

Utilisation of Pulp Black Liquor as An Admixture in Concrete

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Abstract: Concrete is very important construction material. The main composition of concrete is cement (OPC), coarse aggregate (blasted rubble), fine aggregate (sand) and water. This study aims to introduce a low cost admixture which is a waste product from paper industry which are disposed to water resources and causing serious environmental problems .So, by incorporating PBL to concrete pollution can be reduced and the properties of concrete can be improved. Here we are trying to study the effect of pulp black liquor (PBL) as an admixture in concrete. The investigation is made by using the pulp black liquor from Hindustan Newsprint Limited Vellore (HNL). The properties of pulp black liquor and its performance on concrete with three different design mixes and setting times of cement (OPC) were observed. The results shows that pulp black liquor increases the strength of concrete, improves compaction, reduces honey combing and retards the initial setting time and final setting time of concrete.

Keywords: PBL, OPC, HNL, Admixture.

I. INTRODUCTION

Concrete is the second most consumed material in the world. The versatility and mould ability of this material, its high compressive strength ,and the discovery of the reinforcing and pre stressing techniques which help to make up for its low tensile strength have contribute largely to its widespread use .We can rightly say that we are in the age of concrete .Concrete is a side made material unlike other materials of construction and as such can vary to a very great extend in its quality, properties and performance owing to the use of natural materials except cement.

Admixture is defined as a material, other than cement, water and aggregates that is used as an ingredient of concrete and is added to the batch immediately before or during mixing. These days concrete is being used for wide varieties of purposes to make it suitable in different conditions .In these conditions ordinary concrete may fail to exhibit the required quality performance or durability. In such cases, admixture is used to modify the properties of ordinary concrete so as to make it more suitable for any situation.

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 an important liquid fuel in the pulp and paper industry. It consists of the remaining substances after the digestive process where the cellulose fibers have been cooked out from the wood. One of the main ingredients in black liquor is lignin, which is the material in trees that binds wood fibers together and makes them rigid, and which must be removed from wood fibers to create paper.

The organic admixtures induce physical effects which modify the bond between particles and can act on the chemical processes of hydration particularly on the nucleation and crystal growth. Accordingly the black liquor constitutes a new and promising admixture.

II. EXPERIMENTAL DETAILS

A. Raw Materials

- The waste of pulp black liquor from paper industry was provided by Hindustan newsprint limited, Vellore.
- OPC 43 Grade cement
- 20 mm aggregates

B. Tests and Results

Mainly two properties of concrete were studied, compressive strength and setting time of concrete. For the analysis of compressive strength, cubes and beams of different design mixes were casted with different percentages of pulp black liquor such as 0,1,2,3 percentages.

Design mixes of M20, M25, and M30 were prepared with a water cement ratio 0.42

Table I. Mix Proportion M20

Cement	360kg/m ³
Fine Aggregate	711kg/m ³
Coarse Aggregate	1282kg/m ³
Water Cement Ratio	0.42

Table II. Mix Proportion M25

Cement	380kg/m ³
Fine Aggregate	697kg/m ³
Coarse Aggregate	1258kg/m ³
Water Cement Ratio	0.42

Table III. Mix Proportion M30

Cement	400kg/m ³
Fine Aggregate	684kg/m ³
Coarse Aggregate	1234kg/m ³
Water Cement Ratio	0.42

Table IV. Analysis of Pulp Black Liquor

SL NO.	PARTICULARS	UNITS	CP BLACK LIQUOR
1	pH	--	11.7
2	Tw at 30° C	--	5.5
3	Total solids	%	7.03
4	RAA as Na ₂ O	Gpl	1.12
5	TTa as Na ₂ O	Gpl	17.36
6	NaOH as Na ₂ O	Gpl	1.24
7	Na ₂ S as Na ₂ O	Gpl	1.24
8	TAA as Na ₂ O	Gpl	2.48
9	Na ₂ CO ₃ as Na ₂ O	Gpl	14.88
10	In organics ,as such	%	41.5
11	Inorganics,as NaOH	%	33.6
12	Calorific value	Cals./g	3240
13	Acid insolubles	Gpl	0.11
14	Silica	Gpl	0.10
15	R ₂ O ₃	Gpl	0.08
16	Calcium as CaO	Gpl	0.32
17	Magnesium as MgO	Gpl	0.19
18	Sulphate as Na ₂ SO ₄	Gpl	0.64
19	Total sodium as Na	Gpl	13.6
20	Potassium as K	Gpl	0.12
21	Chloride as NaCl	Gpl	1.22

C. Compressive strength Analysis

In order to analyze the compressive strength, concrete cubes (15x15x15cm) and flexural beams were casted in different mixes (M20, M25, M30) by adding 0,1,2,3 percentages of PBL. Compressive strength was tested in 7 days and 28 days.

