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Characterization of Concrete Strength, Durability and Workability Impacted by a Super - Plasticizing Additive

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ABSTRACT

The purpose of this study is to examine the workability, rate of flow, and compressive strength properties of natural concrete and super-plasticizer concrete over time, taking into account their water-cement ratio. Laboratory tests were conducted on various concrete mixes concerning 0.50, 0.55, and 0.60 water–cement ratios. Different dosages by weight between 0% through 1% of Master Glenium 118 superplasticizers were applied to determine the effects of superplasticizer admixture on the compressive strength and workability of concrete thereafter, the influence of superplasticizer admixture on concrete quality by lowering the amount of mixing water was obtained. Results showed that the addition of the new superplasticizer admixtures to the fresh concrete improved its workability. Hence, the flow rate and slump of natural concrete improve as the water content in the concrete and superplasticizer dosages increase. For hardened concrete's compressive strength test, the result also showed that adding the super-plasticizer admixture into the concrete mix appropriately decreases the weight of the concrete and reduces the strength required in the crushing of the concrete after 7, 14, 21 and 28 days of curing. It is observed that the compressive strength of the natural concrete increase as the curing period increases from 7 to 28 days, and even increase more for the super-plasticizer concrete. More so, the weight of the natural concrete decreases as the curing period increases from 7 to 28 days, and even decreases more for the super-plasticizer concrete thereby producing lightweight concrete which is more durable with a considerably higher economic benefit. The superplasticizer applied in this study significantly maintained the required workability without resorting to excessive water, thus addressing concerns of past studies.

1. Introduction

Concrete is arguably the most extensively used material in the construction sector because of its high strength, durability and versatility in terms of shapes and forms, as well as its capacity to be

shaped to suit certain requirements [1]. According to previous experience, the compressive strength of lightweight concrete typically decreases with the reduction in density [2]. The correlation of high compressive strength and low density gives the opportunity to potentially use lightweight concrete in the new field of industry, where the weight of the material plays a key role [3, 4]. The continual pursuit of improving concrete properties has led to the exploration and utilization of different techniques and materials. Owing to its strength, compliance, and long lifespan, concrete is often used as building materials worldwide and various admixtures can be mixed to improve its strength, durability, and workability to obtain the necessary qualities [5].
Admixtures can be liquids, powders, or solids and are typically added during the mixing process [6]. There are Various admixtures which has been studied by previous researchers they include; an accelerating admixture which speeds up the setting and initial strength development of concrete or mortar, enabling faster construction [7]. Calcium chloride and non-chloride accelerators are commonly used in cold weather conditions or when rapid strength gain is desired [8]. The air-entraining admixtures create small, stable air bubbles in concrete, improving its resistance to freeze-thaw cycles [9]. They enhance durability, especially in regions with cold climates. Vinsol resin and synthetic surfactants are examples of air-entraining admixtures [10]. Pozzolanic admixtures, such as fly ash or silica fume usually applied to concrete to improve its strength, durability, and chemical resistance [11]. Another one is the chemical admixtures known as superplasticizing admixtures are added to concrete mixtures in minute amounts to increase workability without reducing strength. By spreading out cement granules, lowering interparticle friction, and enhancing the fluidity of the concrete mixture, these admixtures have an effect [12]. The use of superplasticizers enables enhanced placement and compaction in intricate formwork and crowded reinforcement, as well as better compaction, decreased voids, and improved placement [13]. The difference between a superplasticizer and a water reducer is that a superplasticizer will greatly reduce the amount of water needed to mix concrete thereby producing concrete that is extremely strong or workable [14, 15].

There are many categories of superplasticizers, they include; Sulfonated Melamine Formaldehyde (SMF), Sulfonated Naphthalene Formaldehyde (SNF), Polycarboxylate Ethers (PCE), Modified Lignosulfonates. The efficiency of superplasticizing admixtures is affected by several variables, including dosage, admixture type, cementitious material(s) used, and mixture proportions. Based on particular application requirements, substantial research has been done to identify the right dosage and combination of admixtures to optimize the performance of these admixtures [16].

