Use of Rice Straw Ash as Cement Replacement Material in Concrete

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ABSTRACT- The impact of employing Rice straw ash as a partial substitute material for cement in concrete mining is presented in this research. Rice straw ash is the residue left over after open burning Rice straw. The appropriateness of Rice straw ash obtained from uncontrolled burning of Rice straw as a partial replacement for cement in concrete is investigated in this study. The compressive strength and workability of concrete blended Rice straw ash cement are examined and investigated by substituting cement by 15%, 20%, 25%, and 30% by weight to OPC. Slump tests were performed on new concrete, and compressive strength tests were performed on hardened concrete. Several cubes were evaluated after 7 and 28 days. The results demonstrate that Rice straw ash is a decent replacement material. The slump value dropped as Rice straw ash increased. The compressive strength decreased as RSA increased.

Keywords: Rice Straw, Rice Straw Ash, Slump Test, Sieve Analysis, Compressive Strength.

INTRODUCTION

Concrete is a man-made substance that has been utilized widely and worldwide for a long time. Concrete is a mixture of fine and coarse aggregates mixed with cement and water hydraulic paste. It is an essential building material that is also used in other infrastructure projects across the world. It is known as the second most widely utilized substance by humans. In reality, the use of natural resources, such as coarse and fine natural aggregates, and cement as a binding element for the creation of concrete, has resulted in significant deterioration of natural resources. Concrete production is primarily responsible for the discharge of greenhouse gases from an ecological standpoint. It is accounted for that yearly creation of cement is around 1.6 billion tons around the world, which releases 7% of the worldwide carbon dioxide into the climate Keeping in view these worries of climate, cost of materials for development, deficiency of natural substances and more popularity of energy, practice of using substitute strong waste material is turning into a typical worry of the globe. Numerous scientists have directed exploratory examinations that zeroed in on observing opportunities for choices to be utilized as concrete subbing materials that are of less worth which incorporate modern and agrarian squanders, whose potential advantages can be valued through reusing, reutilizing and reestablishing processes. Subsequently, researchers have been investigating the viable and reasonable utilization of waste materials which are pozzolonic in nature as a concrete substitute. It is proposed by scientists that utilization of strengthening cementitious materials in substantial assists with lessening the unfriendly natural impacts connected with the assembling system of concrete or cement. With use of these losses as valuable and substitution materials there is impressive energy preservation and decrease in the utilization of concrete which supports the decrease of arrival of carbon dioxide in the climate [3].For the most part concrete is composite development material made out of concrete and other filler material like coarse totals, fine totals, compound admixtures and water for endless supply of work the concrete, fine totals, coarse totals and water on blended in unambiguous extent to create new and plain concrete. The point of blend configuration is to accomplish max. sturdiness, usefulness and compressive strength with respect to as conceivable without settling with quality. Engineers on attempting to expand the restrictions of cement with assistance of some imaginative substance admixture alongside changed assembling method. The utilization of cement is expanded and the pace of development is expanded. Concrete is utilized in development of various designs with long life. In a study counseled not many quite a while back it was tracked down that million tons of waste material is created and consumed consistently like Rice straw debris. Proper use of such waste materials brings biological & economic benefits. In addition, there could be extensive improvement in the strength and solidness properties with utilization of advantageous establishing materials in concrete. Hence, wide-range research has been completed on number of beneficial materials, similar to rice husk debris, metakaolin debris, sewage muck debris, palm shale oil, and so forth .A significant horticultural side-effect got from grain creation is Rice straw waste, which empowers natural contamination in light of the fact that the ranchers consume it in open fields. In any case, when Rice straw waste is appropriately scorched under controlled circumstance brings about a material that has solidifying properties and that can be utilized in concrete as valuable establishing material .The subsequent debris has higher level of silica present, additionally higher fineness contrasted with concrete, thusly the Rice straw debris is considered as the conceivable wellspring of valuable solidifying material.

