then de-molded and submerged in clean water for a total curing period of 28 days.

Figure 3: Specimen (Casting and Curing)

3.6 Tests on Hardened Concrete

When concrete is hardened then two tests are generally applied one is the compression test and the other one is the tensile or split test shown in Figure 4.

3.6.1 Compression Test

The compression test determines the compressive strength of concrete specimens following the ACI-318 standard. Specimens, that have been moist-cured for 28 days, are tested after removal from the curing room. The diameter and height of each specimen are measured with a Vernier caliper and ruler, and the mass is recorded. Before testing, the platens of the testing machine are cleaned to remove any oil or debris, and the surfaces of the specimens are brushed and wiped to remove loose particles. The specimen is placed between the platens of the testing machine, with its axis aligned with the center of the spherically seated platen. A rubber cap is placed on the specimen's rough surface, and the upper plate is lowered to ensure uniform bearing. The force is applied gradually and continuously at a rate of 20±2 kN/s until the specimen fails. The maximum force recorded is then used to calculate the compressive strength by dividing this load by the specimen's cross-sectional area.

3.6.2 Split Tensile Test

The split tensile test measures the tensile strength of concrete according to ACI-318 standards. The procedure involves the following steps: After a curing period of 28 days, remove the specimen from the water and dry its surface. Mark diametrical lines on both ends to ensure alignment along the same axial plane. Measure and record the specimen’s weight and dimensions. Adjust the compression testing machine to the required range. Place a metal strip on the lower plate of the machine, position the specimen on top, and ensure the marked lines are vertical and centered. Position another metal strip above the specimen and lower the upper plate until it makes contact. Apply the load gradually and evenly, avoiding abrupt impacts, until the specimen breaks. Record the breaking load (P). The experimental procedure is detailed in Figure 5.

Figure 4: Compression and Split Tensile Test on CTM

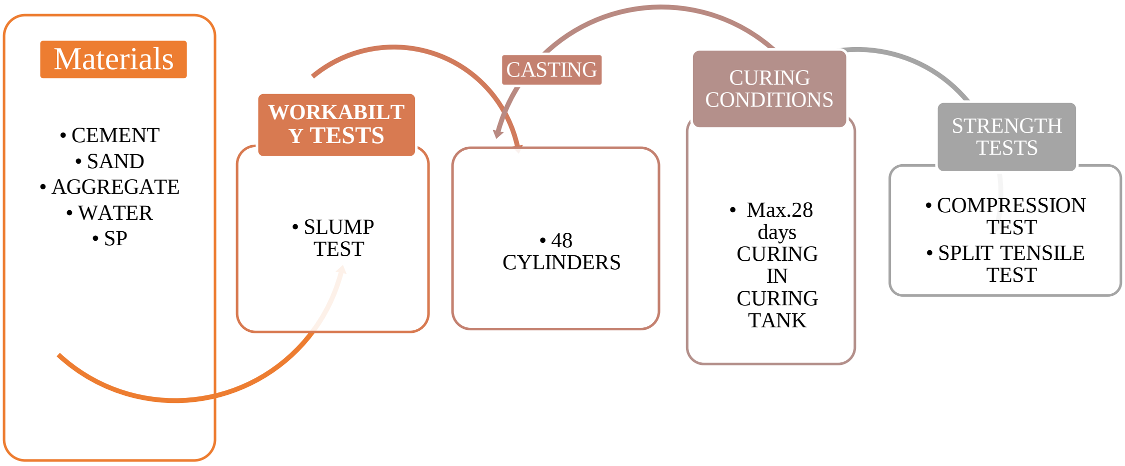

Figure 5: Flow Chart of the Whole Experiment

4. Results & Discussions

Cement concrete is widely used in construction due to its versatility and ease of molding into various shapes. However, ordinary cement concrete has limitations, including low tensile strength, limited ductility, and poor resistance to cracking. Internal microcracks can lead to brittle failure. As modern civil engineering projects demand specific structural and durability requirements, it has become essential to modify traditional cement concrete to meet these needs.

In our project, partial cement replacement with a superplasticizer (SP) was analyzed. The results show that increasing the SP dosage generally leads to higher compressive strength and greater water reduction. Compressive strength tests at 7, 14, and 28 days, using different dosages of sulfonated naphthalene formaldehyde (SNF) as a partial substitute for water, indicate an improvement in strength over time. Furthermore, the reduction in water from the initial amount used increases with higher SP dosages.

Results also reveal a trend where an increase in SP dosage corresponds with a decrease in the water-to-cement (w/c) ratio. But at a particular percentage of SP, it seems that compressive strength is being decreased instead of increasing. It shows that at a certain percentage of SP compressive strength increases but after that particular percentage of SP compressive tends to decrease. For this purpose, we used cylinders of size 6" X 12" to check the compressive and tensile strengths of concrete. All the specimens were cured for 7, 14, & 28 days according to the required testing.

