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DURABILITY PROPERTIES OF CONCRETE CONTAINING NANO SILICA AND SLAG SAND FOR HIGH STRENGTH CONCRETE

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Abstract

Formulated the concrete mix proportions using M60 Grade cement. Calculate the cement's standard consistency, specific gravity, and fineness, as well as its initial and final setting times. Determine the fine and coarse aggregate properties, including bulk density, sand bulking, fineness modulus, specific gravity, and a sieve analysis of fine aggregate. Learn about concrete's characteristics by conducting tests like the slump and vee-bee, and figuring out its water-to-cement ratio (W/C). The cubes are cast with the correct W/C ratio, cured in water, acid, and base, and then tested at 28, 30, 90, and 120 days (acid and base Cured Cubes). Once the curing time is up, measure the cubes' compressive strength using a compressive testing machine. Curing is accomplished with sulfuric acid and sodium hydroxide in this instance. Its weight in water accounts for 5% of its total usage. The percentages of nano silica used to partially replace cement are 5%, 10%, 15%, and 20% respectively.

Keywords: Nano Silica, Slag sand, High Strength

I. INTRODUCTION

Mineral admixtures have been widely used in place of cement for quite some time as an integral part of contemporary concrete technology. Different methods exist for implementing this alteration, so you can choose the one that best suits your needs. Many different purposes can be served by incorporating mineral admixtures into concrete. 5. Making eco-friendlier concrete with the goal of improving environmental sustainability One way to reduce construction costs is to use a cement substitute. Second, strengthening hardened concrete's resistance to wear. Three, enhancing the concrete's mechanical properties in a number of ways During concrete placement in warm weather, minimising the concrete's heat output and temperature increase is a top priority. 5. Making eco-friendlier concrete with the goal of improving environmental sustainability 1. enhancing the durability of the set concrete. 2. Enhancing the concrete's durability once it has hardened. 3. Modifying the concrete's mechanical properties. They may replace Portland cement in batching facilities and in the creation of mixed cements. GGBFS (hereafter slag) and fly ash have been the two most used mineral admixtures in recent years. And this has persisted for a long time. All references to "slag" from this point forward will include both ground and granulated blast furnace slag. Before now, the two concepts were considered separate. Slag-based concretes (those with a slag content of 50% or higher) have been used in saltwater environments and places where sulphate is abundant in the underlying

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ground water. This is due to the fact that these concretes can withstand sulphate attacks (Mehta 1991; ACI 233R 2003).

Fly-ash, a mineral admixture, can be used as a substitute for cement in concrete at high percentages thanks to its pozzolanic nature. This is due to the many benefits associated with substituting fly-ash for cement in concrete. The most common type of material used for this purpose is fly ash. The ability to produce concrete at the targeted cost is only one of its many features. Slag and fly ash-heavy concretes may cause health problems (Langley et al., 1989; Bilodeau & Malhotra, 2000; Mindless & associates, 2003) cure well and attain strengths comparable to or greater than those of concretes without these materials if the curing process is given enough time. However, this is only true if the curing process is allowed sufficient time. However, early strengths of concretes made with these minerals are typically lower than the early strengths concretes that don't include any fly ash or slag. This is because these minerals hydrate and react more slowly than others. For one thing, these minerals take longer to hydrate and react than others do, which is why they are so ineffective. The reason for this is that these minerals take longer to hydrate and react than other minerals.

Silica fume has long been used to increase early strengths in concretes with a high slag or fly ash content, complementing the effects of these mineral admixtures. The purpose of this was to make the concrete last longer, so we did this. In Chapter 2 of this book, we'll talk about how to explain the reaction mechanism at work when silica fume is mixed with cement. You can accomplish this by thinking about the individual effects that each of these mineral admixtures has on the cement.