A. Rice Straw

Rice straw ash is a byproduct of the agricultural business. It is created when Rice straw is left behind after harvesting. Every year, this result in massive amounts of Rice straw being generated. The goal of this research is to utilise this waste material to replace cement. The use of Rice straw as a partial substitute for OPC in concrete was investigated in this study. Rice straw is one of the most common types of agricultural waste, and it is frequently abandoned and burnt year after year, causing environmental problems. A unique carbon electrode generated from Rice straw was discovered to be suited for symmetric, solid-state, and flexible type SCs in this work (Over 5000 cycles, the electrode system demonstrated a high SSA (1486.2 m2 g 1), a significant specific capacity of roughly 294.2 F g-1, and a retention capacity of 97.7% [6]. Rice straw-based biomass electrode shown exceptional flexibility, energy density, lower temperature resistance, and commercial and economic worth. Rice straw electrode produced SC demonstrated energy density (14.2 Wh kg 1) and power density (440.1 W kg 1) and was found to be useful for a

variety of applications. Rice straw, a result got in the wake of collecting of Rice grains, has a yearly worldwide creation of 529 million tons .Rice straw is made out of internodes (57 ± 10%), hubs (10 ± 2%), leaves (18 ± 3%),
teases (9 ± 4%), and rachis (6 ± 2%). Compositional examination of Rice straw has shown the presence of cellulose (34-40%), hemicellulose (20-25%), and lignin (20%) [7]. Rice straw, rice straw, and corn Stover are the most plentiful lignocellulosic biomasses among horticultural deposits on the planet utilized fundamentally as feed for domesticated animals or agrarian enhancements. Rice straw comprises essentially ofcellulose (28%-39%), hemicelluloses (23%-24%), lignin (16%-25%), and less items in debris and protein [8]. Among the few hemicelluloses, xylans have been found to add to bringing down blood cholesterol, diminishing the postprandial glucose and insulin reactions as well as showing antitumor impacts. The xylan part of hemicellulose tracked down in oat squanders (straw, corn cob) can be additionally taken advantage of for the creation of xylooligosaccharides (XOs). XOs are esteem added oligosaccharides with a utilitarian job as prebiotics. They are unpalatable and keep up with gastrointestinal wellbeing [9]. Figure 1 is showing the Rice straw ash before grinding used in the project and figure 2 is of Rice straw ash after grinding used in the project

I. OBJECTIVES

- The main goal of this study is to explore the influence of RSA on the characteristics of concrete of M25 grade when it is used as partial replacement of Cement.
- To test and compare the workability (Slump test) of M25 grade concrete with and without Rice straw ash.
- To test and compare compressive strength, Split Tensile and flexural strength of M25 grade concrete with and without Rice straw ash.

II. MATERIAL & METHODOLOGY

A. Material Used

For the casting process, various construction materials are used like Rice Straw, cement, Water, fine aggregates and coarse aggregates.

B. Rice Straw Ash

After drying, it was open burned, and the leftover ash was filtered through a No. 200 BS test sieve.

Figure 1: Rice Straw

Figure 2: Rice Straw Ash (After grinding)

Oxide	%(by weight)
SiO2	8.8
Al2O3	1.4
Fe2O3	1.2
MgO	1.9
CaO	4.2

Table 1: Properties of RSA

Table 1 is showing the properties of RSA in which the percentage of different oxide are shown as per the weight.

C. Cement

The cement utilized was OPC 43 grade with a consistency
(P) of 28%. With a specific gravity of 3.15, the Initial setting time is 37 minutes and the final setting time is 581 minutes.
The cement was tested for various qualities, and the measurements have been made precisely while keeping in mind the restrictions established by IS: 8112-1989.

Figure 3: Cement

D. Aggregates

The coarse total where 12-20 mm in size with fineness modulus 2.389 affirming to Zone II.

Figure 4: Aggregates

E. Water

The water used for testing and curing was drawn from a nearby faucet. The w/c proportion utilized in this venture is kept steady at 0.39.

F. Methodology

The strength parameters of concrete blended Rice straw ash cement, namely compressive strength and workability, are tested and examined by substituting cement by 15%, 20%, 25%, and 30% by weight to OPC. The compressive strength of cubic samples with dimensions of 150*150*150 mm was studied. They were loaded after 7 and 28 days. The force was applied perpendicular to the cube's upper face, and the compressive testing equipment's loading speed was 5 mm/min. The testing instrument's loading capability was approximately 3000 kN. For this study, three concrete cubes with dimensions of 150x 150x 150mm were cast for each mix to test compressive strength with varying RSA percentages after 7 and 28 days. Additionally Flexure strength test and Split elasticity Test were performed and the outcomes were investigated as needs be with the substitution of RSA. For Flexure strength, examples 400 mm x 100 mm x 100 mm were casted and for Split ductile chamber of breadth 150mm and level of 300 mm were appropriately restored for 28 days prior to testing.

