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PULP BLACK LIQUOR AS AN ADMIXTURE IN CONCRETE

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Abstract - *Concrete plays a major role in the field of construction. The main composition of concrete is cement, coarse aggregate, fine aggregate and water. One major challenge facing the civil engineering community is to execute projects in harmony with nature using the concept of sustainable development involving the use of high performance, environment friendly materials produced at reasonable cost. Nowadays to improve the characteristics of concrete, addition of admixture to the concrete is widely used. Here in this project, we introduce easily available and cost effective admixture pulp black liquor (PBL), a byproduct from paper industry. The continuous discharge of pulp black liquor to the land will cause serious environmental issues. So by adding pulp black liquor to concrete as an admixture, can reduce environmental issues and improve the properties of concrete like workability, compressive strength and split tensile strength.*

Key Words: Concrete, Admixture, PBL, Metakaolin.

1. INTRODUCTION

Concrete is a composite material composed of coarse aggregates and filler materials embedded in a hard matrix of material (the cement or binder) that fills the voids between the aggregate particles and glues them together. Here we should indicate that admixtures are almost always used in modern construction practice and thus become an essential component of modern concrete. Admixtures are defined as materials other than fine and coarse aggregate, water, fibre and cement, which are added into concrete batch immediately during or before mixing. Due to the increased demand it is necessary to find a low cost admixture.

The pulp black liquor, a waste product from paper industry which has low viscosity and high solubility and it is readily available; due to these factors we are trying to use it as an admixture in concrete. Black liquor is used as an important liquid fuel in the pulp and paper industry. It consists of the remaining substances after the digestive process where the cellulose fibres have been separated out from the wood. Lignin is the major ingredient in pulp black liquor, which is the material in trees that binds wood fibres together and makes them rigid, and which must be removed from wood fibres to create paper.

Fig .1: Pulp Black Liquor

1.1 Objectives

- To develop Pulp Black Liquor(PBL) modified concrete by introducing pulp liquor produced during the pulping process in paper industry.
- To study the effect of PBL in the properties of ordinary concrete.
- To find the optimum dosage of Pulp Black Liquor.
- Compare the result obtained from PBL modified concrete and with the concrete incorporate with metakiolin.

2. EXPERIMENTAL INVESTIGATION

2.1 Materials Used

- The waste of pulp black liquor from paper industry was provided by Canara Paper Mill, Changanassery.
- OPC 53 grade cement.
- M sand as fine aggregate.
- 20mm size coarse aggregate.
- Metakaolin from Astra Chemicals, Chennai.

2.2 Properties of Material

The physical properties of cement, fine aggregate, coarse aggregate are tabulated in table 1.

Table 1: Physical properties of material

Sl . no	Property	Results obtained
1	Specific gravity of cement	3.19
2	Specific gravity of fine aggregate	2.64
3	Specific gravity of coarse aggregate	2.69
4	Water absorption of coarse aggregate	0.5%
5	Fineness modulus of fine aggregate	3.78
6	Fineness modulus of coarse aggregate	3.05

2.3 Preparation of specimen

For M25 grade concrete

Water cement ratio = 0.47

Cement: Sand: Coarse aggregate: water = 1 : 1 : 2 : 0.47

Sum of proportions by weight = 4.47

Table 2: Quantity of material

	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water content (kg)
For 1m^3	536.9	536.8	1073.8	252.3
For 1 cube	2.08	2.08	4.16	0.98
For 1 cylinder	3.28	3.28	6.55	1.54

2.4 Tests on Specimen

(i) Slump test

The slump test was carried out as per IS 1199:1959, to study the workability of concrete in the laboratory during the progress of the work or in the field and to check the uniformity of the concrete from batch to batch. Apparatus used are mould for slump test, non porous base plate, measuring scale, tamping rod etc. The mould for the test was in the form of frustum of the cone having height 30cm, bottom diameter 20cm and stop diameter 10 cm, which shown in Fig.2. The tamping rod of steel 16mm diameter and 60mm long and rounded at one end. The IS specifications for slump test as per IS 456:2000 are shown in table 3.

