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A Research on Concrete With Partial Replacement of Coarse Aggregate With Coconut Shell And Cement With Silica Fume

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Abstract
investigated the feasibility of using partial coconut shell on coarse aggregate to address issues of availability, affordability, quality, and pollution, as well as the partial replacement of silica fume with cement, in our article. Concrete is a high-quality natural aggregate-based construction material. Natural resources are continually diminishing in emerging countries like India due to fast industrialization and construction. In the current situation, finding alternate materials for manufacturing concrete is a top priority. Coarse aggregate is a key component in the production of concrete for a variety of projects, including infrastructure development, low and high-rise buildings, and residential complexes. It takes up 65-80% of the concrete surface. Coconut shell is a waste product of industrial and agricultural activities that has caused challenges with disposal and management.

Key words: *Coconut Shell, Silica Fume, Compressive Strength, Split Tensile Strength, Flexural Strength*.

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I. INTRODUCTION

Civil engineers are the foundation of any developing country's infrastructure development. The demand for concrete has risen dramatically in recent years as a result of the expansion of infrastructure. Concrete is an important building material that is widely used around the world. The use of concrete has been steadily growing. As a result, several negative effects in concrete production exist, such as coarse aggregate extraction from natural resources and river sand scarcity, which leads to material depletion and ecological imbalance. Various studies have discovered that coarse aggregate can be replaced. Plastic, paper and pulp industry waste, textile waste, rice ash, recycled rubber tyres, and broken bricks are just a few examples of materials that can be used to replace aggregate in concrete. Coconut shell is a by-product of the coconut industry that can be used as coarse aggregate in concrete. According to a 2016 report, India is the world's third largest coconut grower. Every year, India produces approximately 119 million tones of coconut. Coconut shells pile on land and disintegrate over a period of 100 to 120 years. As a result, there is a severe environmental problem with the disposal of coconut shells. As a result, coconut shells can be utilized as aggregate in concrete to save waste. This project's main goal is to investigate the strength of coconut shell concrete with various replacement percentages. A research of the applicability of silica fume in concrete has also been attempted

II. LITERATURE REVIEW

2.1 GENERAL

The publication published by several scholars across the world on the use of coconut shells as a coarse aggregate as an alternative to natural aggregate in concrete with silica fume addition is described below

2.2 REVIEW OF LITERATURE

Lakhbir Singh et.al., (2016) - This research looks into the possibility of using silica fume to partially replace cement. The ability to manufacture silica fume modified concrete that is flowable but cohesive in nature, resulting in high early and late age strength as well as resistance to harsh environments, has had a considerable impact on industries. The nature of silica fume and how it influences the properties of fresh concrete are the subjects of this study. The impact of partially substituting silica fume for cement on concrete strength measures have been studied. By arranging cubes and cylinders on a table, the strength parameters of concrete without partial replacement were studied first, followed by the strength parameters of concrete with partial replacement with silica fume.

Ajay lone et.al., (2016) - studied the test on coconut shell as partial replacement of coarse aggregate in cement concrete. The rising cost of constructing construction materials is a major source of concern in today's built environment. The cost of construction materials is steadily increasing. Concrete is made up primarily of coarse particles. The use of coconut shell as a coarse aggregate replacement has been reviewed in this work based on the results of detailed experimental results. For the manufacturing of concrete, the construction sector is completely reliant on cement, sand, and aggregates. The properties of concrete with coconut shells (CS) as a partial replacement for aggregate were investigated. With a constant water–binder ratio of 0.45, control concrete with standard aggregate and CS concrete with 25% and 50% coarse aggregate substitution were made. At 7, 14, and 28 days, workability, density, water absorption, compressive strength, flexural strength, and tensile strength of all mixes were measured. The findings revealed a continuous reduction in workability.

Palak Patel et.al., (2015) - investigated the use of coconut shell as a coarse aggregate in concrete. Coconut shell is an agricultural waste product that comes in large quantities. Construction supplies are becoming increasingly expensive. It's only natural to use other materials to fix a problem with natural aggregate. Waste resources such as recyclable aggregate, foundry sand, glass ware, bottom ash, and coconut shell were replaced with natural aggregate. The compressive strength, split tensile strength, and flexural strength of coconut shell as a coarse aggregate are investigated in this work. The main purpose is to use coconut shell waste as an alternative to concrete.

