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Experimental investigation on properties of concrete using lime sludge

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ABSTRACT

The sand requirement for construction activities increased proportionately but, all the materials required for producing concrete are obtained from the earth's crust only. Hence, the natural resources are exploited in an extremely high manner and resulted in depletion of the same and creating environmental strain. The sugar and paper industries are generating a huge quantity of lime sludge as waste, this waste may create ecological problems because of its dumping in open places causing environmental pollution. A proper utilization of lime sludge from sugar industry is to be used in concrete. This experimental study is aimed to utilize such lime sludge as a partial replacement material for sand in concrete and to study the suitability of this waste material for sand replacement. M25 grade of concrete is taken for investigation. The sand is replaced by lime sludge of 0%, 10% and 20%. The concrete mix design is done as per IS 10262-2009. The properties are studied including the workability characteristics of fresh concrete such as Slump, Compaction factor and strength properties of hardened concrete including Compressive strength, Split tensile strength and Flexural strength for various percentage of replacement of sand by lime sludge.

Keyword: Lime Sludge, Replacement in sand, Compressive strength, Split tensile strength and Flexural strength.

INTRODUCTION

India being an agricultural based country, a lot of Agro Industries as come up. The lime sludge is generated from paper, acetylene, sugar, fertilizer, sodium chromate and soda ash industries. To date, these by-products used in other industrial branches and in the field of Civil Engineering constructions. Now a days the concrete is most used manmade material in the world. The extent of quality control is often uneconomical compromise and depends on the size and type of job now a days engineers and scientists are trying to increase the strength of concrete by adding the some other cheap and waste material as a partial replacement of cement and sand or as a admixture fly ash, micro silica, steel slag, lime sludge etc. The sludge are disposed off wet in the form of slurry/filter cake into lagoons/settling tanks and are considered potential health and environmental hazards. So research is being conducted to improve the strength of concrete by the addition of various admixtures to the concrete. In this work, it has been planned to use it in concrete with the partial replacement by using lime sludge added as an additional ingredient in different proportions to enhance the binding properties of concrete [1].

LITERATURE REVIEW

Vaishali Sahu., (2014) study the use of fly ash and lime sludge as partial replacement of cement mortar. The fly ash and ordinary Portland cement was sieved and portion retained on 90 micron was used. The sludge was oven dried for about 16-18 hours at 60^{o}C and the lumps were broken gently using the pestle. It was sieved through 150 micron sieve and portion retained on 90 micron sieve was used. To set of mortar mix (type I and type II) were prepared, each set with two different types of binders. Type I mortar is cement less mortar, were 100% cement is

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replaced with a combination of fly ash and lime sludge with 0 and 1% of gypsum. Type II mortar consists of 20% cement content, fly ash and lime sludge. All the sets of mortar were prepared with 1:3 binder-to-sand ratio. They concluded that the addition of gypsum showed positive effect on strength dud to accelerated pozzolanic reaction. For type I mortar (mortar with 0% cement content), the highest strength of 6 N/mm^2 was observed, for binder with 1% gypsum, after 28 days curing period. By increasing the content of lime sludge and subsequent decrease of fly ash content mortar with 20% cement showed increased strength of binder IV as compared to binder III. The maximum strength achieved after 28 days curing for type II mortar was 14 N/mm^2.

Ahmad et al., (2013) carried out the study of concrete involving use of waste paper sludge ash as partial replacement of cement and concluded that 5% replacement of cement by waste paper sludge ash showed 10% increase in compressive strength at 7 days and 15% increase in compressive strength at 28 days. Cement in concrete can be replaced by waste paper sludge ash up to 5% by weight showing 15% increase in compressive strength at 28 days. With increase in waste paper sludge in ash content, percentage water absorption increases. With increase in waste paper sludge ash content, average weight decreases by 4.58% for mixture with 20% waste paper sludge ash content thus making waste paper sludge ash concrete light weight. Workability of concrete mix decreases with increase in waste paper sludge ash content. Splitting tensile strength decreases with increase in waste paper sludge ash content and is more than reference concrete at 5% replacement according to Adepegba the annual cement requirement in Nigeria is about 8.2 million tons and only 4.6 million tons of Portland cement are produced locally. The balance of 3.6 million ton are more is imported. If alternative cheap cement can be produced locally, the demand for Portland cement will reduce. The search for suitable for local materials to manufacture pozzolana cement was therefore intensified. Most of the increase in cement demand could be met by the use of supplementary cementing materials, in order to reduce the green gas emission (Bentur, 2002).

