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Study of Optimum Mix Design of Light-Weight Self Compaction Concrete

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ABSTRACT-The tremendous growth in population, globalization and industrialization have led to the development of the construction sectors. The construction sector contributes a majorly to the development of the country based on its infrastructural needs. Also, concrete turns out to be the best and greatest construction building material in the global scenario. Concrete has become a highly sort out construction material because it could be cast in-situ and precast satisfying the construction feasibilities. The concrete is bifurcated into special types of concrete for decades. One such special type includes Self-Compacting Concrete (SCC). SCC has gained high priority among other types of special concrete. SCC has got a unique superior property of easy flowing nature. The greatest credit of using SCC is that it is user-friendly because it does not require compaction, consumes less time, and provides a smooth surface and textured finish. It does not require skilled labour. These advantages have scored and drawn the attention of the construction sector. Nowadays, most of the ready-mix plants use SCC to serve their building. The findings from the current investigation are summarized below. The workability of concrete increase with the increase in the variation in the partially replacement of cement with nano silica and Coarse aggregate with the pumice light weight aggregate. The maximum compressive strength of M40 grade for 7 days of all the mixed combinations is found to be 38.88 N/mm^2 when coarse aggregate was replaced with 36% by pumice light weight aggregate and binder i.e., cement with 0.8% by nano silica.The maximum compressive strength M40 grade of concrete for 28 days of all the mixed combinations is found to be 54.42 N/mm^2 when coarse aggregate was replaced with 36% by pumice light weight aggregate and binder i.e., cement with 1.6% by nano silica. The maximum split tensile strength M40 grade for 7 days of all the mixed combinations is found to be 3.46 N/mm^2 when coarse aggregate was replaced with 36% by pumice light weight aggregate and binder i.e., cement with 0.8% by nano silica. The maximum split tensile strength M40 grade for 28 days of all the mixed combinations is found to be 5.85N/mm^2 when coarse aggregate was replaced with 36% by pumice light weight aggregate and binder i.e., cement with 1.2 % by nano silica respectively. The maximum flexural strength M40 grade for 7 days and 28 days of all the mixed combinations is found to be 6.78 N/mm^2& 9.24 N/mm^2 respectively. when coarse aggregate was replaced with 36% by pumice light weight aggregate and cement with 1.6 % by nano silica respectively. By using of waste materials such as pumice light weight aggregate and nano silica in concrete the structure becomes light weight and economical and environment can be also protected for pollution etc.

KEYWORDS- Nano Silica, Pumice Light Weight Aggregate, Slump Test, Compression Test, Flexural Test Split Tensile Test.

I. INTRODUCTION

The material for construction known as concrete is made of cement, fine aggregates (sand), and coarse aggregates that are all combined with water and then allowed to dry [1]. In order to produce concrete, Portland cement is the most used form of cement. Studying concrete's characteristics and putting them to use in real-world situations is known as concrete technology. For the construction of foundations, columns, beams, slabs, and other load-bearing elements of a building, concrete is employed [2]. There are different types of binding material is used other than cement such as lime for lime concrete and bitumen for asphalt concrete which is used for road construction. For concrete projects, a variety of cements with various qualities and uses are employed. Some of the type of cement is Portland Pozzolana Cement (PPC) [3], rapid hardening cement, Sulphate resistant cement etc. To achieve the necessary strength, materials are combined in a specified ratio. Strength of mix is described as M5, M10, M15, M20, M25, etc., where M stands for mix and 5, 10, 15, etc., is their strength in kN/m2. Different admixtures can be employed to offer various qualities [4]. To enhance the physical qualities of the wet mix or the completed product, mixes or additives like pozzolans or superplasticizers are used. Various types of concrete are manufactured these days for construction of buildings and structures. These have special properties and features which improve quality of construction as per requirement [5].

A. Self-Compacting Concrete

Self-Compacting Concrete (SCC) is a type of concrete that is highly fluid and can flow and fill the formwork without the need for external vibration. SCC is also known as self-levelling concrete or self-consolidating concrete. SCC is made using similar materials as traditional concrete, such as cement, water, and aggregate [5]. However, SCC also includes a higher amount of fine materials, such as fly ash or silica fume, which help to improve its flow properties. The key advantage of SCC is that it does not require any external vibration, which can save a significant amount of time and effort during construction. This makes it an ideal choice for complex or intricate structures, where traditional concrete placement methods may not be feasible [6]. SCC also offers several other benefits, including improved durability, increased strength, and reduced noise levels. It can also improve worker safety by reducing the need for workers to be in close proximity to concrete placement and vibration equipment. Overall, self-compacting concrete is an innovative solution for construction projects that require highly fluid and easily placed concrete. Its unique properties can lead to significant cost and time savings, while also improving the quality and safety of the final structure [7]. Self-compacting concrete (SCC) is a type of concrete that can flow and fill complicated shapes and forms without the need for external vibration. It is also known as self-consolidating concrete or self-levelling concrete. SCC is made to have a high viscosity, allowing it to cover the full formwork and flow evenly around reinforcement while keeping its homogeneity without segregation or bleeding. It is made using a combination of high-range water reducers, viscosity-modifying agents, and superplasticizers [7]. These additives reduce the water content in the concrete mixture, increase the plasticity, and maintain the flow properties of the concrete. SCC can be used in various construction applications, including the casting of complex-shaped architectural features, reinforced concrete structures, precast concrete elements, and foundation walls. It can improve the quality of construction by reducing labour costs and increasing the durability and longevity of the structure [7].

