

Use of Lime Sludge and Pulp Black Liquor in Concrete

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ABSTRACT

Concrete is one of the most important used construction materials all over the world. Concrete is the mixture of cement sand and aggregate. The availability of this material is being reduced day by day which results in high cost of construction. In this project, we have used waste material from the BGPPL (paper industry) i.e. lime sludge and pulp black liquor as this both material are directly disposed in the water resources or on the land, it creates pollution. We have aimed to introduce both this material PBL and lime sludge. Lime sludge is used as replacement to the cement as it has similar properties as cement. Pulp black liquor is used as an admixture in concrete. Various parameters of concrete such as compressive strength, tensile strength and workability are being investigated in this project.

Keywords/ Index Term—Lime Sludge, Pulp Black Liquor (PBL)

1. INTRODUCTION

The huge quantity of concrete is consumed by construction industry all over the world. In India, the conventional concrete is produced by using natural sand, cement, coarse 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. In the context of concrete, which is the predominant building material, it is necessary to identify less expensive substitutes.

Paper and pulp industry in India is generating nearly 0.8 million tonne of lime sludge that too only in organized sector. Currently installed capacity for paper manufacture in India is about 4.6 MT out of its 380 paper mills scattered throughout the country. Out of 380 plants 32 plants are in the large scale sector and the rest in medium and small scale sector. Pulp and paper mill generate materials that may be harmful to the air, water and land. Pulp and paper processes generate large volume of wastewater which might adversely affect freshwater or marine ecosystem. Residual wastes from wastewater treatment process may contribute to existing local and regional disposal problems and air emission from pulping processes

and power generation facilities may release odour, particulates and other pollutants.

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. In this project the effect of PBL on concrete with replacing lime sludge to cement is to be studied.

1.1 Concrete

Cement concrete is a mixture of coarse aggregate, fine aggregate, cement and water in a certain proportion so as to make concrete of a desired quality.”

1.2 Pulp black liquor:

Admixture is defined as a material, other than cement, water and aggregates that is used as an ingredient of concrete and is added to improve the properties of concrete. 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 is a waste product from paper industry, it 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.

1.4 Lime sludge:

In order to make concrete industry sustainable, the use of waste materials in place of natural resources is one of the best approaches. Paper mill sludge is a major economic and environmental problem for the paper and board industry. An enormous quantity of waste paper sludge is generated all around the world. In India, 0.7% of total urban waste generated comprises of paper sludge. UK produces over 1.5 million tons of waste paper sludge annually. Paper mill sludge is a major economic and environmental problem for the paper and board industry. The material is a by-product of the de-inking and re-pulping of paper. The main recycling and disposal routes for paper sludge are land-spreading as agricultural fertilizer.

2. SCOPE & OBJECTIVE

- To find out the optimum replacement of lime sludge to cement in concrete.

- To find out the percentage of admixture as black pulp which gives the optimum strength of concrete?
- To compare the result of various percentage of replacement with adding admixture PBL.
- To gives the proportion which produce the low cost concrete.
- To study about PBL as a replacement to water in concrete.
- To study about the effect of combine use of lime sludge and PBL on concrete.

3. METHODOLOGY

3.1 Testing on materials

1.Cement :

- Consistency of cement
- Fineness of cement
- Initial setting time
- Final setting time

2.Lime sludge:

- Fineness of lime sludge
- Water absorption

3.Sand:

- Fineness modulus
- Specific gravity of sand

4.Coarse aggregate:

- Fineness modulus
- Specific gravity
- Impact value test
- Absorption value test

