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RESEARCH ARTICLE

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EFFECT & STRENGTH CHARACTERSTICS OF CONCRETE USING LIME SLUDGE AND FLYASH

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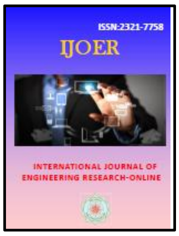

ABSTRACT

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 cementations 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. Fly ash is a naturally-cementations coal combustion by-product. 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 tone fly ash per year. In the present study, concrete cubes have been cast by replacing cement (0% and 5%) with fly ash and (0%, 5%, 10% and 15%) and lime sludge. The method adopted in this investigation is as per the IS code specifications.

Keywords- Concrete cubes; Flyash;Lime sludge.

1. Introduction

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 cementations 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. Concrete has relatively high compressive strength, but much lower tensile strength. For this reason it is usually reinforced with material that is strong in tension (often steel). Concrete can be damaged by many processes, such as freezing of trap. Concrete is widely used for making architectural structures, foundations, brick/block walls, pavements, bridges/overpasses, motorways/roads, runways, parking structures, dams, pools/reservoirs, pipes, footings for gates, fences and poles and even boats.Concrete is a site made material. Unlike other materials of construction and as such can vans to a very great extent in its quality, properties and performance to the use of natural materials except cement. The key to achieve a strong, durable concrete ruts in the careful proportioning and mixing of the ingredient A properly designed mixing processes the designed workability for the fresh concrete and the required for the fresh concrete and the required durability and strength for the hardened concrete.

Mineral Add Mixtures: Mineral admixtures are usually added to concrete in larger amounts to enhance the workability of fresh concrete and to improve resistance of concrete to thermal cracking, alkali aggregate expansion, and sulphate attack and to enable a reduction in cement concrete. Some of the mineral admixtures are Fly ash, Lime sludge.

Fly Ash: Fly ash is a naturally-cementitious coal combustion by-product. 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 fly ash per year. With the increasing demand of power and coal being the major source of energy, more and more thermal power stations are expected to be commissioned their capacities in near future. Fly ash has been considered as a “Pollution Industrial Waste” till about a decade back and was being disposed off in ash ponds.

Chemical Admixtures: Chemical admixtures are added to concrete in very small amounts mainly for the entrainment of air, reduction of water content, plasticization of fresh cement mortar mixtures, or control of setting time. Chemical admixtures reduce the cost of construction, modify properties of hardened concrete, ensure quality of concrete during mixing, transporting, placing, curing and overcome certain emergencies during concrete operations. Based on their functions, admixtures can be classified into the following five major categories Retarding admixtures, Accelerating admixtures, Super plasticizers, Water reducing admixtures & Air-entraining admixtures.

2. Literature review

Vaishali Sahu, V.Gayathri (2014) of ITM University, Gurgaon, Haryana have done some research work on “The Use of Fly Ash and Lime Sludge as Partial Replacement of Cement Concrete” and the report was published as an article in “International Journal of Engineering and Technology Innovation” of volume 4. We have taken this report as one of the main references to do our mini project.They have replaced cement of 53 grade with lime sludge and the proportions taken as 5%,10%,15%,.After proper curing they obtained the compressive strength of concrete cubes decreases at 10% and 15%. So it decreases continuously.The second report entitled by Calkins, Nova in 1973 of “Characterization of lime Sludges” which was published in “Journal of American Water Works Association” was considered as another reference. The compressive strength, of concrete samples made with different fibers amounts varies from 5%,10%,15%,20% and 25% were studied. The samples with added lime sludge 10% and fly ash of 5% showed results in comparison with the others.The third report entitled by N.S.Pandian in 2004 of “Fly ash characterization with reference to geotechnical applications” was published in Journal of Indian of Institute of Science, vol. 84 pages from 189-224. In this report we refer the fly ash characteristics.

Materials

The ingredients of concrete consist of Cement, fine aggregate and coarse aggregates, water. When the reaction of water with cement takes place hydration process is done and a hard material is formed. In this research we used waste lime sludge as a partial replacement and filler material. The ingredients are used in proper proportion.

Cement

OPC of 53 grade is used in this project. It is the basic ingredient of concrete, mortar and plaster. Cement is the binder, a substance that sets and hardens and can bind other materials together. Portland cement is the most common type of cement use around the world. It is a fine powder produced by heating materials in a kiln to form clinker grindings. The clinker and adding small amounts of other materials.