Fig .2: Slump test

Table 2: IS Specifications for Slump Test (IS 456 :2000)

Degree of Workability	Slump Value (mm)
Very low	< 25
Low	25 – 75
Medium	50 – 100
High	100 – 150
Very High	> 150

(i) Compressive strength test

Compressive strength is the ability of material or structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size, while in tension, size elongates.Compressive strength of concrete cube test provides an idea about all the characteristics of concrete.

By this single test one judge that whether concreting has been done properly or not. Concrete compressive strength for general construction varies from 15 MPa to 30 MPa and higher in commercial and industrial structures. Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, quality control during production of concrete etc. Compressive strength was measured on hardened concrete with a calibrated hydraulic press according to the ECP using concrete cubic specimens of 150 mm side length.

Fig.3: Compression testing machine

(ii) Tensile strength test

The tensile strength of concrete is one of the basic and important properties which greatly affect the extent and size of cracking in structures. Moreover, the concrete is very weak in tension due to its brittle nature. Hence, it is not expected to resist the direct tension. So, concrete develops cracks when tensile forces exceed its tensile strength. Therefore, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack.Furthermore, splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. Test for splitting tensile strength was carried out in compression testing machine. The test setup is shown in Fig.4.

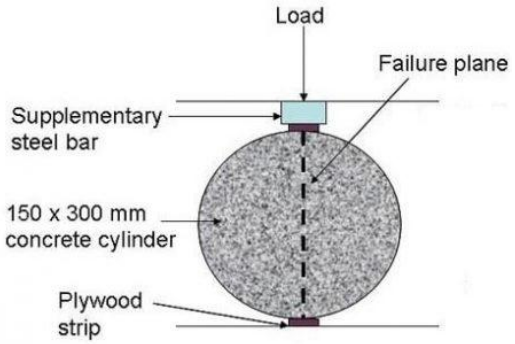

Fig.4: Loading arrangement of split tensile strength test

3. RESULTS AND DISCUSSION

3.1 Slump Test

Concrete slump test or slump cone test is to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progress of the work. The Fig. 4 shows the effect of the addition of the bamboo black liquor on concrete slump. Workability of the concrete mixes with 0%, 0.5%, 1.0%, 1.5% and 2% replacement of water with black liquor was determined.

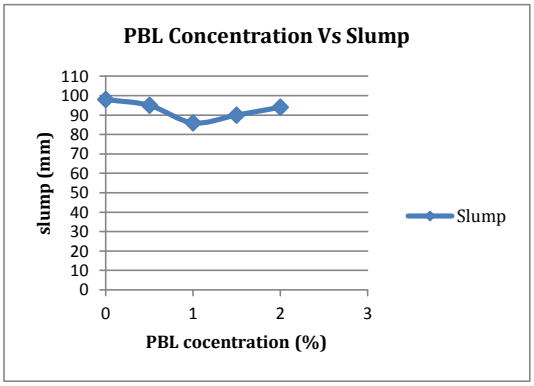

Fig.5: Variation in workability

The black liquor acts as a dispersing agent by neutralizing the electrostatic charges of the concrete mixture, especially the cement. This neutralization minimizes agglomeration of the solid particles allowing them to mix better with water. This will increase workability. The amount of paper pulp replacement, paper pulp physical properties and the carbon content of the paper pulp would be the main reasons for the reduction of concrete workability.

3.2 Compressive Strength Test

(i) PBL used as admixture in concrete

Concrete mix with varying concentration, 0%, 0.5%, 1.0%, 1.5% and 2.0% of PBL admixtures are tested. Fig.6 represents the effect of using bamboo black liquor on the compressive strength of concrete.

