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M-Sand and Coconut Shells can Partially Substitute Natural Sand and Coarse Aggregate in a Concrete Mix

Mohit Sahu[1,]*, Talib Qureshi[2], Unzila Fatima,[3] Mehtab Ahmad[4]

Abstract

This study explores a green approach to concrete production by using coconut shells and Manufactured Sand (M-Sand) as partial substitutes for traditional coarse aggregates and natural sand. Additionally, it investigates the role of silica in enhancing concrete properties. Coconut shells, often seen as waste, are utilized as lightweight aggregates, reducing the need for heavy natural aggregates. M-Sand replaces some of the natural sand, conserving this resource and reducing carbon emissions. To increase concrete's strength and durability, silica is added. Lab tests, including gradation analysis, strength, workability, and durability assessments, determine the ideal mix proportions for these materials. The results show that coconut shells (up to 0-15%) and M-Sand (up to 0-100%) can effectively replace traditional materials without compromising concrete quality. This eco-friendly approach offers a sustainable alternative for the construction industry. It conserves resources, reduces the environmental footprint, and enhances concrete performance. For widespread usage, issues including long-term durability and quality control must be resolved. This study supports the worldwide movement for sustainable development by advancing more ethical and ecological building methods.

Keywords: Compressive Strength, Coconut Shells, Silica, M-Sand, coarse aggregate, concrete mix

INTRODUCTION

Concrete is the vital civil engineering material. Its manufacturing involves utilization of ingredients like cement, sand, Aggregates and water. The coconut shell and M-sand at different percentage is used. Additionally, this study explores the feasibility of utilizing coconut shells in conjunction with M-sand to enhance construction practices. Due to its lightweight nature, coconut shells contribute to the production of lightweight concrete. The investigation involves varying the replacement percentages of coconut shell coarse aggregate, ranging from 0% to 15%. Replacement of fine Aggregate of M-sand by 0%, 12%, 25%, 50%, 100%.

Design mix used is M20 grade and testing of specimens are conducted after 7, 14 and 28 days of curing.

One of the main pillars of contemporary civilization, the construction sector, is going through a paradigm change in favor of sustainability and environmental responsibility.

With the increasing global recognition of environmental issues, there is an urgent demand to explore inventive methods for diminishing the carbon footprint associated with construction materials and methodologies. In this context, the

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integration of alternative materials and sustainable methodologies has gained prominence. One such approach involves the use of coconut shells and Manufactured Sand (M-Sand) as partial replacements for conventional coarse aggregates and natural sand in concrete mixtures.

Coconut shells, often considered as agricultural waste, and M-Sand, a manufactured fine aggregate, present intriguing opportunities to transform the construction landscape.

These materials possess the capacity not only to diminish the environmental repercussions of concrete manufacturing but also to alleviate the exhaustion of finite natural resources like river sand and coarse aggregates. The pressing need to address environmental issues including deforestation, sand mining, and the enormous energy costs involved in producing traditional concrete is what is causing this shift towards sustainable building materials.

The purpose of this study is to investigate the viability and effectiveness of using coconut shells in concrete mixes in place of some of the coarse aggregates. It also investigates the potential of M-Sand as an alternative to natural sand, offering a multifaceted approach to greener and more sustainable concrete production.

Understanding the benefits, challenges, and performance implications of these substitutions is of paramount importance in ensuring that they align with structural requirements and construction industry standards.

The use of coconut shells and M-Sand in concrete not only symbolizes a departure from the status quo but also signifies a profound commitment to eco-friendly and responsible construction practices. This innovation holds the promise of reducing carbon emissions, conserving natural resources, and embracing locally available, renewable materials. However, it necessitates a meticulous exploration of quality control, structural suitability, and long-term durability to ensure that the resultant concrete mixtures not only meet but surpass the expected performance Criteria. The foundation for a thorough investigation of the use of M-Sand and coconut shells as sustainable substitutes in the manufacturing of concrete is laid out in this first chapter. It encapsulates the urgency of environmental sustainability in construction practices and outlines the key objectives, significance, and structure of the study, aiming to contribute to a greener and more responsible future for the construction Industry [1-3].

Scope of the Work

The coconut shell, a longstanding agricultural byproduct harvested worldwide for diverse applications, presents a promising avenue for lightweight construction methodologies. Utilizing the outer shell cover of the coconut offers a potential solution that not only diminishes soil pollution but also fulfills a role as filling material in concrete construction. Through meticulous optimization of concentration and dosages, the substitution of this cover with natural coarse aggregate can be effectively managed [4].

Waste Material in India

Almost everywhere in the globe, where it is practicable, economical, or ecologically friendly, different policies have been put in place with the goal of decreasing the use of primary aggregates and promoting reuse and recycling. As a result, 15-20% of solid waste is recycled into different building materials and components by the informal sector and secondary industries in developing nations like India. Low-cost materials could be made from the disposed-of solid waste, which represents wasted resources, as part of an integrated solid waste management plan that also involves recycling, reuse, and recovery [5].

India presently produces 960 million metric tons of solid waste each year due to industrial, mining, municipal, agricultural, and various other processes Of this, 350 MT are agriculturally derived organic

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wastes, and 290 MT are mining and industrially derived inorganic wastes. But according to reports, India alone has produced 600 MT of trash from agricultural sources [6].

Current state of the Coconut Shell

One of the world's most beneficial plants is the coconut palm. 92 countries worldwide grow coconuts. 51 billion coconuts are produced worldwide each year from 12 million hectares of land. The origin of the coconut is thought to be Southeast Asia. Seventy-eight percent of global production is contributed by the four main players: Indonesia, Sri Lanka, the Philippines, and India. According to FAO data from 2007, global coconut production reached 61.5 million metric tons (MT), with Indonesia, the Philippines, India, Brazil, and Sri Lanka being the leading contributors. Most of the coconut cultivation, around 93%, is concentrated in the Asian and Pacific regions, covering approximately 12 million hectares of land. Annual coconut production, estimated at 10 million metric tons in copra equivalents, is primarily processed into copra, with over 50% of the global yield utilized for this purpose [7].