Table V. 7th Day Compressive Strength of M20 Concrete

Concrete mix	% of pulp black liquor added	Specimen no	Compressive strength(N/mm ²)	Average 7 day compressive strength(N/mm ²)
M20	0	1	13.5	13.18
		2	12.8	
		3	13.25	
	1	1	19.5	19.42
		2	19.71	
		3	19.04	
	2	1	29.25	28.66
		2	28.01	
		3	28.72	
	3	1	14.81	15.14
		2	15.6	
		3	15.02	

Table VI. 28th Day Compressive Strength Of M20 Concrete

Concrete mix	% of pulp black liquor added	Specimen no	Compressive strength(N/mm ²)	Average 28 th day compressive strength(N/mm ²)
M20	0	1	19.5	19.5
		2	19	
		3	20	
	1	1	29	28.93
		2	29.2	
		3	28.6	
2	1	43.1	42.55	
	2	41.4		
	3	42.55		
M20	3	1	25.8	29.58
		2	32.7	
		3	30.25	

Graph I

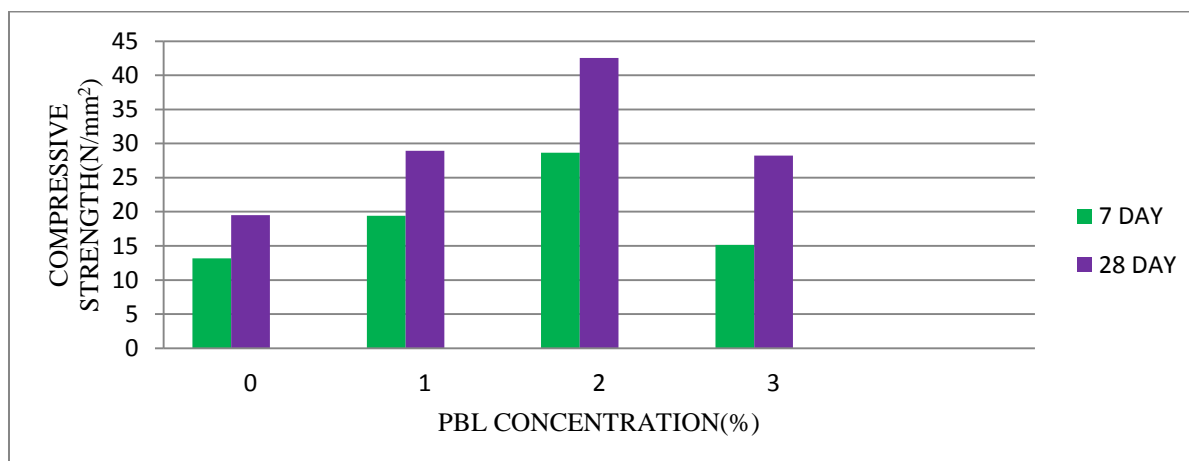


Table VII. 7th Day Compressive Strength Of M25 Concrete

Concrete mix	% of pulp black liquor added	Specimen no	Compressive strength(N/mm ²)	Average 7 day compressive strength(N/mm ²)
M25	0	1	17.51	17.17
		2	16.93	
		3	17.08	
	1	1	25.40	25.37
		2	25	
		3	25.7	
	2	1	20.15	20.12
		2	19.86	
		3	20.36	
	3	1	18.40	18.8
		2	19.36	
		3	18.71	

Table VIII. 28th Day Compressive Strength Of M25 Concrete

Concrete mix	% of pulp black liquor added	Specimen no	Compressive strength(N/mm ²)	Average 28 th day compressive strength(N/mm ²)
M25	0	1	26.2	29.84
		2	35.8	
		3	27.51	
	1	1	37.5	37.25
		2	36.8	
		3	37.46	
	2	1	30.4	30.33
		2	30.53	
		3	30.05	
	3	1	35	35.6
		2	36.1	
		3	35.72	

