International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 03 | Mar 2021 www.irjet.net p-ISSN: 2395-0072

EXPERIMENTAL INVESTIGATION ON PROPERTIES OF CONCRETE USING LIME SLUDGE WITH PARTIAL REPLACEMENT OF FINE AGGREGATE

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Abstract - The cement and sand requirements for construction activities increased proportionally 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. M30 grade of concrete is taken for investigation. The sand is replaced by lime sludge of 10%, 20%, 30% and 40%. The concrete mix design is done as per IS10262-2009. 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.

Key Words: Lime Sludge, Compressive strength, flexural strength, spilt tensile strength etc..,

1. INTRODUCTION

1.1 General

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 of 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.

1.2 OBJECTIVES

The main objectives of the project is to replace fine aggregate with Lime Sludge

- To determine the Compressive Strength of concrete with 0, 10, 20, 30, 40% replacement of fine aggregate with Lime Sludge.
- To determine the Flexural Strength of concrete with 0, 10, 20 , 30 ,40 % replacement of fine aggregate with Lime Sludge.
- To determine the Split Tensile Strength of concrete with 0, 10, 20, 30, 40% replacement of fine aggregate with lime sludge.

1.3 SCOPE

- The following are the preliminary test conducted to study the stability of material
- Specific gravity tests for fine aggregate and coarse aggregate
- Grading of fine aggregate and coarse aggregate
- For the experimental investigations the following parameters are considered
- Concrete grade : M30
- Cement : OPC 43grade
- Sand : M – Sand
- Coarse aggregate : Angular well graded aggregates of nominal size 20mm
- Lime sludge : Industries 0 - 40% by replacement of sand

- Lime sludge concrete mix design has been made as per IS 10262-2009 For M30 grade concrete. The workability of fresh concrete has been checked by slump and compaction factor test. Compressive strength of cubes at 7 days and 28 days and flexural strength of beams are carried on hardened concrete at 28 days. The result have been plotted as graph/bar charts and compared.

2. LITERATURE REVIEW

VaishaliSahu and V.Gayathri., (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°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 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.

SajadAhmad 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).

Sahu. V (2013) study the use of fly ash and lime sludge as partial replacement of cement in 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°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. Two sets 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, where 100% cement is replaced with a combination of fly ash and lime sludge with 0 & 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 due to accelerated pozzolanic reaction. For type I mortar (mortar with 0% cement content), the highest strength of 6 N/mm2 was observed, for binder with1% gypsum, after 28 days curing period. By increasing the content of Lime sludge and subsequent decrease of Fly ash content under 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/mm2.

Archaneshwar Kumar. K, et al., (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 compar,ed with controlled concrete. Results indicated that the decrease in compressive strength with the increase in Lime sludge replacement.

SarikaG.Javiya and Zalak P.Shah, et. al., studied Hypo sludge utilization in mortar by replacing cement by hypo sludge towards compressive strength, water absorption and sorptivity with different time lapses. .In the reference paper, A manjatale et al, carried out investigation on effect of fly ash on mechanical properties of the concrete like workability, setting time, density, air content, compressive strength by replacing the cement with 20%,40% and 60% of fly ash. M15, M20 & M25. The modulus of elasticity of concrete decreases with increase of replacement of cement by hypo sludge is reported by Solanki and Pitroda. Use of hypo-sludge in pavement construction will improve

transportation functionality & ecological sustainability and results in developed traffic safety and reduces life cycle cost by Pitroda et al.

