Utilization of Sawdust Ash as an additive of cement in concrete and study of its mechanical properties

Utilización de Ceniza de Aserrín como aditivo del cemento en hormigón y estudio de sus propiedades mecánicas

Utilização da Cinza de Serragem como aditivo de cimento em concreto e estudo de suas propriedades mecânicas

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Summary. - The sustainability of the concrete industry is in jeopardy because it is one of the biggest consumers of natural resources. Environmental and monetary issues are the main difficulties the concrete industry is currently dealing with. In this study, the potential substitution of sawdust ash for cement in the production of concrete is explored. In this project, the potential substitution of sawdust ash for cement in concrete production was explored, a typical carpentry waste, and then we utilize several testing techniques to examine how it impacts the mechanical characteristics of concrete. In an experiment, the compressive, tensile, and flexural strengths of concrete samples made with various ratios of sawdust ash and cement were examined. The samples were made following ASTM C-109, ASTM C-496 and ASTM C-78 for compression, tensile and flexural testing. In place of cement, saw dust ash was added to the M-15 (M indicates 'mix' and 15 indicates compressive strength of 15MPA) sample in weight percentages of 5%, 10%, 15%, 20%, and 25%. The concrete samples were tested to ascertain their compressive, tensile, and flexural strengths after 14 days. Comparisons between the results and untreated concrete were done. In this study, the behavior of concrete was investigated when sawdust ash was replaced for cement to weight-based extents of 0%, 5%, 10%, 20%, and 25%. This could address the problem of how to dispose of sawdust ash while also enhancing the properties of concrete.

Keywords: Tensile strength, compressive strength, flexural strength of concrete, sawdust ash, concrete cubes, sustainable construction.

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Resumen. - *La sostenibilidad de la industria del hormigón está en peligro porque es uno de los mayores consumidores de recursos naturales. Las cuestiones medioambientales y monetarias son las principales dificultades a las que se enfrenta actualmente la industria del hormigón. En este estudio se explora la potencial sustitución de cenizas de aserrín por cemento en la producción de hormigón. En este proyecto, se exploró la posible sustitución de cenizas de aserrín por cemento en la producción de concreto, un desperdicio típico de carpintería, y luego utilizamos varias técnicas de prueba para examinar cómo afecta las características mecánicas del concreto. En un experimento, se examinaron las resistencias a la compresión, la tracción y la flexión de muestras de hormigón elaboradas con diversas proporciones de ceniza de aserrín y cemento. Las muestras se fabricaron siguiendo las normas ASTM C-109, ASTM C-496 y ASTM C-78 para ensayos de compresión, tracción y flexión. En lugar de cemento, se añadió ceniza de aserrín a la muestra M-15 (M indica "mezcla" y 15 indica resistencia a la compresión de 15 MPA) en porcentajes en peso de 5%, 10%, 15%, 20% y 25%. Las muestras de concreto fueron ensayadas para determinar sus resistencias a compresión, tracción y flexión después de 14 días. Se realizaron comparaciones entre los resultados y el hormigón sin tratar. En este estudio, se investigó el comportamiento del concreto cuando se reemplazó la ceniza de aserrín por cemento en proporciones basadas en peso de 0%, 5%, 10%, 20% y 25%. Esto podría abordar el problema de cómo eliminar las cenizas de aserrín y al mismo tiempo mejorar las propiedades del hormigón.*

Palabras clave: *Resistencia a la tracción, resistencia a la compresión, resistencia a la flexión del hormigón, cenizas de aserrín, cubos de hormigón, construcción sostenible.*