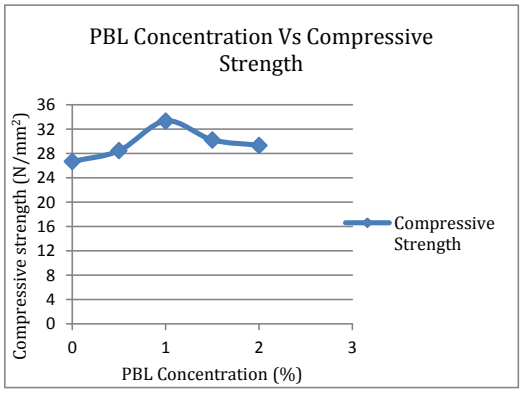

Fig.6: Variation of compressive strength with PBL after 28 days

Increasing the black liquor amount above a certain limit may reduce concrete compressive strength due to the extra amount of the charged ions that may recharge the solids again reducing their ability to mix with water. Hence, both

the slump and the compression strength will start to decrease with the extra increase in the black liquor amount above a maximum value At 1% black liquor replacement, the maximum compressive strength obtained after 28 day curing is 33.33 MPa, which is more than the compressive strength of M25 grade conventional concrete

(ii) Metakaolin used as admixture in concrete

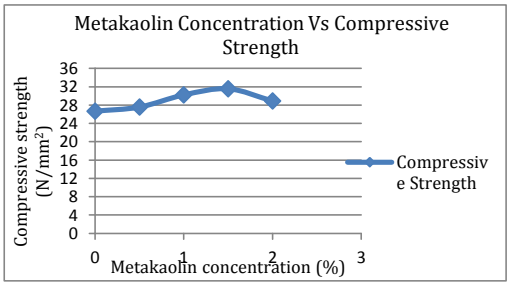

Fig.7: Variation of compressive strength with Metakaolin after 28 days

When we test the concrete cubes with varying concentration of metakaolin admixture, an increasing compressive strength was observed up to 1.5 % addition of metakaolin. The maximum compressive strength obtained is 30.22MPa.

3.2.1 Comparison of Compressive Strength

In this project work, the compression test on concrete was carried out by adding PBL admixture and metakaolin admixture sepparately. The comparative study of PBL modified concrete with conventional concrete and metakaolin modified concrete are shown in Fig.7. After the study it is revealed that about 1% PBL admixture improves the compressive strength of the M25 grade concrete to 33.33 MPa. Which will be greater than the compressive strength of conventional concrete as well as the metakaolin modified concrete? The conventional concrete is represented by CC, and the compressive strength obtained is about 26.67 MPa. At the same time the maximum compressive strength of 30.22 MPa achieved at 1.5% of metakaolin is added to the mix. This is more than the conventional concrete. But, less than the PBL modified concrete.

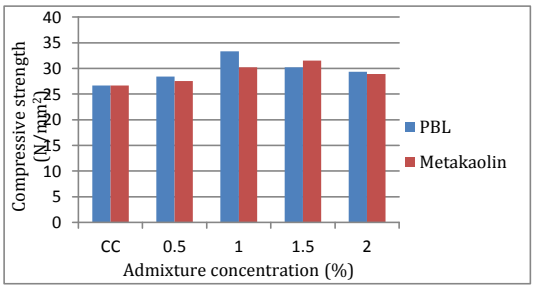

Fig.8: Comparison of compressive strength

3.3 TENSILE STRENGTH TEST

(i) PBL used as admixture in concrete

The cylindrical specimen with varying concentration of PBL admixture was subjected to a sustained varying tensile force until their ultimate load carrying capacity or failure of specimen. It can be observed that the tensile strength is increases from 3.68 MPa to 5.66 MPa.

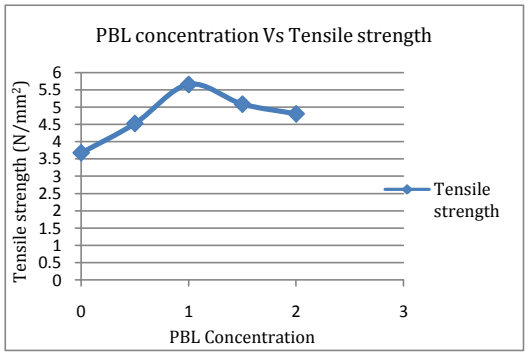

Fig.9: Variation of tensile strength with PBL concentration

(ii) Metakaolin used as admixture in concrete

The test was carried out to obtain split tensile strength of M25 grade concrete. The split tensile strength of concrete is tested for 28 days for 0%, 0.5%, 1%, 1.5% and 2% replacement of metakaolin The maximum tensile strength of 4.95 MPa is achieved when about more than 1.5 % of metakaolin is added to the concrete mix.