A small portion undergoes processing into desiccated coconut and other edible kernel products, while the rest is consumed as fresh nuts. A study conducted by the Central Plantation Crop Research Institute (CPCRI) revealed that India's coconut production was projected to reach a record high of 14,370 million nuts during the 2006-07 period. Increased productivity in Tamil Nadu significantly contributed to this surge in production. In India, the southern states account for 90% of the total coconut output, with Kerala leading with 5,400 million nuts and Tamil Nadu following closely with 4,190 million nuts. Recent statistics from the Government of India for 2008-09, 2009-10, and 2011-12 highlight India's emergence as the world's largest coconut producer, with a production figure of 15,840 million nuts, representing 26.9% of global production. Approximately 90% of coconut cultivation in India is attributed to the four southern states: Kerala, Tamil Nadu, Karnataka, and Andhra Pradesh [8].

Present use of coconut Shell

Renowned for their durability, toughness, and resistance to abrasion, coconut shells are highly favored for a multitude of applications. Traditionally, they have been used for crafting ornaments, household items, and as a source of activated carbon. Industries utilize powdered coconut shells in the production of plastics, adhesives, and abrasives. Additionally, they are widely used in insect repellents like mosquito coils and agarbathis. This research aims to explore the feasibility of using coconut shells as coarse aggregate in concrete, creating what is termed as coconut shell aggregate concrete (CSAC). Typically discarded as waste after the coconut flesh is removed, these shells represent a significant untapped resource. Exploring their potential in concrete production, like other lightweight aggregates, presents an interesting area for study [9, 10].

The Research's Objectives

The development of structural LWC from coconut shells, which are widely available in the area, would be a significant accomplishment for the regional building sectors. Therefore, the primary aim of this study is to assess the feasibility of utilizing coconut shells obtained from solid waste as coarse aggregate for structural lightweight concrete (LWC). The research objectives outlined are as follows:

- Investigate the properties of coconut shells and their compatibility with cement, with the objective of producing coconut shell aggregate concrete achieving a compressive strength exceeding 20 N/mm² at 28 days.
- Explore the strength characteristics of concrete by varying the replacement of coarse aggregate.
- Analyze the effects of replacing both coarse and fine aggregates on the strength properties of concrete.
- Evaluate the behavior of compressive and split tensile strengths within the investigated concrete compositions.

REVIEW OF LITERATURE

1. *Pooja Meena (2021):* The replacement of coarse aggregate of coconut shell by 5% and 10%. Nominal mix used is M20 grade and testing of specimens are conducted after 7 and 28 days of curing.
2. *Kajal Bansal (2019):* Coconut shells are replaced by 0%, 5%, 10%, 15%, 20%, 25% of coarse Aggregate. Coconut shells used in this are in the range less then 20mm. Cubes of various proportions are made. Testing of specimens are done after 7 days, 14 days and 28 days.
3. *Lopa M. Shinde (2015):* They recommended to promote sustainable development of the structure in order to lower the impact of the environment. It highly issues the concern about recycling the material to lower the burden on natural resources.

MATERIAL USED

Material Specification

3.1 Material Specification: Cement, water, fine aggregate, and coarse aggregate are the ingredients used to make concrete. Improved workability and strength can be achieved by using higher-quality materials. Provisions are made in accordance with IS 456:2000 to ensure any structure's safety.

Cement

In the experimental work cement used is Ordinary Portland cement. Various properties were evaluated such as fineness of cement, setting time, soundness test and compressive strength as shown in the following Table 1 Figure 1.

Fine Aggregate

According to IS 456:2000, the different characteristics of fine aggregate, including bulk density, specific gravity, and fineness modulus, were calculated. In the experimental effort, fine aggregate was made of sand that was readily available locally. The objective of the test is to ascertain the fineness modulus, which involves conducting a sieve analysis. Sand's fineness modulus of 3.25 is determined, confirming grading zone II in accordance with IS 383:1970's grading limit for fine aggregate. The bulk modulus is 2.65, and the fineness modulus is substantially within the range of 2.5 to 3.37. Table 2 discusses sand sieve analysis and Figure 2.

Table 1. Properties of Cement details.

Sr. No.	Particulars	Experimental Values
1.	Fineness of grinding (Residue on I.S. sieve no.9	1%
2.	Normal Consistency (%) water consistency	31%
3.	Setting time Initial setting time (min) Final setting time (min)	85 min 290 min
4.	Compressive strength (average of three cubes)	26.35 N/mm^2
5.	Soundness Test (expansion after boiling)	1 mm

Figure 1. Properties of Cement.

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Coarse Aggregate

During the experiment, coarse aggregate with a maximum particle size of 10 mm was utilized. According to IS 383:1970(3), coarse aggregate was tested for a variety of characteristics, including bulk and fineness moduli. The sieve analysis of coarse aggregate is displayed in Table 3 and 4, Figure 3.

Table 2. Sieve analysis of sand.

Sr. No.	I.S. Sieve size	Weight Retained (Kg)	Cumulative Weight Retained (Kg)	Cumulative % Retained	Cumulative % Passing
1.	4.75 mm	0.02	0.02	2.0	98.00
2.	2.36 mm	0.2	0.22	22.00	78.00
3.	1.18 mm	0.29	0.51	51.00	49.00
4.	600 micron	0.16	0.67	67.00	33.00
5.	300 micron	0.198	0.868	86.80	13.20
6.	150 micron	0.102	0.97	97.00	3.00
7.	Pan	0.030	-	-	-
-		1Kg	-	325.00	-

Fineness modulus (F.M.) = 325.00/100 = 3.25

Figure 2. Sieve analysis of sand test.

Figure 3. Sieve analysis of coarse aggregate test.

The physical properties of coarse aggregate are mentioned in the following Table 4.