Resumo *. - A sustentabilidade da indústria do betão está em perigo porque é um dos maiores consumidores de recursos naturais. As questões ambientais e monetárias são as principais dificuldades com que a indústria do betão enfrenta actualmente. Neste estudo, é explorada a potencial substituição da cinza de serragem por cimento na produção de concreto. Neste projeto, foi explorada a potencial substituição da cinza de serragem por cimento na produção de concreto, um típico resíduo de carpintaria, e em seguida utilizamos diversas técnicas de testes para examinar como isso impacta às características mecânicas do concreto. Em um experimento, foram examinadas as resistências à compressão, tração e flexão de amostras de concreto feitas com diversas proporções de cinza de serragem e cimento. As amostras foram confeccionadas seguindo ASTM C-109, ASTM C-496 e ASTM C-78 para ensaios de compressão, tração e flexão. No lugar do cimento, cinza de serragem foi adicionada à amostra M-15 (M indica 'mistura' e 15 indica resistência à compressão de 15MPA) em porcentagens em peso de 5%, 10%, 15%, 20% e 25%. As amostras de concreto foram testadas para verificar suas resistências à compressão, tração e flexão após 14 dias. Foram feitas comparações entre os resultados e o concreto não tratado. Neste estudo, o comportamento do concreto foi investigado quando a cinza de serragem foi substituída por cimento em extensões de peso de 0%, 5%, 10%, 20% e 25%. Isto poderia resolver o problema de como descartar as cinzas de serragem e, ao mesmo tempo, melhorar as propriedades do concreto.*

Palavras-chave: *Resistência à tração, resistência à compressão, resistência à flexão do concreto, cinza de serragem, cubos de concreto, construção sustentável.*

1. Introduction. - Concrete, the most common building material globally, is composed of cement, water, and aggregate. Its production requires significant energy and carbon, generating 5-10% of annual anthropogenic CO_2 emissions. Efforts to reduce cement emissions and make it greener have been ongoing due to the environmental impacts of global warming.[1]. Since sawdust is a byproduct of the timber industry and is frequently seen as waste, using sawdust composite in buildings is relevant since it can function as a sustainable resource. However, it offers a sustainable substitute for conventional building materials like steel or concrete by incorporating sawdust into composite materials. It is also feasible to modify the construction process' carbon footprint by using sawdust[2].While scientists, researchers, people, and governments are sincerely trying to find solutions for these top global concerns, they pose a serious threat to our ecosystem on a worldwide scale [3].

One of the main causes of climate change is human activity, which has detrimental effects on the environment such as increasing sea levels, heat waves, global temperatures, and the melting of permafrost. The most widely used building material, concrete, is overused worldwide and accounts for 7% of emissions of carbon dioxide from human activity. The issue is exacerbated by the growing population and demand for concrete, which in turn affects cement output. Building expenses have gone up as a result of this, especially in developing countries. [4].Cement production, a major contributor to global CO_2 emissions, also depletes limestone reserves. In the past, river sand was the most often used option for the fine aggregate component of concrete, but overuse of the material has raised environmental hazards, lowered the availability of trustworthy river sand sources, and increased the material's cost [5].

One of the most often utilized building materials is concrete. Cement, fine aggregate, coarse aggregate, and water are the components of concrete. One of the greatest adhesives for concrete is cement, which is harmful to the environment. During the production of Portland cement, more carbon dioxide and other potentially hazardous greenhouse gases are emitted into the atmosphere. [4] Manufacturing releases carbon dioxide, which adds to global warming and other environmental problems like dust pollution and ozone layer thinning [6]. Almost 3 billion tons of Portland cement are consumed each year, and for every 600 kg of cement manufactured, 400 kg of carbon dioxide gas is created.

On the other hand, as a result of present expansion and housing demands, consumption of the individual components of concrete has gradually improved. The cement business works around the clock to supply the demand from consumers. Moreover, quarrying for natural aggregates is problematic. Natural aggregates' natural sources are quickly vanishing, according to a recent analysis of their use. Alternative means of maintaining natural aggregates should be investigated to avoid damage to the environment from aggregate quarrying and the effects on the cement industry [7]. The effective plan to reduce environmental impact while also lowering energy, cost, and waste emission is to use extra cementitious materials as a partial replacement for cement mortar and concrete [5]. Many trials on extra binders or cement replacement are ongoing to address the aforementioned. As a result, municipal, industrial, commercial, and agricultural wastes with significant cementitious properties were utilized as potential non-conventional building materials [8].

Communities should consider using locally available materials for building houses, as demand for cement and natural sand increases. Waste materials, like fly ash, slag, limestone powder, siliceous minerals, and saw dust ash, can reduce production costs, increase concrete strength, and reduce environmental impact[4]. Researchers from all over the world have used a range of various materials to partially or completely replace the components of concrete. Nonetheless, the contradictory results show that more research is still needed to enhance the general public's understanding of the use of such items. This study suggests switching some of the cement with sawdust ash. Several sawdust ash volumes are used. To assess the impact of using sawdust ash as a partial replacement for cement, the compressive and tensile strengths of concrete specimens are assessed [7].

