iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** VII **Month of publication:** July 2018

DOI: http://doi.org/10.22214/ijraset.2018.7022

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VII, July 2018- Available at www.ijraset.com

An Experimental Investigation of Rice Husk Ash and Waste Paper Sludge Ash as Partial Replacement of Cement

Ankit[1], Akash batra[2], Pappu Sharma[3]
[1]*M.Tech Scholar, Civil Department, Indus Institute of Engg. And Technology-Jind, 126102, India*
[2, 3]*Assistant professor, Civil Department, Indus Institute of Engg. And Technology-Jind, 126102, India*

Abstract: Concrete and cement motar are widely used now a days by construction industry. Keeping the environment in mind we have to manage the waste (industrial waste), but if these industrial waste are incorporated with cement concrete it not only increase the strength of concrete but also can decrease the cement content. In this research waste rice husk ash and waste paper sludge is used. The paper sludge production is a by product of paper making in the paper mill and rick husk is obtained from the processing of rice. By adding these components into the cement it increases the strength, flexural and compressive strength of concrete. The rice husk ash (RHA) and waste paper sludge were added to the concrete at varying percentages (15%, 10%) and (15%, 20%).

Keywords: Concrete, Cement, Rice Husk Ash, Waste paper sludge

I. INTRODUCTION

Concrete is one of the most widely used construction products in the world. It is mixture of cement, fine aggregate, course aggregate and water. Concrete construction does not require highly skilled labour. The durability of concrete depends upon proportioning, mixing and compacting of the ingredients. The cost of construction materials is increasing day by day because of high demand, scarcity of raw materials, and high price of energy. Agricultural waste (rice husk ash) and industrial by – product (silica fume) (waste paper) have been widely used as partial replacement materials or cement replacement materials in concrete works. The advantages by incorporating these supplementary cementing materials include energy consumption saving (in cement production), low cost, engineering properties improvement, and environmental conservation through reduction of waste deposit. Durability is linked to the physical, chemical and mineralogical properties of materials and permeability. Any improvement in these properties is likely to aid durability.

The ability to use an agricultural waste product to substitute a percentage of Portland cement would not only reduce the cost of concrete construction in these countries, but would also provide a means of disposing of this ash, which has little alternative uses. Additionally, cement manufacturing is an energy-intensive process, so in addition to reducing the cost of concrete construction and providing a means for disposing of an agricultural waste product, incorporating RHA into concrete as a partial substitute for Portland cement would also stand to reduce the amount of energy associated with concrete construction. The rapid industrialization has resulted in generation of large quantities of wastes. Most of the wastes do not find any effective use and create environmental and ecological problems apart from occupying large tracts of valuable cultivable land. It has been observed that some of these wastes have high potential and can be gainfully utilized as raw mix / blending component in cement manufacturing.

II. LITERATURE REVIEW

A. Studies On Rice Husk Ash Cement Concrete

The effect of partial replacement of OPC cement by RHA from 10% to 30% for M30, M40 and M50 and tested the cubes at 28, 60, 90 and 120 days after curing in water. For the durability performance he conducted the water permeability, water absorption and rapid chloride ion penetration (RCPT).

The results showed that:-Increased in the amount of RHA in the mix results in dry and unworkable mixtures unless Super plasticizer (Sp) is added. The inclusion of Sp in RHA concrete while maintaining the w/b ratio increased the slump and improved the cohesiveness of the concrete. The optimum replacement of OPC with RHA taken at 28 days strength for Grade 30 and Grade 40 was 30%, while for Grade 50 was 20%. Replacement of OPC with RHA reduced the water permeability of the concrete. The water absorption values of RHA concrete are lower than the OPC control concrete. These results emphasize the beneficial effect of incorporating RHA to increase the durability of concrete, irrespective of their concrete grade. The percentage of water absorption obtained for all the grades are between 3% - 5% which can be considered as average absorption.

Y.-m. Chun et al (July 11-13, 2005) Fibrous residuals generated from pulp and paper mills were included in concrete. By using right amounts of the fibrous residuals, water, and high-range water reducing admixture (HRWRA), concrete mixtures containing the residuals were produced equivalent to a reference concrete (no residuals) in slump and compressive strength.

