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An Experimental Investigation of Structural Properties of Paper Pulp Based Concrete

Deepti Thakur
Roll No.:501405018006
Enrollment No.:AL2544
Shri Shankaracharya
Technical Campus,
Junwani, Bhilai (C.G.)

Abstract:- The use of Paper Pulp in concrete is relatively a new development in the world of concrete technology and lot of research must go in before this material is actively used in concrete construction. The previous studies suggested that Paper Pulp used in concrete is perfect example of make best from waste; the waste papers are fully utilized. In this study the various properties of Concrete made by Paper pulp based is done like Workability, W/C Ratio, Compressive strength, Tensile strength, Flexural Strength etc. for different grades of concrete. The investigation is based in the laboratory results obtained during the studies and the laboratory equipments and tools used are as per Indian Standard Provision and certified by the university which is used for consultancy purpose too. The locally available (near by the research Area) Paper Pulp used in this study which is found from the wastage. The Conclusion is further made after the study and graphs are drawn for two comparative grades of concrete.

Keywords:- *Workability, W/C Ratio, Compressive Strength, Tensile Strength, Flexural Strength.*

I. INTRODUCTION

Use of the industrial wastes in the construction work might lead to a finding the possibility to decrease the environment pollution by paper industry wastes and it will also bring down the cost of construction. The use of paper sludge in concrete used as an alternative to landfill disposal.

The dry paper sludge mainly contains silica and calcium oxide, followed by alumina and magnesium oxide. Cement mixed with 10% and 20% calcined paper sludge exhibits a small decrease in compressive strength than the ordinary Portland cement. A study on the reuse of paper de-inking sludge, undertaken in Spain, shows its potential as raw material for yielding a product with pozzolanic activity.

The compressive strength and drying shrinkage of concrete containing paper sludge were also comparable to the ordinary Portland cement when the proper amount of super plasticizer is mixed. Concrete containing an average of 15% paper sludge as fine aggregates had a lower 28-days compressive strength than the reference ordinary Portland cement.

Although there are potential advantages of including paper-mill residuals in a concrete mixture, such as cost savings in both waste management and concrete production, to date still lot of work has to be done on the utilization of paper pulp in concrete production. This thesis work summarized the behavior of concrete with the waste paper sludge by replacement of cement in the range of 5%, 10%, 15% and 20% which may helps to reduce the disposal problem of sludge and enhance the properties of concrete.

In 1987, Thomas, in his paper he made an attempt to prepare the composite concrete using the Portland cement and fibrous sludge from paper recycling plant. These composites were studied for potential use of wall boards, fire retarders and insulations. The paper sludge used in the experiment contained 55% cellulose fibres, 44% Kaolinitic clay and 1% ink and dyes.

Two methods of concrete mixing were devised. One method involved mixing the cement with dewatered sludge with 35% solid content. The other method was mixing the cement with wet sludge with 5% solid content. In both methods, the mixes were vacuum dewatered. Then it was filled in the 2 inches diameter pipe and was compacted with the vibration. For the compression test the specimen was cut into 4 inches length. The compressive strength was about four times. This was due to the improved dispersion of fibres.

For the flexural strength 2 inches deep and 1.5 inches wide beams were casted and tested under centre point flexural loading on a 10 inches span. The flexural strength was lower than the conventional mortar. The composite of cement and wet sludge showed a considerable load carrying capacity beyond cracking.

In 1997, Naik et. All, it was an attempt to study the use of pulp and paper mill residuals in concrete. In this study three sources of dewatered residuals were used. The two sources contained virgin cellulose fibres and one source was from recycled de-ink mill. The residuals were composed of moisture, wooden fibers, kaolin type clay, calcium carbonate and carbon. For the preparation, tilting mixer was used for mixing the ingredients. Pea gravel of 3/8 inches maximum size were used as a coarse aggregates and regular sand as a fine aggregate.

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Before mixing, the paper residuals were deflocculated. The amount of paper pulp residuals required for each concrete mixes were immersed in a high range water reducing admixture and water in a plastic bucket. It was assumed that the high range water reducing admixture would help deflocculate wooden fibres in the residuals. The slump of all the mixes falls between the 2.5 to 6.5 inches. The water cement ratio ranged between 0.39 to 0.52. The density of mixes containing residuals is equivalent to the mixes without containing residuals. The density of the residual concrete decreased with the increase of the residuals. This research was therefore dedicated to the development, the manufacture, and the engineering properties of the fresh and hardened paper pulp-based concrete.