Coconut shell

Particles of coconut shell are utilized as an investigative reinforcing material. In a grinding machine, shell particles with sizes ranging from 20 to 600 mm are created. The features of coconut shell include high strength and modulus. In order to examine their properties, coconut shells were gathered from different temples and shops, as seen in The characteristics of coconut shell as presented in Table 5 and Figure 4.

Table 3. Sieve analysis of coarse aggregate.

Sr. No.	Sieve size	Weight retained (Kg)	Cumulative % retained	% Passing
1	40 mm	Nil	Nil	Nil
2	20 mm	0	0	100
3	10 mm	1.465	29.2	70.7
4	4.75 mm	2.165	72.6	27.4
5	2.36 mm	0.96	91.8	8.2
6	1.18 mm	0.145	94.7	5.3
7	600 micron	0.075	96.2	3.8
8	300 micron	0.1	98	1.8
9	150 micron	0.09	98.2	1.5
10	Pan	0.02	-	-
	Total	5.0	482.6	-

Table 4. Physical properties of coarse aggregate.

Sr. No.	Properties	Results
1.	Particle shape, size	Angular, 20 mm
2.	Bulk Density	1.585
3.	Specific gravity	2.76

Table 5. Physical properties of coconut shells.

Sr. No.	Properties	Results
1.	Specific gravity	1.33
2.	Bulk density kg/m^3	800
3.	Shell thickness (mm)	2-7

Figure 4. Coconut shell.

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Manufactured Sand (M-sand)

M-Sand boasts improved strength, durability, and overall economy in addition to balanced physical and chemical qualities that allow it to survive any harsh climatic and environmental conditions. Concrete flaws including honeycombing, segregation, voids, capillaries, etc. can be fixed by using M-Sand.

It has been accurately rated in the required percentage. Because it lacks organic and soluble compounds that alter cement's characteristics and setting time, concrete can keep the necessary strength. It is free of contaminants like silt, dust, and clay coatings, which raise water requirements and weaken the binding between cement paste and aggregate, unlike river sand. enhanced concrete quality and longevity as a result Figure 5.

Silica Fume

A byproduct of making silicon alloys such ferrochromium, ferromanganese, calcium silicon, etc. is silica fume, which is hazardous to human health and the environment. Concrete's mechanical properties and durability have been found to be enhanced by silica fumes. Admixtures are added to a lot of contemporary concrete mixes to change the microstructure and lower the calcium hydroxide concentration through a pozzolanic process. Following that, cement composites' microstructures are modified to enhance their mechanical, durable, and service-life qualities Table 6 and Figure 6.

Silica fume which

- Conform to ASTM C 1240
- Specific Gravity is 2.22
- IS 15388:2003

METHDOLOGY

Batching

Batching: The amount or ratio of components, such as cement, aggregates, water, and other materials, is measured by weight to create the concrete mix. The M20 Nominal mix states that in order to produce concrete of a consistent quality, the necessary materials must be estimated, mixed, and added to the mix using both weight and volume in accordance with the Nominal mix Figure 7.

Mixing

Mixing: The ratio of concrete to be mixed depends on the desired strength. When the mix ratio for concrete is 1:1.5:3, it indicates that one part cement, one part sand, three parts aggregate, and 1.5 parts sand should be added. On a construction site, several techniques are used.

Figure 5. Manufactured Sand.

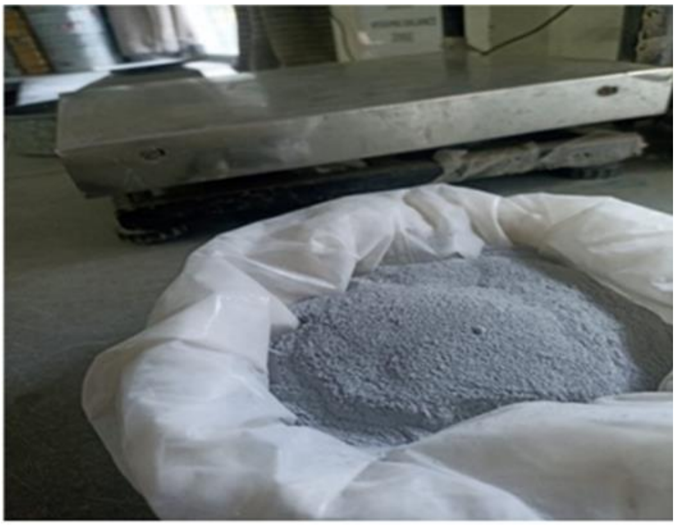

Figure 6. Silica Fume.

Table 6. Property comparison of aggregate & coconut shell.

Aggregate	Coconut Shells
1. *Density:* Generally have higher density compared to coconut shell. 2. *Strength:* Typically provide higher compressive and tensile strength to concrete. 3. *Weight:* Heavier, contributing to higher overall concrete density. 4. *Absorption:* Absorb less water, leading to better workability and durability. 5. *Durability:* Generally more durable and resistant to environmental factors. 6. *Workability:* Generally result in more workable concrete mixes. 7. *Sustainability:* Limited availability, and extraction can have environmental impacts. 8. *Cost:* Often more cost-effective.	1. *Density:* Lower density compared to traditional aggregates, which can result in lighter concrete. 2. *Strength:* Lower strength compared to traditional aggregates, especially in terms of compressive strength. 3. *Weight:* Lighter, resulting in reduced concrete weight. 4. *Absorption:* Can absorb more water, potentially affecting the workability and durability of the concrete. 5. *Durability:* May be less durable, especially in harsh environmental conditions, unless properly treated. 6. *Workability:* May require adjustments to the mix design to maintain workability. 7. *Sustainability:* Considered more sustainable as it is a byproduct of the coconut industry. 8. *Cost:* May be more expensive due to processing and treatment requirements.

