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INVESTIGATION OF FIBRE REINFORCED HIGH-PERFORMANCE CONCRETE PROPERTIES USING NANO CEMENT AND RECYCLED AGGREGATES

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Abstract : Concrete is one of the most essential and commonly utilized construction materials in India. Numerous developments in concrete are occurring as a result of the use of locally available materials. Researchers in the field of concrete engineering have demonstrated unequivocally that waste materials such as aggregate can be recycled and repurposed in fresh concrete. Recycling is the process of reusing previously discarded resources in order to create new ones. Utilizing waste material as a secondary raw resource is the most cost-effective way to address the issue of excessive waste without sacrificing quality. We can now explore a new notion called sustainability as a result of technological advancements. Sustainable development should prioritize environmental protection and the conservation of rapidly decreasing natural resources. The fact that concrete is fragile under tension is a well-known fact. Concrete's mechanical qualities can be improved by adding fibres. The qualities of the concrete and the fibres define the character and performance of Fibre Reinforced High-Performance Concrete (HPC). Cement, fine aggregate, Nano silica, steel fibres, and carbon nanofibers are the constituent ingredients of high-performance concrete. The concentration of fibres, the geometry of the fibres, the orientation of the fibres, and the dispersion of the fibres are all characteristics of fibres that are of importance for research. The addition of fibres to concrete helps control cracks, prevents crack coalescence, and modifies the material's behaviour by increasing ductility. The material's static flexural strength, fatigue resistance, fracture toughness, and ductility are improved by the inclusion of fibres. The following experiments in fiber-reinforced high-performance recycled aggregate concrete are planned. To investigate the behaviour of compressive and tensile strengths. To study the flexural strength behaviour of concrete and to obtain high strength, cheap cost, and long-lasting durability.

***Keywords*- HPC, recycled aggregate, flexural strength.**

1. Introduction

In the building industry and the concrete manufacturing sector, it has become evident that utilising readily accessible aggregate rather than locating the optimal aggregate to produce an optimum concrete for all applications is the best alternative. Simultaneously, substantial advancements in concrete recycling result in the production of hundreds of tonnes of Recycled Concrete Aggregate (RCA), which may be used to make a variety of types of concrete. The 1994 release of the RILEM Technical Committee 121's 'Specification for Concrete with Recycled Aggregate' was an important step toward boosting the usage of recycled concrete aggregate in new concrete (RILEM, 1994). The definition complemented several research efforts conducted by researchers worldwide, particularly in the United States, Europe, and Japan. The research efforts have been directed toward two primary objectives: first, a better knowledge of the fundamental technical features of locally manufactured recycled concrete aggregate, and second, the aggregate's use in concrete.

As buildings, roads, bridges, and other structures are demolished every year, hundreds of thousands of tons of debris is generated. As the world moves towards saving the environment, and governments offer tax rebates to those investing in fuel-efficient technologies in an effort to reduce their carbon footprint; recycling this debris is the perfect way for any contractor to save the environment and their expenses, all while ensuring strength in the foundation of their new structures. Due to its assimilated nature, it provides even higher economies of scale than those possible with the use of regular aggregates. Demolished concrete is collected from sites and put through crushing machines for converting to smaller sizes. Recycled concrete aggregates contain not only the original aggregates, but also hydrated cement paste. This paste diminishes the specific gravity and enhances the porosity compared to similar natural aggregates. Higher porosity of RCA leads to a higher absorption

Nanotechnology has a significant impact in the construction sector. Several applications have been developed for this specific sector to improve the durability and enhanced performance of construction components, energy efficiency and safety of the buildings, facilitating the ease of maintenance and to provide increased living comfort. Addition of nanoparticles will lead to stronger, more durable, self-healing, air purifying, fire resistant, easy to clean and quick compacting concrete. The extraordinary chemical and physical properties of materials at the manometer scale enable novel applications ranging from structural strength enhancement and energy conservation to antimicrobial properties and self-cleaning surfaces. Consequently, manufactured nanomaterials (MNMs) and nanocomposites are being considered for various uses in the construction and related infrastructure industries.

2. Related Work

Nowadays, advancements in concrete technology are being developed. Cement and other basic materials such as sand, aggregates, and water retain their original properties. The use of air entrainers, superplasticizers, and water-reducing additives enhances OPC concrete's uniqueness. Numerous recent tests have been conducted to determine the possibility of using demolition waste in the construction of concrete structures. “Thomas Omollo Ofwa, David Otieno Koteng, John Nyiro Mwero (2020)[1]”, International Journal of Civil Engineering explores the effect of selected superplasticizers in the production of free-flowing concrete with CEMII/B-P targeting high strength.Cube crushing strength above 60MPa was obtained at 28 days, together with initial flowability.However, workability reduced rapidly leading to stiffening within 30 minutes. Such concrete would not allow sufficient time for transportation, placement and finishing and therefore has limited application. “Suchitra Ramasamy, ShahironShahidan, Sharifah S.M. Zuki, Mohamad A.M. Azmi (2020) [2]”A Review: Properties of Micro Steel Fibre (MSF) in High-Performance Concrete in Terms of Crack Propagation, International Journal of Engineering Trends and Technology (IJETT),Anjali Prajapati, Piyush Prajapati, Mohammed Qureshi (2017)[3]. IJEDR studied the effect of performance of HPC using mineral admixture i.e. fly ash and GGBS with M-60 grade of IS cube specimen. The compressive strength continued to increase as the curing period increase and greatest compressive strength was achieved when mixture content 30% of fine aggregate replaced with foundry sand and 10% GGBS. “A. S. Carey, I. L. Howard, D. A. Scott, R. D. Moser, J. Shannon, and A. Knizley January 2020 [4]”evaluated constituent proportions on mechanical and thermal properties of ultra-high-performance concrete. However, as fine aggregates and steel fibres were added to cement paste, compressive strengths increased drastically. Plots were provided that showed how UHPC’s compressive strength is due to synergistic relationships between cement paste, fine aggregates, and steel fibres where the absence of any ingredient reduced strength. Tensile strength and elastic modulus, on the other hand, were dominated by steel fibres and fine aggregate, respectively