4.1 Compressive Strength Test

The results of compressive strength of control concrete (P.C.C) and partially replaced cement concrete (PRCC) with 0.5%, 1 % & 1.5% replacement of cement with super-plasticizer (Chemrite: SP-303). For concrete, we consider compressive strength because concrete is strong in compressive strength other than tensile strength. So, we usually take notice the compressive strength results should more and more and it should be stronger in compressive strength. And for tensile strength, we put reinforcement so that it also can bear tensile load.

Table 5 & Figure 6,7,8,9 show that the compressive strength of concrete is increased when the w/c ratio decreases with the help of a high-range water reducer super-plasticizer. But this increment of compressive strengths is not throughout the increment of super-plasticizer but at a certain percentage of super-plasticizer, compressive strengths increased which is 0.5% to 1.5% that is the percentage in which we can obtain maximum and better results of compressive strength. However, we see that after the 1.25% super-plasticizer, the compressive strength of concrete tends to decrease. So, we can obtain better and better results between 0% to 1.5%.

Table 5: Results of CS of Concrete on Various Days

SP Dosage (%)	W/C (ratio)	7 Days C.S (N/mm^2)	Avg. C.S (N/mm^2)	14 Days C.S (N/mm^2)	Avg. C.S (N/mm^2)	28 Days C.S (N/mm^2)	Avg. C.S (PSI)
0	0.60	25	25	27	26.16	29	26.33
		26		26.5		27	
		24		25		30	
0.5	0.55	32	32	34	33.67	31	32.5
		30		32		33	
		34		35		33.5	
1	0.50	37	38.67	41	39.33	47	44.33
		39		39		44	
		40		38		42	
1.5	0.46	35	34.33	39	39.17	42	40.33
		32		38.5		40	
		36		40		39	

Figure 6: Compression of a cylinder

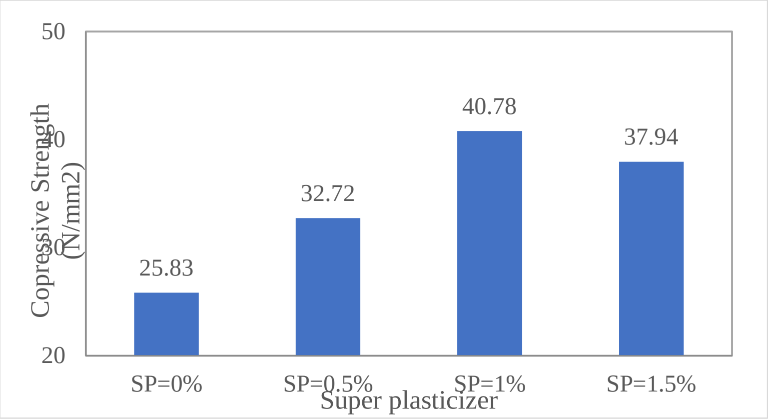

Figure 7: Relation b/w SP & C.S

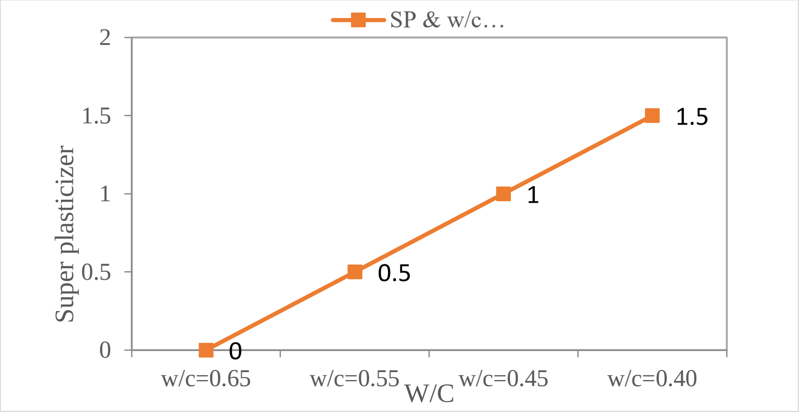

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Figure 8: SP & W/C variation

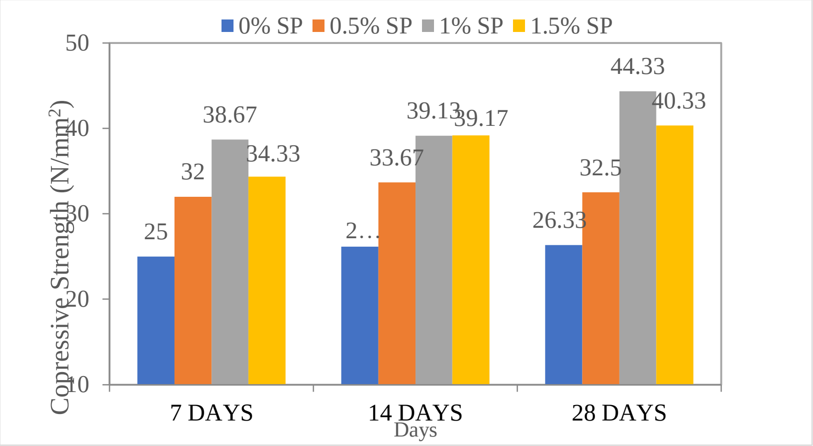

Figure 9: Comparison of compressive strengths on different days

4.2 *Split Tensile Test*

The results of tensile strength of control concrete (P.C.C) and partially replaced cement concrete (PRCC) with 0.5%, 1 % & 1.5% replacement of cement with super-plasticizer (Chemrite: SP-303). That test is used to determine how much concrete can sustain the tensile force that is being applied to it. So that test is used to find the tensile strength of concrete.