II. PAPER SLUDGE BASED CONCRETE

In this project, waste paper pulp from pulp and paper mill industries is used as the partial replacement of the cement; zone-II sand is used as a fine aggregate and stone as a coarse aggregate to produce the concrete. The cement and paper pulp bind the loose coarse aggregates, fine aggregate sand other un-reacted materials together to form the concrete, with or without the presence of admixtures. The manufacture of concrete is carried out using the basic concrete technology methods. As in the case of OPC concrete, the paper pulp-based concrete, the aggregates occupy the 75-80% by mass. The mixture of coarse and fine aggregates was mixed thoroughly first, then cement is added and mixed thoroughly after that waste paper pulp is added to the mix and water is added and thoroughly mixed.

➢ *Objective of The Study*

The aims of this study were:

- To develop a mix proportion to manufacture paper sludge concrete.
- To identify and study the effect of replacing cement with other supplementary cementations materials like paper sludge that affects the properties of concrete.
- Fresh and hardened properties of paper sludge concrete,
- Water penetrability property for the paper sludge-based concrete.
- To study the durability characteristics of paper sludge-based concrete.

III. CONCRETE

An important ingredient in the conventional concrete is the Portland cement. Actual production of Portland cement contributes 13.5 billion tons of carbon dioxide per year (0.87 ton of carbon dioxide for each ton of produced cement) which is equivalent to 7% of the total global emission of carbon dioxide to the atmosphere. Paper sludge concrete is made out of waste material from paper industry therefore does not have an industry of it and does not contribute to carbon dioxide emissions. In the Portland cement production process a mixture of powdered raw materials requires heating to over 14000 C to obtain cement powder, with its corresponding high use of fuels. Paper sludge concrete, on the other hand, can be produced out of waste product of paper. In order to produce environmentally friendly concrete, Mehta (2002) suggested the use of fewer natural resources, less energy, and minimise carbon dioxide emissions. He categorized these short-term efforts as 'industrial ecology'. The long-term goal of reducing the impact of unwanted by-products of industry can be attained by lowering the rate of material consumption. Likewise, McCaffrey (2002) suggested that the amount of carbon dioxide (CO2) emissions by the cement industries can be reduced by decreasing the amount of claimed material in cement, by decreasing the amount of cement in concrete, and by decreasing the number of buildings using cement.

IV. WASTE PAPER PULP

The waste paper pulp used in this study was collected from Dhanlakshami Paper Mill, Dongargaon, Rajnandgaon, Raipur and Bilaspur which is then dried in oven and pulverized. Chemical analysis of the paper pulp has been done by using Energy Dispersive X-ray Fluorescence Spectrometer (XRF, Philips, PW 1840). Proximate and ultimate analysis of paper pulp has been carried out using gravimetric methods. X-Ray Diffraction pattern has been recorded on a model XRD-Philips X'Pert Pro with a scan rate of 2o /min. XRD pattern have been recorded in the 2θ range of 5o -100o . Thermogravimetric differential thermal analysis (TG-DTA) (Mettler, TA 4000) has been carried out to determine the thermal stability. Scanning electron micrograph photographs have been recorded using JEOL Model No JXA – 840 A, Japan. SEM images for paper pulp clearly indicate the presence of irregular pores and fibrous nature. The paper pulp holds the moisture in these pores and the fibrous envelops providing obstacle for moisture to move towards the surface. Fibrous nature gives very high energy absorbing ability and hence the high compressive strength. Paper pulp mainly contains Si (60%) and Ca (14%) (Table 2.1) depicting the XRF scan data. Table 2.2 gives the proximate analysis, and Table 2.3 presents an ultimate analysis.

➢ *Use of Paper pulp in concrete*

Use of paper sludge as a partial replacement for Portland cement. It can replace up to 5- 25% by mass of Portland cement, and can add to the concrete's final strength and increase its chemical resistance and durability. Development of this concrete successfully replaces the use of OPC in concrete up to 40% and yet possesses excellent mechanical properties with enhanced durability performance. Due to the use of paper pulp, it can also increase workability of cement till 10%. The replacement of Portland cement with paper pulp is considered by its promoters to reduce the greenhouse gas of concrete, as the production of one ton of Portland cement produces approximately one ton of CO2 as compared to zero CO2 being produced using waste paper pulp. It is used in many water front structures, concrete roads and roller compacted concrete dams. There is high potential for this material on account of sound economy and usefulness to absorb large quantity of underutilized.

➢ *Application of paper pulp-based concrete:*

Paper pulp-based concrete with properties such as abundant raw resource, less energy consumption, low production cost, high early strength, fast setting. These properties make paper pulp-based concrete find great applications in many fields of industry such as civil engineering, waste management, and art and decoration of buildings.