Fine Aggregate

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Aggregate constitute to 26% of the total volume of concrete Aggregate most of which passes 4.75-mm IS Sieve.

Physical properties of fine aggregate

Sl. No.	Properties	Test Values
1	Specific gravity	2.58
2	Bulking of sand	25%
3	Fineness modulus	3.12
4	Bulk density	
	i) Rodded bulk density	1718 kg/m^3
	ii) Loose bulk density	1518 kg/m^3
5	Water absorption	1.22%
6	Particle size variation	0.15 to 4.75

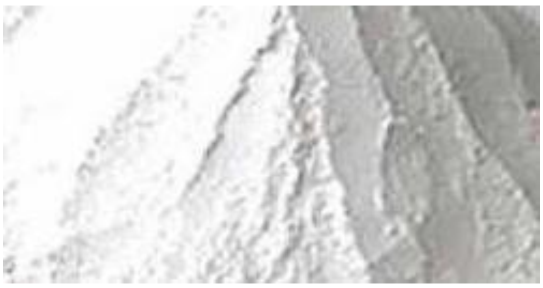
Lime Sludge

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.

chemical composition of lime sludge

Oxides	wt%
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_3	0.6
P_2O_5	0.3
MnO	0.3
CaO	0.2
others	$\leq$0.09

The study has revealed that sludge from paper industry can be utilized up to 74 percent (dry basis) as a component of raw mix for the manufacture of cement clinker. In addition to it around 30 percent (dry basis) lime sludge can also be utilized for the manufacture of masonry cement.



Lime Sludge

Lime sludge is generated from paper, acetylene, sugar, fertilizer, sodium chromate and soda ash industries. Approximately 4.5 million tons of sludge in total are generated annually from these industries. All the lime sludge other than carbide sludge contain lime as calcium carbonate. The carbide sludge from acetylene industry mainly contains lime as calcium hydroxide.

Fly Ash

Fly ash is a naturally-cementitious coal combustion by-product. 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 fly ash per year. With the increasing demand of power and coal being the major source of energy, more and more thermal power stations are expected to be commissioned/augment their capacities in near future. fly ash has been considered as a "Pollution Industrial Waste" till about a decade back and was being disposed off in ash ponds. Indian coal has high ash content (35%-45%) and low calorific value (3500 kcal/kg – 4000 kcal/kg) as a result of which huge quantity of fly ash is generated.

Schematic representation of Flyash

Tests on materials

Fineness of Cement by DrySieving Method

The principle of this is that we determine the proportion of cement whose grain size is larger than specified mesh size. The apparatus used are 90µm IS Sieve, Balance capable of weighing 10g to the nearest 10mg, a nylon or pure bristle brush, preferably with 25 to 40mm, bristle, for cleaning the sieve.

Standard Consistency of Cement Paste

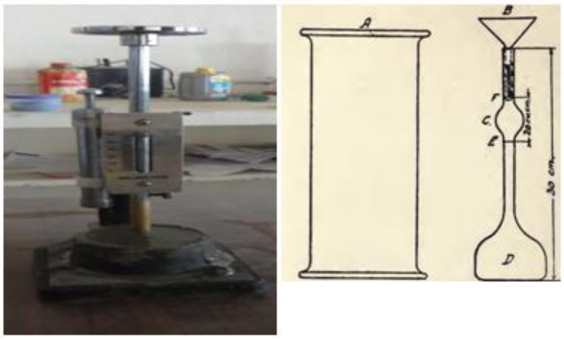
The principle of standard consistency of cement is that the consistency at which the Vicat plunger penetrates to a point 5-7mm from the bottom of Vicat mould. Apparatus used are Vicat‟s apparatus using 10mm diameter plunger fitted into the needle-holder, vicat mould, gauging trowel, measuring jar, balance, glass plates, stop watch, mixing tray, and sample of cement.

Practical Relevance

The water requirement for making specimens for the determination of initial and final setting times and of tensile and compressive strength of cement sand motors and for soundness test depends upon the normal consistency of cement to be used. This normal consistency or water demand of cement depends upon the compound composition and fineness of the cement.

Specific gravity of cement

Specific gravity is normally defined as the ratio between the weight of a given volume of material and weight of an equal volume of water. To determine the specific gravity of cement, kerosene which does not recent with cement is used. Apparatus used are specific gravity bottle, balance, weigh box, cement, kerosene, cement.