“Raghavendra Y BRamalinga Reddy YNabilHossineyDinesh H T (2021) [5]”. focused on utilization of GGBS as partial replacement (i.e., 50% by weight) to Portland cement in producing HSC at a ready-mix facility at Bangalore city.The addition of GGBS as partial replacement to Portland cement reduced the water demand and improved the workability of concrete mixtures. This can be attributed to surface characteristics of GGBS, which is smooth and reduces the requirement for water. The compressive strength for all the mixes containing GGBS was lower after 7 days of moisture curing. However, after 28 days moisture curing all the mixes containing GGBS showed improved compressive strength when compared to control mix. With respect to durability properties, all the mixes containing GGBS showed improved performance. The replacement of Portland cement by 50% GGBS reduced the cost of concrete mix by as much as 23% when compared to industry mix.”Liang Wang et al. (2017) [6]” developed a method for improving the quality of recycled coarse aggregate that is both environmentally friendly and cost-effective. Once the acetic acid solution has been used to dissolve and weaken the mortar, mechanical rubbing is used to remove the old aggregates from the surface of the concrete. A 25 % increase in material strength can be achieved by using treated aggregates in fresh concrete. This is a simple method that does not require the use of any harmful chemicals. By combining the waste solution with other wastes, it can also be used to create high-value-added items.

2.1 “Chunheng Zhou and Zongping Chen (2017) [7]” concluded that recycled concretes built using recycled crushed rock aggregate and recycled pebbles aggregate have equivalent flexural strength, compressive strength, Poisson ratio, and elastic modulus. The results indicated that the mechanical characteristics of various types of recycled coarse aggregate vary significantly.Mechanical properties of recycled aggregate concrete were researched by Ngoc Kien Bui et al. (2017) [8]”at various percentages of recycled aggregate substitution. In comparison to the old procedure, the new methodology greatly improved the mechanical qualities of recycled aggregate concrete. The new approach for RAC allows for an increase of up to 50% in the amount of RA in concrete, whereas the previous method requires that the quantity of RA be less than 30%. Geopolymer concrete structural parts were recently made more affordable by “Kim Hung Mo et al. (2016) [9]”. When recycled aggregate concrete is heated to high temperatures, it loses its energy absorption capacity, strength strain curve, young’s modulus, and compressive strength, according to a study by “Chen et al. (2014) [10]”. When exposed to high temperatures, steel fibres avoided spalling and significantly improved the ductility and cracking behaviour of recycled aggregate concrete. Steel-recycled aggregate concrete bonding was studied structurally by “Marco Breccolotti et al. (2013) [11]”. A reliability analysis is performed on recycled aggregate concrete to determine whether the existing anchorage length and lap splice design formulas can be relied on. W. C. Egwuonwu, Z. S. A. Iboroma, And E. N. Barisua (2019) {11}” examined the cementitious efficiency of metakaolinin high strength concrete production and carried out the mix design using absolute volume method. Mishra, S. K. Das, S. K. Singh, And S. M. Mustakim (2019) {12}” concluded that geopolymer concrete is a greener alternative to OPC based concrete and holds a lot of potential for the future as it is not very resource intensive and is a greener alternative to the current generation of concrete. While on one hand OPC concrete consumes a lot of non-renewable natural resources, has a huge carbon footprint and is the cause of wastage of a lot of potable water making it a threat to the environment, on the contrary geopolymer solves all of these problems and uses industrial as its source material. N. M. Azmee, And N. Shafiq (2018) {13}” gave an overview of UHPC focusing on its fundamental introduction, design, applications and challenges. UHPC has several advantages over conventional concrete but the use of it is limited due to the high cost and limited design codes.

2.2 Ganesh Khatri, L. Aparna, P. Thrivikrama Reddy (2018) [14]" concluded that the slag sand can be replaced partially for natural sand. The reason being Slag sand has more water absorption. T Murugesan, R. Vidjeapriya, A. Bahurudeen (2020) [15]" found from their experimental study that there was a significant improvement in strength and durability of bagasse ash-blended concrete specimens up to 20% replacement level when compared to the conventional concrete specimens. Mohdfakri Muda, Saffuan Wan Ahmad, Fadhluhartini Muftah, Mohdsyahrulhisyam, Mohd Sani (2019) [16]" found that the height of the slump is reduced with increasing of the sand replacement in mortar. Additionally, the maximum load and compressive strength of the mortar is also decreased when the washed BA as a sand replacement added. Lastly, the specimen with 15% of sand replacement of washed BA is the best mortar mix which provided reasonable compressive strength and workability. Joaquin Abellan Garcia, Jaime Fernandez, Nancy Torres Castellanos (2020) [17]", performed a numerical optimization to obtain an eco-friendly mixture with the proper flow, highest compressive strength and minimum content of cement. The use of 603 kg/m3 of cement in the mixture can be considered as the most appropriate amount to be employed in UHPC mixtures, fulfilling the limit values of compressive strength and spread flow. Aishwaryadevi S. Jangam , Prof. Santosh S. Mohite , Mr. Bajirao V. Mane (2020) [18]" focused on the effect of performance of HPC using mineral admixture i.e., fly ash and GGBS with M-60 grade. The compressive strength continues to increase as the curing period increase and greatest compressive strength is achieved when mixture content 30% of fine aggregate replaced with foundry sand and 10% GGBS.Also, it is observed that development of tensile strength increases as replacement of sand by 10% of GGBS gives higher strength compared to control mix. Also, maximum flexural strength is achieved in M4 mix proportion, ggbs 10% replaced by the cement and FS is 10% replaced by the fine aggregate and the strength gained 5.104 MPa. In all mix proportion strength gain up is excellent, but 14 days compressive strength is less, and for 28 days strength gain is high because of combination of fly ash and GGBS. Szymon Grzesiak, Matthias Pahn, MilanSchultz-Cornelius, Stefan Harenberg and Christoph Hahn (2021) [19]" focussed on the influence of fiber addition on the properties of High-Performance Concrete. They concluded that the percentage of air voids in the concrete corresponds to the compressive strength and the modulus of elasticity of the concrete. The fibre addition of 15kg/m3 in the concrete composition reduced the compressive strength from 83.2MPa to 79.6MPa. PP and PVA fibres have proven to be effective in increasing the splitting tensile strength of concrete which allows better utilisation of material capacities and has an impact on the production costs of FRC members. ACI Committee 239 (2018) [20], suggested that most UHPC material properties (proprietary and non-proprietary) can be determined using tests similar to conventional concrete tests and Sufficient flow, compressive strength, and tensile strength can be achieved by non-proprietary UHPC mixes.