1. **Toxic waste treatment:** The components like phosphogypsum, florogypsum and red mud contain harmful impurities which adversely affect the strength and other properties of the building material based on them. Out of these wastes its paramount to use them in the construction.
2. **Civil Engineering:** It can set and harden at room temperature, and can gain reasonable strength in a short period. Some proportions of paper pulp-based concrete have been tested and proved to be successful in the field of low construction. They possess properties as hard surface, thermal stability, excellent durability and high acid resistance. Cement can be easily replaced by the paper pulp.
3**. Global warming and energy saving:** Energy plays a great role in growth of developing nations like India, availability of less non renewable energy sources combined the requirements of high energy for the building material like cement, the use of the industrial waste in this scenario cannot be underestimated. During the manufacturing of cement for the production of 1tonne cement we need around 1-1.5tonnes of natural resources. In addition, during the production of 1tonne cement equal amount of carbon dioxide is also produced.

V. MIXTURE PROPORTIONS

The specimens were 10x10x15 mm in size. The best compressive strength obtained was more than 33.53 MPa for mixtures that used paper pulp 30% for the replacement of cement, after curing the specimens for 28days.

Naik (1997) it was an attempt to study the use of pulp and paper mill residuals in concrete. In this study three sources of dewatered residuals were used. The two sources contained virgin cellulose fibres and one source was from recycled de-ink mill. The residuals were composed of moisture, wooden fibers, kaolin type clay, calcium carbonate and carbon. For the preparation, tilting mixer was used for mixing the ingredients. Pea gravel of 3/8 inches maximum size were used as a coarse aggregates and regular sand as a fine aggregate.

VI. APPLICATIONS OF PAPER SLUDGE CONCRETE

- The residuals from pulp and paper mill industries are very valuable ingredient for making durable concrete during harsh winters.
- This concrete can be used for construction of sidewalks, streets, parking lots, parking structures, highways, bridges, airfield pavements and industrial floors.
- This concrete can be used to the structures which are subjected to the cycles of freezing and thawing, often in the presence of a de-icing salt.
- The residuals can be used to slow down setting of fly ash slurry and can be used in the future.
- The residuals can be used for fast construction, maintenance and repair of underground pipes and bridge abutments.

VII. SOURCE MATERIALS

➢ *Physical Properties Of Paper Pulp*

Ash content: - It consists of various types of chemicals which were used during pulp extraction. It is the residue left after burning pulp at 525°C.

Coarseness of pulp: - It is the measure of average weight of fiber per unit length. It is a measure of cross sectional area for an average length fiber. The fine Fibers has good bonding property as compared to coarse fibers. In addition to that coarser fibers also result in fewer fibers per mass of pulp.

Conductivity: - Iron ion presence in the pulp contributes to conductivity. Pulp used for electrical purpose is too cleaned with demineralized water. Non metallic bars and contacting surfaces of all equipment are made of stainless steel.

Drainage time: - Drainage property of pulp gives an idea about fiber length of pulp, damage happened to the fiber during pulping process and energy required to achive slowness during stock preparation.

Consistency: -If the consistency of pulp is higher it will require minimum water. It will also help in decrease in use of chemicals.

Moisture content: - Most of the pulp in the market are air dry. Wet lap is not dried at source at transported at 50% moisture content.

Fiber diameter: - The effect of fiber diameter directly affect the fiber flexibility.

Fiber length of pulp: - Pulp strength is directly promotional to fiber length and dictates is final use. It is good to blend short fiber with long fiber to optimize fiber cost and strength.

Fiber strength: - It is an intrinsic property of an individual fiber. It is an indication of maximum strength obtained from a pulp.

Fines content: - The percentage of fines consist of particles measuring less than 0.2mm in length.

Yield: - It depends on pulping process. Mechanical processes which provide high yield retain almost all constituent of wood. Lignin does not bond to itself don't and doesn't contribute to any bonding resulting in weak pulp.

Tensile strength of pulp: - It is an indication of maximum possible strength which we can get when pulp is be atom under ideal condition. It is higher than or equal to steel.

➢ *Chemical Properties Of Paper Pulp*

Extractives: - Lower the carbohydrate shows cellulose degradation during pulping; it will affect the pulp strength and other properties.

Specific refining energy: - The higher the value leads to good formation of strength and plenty of inter fiber surfaces

Viscosity of pulp: - It gives the estimate of average degree of polymerization of the cellulose fiber.

Zeta potential: - It tells us about the electrical interaction between the particle high value of zeta potential prevents flocculation change in zeta potential affect the strength and admixture requirement.

VIII. EXPERIMENTAL PROGRAM

➢ *Materials*

Paper Pulp: In this thesis work an attempt is made to produce the concrete specimens constituting calcined source material (waste paper pulp). Curing for the specimens is carried out at room temperature. The paper pulp used in the experiment is taken from Dhanlakshmi paper mill, Dongargaon, Rajnandgaon, Raipur and Bilspur.

➢ *Fine Aggregate and Coarse Aggregate*

Zone-II sand was considered for work and the properties of zone-2 and machine crushed stone used as coarse aggregate. The size of aggregate varies from 20mm to 4.75mm.

