A Review on Partial Replacement of Fine Aggregate by Waste Paper Sludge in Concrete

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***Abstract*—The rapid increase in construction activities leads to scarcity of conventional construction materials such as cement, fine aggregate and coarse aggregate. Researchers are being conducted for finding cheaper materials. In India, there are many industries producing large amount of effluent treatment paper waste sludge which leads in problems of disposal. In the Pulp and Paper Industry several types of solid wastes and sludge are generated. Solid waste is mainly produced from pulping, deinking processes and wastewater treatment. The waste generation is strongly affected by the production process and wastewater treatment technologies. Paper manufacturing is a highly capital, energy and water intensive industry. In India, around 905.8 million m3 of water is consumed and around 695.7 million m3 of wastewater is discharged annually by this sector. The amount of waste generated in paper production varies greatly within different regions, because of different recycling rates. The purpose of this study is to find an alternate source for Fine aggregate, cement and as an admixture. In this project concrete was tested with w/c ratio of 0.45.**

***Index Terms*—Paper waste sludge, concrete, admixture, w/c ratio, deinking processes.**

I. INTRODUCTION

"Environment" is defined as the sum total of water, air and land and the inter relationships which exists among and between water, air and land, and human beings, other living creatures, plants, micro-organisms and property. Any solid, liquid or gaseous substance present in such concentration as may be or tend to be injurious to environment is called an environmental pollutant [EP, Act, 1986] India, being a signatory to the United Nations Conference on the human Environment held in Stockholm in 1972 and other subsequent Conferences aimed at arresting the degradation of environment and conserving it, is committed to take appropriate and adequate steps for the preservation of natural resources of the earth and for the protection and improvement of human environment.

At present, the disposal solution employed is land filling even though the paper sludge is a decomposable organic material. However, the volume of paper sludge to be disposed of remains considerably high and become less feasible in recent years as environmental concerns have lead to rapidly increasing costs. Due to the limited landfill space available and stringent environmental regulations, many paper pulps are attempting to develop efficient, economic and environmental sound alternatives for utilizing this waste paper sludge [6, 20, 21]. Manuscripts must be in English. These guidelines include complete descriptions of the fonts, spacing, and related information for producing your proceedings manuscripts. Please follow them.

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Therefore, the civil engineers have been challenged to convert this paper sludge, in general, to useful building and construction materials. Utilization of paper sludge for construction shall not only solve waste problems, but also provide a new resource for construction purposes. Concrete is the most used construction material in the industrialized countries. However, the concrete production needs natural resources (water and aggregates) and cement whose production is costly due to the energy required. In order to reduce the use of natural content, sludge from water treatment plant is used for concrete production as fine aggregate. This sludge has disposal problems in order to reduce that reuse of that resources are about to tested with different percentage of replacement. This may drastically reduce the sludge content and even the cost of concrete. Sludge is a product which is obtained during the treatment of wastewater. The characteristic of sludge differ upon the region and the method of treatment. Sludge is formed after undergoing various steps such as stabilization, composting, anaerobic digestion, and thickening, dewatering and drying. This sludge contains maximum amount of nitrogen content and so it is majorly used for agricultural purpose.

II. LITERATURE REVIEW

Paper sludge, also known as paper fiber bio solids, is the residue left over from the paper recycling process. It consists of unusable short fibers, inks and dyes, clay, glues and other residue, along with any chemicals used in the recovery process. Sludge from pulp and paper mills are mainly cellulose fibers generated at the end of the pulping process prior to entering the paper machines. Paper sludge obtained directly from a mill wastewater treatment plant is composed generally of 50-75% organics (cellulose fibers and tissues) and 30% - 50% kaolinite clay.

Currently almost all the solid waste of pulp and paper origin is being land filled. Due to the large volume of sludge, prohibition of sludge dumping in the ocean, and the lack of suitable land space, municipalities are turning to incineration. About 10% of its original volume can be reduced with the incineration processes. However, the volume of sludge ash to be disposed of remains considerably high Due to the limited landfill space available and stringent environmental regulations, as well as the potential for ground-water contamination generated from landfill leachate, many wastewater treatment plants using sludge-incineration processes to develop alternatives for utilizing ash residual. Alternative uses of paper sludge were studied based on the good sorbent and pH-controlling capacity of this material.