Sawdust is produced as a byproduct or waste during several stages of the production of timber, including as sawing, planning, routing, drilling, sanding, and joinery. Small, irregular wood chips or merely microscopic wood particles make up this waste stream. Sawdust is frequently spilled, fired, or landfilled in an open area [9]. Sawdust burning increases greenhouse gas emissions and adds to the burden in landfills [10]. Sawdust, an organic waste, is a result of the mechanical shaping and size of wood (timber). The dust is often burned for home heating. The final result is a kind of pozzolana called saw-dust ash (SDA). Concrete made from dry sawdust is 30% lighter than regular concrete and features insulate similar qualities to those of wood. When the ratios of cement to sawdust are right, it is not combustible. The use of sawdust concrete as a key building material provide a purpose [11].

Sawdust, which is made up of tiny pieces of wood, is a result of using a saw or other tool to cut, compress, or otherwise process another material. Moreover, it is a side effect of some animals that reside in wooded area. The daily process of chopping wood results in additional wood waste being produced. The sawdust exhibits both pozzolanic and cementitious abilities [12]. It is possible to replace conventional cement with sawdust ash, which is created when sawdust burns at a high temperature and contains a considerable portion of silicate and aluminate. A few studies have looked into the use of sawdust ash (SDA) as a partial substitute for cement in concrete mixtures [9], [13], [14].

This study indicates changing some of the cement with sawdust ash. Several sawdust ash doses are applied. In a bid to assess the impact of using sawdust ash as a partial replacement for cement, the compressive and tensile strengths of concrete specimens are assessed [7]. Inappropriate handling of wood ash could result in adverse effects on the environment and human health. Since cement is the most expensive component of concrete, using it instead of SDA might save a lot of money on construction. [12]. The sawdust for this investigation was gathered from sawmills. To prevent sand and sawdust from mixing, the Sample was carefully assembled. The acquired sample was open burned in a metal container until it was burnt to ash. After cooling, the sawdust ash (SDA) was ground in a mortar and pestle. To determine the yield and conduct tests to measure the compressive, tensile, and flexural strength of saw dust ash-containing concrete [15].

In this study, cement was replaced with sawdust ash in weight-based proportions of 5%, 10%, 15%, 20%, and 25%. The compressive, tensile, and flexural strengths of concrete specimens were examined. Implementing eco-friendly practices and technologies can reduce the carbon footprint of cement production, which contributes to 5-10% of annual CO_2 emissions, promoting sustainable development, and responsible resource management.

2. Methodology. –

2.1 Cement and Aggregates. - The entire project was built with regular Portland cement. Clean river sand that had been put through a no.4 sieve and was kept on a no. 200 screen was used to make the fine aggregates used throughout the project. The stone that had been physically crushed and stored on no. 4 sieves was used to make the coarse aggregates.

2.2 Saw Dust Ash. - Sawdust Ash is a by-product created when the wood is sawed, ground, drilled, sanded, or otherwise processed into powder. Little pieces of wood are present inside. For this project, sawdust from a local workshop had to be collected. To minimize sand contamination, samples were painstakingly taken by tightly stuffing fresh sawdust ash samples into bags. To speed up the burning process, the obtained sawdust was exposed to the sun for ten days. The gathered sawdust samples were burned to ashes in a drum. After cooling, the ash was pulverized and is being used in research. Table 1 lists the chemical makeup of sawdust, and Table 2 lists its physical traits.