3. Materials and methodology

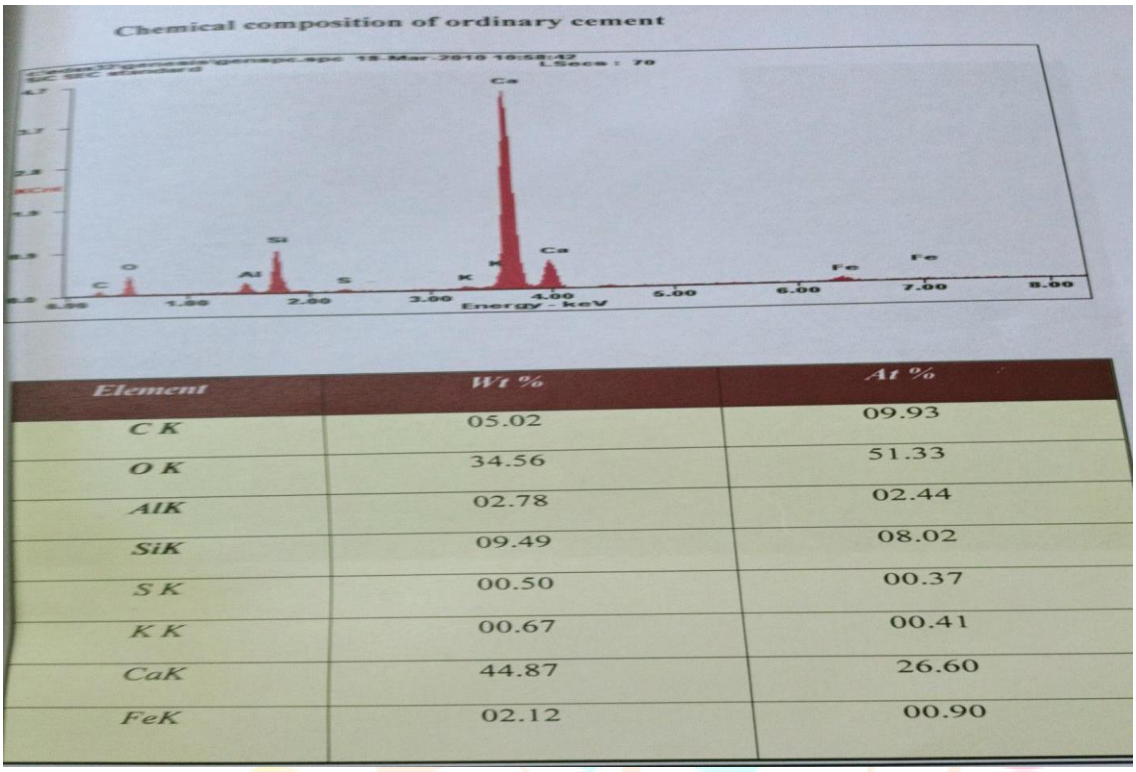
Cement, fine aggregate, Nano silica, steel fibres, and carbon nanofibers are the constituent ingredients of high-performance concrete. To obtain the needed workability, chemical admixtures such as superplasticizers, which are highly water-reducing agents, are utilized. The properties of all of these constituent materials were tested in accordance with the procedures stipulated by the applicable International Standards Organization regulation.

3.1Cement

A total of 53 grades of ordinary Portland cement (Ultra-tech) were employed in this investigation. The following are some of the other characteristics of cement:

- Specific gravity: 3.16
- Density: 1.48gm/cc

Not only are mortar-cube tests used to pick the cement for high-performance concrete, but also compressive strength tests are used to determine the appropriate cement. It is preferable to use cement with the highest compressive strength.



Element	Wt %	At %
C K	05.02	09.93
O K	34.56	51.33
AlK	02.78	02.44
SiK	09.49	08.02
S K	00.50	00.37
K K	00.67	00.41
CaK	44.87	26.60
FeK	02.12	00.90