B. Light Weight Concrete

Lightweight concrete is a type of concrete that has a significantly lower density compared to traditional concrete. It is made by replacing some or all of the traditional aggregate (e.g. gravel and sand) with lightweight materials, such as expanded clay, shale, or slate, perlite, vermiculite, or polystyrene beads [8]. The density of traditional concrete is around 2400 kg/m3, while the density of lightweight concrete can vary depending on the materials used and the application, but it typically ranges from 1600 kg/m3 to 2000 kg/m3. This lower density makes lightweight concrete easier to handle and transport, reduces the overall weight of a structure, and can also lead to cost savings in certain applications. There are several different types of lightweight concrete, each with its own specific properties and uses [8]. For example, aerated concrete is a type of lightweight concrete that is made by adding aluminum powder to a mixture of cement, lime, and water. The aluminum powder reacts with the other materials to produce hydrogen gas, which creates bubbles in the concrete and makes it lighter. Aerated concrete is commonly used for insulation and fireproofing. Another type of lightweight concrete is known as cellular concrete, which is made by mixing a foaming agent with a cement slurry [9]. The foaming agent creates bubbles in the mixture, which increases its volume and reduces its density. Cellular concrete is often used for filling voids or as a lightweight backfill material. Polystyrene concrete is another type of lightweight concrete that is made by mixing polystyrene beads with cement, water, and sometimes other additives [9]. The polystyrene beads act as an aggregate and make the concrete lighter. Polystyrene concrete is often used for insulation, as well as for precast concrete elements such as blocks, panels, and pipes. Lightweight concrete also has several advantages over traditional concrete. For example, it has better thermal insulation properties, which can help reduce energy consumption and improve comfort in buildings. It is also more resistant to fire, which can improve safety in buildings. Additionally, the lower weight of lightweight concrete can reduce the load on a building's foundation and support structure, which can lead to cost savings and improved durability [10].

C. Objective Of The Study

- To investigate the workability by using slump test by replacing of cement with Nano Silica and coarse aggregate with Pumice Lightweight aggregate on M40 grade of concrete.
- To investigate the compressive strength by replacing of cement with Nano Silica and coarse aggregate with Pumice Lightweight aggregate on M40 grade of concrete.
- To investigate the split tensile strength by replacing of cement with Nano Silica and coarse aggregate with Pumice Lightweight aggregate on M40 grade of concrete.
- To investigate the flexural strength by replacing of cement with Nano Silica and coarse aggregate with Pumice Lightweight aggregate on M40 grade of concrete.
- To minimize the overall environmental effects of concrete production using these materials as partial replacement.

II. MATERIALS USED

The materials in general, are used conformed to the specifications laid down in the relevant Indian standard codes [10]. The materials used for making concrete mix specimens were having the various characteristic are mentioned:

- OPC Cement 43 Grades
- Sand
- Coarse aggregate
- Pumice Lightweight aggregate
- Nano Silica
- Water

A. OPC Cement 43 Grades

Cement is a fine powder made from a mixture of limestone, clay, and other minerals, which is used as a binder to hold together other materials such as sand, gravel, and water in construction applications [11]. The most commonly used type of cement is Portland cement, which is produced by heating limestone and clay in a kiln and then grinding the resulting clinker into a fine powder. Chemically, cement is composed mainly of calcium, silicon, aluminum, and iron, along with small amounts of other elements such as sulfur, potassium, and magnesium [12]. When mixed with water, the chemical components of cement react to form a hard, durable material known as cement paste. This paste is responsible for binding together the aggregates (such as sand and gravel) to form concrete, which is one of the most widely used construction materials in the world [12]. The physical properties of cement include its fineness, setting time, strength, and durability. Fineness refers to the particle size of the cement powder, with finer particles leading to greater surface area and improved strength development. Setting time refers to the time it takes for the cement paste to harden, with faster setting times being desirable for some applications [13]. Strength is a measure of the amount of weight that a cement mixture can support, and is influenced by factors such as the composition of the cement, the water-cement ratio, and the curing conditions. Durability refers to the ability of cement to resist damage from environmental factors such as weathering and chemical attack [14].

Figure 1: Sample of cement

B. Coarse Aggregate

Coarse aggregate is a term used in construction to describe the larger particles of material that are used in the production of concrete. In India, the Bureau of Indian Standards (BIS) is responsible for setting the standards for construction materials, including coarse aggregate. The most recent version of the code that sets the standards for coarse aggregate in India is IS 383:2016. According to IS 383:2016, coarse aggregate is defined as the portion of the aggregate that is retained on the 4.75mm sieve. The code specifies the requirements for the quality and grading of coarse aggregates used in concrete [15].