Chemical Property	SDA% by weight
Ph	11.12
SiO_2	50.20
AL_2O_3	1.02
Fe_2O_3	14.23
CaO	5.45
MgO	0.09
MnO	5.60
Na_2O	0.07
K_2O	9.57
P_2O_5	0.56
SO_3	0.58

Table I. Chemical Composition of Sawdust ash [11]

Property	Values
Specific Gravity	2.19
Loose bulk Density (kg/m³)	1040
Loss in Ignition (%)	4.30
Yield (%)	3.00
Moisture Content (%)	0.30

Table II. Physical Properties of Saw dust ash [12]

2.3 Mixture Design and Sample Preparation. - The six concrete combinations that will be the subject of this study will each have a specific composition that is detailed in Table 2. Sawdust ash (SDA) will substitute for Portland cement (PC) at 0%, 5%, 10%, 15%, 20%, and 25% SDA. One of the mixtures is referred to as (0SDA), which denotes the absence of SDA. The mixture ID indicates the percentage of PC that have been replaced with SDA. As an example, the term 20SDA refers to a concrete mixture in which 20% of the Portland cement is replaced by SDA. In each of the combinations water was used for mixing and curing the concrete.

The dry ingredients were mixed for 4 minutes for each formulation before the water was added gradually while the mixture was still going on. After all the water was added, the mixture was again mixed. When the fresh properties of the mixtures were tested, the fresh mixture was poured into the pre-oiled mold for various tests to be performed. After around 24 hours, the samples were demolded, and they were then cured in water for 14 days. The whole data is displayed in Table 3.

The concrete grade that was used was M-15, which used cement, fine aggregates, and coarse aggregates in ratios of 1:2:4 (1 part of cement, 2 parts of sand, and 4 parts of coarse aggregate) under ASTM C-109 and had a water to cement ratio of 0.65.

Concrete Mix Design					
Saturated Surface Dry Aggregates					
%	**Cement**		**Fine Aggregates**	**Course Aggregates**	**Water**
	Pure Cement	**Saw Dust Ash**			
	kg	kg	kg	kg	ml
0%	1.375	0	2.75	5.5	893.75
5%	1.30625	0.06875	2.75	5.5	893.75
10%	1.2375	0.1375	2.75	5.5	893.75
15%	1.16875	0.20625	2.75	5.5	893.75
20%	1.1	0.275	2.75	5.5	893.75
25%	1.03125	0.34375	2.75	5.5	893.75

Table III. Concrete Mix Design

2.4 Casting of Specimens. - Different types of specimens are casted for this experimental research study.

2.4.1 Concrete Specimens for Compressive Testing. - 18 concrete specimens in the shape of 6”x 6” cubes were prepared for compressive strength testing. The specimens included varying levels of sawdust ash replacement for cement, specifically at 0%, 5%, 10%, 15%, 20%, and 25**%.** The concrete specimens prepared for Compressive testing has volume of $216in^3$, $205.2in^3$, $194.4in^3$, $183.6in^3$, $172.8in^3$ and $162in^3$ at 0 %, 5%, 10%, 15%, 20%, and 25% respectively when using these percentages of cement.

Concrete Specimens (Cube)	
Mixture Type	Compressive Strength Testing Specimen
	No. of Specimen for 14 Days of Curing
0%	3
5%	3
10%	3
15%	3
20%	3
25%	3

Table IV. Number of concrete specimens for compressive testing

Figure I. Representation of concrete for compressive testing

2.4.2 Concrete Specimens for Tensile Testing. -18 concrete specimens in the shape of 6"x 6" cylinders were prepared for tensile strength testing. The specimens included varying levels of sawdust ash replacement for cement, specifically at 0%, 5%, 10%, 15%, 20%, and 25%. The concrete specimens prepared for tensile strength testing has volume of $200.74in^3$, $190.703in^3$, $180.666in^3$, $170.629in^3$, $160.592in^3$ and $150.555in^3$ at 0 %, 5%, 10%, 15%, 20%, and 25% respectively when using mentioned percentages of cement.

Concrete Specimens (Cylinder)	
Mixture Type	**Tensile Strength Testing Specimen**
	No. of Specimen For 14 Days of Curing
0%	3
5%	3
10%	3
15%	3
20%	3
25%	3

Table V. Number of concrete specimens for tensile testing

Figure II. Representation of concrete for tensile testing

2.4.3 Concrete Specimens for Flexural Testing. - 18 concrete specimens in the shape of beams were prepared for flexural strength testing. The specimens included varying levels of sawdust ash replacement for cement, specifically at 0%, 5%, 10%, 15%, 20%, and 25%. The concrete specimens prepared for flexural strength testing has volume of $320in^3$, $304in^3$, $288in^3$, $272in^3$, $256in^3$ and $240in^3$ at 0 %, 5%, 10%, 15%, 20%, and 25% respectively when using mentioned percentages of cement.