The approach of the incorporation the superplasticizing admixtures, which have gained significant attention in recent years due to their potential to enhance concrete performance by impacting the strength of concrete has also been widely studied in addition to their impact on workability [17]. The use of superplasticizing admixtures in concrete construction has become increasingly prevalent due to their ability to improve workability and reduce water content while potentially enhancing the mechanical properties of concrete. However, there is a need to comprehensively investigate the effect of superplasticizers on various properties of concrete to optimize their use in construction projects. Superplasticizer retards the setting time of concrete, by allowing more time for transportation, placement, and finishing. They are often used in hot weather or for large concrete. Lignosulfonates and gluconates are commonly used retarding admixtures [5].

Another important factor that is impacted by the addition of superplasticizing admixtures is the resilience of concrete buildings. These admixtures improve compaction and decrease porosity, which results in lower permeability and increased resistance to chloride ion penetration and other aggressive chemicals, authors in [18] studied how superplasticizers affected the resilience of concrete. According to the study, adding superplasticizing admixtures dramatically reduced the amount of chloride ions that could penetrate concrete, increasing the material's resistance to corrosion caused by chloride and extending its lifetime in harsh settings.

Adding superplasticizers has led to an increase in the use of fibre-strengthened concrete globally (Iyer, 2020) [19]. The eco-friendly, higher structural performance, and low energy impact result in this. The main uses of concrete with cementitious material include long-span bridges, columns for high-rise structures, highway structures, and offshore structures [20]. High-strength concrete is tentatively defined as concrete with a compressive strength of more than 60 MPa [2]. In 2019, authors in [21] that the compressive strength range of medium-strength concrete ranges from 28 MPa to 35 MPa.

Numerous studies have been carried out on the impact of superplasticizing admixtures on concrete characteristics. Academics have examined the impact of superplasticizers on concrete's workability in a crucial area. Authors in [22] conducted a thorough investigation to evaluate the workability traits of concrete with various superplasticizers. The study's conclusions demonstrated that the use of polycarboxylate-based superplasticizers had a significant impact on flowability and slump retention. The use of these additives allows for the creation of concrete with higher slump values or self-consolidating concrete (SCC) with superior flow properties.

An experimental investigation was carried out in 2020 by authors in [23], they examined how superplasticizers affected the strength development of concrete. The results indicated that a particular superplasticizer made from polycarboxylates enhanced the early-age and long-term strength qualities. The concrete's compressive and flexural strengths were strengthened by using superplasticizers that improved particle dispersion and decreased water content. The addition of superplasticizing admixtures to concrete has been proven to be a successful way to enhance its qualities. Better placement and compaction are achieved through improved workability of these admixtures. We learn a great deal about the advantages and prospective uses of superplasticizing admixtures in concrete construction by taking into account the current research investigations carried out by authors in [18], [22] and [24].

Superplasticizers are used to disperse cement particles in the concrete mixture, resulting in improved particle suspension and flowability. By reducing the surface tension between water and cement particles, they can increase the fluidity of the mixture without compromising its strength [25]. The workability of concrete is significantly improved by superplasticizers, making it easier to place, compact, and shape. In applications where concrete needs to flow around intricate reinforcement or in congested areas, this is particularly important. Although superplasticizers reduce the water content, they do not compromise the strength of the concrete. They can enhance the strength by enabling a lower water-cement ratio, resulting in denser and stronger concrete [12]. Concrete with superplasticizers exhibits improved durability due to its reduced permeability. The decreased water content and increased density lead to better resistance against chemical attacks, freeze-thaw cycles, and abrasion [26]. Superplasticizers help prevent the segregation of coarse aggregates from the concrete mixture and reduce the tendency for bleeding, which is the migration of water to the surface. This results in a more homogeneous and uniform concrete mixture [8].

Superplasticizers improve the permeability of concrete, allowing for easier transportation and placement in large-scale construction projects. The enhanced flowability reduces the electrostatic forces between particles, thereby preventing them from clumping together and reduced viscosity makes the concrete more suitable for pumping through narrow pipelines [27, 28, 29]; due to the high flowability and self-levelling of the superplasticizer concrete, is self-compacting concrete (SCC) as it requires minimal or no vibration during placement. The workability and high-performance concrete mixture properties of concrete make it suitable in precast concrete applications, allowing for efficient casting and moulding of complex shapes and forms [9, 30, 31, 32]. Modern construction practices rely on them to construct complex structures, enhance productivity, and improve the overall quality and durability of concrete [15, 33].