4. RESULTS & DISCUSSION

- Flakiness and Elongation test

3.2 Mix design proportion (as per IS-10262)

3.3 Preparation of Mix using following criteria;

1.Replacing cement with lime sludge

- 10%
- 20%
- 30%
- 40%

2.Replacing with PBL water

- 1%
- 2%
- 3%
- 4%

3.Replacing cement with lime sludge and PBL as a admixture

- 10% & 1%
- 20% & 2%
- 30% & 3%
- 40% & 4%

3.4 Testing of Concrete

1.Compressive test

2.Workability test

4.1 Compressive strength of concrete after replacing cement with lime sludge. (For 7 days)

% Replacement	Sr. No	Loading (KN)	Compressive Strength (N/mm ²)	Average Strength (N/mm ²)
0	1	164	7.28	7.61
	2	180	8	
	3	170	7.55	
10	1	167	7.42	9.91
	2	220	9.77	
	3	282	12.53	
20	1	254	11.28	10.41
	2	205	9.11	
	3	226	10.04	
30	1	165	7.33	8.81
	2	184	8.17	
	3	246	10.93	
40	1	209	9.28	8.81
	2	206	9.15	
	3	180	8	

Table No.4.1

4.2 Compressive strength of concrete after replacing cement with lime sludge. (For 28 days)

% Replacement	Sr. No	Loading (KN)	Compressive Strength (N/mm ²)	Average Strength (N/mm ²)
0	1	769.55	34.2	30.40
	2	627.5	27.88	
	3	655.5	29.13	
10	1	704	31.28	29.46
	2	650	28.88	
	3	635.5	28.24	
20	1	569.5	25.31	26.45
	2	606.5	26.95	
	3	609.5	27.08	
30	1	534.5	23.75	22.81

40	2	510.5	22.68	15.07
	3	495	22	
	1	335	14.88	
	2	330.5	14.68	
	3	352.5	15.66	

Table No.4.2

4.3 Compressive strength of concrete after replacing water with PBL (for 7 days)

% Replacement	Sr. No	Loading (KN)	Compressive Strength (N/mm ²)	Average Strength (N/mm ²)
0	1	164	7.28	7.61
	2	180	8	
	3	170	7.55	
1	1	467	20.76	21.72
	2	567	25.20	
	3	432	19.20	
2	1	455	20.22	19.53
	2	482	21.42	
	3	382	16.98	
3	1	525	23.33	20.65
	2	376	16.71	
	3	493	21.91	
4	1	531	23.60	23
	2	490	21.77	
	3	532	23.64	

Table No.4.3

4.4 Compressive strength of concrete after replacing water with PBL (for 28 days)

% Replacement	Sr. No	Loading (KN)	Compressive Strength (N/mm ²)	Average Strength (N/mm ²)
0	1	769.55	34.2	30.40
	2	627.5	27.88	
	3	655.5	29.13	

1	1	837.5	37.22	33.06
	2	625	27.77	
	3	769.5	34.20	
2	1	782.5	34.77	37.69
	2	936.5	41.62	
	3	825.5	36.68	
3	1	873	38.88	35.72
	2	707.5	31.44	
	3	830.5	36.91	
4	1	888	39.46	45.69
	2	1075.5	47.8	
	3	1120.5	49.8	

Table No.4.4

4.5 Compressive strength of concrete after replacing cement with lime sludge & with PBL as admixture (for 7 days)

% Replacement	Sr. No	Loading (KN)	Compressive Strength (N/mm ²)	Average Strength (N/mm ²)
0	1	164	7.28	7.61
	2	180	8	
	3	170	7.55	
10 & 1	1	383	17.02	17.75
	2	465	20.67	
	3	350	15.56	
20 & 2	1	387	17.20	16.25
	2	360	16	
	3	349	15.55	
30 & 3	1	292	12.98	10.49
	2	146	6.48	
	3	270	12	
40 & 4	1	130	5.78	7.70
	2	180	8	
	3	210	9.33	

