Experimental Study on Partial Replacement of Cement and Fine aggregate with Agro Waste in PCC

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Abstract: Partial replacement of fine aggregate and cement by agro product. When agro waste is added to the concrete the compressive strength of concrete is found to reduce marginally. However, this marginally reduction can obtain with applicable percentage of addition thereby satisfaction result can be achieved. It is also result in lower consumption of natural material in the manufacture process in concrete thereby resulting in environmentally friendly and cheaper.

This experimental study considered the use of coconut shell ash and sawdust particles as replacement of cement and fine aggregate respectively in production of concrete. It investigated the physical properties of coconut shell charcoal powder and sawdust as well as the workability, compressive strength and flexure strength properties of concrete produced by replacing by replacing 5% of volume of cement by coconut shell ash and 5%,10% and 15% of volume of fine aggregate by sawdust cement and fine aggregate respectively. It also aimed to provide new knowledge on how to improve the construction industry methods by using coconut shell charcoal powder and sawdust mixture that would guarantee product performance and contribute to saving the environment. However, the resulting concrete density was still beyond the maximum limit for lightweight concrete hence a number of recommendations on modifications to the sawdust and coconut shell charcoal powder were made to increase the amount that can be incorporated in concrete.

Keywords: Coconut shell ash, Sawdust, Light weight concrete, Workability, Compressive Strength, Flexure Strength.

I. INTRODUCTION:

Over the Past decade, India has experienced a boom in its construction industry resulting in multiple infrastructure development projects across the country. This has been largely attributed to the steady economic growth and the stable political situation that has attracted both local and foreign investment. Consequently, there has been increased demand for not only suitable but cheaper construction materials. The demand is set to be further heightened as the country seeks to be a middle-income economy by the year 2030.

Concrete is widely used as construction material for various types of structures due to its durability. For a long time it was considered to be very durable material requiring a little or no maintenance. Many environmental phenomena are known significantly the durability of reinforced concrete structures. We build concrete structures in highly polluted urban and industrial areas, aggressive marine environments and many other hostile conditions where other materials of construction are found to be nondurable. In the recent revision of IS: 4562000, one of the major points discussed is the durability aspects of concrete. So the use of concrete is unavoidable. At the same time the scarcity of aggregates are also greatly increased nowadays. Utilization of industrial soil waste or secondary materials has been encouraged in construction field for the production of cement and concrete because it contributes to reducing the consumption of natural resources. They have been successfully used in the construction industry for partial or full replacement for fine and coarse aggregates.

Fine Aggregate and Coarse Aggregate are used as a filler material in the concrete and Cement is used for binding and strength parameter of the concrete. In Concrete, Fine Aggregate plays a major role in construction. Now-a-days, good quality natural river sand is not readily available. It is to be transported from a large distance. These resources are also exhausting very rapidly. So, there is an urge to find some alternative to natural river sand.

Natural River Sand takes millions of years for its formation. So, to overcome this problem, the material which has the properties almost similar to that of the Fine Aggregate may be used as a replacement in Concrete.
Concrete has been predominantly used as the preferred material for construction due to its various qualities especially strength that have made it easy and suitable for numerous construction purposes. Selection of aggregates used in concrete is important as aggregate makes approximately 60 to 75% of the total volume of concrete. Not only do they contribute to the strength exhibited by concrete but also to its bulkiness, a property that enables the concrete to be placed. There has been research carried out on aggregates reading to a better understanding of the basic mechanisms governing concrete strength, rheology, cracking etc. This has resulted in modifications of aggregates contained in concrete with an aim of either enhancing or completely changing the properties of concrete produced hence the use of special concrete such as no fines concrete, porous concrete and light weight concrete.
Various materials have been used in concrete to make it less dense especially highly porous materials. These can be classified by their origin as either natural or artificial aggregates. Examples of natural light weight aggregates include pumice, scoria and tuff. These are derived from igneous rocks and often glassy in nature but have different network of voids with pumice exhibiting tube like voids; scoria has spherical voids whereas tuff has an irregular core structure. Before the use materials are first crushed and sieved to obtain the right gradation. Actually, use of lightweight concrete can be traced back to Ancient Rome where pumice was used to construct the pantheon dome to reduce its weight. The building still stands today attesting to the durability of lightweight concrete.
Artificial lightweight aggregates used include slate, shale and expanded clay. These often have similar properties hence treated as single type. Similar to natural aggregates, they are crushed and graded. They are then heated at a temperatures of between 1000-2000 degree centigrade causing expansion and partial melting that forms an impervious viscous coating that prevents escape of gases generated during combustion. The material resulting is then crushed and screened. Examples of commercial artificial aggregates into Leca, Aglite and Sintag.
This experimental study focuses on using raw sawdust and coconut shell charcoal powder as partial replacement of fine aggregate and coarse aggregate contained in concrete, with an aim of coming with acceptable concrete mixture the results in lighter concrete that can be used in building construction particularly partitions and residential class concrete slab while ensuring properties of concrete such as compressive strength and tensile strength are maintained within standard limits.

