EFFECT OF PAPER SLUDGE ON THE PROPERTIES OF CEMENT CONCERETE

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Abstract: Many researches have been currently going to modify and improved the concrete properties by the addition of different types of materials. This paper represents the Optimum use of the waste paper sludge with the concrete mixture and will also help in achieving the desired results. This paper shows the investigation on M25 grade due to incorporation of waste paper sludge. In this paper we used the waste paper sludge of various properties at various percentages as 0%,5%,10%,15%.,20% by the weight of cement on M25 grade of mix proportion (1:1.60:2.80) with water cement ratio 0.45. It can be concluded that the compressive strength , Flexural strength and split Tensile Strength of waste paper sludge containing concrete increases at the optimum percentage of 5 % as compared to the plain concrete. After more addition of waste paper sludge , all strengths starts to decrease.
Keywords: waste paper sludge, Compressive Strength, Flexural Strength and Split Tensile Strength

I. INTRODUCTION

Waste management is an industry which revolves around the collection, storage and waste disposal. A waste management system is a particular method to treat waste materials consisting collection, recycling, and disposal or waste processing.Recycling, reuse, combustion and landfill methods reduce construction and demolition waste. Land filling method is cheaper and easier than recycled in order to reduce construction waste, but human meets nowadays problems to find the landfills. Thus, the natural resource protection is one of the important parts of environmental issues.. Pulp and paper mill residual solids also called sludge are composed mainly of cellulose fibers, moisture and paper making fillers like kaolinite clay and calcium carbonate. The raw dry paper sludge mainly contains silica and calcium oxide followed by alumina and magnesium oxide.

Therefore the demand of the concrete and the required raw materials are very high. This causes the hike in the costs of cement, fine and coarse aggregates. Quite often the shortage of these materials is also occurred. To avoid the problems like cost hike and cuts in supply of concrete and mortar, the alternate material or the partial replacements for the cement and aggregate should be developed by recycling of waste materials. As a structural point of view we find that alternate material which not only improve the various properties of concrete but also safe for the environment. To produce low cost concrete by blending various ratio of cement with sludge and to reduce disposal and pollution problems due to sludge it is most essential to development of profitable building materials from sludge. To make good quality paper limited number of times for recycled paper fiber can be used which produce a large amount of solid waste. Sludge is used in concrete formulation as a supplementary cementatious material .The availability of waste paper sludge is not a difficult task . So this research work is helps to studied the various properties of the paper sludge when mix in to the concrete and the various structural parameters of the concrete with waste sludge. In the world of construction, concrete like other materials is playing an important role in development. Concrete is a composite material which is a mixture of cement, fine aggregate, coarse aggregate and water. The major constituents of which is natural aggregate such as gravel, sand, The goal of sustainable construction is to reduce the environmental impact of a constructed facility over its lifetime. Concrete is the main material used in construction in the world. Due to increase in Construction activities worldwide, waste paper sludge concrete is a sustainable building material due to reduced amount of cement usage and recycled paper being put to good use. It has numerous advantages in construction industry, namely low carbon footprint, recycled material usage, low embodied energy, high strength to weight ratio, high thermal insulation, high sound absorption, aesthetic and cost effective. It is perceived as an environment friendly material due to the vital recycled content. By doing so, the total weight, cost and the carbon emissions during production are reduced. Its use remains limited, because of the lack of official data about its structural properties, mechanical properties and durability. In order to establish waste paper sludge concrete as a standard material, further experimentation is needed

When paper is mixed with cement, it creates a very good bond and the final product is both lightweight and strong. Fibers contribute to sound insulation properties and help in crack control. Portland cement is an integral component of the mix and acts as a binder. Cement reduces the drying time and the effect of pulp shrinkage and increases the strength and dimensional stability. Concrete with paper pulp is far lighter in weight and has remarkable insulating qualities, unlike concrete which is relatively heavy. It can be easily shaped when cured and dried. The most important benefit of paper sludge concrete is the reduction of cement in the mix. Carbon footprint during production, the total cost and weight are reduced, resulting in an eco-friendly and lightweight material. Paper fibers result in excellent heat and sound insulating properties. It incentivizes the recycling of waste paper, especially in communities with no recycling services. It is viable option for low cost housing and temporary shelters and offices.