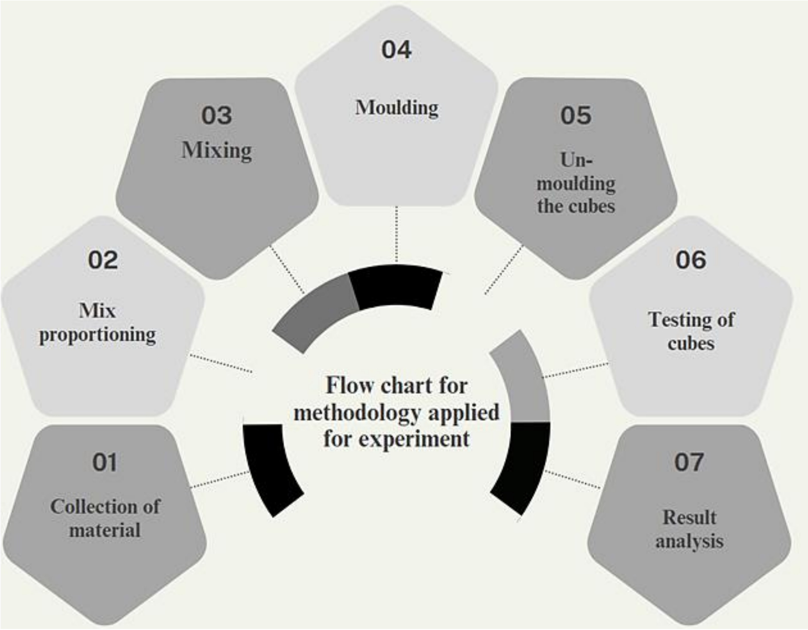

Figure 7. Methodology.

Placing of concrete /Coconut Concrete

Concrete casting, sometimes known as coconut concrete, is a big job that greatly affects a structure's functionality and long-term durability Table 7.

Aggregate Tests

AIV (Aggregate Impact Value)

With the help of the aggregate impact test (AIV Test), we can measure this factor. The aggregate impact test gives a relative measure of the resistance of an aggregate used in the pavement or structural construction to sudden shock or impact Table 8 and Table 9 Figure 8 and 9.

Aggregate Crushing Value Test

The aggregate crushing value gives a relative measure of the resistance of an Aggregate to crushing under a gradually applied compressive load Figure 10.

Crushing Strength Test

Empty Jug = 855Kg (W2)
Aggregate + Jug = 3565 Kg (W1)
Aggregate passing 2.36mm =250g (W3)
Aggregate Crushing Value = W3/(W1-W2) x 100
= 250/(3565-855) x 100
= 9.22%

Crushing Strength Test

Empty Jug = 0.855Kg (W2)
Coconut shell + Jug = 1.870 Kg (W1)
Coconut passing 2.36mm =0.083kg (W3)
Aggregate Crushing Value = W3/(W1-W2) x 100
= 0.083/ (1.870-0.855) x 100
= 8.17%

Table 7. Representing quantity of material used in one cube in varying mixes.

Sr. No	Material	Concrete (M20)	Coconut Concrete (5% Coconut shell), (12% M-Sand)	Coconut Concrete (8% Coconut Shell), (25% M-sand)	Coconut Concrete (12% Coconut Shell), (50% M-sand)	Coconut Concrete (15% Coconut Shell), (100% M-sand)
1	Cement	1.368 kg	1.368 kg	1.368 kg	1.368 kg	1.368 kg
2	Sand	2.271 kg	1.999 kg	1.704 kg	1.135 kg	-
3	M-Sand	-	0.272kg	0.567 kg	1.135 kg	2.271 kg
4	Aggregate	4.35 kg	3.970 kg	3.910 kg	3.850 kg	3.790 kg
5	Coconut	-	0.190 kg	0.200 kg	0.220 kg	0.240 kg
6	Silica	-	0.072 kg	0.102 kg	0.145 kg	0.153 kg
7	Water	0.50	0.45	0.49	0.52	0.56

Table 8. Material- Aggregate.

Aggregate Impact Value of Aggregate (IS:2386 - Part - 4) And Date of Testing:-12\09\23			
Observations	***Test***		
	1	2	3
Weight of aggregate sample filling in the cylinder = W_1 (gm)	310	316	309
Weight of aggregate passing 2.36 mm sieve after the test = W_2 (gm)	50	55	61
A.I.V. =(W_2/W_1) X 100 %	16.12%	17.40	19.74
Average A.I.V. %	17.53%		

Table 9. Aggregate Impact Value of Aggregate (IS:2386 - Part - 4).

Material: Coconut shell	**Date of Testing :10\10\23**		
Observations	***Test***		
	1	*2*	*3*
Weight of aggregate sample filling in the cylinder = W_1 (gm)	243	254	261
Weight of aggregate passing 2.36 mm sieve after the test = W_2 (gm)	21	26	33
A.I.V. =(W_2/W_1) X 100 %	8.64%	10.23%	12.64%
Average A.I.V. %	10.50%		

Figure 8. Material- Coconut Shell.

Figure 9. Material- Aggregate.

Silt Test

The objective of the Silt Content Test for Sand is to determine the amount of silt present in the sand (fine aggregate). The apparatus required includes a 250 ml measuring cylinder, water, sand, and a tray.

To conduct the test, begin by filling the measuring cylinder with a 1% solution of salt and water up to the 50 ml mark. Add sand to it until the level reaches 100 ml. Then fill the solution up to 150 ml level Figure 11.

Figure 10. Sand test.