Pravin V. Khandve et.al., (2014) - conducted a study on shell as partial replacement of coarse aggregate in concrete: review The cost of construction materials is steadily increasing. The coarse aggregate is the most important component of the concrete. Many academics are now investigating materials that can both reduce and increase the cost of construction. The ability to use some agricultural wastes as well as industrial byproducts from various industries as construction materials will be highly desirable in emerging countries, and has been found to offer several practical advantages. The coconut shell was found to have a lot of potential as a partial replacement for aggregate in concrete. The current work is only a collection of information regarding research that has already been completed by other academics.

Hanumesh b m et.al., (2015) - conducted a study on the mechanical properties of concrete incorporating silica fume as partial replacement of cement and derived the mechanical properties of concrete. Concrete is the most significant engineering material, and its qualities can be altered by adding additional materials. There is an increasing need for concrete with higher compressive strength as the trend toward wider usage of concrete for prestressed concrete and high-rise buildings grows. Mineral admixtures, sometimes known as mineral additives, have been used in cement for a long time. The average cement particle is 100 times smaller than silica fume particles. Because of environmental problems, its treatment and disposal are a source of worry. Silica fume is classified as a supplemental cementitious ingredient in most cases. These materials have pozzolanic, cementitious, or a combination of pozzolanic and cementitious characteristics. These qualities can have a variety of effects on concrete behavior. In this study, an attempt was made to employ silica fume as a supplemental material for cement and to determine the maximum amount of cement that could be replaced for M20 grade concrete. The major goal of this research is to compare the mechanical properties of M20 grade control concrete and silica fume concrete with various percentages of silica fume as a partial replacement for cement (5, 10, 15, and 20%).

III. METHODOLOGY

3.1 GENERAL

Based on the study of literature reviews, methodology for this study is proposed in this chapter.

3.2 Methodology

The methodology of the work starts from the study on the Literature review and properties of the materials and the past work done from the collection of the literature for review. Basic tests on materials and its material properties were studied. Physical, chemical, and mechanical properties of coconut shells, as well as the compatibility of coconut shells with cement, were investigated. The coconut shell aggregate concrete was made using the same procedures and methods that were used to make conventional concrete. Numerous trial mixes were conducted by varying cement content, silica fume, sand, coconut shells and water-cement (w/c) ratio. After that, the appropriate trial mixes were selected, and the workability, strength, density, and durability requirements for various concrete applications were taken into account while choosing the best coconut shell aggregate concrete mix. The concrete mix was also tuned for the ratio of coconut shells to cement and the w/c ratio. This optimal combination was then used to make coconut shell aggregate concrete specimens for the rest of the investigation.

IV. MATERIALS AND METHODS

4.1 GENERAL

This chapter covers the materials that will be used in the project.

4.2 MATERIALS

M30 concrete mix is created for 53 grade OPC in this study. The materials utilised include cement, crushed natural stone as fine and coarse aggregate, silica fume, and coconut shell.

4.2.1 Cement

study standard consistency, initial and final setting times, specific gravity, and fineness of cement are all tested. The conventional concrete can be designed according to IS10262 based on the test findings. (MIX DESIGN CODE), M30 Grade concrete is finally designed

Table 4.1 Properties of cement

S.NO	TEST	RESULT
1	Specific gravity	3.15
2	OPC grade of cement	53
3	Consistency	32%
4	Fineness	3.33%
5	Initial setting time (minutes)	28 minis
6	Final setting time (minutes)	590 minis

4.2.2 Coarse Aggregate

As coarse aggregate, normal crushed aggregate with a maximum size of 20 mm was employed. Water Absorption Capacity, Specific Gravity, and Fineness Modulus of coarse aggregate are some of the studies were studied.

Table 4.2 Properties of coarse aggregate

S.NO	TEST	RESULT
1	Fineness	6.5%
2	Water absorption	0.29%
3	Specific Gravity	2.7

4.2.3 Fine Aggregate

As fine aggregate, well-graded river sand with a grain size of 4.75 mm was employed. Prior to mixing, the sand was air-dried and sieved to remove any extraneous particles. Water Absorption Capacity, Specific Gravity, and Fineness Modulus of fine aggregate are some of the experiments were studied.