Graph II

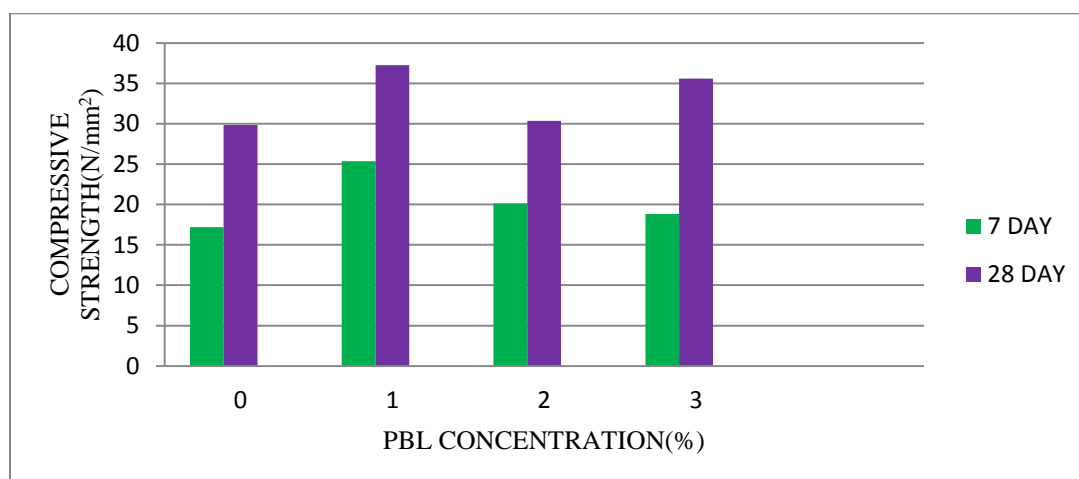


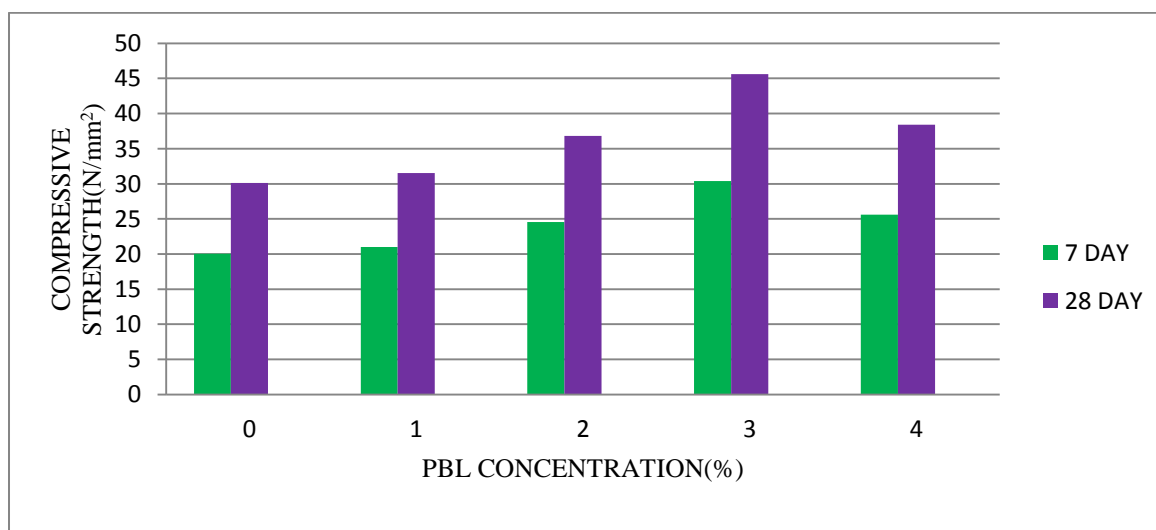
Table IX. 7th Day Compressive Strength Of M30 Concrete

Concrete mix	% of pulp black liquor added	Specimen no	Compressive strength(N/mm ²)	Average 7 th day compressive strength(N/mm ²)
M30	0	1	19.67	20.06
		2	20	
		3	20.53	
	1	1	20.64	21.01
		2	20.8	
		3	21.6	
	2	1	24.55	24.54
		2	25.58	
		3	23.5	
	3	1	28.92	<u>30.4</u>
		2	30.41	
		3	31.87	
4	1	25.86	25.62	
	2	25		
	3	26		

Table X. 28th Day Compressive Strength Of M30 Concrete

Concrete mix	% of pulp black liquor added	Specimen no	Compressive strength(N/mm ²)	Average 28 th day compressive strength(N/mm ²)
M30	0	1	30.8	30.1
		2	29.5	
		3	30	
	1	1	30.96	31.52
		2	31.2	
		3	32.4	
	2	1	36.82	36.8
		2	38.37	
		3	35.25	
	3	1	43.38	<u>45.6</u>
		2	45.62	
		3	47.8	
4	1	38.8	38.4	
	2	37.5		
	3	39		