Objectives:
- To determine the workability of fresh concrete that contains different proportions of sawdust and coconut shell ash.
- To determine the compressive strength of cubes made resulting from partial replacement of sand with sawdust and cement with coconut shell ash and compare them to those of cubes made from conventional concrete.
- To determine the flexural strength of beams resulting from partial replacement of sand with sawdust and cement with coconut shell ash and comparing these against beams made using normal concrete.
- To establish the optimum replacement level of sawdust and coconut shell ash in the specific grade of concrete.

II LITERATURE REVIEW

O. Oyedepo et.al. (2015) This paper is aimed at using a mix design ratio of 1:2:4 and water binder ratio of 0.63, concrete cubes were casted using varying ordinary Portland cement: palm kernel shell ash and ordinary Portland cement: coconut shell ash ratios of 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50 respectively. This research reveal that partial replacement of cement with 20% PKSA and CSA in concrete gives an average optimum compressive strength of 15.4 N/mm2 and 17.26 N/mm2 respectively at 28 days. While, the optimum value of compressive strength obtained at 28 days is 20.58 N/mm2 at 10% replacement with CSA. The value obtained is suitable for both light weight and heavy weight concrete respectively. Thus, the research show that the use of PKSA and CSA as a partial replacement for cement in concrete, at lower volume of replacement, will enhance the reduction of cement usage in concretes, thereby reducing the production cost and the environmental pollution caused by the dumping of the agricultural waste.

R.R Kumar et.al (2017) concluded that coconut Shell Ash and Eggshell Powder can be formed into useful binding materials. The properties of both wastes are within the range of the values of concrete making cement replacing material. The 10% replacement of cement by Coconut Shell Ash and Eggshell Powder has found to be attaining nearer strength as like conventional concrete. It had that partial replacement of cement with 2.5%, 5%, and 15% of Coconut Shell Powder and Egg Shell Powder in concrete gives an average optimum compressive strength in concrete. The use of Coconut Shell Powder and Eggshell Powder as a partial replacement of cement produced a cheaper structural light weight concrete using the optimum compressive strength value and lower volume of replacement, will enhance the reduction of cement usage in concretes, thereby reducing the production cost and the environmental pollution caused by the dumping of the agricultural waste. The flexural strength of the eggshell concrete increases with the addition of eggshell powder up to 15 percent.

Alban Chidiebere Ogbonna et al. (2021) This study discuss with concrete batching and mixing proportion of 1: 3: 2.5 of cementitious materials, fine aggregate and coarse aggregate used in this study gives cement content at the range of 282.4kg/m3 to 225.92kg/m3 for 0% to 20% replacement of cement with a mixture of coconut shell ash and eggshell powder. This satisfies the minimum cement content of 148.32kg/m3 and the minimum cementitious material content of 267kg/m3. The compressive strength results showed that, up to 20% replacement of cement with coconut shell ash and eggshell powder satisfied the minimum 28 days compressive strength requirement of 35N/mm2 to 41N/mm2 for standard and high-performance roller compacted industrial plant access roads and parking lots.

Naraindas Bheela et.al. (2021) This study discuss with concrete proportion of M25 in % range of 0% to 20%. The modulus of elasticity is achieved maximum at 10% of CSA utilized as a cementitious material in concrete at every curing period. Replacing OPC with CSA in concrete can increase compressive, split tensile and flexural strength with time due to its pozzolanic properties. However, the recommended replacement with OPC is 10%.