From the results:- By using proper amounts of fibrous residuals, water, and HRWRA, concrete mixtures containing the residuals were produced comparable to reference concrete mixtures (no residuals) in slump and compressive strength. In general, HRWRA was used in proportion to the amount of wood fibers in concrete. In general, the length change (drying shrinkage) of concrete mixtures containing the residuals was equivalent to that of the reference concrete mixtures. The wood cellulose fibers in a residual significantly enhanced the FT resistance of non-air-entrained concrete, bringing the resistance up to the level of air-entrained concrete. Use of pulp and paper mill fibrous residuals in concrete can save the pulp and paper industry disposal costs and produce a “greener” concrete for construction.

Abdul Ghani et al (2008) they studied that Concrete mixes containing various contents of the paper were prepared and basic strength characteristics such as compressive strength, splitting tensile, flexural, and water absorption were determined and compared with a control mix. Four concrete mixes containing of the waste, which are control mix, 5%, 10%, 15% as an additional materials to concrete were prepared with ratios of 1:2:3 by weight of cement, sand, and aggregate respectively. The maximum size of aggregate was 20mm.

From the results:-In general, each group of concrete mixes containing wastepaper, compressive strength, tensile strength, and flexural strength of concrete decreased with the increase of the amount of wastepaper. Concrete mix with 5% wastepaper showed higher tensile strength and flexural strength than control mix. Good relationship was observed in compressive, tensile, and flexural strength of concrete mixes containing wastepaper. Good relationship was observed between density and strength of concrete mixes containing wastepaper.

Satish Kumar et al (Sept-Oct,2012) experimental study was carried out to find the suitability of the alternate construction materials such as, rice husk ash, sawdust, recycled aggregate and brickbats as a partial replacement for cement and conventional aggregates. For this concrete cubes of six 150mm x150mm were casted with various alternate construction materials in different mix proportion and with different water cement ratios. Their density, workability and compressive strengths were determined and a comparative analysis was done in terms of their physical properties and also cost savings. Test results indicated that the compressive strength of the OPC/RHA concrete cube blocks increases with age of curing and decreases as the percentage of RHA content increases. It was also found that the other alternate construction materials like saw dust, recycled aggregates and brick bats can be effectively used as a partial replacement for cement and conventional aggregates.

III. MATERIALS AND METHODS

A. Cement

Cement is a material, generally in powder from, that can be made into a paste usually by addition of water and, when poured, will set into a solid mass. Numerous organic compounds used for adhering, or fastening materials, are called cements. Cement is binder material with adhesive and cohesive properties. Cement, when mixed with coarse aggregate, fine aggregate and water it made concrete. The function of cement is first of all to bind the sand and stone together and second to fill up the voids in between sand and stone particles to form a compact mass. There is a wide variety of cements that are used to some extent in the construction and building industries, or to solve special engineering problems. The chemical compositions of these cements can be quite diverse, but by far the greatest amount of concrete used today is made with Portland cements. In principle, the manufacture of Portland cement is very simple and relies on the use of abundant raw materials. An intimate mixture, usually of limestone and clay, is heated in a kiln to 1400 to 1600°C (2550 to 2900°F),which is the temperature range in which the two materials interact chemically to form the calcium silicates. High-quality cements require raw materials of adequate purity and uniform composition. Limestone (calcium carbonate) is the most common source of calcium oxide, although other forms of calcium carbonate, such as chalk, shell deposits, and calcareous muds, are used .(Usually, iron-bearing alumino-silicates are invariably used as the primary source of silica, but clays or silts are preferred since they are already in a finely divided state.

B. Aggregates

Generally, aggregates occupy 70% to 80% of the volume of concrete and have an important influence on its properties. They are granular materials, derived for the most part from natural rock (crushed stone, or natural gravels) and sands. In addition to their use as economical filler, aggregates generally provide concrete with better dimensional stability and wear resistance. In order to obtain a good concrete quality, aggregates should be hard and strong, free of undesirable impurities, and chemically stable. Soft and porous rock can limit strength and wear resistance, and sometimes it may also break down during mixing and adversely affect workability by increasing the amount of fines. Rocks that tend to fracture easily along specific planes can also limit strength and wear resistance. Aggregates should also be free of impurities like silt, clay, dirt, or organic matter. If these materials coat the surfaces of the aggregate, they will isolate the aggregate particles from the surrounding concrete, causing a reduction in strength. Silt, clay and other fine materials will increase the water requirements of the concrete, and the organic matter may interfere with the cement hydration.