Figure 3.1

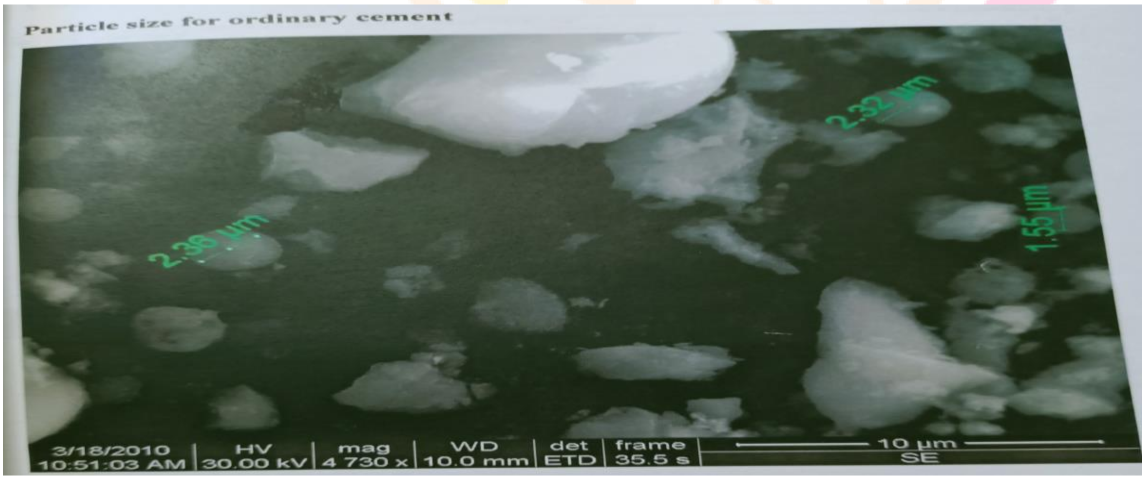
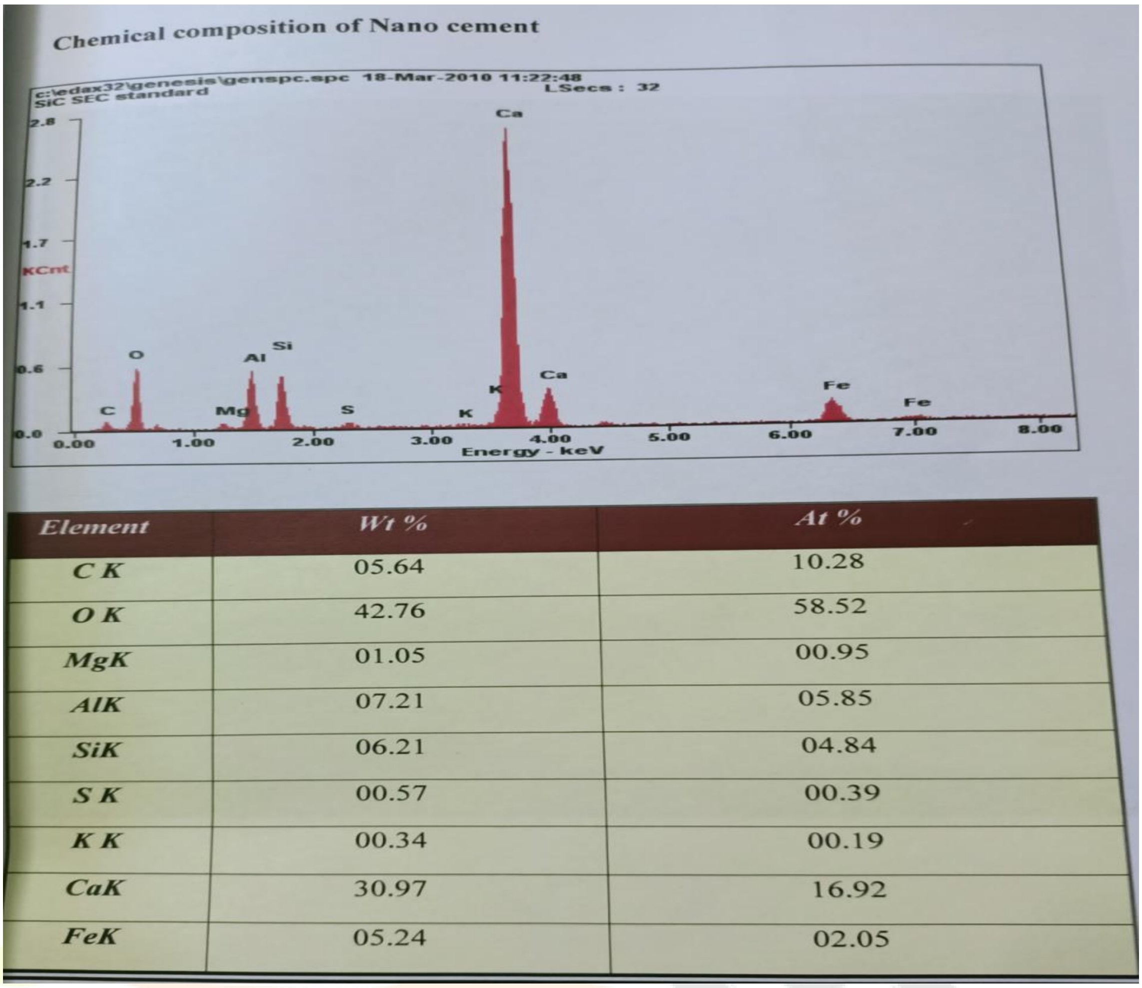


Figure 3.2

3.1. a) Nano Cement

Ordinary Portland cement of 53 grade was ground in a ball mill to produce nano cement. The characterization of nano cement was studied using Scanning Electron Microscope(SEM) andX-ray powder diffraction (XRD) methods. From the analysis, it has been found that the particles were converted to nano scale, the specific area has been increased and in the chemical composition, major constituents remain almost the same and the minor constituent varies to an extent.



Element	Wt %	At %
C K	05.64	10.28
O K	42.76	58.52
MgK	01.05	00.95
AlK	07.21	05.85
SiK	06.21	04.84
S K	00.57	00.39
K K	00.34	00.19
CaK	30.97	16.92
FeK	05.24	02.05