In this study, an experimental investigation was performed to evaluate the influence of superplasticizing admixtures on the workability, durability and compressive strength of normal concrete and one made with superplasticizer additive at various water-cement ratios. This was done by adding different dosages of a new superplasticizer to concrete to determine the rate of strength development and ultimate compressive strength; hence, the optimal superplasticizer dosage for various concrete applications can be achieved. This research not only contributes to the scientific understanding of concrete behaviour but also has practical implications for the construction industry, where optimizing concrete performance can lead to cost savings, reduced environmental impact, and enhanced structural integrity. The main focus of research in this field has been on improving the performance and durability of lightweight concrete.

2. Experimental Program

This work is a comparative analysis of the mechanical and rheological properties of natural concrete and superplasticizer concrete (concrete made with admixture). This will be achieved by investigating the workability of both concrete at 0.5%, 0.55% and 0.6% water-cement ratio as fresh concrete thereafter, the compressive strength of these two specimens was also evaluated after 7 days, 21 days and 28 days of curing period.

2.1 Materials and Equipment

The materials used in this study were cement, fine, coarse aggregates, and water. A chemical Master Glenium 118 superplasticizing superplasticizer was added to change the properties of concrete for certain applications. In other to carry out the practical experience on the effect of super plasticizing admixture on the properties of concrete, all the tools, appliances, and equipment were obtained from the structural laboratory of the civil engineering department. The tools and equipment include a Compression testing machine, Concrete electric mixer, Sieve, Sieve brush, 150mm by 150 mm-by-150 mm concrete mould, and a 25mm diameter tapping rod. Others are Shovel, Trowel, Electronic scale, and Wheelbarrow.

2.1.1 Cement

Dangote brand cement of ordinary Portland cement (50kg) of grade 42.5N conforming to the requirements of BS12:1978 with a specific gravity of 3.15 was purchased from a cement dealer at Obiuno community in Osunmenyi, Nnewi South L.G.A of Imo state, Nigeria, and stored in a cool and dry place before use for the test. This particular type and grade of cement was selected as recorded in the work of Onyeka [32] for its ability to influence the rate of development of compressive strength of concrete.

2.1.2 Water

Clean potable water from the Civil Engineering Workshop in Federal University Owerri, Imo State Nigeria, and taps to ensure continuous hydration and conform to the specification of BS EN 1008 was used for both specimen preparation and curing. In line with the specification, the water used was free from reactive elements such as reactive ions and impurities to guarantee the quality of concrete

2.1.3 Fine and Coarse Aggregate

Aggregates occupy about 60%–80% of the volume of concrete. All aggregates must be free from dust as dust may affect the bond between the aggregate and cement particles. Aggregates were cleaned before mixing to wash away the fine particles on the surface of the aggregates. In the selection of aggregate used in this practical, careful attention was paid to aggregate size, particles of shape, aggregate strength and cleanness. Coarse aggregate used for this practical was well selected from the set of granite sold at Obinze; it was free from detrimental coatings of dust and clay. The aggregate's strength and absence of visible cleavage were crucial for the required cube strengths. The most common size used in construction is the nominal size of 20mm for coarse aggregate. Sharp sand was obtained from the Otammiri River, which is situated in Owerri L.G.A of Imo state, Nigeria. The test could have been affected by the drying of the sand to remove moisture.

2.1.4 Super-plasticizer

Master Glenium 118 is a superplasticizer that can develop both early and final strength. By using Master Glenium 118 superplasticizer, concrete's slump retention and workability can be improved. MasterGlenium 118 should be dosed at 0.8 to 2.5 L/100kg of total cementitious material. To analyze performance, three design mixes of concrete with different water–cement ratios of 0.50, 0.55, and 0.60 and two superplasticizer dosages of 0.8% and 1% of cement content required for mix of normal concrete were prepared.

2.2 Design Method

Mix design is now a standard method in most countries through the use of the Design of Experiment (DOE) method. The relationship between water/cement ratio and compressive strength was determined by the type of cement and aggregate used in this method. This was carried out in accordance with the work of Onyeka [4]. Concrete mix proportioning requires the following basic data:

2.2.1 Grade Designation, Maximum Nominal Size of Aggregate and Maximum Water-Cement Ratio

This was performed to obtain characteristic compressive strength of concrete. The maximum nominal size of the aggregate to be used in concrete is governed by the size of the section to be concreted and spacing of the reinforcement. The maximum water cement ratio to be used for a particular work is governed by the desired strength and limited by the durability requirements. Hence, the author arrived at w/c ratio of 0.5, 0.55 and 0.6 for the control mix and mix comprised of superplasticizer.