C. Water

Drinking water is good for making concrete. Water serves following purposes Water is used to prepare a plastic mixture of the various ingredients and to impart workability to concrete. Water is also needed for the hydration of the cementing materials to set and harden during the period of curing.

D. Rice Husk Ash (RHA)

Rice milling generates a by-product known as husk. Rice husk ash is an attractive pozzolan. Due to its low cost and high activity it has a promising perspective in sustainable construction. The main component of the rice husk ash is silica, which is the element that governs the reactivity of the ash. The Rice Husk Ash is obtained by burning the Rice Husk, obtained from local mills, in heaps of 50 to 60kg in open air .

E. Waste Paper Sludge Ash

Paper mill sludge is a major economic and environmental problem for the paper and board industry. The material is a by-product of the deinking and re-pulping of paper. The million tonnes quantity of paper mill sludge produced in the world.

F. Normal Consistency

This test determines the quantity of water required to produce a cement paste of standard consistency for the use in other test. The Vicat's apparatus(IS: 5513-1976) is used for this purpose. The consistency of standard cement paste is defined as that consistency which will permit the Vicat's plunger 50mm long and having the bottom of the Vicat's mould.

1) *Apparatus:* Vicat's apparatus with mould, Plunger, Balance, Measuring cylinder, Non-porous plate

G. Initial and Final Setting Time

Vicat's apparatus will be used to estimate initial and final setting time of cement at normal consistency.

1) *Apparatus:* Vicat's apparatus with mould and non-porous plate, Initial setting time 1 sq. mm Needle, Final setting time 1 sq. mm Needle with enlarged base**,** Balance, Measuring cylinder**,** Stopwatch, Thermometer.
2) *Samples:* Cement**,** Potable water.

Vicat apparatus

H. Fineness Test of Cement

This test will be performed according to IS:4031-15.

1) *Apparatus:* Balance capacity 500 gm, I.S. Test sieve 90 micron.
2) *Samples:* Cement

I. Sieve Analysis of Fine Aggregates
To determine the gradation of fine aggregates
1) *Apparatus:* Sieves of the sieve 10mm, 4.75mm, 2.36mm, 1.18mm, 600micron 300 micron 150 micron and 75 micron, Balance and standard weights, Oven.
2) *Sample:* Fine aggregate

J. Sieve Analysis of Coarse Aggregates
To determine the gradation of coarse aggregates
1) *Apparatus:* Sieves of sizes 25mm, 20mm, 10mm, 4.75mm & 2.36mm, Balance, Oven
2) *Samples:* Coarse Aggregates

K. Impact Test
This test was performed according to IS: 2366 (Part IV) - 1963. The aggregate impact value test gives relative measure of the resistance of an aggregate to sudden shock or impact.
1) *Apparatus:* Impact testing machine (metal base),A cylindrical steel cup of internal dimensions: dia. – 102 mm & depth – 50 mm,A metal hammer weighing 13.5 to 14 k, Means for raising the hammer and allowing it to freely fall between the vertical guides from a height of 380 + 5 mm, IS sieves of sizes 12.5, 10 & 2.36 mm, A cylindrical metal measure, of sufficient rigidity to retain its form under rough usage, A straight metal tamping rod of circular cross-section 10mm in dia. and 230mm long, rounded at one end. Balance of capacity not less than 500gmsreadable and accurate to 0.1gm. A suitable oven thermostatically controlled to maintain a temperature of 1000 C to 1100 C.
2) *Samples:* Coarse Aggregate 100 to 200 gms.