Concrete Specimens (Beam)	
Mixture Type	**Flexural Strength Testing Specimen**
	No. of Specimen For 14 Days of Curing
0%	3
5%	3
10%	3
15%	3
20%	3
25%	3

Table VI. Number of concrete specimens for flexural testing

Figure III. Representation of concrete for flexural testing

2.5 Tests on Fresh Concrete. - The slump test, following ASTM C143, assesses the workability of concrete by measuring the difference between initial height and final settlement. It helps adjust mix design and placement techniques, ensuring proper construction processes and better-quality structures.

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2.6 Tests on Hardened Concrete. - Split tensile, compressive, and flexural strength tests were conducted for hardened concrete.

2.6.1 Compressive Strength Test. - The compressive strength test is a fundamental mechanical test used to determine the ability of a material to withstand compressive loads without failing or undergoing deformation. It is a critical property for materials that are subjected to compressive forces, such as concrete, masonry, rocks, ceramics, and metals. The compressive strength of the material was calculated by dividing the total load on the specimens by the area of the specimen. The following equation can be used to find the Compressive Strength (ASTM C-109).

$$\text{Compressive Strength} = P/A$$

Where, P = Optimum Weight in Pounds. A= Area of Cross Section.

To calculate Compressive Strength in kPa:

$$\underset{\text{(in kPa)}}{\text{Compressive Strength}} = \underset{\text{(in Psi)}}{\text{Compressive Strength}} \times 6.895$$

Figure IV. Experimental Setup of Compression Test of Concrete Specimens by UTM

2.6.2 Tensile Strength Test. - The tensile strength test is a mechanical test used to determine the maximum amount of tensile (pulling) force a material can withstand before it breaks or deforms. It is an essential test in materials science and engineering to evaluate the strength and quality of various materials. The following equation was used to get the Splitting Tensile Strength (ASTM C 496).

$$\text{Tensile Strength} = (2P)/(\pi ld)$$

Where,
T = Tested specimen's tensile strength.
P = Maximum Load in Pounds.
L = Specimen's Length.
d = Specimen's Diameter.
To calculate Tensile Strength in kPa :
Tensile Strength = Tensile Strength x 6.895

Figure V. Experimental Setup of Tensile Strength Test of Concrete Specimens by UTM.

2.6.3 Flexural Strength Test. - The flexural strength test, also known as the modulus of rupture test or bending strength test, is a mechanical test used to determine the strength and behavior of a material when subjected to bending forces. It is commonly performed on brittle materials such as ceramics, concrete, glass, and some types of polymers. The test involves applying a three-point or four-point bending load to a rectangular or cylindrical specimen. The below mentioned equation of rupture modulus (ASTM C-78) was used:

$$R = (Pl)/ (bd^2)$$

Where,
R = Rupture modulus of the tested specimen.
P = Force exerted on tested specimen.
L = Specimen's length.
B = Specimen's width at the fracture of the test specimen.
D = Specimen's depth at the fracture of the test specimen.

Figure VI. Experimental Setup of Flexural Strength Test of Concrete Specimens by UTM.

3. Results and Discussions

3.1 Fresh Concrete. - As the levels of sawdust ash rose, the slump values also rose. Because they don't absorb as much water as cement, the sawdust ash particles in the concrete mix are more workable than cement.

3.2 Compressive Strength Results of Concrete. - Compressive strength tests on the concrete sample were performed after 14 days of curing. Specimens were created of a 6” x 6” cube and kept inside the curing container of water following ASTM C-109. The cubical specimens have a height of 6 inches (152.4mm) and a width of 6 inches (152.4mm). Three Specimens of each of the different percentages (0%, 5%, 10%, 15 %, 20%, and 25%) were evaluated on a compression testing machine at 14 days of curing. The compressive strength of the material was calculated by dividing the total load on the specimens by the area of the specimen. There were 4 samples of 6” cubes for every mixture type (0%, 5%, 10%, 15%, 20%, and 25% of SDA). In this research, the specimen has a 36 in^2 cross-sectional area. Table 7 presents the experimental result of compressive strength of concrete for 14 days respectively.