Schematic representation of Vicat Apparatus and Specific Gravity Bottle

Determination of Initial and Final Setting Time

1. Place the test block confined in the mould and resting on the non-porous plate, under the rod bearing the needle (C) lower the needle gently until it comes in contact with the surface of the test block and quickly release, allowing it to penetrate into the test block. In. the beginning, the needle will completely pierce the test block.

2. Repeat this procedure until the needle, when brought in contact with the test block and released as described above, fails to pierce the block beyond 5.0 ±0.5 mm measured from the bottom of the mould.

3. The period elapsing between the time when water is added to the cement and the time at which the needle fails to pierce the test block to a point 5.0 ±0.5 mm measured from the bottom of the mould shall be the initial setting time.

Schematic representation of Le-Chatelier Apparatus

Tests on Aggregate

The following tests are conducted on aggregates

Sieve Analysis

Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregate. This is done by sieving the aggregates as per IS:2386(part-I) -1963.

In this we use different sieves as a standardized by the IS code and then pass aggregate through them and thus collect different sized particles left over different sieves.

The apparatus used are –i) A set of IS Sieve of sizes – 80mm, 63 mm, 50 mm, 40 mm, 31.5 mm,
25 mm, 20 mm, 16 mm, 12.5 mm, 10 mm, 4.75 mm, 3.35 mm, 2.36 mm, 1.18 mm, 600µm, 300µm, 150 µm, and 75 µm.

Specific gravity of Fine Aggregate

A balance of capacity not less than 3 kg, readable and accurate to 0.5gm and of such a type as to permit the weighting of the vessel containing the aggregate and water. A well ventilated oven to maintain a temperature of 100˚c to 110˚c. Pycnometer of about 1 liter capacity having a metal conical screw top with a 6mm hole at its apex. The screw top shall be water tight.A means supplying a current warm air.A tray of area not less than 32 cm^2. An air tight container large enough to take the sample. Filter papers and funnel.

Schematic representation of Sieves set and Pycnometer

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Aggregate Impact Value

The impact machine shall rest without wedging or packing upon the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.The cup shall be fixed firmly in position on the base of the machine and the whole of the test sample placed in it and compacted by a single tamping of 25 strokes of the tamping rod.The hammer shall be raised until its lower face is 380 mm above the upper surface of the aggregate in the cup, and allowed to fall freely on to the aggregate. The test sample shall be subjected to a total of 15 such blows each being delivered at an interval of not less than one second.

Schematic representation of Aggregate Impact Testing Machine

Slump Cone Test

Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It is not suitable method for very wet or dry concrete.

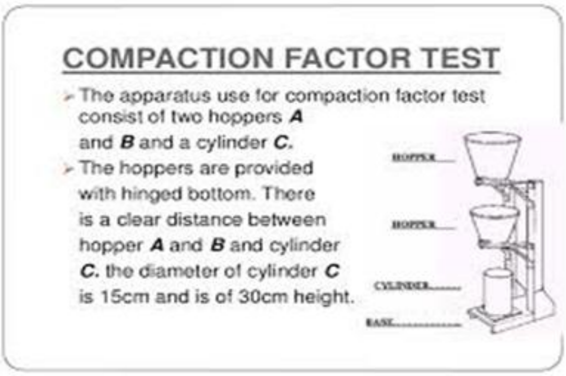
Schematic representation of Slump cone

It does not measure all factors contributing to workability, nor is it always representative of the place ability of the concrete. However, it is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch.

Compaction Factor Test

The compacting factor test is designed primarily for use in the laboratory but it can also be used in the field. It is more precise and sensitive than the slump test and is particularly useful for concrete mixes of very low workability as are normally used when concrete is to be compacted by vibration. Such dry concrete are insensitive to slump test.

This test works on the principle of determining the degree compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height. The degree of compaction, called the compacting factor is measured by the density ratio i.e., the ratio of the density actually achieved in the test to density of the same concrete fully compacted.



Schematic representation of Compaction Factor Apparatus

Tests on Hardened Concrete

After the specimens have been made, they shall be stored in a place free from vibration, in moist air of at least 90 percent relative humidity and at a temperature of 27 ± 2°C for 23 hours ±15 minutes from the time of addition of water to the ingredients.The specimens shall then be gently lowered into the curing tank

and shall remain totally immersed for a period of 3 $^{1}{}_{2}$ hrs ± 5 minutes. The temperature of the water in the curing tank shall be at boiling (100°C) at sea level. The temperature of water shall not drop more than 3°C after the specimens are placed and shall return to boiling within 15 minutes.