L. Specific Gravity
This test was performed according to IS 2386-Part(iii) 1963.To determine the specific gravity and water absorption of fine aggregates.
1) *Apparatus:* Pycnometer-500 ml,Oven
2) *Samples:* Fine Aggregate, Potable Water

M. Compaction Factor Test
This test works on the principle of determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height. It is more precise and sensitive than the slump test.
1) *Apparatus:* Compaction Factor Apparatus

N. Compressive Strength
This test is performed on cube specimens to determine compressive strength at various ages.
1) *Apparatus:* Testing Machine -The testing machine may be of any reliable type, of sufficient capacity for the tests and capable of applying the load at the rate specified. The permissible error shall be not greater than ± 2 percent of the maximum load. The testing machine shall be equipped with two steel bearing platens with hardened faces. One of the platens (preferably the one that normally will bear on the upper surface of the specimen) shall be fitted with a ball seating in the form of a portion of a sphere, the centre of which coincides with the central point of the face of the platen. The other compression platen shall be plain rigid bearing block. The bearing faces of both platens shall be at least as large as, and preferably larger than the nominal size of the specimen to which the load is applied.

O. Splitting Tensile Strength
This test is performed on cylinder specimen to evaluate its tensile strength at various different ages.
1) *Apparatus:* Compression Testing Machine, Bearing Strips - 2 each, 1/8 in. thick plywood strips, 1 in. wide (the length shall be slightly longer that of the specimens). The bearing strips are placed between the specimen and the upper and lower bearing blocks of the testing machine (or between the specimen and supplementary bearing bars if used), Supplementary Bearing Bars - Steel bar 2 in. wide, 3 in. thick, and 12 in long.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VII, July 2018- Available at www.ijraset.com

IV. METHODOLOGY

A. General

This chapter describes the properties of material used for making concrete mixis determined in laboratory as per relevant codes of practice. Different materials used in tests were OPC, coarse aggregates, fine aggregates, rice husk ash and waste paper sludge ash.

B. Mix Design

The concrete mix design was done by using IS 10262:2009 for M-20 grade of concrete.

1) *Design stipulations for proportioning*
a) Grade designation : M20
b) Type of cement : OPC 43 grade, IS 8112
c) Max. nominal size of agg. : 20 mm
d) Minimum cement content: 320 kg/m^3
e) Maximum water cement ratio : 0.55
f) Workability : 75 mm (slump)
g) Exposure condition : Mild
h) Degree of supervision: Good
i) Type of agg. : Crushed angular agg.
j) Maximum cement content : 450 kg/m^3
k) Chemical admixture : Not used

2) *Test data for materials*
a) Cement used : OPC 43 grade
b) Specific gravity of cement : 3.15 \
c) Specific gravity of
i) Coarse aggregate : 2.68
ii) Fine aggregate : 2.65
d) Water absorption
i) Coarse aggregate : 0.6 percent
ii) Fine aggregate :1.0 % \
e) Free (surface) moisture
i) Coarse aggregate : Nil (absorbed moisture full)
ii) Fine aggregate : Nil
f) Sieve analysis
i) Coarse aggregate : Conforming to Table 2 of IS 383
ii) Fine aggregate : Conforming to Zone I of IS 383

Table 1 The mixture proportions used in laboratory for experimentation are shown in table

Mix	Percentage (%)	w/c ratio	Water (Kg/m^3)	Cement (Kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (Kg/m^3)	RHA (Kg/m^3)	WPSA (Kg/m^3)
Control	-	0.50	186	372	562	1217	-	-
Rice Husk Ash	5	0.50	186	353.4	562	1217	18.6	-
	10	0.50	186	334.8	562	1217	37.2	-
	15	0.50	186	316.2	562	1217	55.8	-
	20	0.50	186	297.6	562	1217	74.4	-
Waste Paper Sludge Ash	5	0.50	186	353.4	562	1217	-	18.6
	10	0.50	186	334.8	562	1217	-	37.2
	15	0.50	186	316.2	562	1217	-	55.8
	20	0.50	186	297.6	562	1217	-	74.4
Mixture of RHA and WPSA	5	0.50	186	353.4	562	1217	9.3	9.3
	10	0.50	186	334.8	562	1217	18.6	18.6
	15	0.50	186	316.2	562	1217	27.9	27.9
	20	0.50	186	297.6	562	1217	37.2	37.2

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VII, July 2018- Available at www.ijraset.com