Figure 2: Sample of coarse aggregate

C. Water

The Bureau of Indian Standards (BIS) recently revised the code for concrete mix design, known as IS 10262:2019, which includes guidelines on the use of water in concrete making. According to the revised code, the water-cement ratio (w/c ratio) should be selected based on the strength and durability requirements of the concrete, as well as the type of cement and its fineness [16]. The w/c ratio is the ratio of the weight of water to the weight of cement in the concrete mix. The new code also recommends that the total quantity of water used in the concrete mix should not exceed the maximum limit specified for a given w/c ratio. This maximum limit is based on the assumption that the aggregates used in the concrete mix are of a certain type and have a certain moisture content [16]. If the actual moisture content of the aggregates is different from the assumed value, then the quantity of water used in the mix should be adjusted accordingly. In addition to the above guidelines, the code also specifies that the water used in concrete making should be clean and free from harmful impurities such as oil, organic matter, and chemicals. The pH value of the water should be between 6 and 8, and the temperature of the water should not exceed 30°C. The use of superplasticizers and other chemical admixtures to improve the workability and strength of the concrete is also allowed, provided that they comply with the relevant standards [17].

D. Nano Silica

Nano silica, also known as silica fume, is a highly reactive pozzolanic material that is produced as a by-product of the production of silicon metal and ferrosilicon alloys. It consists of amorphous, spherical particles that are around 100 times smaller than the particles of regular cement. The small particle size of nano silica gives it unique properties that can be advantageous in various applications [18].

Figure 3: Sample of Nano silica

E. Pumice Light Weight Aggregate

Pumice is a volcanic rock formed from solidified lava that has a unique porous structure. This structure makes pumice an ideal material for producing lightweight aggregate for concrete. Pumice lightweight aggregate is a cost-effective and sustainable alternative to traditional heavy aggregates, such as gravel, sand, and crushed stone, which can add significant weight to concrete [19].

Pumice lightweight aggregate is made by crushing and screening the volcanic rock into various sizes. The resulting lightweight aggregate is then washed, dried, and graded to meet the required specifications for use in concrete. Pumice lightweight aggregate is typically used in lightweight concrete mixes, where it can replace traditional heavy aggregates to reduce the weight of the concrete and improve its insulation properties [19]. One of the key advantages of using pumice lightweight aggregate in concrete is its low density. Pumice is one of the lightest natural minerals, with a density of around 0.25-0.45 g/cm³. This means that pumice lightweight aggregate can reduce the weight of concrete by up to 40%, making it an ideal choice for applications where weight reduction is critical, such as in high-rise buildings, bridges, and other structures where heavy loads are a concern. Pumice lightweight aggregate also has excellent insulation properties [20]. Its porous structure allows air to circulate within the concrete, reducing the transfer of heat and cold through the material. This can lead to energy savings in buildings by reducing the need for heating and cooling, and can also improve the thermal efficiency of precast concrete components. In addition to its low weight and insulation properties, pumice lightweight aggregate has other benefits for concrete [20]. It is highly durable and resistant to abrasion, making it suitable for use in high-traffic areas such as car parks and industrial floors. It is also non-toxic and non-combustible, making it a safe and environmentally friendly alternative to heavy aggregates. Overall, pumice lightweight aggregate is an excellent choice for concrete applications where weight reduction, insulation, durability, and sustainability are important considerations. Its unique properties make it a valuable addition to the range of materials available to architects and engineers for designing and constructing modern buildings and infrastructure [21].

Figure 4: Sample of Pumice Light Weight Aggregate

F. Workability (Slump Test)

The slump cone test is a widely used method in the construction industry to measure the workability of concrete. It is a simple and quick test that can provide valuable information about the consistency of the concrete and its ability to flow and be compacted. The test involves filling a metal cone with freshly mixed concrete and then slowly lifting the cone vertically while allowing the concrete to flow out and settle [22]. After the cone is removed, the height of the concrete is measured, and this measurement is used to determine the slump of the concrete. The Indian Standards Institution has established a standard for the slump cone test, which is known as IS 1199-1959. This standard provides detailed instructions on how to conduct the test, including the equipment required, the procedures to follow, and the calculations needed to determine the slump [23]. The equipment required for the slump cone test includes a metal cone with a base diameter of 20 cm, a top diameter of 10 cm, and a height of 30 cm. A tamping rod with a diameter of 16 mm and a length of 60 cm is also required, as well as a non-absorbent base plate, a ruler, and a scoop for measuring the concrete. To conduct the test, the cone is placed on the non-absorbent base plate, and the cone is filled with concrete in three equal layers, each of which is tamped 25 times with the tamping rod. After the cone is filled and tamped, the cone is lifted vertically, and the concrete is allowed to settle for a few minutes [23]. The height of the concrete is then measured, and this measurement is used to determine the slump of the concrete using the formulas provided in the standard. The slump is expressed in millimetres, and it indicates the consistency of the concrete. A higher slump value indicates a more workable concrete, while a lower slump value indicates a stiffer concrete.

G. Compression Test

A compression test is a common test method used to evaluate the compressive strength of concrete. In this test, a cube-shaped concrete specimen is subjected to a compressive load until failure. The test provides important information about the quality of the concrete and its ability to resist external forces [24]. The compression test of concrete is conducted as per the Indian Standard code of practice, IS 516:1959. This code provides guidelines for the sampling and testing of concrete specimens for determining the compressive strength of concrete. According to the IS code, the cube specimen used for the compression test should have a size of 150mm x 150mm x 150mm. The specimen should be cast in a mould in such a way that its surface is smooth and free from any irregularities or projections [24]. The concrete used for casting the specimen should be of the same mix and proportion as that used for the actual construction. After casting, the specimen should be cured for a minimum of 7 days in a moist room or under water. The curing temperature should be maintained between 27°C to 32°C. The specimen should be protected from direct sunlight, wind, and other adverse environmental conditions during the curing period. Once the curing period is over, the specimen is tested for its compressive strength. The test is conducted using a compression testing machine. The machine should be calibrated and verified as per the requirements of the IS code. The load is applied to the specimen at a uniform rate of 140 kg/cm2 per minute until failure.