Table 3. Properties of fine aggregate

S.NO	TEST	RESULT
1	Fineness	2.75%
2	Water absorption	1.34%
3	Specific Gravity	2.67

4.2.4 Silica Fume Silica fume

Micro silica, commonly known as silica fume, is a non-crystalline amorphous polymorph of silicon dioxide. It's an ultrafine powder made up of spherical particles with an average particle diameter of 150 nanometers that's collected as a by-product of silicon and ferrosilicon alloy manufacture.

Table 4.4 Properties of silica fume

S.NO	TEST	RESULT
1	Specific gravity	2.3
2	Color	Grey to off- white
3	Average particle size	0.15µm
4	Particle shape	Spherical

4.2.5 Coconut Shell

Coconut shells that had already been broken into two pieces were collected; air dried for five days at a temperature of 25 to 30 C; fiber and husk on dried shells were removed; and the shells were manually broken into small chips and sieved through a 12.5mm sieve. Coconut shells were used to replace coarse debris that had

gone through a 12.5mm filter. The material that remained after passing through a 12.5mm filter was discarded. Coconut shells absorbed 8% of the water they were exposed to, and their specific gravity at saturated surface dry condition
was 2.7

Table 4.5 Properties of coconut shell

S.NO	TEST	RESULT
1	Fineness	6.55%
2	Diameter	36 micron
3	Bulk density	655kg/m3
4	Specific gravity	2.7
5	Water absorption	8%

4.5 Mix Proportion

M30 grade of design mix according to IS 10262 - 2019 was utilised in this research. The cement, fine aggregate, and coarse aggregate proportions in the concrete mix are 1: 1.50 : 2.58 by volume, with a water cement ratio of 0.45.

Table 4.6 Mix proportion

W/C Ratio	Cement	Fine Aggregate	Coarse Aggregate
0.45	1	1.50	2.58

4.6 Casting and Curing

Casting and Curing Detail: Coconut shell were added in concrete in step of 5% (0%, 5%, 10%, 15%).Slica Fume were added in concrete in step of 0.5% (0%, 5%, 10%, 15%). For each percent of Coconut shell replacing Course Aggrecate and addition of Slica Fume, 3 cubes, 3 cylinders and 3 prism were casted for 28 days and additionally 1 beam were casted. Final strength of cube,Prism, cylinder and beam were tested after 28 days curing.

V. TEST PROCEDURE

5.1 FRESH CONCRETE

Fresh concrete is a form of concrete that may be moulded and is still in a plastic state. It's also referred to as green concrete. The degree of compaction determines the potential strength and durability of concrete of a given mix proportion. It is consequently critical that the concrete consistency be such that it can be easily carried, put, and finished in order to provide the desired strength and durability. The first 48 hours are critical for the concrete structure's performance. It effects ultimate strength fc, Ec (elastic modulus), creep, and durability over long periods of time.

5.1.1 Slump Test

Cone Slump Test In the Slump Cone test, a conical cone with both ends open is used. The fluidity, workability, and consistency of the concrete mix are indicated when the slump cone fills with concrete and the resulting concrete level spreads throughout the surface.

Slump Test Values

- Very low workability: slump value 0-25mm or 0-1 inch.
- Low workability : slump value 25-50mm or 1-2 inches.
- Medium workability : slump value 50-100mm or 2-4 inch.
- High workability : slump value 100-175mm or 4-7 inches.

5.1.2 Compaction Factor

The compaction factor test is a laboratory workability test for concrete. The weight ratio of partially compacted to fully compacted concrete is known as the compaction factor. It was created by the United Kingdom's Road Research Laboratory and is used to measure the workability of concrete. For concrete with low workability, the compaction factor test is utilised instead of the slump test.

$$\text{Compaction factor test} = \frac{W_1 - W}{W_2 - W}$$

Where

W = Weight of empty cylinder.

W1 = Weight of partially compacted concrete.

W2 = Weight of fully compacted concrete.