Table No.4.5

4.6 Compressive strength of concrete after replacing cement with lime sludge & with PBL as admixture (for 28 days)

% Replacement	Sr. No	Loading (KN)	Compressive Strength (N/mm ²)	Average Strength (N/mm ²)
0	1	769.55	34.2	30.40
	2	627.5	27.88	
	3	655.5	29.13	
10 & 1	1	814.5	36.20	39.29
	2	979	43.51	
	3	858.5	38.15	
20 & 2	1	684	30.40	29.77
	2	660.5	29.35	
	3	665	29.55	
30 & 3	1	515.5	22.91	21.20
	2	487.5	21.66	
	3	428.5	19.04	
40 & 4	1	237	10.53	10.72
	2	250	11.11	
	3	236.5	10.5	

Table No.4.6**4.7: Workability of concrete (By replacing cement with lime sludge)**

Sr.No.	Replacement (%)	Slump Value (mm)
1.	0%	85
2.	10%	92
3.	20%	81
4.	30%	83
5.	40%	80

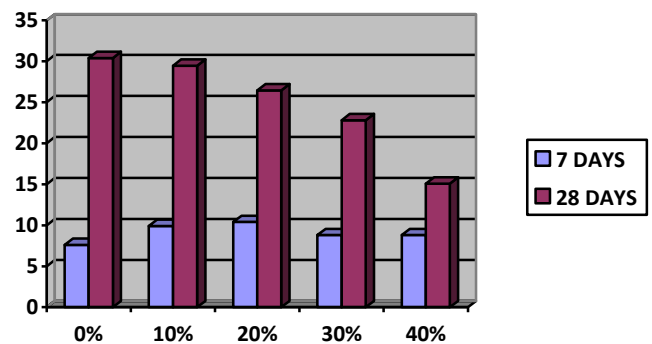
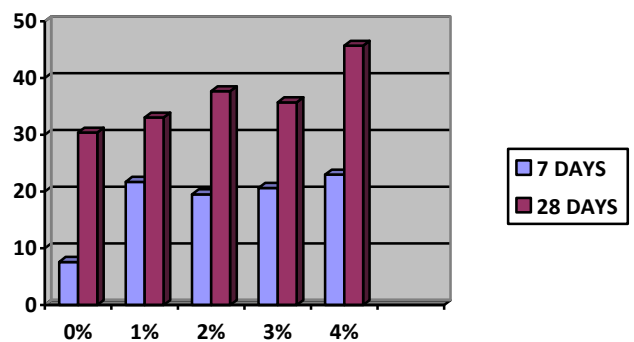
Table No.4.7**4.8: Workability of concrete (By replacing water with pulp black liquor)**

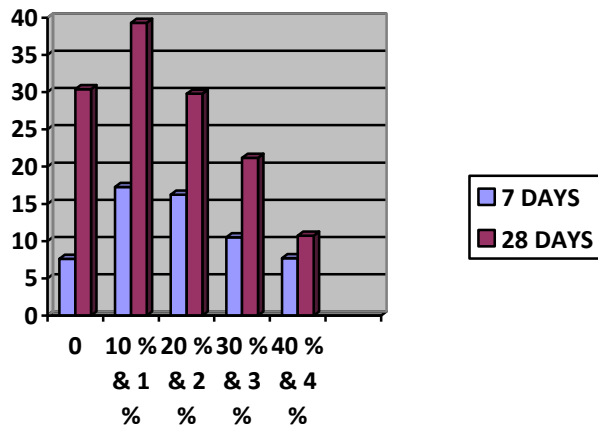
Sr.No.	Replacement (%)	Slump Value (mm)
1.	0%	85
2.	10%	95
3.	20%	83
4.	30%	81

5.	40%	84
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Table No.4.8**4.9: Workability of concrete (By after replacing cement with lime sludge and use PBL as an admixture)**

Sr.No.	Replacement (%)	Slump Value (mm)
1.	0%	85
2.	10%	94
3.	20%	82
4.	30%	84
5.	40%	81

Table No.4.9**4.10 Compressive strength of concrete after replacing cement with lime sludge****4.11 Compressive strength of concrete after replacing water with PBL****4.12 Compressive strength of concrete after replacing cement with lime sludge & with PBL as admixture**