Figure 5: Compression Test Machine

H. Split Tensile Test

The split tensile test is a widely used method to determine the tensile strength of cylindrical concrete specimens. This test is performed as per IS 5816:1999, which is the Indian standard code for testing concrete. In this test, a cylindrical specimen of concrete is subjected to a compressive load until it fails. The load is applied to the specimen through two steel plates placed at the top and bottom of the specimen [25].

I. Flexural Strength Test

The flexural strength of a concrete beam specimen is a measure of its ability to resist bending. It is an important property of concrete that is used to evaluate the performance of reinforced concrete members like beams, slabs, and columns. In India, the flexural strength of concrete beam specimens is evaluated as per the [26] Indian Standard code of practice for plain and reinforced concrete, IS 456:2000. According to IS 456:2000, the flexural strength of a concrete beam specimen is determined by conducting a flexural test on the specimen. The test is conducted using a three-point loading system, where the specimen is supported at two points and a load is applied at the center of the specimen. To conduct the flexural test, a rectangular beam specimen is cast with a specified mix design and dimensions. The specimen should have a minimum length of 10 times its depth and a minimum width of three times its depth. The depth of the specimen should be at least 150 mm for normal weight concrete and 100 mm for lightweight concrete [27].

III. RESULT ANALYSIS

A. Slump Test

The slump test is the workability test for concrete, involves low cost and provides immediate results. Due to this fact, it has been widely used for workability tests since 1922. The slump is carried out as per procedures mentioned in astm c143 in the united states, is: 1199 – 1959 in india and en 12350-2 in europe. Generally concrete slump value is used to find the workability, which indicates water-cement ratio. The table no. 1 and figure no. Shows variation in slump used in investigation.

Table 1: Test Result Slump Variation in Samples (mm)

Mix	Fine aggregate percentage	Coarse aggregate percentage	Pumice aggregate percentage	Cement percentage	Nano silica percentage	Slump value (mm)
FR00	100	100	0	100	0	42
FR01	100	88	12	99.6	0.4	46
FR02	100	88	12	99.2	0.8	53
FR03	100	88	12	98.8	1.2	68
FR04	100	88	12	98.4	1.6	75
FR05	100	76	24	99.6	0.4	82
FR06	100	76	24	99.2	0.8	87
FR07	100	76	24	98.8	1.2	92
FR08	100	76	24	98.4	1.6	96
FR09	100	64	36	99.6	0.4	102
FR10	100	64	36	99.2	0.8	108
FR11	100	64	36	98.8	1.2	112
FR12	100	64	36	98.4	1.6	118
FR13	100	52	48	99.6	0.4	129
FR14	100	52	48	99.2	0.8	135
FR15	100	52	48	98.8	1.2	139
FR16	100	52	48	98.4	1.6	142

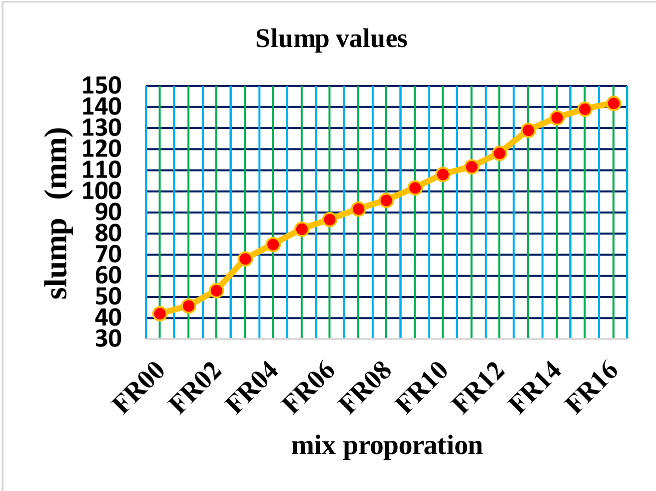

Figure 6: Graph of Slump Variation in Samples

B. Compressive Strength Test

Compressive strength of M40 solidified concrete cube specimens after 7 days and 28 days.

- ***Compressive strength of M40 solidified concrete cube specimens after 7 days.***

Compressive strength is the ability of material or structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size. For cube test two types of specimens either cubes of 15cm X 15cm X 15cm or 10cm X 10cm x 10cm depending upon the size of aggregate are used. These specimens are tested by compression testing machine after 7 days curing. Load should be applied gradually at the rate of 140 kg/cm^2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete. The compressive strength of M40 are presents in table 2 the results of compressible strength of concrete with varying percentages of nano silica and pumice light weight aggregate are shown graphically in figure 7 which are as follows:

