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AN EXPERIMENTAL RESEARCH ON PARTIALLY REPLACEMENT OF CEMENT IN M20 CONCRETE WITH RICE HUSK ASH AND WASTE PAPER SLUDGE

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ABSTRACT
In this developing era concrete and cement mortar are widely used by the construction industry ,with this development .Large amount of industrial wastes are generated and if these wastes are not properly used it will create severe problems ,keeping the environment in mind, concrete engineers are trying to find some alternative materials which will not only replaces the cement content but also improves the strength of concrete. In this research work the Rice Husk Ash and waste Paper Sludge are used .The paper sludge which is the by product collected from paper mill and rice husk ash obtained from the rice processing units ,by adding these two products with concrete ,not only replaces the cement content but also increases the strength of concrete like compressive, flexural & split tensile strength etc .These two materials RSH & WPSA were incorporated with concrete with varying percentages of 2%,4%,8%, & 10% .The proper codal precautions were followed during the manufacturing the concrete cubes of 150 X 150 X 150mm and cylinders of size 150 mm X 300 mm casted with varying percentages of RHA & WPSA . The total number of specimen which were prepared 78 cubes and cylinders were casted with proper curing and the series of tests were conducted on these specimens like Split tensile ,Flexural ,Compressive strength ,Normal consistency test etc .

KEYWORDS: Construction, Rice Husk, Paper Sludge, Cement

1. INTRODUCTION
Concrete is one of the mostly widely used material in the world .it is the mixture of cement ,fine aggregate , coarse aggregate and water. The strength of concrete depends upon the ingredients which are used in preparing this .The cost of constructional materials increases day by day due huge demand of it . so the concrete engineers look towards the alternative material that not only improves the strength of concrete but replaces the cement content which intern relate the cost of our construction work. The main advantage of incorporating the supplementary cementing material not only improves the strength but also help in preventing the pollution. It also improves the durability. Durability id linked to the physical, chemical and mineralogical properties of material and permeability.

Rice husk ash:-
Rice husk ash (RHA) is a by-product from the burning of rice husk. Rice husk is extremely prevalent in East and South-East Asia because of the rice production in this area. The rich land and tropical climate make for perfect conditions to cultivate rice and is taken advantage by these Asian countries. The husk of the rice is removed in the farming process before it is sold and consumed. It has been found beneficial to burn this rice husk in kilns to make various things. The rice husk ash is then used as a substitute or admixture in cement. Therefore the entire rice product is used in an efficient and environmentally friendly approach. Rice husk ash is produced in large quantities globally every year and due to the difficulty involved in its disposal, can lead to RHA becoming an environmental hazard in rice producing countries, potentially adding to air and water pollution. Rice husk ash is a natural pozzolan, which is a material that when used in conjunction with lime, has cementitious properties.

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Several studies have shown that due to its high content of amorphous silica, rice husk ash can be successfully used as a supplementary cementitious material in combination with cement to make concrete products. RHA can be carbon neutral, have little or no crystalline $Si0_2$, or no toxic materials, as in the case of off-white rice husk ash. According to the Food and Agricultural Organization of the United Nations, global production of rice, the majority of which is grown in Asia, totaled 746.4 million tons in 2013. This means that the volume of unused rice husks amounted to 150 million tons. Due to their abrasive character, poor nutritive value, very low bulk density, and high ash content only a portion of the husks can be used as chicken litter, juice pressing aid, animal roughage and pesticide carrier. The remaining husks are transported back to field for disposal, usually by open field burning. RHA is obtained by burning of rice husk. When RH is properly brunt, it has high silica content and can be used as an admixture in mortar and concrete. India produces about 122 million tons of Paddy every year. About 20-22% rice husk is generated from paddy and 20-25% of the total husk becomes a Rice Husk ash after burning. The RHA is used as Pozzolanic material for making concrete.