Incorporating such materials into concrete was once thought to be impossible, but advances in nanotechnology and the availability of nano-silica have made this a reality. As an amorphous material on the nanoscale with high reactivity, nano-silica goes by this name as well. Sometimes you'll see NS for "nano-silica." Particles of silica fume tend to be larger than 100 nm in size, while spherical NS particles have diameters of between one hundred and one hundred and five nanometers (Sobolev and Gutierrez 2005; Camillo et al. 2007; Sanchez and Sobolev 2010). In terms of both size and surface area, NS particles are on the smaller end of the spectrum compared to silica fume. To increase the early compressive strengths of concrete containing significant levels of slag or fly ash, NS may be more effective than silica fume. Whereas several studies have looked at the use of silica fume in concrete, very few have looked at the use of NS.

In recent years, it has been shown that adding NS to cement pastes and mortars in very minute quantities may increase their early-age and 28-day strengths (Qing et al., 2007). These findings were first published in Cement & Concrete Research (Li et al. 2004; Jo et al. 2007). Also, when combined with fly ash, nano-silica boosts concrete's early strength (Li 2004; Said and Zeidan 2009). There is evidence that NS can improve the strength of cement mortars (Li et al. 2004; Jo et al. 2007) and fly ash concretes (Schaefer and Maji 2009) compared to those made with silica fume alone. There are reports like this in Schaefer and Maji (2009). In any case, the question of whether or not NS can be used to increase the initial strength of concrete remains that already has a high slag content is unknown. Clearly, this is a question of paramount importance. In order to reap the benefits of NS, it is crucial to achieve uniform dispersion of the compound. This is because NS is composed of extremely fine particles that tend to aggregate due to high surface interaction. Methodological procedures are being followed to ensure that the research project meets the objectives and scopes specified below.

II. LITERATURE REVIEW

[1] ACI 116R (2000). “Cement and concrete terminology”. Within this section, for the sake of your convenience, we have provided definitions of some of the terms that are used in the industry on the most frequent basis. The report defines more than 1400 terms that are associated with the production of cement, in addition to construction, design, and research in concrete. For your edification and convenience, we have arranged these explanations in alphabetical order.

[2] ACI 233R (2003). “Slag cement in concrete and mortar”. Common knowledge holds that Concrete may use iron blast-furnace slag as either an aggregate or cementitious material. The last several years, slag cement has gained popularity as an alternative cementitious material for use in concrete. In addition to Portland cement, slag cement is discussed as a potential cementitious material for use in this report. Other than iron ores, the smelting processes that produce slags are outside the scope of this report. These usage suggestions and material descriptions are for solely granulated iron blast-furnace slag is used to produce this cement.

[3] ACI 234R (2006). “Guide for the use of silica fume in concrete”. Recent typical applications of silica-fume concrete; how silica-fume concrete is proportioned, specified, and handled in the field; areas where further research is needed; and a description of the physical and chemical properties of silica fume are all covered in this report.

[4] ASTM C 33 (2003). “Standard specification for concrete aggregates”. For the most part, concrete makes use of both fine and coarse aggregate, while lightweight and heavyweight aggregate are employed for certain applications must meet the standards set forth in this specification. Contractors, concrete producers, and other buyers can use this specification as part of a purchase order to detail the materials that will be delivered. For the most part, this criterion is sufficient to guarantee adequate materials for concrete. It's understood that it could be excessively restrictive or lax relative to what's required, depending on the task at hand or the location. More stringent There might be restrictions on substances that discolour the concrete for instance, in contexts where aesthetics are highly valued. The specifier is responsible for ensuring that the aggregates required for the work are readily available in the area, and meet the necessary standards for grading, physical, chemical, or any combination thereof.

[5] ASTM C 109/C 109M (2002). “Standard test method for compressive strength of hydraulic cement mortars (using 2-in or [50-mm] cube specimens)”. It is possible to increase the compressive strength of mortars such as hydraulic cement by evaluated using this test method, and the results can be used to check for specification compliance. In addition, many other standards and evaluation procedures cite this test as a reference. Results from this method of testing should be used with caution when attempting to predict concrete strength.