Table 2: Compressive strength of M40 concrete

mix	Fine aggregate percentage	Coarse aggregate percentage	Pumice aggregate percentage	Cement percentage	Nano silica percentage	Compressive strength (7 days) N/mm²
FR00	100	100	0	100	0	33.65
FR01	100	88	12	99.6	0.4	33.36
FR02	100	88	12	99.2	0.8	34.33
FR03	100	88	12	98.8	1.2	35.15
FR04	100	88	12	98.4	1.6	36.03
FR05	100	76	24	99.6	0.4	36.67
FR06	100	76	24	99.2	0.8	37.21
FR07	100	76	24	98.8	1.2	37.73
FR08	100	76	24	98.4	1.6	38.12
FR09	100	64	36	99.6	0.4	38.34
FR10	100	64	36	99.2	0.8	38.88
FR11	100	64	36	98.8	1.2	37.79
FR12	100	64	36	98.4	1.6	36.48
FR13	100	52	48	99.6	0.4	35.65
FR14	100	52	48	99.2	0.8	35.21
FR15	100	52	48	98.8	1.2	34.93
FR16	100	52	48	98.4	1.6	33.74

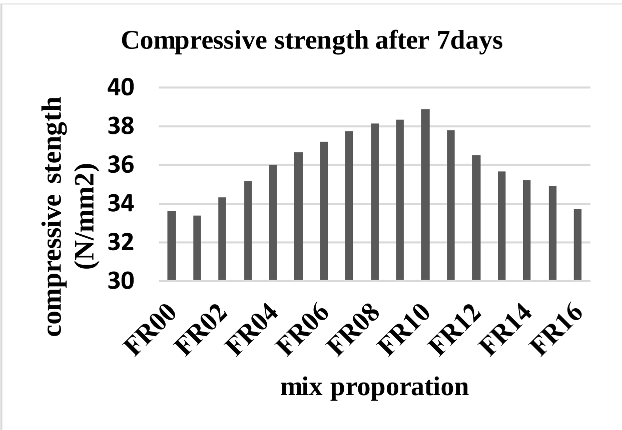

Figure 7: Graph of compressive Strength of M30 Concrete for 7 Days

Compressive strength of M40 solidified concrete cube specimens after 28 days.

The compressive strength of M40 are presents in table 3 the results of compressible strength of concrete with varying percentages of nano silica and pumice light weight aggregate are shown graphically in figure 8 as shown below:

Table 3: Compressive strength of M40 concrete

mix	Fine aggregate percentage	Coarse aggregate percentage	Pumice aggregate percentage	Cement percentage	Nano silica percentage	Compressive strength 28 days (N/mm²)
FR00	100	100	0	100	0	47.95
FR01	100	88	12	99.6	0.4	48.09
FR02	100	88	12	99.2	0.8	49.35
FR03	100	88	12	98.8	1.2	49.51
FR04	100	88	12	98.4	1.6	50.75
FR05	100	76	24	99.6	0.4	50.91
FR06	100	76	24	99.2	0.8	51.25
FR07	100	76	24	98.8	1.2	51.79
FR08	100	76	24	98.4	1.6	52.45
FR09	100	64	36	99.6	0.4	52.92
FR10	100	64	36	99.2	0.8	53.24
FR11	100	64	36	98.8	1.2	53.88
FR12	100	64	36	98.4	1.6	54.42
FR13	100	52	48	99.6	0.4	54.03
FR14	100	52	48	99.2	0.8	53.48
FR15	100	52	48	98.8	1.2	52.81
FR16	100	52	48	98.4	1.6	52.13

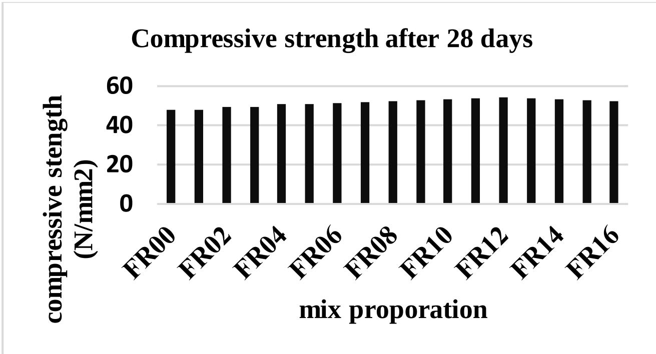

Figure 8: Compressive strength of M40 concrete for 28 days

C. Split Tensile Strength

Splitting Tensile strength of M40 solidified concrete cylinder specimens after 7 days and 28 days.

Split tensile strength of M40 solidified concrete cylinder specimens after 7 days.

The tensile strength of concrete is one of the basic and important properties which greatly affect the extent and size of cracking in structures. The sample size is cylinder of diameter 15 cm and height of 30 cm. The mould used is metal with mean internal diameter of the mould is 15 cm ± 0.2 mm and the height is 30 +/- 0.1 cm. The mould should be coated with a thin film of mould oil before use to prevent adhesion of concrete the Split tensile strength of M40 are presents in table 4 the results of Split tensile strength of concrete with varying percentages of nano silica and pumice light weight aggregate are shown graphically in figure 9.