The sludge of the paper industry can be divided into several categories: the waste paper sludge coming from the production of virgin wood fiber, called primary sludge; the waste paper sludge produced by removing inks from post-consumer fiber, called de-inking paper sludge; the activated sludge from the secondary systems, called secondary sludge; and combined waste paper and activated sludge, called combined sludge. The highest volume solid residues generated by the pulp and paper industry are wastewater treatment residuals and ash (from burning coal, wood/bark, and wastewater treatment residuals). Residual is removed by two steps in the process of treating the wastewater Primary clarifier process is the first stage of the wastewater treatment to remove the solid, called primary residual. Primary clarification is usually carried out by sedimentation and sometimes by dissolved air flotation. Primary residual consists mainly of cellulose fibers and papermaking fillers. Secondary treatment will take part after the water complete clarified by the primary treatment.

Secondary treatment is usually a biological process in which micro-organisms convert soluble organic matter to carbon dioxide and water while consuming oxygen. Secondary residual is mainly microbial biomass (also called bio solids) grown during this process and removed through clarification. Cellulose determines the character of the fiber. Cellulose is a polymer of glucose and a carbohydrate of high molecular weight is a major constituent of wood substance (approximately 50 percent by weight). The chemical formula for cellulose is $(C6H10O5)$ n, where n is the number of repeating glucose units or the degree of polymerization (DP). Degree of polymerization values of native cellulose fibers and papermaking fibers are about 3500 and 600-1500. Hemicelluloses, various polymers built up of units of one or more species of sugar, such as glucose, galactic, xylems, and mannose-designates materials other than cellulose and found in wood.

The nature and proportion of the hemicelluloses found in different woods vary. They exhibit some degrees of orientation and crystalline, particularly when they are in close association with cellulose, but are largely amorphous. Fresh concrete or plastic concrete is a freshly mixed material which can be molded into any shape. The relative quantities of cement, aggregates and water mixed together, control the properties of concrete in the wet state well as in the hardened state. water and the quantity of water required for chemical combination with cement and to occupy the gel pores. The theoretical water/cement ratio required for these two purposes is about 0.38.

III. MATERIAL & METHODOLOGY

The analytical work will be carried out using the references, IS codes and IRC codes this chapter describes the materials used, the preparation of the test specimens and the test procedures. On the initial stage, all the materials and equipments needed must be gathered or checked for availability. Then, waste paper sludge was used in the concrete mixes according to the predefined proportions. Once the characteristic of the materials selected has been tested through appropriate tests, the applicable standard of specification should be referred. Finally, the results obtained were analyzed to draw out conclusion.

Material properties Cement, natural fine aggregates, natural coarse aggregates, recycled coarse aggregate, recycled plastic course aggregate, water are to investigate. Primary and secondary sludge may be expected to contain settle able materials from raw wastewater and the products of microbial synthesis. Other materials are also removed from wastewaters and incorporated into primary and secondary sludge. The large surface area of particles incorporated into sludge provides sites for adsorption of constituents from the liquid phase. Non-degraded organic compounds in solution may partition into the organic fraction of the particles. Bio flocculation may incorporate colloidal particles that otherwise would not be removed by sedimentation into settle able particles. These and other mechanisms result in selective enrichment of wastewater constituents in sludge.

Fig1: - Paper sludge stored before processing

Additionally, wastewater sludge is mostly water and, hence, wastewater constituents remaining in the liquid phase also are included in sludge. Because primary and secondary sludge have different properties, advantage is sometimes sought by treating them separately. As an illustration, secondary sludge thickens better using the dissolved air flotation process than by gravity thickening, and it is sometimes thickened separately from primary sludge. The two sludge almost invariably are combined prior to the end of the treatment, and, for purposes of discussing the ultimate utilization of treated sludge, they are not further distinguished. A wide variety of sludge treatment processes are used to reduce sludge volume and alter sludge properties prior to disposal or use of the treated product. Sludge treatment is considered herein to comprise engineered processes for altering sludge quality prior to disposal or reclamation. When sludge is applied to land, inactivation of remaining pathogenic organisms and viruses continues, biological stabilization of residual organic material progresses, and biologically-mediated and a biotic chemical transformations occur. Sludge is produced from the treatment of wastewater in septic tank and activated sludge systems.