Table 5.1 Compaction Factor Values

S.NO	Application	Workability	Compaction Factor Values	Corresponding slump in (mm)
1	Vibrated concrete for pavements roads	Very low	0.78	0 -25
2	Mass concrete foundations without vibration	Low	0.85	25 -50
3	Reinforced concrete	Medium	0.92	50 – 100
4	Highly Reinforced Concrete	High	0.95	100 – 180

5.2 HARDENED CONCRETE

Destructive tests are those in which the strength of a specimen is determined by causing full structural disruption (Loaded up to the failure). There are various damaging testing methods available. Compressive Strength Test, Split Tensile Strength Test, and Flexural Strength Test are the three tests.

- Compressive Strength Test
- Split Tensile Strength Test
- Flexural Strength Test

5.2.1 Compressive Strength Test

Cubes of 150 x 150 x 150 mm were cast and tested for compressive strength according to IS: 516-1959 on a compression testing equipment with a capacity of 2000 kN.

5.2.2 Procedure

The Compressive Strength Test is carried out according to the steps below.

1. Averaging perpendicular dimensions at least twice determines the size of the test specimen.
2. Center the specimen on the compression testing machine, and apply a constant and uniform load to the surface perpendicular to the tamping direction.
3. Increase the weight until the specimen fails, then record the highest load handled by each specimen during the test.

The following is how compressive stress was calculated:

Compressive strength = P/A x 1000

Where, P = Load in KN

A = Area of cube

5.2.3 Split Tensile Strength Test

For the splitting tensile strength test, cylinders with a diameter of 150 mm and a length of 300 mm were cast and tested on a compression testing machine in accordance with IS: 5816-1999.

5.2.4 Procedure

The tensile strength test is carried out according to the steps below.

1. Draw diametrical lines in the same axial plane on the two ends of the specimen.
2. Averaging the diameters of the specimen lying in the plane of pre-marked lines measured near the ends and the middle of the specimen will give you the diameter to the nearest 0.2 mm. By averaging the two lengths

measured in the plane including pre-marked lines, the length of the specimen must also be taken to be within 0.2 mm.
3. Center one of the plywood strips in the lower platen's centre. Place the specimen on the plywood strip and orient it so that the lines on the specimen's end are vertical and centred.
4. The second plywood strip is centred on the lines marked on the cylinder's ends and placed lengthwise on the cylinder.
5. Apply the load without shock and gradually raise it until no further load can be sustained, resulting in a split tensile stress of roughly 1.4 to 2.1 N/mm2/min. Note the maximum load on the specimen. 6. The split tensile strength was calculated as follows:

Split tensile strength = 2P/πdL x 1000

Where, P = Load in KN = 3.142

d = Diameter of cylinder

L = Length of cylinder

5.2.5 Flexural Strength Test

For the flexural strength test, 100 x 100 x 500 mm beams were cast and tested on a 400 mm effective span with two point loading according to IS: 516- 1959.

5.2.6 Procedure

The flexural strength test is carried out according to the steps below.
1. Clean the beam with a brush. Place the beam in the breaking machine on its side, facing away from the moulded position.
2. Align the bearing plates squarely with the beam and adjust the distance using the machine's guide plates.
3. To help distribute the load, place a strip of leather or similar material under the upper bearing plate.
4. Turn the screw in the plunger's end to bring the jack's plunger into contact with the ball on the bearing bar.
5. Once contact has been made and only strong finger pressure has been applied, set the dial gauge needle to "0." We're going to apply two point loading to the beam specimen, and we're going to keep going until it breaks.
6. The flexural strength was calculated as follows:

Flexural strength = PL/bd2 x 1000

Where, P = Load in KN

L = Effective length of prism

b = Width of the prism

d = Depth of the prism

5.3 DURABILITY TEST

The duration of time a product, part, material, or system can achieve its performance requirements is measured in durability testing. Consider the lifespan. It's usually thought of as a subset of reliability testing. Durability testing is a type of performance testing that determines a system's characteristics over time under varied load circumstances. This testing allows us to determine whether transaction response times are stable over the course of the test.

The following parameters are measured while testing for durability:
- Memory leaks
- Evaluated I/O activity levels
- Valuate database resource consumption

5.3.1 Test Of Water Absorption

Square shape moulds 150x150x150mm were utilised to cast the specimens. The specimens were de-moulded and cured for 28 days after 24 hours of casting. It was then removed and cleaned dry.