Table 4: Split tensile strength of M40 concrete

mix	Fine aggregate percentage	Coarse aggregate percentage	Pumice aggregate percentage	Cement percentage	Nano silica percentage	Tensile strength (7 days) N/mm²
FR00	100	100	0	100	0	2.63
FR01	100	88	12	99.6	0.4	2.71
FR02	100	88	12	99.2	0.8	2.76
FR03	100	88	12	98.8	1.2	2.82
FR04	100	88	12	98.4	1.6	2.87
FR05	100	76	24	99.6	0.4	2.94

FR06	100	76	24	99.2	0.8	3.05
FR07	100	76	24	98.8	1.2	3.21
FR08	100	76	24	98.4	1.6	3.34
FR09	100	64	36	99.6	0.4	3.42
FR10	100	64	36	99.2	0.8	3.46
FR11	100	64	36	98.8	1.2	3.38
FR12	100	64	36	98.4	1.6	3.32
FR13	100	52	48	99.6	0.4	3.19
FR14	100	52	48	99.2	0.8	3.09
FR15	100	52	48	98.8	1.2	2.98
FR16	100	52	48	98.4	1.6	2.78

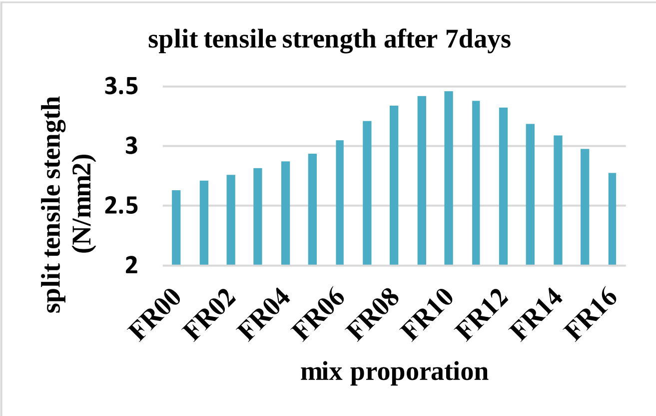

Figure 9: Showing split tensile strength of M40 concrete for 7days

Split tensile strength of M40 solidified concrete cylinder specimens after 28 days.

One of the important properties of concrete is "tensile strength" as structural loads make concrete vulnerable to tensile cracking. This is obtained by performing split tensile test on concrete specimen. The cylindrical mould shall be of 150 mm diameter and 300 mm height conforming to IS: 10086-1982. Tensile strength of concrete is much lower than its compressive strength (that's why steel is used to carry the tension forces). After the specimens are removed from the moulds to be submerged in clean fresh water for curing period (such as 7 or 28 days). The Split tensile strength of M40 are presents in table 5 the results of Split tensile strength of concrete with varying percentages of nano silica and pumice light weight aggregate are shown graphically in figure 10.

Table 5: Split tensile strength of M40 concrete

mix	Fine aggregate percentage	Coarse aggregate percentage	Pumice aggregate percentage	Cement percentage	Nano silica percentage	Tensile strength (28 days) N/mm^2
FR00	100	100	0	100	0	3.93
FR01	100	88	12	99.6	0.4	4.04
FR02	100	88	12	99.2	0.8	4.21
FR03	100	88	12	98.8	1.2	4.28
FR04	100	88	12	98.4	1.6	4.36
FR05	100	76	24	99.6	0.4	4.43
FR06	100	76	24	99.2	0.8	4.55
FR07	100	76	24	98.8	1.2	4.76
FR08	100	76	24	98.4	1.6	4.94
FR09	100	64	36	99.6	0.4	5.25
FR10	100	64	36	99.2	0.8	5.63
FR11	100	64	36	98.8	1.2	5.85
FR12	100	64	36	98.4	1.6	5.55
FR13	100	52	48	99.6	0.4	5.32
FR14	100	52	48	99.2	0.8	5.08
FR15	100	52	48	98.8	1.2	4.76
FR16	100	52	48	98.4	1.6	4.63

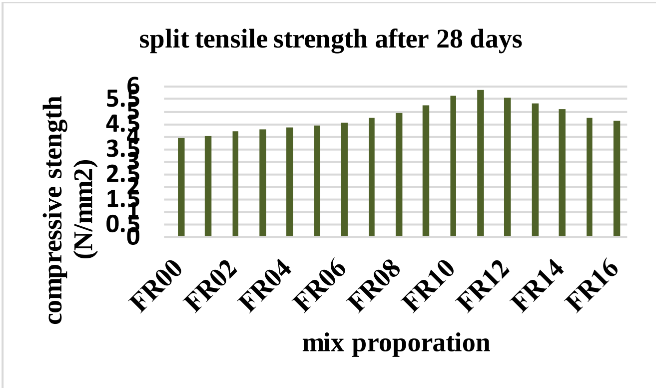

Figure 10: Showing split tensile strength of M40 concrete for 28 days

D. Flexural Strength

Flexural strength of M40 solidified concrete beam specimens after 7 days and 28 days.

Flexural strength of M40 solidified concrete cylinder specimens after 7 days.

The Flexural strength of concrete is one of the basic and important properties which greatly affect the mould should be coated with a thin film of mould oil before use to prevent adhesion of concrete the Split tensile strength of M40 are presents in table 6 the results of Flexural tensile strength of concrete with varying percentages of nano silica and pumice light weight aggregate are shown graphically in figure 11.