Waste paper sludge ash:-

These days there is an increasing emphasis on a cleaner environment and maintaining the balance of the eco-system of the biosphere. It is generally believed that environmental protection with zero risk and economic growth do not go hand in hand, but at the same time it is also true that sustainable growth with environmental quality is not an unattainable goal. The problem is multi-dimensional and multifaceted and calls for integrated efforts by the industry, Govt. policy makers, environmental managers and development agencies to look into generation, disposal and utilization aspects.India produces over 300 million tonnes of industrial wastes per annum by chemical and agricultural process. These materials create problems of disposal, health hazards and aesthetic. Paper fibers can only be recycles a limited number of times before they become too short or weak to make high quality paper. Which means that the broken, low- quality paper fibers are separated out to become waste sludge. Paper sludge behaves like cement because of silica and magnesium properties which improve the setting of the concrete. The amount of sludge generated by a recycled paper mill is greatly dependent on the type of furnish being used and end product being manufactured.Paper mill sludge can be used as an alternative material applied as partial replacement of fine aggregates in manufacturing fresh concrete intended to be used for low cost housing projects. About 300 kg of sludge is produced for each tone of recycled paper. This is a relatively large volume of sludge produced each day that makes making landfill uneconomical as paper mill sludge is bulky. By adjusting the mixture to an equivalent density, concrete mixtures containing the residuals can be produced that are equal in slump and strength to a reference concrete without residuals. The raw dry paper sludge mainly contains silica and calcium oxide, followed by alumina and magnesium oxide.The paper mill sludge consumes a large percentage of local landfill space for each and every year. Worse yet, some of the wastes are land spread on agricultural land or running off into area lakes and streams. Some companies burn their sludge in incinerators, contributing to our serious air pollution problems. To reduce disposal and pollution problems emanating from these industrial wastes, it is most desire to develop profitable materials from them. Keeping this in view, investigations were undertaken to produce low cost concrete by blending various ratios of cement with hypo sludge .In 1995, the U.S. pulp and paper industry generated about 5.3 million metric tons of mill wastewater-treatment residuals (on oven-dry basis), which is equivalent to about 15 million metric tons of dewatered (moist) residuals. About half of this was disposed in landfills/lagoons, a quarter was burned, one-eighth was applied on farmland/forest, one sixteenth was reused/recycled in mills, and the rest, one sixteenth, was used in other ways. Pulp and paper mill residual solids (also called sludge) are composed mainly of cellulose fibers, moisture, and papermaking fillers (mostly kaolinitic clay and/or calcium carbonate) Utilization of the widely spread industrial wastes in the civil construction practice may lead to a real possibility of significant decrease in the environment pollution by paper and lime production wastes and perceptibly economize the price of civil construction. The use of paper-mill residuals in concrete formulations was investigated as an alternative to landfill disposal..

2. OBJECTIVE

- To study the behavior of concrete for various proportion of RHA,WPSA and combination of both (RHA+WPSA) with the strength parameters and workability parameters.
- To examine the feasibility of using unprocessed rice husk ash and waste paper sludge ash to reduce the amount of cement.

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3. PROBLEM FORMULATION

The methods for disposing of the straw and stubble residue remaining in the fields after harvest are either burning or baling. Although some limited uses of rice straw such as animal feed or paper making are maintained. But the remaining husks are transported back to field for disposal, usually by open field burning. As a result most farmers tend to burn the straw in open fields, boosting air pollution and serious human health problems due to the emission of carbon monoxide. Sludge consumes a large percentage of local landfill space for each and every year.

4. METHODOLOGY

4.1 Ordinary portland cement

Ordinary Portland Cement (OPC) of 53 Grade (Ambuja cement) was used throughout the course of the investigation. The physical properties of the cement as determined from various tests conforming to Indian Standard IS: 12269:1987 are listed in Table 4.1.

Table 4.1: Properties of OPC 53 Grade

Sr. No.	Characteristics	Values Obtained Experimentally	Values Specified By IS 12269:1987
1.	Specific Gravity	3.10	3.10-3.15
2.	Standard Consistency	31%	30-35
3.	Initial Setting Time	115 minutes	30min(minimum)
4.	Final Setting Time	283 minutes	600min(maximum)
5.	Compressive Strength(N/mm^2) 7 days 28 days	 38.49 N/mm^2 52.31 N/mm^2	 37 N/mm^2 53 N/mm^2

4.2 Aggregates

Aggregates constitute the bulk of a concrete mixture and give dimensional stability to concrete. The aggregates provide about 75% of the body of the concrete and hence its influence is extremely important.