[6] ASTM C 136 (2006). “Standard test method for sieve analysis of fine and coarse aggregates”. 1.1 The sieving of fine and coarse aggregates to determine their particle size distribution is the focus of this test method.

1.2 Coarse and fine fraction grading requirements are present in some specifications for aggregates that refer to this test method. The analysis of such aggregates through a sieve is explained as well.

1.3 SI units are to be considered the norm for all values stated herein. Informational purposes only are served by the values in parentheses. The sieve frame sizes in this test method are designated in SI units that are equivalent to the inch sizes specified in Specification E 11.

1.4 It is not the intention of this standard to cover potential safety issues. Anyone using this guideline is responsible for developing effective health and safety practises and determining any applicable legal limits.

III. METHODOLOGY

Introduction

Compressive strength development was evaluated on specimens made from mortars containing anywhere from 1% to 50% GGBFS or ASTM class F fly ash (ASTM C 618 2008a) over the course of 91 days. This variable was shown to be significantly affected by NS dose, particle size, and dispersion technique. Based on the following considerations, we decided that a content of 50% slag or fly ash was appropriate: (1) this content of slag and fly ash has been used in practise; (2) more than 50% fly ash is not common in practise; (3) early strength of concrete with less than 30% slag may not be significantly affected; and (4) relative comparison of slag and fly ash. The use of a superplasticizer increased the flow rate of the mortars by 104%-112%. Cement pastes were created with the same water-to-cementitious-materials ratio (w/cm) and mix percentage as the mortars in order to determine the rate of heat development and cement hydration in the first 30 hours, and pore structure (slag pastes alone) at 28 days (except for the sand). Many different concrete mixtures were prepared and tested for their setting time, compressive strength development from 3 to 91 days, and resistance to chloride-ion penetration at 28 days in order to compare the performance of NS with that of the reference slag or fly ash concrete and the concrete with silica fume. If the w/cm ratio is less than the value at which full cement hydration can be accomplished, the impact of the NS may be obscured since there won't be enough space or water for hydration and reaction to occur. In general, early strengths are diminished for concrete that has been mixed with a lot of slag or fly ash. A lower w/cm ratio is required to compensate for the increased strength of Portland cement concrete. The ratio of 0.45 w/cm was decided upon after taking these two factors into account.

Materials

Here we describe the properties of the The ingredients include water, superplasticizer, nano-silica, silica fume, sand, coarse aggregate, and fly ash that were incorporated into this study.

Nano-Silica

We compared the impact of NS and silica fume on the onset of mortar strength development using two NS samples with varying specific surface areas. The experiment relied on these two samples. Each of the NS samples used in this analysis had a different specific surface area. However, despite their differences, the total surface area of the two NS sample types was identical. A part of this project's remit included looking into how NS influences the onset of mortar strength. This was a necessary condition that had to be met. In addition, Table 3.1 provides a comprehensive breakdown of the characteristics shared by all of these varied materials. As you look around, you'll see a wide variety of materials. You will find a large selection of materials to select from. The average main particle size of Type 11 NS was 12 nm, whereas Type 22 NS was 7 nm. It was determined that their respective spgs were 200 and 321 m2/g. Both NS had fundamental particles of differing sizes. They also had different primary particle sizes, indicating that they were different NS. Furthermore, there was no correlation between the two NS's primary particle sizes. Furthermore, there was a notable difference between the two NS in that their primary particle sizes did not correspond to one another. Another major distinction between the two nanoparticle types was that the primary particle sizes of the two NS did not correspond to one another. The label for the NS product was developed after careful consideration and adherence to these standards. As for the used silica fume, a particle size analyzer determined that its average particle size was 150 nm, and it was impossible to pinpoint where the fume was coming from. However, the source of the unpleasant vapour could not be pinpointed. The value of 21.30 m2/g was recorded as the value for its specific surface area after being measured.