S. Azhagarsamy et.al. (2021) This research is aimed at using agro waste products in concrete by replacing fine aggregates. The ratios used are (5% rice husk ash, 15% coconut shell, 5%steel fibre, 10% GGBS), (10% rice husk ash, 10% coconut shell, 5 %steel fibre, 10% GGBS), (15% rice husk ash, 5% coconut shell, 5%steel fibre, 10% GGBS) in concrete. From the result it is concluded that maximum compressive strength was found at (15% rice husk ash, 5% coconut shell, 5%steel fibre,10% GGBS) for partial replacement of fine aggregate. Six cubes were casted for each mix of size 150mm x 150mm x 150mm and tested for compressive strength. From the result, it is obvious that though the initial strength for all the mixes is less than the control mix, the final strength gained is more than the control mix. As the percentage of rice husk ash increases, the final strength of concrete also increases. Hence, it is found that the optimum mix can be obtained by replacing 15% of fine aggregate with rice husk ash and 5% with coconut shell. It not only increases the strength of concrete but also helps in producing environment friendly concrete by reducing the intake of fine aggregate and using agro waste products.

Literature Review on Sawdust:

Kumar et al. (2014) carried out an experimental study to compare the cost of the sand used concrete block and sawdust used concrete block and also compared the reduction in weight of two blocks. In this experiment they prepared six test specimens of control concrete and 10%, 15% and 20% fine aggregate replaced by sawdust by volume each. Based on the study carried out on the strength behaviour of sawdust the following conclusions are drawn that is at the initial ages, with the increase in % replacement of sawdust, the weight of concrete reduces, thus making the concrete lighter which can be used as lightweight construction material in many civil engineering projects.

Dr Suji D Narayanan A M et al. (2016) determined the optimum quantity of river sand and to be replaced by quarry dust and sawdust and to obtain maximum results and compared the characteristic strength of normal concrete and concrete with quarry dust and sawdust. In this experimental study, the test was conducted for M30 mix containing quarry dust ranging from 0%, 10%, 20%, 30%, 40% combined with sawdust ranging from 0,5%,10%,15% and 20% remaining % river sand is used. Based on the experimental study following conclusions were made that is the compressive strength of quarry dust and sawdust up to 30% and 15% is almost similar to that of control mix. Split tensile strength of quarry dust and saw dust up to 30% and 15% respectively is almost similar to that of control mix. Two point loading test results shows that the first crack load is almost same for both control mix and quarry dust and sawdust concrete. As a result of this experiment quarry dust and sawdust contain 30% and 15% by wait as shown the best results. Thus indicates the possibility of using quarry dust and sawdust as partial replacement or fine aggregate up to this level. The weight can be reduced upto 20%.

Ugwu J.N et al (2019) this study is on the experimental investigation of fully replacing sand with sawdust on the compressive property of concrete. Design mix ratio 1:2:4 and w/c of 0.58 were used and 24 concrete cubes were cast. 12 cubes were for the sand concrete used as control samples and 12 cubes for the sawdust concrete. The compressive strength of the sawdust concrete was compared with the sand concrete to check their strength gain. The result of the study gave that both the weight and compressive strength of sawdust concrete decreased significantly and the gain in strength was very poor. The gap in the strength gain between the two concrete cannot be compared at all hence, some percentage replacement using sawdust is needed to ascertain its optimum for use as lightweight concrete.

Siti Noratikah Che Deraman et al (2021) the aim of this study is to determine the optimum proportion of durian saw dust as partial replacement for fine aggregate. These wastes utilization would not only be economical but may also help to create a sustainable and pollution free environment. Durian sawdust is one such fibrous waste-product from durian skin. In this paper, untreated durian sawdust has been partially replaced in the ratio of 0%, 5%, 10% and 15% by volume of fine aggregate in concrete. Fresh concrete tests like compacting factor test and slump test were undertaken along with hardened concrete tests like compressive strength test and UPV test. The result shows that durian sawdust of 5% partially replacement of fine aggregate can be used for structural and non-structural purposes.

III. MATERIALS AND PROPERTIES

A.Cement

A powdery substance made by calcining lime and clay, mixed with water to form mortar or mixed with sand, gravel, and water to make concrete. A cement is a binder, a chemical substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete.

The properties of cement are listed in the below table

Table 1 Properties of Cement

Properties	Results
Fineness of cement	93.99%
Normal consistency or Standard consistency	32%
Initial setting time	30 min
Final setting time	10 hours
Specific gravity	3.24

B.Fine Aggregate

When the granular material's particles are so small that they can fit through a 4.75mm screen, it is referred to as fine aggregate. Aggregate is the granular material used to make concrete or mortar. The spaces between the coarse aggregate are filled with the fine aggregate.