This is inherently so because a primary aim of wastewater treatment is removing solids from the wastewater. In addition, soluble organic substances are converted to bacterial cells, and the latter is removed from the wastewater. Sludge is also produced from the treatment of storm water, although it is likely to be less organic in nature compared to wastewater sludge. Sludge should, however, always be handled with care to avoid contact with pathogens. Sludge may be contaminated with heavy metals and other pollutants, especially when industrial wastes are disposed into the sewer. Pre-treatment of industrial wastes is therefore essential before discharge to the sewer. Treatment of sludge contaminated with high concentrations of heavy metals or toxic chemicals will be more difficult and the potential for re-use of the sludge will be limited. Fecal sludge contains essential nutrients such as nitrogen and phosphorus and is potentially beneficial as fertilizers for plants.

The organic carbon in the sludge, once stabilized, is also desirable as a soil conditioner, because it provides improved soil structure for plant roots. Options for sludge treatment include stabilization, thickening, dewatering, drying and incineration. The latter is costliest, because fuel is needed and air pollution control requires extensive treatment of the combustion gases. It can be used when the sludge is heavily contaminated with heavy metals or other undesirable pollutants. Prevention of contamination of the sludge by industrial wastes is preferable to incineration. A conversion process to produce oil from sludge has been developed, which can be suitable for heavily contaminated sludge. The costs of treatment of sludge are generally of the same order as the costs of removing the sludge from the wastewater.

Table1: chemical composition of Sludge

Composition	Percentages
Carbon	40-52
Nitrogen	10-20
Oxygen	20-26
Manganese oxide	5-8
Magnesium oxide	5-10
Sulphur	0.5-1.0

3.1 Methodology

It is the method followed to perform the experiment. In this section we have made step wise procedure to perform experiment which is briefly described as follows:

1) Mix designed
2) Batching
3) Experimental programmed of casting
4) Mixing
5) Compaction
6) Curing
7) Testing

3.2 Mix design Mix design is the process of selection of suitable ingredients of concrete and to determine their properties with object of producing concrete of certain maximum strength and durability, as economical as possible. The purpose of designing is to achieve the stipulated minimum strength, durability and to make the concrete in the most economical manner.

3.3 Mix combinations model

Concrete mixes were produced in the laboratory: P-100 (Control Mix)**,** PF-5-95, PF-15-85, PC-5-95, PC-10-90, PA-0.4 and PA-0.8. Various percentages of paper sludge replacement proportion to fine aggregate, cement and as admixture in concrete are show in Table.

***3.4 Mix design (as per IS10262:2009 & IS456:2000*)** Mix design is the process of selection of suitable ingredients of concrete and to determine their properties with object of producing concrete of certain maximum strength and durability, as economical as possible. The purpose of designing is to achieve the stipulated minimum strength, durability and to make the concrete in the most economical manner.

Table no2: - 8 Mix combinations model

P-100	**Control Mix**
PF-5-95	5% paper sludge replacement of fine aggregate (95% fine aggregate + 5% PMS)
PF-15-85	15% paper sludge replacement of fine aggregate (85% fine aggregate + 15% PMS)
PC-5-95	5% paper sludge replacement of cement (95% cement + 5% PMS)
PC-10-90	10% paper sludge replacement of cement (90% cement + 10% PMS)
PA-0.4	0.4% paper sludge as admixture in concrete
PA-0.8	0.8% paper sludge as admixture in concrete

Table no3-:9 Stipulations for proportioning

A	Grade designation	M 25
B	Type of cement	PPC grade I conforming IS 8112
C	Maximum normal size of aggregate	10 mm
D	Minimum cement content	240 Kg/m^3
E	Maximum water cement ratio	0.60
F	Workability	50 to75 mm
G	Method of concrete placing	Manually
H	Maximum cement content	450 Kg/ m3
I	Degree of supervision	Good
J	Admixture	PMS
K	Type of aggregate	Crushed angular aggregate

3.5Characteristic Strength

The compressive strength of concrete is given in terms of the characteristic compressive strength of 100 mm size cubes tested at 28 days (fck). The characteristic strength is defined as the strength of the concrete below which not more than 5% of the test results are expected to fall. This concept assumes a normal distribution of the strengths of the samples of concrete.