Figure 3.3

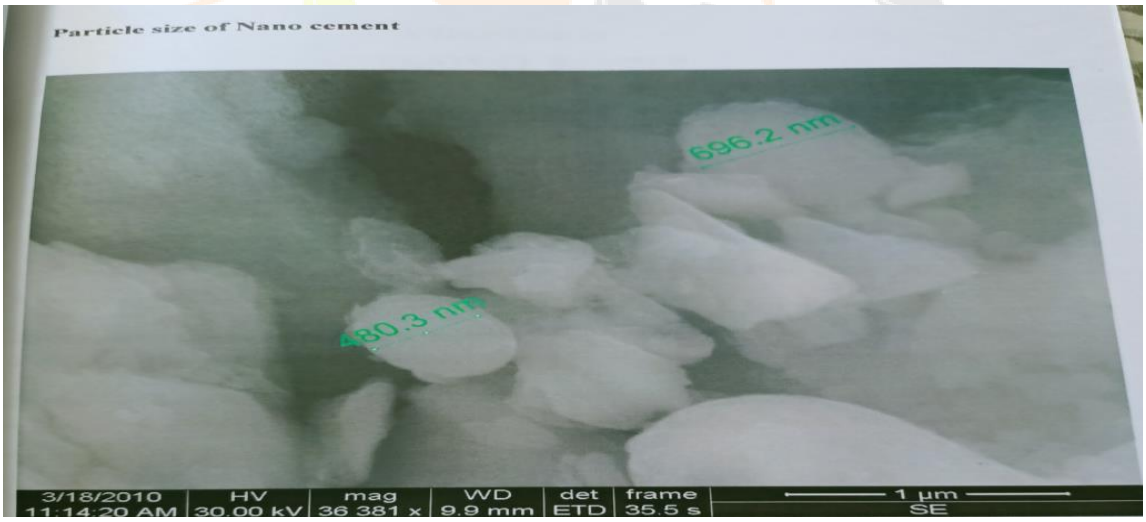


Figure 3.4

3.2 Fine Aggregate

Fine aggregates with a smooth texture and an even distribution of round particles require less water to mix. Fine aggregates should be chosen in accordance with the FA's fineness modulus. A lower fineness modulus results in a more sticky consistency, which impairs workability. Additionally, it raises water demand. Sand with a fineness modulus of 3.0 is utilized in high-performance concrete.

After ensuring that the various physical qualities specified in IS 383(part III)-1970 are met, and after passing through a 4.75 mm IS sieve confirming zone II, the local river sand is employed in the experiment. Additionally, the fine aggregate's additional qualities are included:

- Density : 1.7gm/cc
- Specific gravity: 2.6

3.3 Water

Portable water is generally regarded as acceptable if it complies with IS: 456-2000. As a result, locally accessible water was employed in the casting process. The water-cement ratio is the most critical ingredient in producing high-performance concrete. The conventional mixing procedures use a water-cement ratio of 0.23 to 0.45. Water quality requirements for high-performance concrete are less strict than for normal concrete.

3.4 Nano Silica

The nano-silica is made from silicon dioxide nanoparticles. Astra chemicals in Chennai supplies silicon dioxide. In nature, silicon dioxide is a powdery, white substance. Astra chemicals has ensured the silicon dioxide standards by the provision of a certificate. The table summarises the fundamental features of nano-silica. It is produced as a by-product of the reduction of high-quality quartz with coal in electric arc furnaces for the production of ferro silicon and silicon metal. The siO2 percentage of various forms of silica fumes varies between 85 and 98 percent. Silica is particularly hydrophilic, which means it absorbs a lot of water. It is an extremely fine pozzolanic substance made of amorphous silica formed as a by-product of the manufacture of elemental silicon or Ferro silicon alloys in electric arc furnaces. Silica fume is suitable for use in a wide variety of cementitious products, including concrete, grouts, and mortars, as well as elastomeric, polymer, refractory, ceramic, and rubber applications. Silicon Dioxide (SiO_2): 85 to 97 % Moisture Content: Maximum 2.0 % Loss on Ignition (LOI):Maximum 2.0 % specific gravity: 2.27, Oversize percent retained on 45-µm (325 sieves): Maximum 2 %, Specific Surface: Minimum 18 m^2/g Density: 250 to 700 kg/m^3

3.5 Chemical Admixture

Admixtures including high-range water reducers and superplasticizers are employed. There are several applications for this chemical, including well-dispersed particle suspension. They contribute to the production of self-consolidating concrete and high-performance concrete. They also have the additional benefit of improving the flow properties of concrete. In turn, less water is required in the concrete mix, resulting in a significant improvement in the hardening time of fresh paste compared to the conventional concrete mix. When the amount of water used in the mix is reduced, the strength of the resulting concrete increases. As a general rule, the superplasticizer contributes to improving the workability of a concrete mixture when the water to cement ratio is low, as previously stated. In the casting, the superplasticizer CONPLAST SP 430 was employed, which has a specific gravity of 1.20 based on sulfonated Naphthalene Polymer and is manufactured by FOSROC Chemicals India Pvt. Ltd., Bangalore. The superplasticizer was utilized in the casting to get the desired results. It complies with the requirements of IS 9103 and BS 5075 part III.

3.6 Steel fibres

Static flexural strength, fatigue strength, ductility, and fracture toughness of material are all improved when fibres are added to the mix. The use of steel fibres with hooked ends is often preferable when it comes to increasing the bonding qualities of the fibre and matrix. The table below contains information on the qualities and specifics of the steel fibre that was used.

Table3.1. Steel fibres

CODE	LENGTH l (mm)	DIAMETER d(mm)	ASPECT RATIO (l/d)	DENSITY	TENSILE STRENGTH Mpa
3d65/60BN	60	0.90	65	7.85	1160
4D65/60BN	60	0.90	65	7.85	1500
5D65/60BG	60	0.90	65	7.85	2300

3.7 Carbon nanofibers

Before mixing the carbon nanofiber into the concrete, it is subjected to surface modification and dispersion procedures to prepare it.Surface modification is advantageous to the CNF because it makes their surfaces more hydrophilic. It is accomplished by adding hydrophilic groups, such as PAA, to the margins of graphene sheet sheets (polyacrylic acid). PAA, in addition to making the CNF hydrophilic, reacts with the cementitious matrix, resulting in the formation of linkages with calcium silicate hydrate (C-S-H). The dispersion of CNF is accomplished by adding oxidized nanofiber, PAA, and water and stirring continuously for up to 15 hours, followed by sonication at periodic intervals of one minute at 40-75 percent of maximum power for 40-75 minutes (400 watts). For the final step, 10 minutes of pulsing at 80 percent of maximum power are performed. It is necessary to repeat the dispersion process in order to complete the entire process.

Following the surface modification and dispersion processes, the general mixing operations for the preparation of HPC are carried out in the following order: In the beginning, all of the ingredients (cement, nano-silica, fine aggregate, steel fibres, and superplasticizers) are mixed for 5 minutes at a low speed in an electric mixer until well combined. After that, the water is added, and the mixer is run at three speeds: low, medium, and high, for a total of two minutes. The casting of concrete into the mould is done and the mold is consolidated by a vibration table at high intensity. They are moist treated inside the mould themselves for 20 hours at room temperature, then de-moulded and subjected to steam curing at 70 degrees Celsius for 2 days. Testing should be done after a week.

