Experimental Investigation on Usage of Waste Paper Sludge (WPS) in Concrete Making

P Bhargavi[1] , S Kavitha Karthikeyan[2], G Snekha[2], A Vinothini[2]

[2]Final Year BE Student, [1]Assistant Professors

Department of Civil Engineering, PSVPEC, Chennai, Tamil Nadu, India

Abstract:- Cement is the main component of any construction. Due to rapid usage of natural resources such as lime stones, clay etc. during the production of cement causes larger depletion in our natural reserves. There is a need to think ahead to make arrival of new material which best suites to replace the cement. Every industry produces wastage. All the wastages cannot be replaced. The chemical, physical properties should be characterized before replacing. Paper making generally produces a large amount of solid wastes which are spread over the cropland and contaminants builds up over it. The disposal is the major problem in paper industry. They cause severe air pollution when it is burnt. Paper sludge consists of minimum amount of silica, magnesium and considerable amount of lime, which is the main property of cement. So the disposal and pollution problems can be reduced to greater extent by partially replacing the cement using paper sludge from paper industries. This study investigates the use of waste paper sludge in concrete mix of M30 with 4%, 8%, 12% and 16% as partial replacement of cement. Cube of size 150 x 150 x 150mm, prism bars of 500 x 100 x 100mm, cylinders of 100 x 200mm are casted for both conventional M30 grade concrete and partially replaced concrete. The curing period of 3, 7, and 28days were allowed and test was conducted to determine its compressive strength, flexural strength and split tensile strength. The results obtained through this investigation were found to be satisfactory for the compressive strengths.

***Keywords* – waste paper sludge, paper waste in concrete making, recycle and reuse of paper waste, M30 grade concrete**

I. INTRODUCTION

Ordinary Portland cement is recognized as a major construction material throughout the world and in terms of its per capita consumption, it is second most consumed material in the country, next to water. However, the production of cement has diminished the limestone reserves in the world and requires a great consumption of energy. Rapid increase in construction activities leads to acute shortage of conventional construction materials which results in high cost. However, we should not lose sight of the fact that every production system creates by-products and waste products which can affect the environment. If some industry waste material having similar composition of cement, can be replaced by weight of cement in concrete, then the cost could be reduced without affecting its quality. In the paper manufacturing industry enormous amount of waste are generated annually. Only wastes with strong fibres are recycled to make good quality paper. The weak fibres from the waste are regarded as sludge. These weak fibres when spread on cropland in minimal amount, acts as fertilizers. But when spread in higher amount, it contaminates the soil. Some paper mills turn their sludge in incinerators contributing to serious air pollution. Or, they landfill the waste sludge which leads to disposal problems and soil pollution problems. This landfill situation results in high disposal costs and potentially environmental problems. This waste sludge can be used partially in the concrete as it has the similar properties as that of cement. The utilization of this waste material as an alternative in concrete may be one of the solution. To safeguard and overcome the use of natural resources and our environment from pollution, it is essential to develop a partial replacement for cement. In our project, we have utilized waste paper sludge in concrete making which serves to be an alternative material, thereby reduces the environmental pollution.

II. REVIEW OF LITERATURES

2.1 Pitroda et al published a journal on Innovative use of paper industry waste (hypo sludge) in design mix concrete. Compressive strength reduces when cement replaced hypo sludge in higher percentages. As hypo sludge percentage increases compressive strength and split strength decreases. Use of hypo sludge in concrete can save the paper industry disposal costs and produces a 'greener' concrete for construction. A better measure by an innovative supplementary cementitious construction material is formed through this research.

2.2 IOSR Journal of Engineering vol.3, Issue 11 (November, 2013), IUST Kashmir, Study of concrete involving use of waste paper sludge ash as partial replacement of cement. Compressive strength tests and splitting tensile strength tests were carried out at 7 and 28 days. An increase in compressive strength was observed at 5% replacement of cement by waste paper sludge ash and there after decreasing. The maximum compressive strength measured was 15% more than that of reference mix at 28 days corresponding to concrete mix containing 0% waste paper sludge ash in place of cement.

2.3 International Journal of Emerging Technologies and Engineering (IJETE) volume 1 Issue 7, august 2014. Structural Performance of Concrete by Partial Replacement of Cement with Hypo Sludge (paper waste). The cubes, prisms, cylinders with various mixes and different curing periods which are 3, 7, 2 days by partial replacement of cement with hypo sludge. The strength of concrete has increased with 10% replacement of hypo sludge with cement as compare to conventional concrete and with 20% replacement it is slightly more but with 30% its start decreasing in strength.