Strength Development of Slag Concrete with Nano-Silica

Figure 1 shows the differences in compressive strength development between the reference slag concrete, concrete containing the same quantity of silica fume, and slag concrete with 2% Type 1 NS. Tabular 1 summarises the percent strength gains of slag concrete treated with 2% NS or silica fume in comparison to the reference slag concrete. By day 3, the early strengths of the NS-treated concrete were 22% higher than those of the reference slag concrete, and by day 7, the silica fume-treated concrete had reached the same levels. Strength-wise, however, at 28 and 91 days, all three concretes were about the same. The concrete's coarse aggregate may have reached its strength limit, which could explain the problem.

Discussion on Strength Development

The typical primary particle size of NS is roughly 10 times smaller than that of silica fume. The effects of silica fume on cement paste, mortar, and concrete are summarised in a recent paper by the American Concrete Institute's Committee 234. (2006). NS can also be explained by these mechanisms. The NS is likely to have a more significant physical and chemical effect than the silica fume because of the smaller particle sizes of the NS.

Test Method Analysis

- The primary goal of this research is to find out if nanoparticle-sized silicas can increase the strength of alkaline or basic pre-treated concrete. As a means of accomplishing this, it will be decided whether or not to employ silicas that have been sized down to the level of nanoparticles.
- The goal of this experiment was to see if nano silica could be used to partially replace the cement in a set ratio, and then cured with diluted H_2SO_4 and NaOH. Findings from this study, if confirmed, would suggest that nano silica could be used to partially replace cement. If this study's findings hold, then nano silica could be used to partially replace cement, which would prove the hypothesis correct. If this were the case, then the hypothesis would be verified. For this study to have supported the hypothesis, nano silica would have to be an acceptable replacement for cement.
- This would prove the hypothesis correct, if it were true. The results of this study, if confirmed, would indicate that nano silica could be used as a partial replacement for cement. Because cement was used to test the hypothesis, this seems likely to be the case. A positive result here would indicate that the hypothesis is a reasonable explanation of the data. The results of this study, if the hypothesis is correct, suggest that nano silica could be used to partially replace cement in the construction of buildings and other structures. If the hypothesis were proven correct, then this would be the case.
- This hypothesis was the driving force behind the investigation, so naturally, data collection in support of it was a top priority. That's why that aspect of the inquiry was given so much attention. Since this was supposed to be the point of the study, it was decided that it would be best to carry it out in order to investigate these hypotheses. The research was conducted to look into these speculations. Because of the choice made, the research project has come to a successful close.

IV. WORKABILITY TESTS ON CONCRETE

The level of effort required to place and compact the concrete to its final shape is a measure of its workability. The Slump Cone Test and the V-Bee Test are used to evaluate the practicability of this project.

Slump Cone Test

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows.