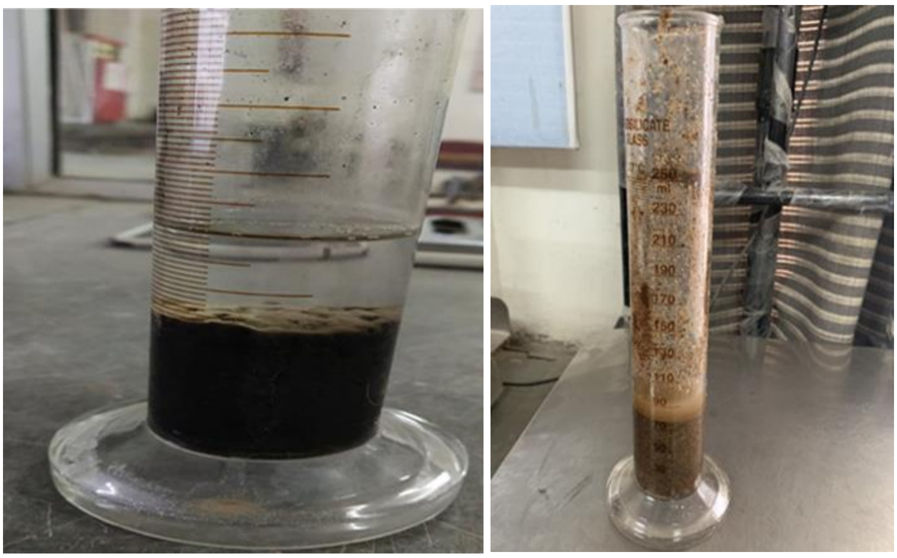
Figure 11. Silt Test.

Sieve Analysis

To verify the gradation of sand particles, a sieve analysis test is conducted. A high-quality mortar and concrete depend on the dispersion of sand particles in the sand volume. The sand sample is put through a succession of IS sieve sizes in this test, arranged from larger to smaller ones at the bottom Figure 12.

Cement Test

Consistency test by Vicat's Apparatus

The Vicat device is typically used to calculate the amount of water needed to make a cement paste with a typical consistency. Also used to ascertain the cement's initial and final setting times Figure 13.

Observations and Calculations:

Weight of cement taken (g) = 400 g
Initial percentage of water added to cement = 32 % by wt of cement
Quantity of water added to cement = 128 g

Results:

Consistency of Cement = (Quantity of water /Weight of cement) X 100
= (126/400) X100
= 31.5 %

Therefore, percentage of water content for standard consistency = 31.5%

Soundness test by Le Chatlier's mould test:

- The change in volume after setting or hardening is caused due to the "unsoundness of cement".
- The expansion limit of PPC cement is 10mm Figure 14 and Table 10.

Calculations

- Volume of expansion of cement = L1 - L2
- L1 = distance between the indicators after immersing in water for 24 hours
- L2 = distance between the indicators after immersing in water at boiling temp for 3 hours

Figure 12. Sieve Analysis.

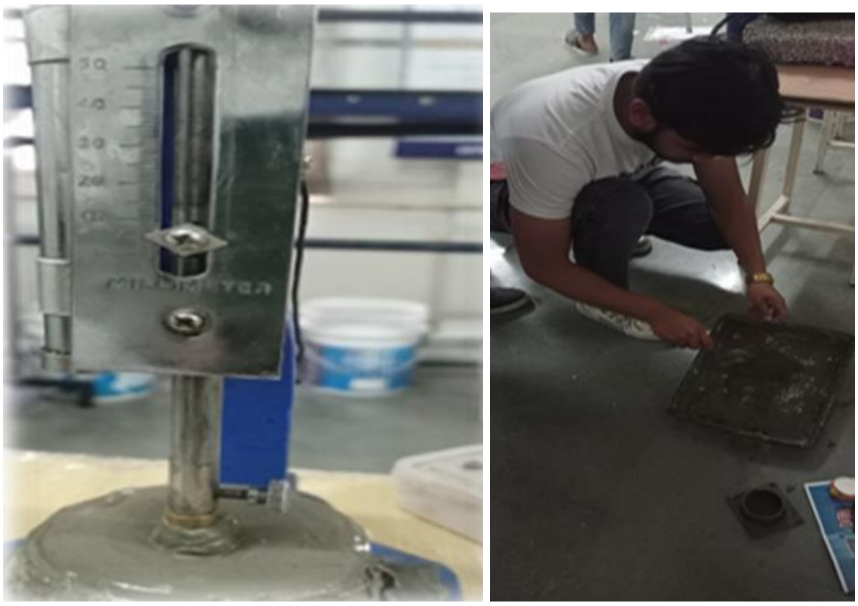

Figure 13. Cement Test.

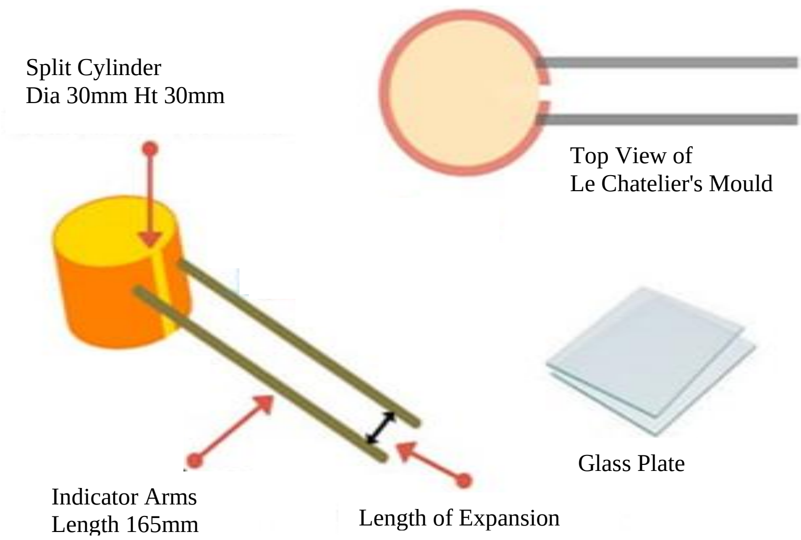

Figure 14. Soundness test by Le Chatlier's mould test.

Table 10. Soundness test by Le Chatlier's mould test details.