Crises of building materials lead to high demand and need for recycling industrial waste or finding alternative source. Wastepaper helps in low- cost, eco friendly and therefore,

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sustainable design. In India's context only a fraction of paper is recycled annually. This means that the rest is still disposed off, mostly ending up in landfills for slow degradation and capacity consumption of dumpsites.

The rapid increase in construction activities leads to active shortage of conventional construction materials such as cement, fine aggregate and coarse aggregate. Therefore concrete will continue to be the construction material in the foreseeable. There is need to improve its properties like workability, strength and durability of concrete..

The concrete technologists are continuously making efforts to overcome problems in different ways and are making improvement to conserve energy, raw materials, development of high strength concrete, pre-stressed concrete, high early strength, and low possible water/cement ratio while maintaining high workability to improve mechanical and structural properties of fresh and hardened concrete so as to make structural concrete as economical. To achieve sustainable issue in construction area, researchers and companies focus on using waste concrete as a new construction material. In the future it may be useful to find new source of paper sludge for the production of concrete due to increase in demand for and decrease in supply of cement. When paper is mixed with cement, it creates a very good bond and the final product is both lightweight and strong. Fibres contribute to sound insulation properties and help in crack control. Portland cement is an integral component of the mix and acts as a binder. Cement reduces the drying time and the effect of pulp shrinkage and increases the strength and dimensional stability. Concrete with paper pulp is far lighter in weight and has remarkable insulating qualities, unlike concrete which is relatively heavy. It can be easily shaped when cured and dried. The most important benefit of paper sludge concrete is the reduction of cement in the mix. Carbon footprint during production, the total cost and weight are reduced, resulting in an eco-friendly and lightweight material. Paper fibres result in excellent heat and sound insulating properties. It incentivizes the recycling of waste paper, especially in communities with no recycling services. It is viable option for low cost housing and temporary shelters and offices. Crises of building materials lead to high demand and need for recycling industrial waste or finding alternative source. Wastepaper helps in low- cost, eco friendly and therefore, sustainable design. In India's context only a fraction of paper is recycled annually. This means that the rest is still disposed off, mostly ending up in landfills for slow degradation and capacity consumption of dumpsites.

II. LITERATURE REVIEW

Anil Kumar, Devika Rani (2016) Due to increase in construction activities there is increase in demand for concrete, which leads to overuse of natural resource. Hence, conservation of natural resources is necessary thing. Among the wastes generated it is presumed that 10%-15% of wastes are hazardous and increasing at the rate of 2% - 5% per year, resulting in environmental pollution and effect to living beings. These wastes can be utilized as alternative construction material, so that it would be one of the consistent ways of disposal. This paper attempts to study the strength parameters such as compressive and tensile strength of Paper Sludge Ash (5%, 10%, and 15%) as a partial replacement of cement.

P Bhargavi, S Kavitha Karthikeyan, G Snekha, A Vinothini (2016) 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.

P.Packialakshmi, R.Aasha jyothi (2016) An experimental study of concrete made with Ordinary Portland Cement (OPC) and 10% of OPC, replaced by hypo sludge. The hypo sludge 10% take as constant and further adding of wood ash from 0% to 30% as cement replacement for concrete. To determine the effect of these materials on concrete properties and was compared to control M20 mix. Concrete specimens were tested for compressive strength, tensile strength, and flexural strength at age of 28 days.