The properties of fine aggregate are listed in the below table

Table 2 Properties of Fine aggregate

Properties	Results
Specific gravity	2.57
Water absorption	2.73%

C.Coarse Aggregate

Concrete is made with coarse aggregates, which are granular and uneven materials like sand, gravel, or crushed stone. Coarse is typically found in nature and can be obtained by blasting quarries or crushing them manually or with crushers.Coarse aggregate refers to materials that are large enough to be caught by a 4.7mm sieve.

The properties of coarse aggregate are listed in the below table

Table 3 Properties of Coarse aggregate

Properties	Results
Specific gravity	2.63
Water absorption	0.81%

D. Coconut shell ash:

It is obtained by collecting the Coconut shells and drying them in sunlight for 3 to 4 days until the moisture is removed from the shells and they are burnt and powder into ash in the mill.

Fig 1 coconut shell ash

E. Sawdust:

It is obtained from carpentry shop from a heap of wood shavings and sawdust which were considered it as waste. It was established that available sawdust was mixture from different types of wood with the most common being Blue gum and Grevillea. Both of these were available in Karimnagar hence could be acquired locally.

Fig 2 sawdust

 Mix Design

In our experimental work, we used concrete of grade M25 with a mix ratio of 1:1:2 and a water-cement ratio of 0.40

IV. METHODOLOGY

1. INTRODUCTION-PROBLEM STATEMENT
2. LITERATURE STUDY
3. COLLECTION MATERIALS
4. DESIGN MIX
5. TEST ON MATERIAL
6. PREPARATION OF FRESH CONCRETE
7. WORKABILITY TEST ON FRESH CONCRETE
8. CASTING OF SPECIMEN
9. CURING OF SPECIMEN
10. TEST ON SPECIMEN
11. RESULT ANALYSIS
12. CONCLUSION

V.TESTS ON FRESH CONCRETE

Fresh concrete is that stage of concrete in which concrete can be moulded in its plastic state. This is also called Green Concrete. Another term used to describe the state of fresh concrete is consistence, which is the ease with which concrete will flow. It is the concrete phase from time of mixing to end of time concrete surface finished in its final location in the structure For fresh concrete to be acceptable, it should:

1. Be easily mixed and transported.
2. Be uniform throughout a given batch and between batches.
3. Be of a consistency so that it can fill completely the forms for which it was designed.
4. Have the ability to be compacted without excessive loss of energy.

5. Not segregate during placing and consolidation.
6. Have good finishing characteristics.

The workability of concrete can be evaluated using one of the three methods below, depending on the water cement ratio in the mix.

1. Slump cone test
2. Compaction factor test
3. Vee-bee test

VI. TESTS ON HARDENED CONCRETE

As the name suggests, hardened concrete has acquired its shape and has served the intended purpose for the designated amount of time; it is no longer plastic. It won't be feasible, meaning that it won't be possible to modify the structure's shape. It is essentially at the "plasticity" stage, where its fluidity has completely disappeared. With time, hardened concrete becomes stronger, thus it's critical to assess the durability and quality of the material. The following tests are conducted on hardened concrete:

1. compressive strength test
2. Split-tensile test
3. Flexural strength test.



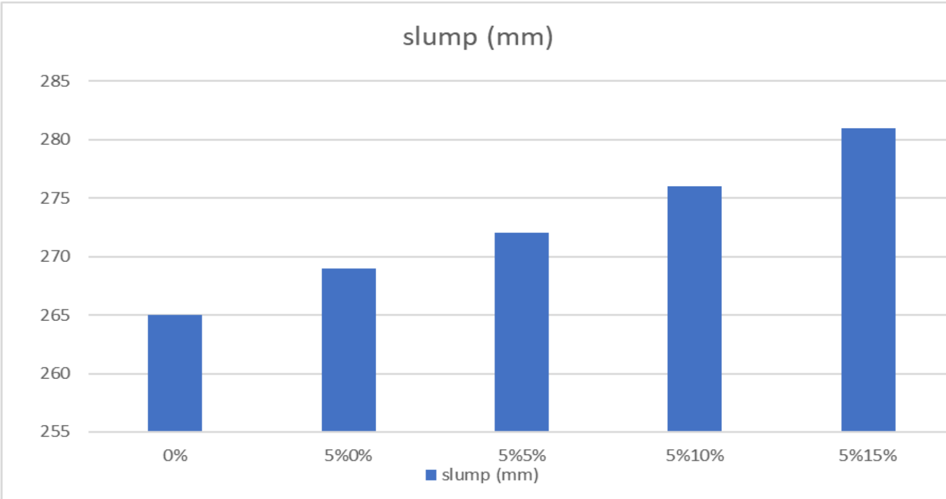
Figure 3 Compressive testing of specimen Figure 4 Tensile testing of specimen Figure 5 Flexure testing on beam