3.8 Mix Design For HPC

Concrete mix design is concerned with determining the most rational proportions of concrete ingredients to use in order to achieve the desired properties when the concrete is hardened. The cement content of concrete that is workable in its plastic state and that will develop the property-designed concrete mix should be kept as low as possible without sacrificing the concrete quality in order to make it an economically viable mix.

The proportions of material used will vary depending on the requirements of the project. The ability to achieve full compaction of fresh concrete is severely hampered if the concrete is not properly workable. As a result, the hardened concrete loses both its strength and its durability. The water-to-cement ratio has been proven to be the most critical consideration in the formulation of concrete mixtures. The ratio of aggregate to cement, aggregate grading, aggregate form and texture, and the amount of entrained air in the aggregate are all essential considerations. Over the past few decades, a lot of effort has been put into determining how these elements affect the properties of concrete. At this point, however, no precise relationships have been established. As a result, the design of a concrete mix is still considered more of an art than a scientific endeavour.

Selection of relevant materials and defining their relative proportions in order to produce cost-effective concrete with specific minimum attributes such as strength, workability and durability while keeping a high level of efficiency is known as mix design.

To a certain extent, different qualities of freshly formed and hardened concrete can be achieved with the same materials even if some established criteria must be met by all components of concrete. Establishing a theoretical mix procedure that can be utilized with any combination of Portland cement, extra cementation materials, aggregates, and admixtures is always going to be a tough task in itself. An initial mix proportioning approach can only provide a starting point for achieving the specified concrete properties.

Table 3.2 Various Mix Design Ratio

S.No	Cement (kg/m3)	Nano Cement	Water (kg/m3)	W/C Ratio	Nano Silica (kg/m3)	SuperPlasticizer (kg/m3)	Coarse Aggregate (kg/m3)	Fine Aggregate (kg/m3)	Carbon and Steel Fibres	Recycled Aggregate (kg/m3)
M1	267.5	267.5	153	0.2635	0	2.675	576.5	641	1.5%	576.5
M2	266.1625	266.1625	153	0.2635	2.675	2.675	576.5	641	1.5%	576.5
M3	264.825	264.825	153	0.2635	5.35	2.675	576.5	641	1.5%	576.5
M4	263.4875	263.4875	153	0.2635	8.025	2.675	576.5	641	1.5%	576.5
M5	262.15	262.15	153	0.2635	10.7	2.675	576.5	641	1.5%	576.5

M6	260.8125	260.8125	153	0.2635	13.375	2.675	576.5	641	1.5%	576.5
M7	259.475	259.475	153	0.2635	16.05	2.675	576.5	641	1.5%	576.5

Nano Cement-- 50% of cement added
Recycled Aggregates -- 50% of Coarse Aggregates added
Nano Silica - 0%, 0.5%, 1%, 1.5%, 2, 2.5%, 3%

4. Results and discussion

4.1 Compressive Strength Test

The cube specimens were subjected to compression testing in a compressive testing machine with a capacity of 2000kN, as per the Bureau of Indian Standard test procedures. Table 4.1 contains a summary of the results of the compression test.

Table 4.1 Compressive Strength Test Result

Sl No	Mix	7days Compressive Strength (N/mm^2)	28days Compressive Strength(N/mm^2)
1	M1	62.5	80.5
2	M2	62.85	80.8
3	M3	63.0	81.5
4	M4	63.2	81.78
5	M5	63.5	82
6	M6	62.5	80.5
7	M7	62	80.3

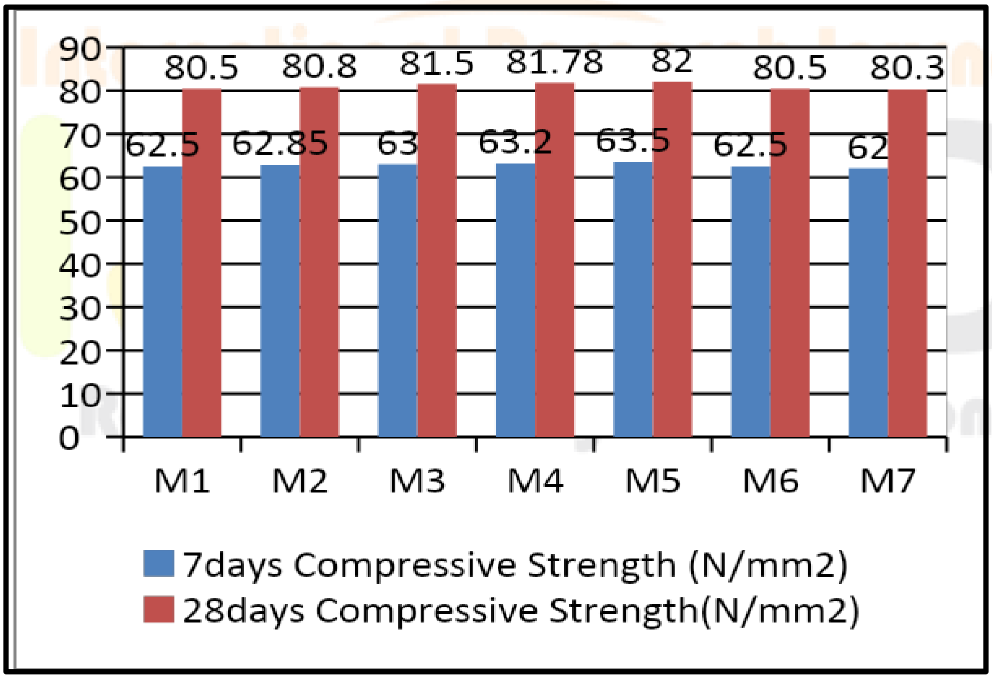


Figure 4.1 Compressive Strength Test Result

4.2 Split tensile strength Test

The tensile strength of a material is defined as its ability to withstand longitudinal stresses quantified in terms of the amount of longitudinal stress necessary to rupture the material. A material's tensile strength is typically referred to as its resistance to longitudinal strains. The split tensile strength of various mixes is shown in Table 4.2 after 28 days of testing.

