

# DURABILITY AND STRENGTH CHARACTER OF CONCRETE USING LIME SLUDGE AND FLYASH AS PARTIAL REPLACEMENT OF FINE AGGREGATE

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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. 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. In the present study, concrete cubes have been cast by replacing fine aggregate (0% and 5%) with fly ash and cement with (0%, 5%, 10% and 15%) lime sludge. The method adopted in this investigation is as per the IS code specifications.

**Key Words:** Compressive strength, compaction factor, target strength, water cement ratio, hardened concrete

## 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 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. 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.

Portland cement production is one of the major reasons for CO<sub>2</sub> emissions into atmosphere. It is due to the use of fossil fuels, including the fuels required to generate electricity during cement manufacturing process. Presently large amounts of fly ash are generated in thermal power plants with adverse impacts on environment and humans.

Dumping of fly ash is the biggest issue now days in India due to fly ash leads to environmental pollution and human hazards are increasing day by day. Fly ash is the most widely used pozzolana in the world (Fly ash is a pozzolanic material and it improves the properties of concrete like compressive strength and Durability). The use of fly ash not only improves the various properties of concrete - both in its fresh and hardened states, but also can contribute to economy in construction costs.

This work describes the feasibility of using fly ash and lime sludge as partial replacement of cement in the production of concrete and to study the effect of them on the mechanical properties of concrete at different replacement levels and also to assess the quality grading of concrete.

## 1.2 ADMIXTURES

Admixtures are materials other than cement, aggregate and water that are added to concrete either before or during its mixing to alter its properties, such as

workability, curing temperature range, set time or colour. Some admixtures have been in use for a very long time, such as calcium chloride to provide a cold-weather setting concrete.

Others are more recent and represent an area of expanding possibilities for increased performance. Not all admixtures are economical to employ on a particular project. Also, some characteristics of concrete, such as low absorption, can be achieved simply by consistently adhering to high quality concreting practices.

Admixtures are now widely accepted as materials that contribute to the production of durable and cost-effective concrete structures. The contributions include improving the handling properties of fresh concrete making, placing and compaction easier, reducing the permeability of hardened concrete, and providing freeze/thaw resistance.

### 1.2.1 TYPES OF ADMIXTURES

Vary widely in chemical composition, and many perform more than one function. Two basic types of admixtures are available namely Chemical admixtures and Mineral admixtures.

All admixtures to be used in concrete construction should meet specifications; tests should be made to evaluate how the admixture will affect the properties of the concrete to be made with the specified job materials, under the anticipated ambient conditions, and by the anticipated construction procedures.

### 1.2.2 MINERAL ADMIXTURES

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
- Quarry dust
- Metakaolin
- Silica Fume
- Ground Granulated Blast Furnace Slag
- Rice husk ash

## 2. SCOPE OF PRESENT INVESTIGATIONS

One of the major challenges of our present society is the protection of environment. Due to the growing of structures, cement and natural aggregates availability is relatively reduced.

Some of the important elements in this respect are the reduction of the consumption of energy and natural raw materials. These topics are getting considerable

attention under sustainable development nowadays.

In the recent past good attempts have been made for the successful utilization of various industrial by-products in concrete.

In addition to this, an alternative source for the potential replacement of natural aggregates in concrete has gained good attention due to the reduction in sources. As a result there is increased need to identify substitute materials to aggregates and cement in the production of concrete.

This work is mainly focusing on to find the effect of fly ash and lime sludge on the properties of concrete mixture as a partial replacement of cement and fine aggregate.

The use of fly ash and quarry dust in concrete is to reduce some percentage of environmental effects and reduce the impact of waste materials on environment.

## 3. OBJECTIVES

The objectives of this project are to reduce the environmental impact by the waste products from various industries.

- To find out the percentage use of admixtures feasible for construction.
- To compare the results of various tests conducted on concrete at different proportions by using fly ash and lime sludge with controlled concrete.
- To find out how much percentage of fly ash and lime sludge is partially replaced by cement and sand in concrete for safe construction.
- To study the influence of hardened properties of concrete such as compressive strength and quality grading of concrete when fly ash and lime sludge is used in the concrete mixes to reduce the cost of concrete production.