Savita Devi, Nitish Gandhi , Mahipal , Nimisha Marmat , Balveer Manda (2016) Paper pulp produced in mill was investigated to work in concrete as an alternative for land disposal. Paper pulp was replaced in concrete by cement in the ratio of 5%, 10%, 15%, and 20% by weight in M20 and M30 grade mix concrete. Compression test, split tensile strength test and flexure test were carried on the concrete after replacement by paper pulp. Tests were carried out on concrete till 28 days. As a result an increment of flexure and split tensile strength was observed till 10% replacement of paper pulp sludge, further increase in percentage of paper pulp sludge observed a decline in the values of flexure and split tensile strength

Lenin Sundar M, Jeeva D and M Vadivel (2016) The aim of project is to produce low cost concrete by blending various ratios of cement with hypo sludge & to reduce disposal and pollution problems due to hypo sludge it is most essential to develop profitable building materials from hypo sludge. To make good quality paper limited number of times recycled Paper fibres can be used which produces a large amount of solid waste. The innovative use of hypo sludge in concrete formulations as a supplementary cementitious material was tested as an alternative to traditional concrete. The initial results of experimental programs aimed at producing and evaluating the Hypo sludge concrete made with Hypo sludge (Paper Industry Waste) are presented and discussed. The mix design of Hypo sludge Concrete was arrived as per Indian

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Standard Guidelines

Cherian Varkey, Jefin P John, Neema V N, Namitha Joshy (2016) Portland cement is the most important ingredient of concrete and is a versatile and relatively high cost material. Large scale production of cement is causing environmental problems on one hand and depletion of natural resources on other hand. This work examines the possibility of using waste paper sludge to produce a low cost concrete by blending various ratios of cement with paper sludge and to reduce disposal and pollution problems due to waste paper sludge. The innovative use of waste paper sludge in concrete as a supplementary cementitious material was tested as an alternative to traditional concrete

Abdullah shahbaz khan, Ram panth, Gagan Krishna R.R, Suresh G. Patil (2014) By utilizing hypo sludge the strength will be increased and also cost reduction in the concrete is achieved. The present dissertation work is directed towards developing low cost concrete from paper industry waste. Dissertation work is carried out with M20 & M30 grade concrete with W/c ratio of 0.55 & 0.45 respectively as a control specimen and hypo sludge is replaced in different percentages such as 10%, 20%, and 30% by weight of cement. Cubes of 150mm x 150mm size, Cylinders of 100 mm dia and 200mm height, and prisms of 100 mm x 100mm x 500mm are casted for conventional concrete and RPH (Replacement of hypo sludge by weight of cement) test specimen respectively. Test was conducted to study the mechanical properties of concrete, such as compressive strength, split tensile strength and flexural strength. The curing period should be 3, 7 and 28 days.

Prof. Jayeshkumar Pitroda1, Dr. L.B.Zala2, Dr.F.S.Umrigar (2013) The paper producing industry generates various wastes coming out from the various processes. From the preliminary waste named as hypo sludge, due to its low calcium is taken out to replace the cement in concrete. Major initiatives are needed in India to use these large volumes in construction industry especially in rigid pavement construction and other infrastructure projects. Moreover Use of Hypo Sludge in construction of rigid pavement will improve transportation functionality and ecological sustainability and results in improved traffic safety and reduced life-cycle cost. Use of Hypo Sludge in construction of rigid pavement will benefit urban growth, public health and surrounding communities by encouraging smart growth by integrating and guiding future growth.

Sajad Ahmad, M. Iqbal Malik, Muzaffar Bashir Wani, Rafiq Ahmad (2013) Cement manufacturing industry is one of the carbon dioxide emitting sources besides deforestation and burning of fossil fuels and concrete industry is one of the largest consumers of natural virgin materials. The global cement industry contributes about 7% of greenhouse gas emission to the earth's atmosphere. In order to address environmental effects associated with cement manufacturing and constantly depleting natural resources, there is a need to develop alternative binders to make concrete industry sustainable. This work examines the possibility of using waste paper sludge ash as partial replacement of cement for new concrete. In this study waste paper sludge ash was partially replaced as 5%, 10%, 15% and 20% in place of cement in concrete for M-25 mix and tested for its compressive strength, tensile strength, water absorption and dry density up to 28 days of age and compared with conventional concrete. From the results obtained, it is found that Waste Paper Sludge Ash can be used as cement replacement up to 5% by weight and particle size less than 90μm to prevent decrease in workability. Further waste paper sludge has very high calorific value and could be used as a fuel before using its ash as partial cement replacement.