2.2.2 Mixing and Batching

Mixing was done using a concrete mixer and then compaction was done by hand. Table 1 showed the concrete mix design and mix characterization recommended for a given batch of concrete. After mixing, batching was done according to the result gotten from the design as presented. The batching was done by weight, measured using a measuring scale in line with work of authors in [34] and [35].

Table 1: Mix design and aggregate grading

REF	CALCULATION	OUTPUT
	From the slump test result, the water/cement ratio is 0.75	w/c = 0.75
	Proposed concrete mix = 1:2:4	Concrete mix = 1:2:4
	Volume ratio: $\frac{0.75}{1} : \frac{1}{3.15} : \frac{2}{2.6} : \frac{4}{2.6}$	
	Total Volume ratio: 0.75: 0.317 : 0.769 : 1.538 = 3.374	Total Volume Ratio: 3.374
	Mass of water: $\frac{0.75}{3.374} \times 0.0405 \times 1 \times 1000 \times 1.1 = 9.9029$kg	Mass of water = 9.9029
	Mass of cement: $\frac{0.317}{3.374} \times 0.0405 \times 3.15 \times 1000 \times 1.1 = 13.1848$kg	Mass of cement = 12.1848kg
	Mass of sand: $\frac{0.769}{3.374} \times 0.0405 \times 2.6 \times 1000 \times 1.1 = 26.3999$kg	Mass of sand = 26.3999kg
	Mass of gravel: $\frac{1.538}{3.374} \times 0.0405 \times 2.6 \times 1000 \times 1.1 = 52.7998$kg	Mass of gravel = 52.7998kg
	Mass of Plasticizer: $13.1848 \times \frac{0.8}{100} = 105.4784$g	Mass of plasticizer = 52.7998kg

2.2.3 Casting and Curing

The mixed concrete was casted into cubes of 150mm-by-150mm-by-150mm diameter moulds. A total of twenty-four (24) cubes were casted, twelve for normal concrete test and twelve for super plasticizing admixture in the concrete. After casting of concrete in the specified cube moulds, the cubes were cured by totally immersing them in water in a curing tank. Below plate shows one of the concrete cubes being put in water. Three cubes were cured for 7 days for both normal concrete and super-plasticizing admixture concrete for 14 days, 21 days and 28 days respectively.

3. Results and Discussion

The result of this work analyzed the effect water to cement variation at various dosages of superplasticizer (Master Glenium 118) on the workability and mechanical strength of concrete produced by cement only as a binder course and concrete made with superplasticizer admixture.

3.1 Superplasticizer Effect on Workability of Concrete Considering Different Water–Cement Ratio

The flow or fluidity and slump results of normal concrete (NC) and that of superplasticizer concrete at different periods of curing are shown in Table 2. An average slump result was calculated after two trial slump tests from which the fluidity of the fresh concrete was achieved. Also, the results in Table 2 shows the relation between superplasticizer, slump and flow dosages considering different water/cement ratio.

The result in Table 2 shows that the average slump and flow of the concrete increase from 5cm and 355cm to 17cm and 485cm with an increase of water/cement ratio from 0.5 to 0.6 respectively. This means that the slump and flow rate of concrete improves as the water content in the concrete increases. Thus, the desired workability found was discovered to depend upon the water content, shape and size of the section to be concreted and the method of transportation, placing and compaction of concrete. Moreover, the slump and flow increased with increasing superplasticizer dosages.

It is shown in the result in Table 2 that, at 0.6 w/c ratio, the minimum slump and flow is 17.5cm and 665cm which was gotten when 0.8% dose of superplasticizer was used, while the maximum slump and flow 27.5cm and 670cm which was gotten when 1.0% dose of superplasticizer was used. At 0.55 w/c ratio, the minimum slump and flow are 15cm and 405cm which was gotten when 0.8% dose of superplasticizer was used, while the maximum slump and flow is 25.5cm and 570cm which was gotten when 1.0% dose of superplasticizer was used. At 0.5 w/c ratio, the minimum slump and flow were 13.5cm and 430cm which was gotten when 0.8% dose of superplasticizer was used, while the maximum slump and flow was 18cm and 470cm which was gotten when 1.0% dose of superplasticizer was used.