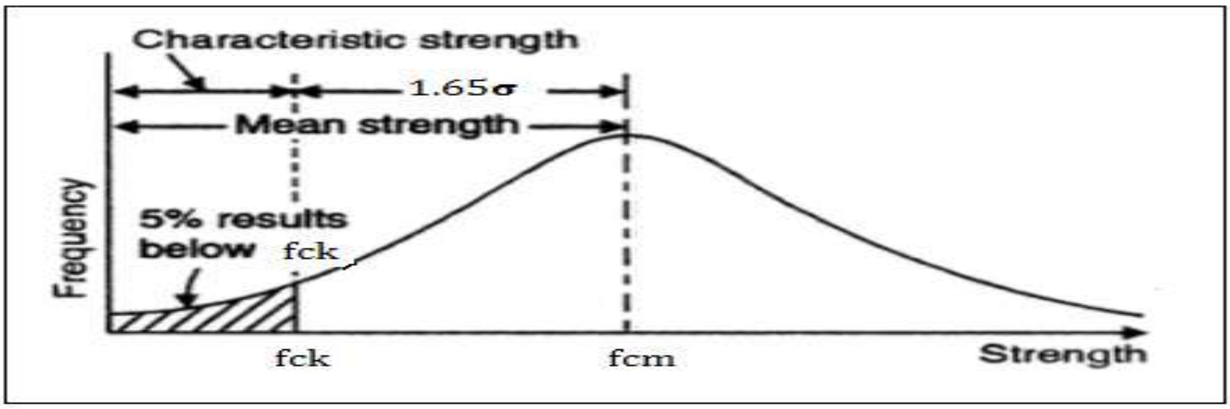

Fig.2: Normal Distribution curve on test specimens for determining compressive strength

Target strength for mix proportioning

$$f'ck = fck + 1.65\ s$$

Where, ***f'ck*** = Target Average compressive strength of 28 Days

fck = compressive strength of 28 Days

s= Standard deviation Standard deviation,

s =5 n/mm2.

Therefore, target strength = 25 + 1.65 x 4 =31.6N/mm2.

Selection of water-cement ratio

From table 5, IS 456: 2000 for RCC structure,

Maximum water-cement ratio = 0.60 Based on experience,

Adopt water-cement ratio as 0.45, 0.45 < 0.60, Hence o.k.

Selection of water content

From table 2, as per IS10262:2009

Maximum water content =208 liters (for 25 to 50 mm slump range)

And for 10mm aggregate

Estimated water content for 75 mm slump as per IS10262:2009 = 208 + (208 x 5%) =219 LTR

Calculation of cement content

Water cement ratio = 0.45 From table no 5,
IS code 456 Cement content = 219 ÷ 0.45 = 486.66 Kg/m3
Adopted cement content is 443 Kg/m3 (450 < 487 > 240) Kg/m3

Proportion of volume of coarse aggregate and fine aggregate content

In the present case water-cement ratio is 0.45.Therefore volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lower by 0.05, the proportion of volume of coarse aggregate is increased by 0.02 (at the rate of ± 0.01 for every ± 0.05 change in water-cement ratio).

Therefore, corrected proportion of volume of coarse aggregate,
For the water-cement ratio of 0.45 = 0.61.
The Volume of fine aggregate content = 1 − 0.61 = 0.39.

IV. CONCLUSION

- Sludge can be used as an effective replacement of fine aggregate and it can be replaced with 20% in concrete.
- The compressive strength is increased with the addition of sludge; Flexural strength is also increased when compared with the control mix. The maximum compressive strength and flexural strength value obtained for OPC 43 grade cement.
- The workability of the mix containing Paper sludge shows an inverse relation with the increase of replacement.
- Replacement. The compressive strength of 0.4% replaced concrete has 99.14% of compressive strength of ordinary concrete and compressive strength of 10%, 15% replaced mix have attained 97.66% and 92.59% of strength of reference mix respectively.
- The split tensile and flexural strength of 5% replaced concrete are less but approximately similar to the ordinary mix.

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