4.2.1 Fine Aggregates

The sand used for the work was locally procured and conformed to Indian Standard Specifications IS: 383-1970. The results are given below in Table 4.2.1 (A) and 4.2.1(B). The fine aggregated belonged to grading zone III.

Table 4.2.1(A): Sieve Analysis of Fine Aggregate

Weight of sample taken =1000 gm					
Sr. No	**IS-Sieve (mm)**	**Mass Retained (gm)**	**Cumulative mass Retained**	**Cumulative %age mass Retained**	**Cumulative %mass passing through**
1	4.74	1	1	0.1	99.9
2	2.36	22	23	2.3	97.7
3	1.18	77	100	10	90
5	600µ	153	253	25.3	74.7
6	300µ	264	517	51.7	48.3
7	150 µ	425	942	94.2	5.8
8	Below150µ	58	1000	100	0
	Total			**Σ283.6**	

FM of fine aggregate = 283.6/100=2.836

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Table 4.2.1(B): Physical Properties of fine aggregates

Characteristics	Value
Specific gravity	2.63
Bulk density	5%
Fineness modulus	2.83

4.2.2 Coarse Aggregates

Locally available coarse aggregate having the maximum size of 20 mm was used in this work. The aggregates were tested as per IS: 383-1970. The results are shown in Table 4.2.1(A) and Table4.2.2(B).

Table 4.2.2(A): Sieve Analysis of Coarse Aggregate (20 mm)

Weight of sample taken =2000 gm					
Sr. No	**IS-Sieve (mm)**	**Mass Retained (gm)**	**Cumulative mass retained**	**Cumulative %age mass Retained**	**Cumulative % mass passing through**
1	40	0	0	0	100
2	20	145	145	7.25	92.75
3	10	1829	1974	98.7	1.3
5	4.74	124	1998	99.9	0.1
6	2.36	0	1998	99.9	0.1
7	1.18	0	1998	99.9	0.1
8	600µ	0	1998	99.9	0.1
9	300µ	0	1998	99.9	0.1
10	150 µ	0	1998	99.9	0.1
11	Below150µ	2	2000	100	0
	Total			**Σ805.35**	

FM of Coarse aggregate = 805.35/100=8.0535

Table 4.2.2(B): Properties of Coarse Aggregates

Characteristics	**Value**
Type	Crushed
Colour	Grey
Shape	Angular
Nominal Size	20 mm
Specific Gravity	2.62
Total Water Absorption	0.89
Fineness Modulus	8.05

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4.3 RHA

In this work, Rice Husk was taken from R. K. Enterprises, Bhangrotu, (Mandi), Himachal Pradesh, India. Rice husk firstly wash with portable water then dried in the sun. After then rice husk burnt in the open atmosphere so as to convert it into ash.

Table 4.3: Physical properties of Rice Husk Ash

Appearance	Fine powder
Particle Size	Sieved through 90 micron sieve
Specific gravity	2.21
Color	Light grey

4.4 Waste paper sludge ash

Waste paper sludge was taken from Haripur Paper Company Baddi. Waste paper was burnt in the open atmosphere so as to convert it into ash.

Table 4.4: Physical properties of Waste Paper Ash

Appearance	Fine powder
Particle Size	Sieved through 90 micron sieve
Color	Dark grey
Specific gravity	2.09

4.5 Mix design

The concrete mix design was done by using IS 10262 for M-20 grade of concrete.

Design stipulations for proportioning

• Grade designation	M20
• Type of cement grade	OPC 53 grade confirming to IS12269:1987
• Maximum nominal size of aggregates	20 mm
• Minimum cement content kg/m^3	320 kg/m^3
• Maximum water cement ratio	0.55
• Workability	75 mm (slump)
• Exposure condition	Mild
• Degree of supervision	Good
• Type of aggregate	Crushed angular aggregate
• Maximum cement content	450 kg/m^3
• Chemical admixture	Not

Test Data for Materials

• Cement used	OPC 53 grade confirming to IS 12269:1987
• Specific gravity of cement	3.10
• Specific gravity of • Coarse aggregate • Fine aggregate	 2.88 2.63
• Sieve analysis • Coarse aggregate • Fine aggregate	Coarse aggregate : Conforming to Table 2 of IS: 383 Fine aggregate : Conforming to Zone III of IS: 383