5.3.2 WATER ABSORPTION TEST

For casting the specimens, square shape moulds 150x150x150mm were used. After 24 hours of casting the specimens were de-moulded and cured for 28 days. It was then taken out, wiped dry and kept ready for testing in water absorption. These tests were carried out as per IS 1237: 1980. When the percentage of water absorption is minimum, the strength of the concrete will be maximum.

The water absorption of each specimen was determined as:

$$\textbf{Per cent water absorption} = ((W_1 - W_2) / W_1) \text{ X } 100$$

Where,

W_1 = weight in g of the saturated specimens

W_2 = weight in g of the oven dried specimen

Table 5.2 Water absorption test sample value

Mix	Sample 1		Sample 2		Sample 3	
	Initial (kg)	Final (kg)	Initial (kg)	Final (kg)	Initial (kg)	Final (kg)
0%	8.63	8.37	8.86	8.56	8.86	8.36
1%	8.84	8.49	9.37	9.02	9.37	9.02

Table 5.3 Water absorption test results

Mix	Sample 1	Sample 2	Sample 3
	W.A %	W.A %	W.A %
0	3.17	3.50	2.47
1	4.12	3.88	2.83

5.3.3 WATER PERMEABILITY TEST

The test was conducted as per IS 3085-1965 cube specimens of 150x150x150mm were tested. The variation in the coefficient of permeability with the variation in percentage of volume fraction of fibres and aspect ratio were studied. The coefficient of permeability was calculated as follows:

$$\mathbf{K = Q / AT\ {}^{H}/_{L}}$$

Where,

K = coefficient of permeability
Q = quantity of water percolating in over the entire period
T = time in seconds over which measured
A = area of specimen in mm^2
H/L = ratio of the pressure head thickness of specimen

Table 5.4 Water penetration depth values and permeability of concrete

Sample	Water depth (mm)		Permeability (m^2) (MIP
	Maximum	Average	
HR	10	10	2.96×10^{-12}
HZ 5%	15	10	4.37×10^{-11}
HZ 10%	20	10	3.11×10^{-12}
HZ 15%	25	10	3.11×10^{-12}

5.3.4 SULPHATE RESISTANT TEST

The tests were conducted as described above, but with a Na2SO4 concentration of pH 9. The specimens were the same size and the variables were the same as in the previous tests. The following is how the test was carried out: A sodium sulphate solution with a Na2SO4 concentration of pH 9 was created. After 28 days of curing, the weighed specimens were maintained in this solution. The specimens were then put through 60 cycles of alternate soaking and drying, while the other set was placed in ordinary water for 60 days. They were taken out after this period, scraped to remove surface deposits, rinsed and dried for 2 to 3 hours at 20oC, then weighed again.

Table 5.5 Loss in strength after immersion in Na2SO4 solution of M30

Percentage	28th day compressive strength	56th day compressive strength Na2SO4 solution
0%	34.61	26.53
1%	42.36	36.85

VI. RESULT AND DISCUSSION

6.1 Compressive Strength Test

Test of Compressive Strength The compressive strength of concrete is determined on a cube at varied coconut shell and silica fume content levels. After 28 days of curing, the strength of the concrete was tested on a cube. After 28 days of curing, the 28-day test evaluates the concrete's final strength. A compression testing equipment is used to determine the compressive strength of concrete. With the addition of coconut shell and silica fume, the strength of concrete gradually improves up to a point, then gradually decreases. When coconut shell and silica fume are added up to 10% to the compressive strength of concrete, the initial strength enhancement is significant.testing value is incressing 15%.

Table 6.1 Compressive Strength Test Result

S.No	Coconut shell (%)	Silica Fume (%)	Compressive Strength (N/mm^2)
			28 Days
M1	0	0	36.54
M2	5	5	39.72
M3	10	10	40.38
M4	15	15	36.72