VII. RESULTS AND DISCUSSIONS

Slump test is conducted on following percentage variations

Table 4 Variation in slump

% of coconut shell ash	% of sawdust	Slump(mm)
0%	0%	265
5%	0%	269
5%	5%	272
5%	10%	276
5%	15%	281



Graph 1 variation in slump

Result: The values indicate that there is a increase in slump with increase in sawdust. As the % increase the workability decreases.

B. Compressive strength test:

Table 5: compressive strength at 7 days

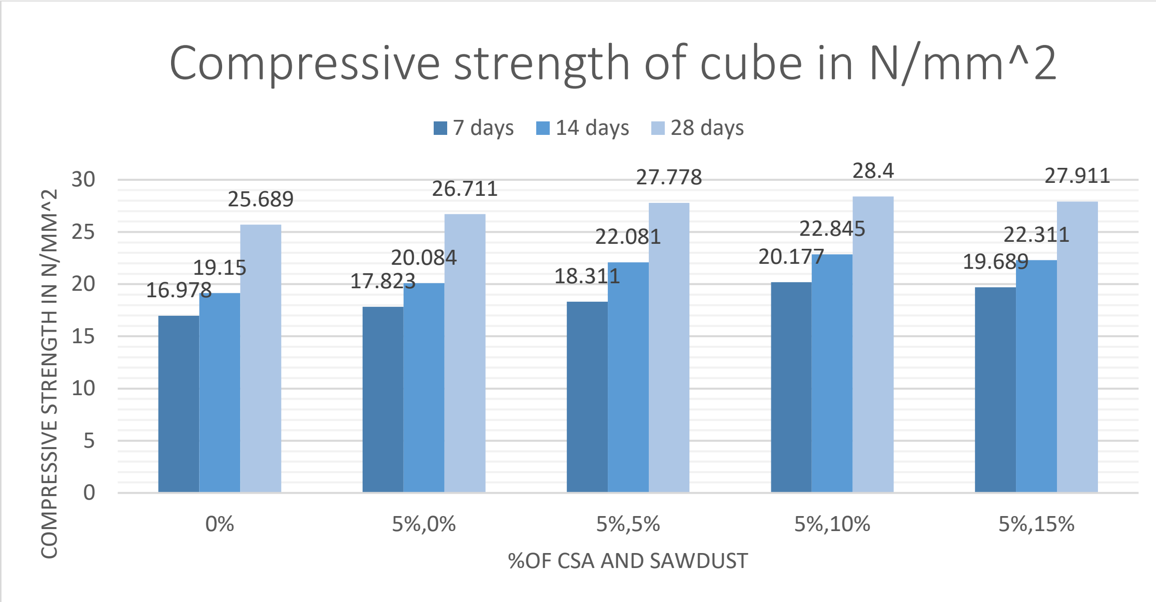
Grade the of concrete	% of CSA replaced	% of sawdust replaced	Load in KN	Area in mm2	Compressive in strength MPa
M 25	0	0	382	22500	16.978
	5	0	401	22500	17.823
	5	5	412	22500	18.311
	5	10	454	22500	20.177
	5	15	443	22500	19.689

Table 6: compressive strength at 14days

Grade of the concrete	% of CSA replaced	% of sawdust replaced	Load in KN	Area in mm2	Compressive in Strength MPa
M 25	0	0	439	22500	19.15
	5	0	469	22500	20.084
	5	5	497	22500	22.081
	5	10	514	22500	22.845
	5	5			

Table 7: compressive strength at 28days

Grade of the concrete	% of CSA replace d	% sawdust of replaced	Load in KN	Area in mm2	Compressive in strength MPa
M 25	0	0	578	22500	25.689
	5	0	601	22500	26.711
	5	5	625	22500	27.778
	5	10	639	22500	28.400
	5	15	628	22500	27.911



Graph.2- Variation of Compressive strength

Result:

Graph.2 shows the variation of 7, 14, 28 days compressive strengths. The compressive strength for 7days is 16.97N/mm2, 17.82N/mm2, 18.31N/mm2, 20.17N/mm2 and 1.96N/mm2were obtained for compressive strengths with 5% Coconut shell ash as partial replacement of Cement and 5%, 10%, 15% of Sawdust with sand. The compressive strength at 5% replacement is 7.85% higher when compared to conventional concrete, at 10% replacement the strength is 18.8% higher than that of conventional concrete strength and at 15% the strength decreases with 15.96% compared to a conventional concrete.