K.Archaneshwar Kumar.,(2016) This research work presents an investigation of compressive strength of cement mortar by adding Lime sludge and Fly ash as a partial replacement of cement in various percentages. In this work cement has been replaced by four proportions of Fly ash & Lime sludge. The four proportions are (100% cement+ 0% Fly ash+0% Lime sludge), (75% cement + 12.5% Fly ash +12.5% Lime sludge), (50% cement + 25% Fly ash + 25% Lime sludge) & (25% cement + 37.5% Fly ash + 37.5% Lime sludge). It has been observed from the 7, 14 and 28 days tests of compressive strength of cement mortar that compressive strength decrease as the percentage of lime sludge increase in the mix when compared with controlled concrete. Results indicated that the decrease in compressive strength with the increase in Lime sludge replacement.

OBJECTIVES

The main objectives of the project are

- To design the concrete mix as per IS 10262-2009
- To determine the workability of fresh PCC/LSC concrete by slump test
- To determine the compressive strength of PCC/LSC after 7 and 28 days
- To determine the flexural strength of hardened PCC/LSC after 7 days and 28 days
- To determine the split tensile strength of PCC/LSC after 7 and 28 days.
- To compare the results as graphs or bar charts and compare the results of various proportions of concrete [2-5].

ADMIXTURES

Admixtures are materials other than cement, aggregate and water that are added to concrete. Admixtures are mixing before or during its mixing to modify one or more of the properties of concrete in the plastic or hardened state. Admixtures are used to modify the properties of concrete or mortar to made them more suitable for the work at hand or for economy [6].

Two basic types of admixtures are available namely Chemical admixtures and Mineral admixtures. The lime sludge admixtures are partially replaced for the sand.

APPLICATION OF LIME SLUDGE CONCRETE

- Highway infrastructure
- Concrete streets
- Culverts
- Pedestrians slab
- Septic

SCOPE OF THE PROJECT

The following are the preliminary test conducted to study the suitability of materials

1) Specific gravity tests for fine aggregate and coarse aggregate.
2) Grading of fine aggregate and coarse aggregate.

For the experimental investigations the following parameters are considered

Concrete grade : M25
Cement : OPC 53 grade
Coarse aggregate: Angular well graded aggregates of nominal size 20mm.
Sand : M sand
Lime sludge : Sugar industry 0 to 20% by replacement of sand.

Lime sludge concrete mix design has been made as per IS10262-2009 for M25 grade concrete. The workability of fresh concrete has been checked by slump and compaction factor test. Compressive strength of cubes at 7days and 28days and flexural strength of hardened concrete carried at 28days. The result have been plotted as graph/bar charts and compared [7].

MATERIALS

The various materials used in the experimental investigation

Include

- Ordinary Portland Cement (OPC)
- Fine Aggregate (M sand)
- Lime sludge
- Coarse aggregate
- Water

CEMENT

Cement is binding material which possesses very good adhesive and cohesive properties which makes it possible to bond with other materials to form compact mass of concrete. Cement used it our project is ordinary Portland cement 53 grades. Portland cement is the most common type of cement use around the world [8].

FINE AGGREGATE

M Sand is manufactured sand which is a substitute of river sand for construction purposes. M sand is produced from hard granite stone by crushing. The size of manufactured sand (M sand) is less than 4.75mm. Manufactured sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency suitable river sand in most part of the word [9].

COARSE AGGREGATE

Coarse aggregate used for concrete should be clean and free from clay, loam, vegetable and other organic materials.

Aggregate for load bearing concrete must be hard, strong, non-porous and elongated particles. The maximum size of the aggregates depends upon the type of concrete, here the aggregate is being obtained from crushers in government approved granite quarry.

WATER

The water should be free from iron, vegetable matter (or) other type of substances which likely to have advances affect on concrete. It should be free from oils, acids (or) alkali other organic and inorganic impurities.

LIME SLUDGE

Lime sludge which essentially contains calcium carbonate with varying amounts of free lime is a waste product from sugar, paper and fertilizer and calcium carbide industries. The annual production of lime sludge is approximately 48mt. The utilities lime sludge for the manufacture of cement and lime have been investigation for commercial exploitation.