2.4 L Ravindra Singh et al. Int, Journal of Engineering Research and Applications, vol.5, Issue 4, (Part - 7) April 2015, Application of Paper Waste in Cement. Concrete mixes containing 10% and 15% of paper waste, have shown an increase of 3.0% and 1.4% in compressive strength and there was a decrease of 1.9% on addition of 20% of paper waste. Slump value of concrete mix was decreased by 6.3% with 10% addition of paper waste while it remained constant at 6.3% decrease on addition of 15% of paper waste. Water absorption of concrete mix with 10%, 15% and 20% paper waste addition decreased continuously by 0.1%, 0.2% and 0.4% respectively. Cost of production of concrete gets reduced by 1.5%, 2.2%, and 3.0% with addition of 10%, 15% and 20% paper waste respectively. It can be concluded that an application of 10% of paper waste to concrete mix may be conveniently allowed.

III. STUDY OF MATERIALS

The materials used in this project are cement, waste paper sludge, fine aggregate, coarse aggregate, and water.

3.1 Ordinary Portland cement (OPC): The cement used for this project was OPC 53 grade cement. All the test on cement was conducted according to IS 4031. The following tests are done:

Specific gravity of cement - IS 4031 part 11
Fineness test of cement – IS 4031 part 1
Consistency of cement – IS 4031 part 4
Initial and final setting time – IS 4031 part 5

3.2 Fine aggregate: Sand is extremely needful material for construction. The fine aggregates obtained from river beds are used in this experiment as per IS 383-1970. The specific gravity of sand was 2.74.

3.3 Coarse aggregate: Coarse aggregates are small stones which are natural material. The angular shaped coarse aggregate of size 20mm conforming to IS 383-1970 was used.

3.4 Waste Paper Sludge (WPS): The materials collected from Paper Industry, which cannot be recycled to make paper are considered as Waste Paper Sludge. This WPS mainly consists of water, fibre, cellulose and alum. This WPS content when added in cement partially, the cement volume can be reduced, that results in preserving the natural materials such as limestone, clay, etc.

Fig. 1: Waste paper sludge

Table 1: Comparison of properties of Cement and WPS

Properties	Cement (%)	WPS (%)
Lime	67	47
Magnesium	4	3.34
Silica	17	9.60
Alumina	50	6.32

IV. CALCULATION OF MATERIALS

Ratio of cement, fine aggregate and coarse aggregate = 1:1.6:2.7
Exposure condition = Moderate
Water-cement ratio = 0.42

4.1 Final quantity of materials: For casting 3 cubes (150x150x150mm), 3 prism bars (500x100x100mm), 3 cylinders (100x200mm), and the following quantity of materials were calculated.

Cement = 14.77kg
Fine aggregate = 23.63kg
Coarse aggregate = 39.87kg

V. CASTING OF CONCRETE CUBES

Cement, fine aggregate, coarse aggregate with water are mixed and cubes, prism bars and cylinders are casted for M_{30} grade of concrete. Three cubes, three prisms and three cylinders are casted with 4%, 8%, 12%, and 16% of waste paper sludge as a partial replacement for cement. Mechanical vibrators are used to compact the casted concrete. Curing of concrete done for conventional and partially replaced concrete and tests was conducted on 3rd, 7th and 28th day to check the hardened properties.

Fig. 2: Casting of Concrete

VI. COST ANALYSIS OF WPS CONCRETE

Cost is the major factor which influences every project, whether to be implemented or not. So, the cost of using WPS in concrete is analyzed and the approximate cost is estimated. The price of materials is of market rates. The cost is reduced because of less cement content.

6.1 General cost of the materials

Cement = Rs. 400/ bag
Sand = Rs. 840/m^3
Coarse aggregate = Rs. 700/ m^3
WPS = Rs. 1.00/kg

Fig. 3: Casted Concrete cubes

6.2 Cost Analysis for 1m^3

The cost is worked out for one metre cube of concrete. The cost for conventional concrete is first worked out and the costs for various % of replacement of WPS for cement are calculated and the reduction in cost percentage is found to be satisfactory. Through this its clear that the partial replacement of WPS can reduce the cost in concrete making.