V. RESULTS AND DISCUSSION

A. Slump Test

The slump value of all the mixture are represented in Table 2

The slump value v/s percentage of replacement was shown in Table 2. The slump decreased when a higher amount of RHA, WPSA and combination of both (RHA+WPSA) was mix was added in concrete

Table 2: Slump Tests Results

Mix	Percentage	SlumpValue
Control	0%	90mm
RHA	5%	65mm
	10%	55mm
	15%	25mm
	20%	20mm
WPSA	5%	60mm
	10%	55mm
	15%	50mm
	20%	20mm
Mix (RHA+WPSA)	5%	30mm
	10%	20mm
	15%	15mm
	20%	7mm

B. Compaction Factor Test

The Compaction factor values of all the mixture are represented in Table 3

Table 3: Compaction Factor Results

Mix	Percentage	Compaction Factor
CONTROL	0%	0.93
RHA	5%	0.90
	10%	0.87
	15%	0.83
	20%	0.82
WPSA	5%	0.92
	10%	0.90
	15%	0.85
	20%	0.81
MIX (RHA+WPSA	5%	0.84
	10%	0.83
	15%	0.80
	20%	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.

C. 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 4 are presented in the form of graphical variations, where the compressive strength is plotted against the % of cement replacement.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VII, July 2018- Available at www.ijraset.com

Table 4: Compressive Strength of Control concrete in N/mm^2

Grade of concrete	7Days	14 Days	28Days
M20	20.4	24.85	30.93

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

D. 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 are presented in the form of graphical variations, where the compressive strength is plotted against the % of cement replacement.

Table 5: Split Tensile Strength of Control concrete in N/mm^2

Grade of concrete	7Days	14 Days	28Days
M20	1.94	2.32	2.71

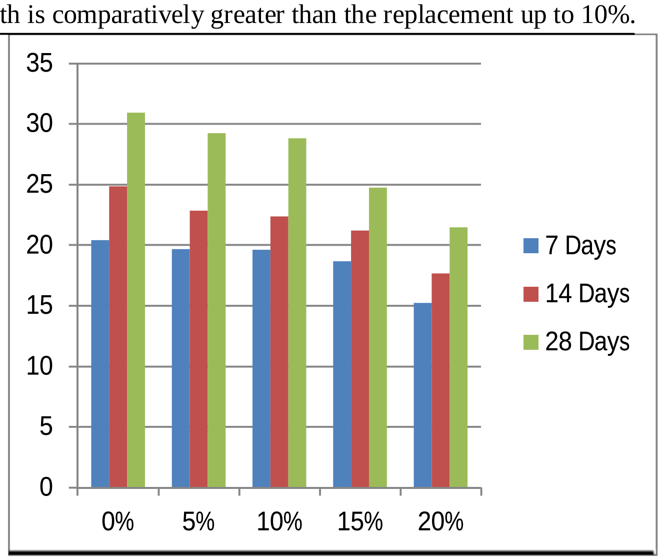
It is clear that as the age advances, the split tensile strength of Control concrete increases. The rate of increase of strength is higher at curing period up to 28 days. However the strength gain continues at a slower rate after 28 days.

E. Effect on Compressive Strength of Concrete Containing various percentages of RHA.

Table 6: Compressive Strength of RHA Concrete

Mix	Percentage of Cement Replacement	Cube Compressive Strength (N/mm^2)		
		7 Days	14Days	28 Days
CONTROL	0%	20.4	24.85	30.93
RHA	5%	19.67	22.87	29.26
	10%	19.63	22.35	28.85
	15%	18.66	21.20	24.74
	20%	15.22	17.69	21.48

As per experimental program and results shown in table no. 6. We can replace cement by RHA up to 10%. Because the compressive strength up to 10% replacement of cement is comparatively equal to control mix design. If cement is replaced by RHA more than 10% the loss in compressive strength is comparatively greater than the replacement up to 10%.