Sumit A Balwai, SP Raut (2012) The use of paper-mill pulp in concrete formulations was investigated as an alternative to landfill disposal. The cement has been replaced by waste paper sludge accordingly in the range of 5% to 20% by weight for M-20 and M-30 mix. By using adequate amount of the waste paper pulp and water, concrete mixtures were produced and compared in terms of slump and strength with the conventional concrete. The concrete specimens were tested in three series of test as compression test, splitting tensile test and flexural test. These tests were carried out to evaluate the mechanical properties for up to 28 days. As a result, the compressive, splitting tensile and flexural strength increased up to 10% addition of waste paper pulp and further increased in waste paper pulp reduces the strengths gradually

Jil Tushar Sheth1, Saransh Joshi(2011) Paper Crete is kind of fibrous cement, made by shredding paper (old newspapers, prints, cardboards etc.) into pulp in water and adding Portland cement to it and in some cases sandy soil to be used as an additive. It gains its inherent strength due to presence of hydrogen bonds in microstructure of paper. This thick mix can then be poured into molds and cast like concrete, to make it into any desired shape and size. Papercrete is a sustainable building material due to reduced amount of cement usage and recycled paper being put to good use. It has numerous advantages in construction industry, namely low carbon footprint, recycled material usage, low embodied energy, high strength to weight ratio, high thermal insulation, high sound absorption, aesthetic and cost effective

MATERIALS USED

Materials required for making waste paper sludge concrete essentially consist of cement, fine sand, coarse aggregates and waste paper sludge. These materials are described below-

CEMENT: Ordinary Portland cement of 43 grade has been used in this experimental work. OPC 43 grade of ULTRATECH cement has been used after investigate the strength of cement at 28 days as per IS 4031-1988.

FINE AGGREGATES: Locally available river sand passed through 4.75mm IS sieve has been used in the preparation of SFRC . It confirms to IS 383-1970 which comes under Zone I. The physical Properties of sand like Fineness Modulus ,Specific Gravity and water absorption are 3.49, 2.67 and 2.31% respectively.

COARSE AGGREGATES: The Coarse aggregate are obtained from a local quarry has been used. The coarse aggregate with a maximum size 20mm having a specific gravity 2.89. In this experimental work coarse gravel of

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20mm and crushed aggregate of 10mm are mixed in 60:40. The physical Properties of coarse aggregates like Fineness Modulus, Specific Gravity are 2.31, 2.89 respectively.

WASTE PAPER SLUDGE

In a similar way to the processes described for basic paper sludges, the products yielded by thermal activation are formed principally of silica (20-30%), lime (34- 45%), alumina (13-20%) and magnesia (2-3.5%). The remaining oxides are present in amounts of less than 1%.

TABLE 1 Physical and Chemical Properties of Waste Paper Sludge

Specific gravity	2.62
Average MC	35.3

Chemical Constituent	Paper Sludge	Cement
Lime	34-45%	63%
Silica	20-30	22%
Alumina	13-20%	6%
Magnesia	2-3.5%	2.5%
Remaining oxides	1%.	2%

FIG. 1 – PAPER SLUDGE

Table 2 Quantity of material per cubic meter for different Mixes

Material kg/m^3	RM0	RM5	RM10	RM15	RM20
Cement	413.3	392.7	372	351.5	330.7
Natural Coarse Agg.	1159.2	1159.2	1159.2	1159.2	1159.2
Paper Sludge	0	20.6	41.3	61.8	82.6
Fine Agg.	663.1	663.1	663.1	663.1	663.1
Water	186	186	186	186	186

III. RESULTS & DISCUSSION

Compressive Strength Test

The tests were conducted according to IS: 5l6-1959(reaffirmed 1999). Specimens were taken out from the curing tank at the age of 7, 14 and 28 days and tested immediately on removal from the water and while they were still in the wet condition. Surface water was wiped off. Plate 4.3 shows the experimental set up for the test.