It is observed that, as the superplasticizer dosage in the concrete increases the workability of concrete increases; this is expected because the superplasticizer helps to retain the concrete in a liquid state for a long time and reduces slump loss during the transportation of concrete to the site. This means that the type and properties of aggregate used in this work influence the workability and strength of concrete; the recommended relative proportions of aggregates to be applied in the concrete with such admixture as seen are determined from the physical properties of aggregates such as grading, shape, size and surface texture.

According to BS 1881: Part 105: 1984, concrete can only be considered uniform and cohesive when it possesses a flow diameter between 50cm and 65cm. Therefore, the addition of these new superplasticizer admixtures to the fresh concrete offered greater control over the rheological properties of concrete and provided flowable concrete with greatly reduced water demand to achieve a desired diameter due to deflocculating and adsorption of highly negative charges on cement particles thereby making superplasticizer concrete more cohesive. This should be done with caution to avoid overdose which would not yield the true expected and desired slump. This means that the concrete made with Master Glenium 118 superplasticizer has a higher slump and thereby proved more workable compared to natural concrete. Thus, transporting and placing such admixture is discovered to have influenced the workability of the mix and can be recommended for improved performance of concrete in the construction industry.

Table 2: Workability of natural concrete (NC) & super-plasticizer (SP) mix concrete for various W/C ratios

Specimen No.	**Mixing Proportions**	**Trial 1 Slump (cm)**	**Trial 2 Slump (cm)**	**Average Slump**	**Estimated Flow (cm)**
X_1	NC mix, For w/c: 0.6	16	18	17	48.5
X_2	W/C: 0.60 & SP: 0.8	18	17	17.5	56.5
X_3	W/C: 0.60 & SP: 1.0	28	27	27.5	67
Y_1	NC mix, For w/c: 0.55	7	9	8	39
Y_2	W/C: 0.55 & SP: 0.8	16	15	15	40.5
Y_3	W/C: 0.55 & SP: 1.0	25	26	25.5	57
Z_1	NC Mix, For w/c: 0.5	4	6	5	33.5
Z_2	W/C: 0.50 & SP: 0.8	14	13	13.5	43
Z_3	W/C: 0.50 & SP: 1.0	17	19	18	47

In summary, achieving high workability in concrete required higher water content, naturally, but could result in issues such as increased porosity, decreased strength, and reduced durability. However, superplasticizers have revolutionized the field by allowing engineers and construction professionals to achieve exceptional workability without resorting to excessive water, thus addressing these concerns. Previous researchers focused on the use of lignosulfonates and other organic materials; however, these initial efforts had limitations, including a reduced compatibility with certain types of cement and the tendency to retard setting times. The Master Glenium 118 superplasticizers chemical compounds used in this work improved the workability of concrete devoid of such limitations.

3.2 Effect of Superplasticizer on Compressive Strength of Concrete Considering Different W/C Ratio

The aggregate content and proportion of fine & coarse aggregate was obtained from mix design and concrete density of 2400kg/m3 was gotten from the chart which was used to produce three trial samples of concrete A, B and C at w/c ratio of 0.5. Stresses was applied to the samples using the compressive testing machine (CTM) and the compressive strength of the concrete was measured. Figure 1 showed the result of the weight of concrete for 7 days, 14 days, 21 days and 28 days curing process for normal concrete (NC) and the super plasticizer concrete (SPC). Figure 2 showed the result of the compressive strength of concrete for 7 days, 14 days, 21 days and 28 days curing process for normal concrete (NC) and the super plasticizer concrete (SPC). The Master Glenium 118 compounds is an improvement of sulfonated naphthalene formaldehyde condensate based on a unique carboxylic ether polymer with long lateral chains; improves dispersion of cement.