III. RESULTS AND DISCUSSION

A. Specific Gravity Test

Specific Gravity is the ratio of density of a material to the density of standard or reference substance.

$$G = \frac{\mathbf{M2 - M1}}{(\mathbf{M2 - M1}) - (\mathbf{M3 - M4}) \boldsymbol{X} \mathbf{0.79}}$$

Where 0.79 is the density of Kerosene.

= 3.4

B. Sieve Analysis Test

Table 2: Shows the sieve analysis results that we got during the test.
We can see the percentage of soil retained and passed from the table.
Co- efficient of curvature $Cc = (D_{30})^2/ (D_{10} \times D_{60}) = 0.94$ Co-efficient of uniformity $Cu = D_{60}/D_{10} = 3.94$

Sizes of sieves	Retained soil (gm.)	% of soil retained	Cumulative % of soil retained	% of soil passed
4.75	0	0	0	100
2.36	141	14	14	86
1.18	262	26.2	40.2	59.8
600	326	32.6	72.8	27.2
425	143	14.3	87.1	12.9
300	56	5.6	92.7	7.3
150	32	3.2	95.9	4.1
75	16	1.6	97.5	2.5
Pan	25	2.5	100	0

Table 2: Sieve Analysis Results

C. Initial and Final Setting of Cement

It is the period passed between the addition of water to the cement and the beginning of the paste's plasticity.

OPC cement should not be less than 30 minutes. Initial setting time was that we got was 33 minutes. The period at which cement totally loses its flexibility and becomes hard is known as the cement's ultimate setting time. Final setting time was that we got was 594 minutes.

Figure 5: Vicats Apparatus

D. Soundness test on cement

The soundness of cement relates to the consistency of volume change during the setting and hardening processes. If the volume change after setting and hardening is unstable, the concrete structures may break, affecting the quality of buildings and potentially causing major accidents, which is known as poor dimensional stability. The result we got was 8mm.

Figure 6: Soundness Test

E. Crushing values test

The aggregate crushing value provides a relative measure of an aggregate's resistance to crushing under a progressively applied compressive stress. When the aggregate crushing value is 30 or greater, the result may be abnormal, and the ten percent fines value should be computed instead. The result we got was 42.

F. Slump Test

The purpose of a concrete slump test or slump cone test is to measure the workability or consistency of a concrete mix created in the laboratory or on the construction site while the work is being done. Concrete slump tests are performed from batch to batch to ensure that the quality of the concrete is consistent during construction. The slump test is the most basic workability test for concrete because it is inexpensive and provides immediate results.

S.No.	RSA (%)	Slump (in mm)
1	0	70
2	15	57
3	20	50
4	25	45
5	30	40

Table 3: Slump Variation with different %of RSA

Table 3 shows the Slump value in mm when we replace cement with different percentages of Rice Straw Ash. We can see the value decreases as we increase the percentage.
The slump test is the most effective method for determining the consistency of concrete. It may be done both in the lab and in the field. It is carried out on new concrete. Slump illustrates that the workability of Rice straw ash concrete reduces as the ash content of the Rice straw increases. The table displays the variance in slump value as a function of the % of RSA applied. As a result of these findings, it was determined that as the amount of RSA in the concrete increases, more water is necessary to make the mix more workable which means slump value decrease with the increase in RSA% as can be seen in the graph below.

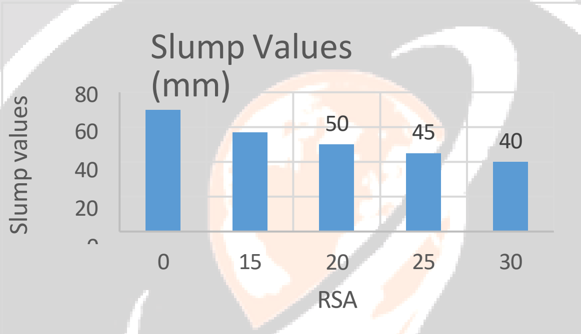

Figure: 7 Slump Variation with RSA%

G. *Compressive Strength Test*

15 cubes of size 150*150*150mm of design mix M25grade were evaluated for this investigation. The specimens were evaluated after 7 and 28 days of cure. The first three regular concrete cubes were compared to partial cement substitution with Rice straw ash. Rice straw ash was employed in varied quantities of 15%, 20%, 25%, and 30% as a replacement for cement, and three cubes were cast for each percentage.

