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AN INTIGRATED ANALYSIS ON INCORPORATION OF RICE HUSK ASHAND WASTE PAPER SLUDGE ASH AS PARTIAL REPLACEMENT OF CEMENT IN M20 CONCRETE

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ABSTRACT

As we also know that during the manufacturing of cement large amount of Co_2 is released into the environment, but if we use such material that will replace the quantity of cement content therefore indirectly we are contributing towards the prevention of our planet from global warming and other pollutions . Also 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 (RHA) and waste paper sludge ash (WPSA). Several studies in the developing countries including Thailand, Pakistan and Brazil worked on the materials like Rice Husk Ash and paper sludge ash, these materials not only enhance the properties on concrete but also contributes towards the green environment.

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. Several studies have shown that due to its high content of amorphous silica, rice husk ash can be successfully

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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.

Properties of RHA

The utilization of rice husk for use as a cementations material in cement and concrete depends on the pozzolanic property of its ash. The pozzolanic reactivity of the ash is closely related to the form of silica present and the carbon content. Since the physical and chemical properties of silica in RHA are strongly influenced by the temperature and the duration of thermal treatment, the yield of a highly reactive ash requires a burning method that can remain a low firing temperature and a short retention period in order to give ash with low carbon content and a high surface area.

RHA Production

For every 1000 kg of milled paddy, about 200 kg (20%) of husk is produced. When this husk is completely burnt, about 50 kg (25%) of RHA is generated. The husk contains about 50% cellulose, 25-30% lignin, and 15-20% of silica. Upon burning, cellulose and lignin are removed, leaving behind silica ash. The use of RHA as a supplementary cementing material requires silica in an amorphous reactive form. Crystalline phases of silica have a negligible pozzolanic reactivity with lime. Generally, the quality of RHA relates to the amorphous SiO_2 content, the porous structure of ash particles and the specific surface area. The amorphous SiO_2 content and the porous structure of RHA depend on the temperature, the duration, and the environment of thermal treatment, as well as the pretreatment of husk before combustion. Analysis of the reports on the influence of combustion conditions on the nature of silica suggests that temperatures below 750°C will be sufficiently safe to produce rice husk ash with high reactivity.

Advantages of using rice husk ash in concrete

The use of RHA in concrete has been associated with the following essential assets:

- Increased compressive and flexural strengths.
- Reduced permeability
- Increased resistance to chemical attack.
- Increased durability.
- Reduced effects of alkali-silica reactivity.
- Reduced shrinkage due to particle packing, making concrete denser.
- Enhanced workability of concrete.
- Reduced heat gain through the walls of buildings.
- Reduced amount of super plasticizer.

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

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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.

Environmental problems
The environmental problems associated with the disposal of industrial wastes are summarized below:
Problems associated with open dumps

- Direct influence by rain, such as leaching.
- Inaccessibility to the area and the surroundings.
- Chemical degradation.
- Breeding of Insects etc. causing health problems.
- When wet dumps get dried up, entrainment of dust in the air.

Problems associated with Covered Dumps

- Buried wastes are subject to:
- Influence by rain through seepage.
- Pollution of nearby water sources.
- Long term alteration in solid stability, strength etc in the region.

Problems associated with River/Ocean Dumping
This has adverse effect on:

- Marine life
- Downstream users of river water
- Change in nature of silt/deposition on river beds leading to soil erosion.

2. 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.

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3. EXPERIMENTAL WORK & METHODOLOGY

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

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.

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

Table 4.2.1(B): Physical Properties of fine aggregates

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

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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 Table 4.2.2(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

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

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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

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

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

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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

Table : The mixture proportions used in laboratory for experimentation are shown in table

Mix	%	w/c ratio	Water (Kg/m³)	Cement (Kg/m³)	Fine Aggregate (kg/m³)	Coarse Aggregate (Kg/m³)	RHA (Kg/m³)	WPSA (Kg/m³)
Control	-	0.50	186	372	562	1217	-	-
Rice Husk Ash	2	0.50	186	353.4	562	1217	18.6	-
	4	0.50	186	334.8	562	1217	37.2	-
	6	0.50	186	316.2	562	1217	55.8	-
	8	0.50	186	297.6	562	1217	74.4	-
Waste Paper Sludge Ash	2	0.50	186	353.4	562	1217	-	18.6
	4	0.50	186	334.8	562	1217	-	37.2
	6	0.50	186	316.2	562	1217	-	55.8
	8	0.50	186	297.6	562	1217	-	74.4
Mixture of RHA and WPSA	2	0.50	186	353.4	562	1217	9.3	9.3
	4	0.50	186	334.8	562	1217	18.6	18.6
	6	0.50	186	316.2	562	1217	27.9	27.9
	8	0.50	186	297.6	562	1217	37.2	37.2

4. RESULTS & DISCUSSIONS

Fresh concrete

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

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	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.

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**
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.

Hardened Concrete

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.

Fig.5.2.1: Compressive Strength of Control Concrete

It is clear that as the age advances, the 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.

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

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.

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

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%.

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.

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

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	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.

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

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.

Effect of Compressive Strength of Concrete Containing various percentages of Mix(RHA+ WPSA)

Table 5.3.7: Compressive Strength of Mix (RHA+ WPSA)Concrete

Mix	Percentage of Cement Replacement	Cube Compressive Strength (N/mm^2)	
		7 days	28 Days
CONTROL	0%	20.4	30.93
MIX (RHA+WPSA)	2%	19.84	28.89
	4%	18.82	27.66
	6%	18.6	24.52
	8%	16.03	18.82

Compressive Strength of Mix(RHA+WPSA) at 28 Days

The results from table no 5.3.7 represents that 10% replacement with Mix(RHA+WPSA) the compressive strength are comparatively equal to Control Mix strength, and further increase in % replacement the strength decreases.

Effect of Split Tensile Strength of Concrete Containing various percentages of Mix(RHA+ WPSA)

Table 5.2.8: Split Tensile Strength of Mix (RHA+ WPSA)Concrete

Mix	Percentage of Cement Replacement	Splitting Tensile Strength (N/mm^2)	
		7 days	28 Days
M20	0%	1.94	2.71
MIX (RHA+WPSA)	2%	1.96	2.95
	4%	1.86	2.81
	6%	1.71	2.64
	8%	1.65	2.24

Split Tensile Strength Mix(RHA+WPSA)

As per the results from table no.5.2.8. The split tensile strength of 2% replacement of cement with Mix(RHA+WPSA) has higher value than the control mix and 4% replacement has comparatively equal split tensile strength to Control Mix. For the 6% and 8% the split tensile structure decreases gradually.

5. 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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