Table: 6. Flexural strength of M40 concrete

mix	Fine aggregate percentage	Coarse aggregate percentage	Pumice aggregate percentage	Cement percentage	Nano silica percentage	Flexural strength (7 days) N/mm^2
FR00	100	100	0	100	0	5.21
FR01	100	88	12	99.6	0.4	5.29
FR02	100	88	12	99.2	0.8	5.36
FR03	100	88	12	98.8	1.2	5.45
FR04	100	88	12	98.4	1.6	5.55
FR05	100	76	24	99.6	0.4	5.72
FR06	100	76	24	99.2	0.8	5.83
FR07	100	76	24	98.8	1.2	5.98
FR08	100	76	24	98.4	1.6	6.13
FR09	100	64	36	99.6	0.4	6.32
FR10	100	64	36	99.2	0.8	6.46
FR11	100	64	36	98.8	1.2	6.61
FR12	100	64	36	98.4	1.6	6.78
FR13	100	52	48	99.6	0.4	6.55
FR14	100	52	48	99.2	0.8	6.24
FR15	100	52	48	98.8	1.2	6.03
FR16	100	52	48	98.4	1.6	5.91

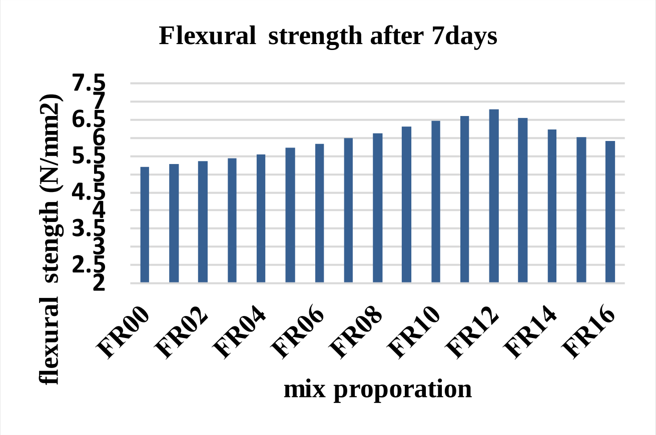

Figure 11: Compressive strength of M40 concrete for 07 days

Flexural strength of M40 solidified concrete beams specimens after 28 days

The flexural test was carried out 100x 100x500mm beams according it IS516- 1959. Table 7 and graph the results of flexural strength with various percentage of replacement. The test was done after 28 days of curing.

Table 7: Flexural strength of M40 concrete

mix	Fine aggregate percentage	Coarse aggregate percentage	Pumice aggregate percentage	Cement percentage	Nano silica percentage	Flexural strength (28 days) N/mm^2
FR00	100	100	0	100	0	6.77
FR01	100	88	12	99.6	0.4	6.98
FR02	100	88	12	99.2	0.8	7.26
FR03	100	88	12	98.8	1.2	7.35
FR04	100	88	12	98.4	1.6	7.43
FR05	100	76	24	99.6	0.4	7.62
FR06	100	76	24	99.2	0.8	7.74
FR07	100	76	24	98.8	1.2	7.86
FR08	100	76	24	98.4	1.6	8.23
FR09	100	64	36	99.6	0.4	8.54
FR10	100	64	36	99.2	0.8	8.72
FR11	100	64	36	98.8	1.2	8.87
FR12	100	64	36	98.4	1.6	9.24
FR13	100	52	48	99.6	0.4	8.93
FR14	100	52	48	99.2	0.8	8.76
FR15	100	52	48	98.8	1.2	8.63
FR16	100	52	48	98.4	1.6	8.41

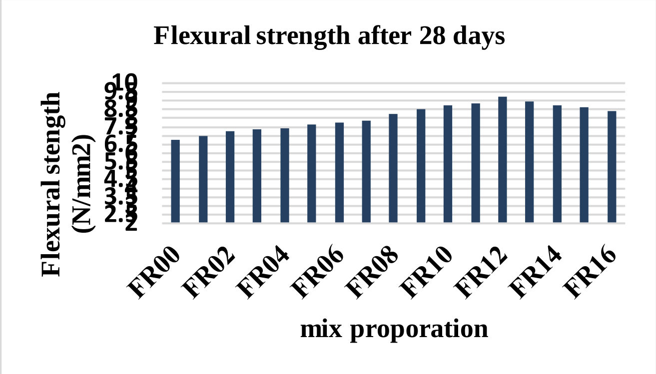

Figure 12: Showing Compressive strength of M40 concrete for 28 days

IV.CONCLUSION

The strength characteristics of concrete mixtures have been computed in the present work by partially replacement of cement by 0%, 0.4%, 0.8%, 1.2% and 1.6 % with Nano silica and Coarse aggregate 0%, 12%, 24%, 36% & 48% with the pumice light weight aggregate. On the basis of present study, following conclusions are drawn.

- The workability of concrete increase with the increase in the variation in the partially replacement of cement with nano silica and Coarse aggregate with the pumice light weight aggregate.
- The maximum compressive strength of M40 grade for 7 days of all the mixed combinations is found to be 38.88 N/mm^2 when coarse aggregate was replaced with 36% by pumice light weight aggregate and binder i.e., cement with 0.8% by nano silica.The maximum compressive strength M40 grade of concrete for 28 days of all the mixed combinations is found to be 54.42 N/mm^2 when coarse aggregate was replaced with 36% by pumice light weight aggregate and binder i.e., cement with 1.6% by nano silica.
- The maximum split tensile strength M40 grade for 7 days of all the mixed combinations is found to be 3.46 N/mm^2 when coarse aggregate was replaced with 36% by pumice light weight aggregate and binder i.e., cement with 0.8% by nano silica. The maximum split tensile strength M40 grade for 28 days of all the mixed combinations is found to be 5.85N/mm^2 when coarse aggregate was replaced with 36% by pumice light weight aggregate and binder i.e., cement with 1.2 % by nano silica respectively.
- The maximum flexural strength M40 grade for 7 days and 28 days of all the mixed combinations is found to be 6.78 N/mm^2& 9.24 N/mm^2 respectively. when coarse aggregate was replaced with 36% by pumice light weight aggregate and cement with 1.6 % by nano silica respectively.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