Days	Compressive strength in MPA
7	15.48
28	27.31

Table 4: Compressive Strengths after 7, 28, days of curing. (Nominal concrete)

Table 4 shows the compressive strengths after curing in MPA after 7 days and 28 days of nominal concrete.

Days	Compressive strength in MPA (15% replacement)
7	12.34
28	24.41

Table 5: Compressive Strengths after7, 28, days of curing (15% RSA)

Table 5 shows the compressive strengths after curing in MPA after 7 days and 28 days when we replace cement with RSA by 15%.

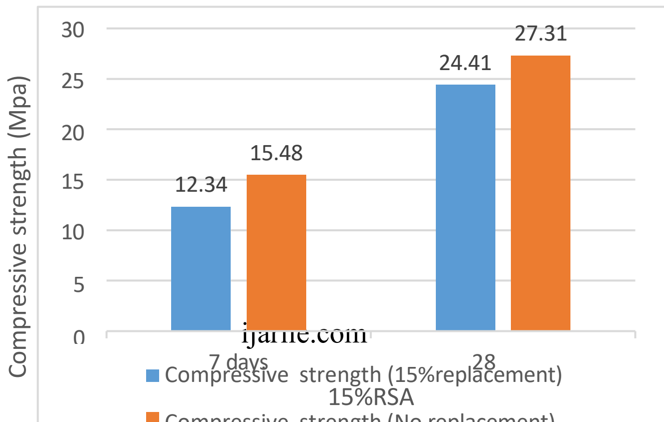

Figure 8: Compressive strength (15% RSA vs. No replacement)

Figure 8 shows the comparison of compressive strengths after curing graphically in MPA after 7 days and 28 days when we replace cement with RSA by 15% and without replacement.
From the above graph we can see that at 15% replacement of RSA gives 20.28% and 10.61% decrease in compressive strength at 7 & 28 days respectively

Days	Compressive strength in MPA (20% replacement)
7	11.59
28	23.64

Table 6: Compressive Strengths after7, 28, days of curing (20% RSA)

Table 6 shows the compressive strengths after curing in MPA after 7 days and 28 days when we replace cement with RSA by 20%.

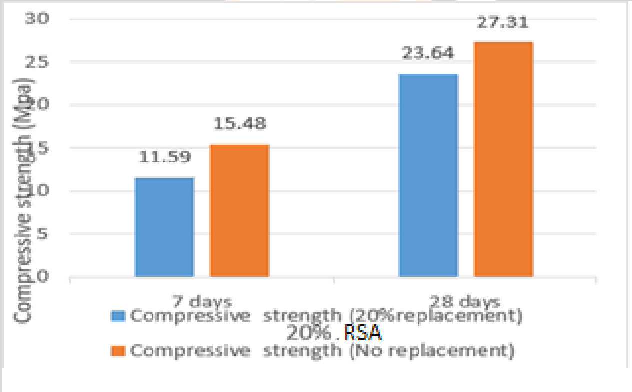

Figure 9: Compressive strength (20% RSA vs. No replacement)

Figure 9 shows the comparison of compressive strengths after curing graphically in MPA after 7 days and 28 days when we replace cement with RSA by 20% and without replacement.

From the above graph we can see that at 20% replacement of RSA gives 25.12% and 13.43% decrease in compressive strength at 7 & 28 days respectively

Days	Compressive strength in MPA (25% replacement)
7	10.97
28	22.17

Table 7: Compressive Strengths after7, 28, days of curing (25% RSA)

Table 7 shows the compressive strengths after curing in MPA after 7 days and 28 days when we replace cement with RSA by 25%.

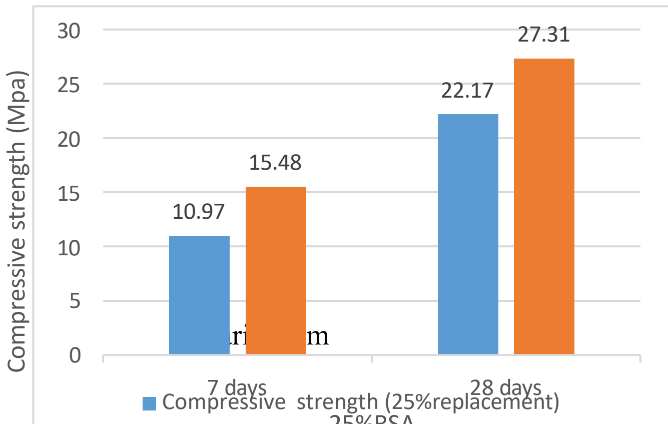

Figure 10: Compressive strength (25% RSA vs. No replacement)