Graph III. Compressive strength vs PBL Concentration M30 Mix

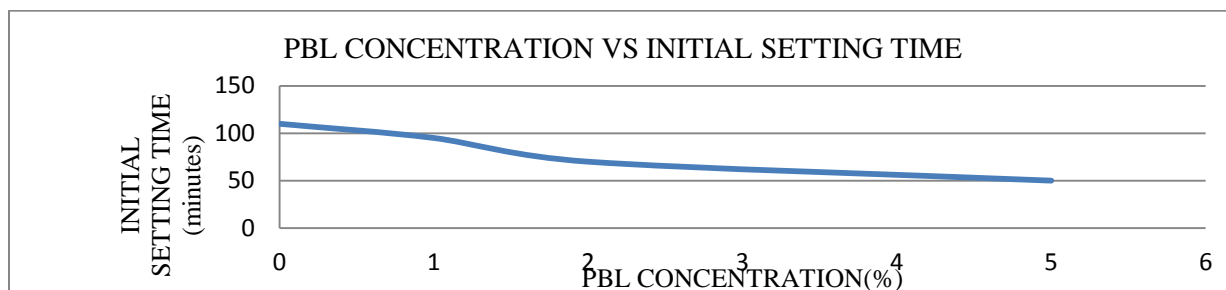


D. Initial Setting Time

Table XI

PBL Concentration	Initial Setting Time(Minutes)
0%	110
1%	95
2%	70
5%	50

Graph IV



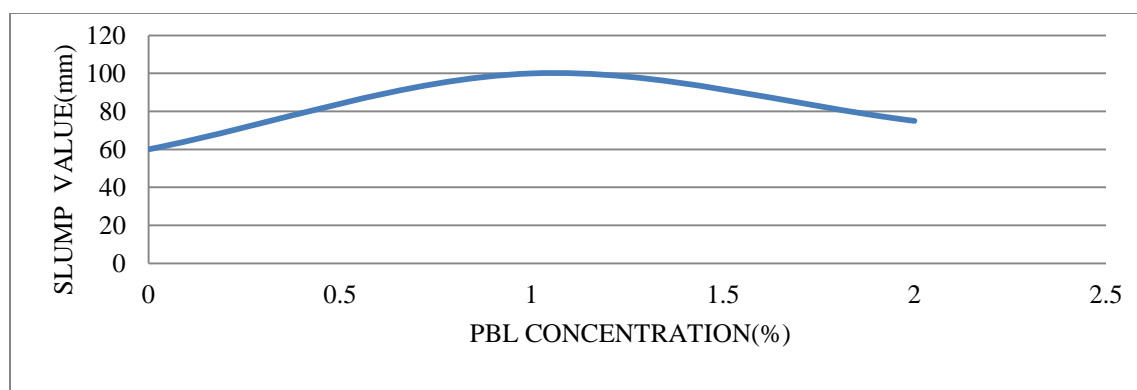
E. Workability

FOR M20 CONCRETE

Table XII

PBL Concentration(%)	Initial Reading(cm)	Final Reading(cm)	Slump Value(mm)
0	15	21	60
1	15	25	100
2	15	22.5	75