The specimens were tested on 2000 KN capacity CTM. The position of the cube when tested was at right angles of that as cast. The axis of the specimens was carefully aligned with the centre of thrust of the spherically seated plate. The load was applied gradually and without shock and increased continuously at the rate of approximately 5KN/second till the failure of the specimen and thus the compressive strength was found out. The results of compressive strength are presented in Table:

Fig 3 - Compression Test

Table 3 Compressive Strength of Concrete

Mix Designation	Curing Period	Load at Failure (KN)	Compressive Strength (N/mm^2)	Average Compressive strength (N/mm^2)
RM0	7 days	475	21.90	21.1
		476	22.00	
		473	22.04	
	28 days	725	32.20	32
		722	32.08	
		719	31.95	
RM5	7 days	505	22.40	22.3
		503	22.30	
		501	22.20	
	28 days	765	34	33.9
		763	33.90	

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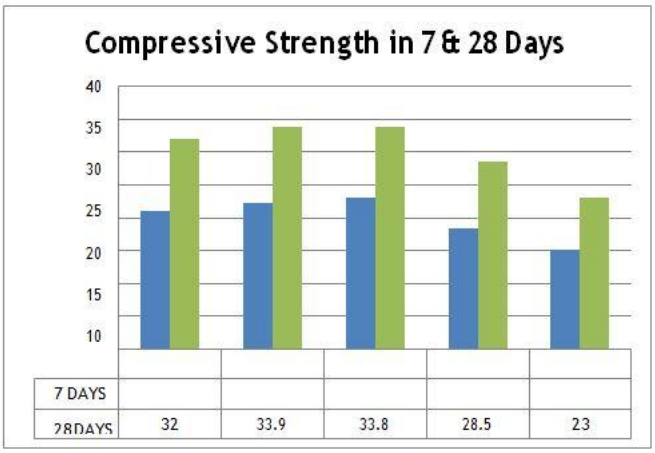
		762	33.86	
RM10	7 days	518	23.04	23.1
		520	23.13	
		518	23.05	
	28 days	762	33.88	33.8
		762	33.90	
		762	33.87	
RM15	7 days	413	18.35	18.3
		411	18.26	
		412	18.31	
	28 days	642	28.53	28.5
		641	28.48	
		641	28.48	
RM20	7 days	341	15.19	15.2
		342	15.20	
		341	15.19	
	28 days	517	22.98	23
		517	22.97	
		517	23.01	



From the above results it is clear that compressive strength of RM5 is highest. Whereas strength of RM10 at 28 days is approximately similar to that of RM5 concrete. But strength of RM20 is decreased from conventional concrete.

The decrease in percentage of strength in RM20 is 30%, 28% respectively for 7 days , 28 days respectively strength as compared to that of RM0 (conventional concrete) and if compared with M5 the increase in strength is 9%, 5.6% respectively for 7, 28 days.

Split Tensile Strength Test

The test method covers the determination of splitting tensile strength of cylindrical concrete specimen. This method consists of applying diametric compressive force along length of cylindrical specimen. This loading induces tensile stresses on the plane containing the applied load. Tensile failures occur rather than compressive failure. Ply wood strips are used so that the load is applied uniformly along the length of cylinder. The maximum load is divided by appropriate geometric factors to obtain splitting tensile strength. The splitting tensile strength was calculated as follows:

Where

P = Max. Load at failure in N

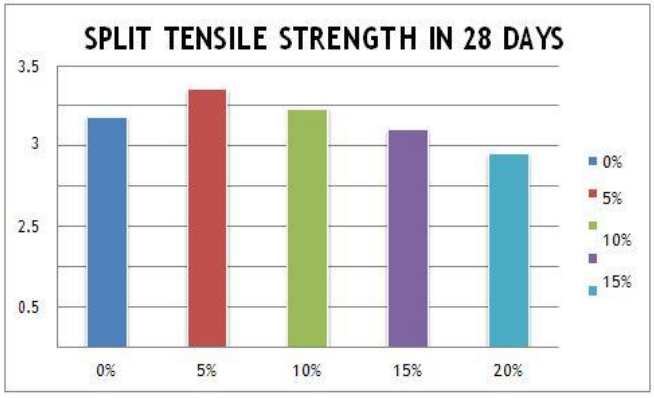
l = Length of cylindrical specimen in mm