S. No	Replacement with Saw Dust Ash (%)	Strength (psi)			Average	
		Specimen 1	Specimen 2	Specimen 3	psi	kPa
1	0%	1530	1373.90	1498.80	1467.56	10118.8
2	5%	1312.5	1500	1343.75	1385.41	9552.44
3	10%	1812.5	1781.25	1718.75	1770.83	12209.9
4	15%	1312.5	1250	1281.25	1281.25	8834.2
5	20%	1200	1156.25	1281.25	1212.5	8360.18
6	25%	1093.75	1137.5	1156.25	1129.16	7785.6

Table VII. Compressive strength of concrete at 14 days.

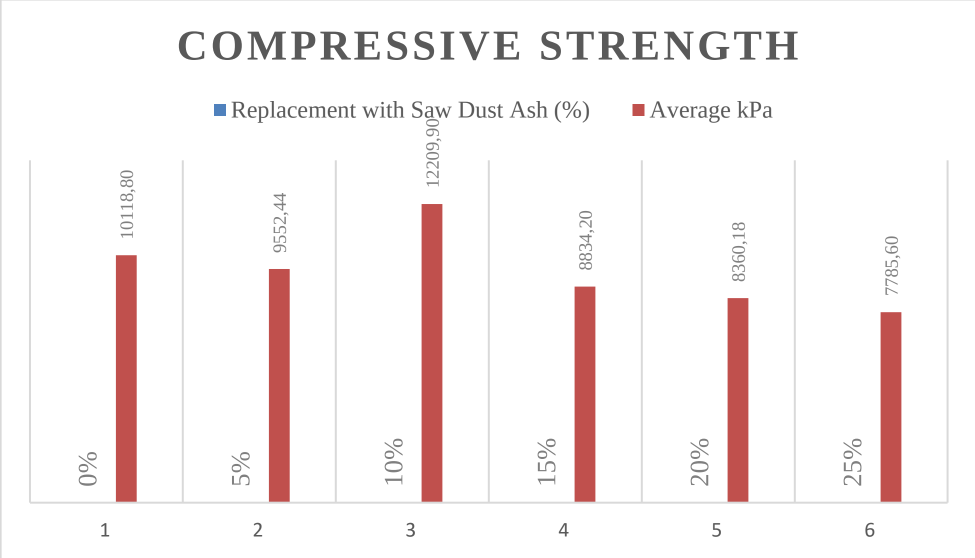

Figure VII. Graphical representation of compressive strength of concrete at 14 days.

The compressive strength of concrete is influenced by factors such as water demand, particle size distribution, chemical reactions, and aggregate-paste bonding. Higher SDA content can lead to increased water demand, reducing compressive strength. Unfavorable particle size distribution can mix compactness and strength. Chemical interactions between SDA and cement can either improve or damage compressive strength. The bond between aggregates and paste is crucial for overall concrete strength, and SDA can negatively affect it. A balance of factors, such as water demand, particle size, beneficial chemical reactions, and strong aggregate-paste bonding, can result in better compressive strength after 14 days, exhibiting maximum compressive strength at 10 % and continues declination at increasing % of SDA.

3.3 Tensile Strength Results of Concrete. - At 14 days of curing, the concrete specimens of the split tensile strength test were evaluated. The split tensile strength test specimens of 4in. (102 mm) in diameter and 8 in. (203 mm) in length respectively were cast. According to ASTM C 496, the specimens were tested using a compression testing machine. There were 3 samples of 4x8-inch cylinders for every mixture type (0%, 5%, 10%, 15%, 20%, and 25% of SDA). In this research, the specimen has a 12.5 cross-sectional area, 0.65 water-cement ratio, and 1:2:4 cement sand and coarse aggregate ratio. Table 8 represents the experimental result of the concrete strength of split tensile cylinders for 14 days respectively.

S. No	Replacement with Saw Dust Ash (%)	Strength (psi)			Average	
		Specimen 1	Specimen 2	Specimen 3	psi	kPa
1	0%	223.62	232.566	219.149	225.11	1552.13
2	5%	192.31	199.02	183.36	191.56	1320.80
3	10%	174.42	176.88	170.62	173.97	1199.52
4	15%	165.47	164.136	152.06	160.55	1107
5	20%	143.11	134.172	144.90	140.72	970.26
6	25%	122.99	129.70	119.86	124.18	856.22

Table VIII. Tensile strength of concrete at 14 days.