Figure 10 shows the comparison of compressive strengths after curing graphically in MPA after 7 days and 28 days when we replace cement with RSA by 25% and without replacement.
From the above graph we can see that at 25% replacement of RSA gives 29.13% and 18.81% decrease in compressive strength at 7 & 28 days respectively

Days	Compressive strength in MPA (30% replacement)
7	10.12
28	21.15

Table 8: Compressive Strengths after7, 28, days of curing (30% RSA)

Table 8 shows the compressive strengths after curing in MPA after 7 days and 28 days when we replace cement with RSA by 30%.

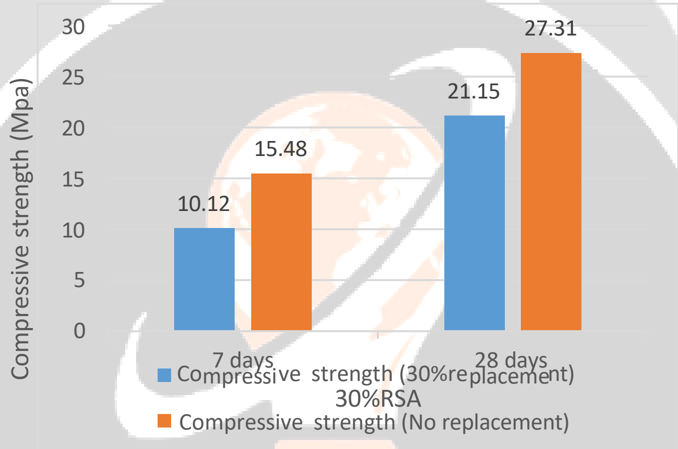

Figure 11: Compressive strength (30% RSA vs. No replacement)

Figure 11 shows the comparison of compressive strengths after curing graphically in MPA after 7 days and 28 days when we replace cement with RSA by 30% and without replacement.

From the above graph we can see that at 30% replacement of RSA gives 34.6% and 22.5% decrease in compressive strength at 7 & 28 days respectively.

H. Flexural Strength Test

The values of flexural strength for nominal concrete are in the table below.

Specimen	Flexural strength (N/mm^2)	Average (N/mm^2)
1	3.39	
2	3.47	3.48
3	3.60	

Table 9: Flexural strength of M25 nominal concrete

Table 9 shows the flexure strengths after curing in MPA after 28 days of nominal concrete. Taken the average of three samples.

RSA%	Specimen	Flexural strength (N/mm^2)	Average (N/mm^2)
	1	2.98	
15%	2	2.92	2.92
	3	2.87	
	1	2.56	
20%	2	2.43	2.43

	3	2.31	
25%	1	2.15	2.17
	2	2.26	
	3	2.12	
30%	1	1.94	1.96
	2	1.98	
	3	1.96	

Table 10: Flexural strength of concrete with RSA

Table 10 shows the flexure strengths after curing in MPA after 28 days when we replace cement with RSA by 15, 20, 25 and 30 %. the average of three samples. The graph below depicts the flexural strength of concrete for various mixtures. After 28 days of curing, the flexural

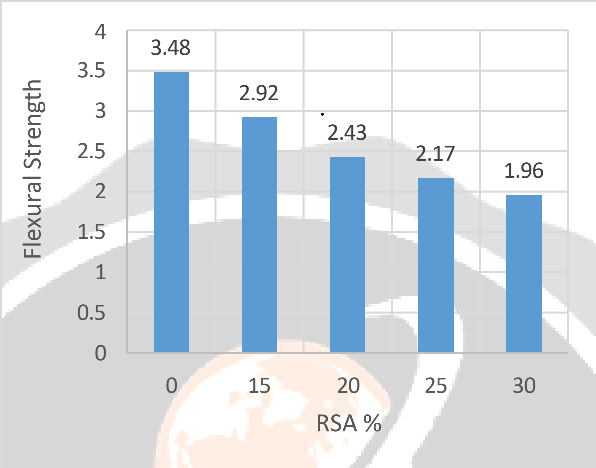

Figure 12: Flexure Strength vs. RSA %

Figure 12 shows the comparison of flexure strengths after curing graphically in MPA after 28 days when we replace cement with RSA by 15, 20, 25 and 30% and without replacement.