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Target Strength For Mix Proportioning
f'ck = fck + 1.65 s
Where,
f'ck = Target average compressive strength at 28 days,
fck = Characteristic compressive strength at 28 days,
s= Standard deviation
From Table 1 standard deviation, s = 4.6 N/mm^2
Therefore target strength = 20 + 1.65 x 4.6 = 27.59 N/mm^2

Selection of Water Cement Ratio
From Table 5 of IS:456-2000, maximum water cement ratio = 0.55 (Mild exposure)
Based on experience adopt water cement ratio as 0.50
0.5 < 0.55, hence ok

Selection of water and sand content From Table 4 of IS 10262:1982

Maximum Size of Aggregate(mm)	Water Content including Surface Water, Per Cubic Meter of Concrete(kg)	Sand as percent of Total Aggregate by Absolute volume
20	186	35

Adjustments from Table 6 of IS 10262:1982

Change in condition	Percent adjustment required	
	Water Content	Sand in total Aggregate
Increase or decrease in water- cement ratio that is 0.05	0	-2
Increase or decrease in value of compacting by 0.10	0	0
For Sand	0	-1.5

Therefore, required sand content as percentage of total aggregate by absolute volume =35-3.5=31.5%
Volume of aggregate= 100-31.5=68.5%

Calculation of Cement Content
Water cement ratio = 0.50
Cement content = 186/0.5 = 372 kg/m^3 >320 kg/m^3(given)
From Table 5 of IS: 456, minimum cement content for mild exposure condition = 300 kg/m^3
Hence OK

Determination of Coarse and Fine Aggregate contents
From Table 3 of IS 10262:1982,for the specified maximum size of aggregate of 20mm,the amount of entrapped air in the wet concrete is 2 percent.Taking this into account and applying
$V= (W+C/S_C+1/P \times fa/S_{fa}) \times 1/1000$
$Ca =1-P/P \times fa \times S_{ca}/S_{fa}$
Where,
V = absolute volume of fresh concrete,which is equal to gross volume(m^3) minus the volume of entrapped air.
W = mass of water (Kg) per m^3 of concrete
C =mass of cement (Kg) per m^3 of concrete

S_c = specific gravity of cement
P =ratio of FA to total aggregate by absolute volume
F_a, C_a = total masses of FA and CA (Kg) per m^3 of concrete respectively
S_{fa}, S_{ca} = specific gravity of saturated, surface dry fine aggregate and coarse aggregate respectively.
$0.98= 186+372/3.10+1/.315 \times fa/2.63) \times 1/1000$
$980 = 306+1.20\ f_a$
f_a = 561.66 Kg/m^3

C_a=1216.74 Kg/m^3
The mix proportion then becomes:
Water:Cement:Fine Aggregate:Coarse Aggregate
186:372:561.66:1216.74
0.5:1:1.5:3.2

4.6 Casting

Before casting, the entire moulds were cleaned and oiled properly. These were tightened properly before casting. The coarse aggregates, fine aggregates, cement and other ingredients (RHA & WPSA) were weighed first with accuracy. The concrete mix was done by hand mixing on a non-absorbing platform. Firstly the dry mix is done. Then made a space in the center of dry mix and 70 to 80% water was added, mix uniformly and rest was sprinkled on the mix. For each mix 12 samples were casted, 6 cubes (150 x 150 x 150mm) for compressive strength at 7and 28days and 6 cylinders for splitting tensile strength at 7and 28 days. Casting was done with varying percentage 5%, 10%, 15%& 20% respectively as a partial replacement of cement with rice husk ash and waste paper sludge ash. Total 156 specimens were made 78 cubes and 78 cylinders.

(A)Oiling of Cubes &Cylinder (B) Dry mixing (C) Filling of Moulds

Fig.4.6: Casting

4.7 Compaction

The compaction was done by hand using tamping bar. The concrete was filled in the moulds in four layers and each layer was approximately one quarter of the height of mould. Each layer was tamped with 25 strokes of the round end of the tamping bar. The strokes should be distributed over the entire area of the mould. Finally the surface of concrete was leveled and finished and smoothened by metal trowel.