## 4. MATERIALS

The various materials used in the experimental investigation include:

- Ordinary Portland Cement (OPC)
- Fine Aggregate (Natural River Sand)
- Fly ash
- Lime sludge
- Coarse aggregate and
- Water

### 4.1 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 is adding small amounts of other materials.

**TABLE 1 Physical properties of OPC**

Sl.No.	Properties	Test values	Standard values (IS 12269:1987)
1.	Specific gravity	3.13	3.15
2.	Standard consistency	33%	Not Specified
3.	Initial setting time(min)	40	>30
4.	Final setting time(min)	350	<600
5.	Fineness	6%	10%
6.	Soundness	1mm	<10

#### 4.2 FINE AGGREGATE

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

**Table 2 Zones of Fine Aggregate**

IS SIEVE DESIGNATION	PERCENTAGE PASSING FOR			
	Grading zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10mm	100	100	100	100
4.75mm	90-100	90-100	90-100	95-100
2.36mm	60-95	75-100	85-100	95-100
1.18mm	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15

#### 4.3 COARSE AGGREGATE

Aggregate is commonly considered as inert filler which around 41% of the cost of concrete. Aggregate most of which is retained on 4.75-mm IS Sieve.

Two types of aggregates are used

- 1)16mm passing and 12.5mm retained.
- 2)25mm passing and 20mm retained.

**Table 3 Physical Properties of Coarse Aggregate**

Sl. No.	Properties	Test Values
1	Specific gravity	2.76
2	Water Absorption	0.41%
3	Impact Value	7.3%
4	Crushing value	26.13%
5	Elongation	20.2%
6	Flakiness	21.4%
7	Fineness modulus	7.36
8	Bulk density	
	i) Rodded bulk density	1605 kg/m <sup>3</sup>
	ii) Loose bulk density	1477 kg/m <sup>3</sup>

#### 4.4 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.

#### 4.5 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.

**Table 4 Chemical Composition of Lime Sludge**

Oxides	wt%
Al <sub>2</sub> O <sub>3</sub>	39.1
SiO <sub>2</sub>	30.2
Fe <sub>2</sub> O <sub>3</sub>	25.8
K <sub>2</sub> O	1.4
TiO <sub>2</sub>	1.4
MgO	0.6
SO <sub>3</sub>	0.6
P <sub>2</sub> O <sub>5</sub>	0.3
MnO	0.3
CaO	0.2
others	≤ 0.09

#### 4.6 FLYASH

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.

#### 5. TESTS ON CEMENT

The following tests have been conducted on cement

- Fineness
- Standard consistency
- Specific gravity
- Initial setting time and Final setting time
- Soundness

**Table 5 Test Results on Cement**

S.NO	PROPERTIES	TEST RESULTS
1	Fineness of Cement	4%
2	Standard Consistency	30%
3	Initial Setting time	145 min
	Final Setting Time	415 min
4	Specific Gravity Of Cement	2.85
5	Compressive Strength of Cement At 28 days	20 N/mm <sup>2</sup>

#### 6. TESTS ON AGGREGATE

The following tests are conducted on aggregates

- Sieve analysis
- Specific gravity
- Bulking of sand
- Water absorption
- Bulk density
- Impact value
- Crushing value

**Table 6 Test results on coarse aggregate**

Property	Test results
Specific gravity	2.72
Impact value	6.07%

**Table 7 Test results on fine aggregate**

Property	Test results
Specific gravity	2.56
Fineness modulus	2.484

#### 7. TEST RESULT ON FRESH AND HARDENED CONCRETE

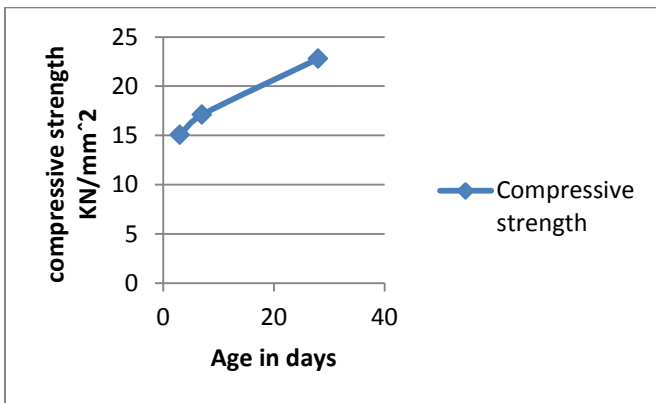
**Table 8 Compressive Strength of The Concrete For 3,7,28 Days**

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 ash 5%	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

