Durability and Strength of Lime Sludge by Partial Replacement of Cement

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Abstract— Concrete is a composite construction material composed of aggregate, cement and water. There are many formulations that have varied properties. The aggregate is generally coarse gravel or crushed rocks such as lime stone or granite, along with a fine aggregate such as sand. The cement commonly Portland cement and other cementitious materials such fly ash and slag cement, serve as a binder for the aggregate. Various chemical admixtures are also added to achieve varied properties. Water is then mixed with this dry composite which enables it to be shaped and then solidified and hardened into rock-hard strength through a chemical process called hydration. The water reacts with the cement which bonds the other components together, eventually creating a robust stone-like material. Lime sludge is generated from paper, acetylene, sugar, fertilizer, sodium chromate, soda ash industries, and water softening plants. Approximately 4.5 million tons of sludge in total is generated annually from these industries. It is extracted by the precipitators in the smokestacks of coal-burning power plants to reduce pollution. About 120 coals based thermal power stations in India are producing about 112 million tonne per year. In the present study, concrete cubes have been cast by Partial replacement of cement with various percentage lime sludge. The method adopted in this investigation is as per the IS code specifications.

Keywords: Concrete, Lime Sludge, PAC, Casting

I. INTRODUCTION

These days there is an increasing emphasis on a cleaner environment and maintaining the balance of the eco-system of the biosphere. It is generally believed in hand, but at the same time it is also true that sustainable growth with environmental quality is not an unattainable goal. The problem is multidimensional and multifaceted and calls for integrated efforts by the industry, Govt. policy makers, environmental managers and development agencies to look into generation, disposal and utilization aspects.

Paper and pulp industry in India is generating nearly 0.8 million tonnes of lime sludge that too only in organized sector. The beginning of the Modern paper Industry in India dates back to 1832 when the first paper machine was established, but actual production were taken up in the end of century. 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.

The production capacity of large scale sector ranges above 100 tpd of paper production and of medium and small scale sector is below 100 tpd. The raw material base for these plants are wood, bamboo, straw and agricultural waste. Most of the large paper mills are based on wood and bamboo. However, in the last couple of years 5 - 6 number of agro based mills have increased their production capacity more than 100 tpd and have installed a chemical recovery system.

A. Materials Used

The following ingredients are used for manufacturing the concrete.

- Cement
- Lime sludge waste
- Coarse aggregate
- Fine aggregate
- Water

PROPERTIES	VALUE
Finness	0%
Specific Gravity	3.15
Initial Setting Time	45 min
Final Setting time	600 min

Table 1: Physical Properties of Cement

1) Lime Sludge

Lime sludge is generated from paper, acetylene, sugar, fertilizer, sodium chromate, soda ash industries, and water softening plants. Approximately 4.5 million tons of sludge in total is generated annually from these industries.

During the process of producing potable water, some commercial products are added to raw water in order to assure its quality for human consumption. In the present study calcium hydroxide, poly aluminum chloride (PAC) and a flocculating agent were added to treat the water.

Fig. 1: Lime sludge

PROPERTIES	VALUE
Fineness Modulus	2.54
Specific Gravity	2.2

Table 2: Physical Properties of Lime Sludge

Sieve no	Wt. retained gms	Cumulative wt. retained gms	% Cumulative wt. retained gms	% Cumulative wt. passing gms	Permissible limits IS 383-1970
10mm	-	-	-	100	100
4.75mm	-	-	-	100	90-100
2.36mm	14	14	1.4	98.6	75-100
1.18mm	104	118	11.8	88.2	55-90
600 mic	364	482	48.2	51.8	35-59
300 mic	397	879	87.9	12.1	8-30
150 mic	113	992	99.2	0.8	0-10
75 mic	8	1000	100	-	-

Table 3: Sieve Analysis of Typical Fine Aggregate

II. EXPERIMENTAL INVESTIGATION

Tests to Be Conducted

The following tests have to be conducted on concrete to ascertain the following Strength properties.

- Cube compression test.
- Split tensile test.
- Flexural strength test

Fig. 2:

Fig. 3: Replacing the cement with Lime sludge waste in cube.