Fig.4.7: Compaction

4.8 Curing of concrete

Curing is the process of preventing the loss of moisture from the concrete whilst maintaining a satisfactory temperature regime. It is essential to use proper and adequate curing techniques to reduce the permeability of the concrete and enhance its durability by extending the hydration of the cement, particularly in its surface zone.

Fig.4.8: Curing Tank

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Also curing prevents the exposure of concrete to a hot atmosphere and to drying winds which may lead to quick drying out of moisture in the concrete and thereby subjected it to contraction stresses at a stage when the concrete would not be strong enough to resists them. Concrete is usually cured by water although scaling compounds are also used. It makes the concrete stronger, more durable, more impermeable and more resistant to abrasion and to frost curing is done by spraying water or by spending wet cloth over the surface. Usually, curing starts as soon as the concrete is sufficiently hard. Normally 14 or more days of curing for ordinary concrete is the requirement. However, the rate of hardening of concrete is very much reduced with the reduction of ambient temperature. The period of curing shall not be less than 10 days. In this work curing was done by immersing the specimens in the curing tank, after they are removed from the casting moulds. The specimens are cured for 7 and 28 days and taken out from water at the time of testing.

5. RESULTS & DISCUSSIONS

5.1 Fresh concrete

5.1.1 Slump Test

The slump value of all the mixture are represented in Table 5.1.1

Table 5.1.1: Slump Tests Results

Mix	Percentage	SlumpValue
Control	0%	90mm
RHA	2%	65mm
	6%	55mm
	8%	25mm
	10%	20mm
WPSA	2%	60mm
	4%	55mm
	6%	50mm
	8%	20mm
Mix (RHA+WPSA)	2%	30mm
	4%	20mm
	6%	15mm
	8%	7mm

The slump value v/s percentage of replacement was shown in Fig 5.1.1. The slump decreased when a higher amount of RHA, WPSA and combination of both (RHA+WPSA) was mix was added in concrete.

5.1.2 Compaction Factor Test

The Compaction factor values of all the mixture are represented in Table 5.1.2

Table 5.1.2: Compaction Factor Results

Mix	Percentage	Compaction Factor
CONTROL	0%	0.93
RHA	2%	0.90
	4%	0.87
	6%	0.83
	8%	0.82
WPSA	2%	0.92
	4%	0.90
	6%	0.85
	8%	0.81

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MIX (RHA+WPSA)	2%	0.84
	4%	0.83
	6%	0.80
	8%	0.78

The compaction factor value of control concrete is 0.93. As we go on increasing the % replacement of cement with the RHA from 5 to 20% the compaction factor value decreases from 0.92 to 0.82. In the case of WPSA the compaction factor value decreases gradually from 0.92 to 0.81. And same as in case of Mix (RHA+WPSA) the compaction factor value decreases gradually from 0.84 to 0.78.

5.2Hardened Concrete

5.2.1: Effect of Age on Compressive Strength

The 28 days strength obtained for M20 Grade Control concrete is 30.93 N/mm^2.The strength results reported in table no 5.2.1 are presented in the form of graphical variations, where the compressive strength is plotted against the % of cement replacement.

Table 5.2.1: Compressive Strength of Control concrete in N/mm^2

Grade of concrete	7Days	28Days
M20	20.4	30.93

The strength achieved at different ages namely, 7 and 28 for Control concrete.

5.2.2 Effect of Age on Split Tensile Strength of Control Concrete

The 28 days tensile strength obtained for M20 Grade Control concrete is 2.71 N/mm^2.The strength results reported in table no 5.2.2 are presented in the form of graphical variations, where the compressive strength is plotted against the % of cement replacement.

Table 5.2.2: Split Tensile Strength of Control concrete in N/mm^2

Grade of concrete	7Days	28Days
M20	1.94	2.71

5.2.2: Split Tensile Strength of Control Concrete

It is clear that as the age advances, the split tensile strength of Control concrete increases. The rate of increase of strength is higher at curing period up to 28 days. However the strength gain continues at a slower rate after 28 days.

5.2.3: Effect on Compressive Strength of Concrete Containing various percentages of RHA.