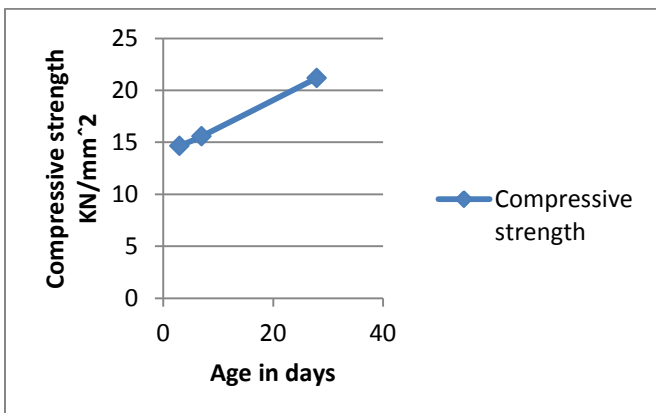
In above table shows the compressive strength values of normal concrete and different %'s of lime sludge

replaced in concrete. Normal concrete gives the best compressive values when compared with other the compressive strength values of different %'s of lime sludge concrete. The results that the normal mix concrete is better when compared with different %'s of lime sludge

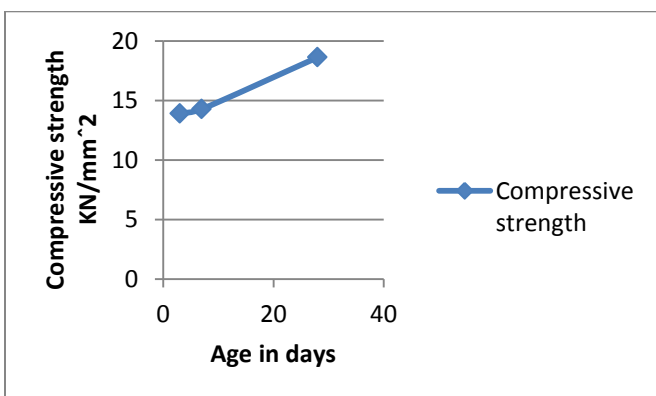
## 8. GRAPHS



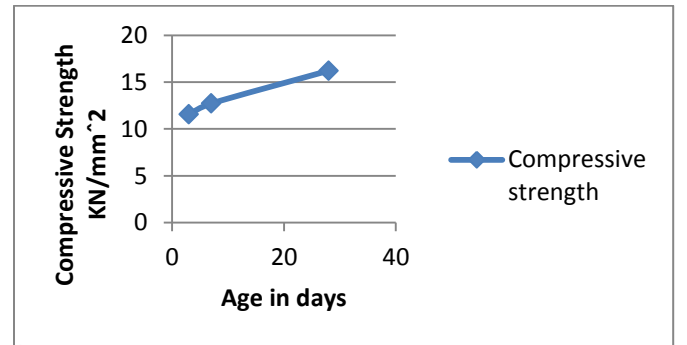
Graph 1 Compressive Strength of Normal Concrete



Graph 2 Compressive Strength of 5 % Lime Sludge



Graph 3 Compressive Strength of 10 % Lime Sludge



Graph 4 Compressive Strength of 15 % Lime Sludge

## 9. CONCLUSION

The graphs shows that the comparison between the compressive strengths of concrete cubes with different percentages of Lime Sludge powder. The curves which shows the variation of compressive strength of concrete in which the partial replacement of the cement is done with different percentages of Lime Sludge powder.

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.

## 10. SCOPE FOR FUTURE WORK

- Only 5% of fly ash and 5%, 10% and 15% of lime sludge as replacements to cement have been studied, other levels of replacement of cement by fly ash and lime sludge can also be studied.
- This investigation was concentrated only on mechanical properties of concrete like compressive strength only. The other mechanical properties tests like flexural strength can also be determined.
- Some tests relating to durability aspects such as water permeability, resistance to penetration of chloride ions, corrosion of steel reinforcement, resistance to sulphate attack, durability in marine environment etc. with fly ash and lime sludge need investigation.
- The study may further be extended to know the behavior of concrete whether it is suitable for pumping purpose or not as present day technology is involved in large projects where pumping of concrete is being done to large heights.
- For use of combined admixtures fly ash and lime sludge in concrete as a structural material, it is necessary to investigate the behavior of reinforced concrete (with fly ash and lime sludge) under flexure, shear, torsion and compression.
- In this work mild exposure condition is considered, same way extreme and very severe exposures condition could be experimented with different admixtures.

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