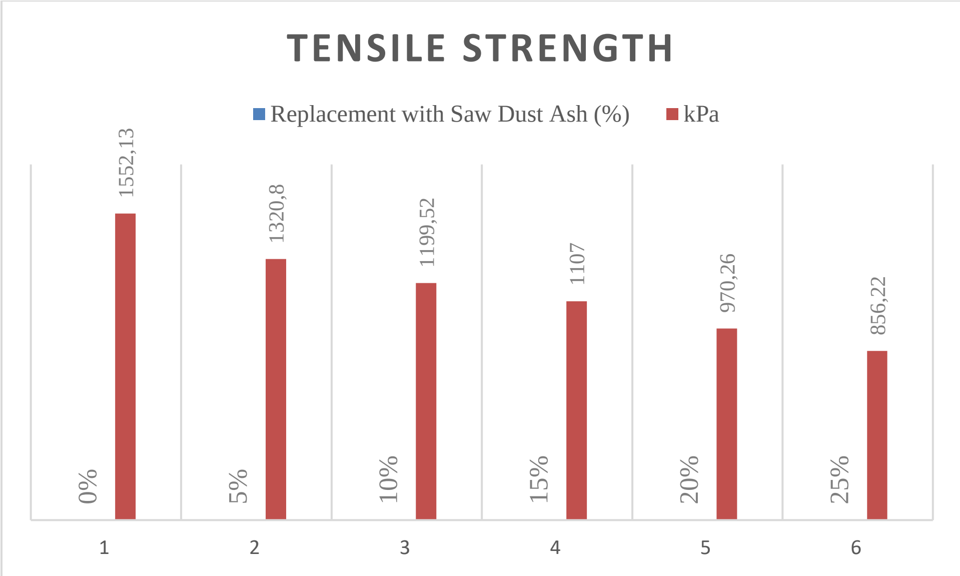

Figure VIII. Graphical representation of tensile strength of concrete at 14 days.

The causes behind the strength trends in concrete with altered SDA replacement levels include factors like water demand and mix properties. Higher SDA content may increase water demand, affecting workability and hydration, which lowers strength. The particle size distribution of SDA influences mix compactness and uniformity, impacting workability and strength. Additionally, the interaction between sawdust ash and cement can disrupt crucial hydration and pozzolanic reactions, affecting overall strength. Lastly, the bond between aggregates and paste in the concrete mix can be impacted by SDA content, contributing to the observed trend of declination in tensile strength.

3.4 Flexural Strength Results of Concrete. - For the flexural strength test, the rupture modulus was evaluated after 14 days of curing. Three specimens for each mixture type were molded at the time of casting. Beam samples were 20 inches long and had a cross-sectional dimension of 4 inches by 4 inches (101.6 mm × 101.6 mm × 508 mm). Samples were kept in a water container for storage. In accordance with ASTM C 78, specimens were tested utilizing 3rd-point loading, and the rupture modulus was obtained. There were two beams for every mixture (0%, 5%, 10%, 15%, 20%, and 25% of SDA) that were cast to test at 14 days of curing. In this research, the specimen has 16 in 2 cross-sectional areas, 0.65 water-cement ratio, and 1:2:4 cement sand and coarse aggregate ratio. Table 9 represents the experimental result of beams of flexural for 14 curing days.

S. No	Replacement with Saw Dust Ash (%)	Strength (kPa)			Average
		Specimen 1	Specimen 2	Specimen 3	kPa
1	0%	3350	3310	3400	3353
2	5%	3046	3075	2950	3023
3	10%	3800	3831	3940	3857
4	15%	3010	2915	2960	2961
5	20%	2460	2550	2390	2466
6	25%	1970	2050	1925	1981

Table IX. Flexural strength of concrete at 14 days.