Sample	L1 (mm)	L2 (mm)	Expansion = L1-L2 (mm)
1	31 mm	26 mm	5 mm
2	24 mm	20 mm	4 mm
3	21 mm	17 mm	4 mm

Concrete Tests Four Tests to Ensure the Quality of Concrete

Slump Test

On a fresh concrete mix, an in-field concrete slump test is performed. It aids in determining whether the concrete that is about to be poured will adhere to the required standards. It is an easy test that can verify the consistency of the concrete over several batches, giving you an opportunity to adjust the mix before it is poured on site. One can determine whether a mix will have great workability or not by measuring the general "slump" of the concrete. This will also reveal whether the water-to-cement ratio is too high Figure 15.

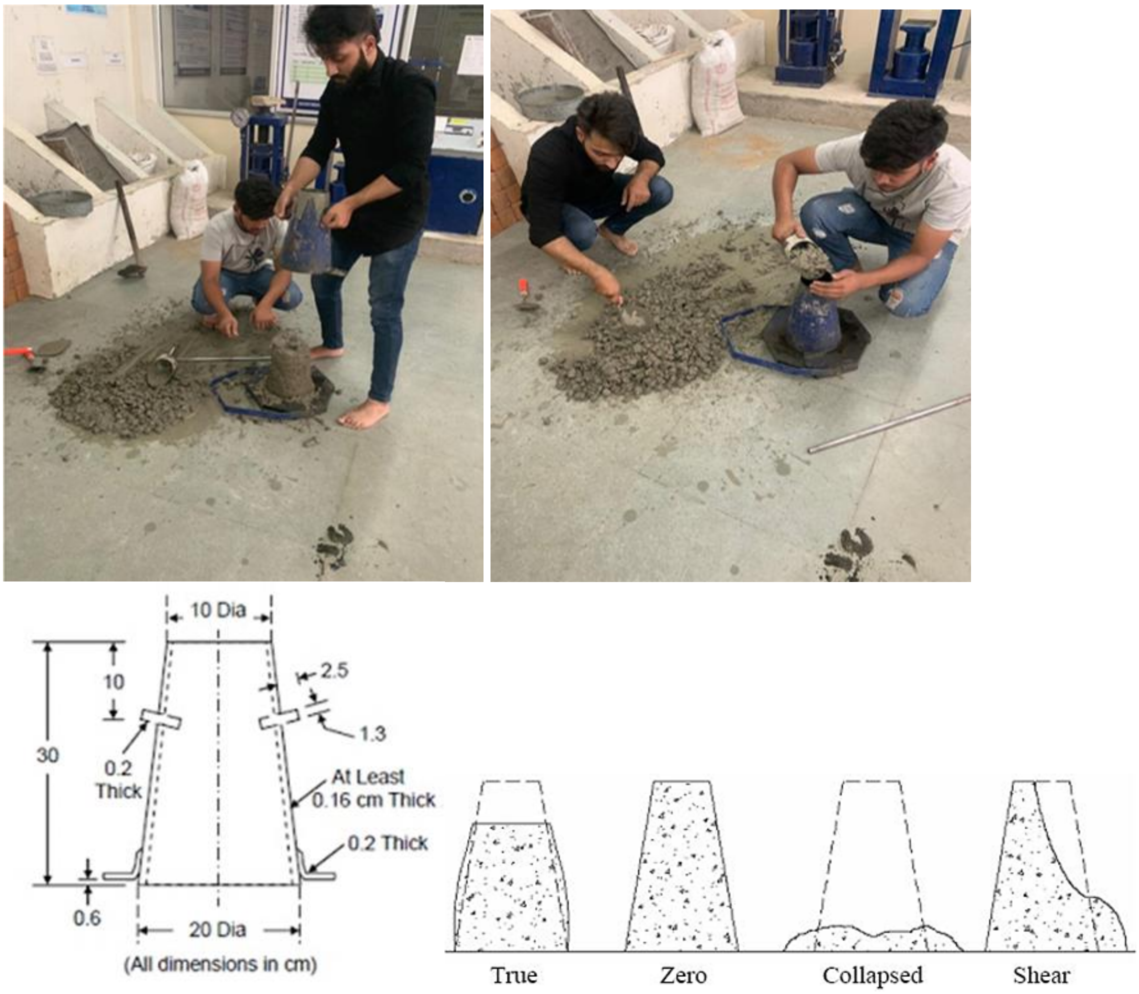

Figure 15. Slump Test.

Recommended Result of Concrete Slump Test

According to IS 456:2000 (Plain and Reinforced Concrete - Code of Practice):

- Concrete is deemed to have very low workability if the slump ranges from 0 to 25 mm.
- Concrete is classified as having low workability when the slump falls between 25 to 50 mm.
- A slump ranging from 50 to 100 mm signifies medium workability of concrete.
- Concrete exhibits high workability when the slump ranges from 100 to 150 mm Table 11 and Figure 16.

Slump Test Apparatus

Following apparatus are used for performing the slump test,

- Slump Test Cone (Mold)
- Tamping rod
- Scale for measurement

Compaction Factor Test

The compaction factor test measures the level of compaction attained by letting concrete fall through a predetermined height with a specified quantity of labor. Although it was intended for use in a laboratory, this can also be utilized in the field or on a working site if conditions allow. Since the concrete slump test is less accurate and sensitive than the compaction factor test, the latter is less suitable and helpful for low workable or dry concrete, which is typically utilized when vibration is to be used to compress the concrete.

Recommended Result of Compaction Factor Test

- If the compacting factor is 0.78 then it is considered as very low workability of concrete,
- If the compacting factor is 0.85 then it is considered as low workability of concrete,
- If the compacting factor is 0.92 then it is considered as medium workability of concrete,
- If the compacting factor is 0.95 then it is considered as high workability of concrete.

Table 11. Compaction factor test details.