Fig. 4: Compressive strength of Lime sludge waste in 28 days

Fig. 5: Tensile strength of Lime sludge waste in 28 days

Fig. 6: Flexural strength of Lime sludge waste in 28 day

III. RESULTS

PERCENTAGE OF LIME SLUDGE	7 DAYS AV. COMP. STRENGTH (MPa)	14 DAYS AV. COMP. STRENGTH (MPa)	28 DAYS AV. COMP. STRENGTH (MPa)
1.	0%	20.44	23.11	27.10
2.	20%	20.88	23.55	28.60
3.	25%	21.02	23.66	28.85

Table 4: Compressive Strength for various replacement percentages

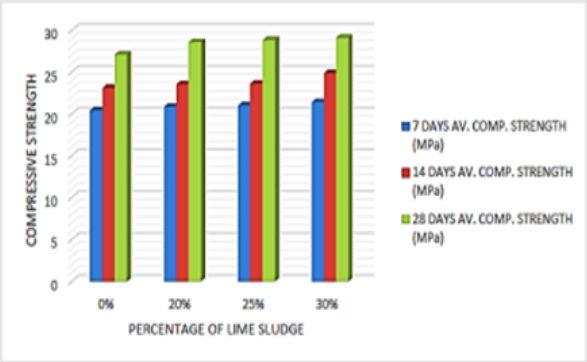

Fig. 7: Bar Chart for Compressive Strength for various replacement percentages

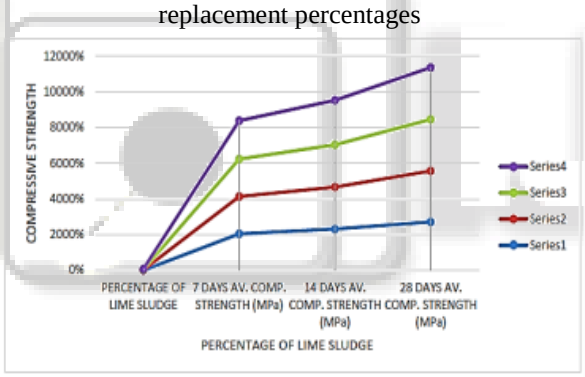

Fig. 8: Graph for Compressive Strength for various replacement percentages

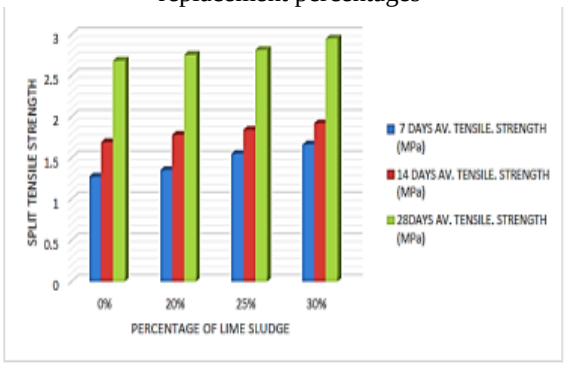

Fig. 9: Bar Chart for Split Tensile Strength for various replacement percentages

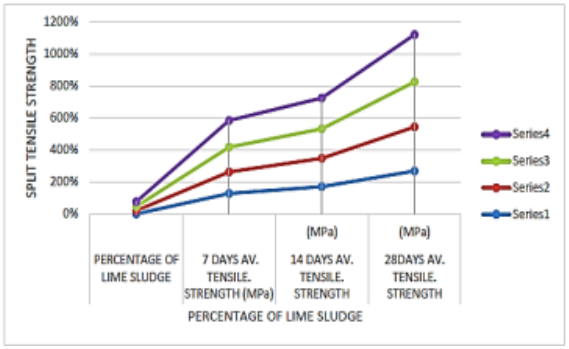

Fig. 10: Graph for Split Tensile Strength for various replacement percentages

IV. CONCLUSION

1) Based on the Compression Strength, 20%, 25%, 30% replacement of Lime sludge waste the 30 % replacement shows 29.13 Mpa strength as the average strength on 28 days of curing.
2) Based on the Split Tensile Strength, 20%, 25%, 30% replacement of Lime sludge waste the 30% replacement shows 2.95 MPa strength as the average strength on 28 days of curing.
3) Based on the Flexural Strength, 20%, 25%, 30% replacement of Lime sludge waste the 30% replacement shows 4.97 MPa strength as the average strength on 28days of curing.

After conducting all the tests on the specimen, it has been observed that upto 30% replacement of cement with lime sludge waste proved to be good in Compression, tension as well as in Flexural Strength, whereas the concrete properties with equal proportion of lime sludge waste and conventional cement confirmed to be inefficient.

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