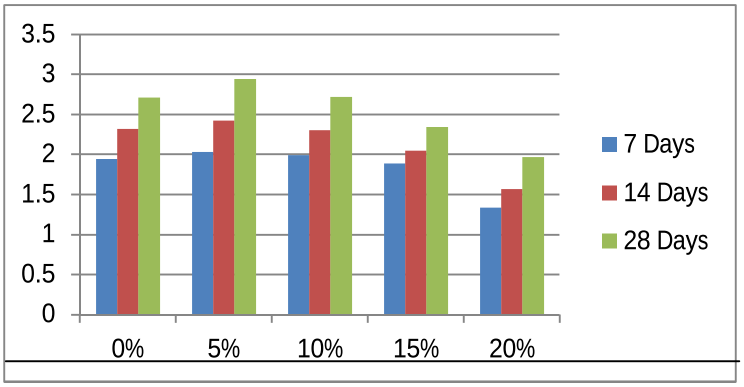


International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VII, July 2018- Available at www.ijraset.com

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

Table 7: Split Tensile Strength of RHA Concrete

Mix	Percentage of Cement Replacement	Split Tensile Strength (N/mm^2)		
		7 Days	14 Days	28 Days
M20	0%	1.94	2.32	2.71
RHA	5%	2.03	2.42	2.94
	10%	1.99	2.30	2.72
	15%	1.89	2.05	2.34
	20%	1.34	1.57	1.97

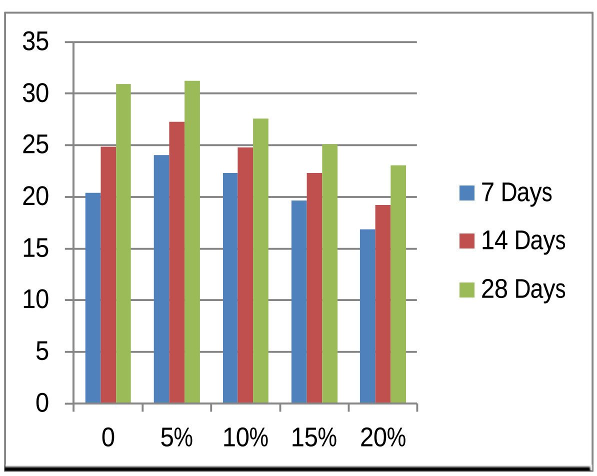


As per table no.7 the split tensile strength for replacement of 5% is higher than control mix design and decreases with further increase in RHA but up to 10% of replacement the split tensile strength is still more than the split tensile strength of control mix design.

G. Effect on Compressive Strength of Concrete Containing various percentages of WPSA

Table 8: Compressive Strength of WPSA Concrete

Mix	Percentage of Cement Replacement	Cube Compressive Strength (N/mm^2)		
		7 Days	14Days	28 Days
CONTROL	0%	20.4	24.85	30.93
WPSA	5%	24.07	27.30	31.26
	10%	22.3	24.80	27.59
	15%	19.67	22.30	25.1
	20%	16.89	19.23	23.04



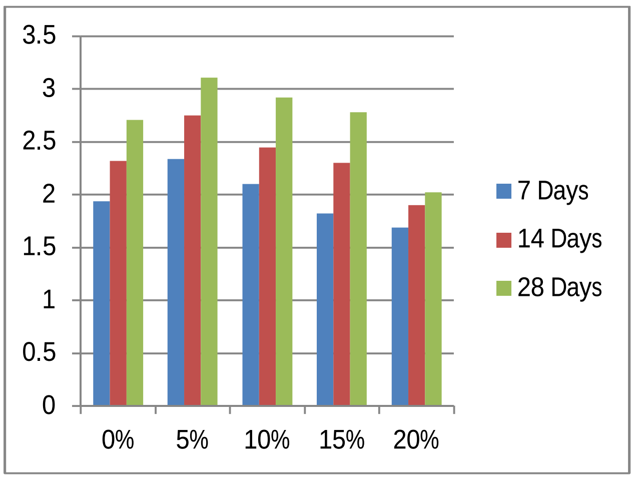
International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue VII, July 2018- Available at www.ijraset.com

As per the results shown in table no. 8 the compressive strength at 8 days for 5% and 10% 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 5% 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 10% replacement the compressive strength is comparatively nearer to the control mix and for further increases in % replacement the compressive strength decreases.