Nancy L Holland, et. al.,The use of cementitious materials, such as hydrated lime and volcanic cements, predates the use of Roman and Portland cements by several millennia. Baker provides an excellent summary of concrete practices up until the start of World War I. Young and Mindess, et. al. present the current practices in the use of concrete and the material properties from a civil engineering perspective. Warner and Rangan, et al. provides a definitive text on the use of reinforced concrete, properties and design from the viewpoint of the structural engineer[9]. This text is predicated on normal weight Portland cement based concrete. Baker presented two rules for concrete design which restated are as follows: 1. For the same fine and coarse aggregate mixture, the strongest concrete is one that contains the greatest percentage of Portland cement in a unit volume of concrete. 2. For the same percentage of Portland cement and the same aggregate, the strongest concrete is made with the combination of fine and coarse aggregate which gives the highest density concrete. There has been a significant body of research on concrete made with Portland cement, though relatively little information related to the effects of hydrated lime as a partial replacement for Portland cement.Barbhuiya, et al., found that lime can be added to fly ash based concrete to increase the early strength so that forms can be stripped more quickly. An alternative to the use of hydrated lime is the use of crushed limestone as a replacement for Portland cement. This use has been studied in the last few decades, both in concrete and mortar use. A report by the Portland Cement Association noted that emphasis needed to be placed on less than five percent crushed limestone replacement of the Portland cement. A traditional cost analysis looks only at the first or construction cost, without considering the long term cost to mitigate for the increased global warming emissions resulting from the manufacturing process of Portland cement. A typical example of the traditional form of the cost analysis can be found in Baker's 1912 book on masonry construction. Future research will address the cost issues and other physical properties.

Swati Chadel, Ajay K Duggal , et. al., studied on to study the effect of partial replacement of lime by cement in mastic asphalt. In this paper investigate the mastic asphalt is grained material it is use the construction work because it's high durability, higher stability and low cost. The effect of partial replacement of lime b cement at percentages are 3%, 6%, 9%, 12% and 15% in the mix. The mastic asphalt sample was prepared with and without coarse aggregate to given percentages. Industrial grade bitumen was used the binder, stone dust was used as fine aggregate size from 2.36mm to19mm used the coarse aggregate in this work. It observed the specimens without coarse aggregates the values satisfy the proposition < 9% nor <12%. With course aggregate the maximum replacement is 12%.

P. Meenaksh studied on partial replacement of cement by barites and lime powder in concrete in this paper design concrete mix is M30 grade of concrete is use. The cement is partial replacement of barites and limestone powder as the percentages are 0%, 10%, 20% and 30% were used the experimental work. The replaced ingredients are increase the compressive strength in early period at 7 days and 14 days also same result obtained. The replacement for concrete not show increases the compressive strength in 28 days.

3. PROPERTIES OF LIME IN CONCRETE

Lime concrete provides good bases to bear the sufficient loads and also provide certain degree of flexibility. It adjusts very well when it is in contact with surface. Lime concrete also exhibits certain degree of water proofing property and thus prevents subsoil dampness in floors and walls. Lime concrete also exhibits volumetric stability. It can be made easily and can be available at much cheaper rates. It also resists weathering effects and is very durable. Lime is one of the oldest binding materials used in several ancient architectural works. A good quality lime should own the following properties:

- It should possess good plasticity.
- It should be flexible and easily workable.
- When used in mortar, it should provide greater strength to the masonry.
- It should solidify in less time and become hard.
- It should comprise of excellent binding properties which adhere to brick or stone masonry units perfectly.
- It possesses high durable properties as it is less shrinkable when used in mortar.

It should be highly resistant to moisture and can be used for pointing works

3.1 DIFFERENCE BETWEEN LIME AND CEMENT

3.1.1 CHEMICAL COMPOSITION

Lime is produced from natural limestone by burning the stone in a kiln until only quicklime calcium oxide is left behind. The quicklime is then mixed with small amounts of water to create hydrated lime, which may be included in cement or mixed with water for use as mortar. Lime hardens by slowly absorbing carbon dioxide and turning back to limestone over time. Cement consists of highly reactive silica-containing compounds when mixed with water, they harden quickly.

3.1.2 PHYSICAL PROPERTIES

Lime hardens much more slowly than cement-containing mortars, making it much more workable. Lime is also less brittle and less prone to cracking, and any cracked areas can absorb carbon dioxide and mend over time. Cement hardens very quickly, but may be too strong for some applications, e.g., working with old bricks. Cement is also prone to cracking as a structure settles, and may eventually require repair.