The compressive strength for 14 days is 19.51N/mm2, 20.84N/mm2, 22.08N/mm2, 22.84N/mm2 and 22.31N/mm2 were obtained. The compressive strength at 5% replacement is 15.3% higher when compared to conventional concrete, at 10% replacement the strength is 19.29% higher than that of conventional concrete strength and at 15% the strength decreases with 16.5% compared to a conventional concrete.

The compressive strength for 28 days is 25.69N/mm2, 26.71N/mm2, 27.78N/mm2, 28.4N/mm2 and 27.91N/mm2 were obtained for compressive strengths with 5% Coconut shell ash as partial replacement of Cement and 5%,10% and 15% of sawdust with sand. The compressive strength at 5% replacement is 8.13% higher when compared to conventional concrete, at 10% replacement the strength is 10.5% higher than that of conventional concrete strength and at 15% the strength decreases with 8.64% compared to a conventional concrete.

C. Split tensile strength:

Table 8: tensile strength at 7 days

Grade of the concrete	% of CSA Replaced	% of sawdust replaced	Load KN in	Dimension	Tensile strength (2P/πDH) N/mm2
M 25	0	0	145	L = 300mm B = 150mm	2.051
	5	0	152		2.150
	5	5	159		2.249
	5	10	164		2.320
	5	15	157		2.221

Splitting tensile strength of concrete at 14 days

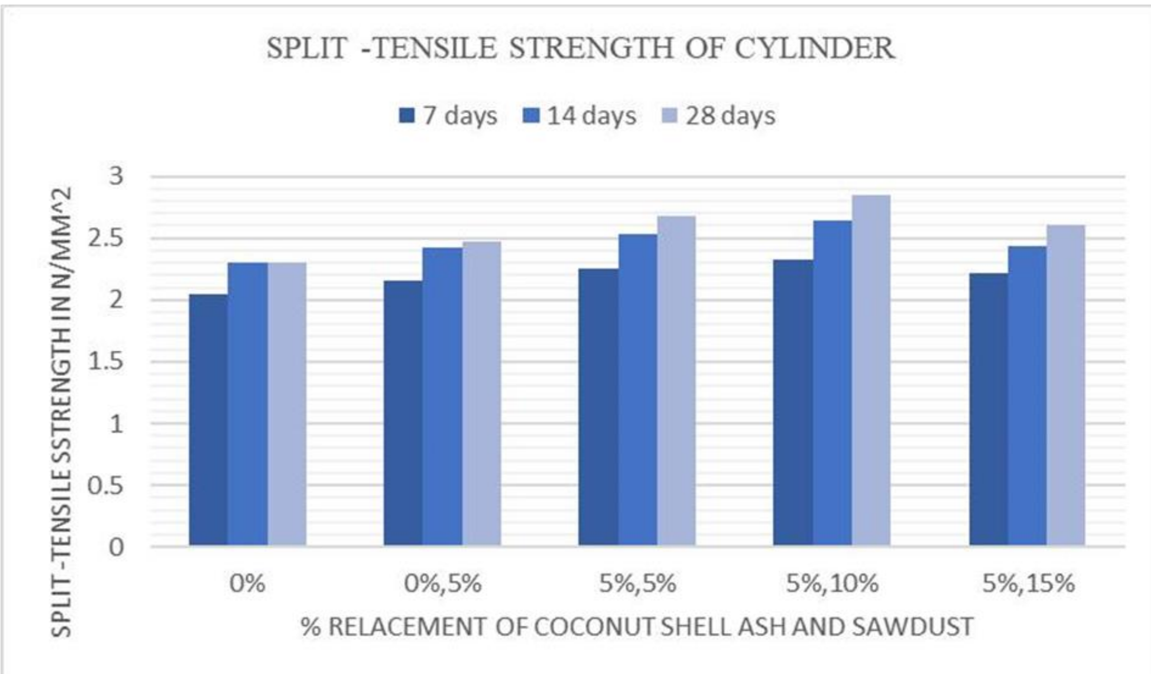
Table 9: tensile strength at 14 days

Grade of the concrete	% of CSA replaced	% of sawdust replaced	Load in KN	Dimension	Tensile strength (2P/πDH) N/mm2
M 25	0	0	163	L = 300mm B = 150mm	2.305
	5	0	171		2.419
	5	5	179		2.532
	5	10	187		2.645
	5	15	172		2.433