S.no	Specimen	w/c	Weight of cylinder+concrete from hopper W2 kg	Weight of cylinder+fully compacted concrete W3	(W2-W1) (W3-W1)
1	M20	0.38%	18.590 kg	20.130 kg	0.884
2	Coconut concrete (5%,12%)	0.52%	17.900 kg	19.920kg	0.846
3	Coconut concrete (8%,25 %)	0.48%	17.790 kg	19.740 kg	0.849
4	Coconut concrete (12%, 50%)	0.50%	16.880 kg	19.650 kg	0.784



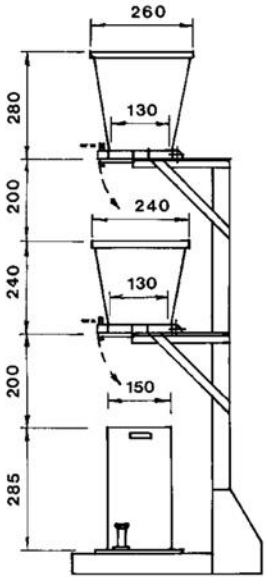

Figure 16. Result of compaction factor test.

Standard Guidelines for Compaction Factor Test

There are various standard guidelines available for performing the compaction factor test. Mentioned below are the standard guidelines available,

- IS 1199 – 1959,
- ACI 211.3-75 (Revised 1987),
- BS 1881: 103:1993 etc.

Compaction Factor Test Apparatus

Following apparatus are used for performing the compaction factor test,

- The compacting factor device is made up of one cylindrical mold and two conical hoppers.
- Tamping rod
- Weighing machine

3) Vee Bee Consistometer Test:

A useful laboratory test for assessing the workability of fresh concrete is the Vee-Bee consistometer test, which uses a Vee-Bee consistometer to quantify workability indirectly. The vee bee test should not be used on extremely wet concrete; it works best on dry concrete. Concrete's mobility and, to some extent, compatibility are assessed with the vee bee consistometer test. Rather than jolting, a vibrator is utilized in the vee bee consistometer test. The duration needed for concrete to change through vibration is determined by the vee bee test.

Recommended Result of Vee Bee Consistometer Test

According to 'IS 1199:1959' (Methods of Sampling and Analysis of Concrete),

- If vee bee time is up to 20 to 15-10 seconds, then concrete is considered as in a very dry consistency.
- If vee bee time is up to 10 to 7-5 seconds, then concrete is considered as in a dry consistency.
- If vee bee time is up to 5 to 4-3 seconds, then concrete is considered as in a plastic consistency.
- If vee bee time is up to 3 to 2-1 seconds, then concrete is considered as in a semi-fluid consistency.

Standard Guidelines for Vee Bee Consistometer Test

There are several established protocols available for doing the vee bee test. The standard guidelines for the Vee Bee Consistometer test are listed below.

- IS 1199 – 1959

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- ACI 211.3-75 (Revised 1987)
- BS EN 12350-3: 2009.

Vee Bee Consistometer Test Apparatus

The following elements make up the vee bee test of concrete, which is conducted with a vee bee consistometer Figure 17:

- Vibrating table
- A Metal pots.
- A steel metal cone or Slump Cone

4) Compressive strength test

Engineers frequently utilize concrete's compressive strength as a performance metric when designing buildings and other structures. The compressive strength of concrete refers to its ability to withstand specific compressive stresses. Conducting the test aids in evaluating whether the concrete satisfies the required performance criteria. Using precisely calibrated cylindrical molds, the compressive strength of concrete can be measured in a laboratory Figure 18 and 19.

Figure 17. Vee Bee consistometer test apparatus.