Fig No 1: Lime Sludge Material

Chemical Composition of Lime Sludge

Oxides	Weight (%)
Al_2O_3	39.1
SiO_2	30.2
Fe_2O_3	25.8
K_2O	1.4
TiO_2	1.4
MgO	0.6
SO_2	0.6
P_2O_5	0.3
MnO	0.3
CaO	0.2

Physical Properties of Lime Sludge

Physical State	Thin to thick liquid
Colour	White to light
Odour	Neutral
Melting Point ($CaCO_3$)	Decomposes at T> 450^oC
Relative Density	1.15-1.40 gr/cm^3
Solubility of ($CaCO_3$) in water	0.0166gr/l at 20^oC
P^H (dissolved)	7-9 in a saturated $CaCO_3$ solution at 25^oC
Reaction with acid	Soluble with release of CO_2

TESTS ON MATERIALS

Test on Cement

The following tests have been conducted on cement

- Fineness
- Standard Consistency
- Specific gravity
- Initial setting time and final setting time
- Soundness

S.NO	PROPERTIES	TEST RESULTS
1	Fineness of cement	6%
2	Standard consistency	38%
3	Initial setting time	40 minutes
4	Specific gravity of cement	3.13

TESTE ON COARSE AGGREGATE

The following tests are conducted on aggregates

- Sieve analysis
- Specific gravity
- Water absorption
- Impact value

Property	Test result
Specific gravity	2.62
Impact value	11%
Water absorption	0.45%

TEST ON FINE AGGREGATE

The following tests are conducted on fine aggregate,

- Specific Gravity
- Fineness modulus

Property	Test result
Specific gravity	2.65
Fineness modulus	3.34

MIX PROPORTIONS

Grade of Concrete M_{25}

MixType	Ingredients in percentage (%) by weight				
	Cement	Sand	Lime sludge	Coarse Aggregate	Water
Normal mix	100	100	0	100	0.45
Mix 1	100	90	10	100	0.45
Mix 2	100	80	20	100	0.45

RESULTS

Test Results on Fresh Concrete

Percentages %	Slump Value Mm	Compaction Factor
Conventional concrete	30	0.90
Lime sludge 10%	25	0.85
Lime sludge 20%	20	0.82

Test Results on Hardened Concrete

Compressive Strength and Split Tensile strength of concrete for 7 days

Percentage %	Compressive Strength in N/mm^2	Split Tensile Strength in N/mm^2
Conventional Concrete	21.65	2.1
Lime Sludge 10 %	23.70	2.3
Lime Sludge 20 %	22.07	1.9

BAR CHART

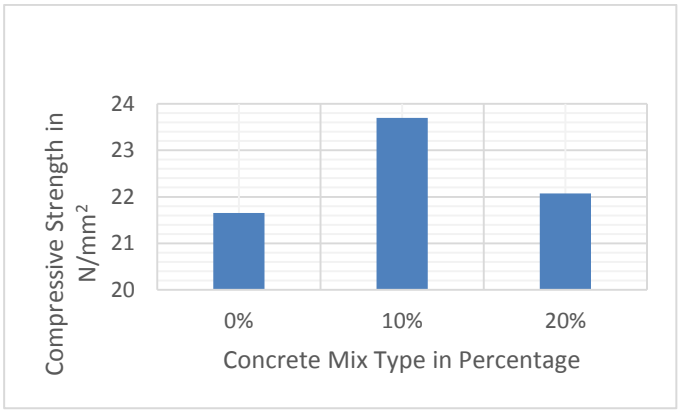

Fig No 2: Compressive Strength of cubes at 7 days curing

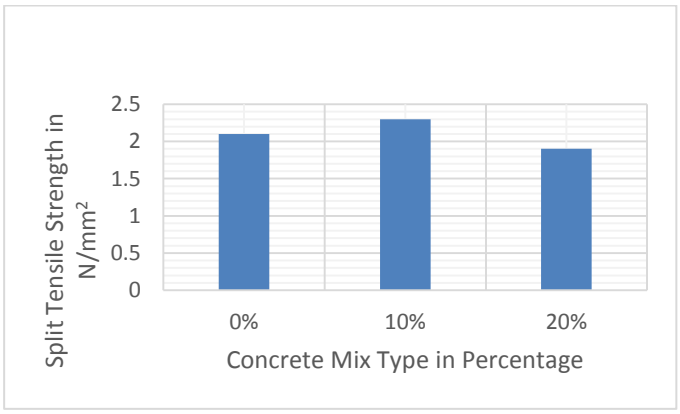

Fig No 3: Split Tensile Strength of cylinder at 7 days curing

CONCLUSION

As we aware that a lot of waste material are being from industries and dumped in thousands of hectares of land causing environmental pollution. Those materials could only be utilized in construction industry. In this projects work it has been found that the lime sludge from the industries could be utilized to make use in concrete works for all construction works.

From our experimental study the following conclusions were drawn,

- The compressive strength of concrete cubes increases up to 10% replacement of lime sludge then decreases.
- The split tensile strength of concrete cylinder increases up to 10% replacement of lime sludge then decreases.
- Even though the workability is reduced by adding lime sludge but the compressive strength is increased up to 10% replacement.

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