Splitting tensile strength of concrete at 28days

Table 10: tensile strength at 28 days

Grade of the concrete	% of CSA replaced	% of sawdust replaced	Load in KN	Dimension	Tensile strength (2P/πDH) N/mm2
M 25	0	0	163	L = 300mm B = 150mm	2.305
	5	0	175		2.475
	5	5	189		2.673
	5	10	201		2.843
	5	15	184		2.603



Graph.3: Variation of Split tensile strength of cylinder

Result:

Graph 3 shows the variation of 7, 14, 28 days Split tensile strength. The Split tensile strength for 7days is 2.051N/mm2, 2.150N/mm2, 2.249N/mm2, 2.320N/mm2 and 2.221N/mm2 were obtained for Split tensile strength with 5%, Coconut shell ash as partial replacement of Cement and 5%, 10%, 15% sawdust with sand. The Split tensile strength at 5% replacement is 9.65% higher when compared to conventional concrete, at 10% replacement the strength is 13.11% higher than that of conventional concrete strength and at 15% the strength decreases with 8.28% compared to a conventional concrete.

The Split tensile strength for 14days is 2.305N/mm2, 2.419N/mm2, 2.532N/mm2, 2.645N/mm2 and 2.433N/mm2 were obtained. The Split tensile strength at 5% replacement is 9.8% higher when compared to conventional concrete, at 10% replacement the strength is 14.7% higher than that of conventional concrete strength and at 15% the strength decreases with 5.55% compared to a conventional concrete.

The Split tensile strength for 28days is 2.305N/mm2, 2.475N/mm2, 2.673N/mm2, 2.843N/mm2 and 2.603N/mm2were obtained. The Split tensile strength at 5% replacement is 15.9% higher when compared to conventional concrete, at 10% replacement the strength is 23.3% higher than that of conventional concrete strength and at 15% the strength decreases with 12.9% compared to a conventional concrete.

D. Flexural strength test:

Flexure strength of beam at 7 days:

Table 11 flexure strength of beam at 7 days

Grade of concrete	% of CSA	% of sawdust	Load (KN)	Length (mm)	BD^2 in mm^2	Flexural strength PL/BD^2 (Mpa)
M25	0	0	5.6	500	10000	2.8
	5	0	5.8	500	10000	2.9
	5	5	6.0	500	10000	3.0
	5	10	6.7	500	10000	3.35
	5	15	5.7	500	10000	2.85

Flexure strength of beam at 14 days:

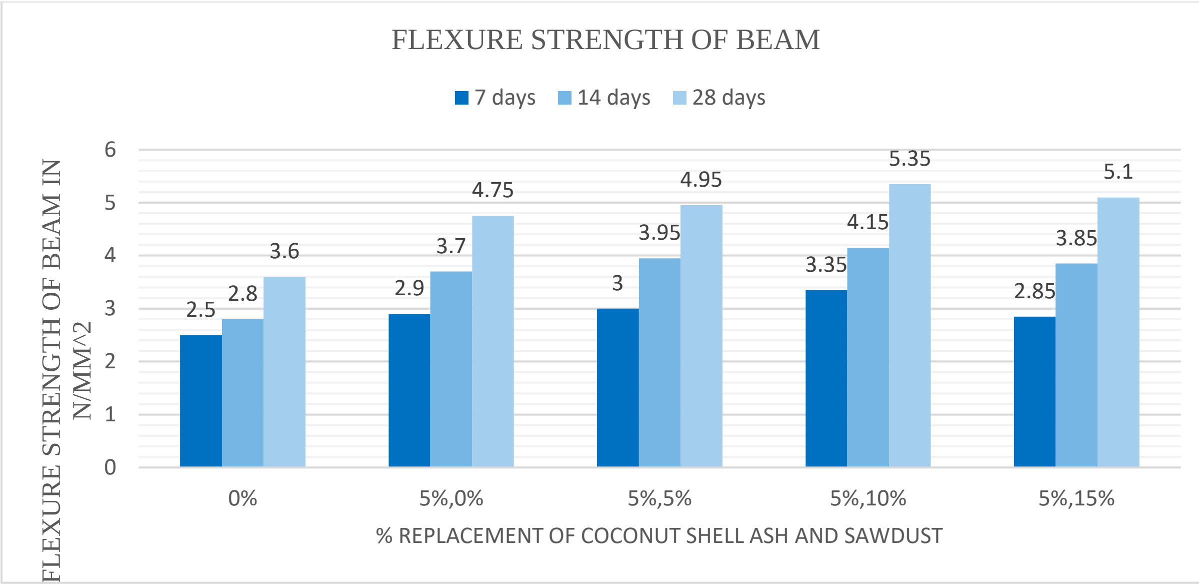
Table 12 flexure strength of beam at 7 days