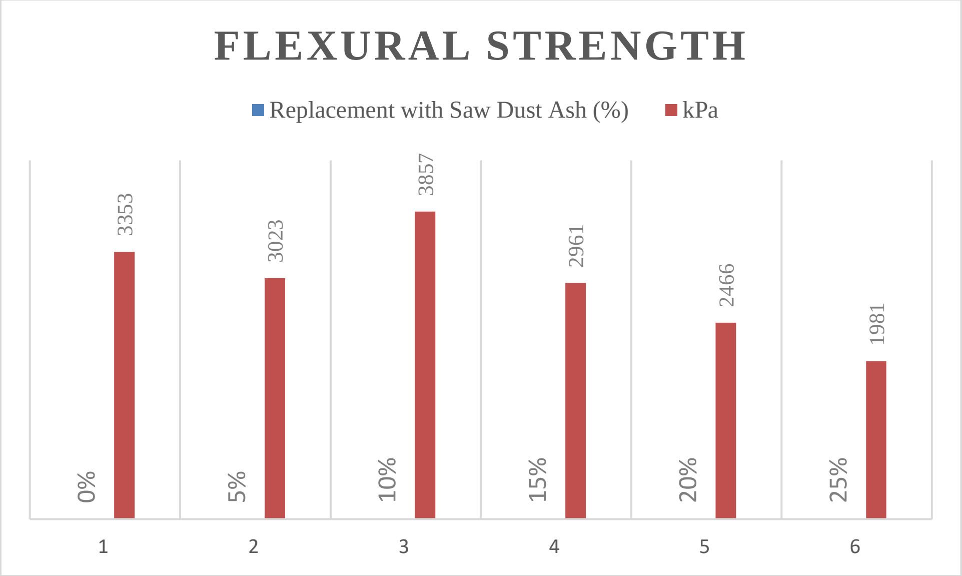

Figure IX. Graphical representation of flexural strength of concrete at 14 days

Concrete strength trends vary with different levels of Sawdust Ash (SDA) due to reasons like water demand, particle size distribution, chemical reactions, and aggregate-paste bonding. Higher SDA content can increase water demand, affecting workability and hydration, and reducing strength. Particle size distribution affects mix compactness and uniformity. Chemical interactions between SDA and cement can either improve or decrease strength, with pozzolanic reactions potentially improving it and disrupting hydration processes potentially reducing it. The bond between aggregates and paste is crucial for overall flexural strength, showing maximum strength at 10% and further declines with increasing % of SDA.

4. Conclusion. - Following are the concluding remarks from this research study.

- The use of sawdust ash in concrete provides additional environmental as well as other technical benefits for all related industries. Partial replacement of cement with sawdust ash reduces the cost of concrete manufacturing.
- The results of the compressive test have indicated that the strength of concrete has shown a reduction of 5.60 %, 12.70 %, 17.38 % and 23.06 % at 5 %, 15 %, 20 % and 25 % of SDA with concrete mix respectively. While, the compressive strength has increased to 20.67 % at 10 % of the concrete mix. Therefore, 10% gives the best result for the compressive strength test after 14 days of curing of the specimens.
- The results of the split tensile strength test have indicated that the strength of concrete decreases as the amount of percentage of SDA increases in the concrete mix. That is 0% gives the best result for the split tensile strength test after 14 days of curing of the specimens.
- The results of the flexural strength test have indicated that the strength of concrete has exhibited a reduction of 9.84 %, 11.69 %, 26.45 % and 40.92 % at 5 %, 15 %, 20 % and 25 % of SDA with concrete mix respectively. However, the flexural strength has increased to 15.03 % at 10 %. Hence 10% gives the best result for the flexural strength test after 14 days of curing of the specimen.
- There is a significant reduction in the density of concrete with the increase in the percentage of sawdust in the concrete.
- Sawdust ash can be used as a cement replacement due to its pozzolanic properties as seen in some of the strength tests conducted. Thus, sawdust ash can replace cement in the concrete up to a certain degree without compromising the concrete strength.

To summarize it can be stated that adding SDA to a fresh concrete mix allows for an increase in both compressive and flexural strength at a rate of 10%. Tensile strength, on the other hand, declines as SDA levels in the concrete mix rise.

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Nota contribución de los autores:

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2. Adquisición de datos
3. Análisis de datos
4. Discusión de los resultados
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6. Aprobación de la versión final del manuscrito

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