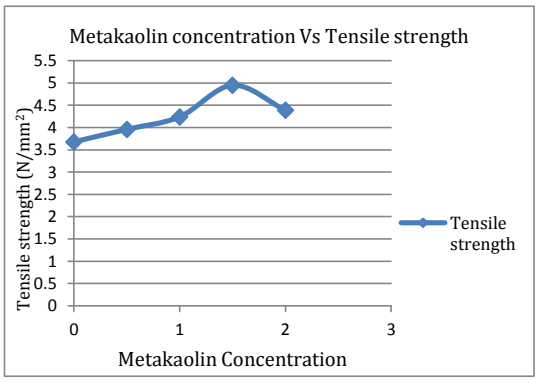

Fig.10: Variation of tensile strength with Metakaolin concentration

3.3.1 Comparison of Tensile Strength

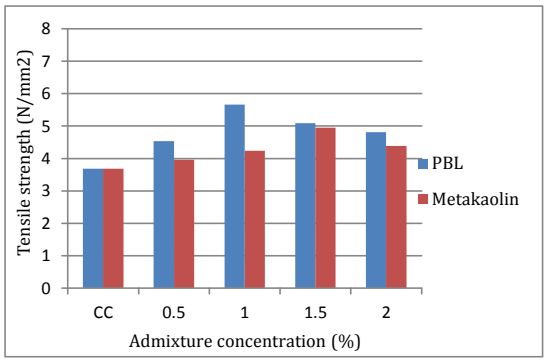

Fig.10: comparison of split tensile strength

Fig.10 shows the variation of splitting tensile strength Vs concentration of admixture. In this project, we are carried out a comparative study on strength of PBL modified concrete with conventional concrete and also with metakaolin modified concrete. In the case of mixing 1% of PBL in concrete, the splitting tensile strength having higher value of 5.66MPa when compared with CC.

4. CONCLUSIONS

The project work consists of testing concrete cubes and cylinders to understand the performance of compressive strength and tensile strength with varying percentage of PBL admixture and metakaolin admixture. Based on the investigations, the following conclusions have been drawn:

(i) It is inferred from the studies that the initial setting time is greater than 30 minutes and decreases with addition of PBL when compared with normal practice.

(ii) The main reason for reduction of workability may be attributed to the quantity of PBL applied and its physical properties and carbon content.

(iii) The study clearly revealed that the application of 1% PBL admixture improves the compressive strength of M25 grade concrete to 33.33 MPa. This combination clearly indicates increase in compressive strength above than that of conventional concrete and metakaolin modified concrete. This shows the positive effect of pulp black liquor on the properties of concrete.

(iv) The addition of PBL waste to cement led to the formation of electrostatic repulsive forces between cement particles and in turn the adsorption of the liquor waste onto the cement surface which reduces the inter particle attraction between the cement particles and helps to enhance the compressive strength.

(v) It can be observed that split tensile strength increases with increasing replacement of PBL admixture upto 1% give maximum tensile strength. The tensile strength is inceases from 3.68 MPa to 5.66 MPa.

(vi) The maximum tensile strength obtained when metakaolin is used as admixture is 4.95MPa, which is greater than the conventional concrete. But, it is lower when PBL is used as admixture in concrete.

(vii) The pulp black liquor waste activates the cement phase and improves the rate of hydration. There was an increase in water absorption of the concrete mixes as the content of the paper pulp increased. This phenomenon is expected since more amount of paper pulp in term of quantity will involve in the hydration process.

(viii) Metakaolin is an another locally available admixture. Since, the cost is high when compared to the PBL and require large quantity to meet the required strength of the concrete. Hence , it is concluded that the PBL admixture is most effective and economically viable and technically feasible to improve the properties of concrete.

(ix) It is finally concluded that the use of black liquor produced by M/S Canara Paper Mill in Changanassery, as a partial replacement for mixing water improved workability, compressive strength, tensile strength and setting time without harmful effects on concrete durability.

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