4. MATERIALS

CEMENT

Cement is a binding material which possess 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 43 grades.

FINE AGGREGATE

Sand is either round or angular grains and is found mixed in various gradation of fineness. A concrete can be made from sand consisting of rounded grains are good as from that in which the grains are angular. River or pit sand should be used and not sea sand as it contains salts and other impurities which affect the structure.

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 carbonate industries. The annual production of lime sludge is approximately 48mt. The utilities lime sludge for the manufacture of cement and lime have been investigated for commercial exploitation.

5. Mix Design: The study uses the design mix M30 grade of concrete using 43 grades OPC in the study. The Mix design was performed as per IS 10262: 2009. The water cement ration for mix is 0.43. The following mix proportion was obtained from the mix design.

Table -1: MIX DESIGN(CEMENT;SAND;AGGREGATE)

CEMENT	SAND	AGGREGATE
368	645.5	1264.04
1	1.754	3.4

6. Casting & Curing: For compressive strength the standard size of cube mould is 150 mm × 150 mm × 150 mm used. Lime is used as a partial replacement of cement to prepare lime concrete in this study. Amount of lime used in this study is 5, 10, 15, 25 and 35% by weight of cement. After casting, each cube should be marked with a legible identification on the top of cubes. Leave the sample undisturbed for 24 hours. After the 24 hours, the moulds are opened and immersed in water for curing till the day of testing. Ponding method was used for curing. Testing is done after 3, 7, 28 days. Three cubes were prepared for each specimen.

7 Testing

7.1 Compressive Strength: Compressive strength is the maximum compressive stress that under a gradually applied load, a given solid material can sustain without fracture. Compressive strength is carried on cubes i.e. 150 mm × 150 mm × 150 mm specimens. Concrete's compressive strength mostly depends on the concrete mix design, quality of concrete, cement strength, water cement ratio, curing etc. It is also affected by the other factors such as mixing of concrete, placing of concrete, curing of concrete as well as quality of concrete ingredients. The compressive strength of concrete was found by universal testing machine of 1000 kN capacity.

Compressive Strength = P/A

Where, P = Compressive load in kN and A = Area of cube

8. RESULT AND DISCUSSION

Average strength of 2 specimens was taken as compressive strength at 7 days and 28 days

COMPRESSIVE STRENGTH OF LIME SLUDGE

S.NO	PROPORTIONAL	7 days	28 days
1	CONVENTIONAL	23.25	32.58
2	10%	22.36	26.96
3	20%	25.32	29.77
4	30%	25.03	28.14

5	40%	22.96	27.10

FIGURE 3

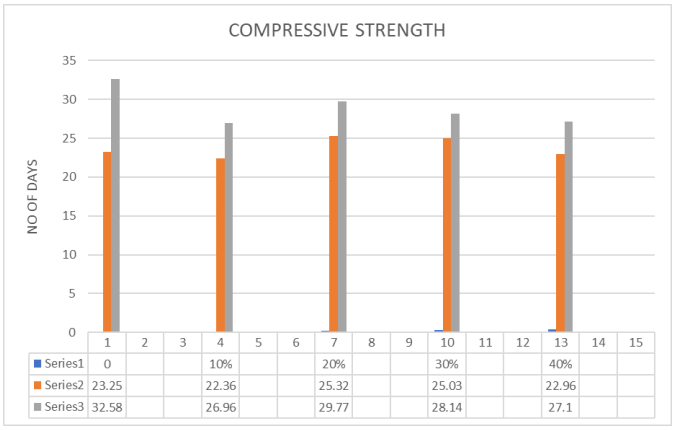

FIGURE 4

9. 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 20% replacement of lime sludge then decreases.
- Even though the workability is increased by adding lime sludge.
- The optimum percentage of the lime sludge replacement is 20%.

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