d = Diameter of cylindrical specimen in mm

Fig. 4 Split Tensile Test

Table 4 Split Tensile Strength of concrete

Mix Designation	Curing Period	Load at Failure (KN)	Split Tensile Strength (N/mm^2)
RM0	28 Days	202	2.86
RM5	28 Days	226	3.20
RM10	28 Days	209	2.96
RM15	28 Days	191	2.70
RM20	28 days	170	2.40



From the above results it is clear that split tensile strength of RM5 is highest. Further addition of PS it decreased the strength. But strength of RM5 is 12% increased from RM0 and strength of RM20 is 16% decreased from conventional concrete.

Flexural strength test

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by loading 150 x 150 x 450mm concrete beams. The flexural strength is expressed as Modulus of Rupture MPa. The results are shown in table 4.16.

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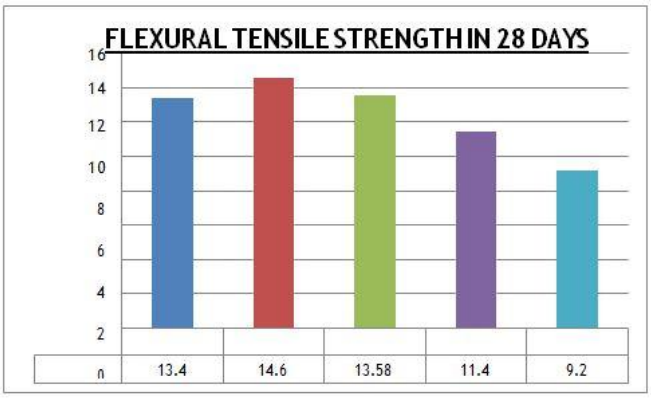
Table 5 Flexural strength test

Mix Designation	Curing Period	Flexural strength (N/mm^2)
RM0	28 Days	13.40
RM5	28 Days	14.60
RM10	28 Days	13.58
RM15	28 Days	11.40
RM20	28 days	9.20



From the above results it is clear that Flexural tensile strength of RM5 is highest. Further addition of PS it decreased the strength. But strength of RM5 is 9% increased from RM0 and strength of RM20 is 31% decreased from conventional concrete.

IV. CONCLUSIONS

The following conclusions are drawn from the present study:

- Compressive strength of concrete decreased with the increase in paper sludge replacement. However, at each replacement level of sludge, an increased and decrease in strength was observed. Compressive strength however of 28 days is higher than at 7 days. Compressive strength is increased with addition of 5- 10% paper sludge.
- It has been seen from the above study that compressive strength increases with age. This is true for all cases of replacement. As we replaced cement with paper sludge, the strength has increased with age.
- Slump is decreased with addition of paper sludge to concrete thus decreases to workability requirements of concrete. Whereas slight addition of paper sludge
- i.e. only 5% replacement of cement can still give satisfactory results
- Split tensile strength is increased with addition of 5% paper sludge. After that It was observed that as the replacement percentage of paper sludge increased, the spit tensile decreased.
- Flexural strength is increased with addition of 5% paper sludge, As we replaced cement with paper sludge, the flexural strength decreased.
- From the cost benefit analysis the cost of paper sludge concrete is less as compare to the conventional concrete, therefore up to 5 to 10% paper sludge in concrete gives the better strength hence it is more economical than conventional concrete.
- So paper sludge can be used in replacement of cement thus reducing environmental hazards. But high quantities of replacements are not recommended as it leads to decrease in strength properties.

Future scope of research

- The combined effects of paper sludge and cement can be studied for aggressive environmental conditions.
- The effects of admixtures in combination with paper sludge can be studied.
- The effect of paper sludge for durability requirements like freeze thaw action, initial surface absorption etc. can be studied.
- Paper sludge concrete usage in other construction areas like roads, bridges can be studied.

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