The result of the weight of concrete after seven (7) days of curing is 8.74kg and 8.30kg while the compressive strength achieved is 7.85 kN/m^2 and 6.37 kN/m^2 for natural concrete and superplasticizer concrete respectively. It is observed that adding the super-plasticizer admixture into the concrete mix appropriately decreases the weight of the concrete and reduces the strength required in the crushing of the concrete after seven days of curing. The means that the super-plasticizer admixture used in this study has ability to convert a heavy concrete into a light weight concrete. The result of the weight of concrete after fourteen (14) days of curing is 8.31kg and 8.30kg while the compressive strength achieved is 7.70 kN/m^2 and 11.33 kN/m^2 for natural concrete and superplasticizer concrete respectively. It is observed that adding the super-plasticizer admixture into the concrete mix appropriately decreases the weight of the concrete and improves the strength required in the crushing of the concrete after 14 days of curing. The means that the super-plasticizers admixture used in this study improves concrete strength and has ability to convert a heavy concrete into a lightweight concrete.

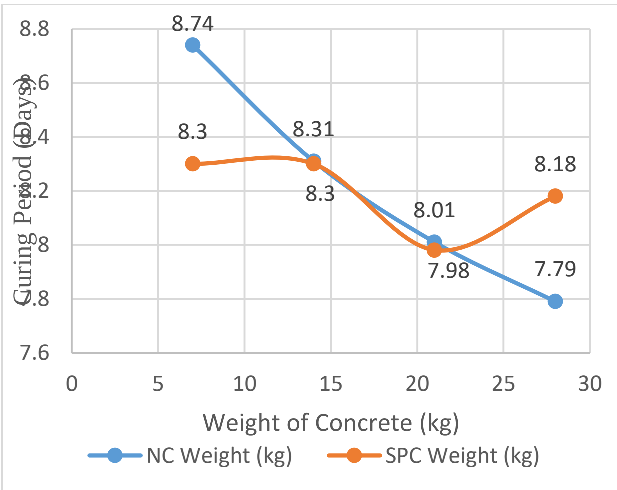

Figure 1. Weight of natural concrete and concrete produced with super-plasticizer

The result of the weight of concrete after twenty-one (21) days of curing is 8.01kg and 7.98kg while the compressive strength achieved is 12.94 kN/m2 and 11.19 kN/m2 for natural concrete and superplasticizer concrete respectively. It is observed that adding the super-plasticizer admixture into the concrete mix appropriately decreases the weight of the concrete and reduces the strength required in the crushing of the concrete after twenty-one days of curing. This means that the super-plasticizer admixture used in this study can convert heavy concrete into lightweight concrete. The result of the weight of concrete after twenty-eight (28) days is 7.79kg and 8.18kg while the compressive strength achieved is 14.81 kN/m2 and 14.37 kN/m2 for natural concrete and superplasticizer concrete respectively. It is observed that adding the super-plasticizer admixture into the concrete mix appropriately decreases the weight of the concrete and reduces the strength required in the crushing of the concrete after twenty-eight days of curing. This means that the super-plasticizer admixture used in this study can convert heavy concrete into lightweight concrete.

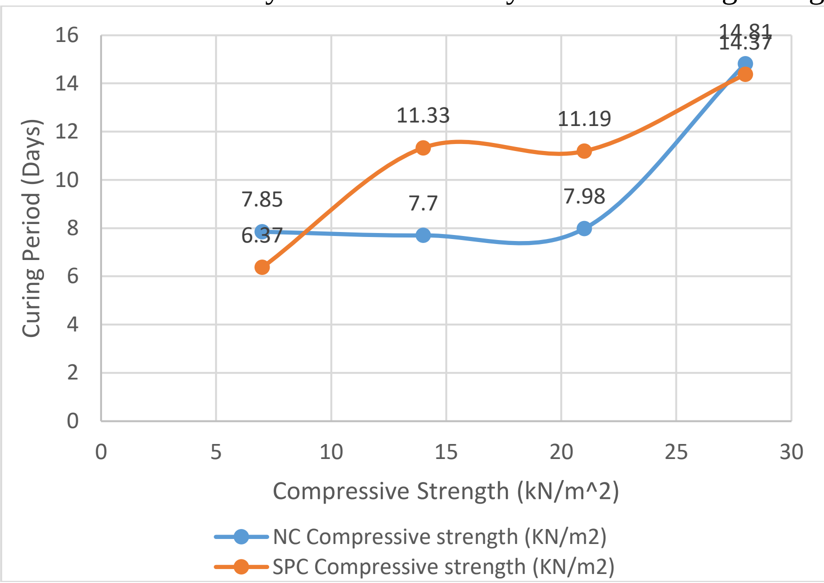

Figure 2. Compressive Strength of natural concrete and concrete produced with super-plasticizer