Table 4.2 Split tensile Strength Test Result

Sl No	Mix	7days split tensile strength (N/mm^2)	28days split tensile strength (N/mm^2)
1	M1	6.75	8.95
2	M2	6.95	9.10
3	M3	7.23	9.50
4	M4	7.33	9.70
5	M5	7.35	9.80
6	M6	7.32	9.80
7	M7	7.29	9.75

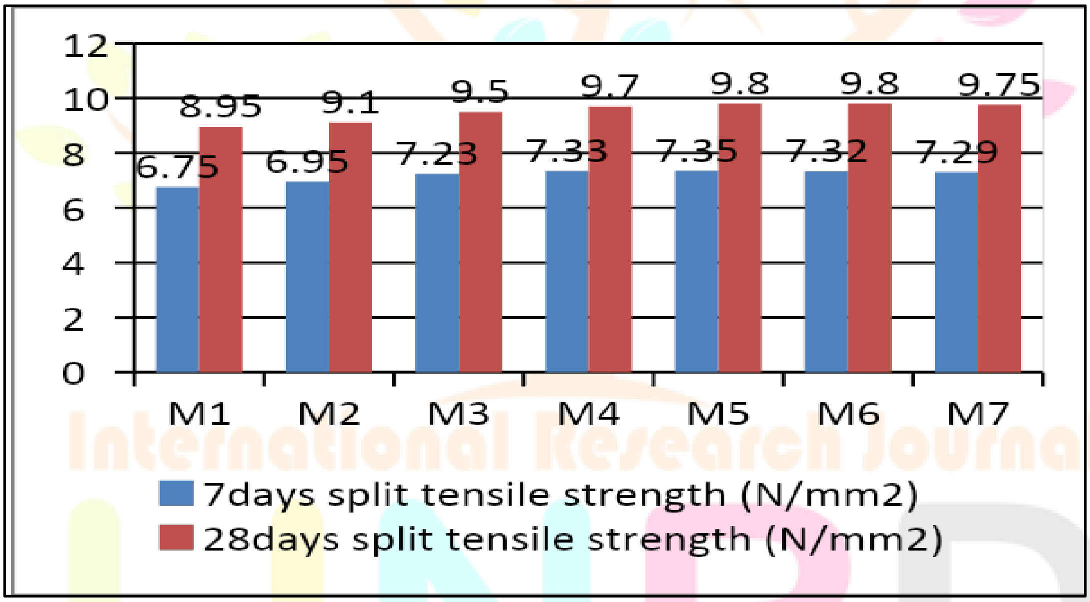


Figure 4.2 Split tensile Strength Test Result

4.3 Flexural Strength Test

Flexural strength is the resistance a concrete block provides just before it fails when subjected to bending (flexure) stresses caused by adequate loading. The flexural strength of various combinations after 28 days is shown in Table 4.3. The combination of Nano cement and Nano silica enhanced the flexural strength.

Table 4.3 Flexural Strength Test Result

Sl No	Mix	7days Flexural Strength(N/mm^2)	28days FlexuralStrength (N/mm^2)
1	M1	4.1	6.10
2	M2	4.8	6.70
3	M3	4.9	6.90
4	M4	5.0	7.1

5	M5	5.1	7.2
6	M6	5.15	7.25
7	M7	5.15	7.25

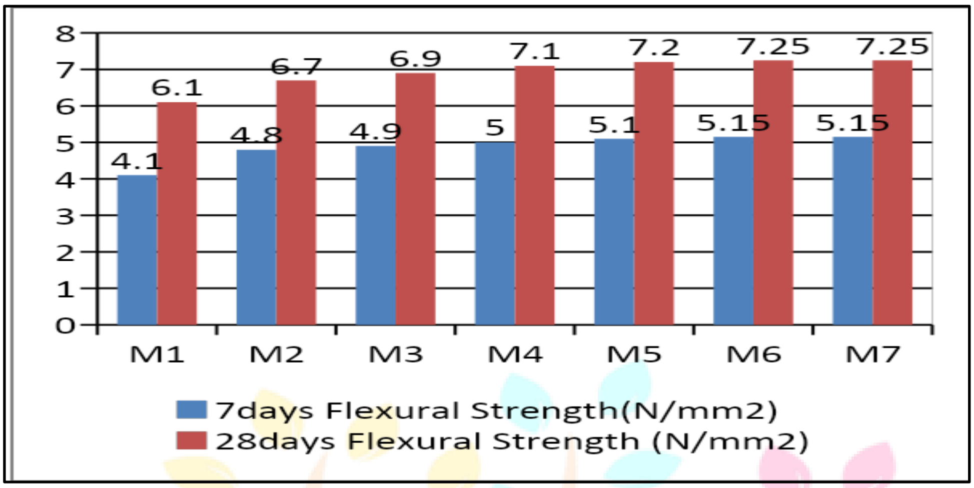


Figure 4.3 Flexural Strength Test Result

4.4 Modulus of Elasticity

Until the material's limit is reached, the concrete's stress-strain curve effectively defines the material's modulus of elasticity. Stresses that cause concrete to crack and create higher levels of stress reduce the value of this material. The modulus of elasticity of various mixes at 28 days is shown in Table 4.4.