Schematic representation of Accelerated Curing Tank

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Compressive Strength

Compressive test is the most common test conducted on hardened concrete, partly because most of the desirable characteristic properties of concrete are quantitatively related to its compressive strength.The compression test is carried out on specimens cubical or cylindrical in shape. Prism is also sometimes used, but it is not common in our country. Sometimes, the compression strength of concrete is determined using parts of beam tested in flexure. The end parts of the beam are left intact after failure in flexure and, because the beam is usually of square cross section, thin part of beam could be used to find out the compressive strength. The cube specimen is of the size 150mm×150mm×150mm

Schematic representation of Compression Testing Machine

Compressive strength of concrete cubs for % of lime sludge

% OF LIME SLUDGE	COMPRESSIVE STRENGTH OF CUBE IN N/MM^2		
	3 DAYS	7 DAYS	28 DAYS
0%	15.06	17.10	22.79
5%	14.67	15.59	21.20
10%	13.90	14.28	18.62
15%	11.57	12.72	16.22

Design mix for m20 grade concrete

Mix Calculations

The mix calculations per unit volume of concrete shall be as follows:

$$Volume\ of\ cement(a) = \frac{Mass\ of\ cement}{specific\ gravity\ of\ cement} \times \frac{1}{1000}$$

$$= \frac{338}{2.85} \times \frac{1}{1000} = 0.11$$

$$Volume\ of\ water(b) = \frac{Mass\ of\ water}{specific\ gravity\ of\ water} \times \frac{1}{1000}$$

$$= \frac{186}{1} \times \frac{1}{1000}$$

=0.186

$$Volume\ of\ aggregates\ V_u = 1 - (a + b)$$

=1-(0.11+0.186)= 0.704

$$Mass\ of\ CA = V_u \times volume\ of\ CA \times mass\ of\ CA \times 1000$$

$$= 0.704 \times 0.62 \times 2.72 \times 1000$$

=1187.2 Kg/m^3

$$Mass\ of\ FA = V_u \times volume\ of\ FA \times mass\ of\ FA \times 1000$$

$$= 0.704 \times 0.38 \times 2.56 \times 1000$$

=684.85 Kg/m^3

Mix proportion per cubic metre

CEMENT	FINE AGGREGATE	COARSE AGGREGATE
338	684.85	1187.22
1	2.026	3.512

Using the conclusion

Test results on cement

DESCRIPTION	TEST RESULT
Grade of Cement	53
Specific gravity	2.85
Initial setting time	145 min
Final setting time	415 min
Normal consistency	31%
Fineness of cement	4%
Compressive Strength	20 N/mm^2

test results on coarse aggregate

PROPERTY	TEST RESULT
Specific gravity	2.72
Impact value	6.07%

Percentages %	3 days MPa	7 days MPa	28 days MPa	Slump value mm	Compaction Factor
Normal Concrete	15.06	17.10	22.79	75	0.89
Lime Sludge 5% + Fly Ash5%	14.67	15.59	21.20	60	0.86
Lime Sludge 10% + Fly Ash 5%	13.90	14.28	18.62	68	0.80
Lime Sludge 15% + Fly Ash 5%	11.57	12.72	16.22	90	0.76

Conclusion

From our experimental investigations we have found that the partial replacement of cement with lime sludge powder decreases the compressive strength, when compared to the normal concrete.
The use of fly ash and lime sludge in concrete proves to be a valuable building material in technical, environmental and economical aspects point of view. From the experimental phase carried out in this study, the following conclusions are drawn:

- Fly ash consumes maximum water for consistency and workability.
- Addition of fly ash to cement enhances the initial setting time whereas reduces the final setting time.
- In general, all the mixes attain the target strength and give more strength when compared to the controlled concrete irrespective of curing period.
- All the mixes gain strength irrespective of curing period.
- The rate of gain in strength of all mixes is faster at early ages than later ages.
- The partial replacement of cement by fly ash and lime sludge in concrete not only enhances the strength of concrete, but also reduces the cost of production of concrete and at the same time, it also eliminates the environmental pollution and hazards caused due to the disposal of these waste by-products on land.

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