A critical study of the result in the Figure 2, it is observed that the compressive strength of the natural concrete (concrete made without admixture) increase as the curing period increases from 7 to 28 days. This strength increase more for the super-plasticizer concrete (concrete made with super-plasticizer admixture) when compared to the natural concrete. On the other hand, it is also found that the weight of the natural concrete decrease as the curing period increases from 7 to 28 days, and even decrease more for the super-plasticizer concrete thereby producing a light weight concrete which is more durable with a considerable higher economic benefits. It was discovered that at 14 and 21 days of curing, the weight of the normal concrete almost coincides with that of super-plasticizer concrete. This weight gives greater value at final (28 days) period of curing which is higher for the concrete produced with super-plasticizer concrete mix. This innovation in the application of this admixture marked a turning point in the concrete industry, opening up new possibilities in the design and construction of structures as concrete mean desired compressive strength can found at any given weight of the concrete.

Figure 2 showed that the compressive strength of concrete increase as the number of days of curing increases for both natural concrete and the concrete made by mixture of super-plasticizer admixture. It is observed that the compressive strength of the concrete decrease when the super-plasticizer admixture is added. This is because the admixture contains polycarboxylate ether-based superplasticizers which causes a reduced stress induced but offered a greater performance benefits and thereby provide exceptional water-reduction capabilities, excellent compatibility with various cements, improved durability and slightly decrease the crushing strength or stress characteristics. It is also found in the Figure 1 that the value of the compressive strength of the both the NC and SPC mixture are very close or almost the same at early curing period (7 days) and later curing period (28 days). This result is satisfactory as most desired strength of a given concrete specimen can still be achieved at last curing period and the same time making the concrete workable. This shows that a continuous evolution of superplasticizer technology has expanded their applicability to a wide range of concrete applications, including high-strength concrete, self-consolidating concrete (SCC), and concrete with low water-cement ratios.

It is observed from this study that the present work using the Master Glenium 118 superplasticizer showed more improved strength, rate of flow and workability in the concrete compared to the past studies [36, 37, 38]. The result of the previous study showed that the author in [36] got the value of slump and rate of flow at 0.6 w/c ratio as 130mm and 530mm for 0.8% superplasticizer dosage while the present work has the value of slump and rate of flow at 0.6 w/c ratio as 175mm and 565mm for 0.8% superplasticizer dosage. This signifies that the superplasticizers used in this study has not only improved the workability of concrete but has also had a positive impact on the concrete strength in construction industry as a whole, thus more suitable compared to the past studies in consideration. It is worthy to note that production of concrete used in this research can lead to the development of high-performance concrete (HPC), ultra-high-performance concrete (UHPC) and self-consolidating concrete (SCC), which are now used in demanding structural applications, such as high-rise buildings, bridges, and infrastructure projects. These advanced concretes offer superior strength, durability, and resistance to various environmental factors.

4. Conclusion and Recommendation

4.1 Conclusion

Superplasticizers have played a transformative role in the field of concrete technology, enabling the construction of safer, more durable, and aesthetically pleasing structures. This study seeks to build upon this foundation by providing a comprehensive analysis of the influence of super-plasticizing admixtures on concrete properties, ultimately contributing to the continued advancement of concrete technology and the improvement of construction practices.

4.2 Recommendation for Future Studies

The use of superplasticizing admixtures in concrete continues to evolve, with ongoing research focusing on optimizing dosage, developing new types of superplasticizers, and exploring their compatibility with supplementary cementitious materials. Additionally, there is a growing interest in sustainable and eco-friendly superplasticizers that reduce the environmental impact of concrete production. Despite the widespread use of superplasticizers and their documented benefits, there is still room for further research and optimization. Different superplasticizers exhibit varying effects on concrete properties, and their performance can be influenced by factors such as cement type, curing conditions, and mix proportions. Therefore, it is essential to understand how superplasticizers interact with these variables and how their dosages can be tailored for specific applications. This research can offer suggestions for further research avenues or investigations that could build upon the study's findings and expand our understanding of superplasticizers' role in concrete performance.

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