Table 4.4 Modulus of Elasticity Test result

Time in mins	Pointer Reading (Nano Cement)	Pointer Reading (OPC)
5	40	30
10	40	25
15	36	20
20	33	13
25	30	9
30	27	5
35	21	-
40	18	-
45	12	-
50	9	-
55	5	-

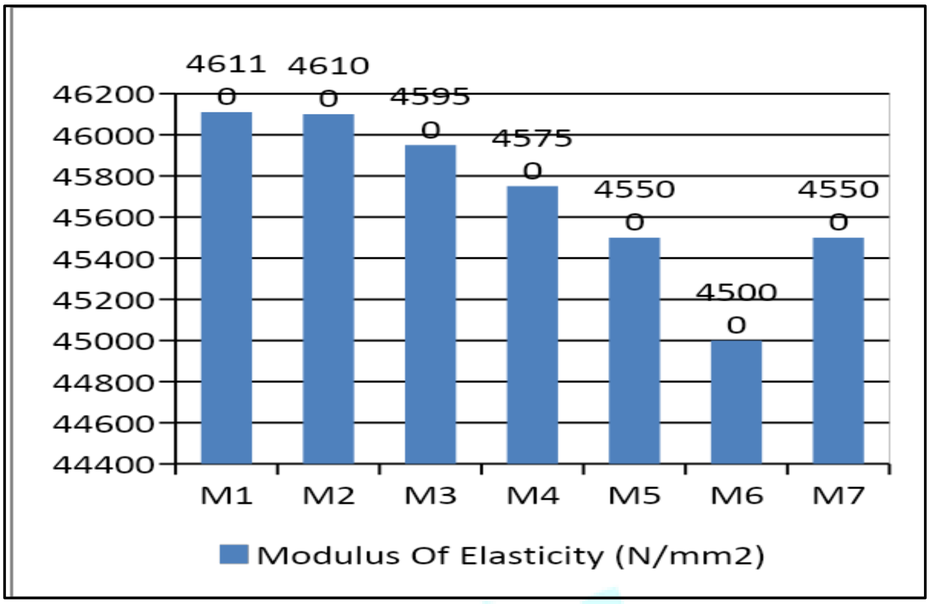
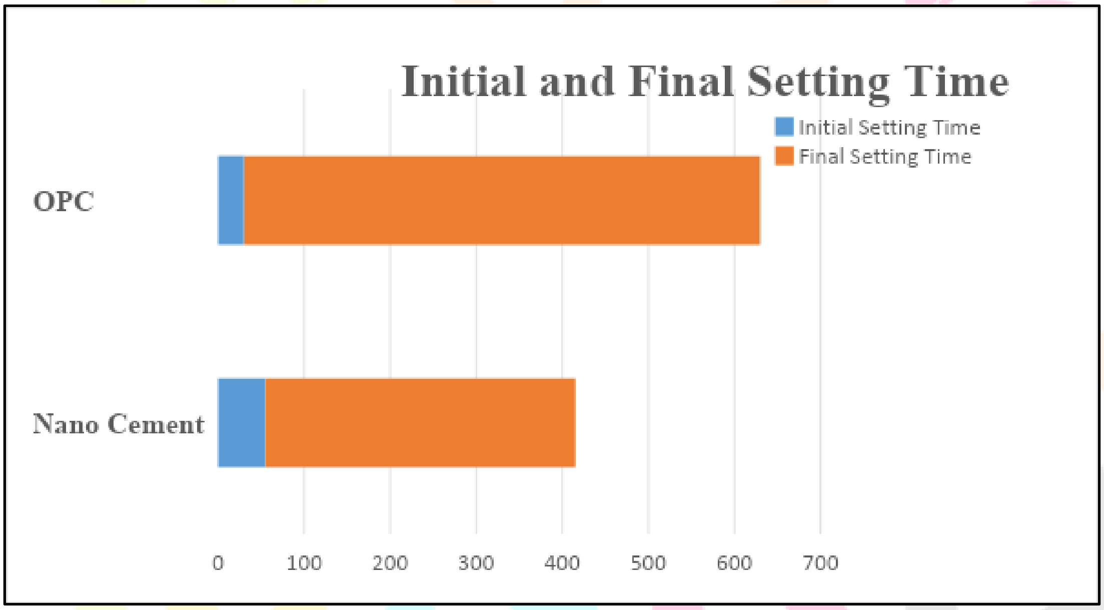


Figure 4.4 Modulus of Elasticity Result

4.5 Initial Setting Time of Nano cement

The time at which cement starts hardens and completely loses its plasticity is called Initial setting time of cement. After mixing cement with water, it takes time to place the cement paste in position, initial setting time possess a primary role in strength & it is mandated that cement paste or concrete is placed in position before it crosses initial setting time. i.e.,30mins. Due to its fineness the initial setting time is found to be 55 mins i.e when compared to ordinary cement the initial setting time increases by 25 mins so that it can be placed in position in a relaxed manner.



4.6 Final Setting Time

The time at which cement completely loses its plasticity and became hard is a final setting time of cement. Depending upon the admixtures added into the cement in the process of manufacture of cement, the setting time differs for different cement. The concrete shouldn't be disturbed until it completes Final setting time i.e., 600mins for Ordinary Portland Cement. . Due to its fineness the final setting time is found to be 420 mins i.e when compared to ordinary cement the final setting time increases by 180 mins so that the removal of scaffolding can be done quickly

5. Conclusion

The primary goal of this work is to characterise the compression behaviour, split tensile strengths, modulus of elasticity, and flexural strength of RAC concrete with the incorporation of nanocement. With the use of nano cement initial setting time had been increased by 25% while the final setting had been decreased by 50% when compared to ordinary cement. Also, shrinkage and permeability value were reduced with increased strength and thus leading to longer durability. The physical properties such as shrinkage, freeze-thaw and abrasion were reduced by the use of nano cement resulting from a denser and less permeable structure and thus enhancing the properties of high performance of concrete. At the same time the influence of nano cement improves the resistance to sulphate attack, acid attack, alkali-aggregate reactions amd thermal degradation which overcomes the characteristics of normal concrete. As recycled aggregate is added to the concrete mix, the split tensile and compressive strengths decrease. But the compressive and split tensile strengths of RAC mixtures increase as nano cement and fibres are added. The compressive strength of concrete was found to increase by 30% when compared to ordinary concrete. Increases in strengths are seen to be greater for mixes with a lower RA content and vice versa. The combination of Nano cement and Nano silica enhanced the flexural strength. Modulus of Elasticity values for RAC mixtures decreases by 15% as the RA content increases while it increases as steel fibres are added to RAC mixtures.

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