Table 1: Slump Cone Test

S.No.	% Cement Replaced with Nano Silica (NS)	Slump Value (mm)
1	0 %	112

2	5 %	104
3	10 %	98
4	15 %	95
5	20 %	89
6	25 %	81

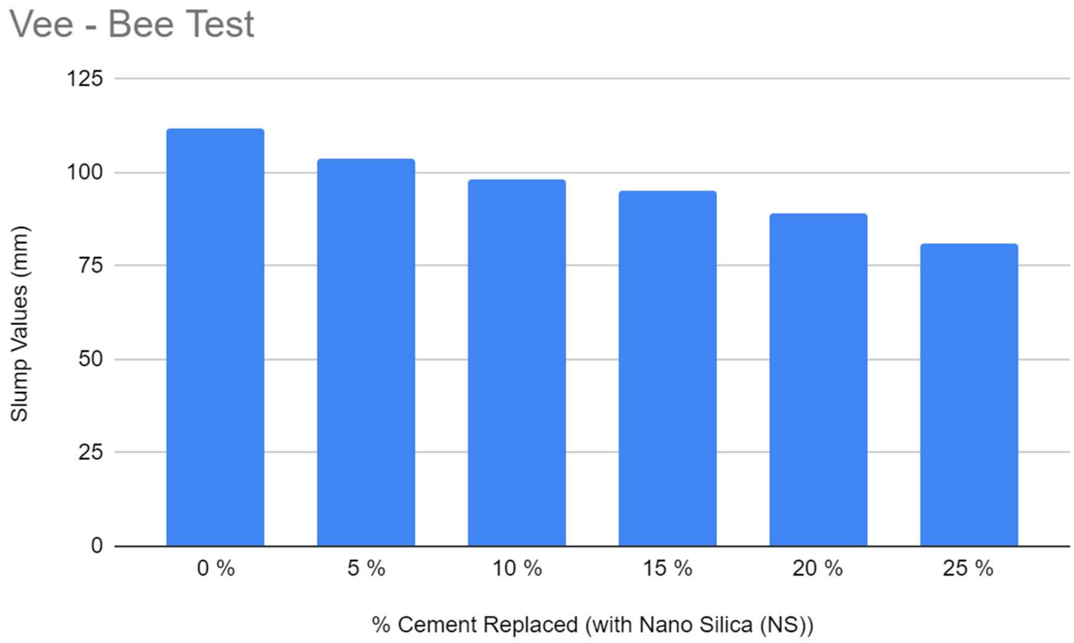

Figure 1: Bar Graph for Slump Cone test

Vee - Bee Test
vee - Bee test a device that uses vibration to measure how much effort is needed to transform a concrete mass from one predetermined shape to another (in this case, from conical to cylindrical).

Table 2: Vee - Bee Test

S.No.	% Cement Replaced with Nano Silica(NS)	Vee - Bee Time (Sec)

1	0 %	4
2	5 %	4.43
3	10 %	4.88
4	15 %	5.52
5	20 %	6.21
6	25 %	5.33

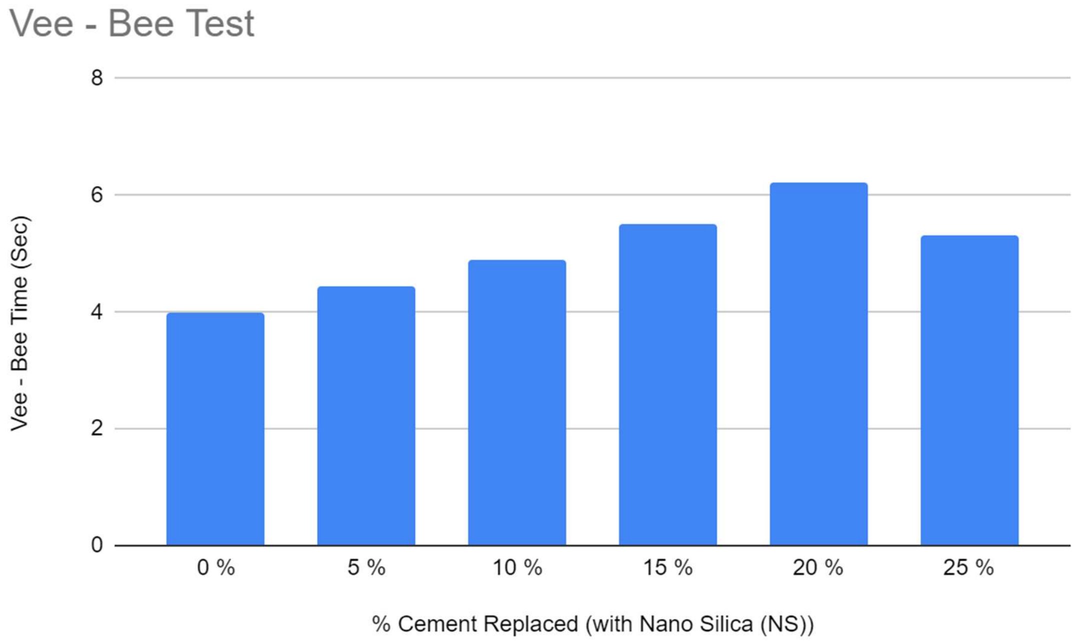

Figure 2: Bar Graph for Vee-Bee Test

Acid Curing

To create acid curing coatings (SH), also called cold-curing coatings, a mixture of alkyd and amino resins is dissolved in organic solvents. Due to their high chemical resistance, quick drying times, and long pot lives (up to 5 days), these coatings find widespread use in the furniture industry. The widespread appeal of these coating systems can be attributed to the introduction of formaldehyde-free variants.