CONCLUSION

- The maximum compressive strength of concrete after replacing cement with lime sludge was found to be 9.91 N/mm² for 7 days and 29.46 N/mm² for 28 days at proportion of 10%.
- The maximum compressive strength of concrete after replacing water with Pulp Black Liquor was found to be 23.00 N/mm² for 7 days and 45.69 N/mm² for 28 days at proportion of 4%.
- The maximum compressive strength of concrete after replacing cement with lime sludge and use Pulp Black Liquor as admixture was found to be 17.75 N/mm² for 7 days and 39.29 N/mm² for 28 days at 10% lime replacement and 1% PBL as admixture.
- The optimum workability of the concrete was found to be at 10%.
- The waste products i.e. lime sludge and PBL can be used in concrete which can reduce soil pollution.
- The use of this waste in concrete can enable for low cost construction works.

SCOPE OF STUDY

- This study aimed at studying the use of B.G.P.P.L.waste i.e. lime sludge and PBL in concrete by analyzing compressive strength and workability.

- Further analysis can also be done on the parameters of tensile strength and flexural strength
- Further study can also be done using other waste from paper mill industry in construction works.

REFERENCES

- [1] A. Jumadurdiyev, M. H. Ozkul, A. R. Saglam and N. Parlak; Cem. Concr. Res., 35, 5 (2005) 874-882.
- [2] H. H. M. Darweesh, A. H. Abdel-kader and M. G. El-Meligy International Journal of Basic and Applied Sciences, 2(3) (2013)230-238 "Utilization of Pulp Black Liquor Waste as a Cement Admixture"
- [3] IS 456-2000,' Plain and Reinforced Concrete-Code of practice' , (Fourth Edition),Bureau of Indian Standards, New Delhi
- [4] IS 383-1970,' Specification for Coarse and Fine Aggregates from Natural Sources for Concrete' ,(Second Edition),Bureau of Indian Standards, New Delhi
- [5] IS 10262-1982,' Recommended Guidelines for Concrete Mix Design' , Bureau of Indian Standards, New Delhi.
- [6] MuhammedShareef K, Navaneeth AP, Bhavia KK , Harikrishna AS, Mohammed Anas PP, Maya P SSRC International Journal of Civil Engineering (SSRC-IJCE) Vol.3-(March 2016) " Pulp Black Liquor- An Admixture in Concrete"
- [7] Paul Shaji, Anagha K J, Anju R Paithackal, Aswathy K P, Sukanya K SMarch International Journal of Civil and Structural Engineering Research ISSN 2348-7607(Online) Vol.2,pp:(132-139) (Oct.2014 – Mar.2015) " Utilisation of Pulp Black Liquor as An Admixture in Concrete"
- [8] R.SRINIVASAN, K. SATHIYA and M. PALANISAMY Universitatea Tehnica " Gheorghe Asachi" din Iasi Tomul L VI (LX), Fasc.1, and (2010) Experimental investigation in developing low cost concrete from paper industry waste

[9] Ramachandran, V.S.; & Feldman, R.F “ Concrete Admixtures Handbook, Properties Science and Technology” , 2nd Edn.; Noyes Publications: New Jersey, (1995) [16]

[10] Samar A. El-Mekkawi a, Ibrahim M. Ismail a, Mohammed M. El-Attar b, Alaa A. Fahmy a, Samia S. Mohammed. Journal of Advanced Research (Feb. 2011) “ Utilization of black liquor as concrete admixture and set retarder aid”

[11] S
ajad Ahmad, M. Iqbal Malik, Muzaffar Bashir Wani, Rafiq Ahmad IOSR Journal of Engineering (IOSRJEN) e-ISSN:2250-3021, p-ISSN:2278-8719 Vol.3 (November. 2013), “ Study of Concrete Involving Use of Waste Paper Sludge Ash as Partial Replacement of Cement”