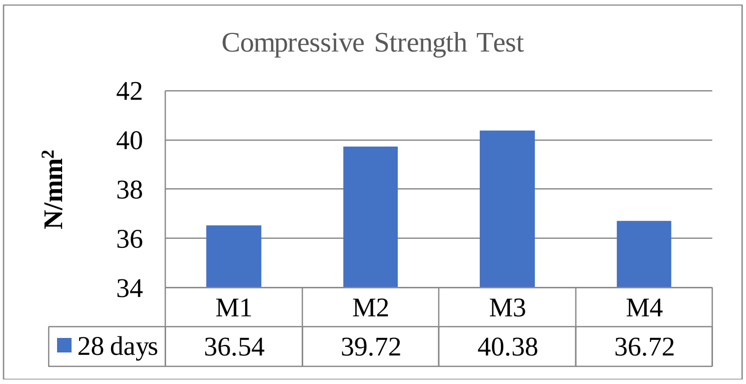

Chart 6.1 Compressive Strength Test Result

6.2 Split Tensile Strength Test

Split Tensile Strength Test Concrete's split tensile strength is measured on a cylinder at various coconut shell and silica fume content levels. Concrete strength was evaluated on a cube after 28 days of curing. The 28-day test determines the concrete's final strength after 28 days of curing. The split tensile strength of concrete is tested using a compression testing machine. The strength of concrete steadily increases with the addition of marble powder and glass fiber up to a point, then gradually diminishes. The initial strength gain in concrete is substantial when coconut shell and glass fibre is added up to 15% and testing values is incressing is 10% .

Table 6.2 Split Tensile Strength Test Result

S.No	Coconut shell (%)	Silica Fume (%)	Split Tensile Strength (N/mm^2)
			28 Days
M1	0	0	3.21
M2	5	5	3.45
M3	10	10	3.62
M4	15	15	3.38

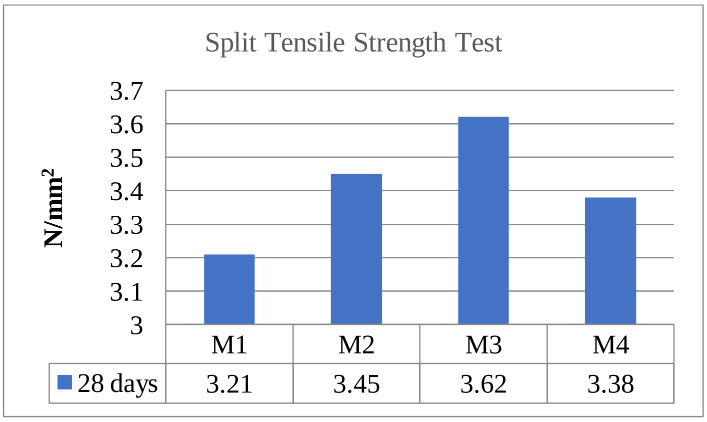

Chart 6.2 Split Tensile Strength Test Result

6.3 Flexural Strength Test

Flexural Strength Test Concrete's flexural strength is measured on a cylinder at various coconut shell and silica fume content levels. Concrete strength was evaluated on a cube after 28 days of curing. The 28-day test determines the concrete's final strength after 28 days of curing. The Flexural strength of concrete is tested using a compression testing machine. The strength of concrete steadily increases with the addition of marble powder and glass fiber up to a point, then gradually diminishes. The initial strength gain in concrete is substantial when coconut shell and glass fibre is added up to 15% and testing values is incressing is 10% .

Table 6.3 Flexural Strength Test Result

S.No	Coconut shell (%)	Silica Fume (%)	Flexural Strength (N/mm^2)
			28 Days
M1	0	0	4.78
M2	5	5	5.68
M3	10	10	5.43
M4	15	15	5.38

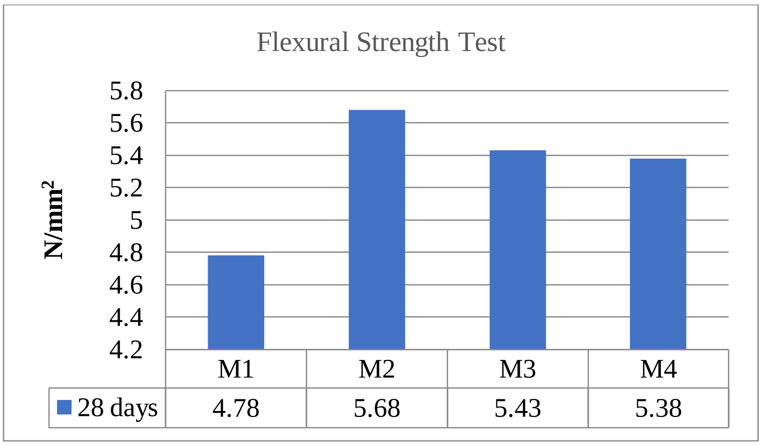

Chart 6.3 Flexural Strength Test Result

6.4 Test on Structural Specimen Beam

Beam is casted for the 10% replacement of coconut shell with cement and addition of 10% of silica fume for which the compressive strength and Split tensile strength was higher. The load deflection data of the concrete beam is shown in the Table 6.4