Table 6 & Figures 10,11,12 show that the tensile strength of concrete is increased when the w/c ratio decreases with the help of a high-range water reducer super-plasticizer. But this increment of compressive strengths is not throughout the increment of super-plasticizer but at a certain percentage of super-plasticizer tensile strengths increased which is 0.5% to 1.5% that is the percentage in which we can obtain maximum and better results of compressive strength. However, we see that after the 1.25% super-plasticizer, the compressive strength of concrete tends to decrease. So, we can obtain better and better results between 0% to 1.5%.

Table 6: Results of Tensile Strength of Concrete on Different Days

SP Dosage (%)	W/C (ratio)	7 Days C.S (N/mm^2)	Avg. C.S (N/mm^2)	14 Days C.S (N/mm^2)	Avg. C.S (N/mm^2)	28 Days C.S (N/mm^2)	Avg. C.S (N/mm^2)
0	0.60	2.5	2.48	2.59	2.55	2.69	2.66
		2.54		2.57		2.59	
		2.4		2.5		2.7	
0.5	0.55	2.8	2.8	2.9	2.88	2.78	2.85
		2.7		2.8		2.87	
		2.9		2.95		2.89	
1	0.50	3.04	3.11	3.2	3.13	3.42	3.33
		3.12		3.12		3.3	
		3.16		3.08		3.24	
1.5	0.46	2.9	2.91	3.12	3.12	3.24	3.17
		2.8		3.1		3.16	
		3		3.16		3.12	

Figure 10: Split Tensile Test

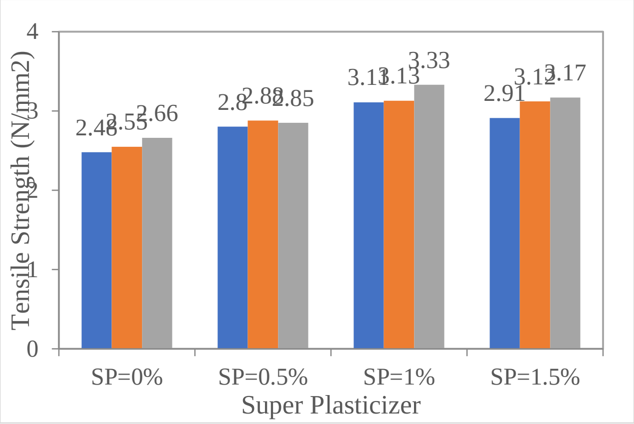

Figure 11: Relation b/w SP & T.S

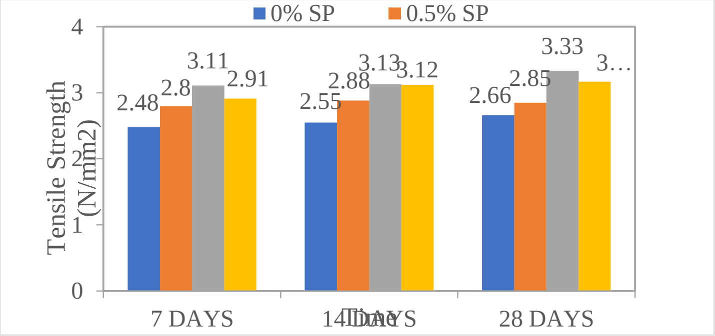

Figure 12: Comparison of Tensile Strengths

5. Conclusions

The use of a small amount of superplasticizer as a cement replacement improved workability, leading to better compaction and increased concrete strength. The addition of sulfonated naphthalene formaldehyde (SNF) via the RGW process generally enhanced concrete's compressive strength at 7, 28, and 56 days, although SNF did not improve 1-day compressive strength in either process. The CCC process with SNF, however, resulted in reduced strength at 56 days. The inclusion of SNF in the concrete mix allowed for water reductions of up to 22.93%.

Using the appropriate dosage of superplasticizers enhances compressive strength. For high compressive strength requirements, sulfonated naphthalene formaldehyde (SNF) should be applied at the maximum recommended dosage, while maintaining control over the slump if feasible. If workability is the primary objective, SNF should partially replace water at an optimal dosage. Even a modest reduction in water content from the superplasticizer can improve compressive strength.

6. Recommendations

1. For partial replacement of cement, for each percentage of replacement, you should carry all the cement experiments of the new cement as: specific gravity, fineness, and specific surface, initial and final setting time.
2. The workability of concrete improves with higher levels of superplasticizer replacement, but strength may decline beyond an optimal percentage. Therefore, superplasticizers can be used to enhance workability while maintaining adequate strength.
3. This super-plasticizer is used where we require more workable concrete and less quantity of water.
4. That is economical if we want to high-strength concrete with the partial replacement of cement and less quantity of water.
5. Proper safety precautions should be taken while handling the specimens.

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