I. *Split Tensile Strength Test*

The values of Split Tensile Strength for plain concrete are written in the table below:

Specimen	Split tensile strength (N/mm^2)	Average (N/mm^2)
1	2.34	2.33
2	2.32	
3	2.31	

Table 11: Split Tensile strength of M25 plain concrete

Table 11 shows the Split tensile strengths after curing in MPA after 28 days of nominal concrete. Taken the average of three samples.

RSA%	Specimen	Split Tensile strength (N/mm^2)	Average (N/mm^2)
15%	1	1.98	1.96
	2	1.94	
	3	1.96	
20%	1	1.75	1.74
	2	1.76	
	3	1.70	
25%	1	1.52	1.55
	2	1.58	
	3	1.51	
30%	1	1.23	1.24
	2	1.27	
	3	1.25	

Table 12: Split Tensile strength of concrete with RSA

Table 12 shows the split tensile strengths after curing in MPA after 28 days when we replace cement with RSA by

15, 20, 25 and 30 %. Taken the average of three samples.

Figure 13 shows the comparison of Split tensile strengths after curing graphically in MPA after 28 days when we replace cement with RSA by 15, 20, 25 and 30% and without replacement.

The graph below depicts the Split Tensile strength of concrete for various mixtures. After 28 days of curing, the Split Tensile strength of ordinary concrete is 2.33 N/mm2. For the concrete mix with RSA in the percentages of 15, 20, 25 and 30%, we saw that there was a gradual decrease in the Split Tensile strength with the increase in RSA and the optimum value of Split Tensile strength was 1.96 N/mm^2 for 15% replacement RSA.

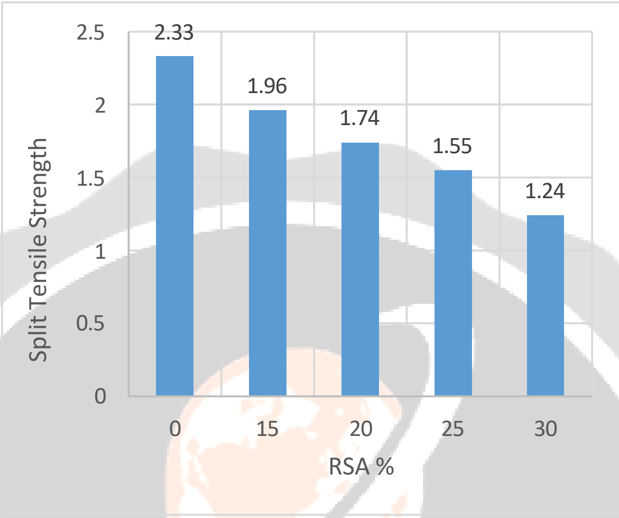

Figure 13: Split Tensile Strength vs. RSA %

III. CONCLUSIONS

From the test carried out and design following this can be concluded:

- We can see that at 15% replacement of RSA gives 20.28% and 10.61% decrease in compressive strength at 7 & 28 days respectively
- We can see that at 20% replacement of RSA gives 25.12% and 13.43% decrease in compressive strength at 7 & 28 days respectively
- We can see that at 25% replacement of RSA gives 29.13% and 18.81% decrease in compressive strength at 7 & 28 days respectively
- We can see that at 30% replacement of RSA gives 34.6% and 22.5% decrease in compressive strength at 7 & 28 days respectively.
- We can see that the flexural strength of concrete decreases as we increase the percentage of RSA and at 15% the optimum strength is 2.92 Mpa which is still a 16% decrease than 3.48 Mpa from the normal plain concrete.
- We can see that the Split Tensile Strength of concrete decreases as we increase the percentage of RSA and at 15% the optimum strength is 1.96 MPA which is still a 15.8% decrease than 2.33 Mpa from the normal plain concrete.
- As the percentage of RSA in the concrete increases, more water is required to make the mix more workable, indicating that RSA has a high water demand.
- As it is a waste and free of charge, using RSA might be cost effective.
- RSA will conserve resources, notably cement, making the building sector more sustainable.
- It will tackle the problem of Rice straw disposal while also being environmentally beneficial.

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