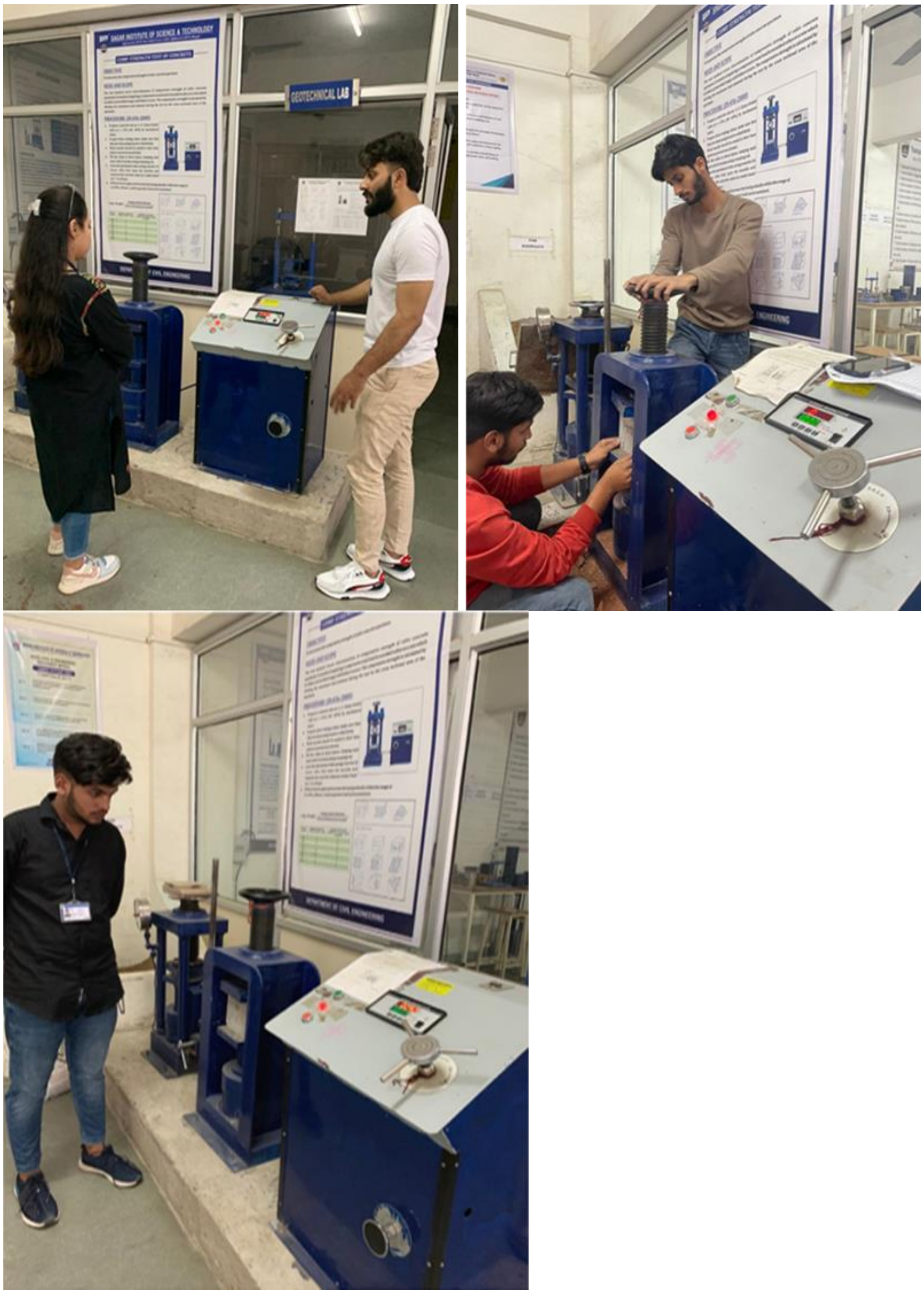

Figure 18. FCompressive strength = Crushing Load (N) / Area of Cube (mm).

DISCUSSION

Till date the cubes are being tested for 7 days compressive strength and it is observed that:

When coconut shell is added to the mix at a rate of 7% in place of coarse aggregate, the compressive strength of the mixture is roughly equal to an M20 grade mix. The compressive strength of the mixture is comparable to an M20 grade mix when 12% of the coarse material is replaced with coconut shells. The compressive strength of a mix containing 15% tire coconut shells is, however, gradually decreasing as the percentage of coarse aggregate replaced by coconut shells increases. This indicates that the mix's compressive strength is lower than that of M20 grade.

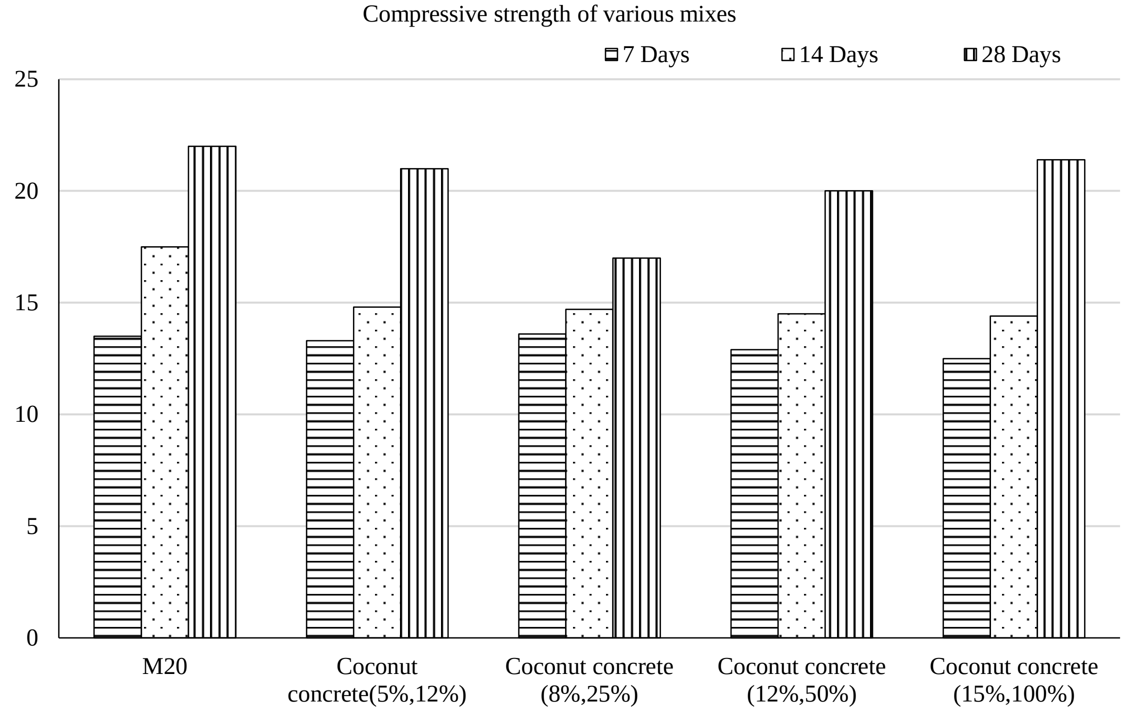

Figure 19. Compressive strength of various mixes.

CONCLUSION

Following examination and consideration of the data, the following findings have been reached:

- The compressive strength of coconut shell mixes remains comparable up to 12%. However, beyond this threshold, there is a decline in compressive strength as the percentage of coconut shells increases.
- Density decreases as the percentage of Coconut Shells replacement increases.
- Water absorption increases as the percentage of Coconut Shells increases.
- Modulus of elasticity decreases as the Coconut Shells percent increases and higher flexibility is obtained.
- Coconut Concrete mix is also one form of light weight concrete and can be used in roadwork and many other Construction works where very high compressive strength is not required.
- Determining the precise areas where this mixture can be applied is crucial.
- The experimental findings demonstrate that M-Sand can be utilized in part instead of natural sand, and that when the percentage of M-Sand is raised to an ideal level, compressive strength increases. The ideal ratio for using M-sand to replace natural sand is 50%.
- Efficiency Small buildings can benefit from the use of concrete infused with silica fume since it requires a high early strength and can shorten the construction time..
- According to the study's experimental findings, coconut shells can partially substitute natural coarse aggregates in concrete building as an aggregate.

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