Table 3: Acid curing

Compressive Strength under Acid Curing			
	Compressive Strength (N/mm2)		
% Cement replaced	**30 Days**	**90 Days**	**120 Days**
0	28.93	20.88	15.91
5	31.62	25.66	19.6
10	34.22	29.33	23.54
15	38.15	32.89	28.36
20	34.07	28.66	24.01
25	30.66	24.66	19.62

Curing process:

Curing is the process of preventing concrete from drying out after it has been placed or during the making of concrete products, allowing the cement to fully hydrate.

Curing times for concrete structures at temperatures above 5º C (40º F) should be at least 7 days, or until 70% of the specified compressive or flexural strength is attained.

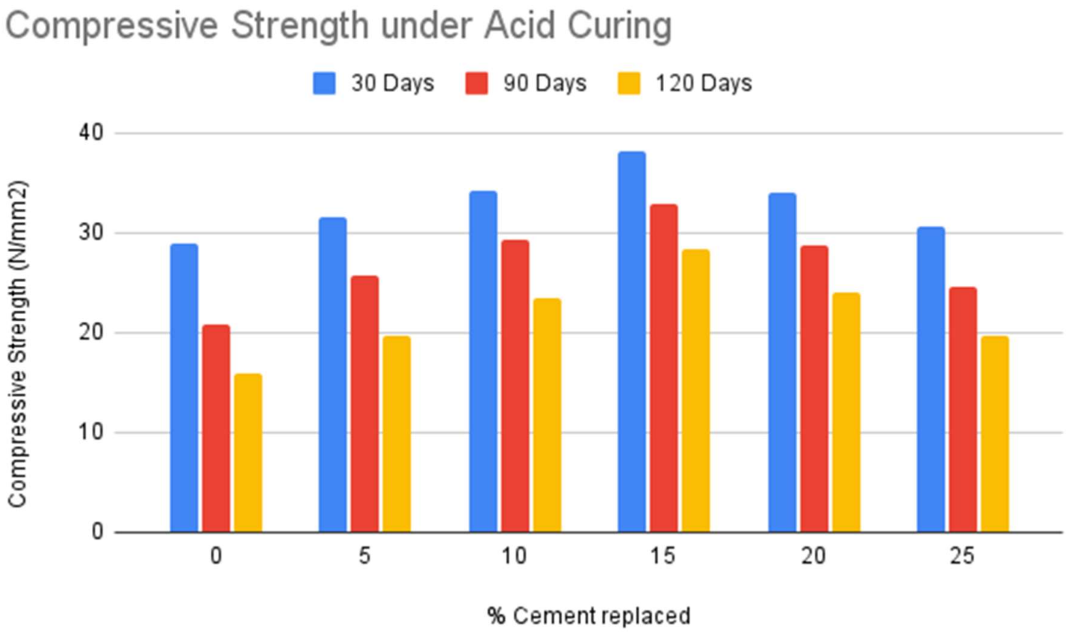

Figure 3: Bar Graph for Compressive Strength under Acid Curing

Base Curing:

Base During curing, the rate and amount of moisture loss from concrete while it hydrates are managed. As the name implies, this curing method involves keeping the exposed surface constantly wet to prevent it from drying out. Common techniques for achieving this goal include ponding water or spraying water over the top of the surface.