H. Effect on Split Tensile Strength of Concrete Containing various percentages of WPSA

Table 9: Split Tensile Strength of WPSA Concrete

Mix	Percentage of Cement Replacement	Split Tensile Strength (N/mm^2)		
		7 days	14 Days	28 Days
M20	0%	1.94	2.32	2.71
WPSA	5%	2.34	2.75	3.11
	10%	2.1	2.45	2.92
	15%	1.82	2.30	2.78
	20%	1.69	1.90	2.02



From the results shown in table no 9 the split tensile strength at 7 Days and 28 Days for 5% and 10% replacement by WPSA is found to be higher than the Control Mix. For 15% the split tensile strength is comparatively equal to the control Mix and for further increase in % replacement of cement the split tensile strength decreases.

VI. CONCLUSIONS

A. The compressive strength and split tensile strength increased up to 20% with 5% replacement of WPSA. Further increase in WPSA decreases the strength gradually and up to 10% replacement it can be used as a supplementary material in M20 grade of Concrete.
B. The above results shows that it is possible to design M20 grade of concrete incorporating with RHA content up to 10%.
C. As test results shows the Mix (RHA+WPSA) can also be used as a replacement of cement.
D. Control mix with 5% WPSA showed higher Compressive Strength than Control mix, RHA concrete and Mix(RHA+WPSA) concrete.
E. 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.
F. The workability of RHA,WPSA and Mix(RHA+WPSA) concrete has been found to decrease with the increase in replacements.
G. 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).
H. 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.

REFERENCES

[1] Ahmad S, Malik M.I., Wani M.B., Ahmad R. (2013). "Study of Concrete Involving Use of Waste Paper Sludge Ash As Partial Replacement of Cement." IOSR Journal of Engineering (IOSRJEN), Vol. 3, Issue 11, pp. 6-15.
[2] Alwash J.J.H., "Use of Rice Husk Ash in cement mortar."
[3] Balwik S.A., Raut S.P. "Utilization of Waste paper Pulp by Partial Replacement of Cement in Concrete." Int. Journal of Engineering Research and Applications (IJERA), Vol. 1, Issue 2, pp. 300-309.
[4] Chun Y.M., Naik T.R., Kraus R.N. (2005). "Durable concrete through use of pulp and paper mill residuals." Composites in Construction, pp. 1-8.
[5] Hossain T., Sarker S.K., Basak B.C. (2011). "Utilization potential of Rice Husk Ash as a construction material in rural areas." Journal of Civil Engineering (IEB), pp. 175-188.
[6] IS: 10262-1982 (Reaffirmed 1999). "Recommended guidelines for Concrete Mix Design." Bureau of Indian Standards, New Delhi (India).
[7] IS: 2386 (Part IV)-1963 (Reaffirmed 1997). "Methods of test for aggregates for concrete." Bureau of Indian Standards, New Delhi (India).
[8] IS: 383-1970 (Reaffirmed 2002)." Specification for coarse and fine aggregates from natural sources for concrete." Bureau of Indian Standards, New Delhi (India).
[9] IS: 4031 (Part 11)-1988. "Methods of physical tests for hydraulic cement." Bureau of Indian Standards, New Delhi (India).
[10] IS: 4031 (Part 15)-1991 (Reaffirmed 2005). "Methods of physical tests for hydraulic cement." Bureau of Indian Standards, New Delhi (India).
[11] IS: 456-2000 (Reaffirmed 2005). "Plain and reinforced concrete-Code of practice." Bureau of Indian Standards, New Delhi (India).
[12] IS:1199-1959 (Reaffirmed 1999). "Methods of sampling and analysis of concrete." Bureau of Indian Standards, New Delhi (India).
[13] Ishimoto B.H, Origuchi T., Yasuda M. (2000) "Use of Papermaking Sludge As New Material." Journal of Material in Civil Engineering, Vol. 12, pp. 310-312.
[14] Kartini. K (2011). "Rice Husk Ash-Pozzolanic material for sustainability." Int. Journal of Applied Science and Technology, Vol. 1 No.6, pp. 169-178.
[15] Kene S.D., Domke P.V., Deshmuh S.D., Deotale R.S. "Assessment of concrete strength using Fly Ash and Rice Husk Ash." Int. Journal of Engineering Research and Applications (IJERA), Vol. 1, Issue. 3, pp. 524-534.