Table 2: Working out of cost

% of replacement	Cement kg/ m^3	FA kg/m^3	CA kg/m^3	WPS / Kg	Total cost Rs	Reduction in cost %
0	443	694	1187	-	4615	-
4	426.38	694	1187	7.332	4490	-2.71
8	408.62	694	1187	14.660	4355	-5.63
12	390.85	694	1187	21.996	4220	-8.60
16	373.09	694	1187	29.328	4085	-11.5

VII. TEST RESULTS

From the of 3, 7 and 28 day results of compressive strength, there is increase in strength when 4% of WPS is added and decrease in strength with further addition of WPS. The flexural strength gets decreased on addition of WPS. The split tensile strength gets increased on addition of 4% of WPS and on further addition the strength gets decreased. On addition of 4%, there is about 6.3% increase in strength when compared to conventional concrete.

Table 3: Comparison of compressive strength obtained on 3rd, 7th and 28th day for M30 grade concrete

Replacement %	Average Compressive strength (N/mm^2)		
	3rd Day	7th Day	28th Day
0	23.318	25.066	30.503
4	23.851	25.257	32.414
8	23.511	25.155	25.422
12	23.407	24.888	22.192
16	23.081	24.6378	20.563

Table 4: Comparison of flexural strength obtained on 3rd, 7th, and 28th day for M30 grade concrete

Replacement %	Average flexural strength (N/mm^2)		
	3rd Day	7th Day	28th Day
0	5.912	5.685	6.740
4	5.916	6.048	6.896
8	5.615	5.908	6.133
12	5.670	5.680	5.860
16	5.630	5.900	5.929

Table 5: Comparison of split tensile strength obtained on 3rd, 7th, and 28th day for M30 grade concrete

Replacement %	Average split tensile strength (N/mm^2)		
	3rd Day	7th Day	28th Day
0	3.904	3.650	3.809
4	3.989	3.883	4.859
8	3.941	3.862	3.841
12	3.872	3.798	3.767
16	3.894	3.780	3.141

VIII. CONCLUSION

The use of Waste Paper Sludge reduces the cement content, which helps in preserving the environment due to pollution and also the natural reserves of our nation. The constraint with WPS concrete is that it becomes less workable as the WPS percentage increases which indicates that more water is required to make the mixes more workable. This means that WPS concrete has higher water demand. This could be overcome by the usage of water reducing admixtures.

On the aspect of the strength the results clearly indicate the increase in the compressive strength of concrete and split tensile strength of concrete increases with addition of WPS, whereas, flexural strength decreases. As far as concrete is concerned if the compressive strength is increasing then the concrete is said to be durable and satisfactory in function.

The cost is very much effective when WPS is added i.e. 2.71%, 5.63%, 8.60%, 11.5% reduction of cost when 4%, 8%, 12%, and 16% added than the conventional concrete. So, 4% of WPS can be added to structural elements and up to 16% can be added for lighter elements such as compound walls and for filling purpose which will be economical and environment friendly.

REFERENCES

[1]. International Journal of Advanced Engineering Technology, *Innovative use of paper industry waste in design mix concrete* by Prof. Jayeshkumar Pitroda.
[2]. IOSR Journal of Engineering vol.3, Issue 11 (November, 2013), IUST Kashmir, *Study of concrete involving use of waste paper sludge ash as partial replacement of cement*.
[3]. International Journal of Emerging Technologies and Engineering (IJETE) volume 1 Issue 7, august 2014. *Structural Performance of Concrete by Partial Replacement of Cement with Hypo Sludge (paper waste).*
[4]. L Ravindra Singh et al. Int, Journal of Engineering Research and Applications, vol.5, Issue 4, (Part - 7) April 2015, *Application of*

Paper Waste in Cement.
[5]. Experimental Investigation In Developing Low Cost Concrete From Paper Industry Waste.
[6]. R Balamurugan et al Int. Journal of Engineering Research and Applications, Vol 4, Issue 4(Version 1), April 2014, *An Experimental Investigation of Partial Replacement of Cement by Industrial Waste (hypo sludge).*
[7]. www.cement.org/cement-concrete-basics/working-with-concrete/curing
[8]. www.city.edu.hk/CIUCAL/design/labexp/test cube/test cubee4.html
[9]. www.engineeringcivil.com/concrete-mix-design-as-per-indian-std-code.html