Curing process:

While curing, neutral cure releases a substance that is not acidic (unlike acetoxy caulks which release acetic acid). There's less of a chance of harm coming to delicate substrates and surfaces. Neutral cure, for instance, is mild enough that it won't stain natural stone or corrode metal.

Table 4: Base curing

Compressive Strength under Base Curing			
	Compressive Strength (N/mm2)		
% Cement replaced	**30 Days**	**90 Days**	**120 Days**
0	25.63	19.02	12.86
5	28.98	23.86	15.68
10	32.89	28.65	18.52
15	38.71	30.44	22.14
20	35.82	26.88	19.32
25	32.41	24.12	17.01

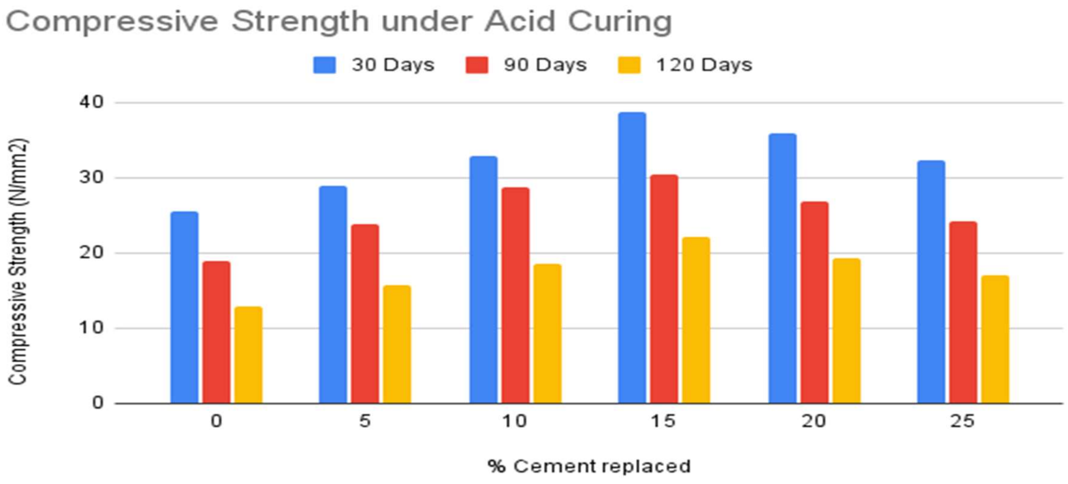

Figure 4: Bar Graph for Comprehensive strength under base curing

V. CONCLUSION

- The primary goal of this research is to find out if nanoparticle-sized silicas can increase the strength of alkaline or basic pre-treated concrete. As a means of accomplishing this, it will be decided whether or not to employ silicas that have been sized down to the level of nanoparticles.

- The goal of this experiment was to see if nano silica could be used to partially replace the cement in a set ratio, and then cured with diluted H_2SO_4 and NaOH. Findings from this study, if confirmed, would suggest that nano silica could be used to partially replace cement.
- If this study's findings hold, then nano silica could be used to partially replace cement, which would prove the hypothesis correct. If this were the case, then the hypothesis would be verified. For this study to have supported the hypothesis, nano silica would have to be an acceptable replacement for cement. This would prove the hypothesis correct, if it were true.
- The results of this study, if confirmed, would indicate that nano silica could be used as a partial replacement for cement. Because cement was used to test the hypothesis, this seems likely to be the case. A positive result here would indicate that the hypothesis is a reasonable explanation of the data. The results of this study, if the hypothesis is correct, suggest that nano silica could be used to partially replace cement in the construction of buildings and other structures. If the hypothesis were proven correct, then this would be the case.
- This hypothesis was the driving force behind the investigation, so naturally, data collection in support of it was a top priority. That's why that aspect of the inquiry was given so much attention. Since this was supposed to be the point of the study, it was decided that it would be best to carry it out in order to investigate these hypotheses. The research was conducted to look into these speculations. Because of the choice made, the research project has come to a successful close.

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