Grade of concrete	% of CSA	% of sawdust	Load (KN)	Length (mm)	BD^2 in mm^2	Flexural strength PL/BD^2 (Mpa)
M25	0	0	6.9	500	10000	3.4
	5	0	7.4	500	10000	3.7
	5	5	7.9	500	10000	3.95
	5	10	8.3	500	10000	4.15
	5	15	7.7	500	10000	3.85

Flexure strength of beam at 28 days:

Table 12 flexure strength of beam at 28 days

Grade of concrete	%of CSA	% of sawdust	Load (KN)	Length (mm)	BD^2 in mm^2	Flexural strength PL/BD^2 (N/mm^2)
M25	0	0	7.24	500	10000	3.5
	5	0	9.5	500	10000	4.75
	5	5	9.9	500	10000	4.95
	5	10	10.7	500	10000	5.35
	5	15	10.2	500	10000	5.1



Graph 4 variation of flexure strength of beam

Result

Graph 4 shows the variation of 7, 14, 28 days Flexural strength. The Flexural strength for 7days is 2.8N/mm^2, 2.9N/mm^2, 3.0N/mm^2, 3.35N/mm^2 and 2.85N/mm^2 were obtained for Flexural strength with 5% coconut shell ash as partial replacement of Cement and sawdust with sand at 0%, 5%, 10%, 15%. The Flexural strength at 5% replacement is 7.14% higher when compared to conventional concrete, at 10% replacement the strength is 19.6% higher than that of conventional concrete strength and at 15% the strength decreases with 1.78% compared to a conventional concrete.

The Flexural strength for 14 days is 3.4N/mm2,3.7N/mm2, 3.95N/mm2, 4.15N/mm2 and 3.85N/mm2 were obtained The Flexural strength at 5% replacement is 16.17% higher when compared to conventional concrete, at 10% replacement the strength is 22.05% higher than that of conventional concrete strength and at 15% the strength decreases with 13.22% compared to a conventional concrete.

The Flexural strength for 28 days is 3.5N/mm2, 4.75N/mm2, 4.95N/mm2, 5.35N/mm2, 5.1N/mm2 were obtained The Flexural strength at 5% replacement is 15.11% higher when compared to conventional concrete, at 10% replacement the strength is 24.4% higher than that of conventional concrete strength and at 15% the strength decreases with 18.6% compared to a conventional concrete.

VIII CONCLUSION

From the results of the various tests carried out the following conclusions could be drawn:

- The use of coconut shell ash and sawdust as supplementary cementitious material and fine aggregate replacement should be encouraged. This leads to cost effective and environmentally friendly construction. It also leads savings in the quantity of cement that would have been consumed and as such sustainability of the cement industry can be guaranteed.
- Concrete becomes less workable as the proportion of sawdust increases at a constant increase in the water to cement ratio. This could be attributed to the high-water demand resulting from the absorbent of sawdust.
- Sawdust and Coconut shell ash exhibits early development of strength compared normal concrete.
- Better mechanical and physical properties of concrete can be obtained with the replacement of cement with a mixture of coconut shell ash and sawdust.
- The compressive strength of sawdust concrete increases with increase in amounts of sawdust. The early exhibited by the 28 days strength by 10 % partial replacement of sand with sawdust and @5% CSA as partial replacement

of cement provided suitable strength above minimum compressive strength for light weight concrete 28.4N/mm^2.

- The tensile strength increases as the amount of sawdust @10% partial replacement of sand with sawdust and @5% CSA as partial replacement of cement the maximum tensile strength obtained at 10% is 2.8N/mm^2
- The flexural strength increases as the amount of sawdust @10% replacement of sand with sawdust and @5% CSA as partial replacement of cement the maximum flexure strength obtained @10% is 5.38N/mm^2.

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