Ultimate Load = 55 KN

Table 6.4 Result on Structural Specimen Testing for M30 at 28 Days

S.NO	LOAD (KN)	DEFLECTION (mm)
1	0	0.00
2	5	0.16
3	10	0.32
4	15	0.83
5	20	1.21
6	25	1.81
7	30	2.14
8	35	2.50
9	40	2.94
10	45	3.10
11	50	3.42
12	55	3.89

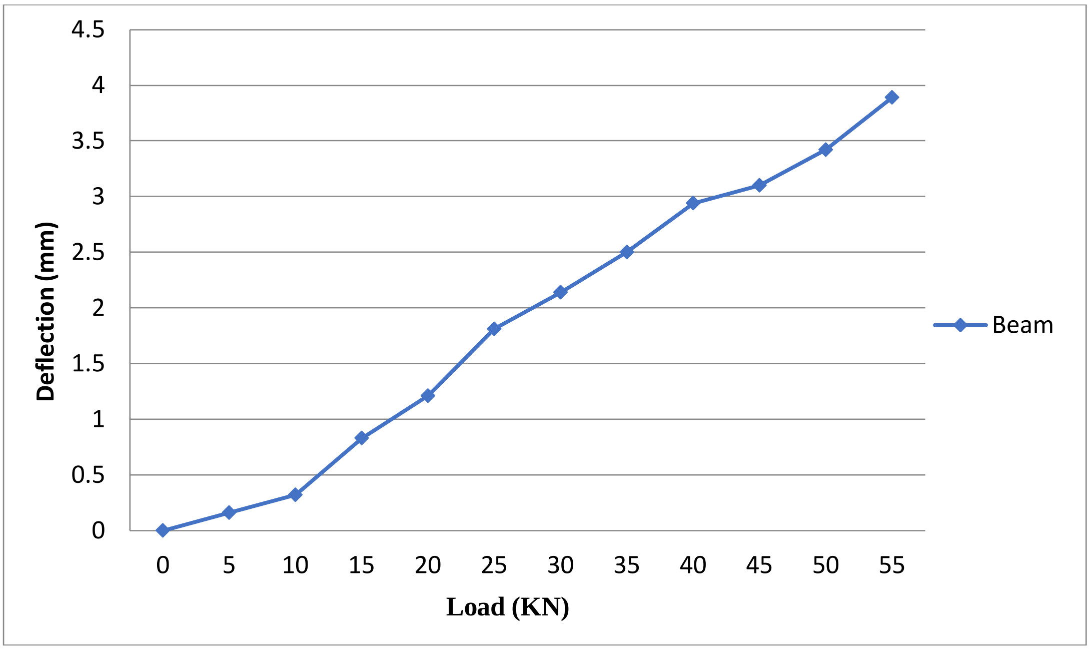

Chart 6.4 Structural Specimen M30 at 28 Days

VII. CONCLUSION

The coconut shell shows potential as a lightweight aggregate in concrete, according to a thorough literature review. Additionally, because of its low cost and abundance of agricultural waste, utilizing coconut shell as aggregate in concrete helps minimize construction material costs. Concrete made from coconut shells is also known as structural lightweight concrete. When utilized to substitute typical coarse aggregate in concrete production, Coconut Shells are shown to be more suited as a low strength-giving lightweight material. Concrete's strength is increased by more than 25% when silica fume is added. Because silica fume is far less expensive than cement, it is particularly important from a financial standpoint. Concrete cavities are also reduced by silica fumes. Silica fume has a finer particle size than cement. When the percentage of silica fumes increases, the uniformity improves dramatically. Attempting to partially replace aggregate with coconut shell in order to make concrete structures more cost-effective while maintaining good strength standards. This could be beneficial in the development of a low-cost housing society

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