Table 5.2.3: Compressive Strength of RHA Concrete

Mix	Percentage of Cement Replacement	Cube Compressive Strength (N/mm^2)	
		7 days	28 Days
CONTROL	0%	20.4	30.93
RHA	2%	19.67	29.26
	4%	19.63	28.85
	6%	18.66	24.74
	8%	15.22	21.48

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5.2.3(A): Compressive Strength of RHA Concrete at 7 Days

As per experimental program and results shown in table no. 5.2.3. We can replace cement by RHA up to 4%. Because the compressive strength up to 4% replacement of cement is comparatively equal to control mix design. If cement is replaced by RHA more than 4% the loss in compressive strength is comparatively greater than the replacement up to 4%.

5.2.4 :Effect on Split Tensile Strength of Concrete Containing various percentages of RHA.

Table 5.2.4: Split Tensile Strength of RHA Concrete

Mix	Percentage of Cement Replacement	Split Tensile Strength (N/mm^2)	
		7 days	28 Days
M20	0%	1.94	2.71
RHA	2%	2.03	2.94
	4%	1.99	2.72
	6%	1.89	2.34
	8%	1.34	1.97

Split Tensile Strength of RHA Concrete at 28 Days

As per table no.5.2.4 the split tensile strength for replacement of 2% is higher than control mix design and decreases with further increase in RHA but up to 4% of replacement the split tensile strength is still more than the split tensile strength of control mix design.

5.2.5: Effect on Compressive Strength of Concrete Containing various percentages of WPSA

Table 5.2.5: Compressive Strength of WPSA Concrete

Mix	Percentage of Cement Replacement	Cube Compressive Strength (N/mm^2)	
		7 days	28 Days
CONTROL	0%	20.4	30.93
WPSA	2%	24.07	31.26
	4%	22.3	27.59
	6%	19.67	25.1
	8%	16.89	23.04

Compressive Strength of WPSA Concrete at 28 Days

As per the results shown in table no.5.2.5 the compressive strength at 7 days for 2% and 4% replacement of cement by WPSA are higher than Control Mix, further increases in % replacement the compressive strength goes on decreases.The compressive strength at 28 Days for 2% replacement is found out to be 31.26 N/mm^{2}which is higher than the compressive strength of 30.93N/mm^2 of control mix. For 4% replacement the compressive strength is comparatively nearer to the control mix and for further increases in % replacement the compressive strength decreases.

5.2.6: Effect on Split Tensile Strength of Concrete Containing various percentages of WPSA

Table 5.2.6: Split Tensile Strength of WPSA Concrete

Mix	Percentage of Cement Replacement	Split Tensile Strength (N/mm^2)	
		7 days	28 Days
M20	0%	1.94	2.71
WPSA	2%	2.34	3.11
	4%	2.1	2.92
	6%	1.82	2.78
	8%	1.69	2.02

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5.2.6: Split Tensile Strength of WPSA Concrete at 28Days

From the results shown in table no5.2.6 the split tensile strength at 7 Days and 28 Days for 2% and 4% replacement by WPSA is found to be higher than the Control Mix. For 6% the split tensile strength is comparatively equal to the control Mix and for further increase in % replacement of cement the split tensile strength decreases.

6. CONCLUSION

- Control mix with 2% WPSA showed higher Compressive Strength than Control mix, RHA concrete and Mix(RHA+WPSA) concrete.
- The study showed that the early strength of RHA, WPSA and Mix (RHA+WPSA) concrete was found to be less and the strength increased with age.
- The workability of RHA,WPSA and Mix(RHA+WPSA) concrete has been found to decrease with the increase in replacements.
- Based on the results of Split Tensile Strength test,it is convenient to state that there is substantial increase in Tensile Strength due to the addition of RHA, WPSA and Mix (RHA+WPSA).
- Use of Waste Paper Sludge Ash, Rice Husk Ash and Mix (RHA+WPSA) in concrete can prove to be economical as it is non useful waste and free of cost.
- Use of waste paper sludge ash in concrete will preserve natural resources that are used for cement manufacture and thus make concrete construction industry sustainable and waste paper sludge can be used as fuel before using its ash in concrete for partial cement replacement and also the disposal problem for paper industries for this waste material is fully solved.

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