1. Siddique, R., Properties of self-compacting concrete containing class F fly ash, Journal of Materials and Design, Vol. 32, 1501-1507 pp., 2011.
2. Japan Society of Civil Engineers, ―Recommendation for Construction of Self Compacting Concrete,157- 164 pp., 1998.
3. IS: 12089 (Specification for Granulated Slag for Manufacture of Portland Slag Cement), Indian Standard Code of Practice, 1987.
4. Nan Su., Kung-Chung Hsu., and His-Wen Chai., ―A simple mix design method for self compacting concrete, Journal of Cement Concrete Research Vol. 31, No. 12, 1799-1807 pp., Dec. 2001.
5. Dinakar, P., Kali, P.S., Umesh, C.S., ―Design of self-compacting concrete with ground granulated blast furnace slag, Journal of Material and Design, Vol. 43, 161–169 pp., Jan 2013.
6. IS: 12269 (53 Grade Ordinary Portland cement Specifications), Indian Standard Code, 1987.
7. IS: 383 (Specification for coarse and fine aggregates from natural sources for concrete), Indian Standard Code of Practice, 1970.
8. IS: 10262 (Concrete Mix Proportioning- Guidelines), Indian Standard Code, 2009.
9. Khayat, K.H., Hu, C., Monty, H., ―Stability of SCC, advantages and Potential applications‖, In: Proceedings of RILEM international conference on self-compacting concrete, Rilem Publications SARL, 143-152 pp., 1999
10. Pai .B.H.V, Nandy M., K.H, Sarkar.P.K, Ganapathy.C.P, -Experimental study on selfm compacting concrete containing industrial by-products, European Scientific Journal, vol12, ISSN 1875-7881, April, 2014.
11. Koehler, E. P., and D. W. Fowler (2007) Aggregates in Self-Consolidating Concrete. Research report 108-2F, International Centre for Aggregates Research, The University of Texas, Austin.n 92.
12. Kumar, P., M. A. Haq, and S. K. Kaushik (2004) Early age strength of SCC with large volumes of fly ash, Indian Concrete Journal, 78, 25 – 29.
13. Lachemi, M., K. M. A. Hossain, V. Lambros, and N. Bouzoubaa (2003) Development of cost effective self-consolidating concrete incorporating fly-ash, slag cement, or viscosity-modifying admixtures. ACI Materials Journal, 100, 419 - 425.
14. Lachemi, M., K. M. A. Hossain, V. Lambros, P. C. Nkinamubanzi, and N. Bouzoubaa (2004a) Performance of new viscosity modifying admixtures in enhancing the rheological properties of cement paste. Cement and Concrete Research, 34, 185 - 193.
15. Lachemi, M., K. M. A. Hossain, V. Lambros, P. C. Nkinamubanzi, and N. Bouzoubaa (2004b). Self-Consolidating Concrete incorporating new viscosity modifying admixtures. Cement and Concrete Research, 34, 917 - 926.
16. Indian Standard 10262: 2009, Concrete Mix Proportioning: Guidelines.
17. Indian Standard 1199: 1959, Methods of Sampling and Analysis of Concrete.
18. Indian Standard 516: 1959, Methods of tests for Strength of Concrete.
19. IS: 10262-1982, Recommended Guidelines for Concrete Mix Design, Bureau of Indian
20. IS: 383-1970, Specification of Course and Fine Aggregate from Natural Sources for
21. IS: 456-2000, Code of practice for plain and reinforced cement concrete, Bureau of Indian Standards, New Delhi, India.
22. Nagaratnam, B. H., Rahman, M. E., Mirasa, A. K., Mannan, M. A., & Lame, S. O. (2016). Workability and heat of hydration of self-compacting concrete incorporating agro-industrial waste. Journal of Cleaner Production, 112, 882-894. doi:10.1016/j.jclepro.2015.05.112.
23. Okafor, F. O. (1988). Palm kernel shell as a lightweight aggregate for concrete. Cement and Concrete Research, 18(6), 901-910.
24. Okamura, H., &Ouchi, M. (2003). Self-compacting concrete. Journal of advanced concrete technology, 1(1), 5-15.
25. Okpala, D. (1990). Palm kernel shell as a lightweight aggregate in concrete. Building and environment, 25(4), 291-296.
26. Rahman, M., Muntohar, A., Pakrashi, V., Nagaratnam, B., &Sujan, D. (2014). Self compacting concrete from uncontrolled burning of rice husk and blended fine aggregate. Materials & Design, 55, 410-415.
27. Shafigh, P., Jumaat, M. Z., & Mahmud, H. (2010). Mix design and mechanical properties of oil palm shell lightweight aggregate concrete: a review. International journal of the physical sciences, 5(14), 2127-2134.
28. Shafigh, P., Jumaat, M. Z., & Mahmud, H. (2011). Oil palm shell as a lightweight aggregate for production high strength lightweight concrete. Construction and Building Materials, 25(4), 1848-1853.