Fineness modulus of fine aggregate: 3.10
Fineness modulus for coarse aggregate: 7.15

Specific gravity for fine aggregate: 2.62
Specific gravity for coarse aggregate: 2.8

➢ *Water*

Portable water supplied by the college was used in the work. The pH of water around 6.5- 7.

Specimens	Dimensions (mm)	Number of specimens casted for OPC M20 & M25	Purpose
Cubes	150x150x150	3+3	Compressive strength, Durability
Cylinders	150 ϕ and 300 height	3+3	Splitting tensile strength and determining the Modulus of Elasticity.
Prisms	100x100x500	3+3	Flexural strength

Specimens	Dimensions (mm)	Number of specimens casted for PPC M20 grade of concrete				Purpose
		5	10	15	20	
Cubes	150x150x150	3	3	3	3	Compressive strength, Durability
Cylinders	150 ϕ and 300 height	3	3	3	3	Splitting tensile strength and determining the Modulus of Elasticity.
Prisms	100x100x500	3	3	3	3	Flexural strength

Specimens	Dimensions (mm)	Number of specimens casted for PPC M25 grade of concrete				Purpose
		5	10	15	20	
Cubes	150x150x150	3	3	3	3	Compressive strength, Durability
Cylinders	150 ϕ and 300 height	3	3	3	3	Splitting tensile strength and determining the Modulus of Elasticity.
Prisms	100x100x500	3	3	3	3	Flexural strength

Table 1:- Number of Specimens casted for OPC and PPC M20& M25 Grade Concrete

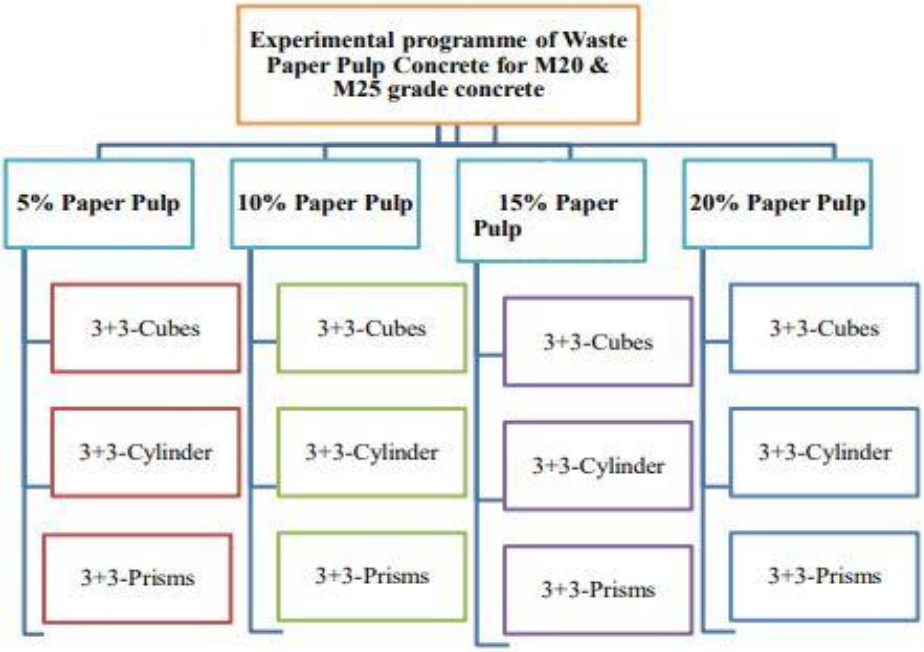

Fig 1: -Experimental Programme

IX. CONCLUSIONS

From a paper-based research study developed in the concrete research area, it has come to the following conclusion.

1. The amount of slump up to 5% instead of the amount of slump increased by 5%.
2. The composting of the waste paper concrete, has10% and 15% paper waste, showed a 6% decrease. In addition when the volume of paper waste did not increase by 20%, the price of paper dropped by 12%.
3. The compressive strength, which separates the tensile strength and the tensile strength until it is increased by 10% cement with a drop sheet after which it gradually decreases.
4. Competitive power decreased by 2.1% after replacing 20% cement with paper pulling.
5. Replacement of cement with 5 to 10% waste paper shows ideal results.
6. Waterproofing of concrete cubes containing 10%, 15% and 20% waste paper has increased by 0.1%, 0,2% and 0.4%.
7. It will help to address the issue of waste disposal in the paper industry and in addition will also help to arrange green concrete.
8. The mass of concrete mix with 10% and 15% of paper waste increased by 0.5% and 0.2% respectively compared to controlled mix but decreased by 0.1% by 20% of paper waste.
9. It can be concluded that the use of 10% of waste paper waste, concrete mixing can be easily allowed.
10. The cost of concrete production, compared with mixed control decreases by 1.7%, 2.4% and 3.2% with the addition of 10%, 15% and 20% waste paper respectively.

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