Graph V. Pbl Concentration Vs Slump Value

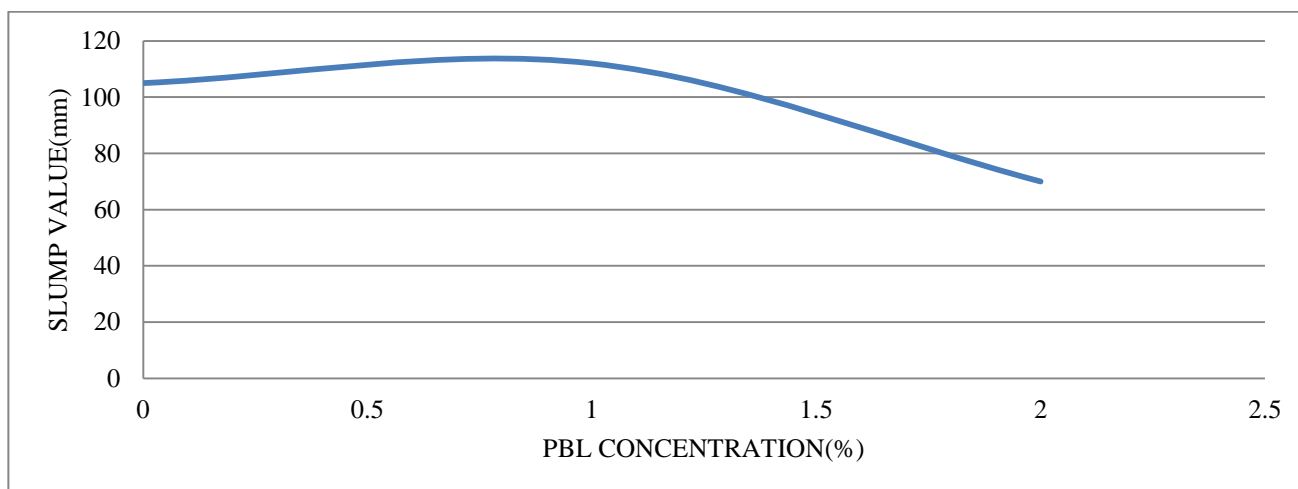


FOR M25 CONCRETE

Table XIII

PBL Concentration(%)	Initial Reading(Cm)	Final Reading(Cm)	Slump Value(Mm)
0	15	25.5	105
1	15	26.2	112
2	15	22	70

Graph VI. Pbl Concentration Vs Slump Value

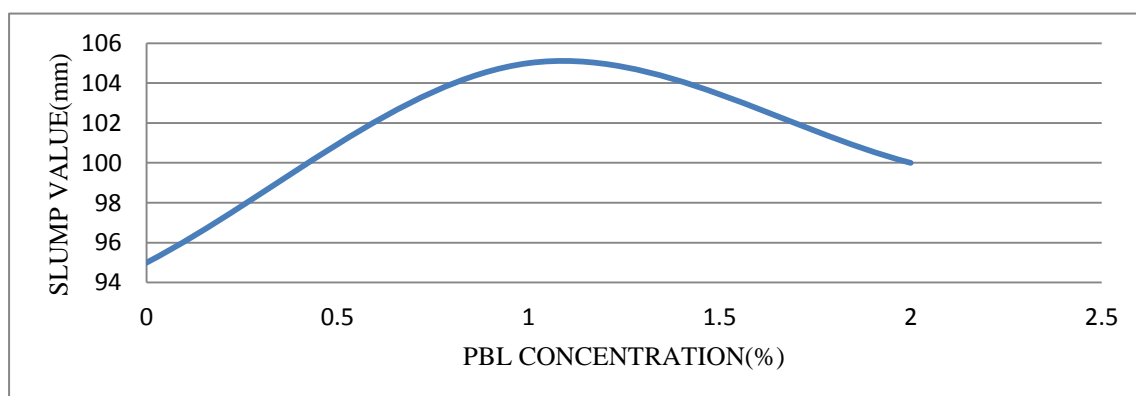


FOR M30 CONCRETE

Table XIV

PBL Concentration(%)	Initial Reading(cm)	Final Reading(cm)	Slump Value(mm)
0	15	24.5	95
1	15	25.5	105
2	15	25	100

Graph VII. Pbl Concentration Vs Slump Value



D. Discussions

The slump value and initial setting time were plotted .It is found that the slump value gradually increases with PBL concentration up to 1% and then decreases.

As the PBL concentration increases the initial setting time decreases. Hence it could be concluded that the PBL waste can act as an accelerator for cement paste.

The compressive strength of concrete depends upon the concentration of PBL, it increases up to a certain concentration and then decreases. The optimum concentrations of PBL for the mixes are different due to the difference in their mix design. The rate of increase of compressive strength is more in lower mixes than the higher mixes.

III. CONCLUSION

The use of black liquor produced by the pulp and paper industry in HNL Vellore is investigated. Black liquor is considered as a low cost admixture to increase the workability and retard setting of concrete. The results of this research show that black liquor noticeably increases the workability of concrete. The PBL waste activates the cement phase and improves the rate of hydration. The incorporation of PBL with OPC decreases the setting time, so it can be used as an accelerator. The compressive strength is also increased up to certain concentration of PBL beyond this concentration, it adversely affects the cement characteristics. The activation effect of the PBL increases the rate of hydration which enhances the cementing characteristics of hardened cement paste. This often has a positive effect on the mechanical properties. It is finally concluded that the use of black liquor produced from the HNL Vellore can be used as an admixture with improved workability, compressive strength, and setting time.

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