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A comparative study on Strength Parameters of LC^3 Concrete and OPC Concrete

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ABSTRACT

The proposed study describes the potential of LC^3 for its use in conventional concrete in comparison to OPC. LC^3 holds promising power to be alternative low clinker cement in place of OPC. The ecological impact of LC^3 production is also found to be positive with dramatic decrease in carbon footprints. This study for the most part centers on the hardened properties such as compressive strength, split tensile strength and flexural strength of concrete at 3days, 7days, 14days and 28days. This study deals with the mechanical properties of concrete of grade M25 with the use of OPC and LC^3. Based on the results it was noted that LC^3 concrete has enhanced mechanical properties compared to OPC Concrete. Hence LC^3 proves to be a better alternative for OPC.

1. Introduction

During the history of the cementing material is as old as the history of engineering construction. Concrete is one of the most widely used construction material today. More than 90% of the structures ranging from building, bridges, roads, dams, retaining walls etc. utilize the concrete for their construction. The versatility and mould ability of this material, its high compressive strength and discovery of reinforcing and prestressing technique has gained its widespread use. This is the popular construction material where strength, durability, impermeability, fire resistance and abrasion resistance are required. Strength durability and workability may be considered as main properties of concrete. In addition, Good concrete should be able to resist wear and corrosion and it should be water-tight, and economical [1]. The concrete must be sufficiently able to withstand without damage all the forced worry with the required factor of wellbeing. At the point when the concrete blend has been structured based on greatest reasonable water-concrete apportion, keeping in view the necessities of sturdiness, it will build up the required quality if appropriately put in dampness is especially fundamental for the improvement for its high quality. To build up a given quality, longer time of damp restoring is required at lower temperature than is essential while relieving is done at higher temperature [2].

Cement is a homogeneous blend of blinder (concrete), fine totals, coarse totals and water in some predetermined extent. The properties of cement in plastic state/solidified state are reliant on the properties and the sort of fixings utilized. Thus, so as to get the required sort of concrete quality, it is important to control the properties of the fixing materials. An exhaustive learning of cooperation of different information of collaboration of different elements of cement is required to be known to make a concrete with stipulated qualities. Cement is generally excellent in pressure however feeble in strain. Cement can be made sturdy by utilizing great nature of materials for example Bond totals and water, by diminishing the degree of voids by appropriate evaluating and proportionate the materials, by utilizing sufficient amount of concrete and low water-bond apportion in this way guaranteeing cement of expanded impermeability. Moreover, through blending, wanted putting, sufficient compaction and restoring of the concrete is similarly essential to have strong cement [3].

2. The origin of term "LC^3"

LC^3 stands for limestone calcined clay cement. It is a low carbon cement developed by Ecok Polytechnique Federale de Lausonne, IIT-Bombay, IIT Delhi, IIT-Madras, Technology and Action for Rural Development (TARA) Central University of Los Villas (Cuba). LC^3 is special type of cement that depends on a mixture of limestone and Calcined clay LC^3 is a low carbon cement which is proportionate/option in contrast to the OPC, LC^3 can lessen 30% of CO_2 emission. The LC^3 can turn into a fundamental development material particularly in quickly developing financial matters where limiting ecological effect and asset consumption are on top need. It is assessed that utilizing LC^3 rather than standard cement can save upto 500 million tons of CO_2 for every year by 2050. India is the principal nation where LC^3 is being tested both in Lab and field on an extensive scale. This LC^3 Cement is Cost compelling and it sends to be delivered with existing assembling hardware, prompting just burely expanded venture for calcining gear. An examination on mechanical and solidness properties on LC^3 concrete is researched that significant explanation behind the better execution was credited to the more minimal and thick microstructure of the framework with the fastener against OPC and F 30. The assessed porosity recommends that the LC^3 folio framework accomplishes much lower penetrability contrasted with the Ordinary Portland Cement and FA30. The parts of the LC^3 Cement in the pilot scale creation in India as 50% clinker, 30% Calcined Clay, 15% Crushed lime stone and 5% Gypsum. A few methodologies to moderate the CO2 outflow and its negative effect for the earth of bond producing includes the decrease of the clinker factor clinker with expanding dimensions of strengthening cementitious materials is restricted by its accessibility contrasted with the concrete interest. The creation of crude materials in LC^3 was chosen to alter as 50% Clinker, 31% Calcined Clay, 15% Limestone and Gypsum in the second pilot scale generation in India. The compound reactivity of the calcined mud can be acquired first by estimation of the warmth discharge and response utilizing isothermal calorimetric and second by bond water assurance in warming set between 110^{0}C and 400^0 C. The investigation gives better hardened properties at 3 days, 7 days, 14 days and 28 days than the 100% PC. This showed that incompletely supplementing clinker by calcined mud joined with limestone (LC^3 mixes) can be utilized to accomplish mixed concretes with great execution at much lower dimensions of clinker. Such mixes can make a critical commitment to decrease of CO_2 emanation related with bond creation. In LC^3 aluminates from the metalaolin like wise respond with Calcite and improve the arrangement of carbo-aluminate stages. The solid evaluated depend on two common place quality evaluations acquired with mixed bonds, and also just Portland cement concrete, the significance of SCMs in terms of aggregate vitality utilization and carbon dioxide outflows.

Hence in this work endeavor has been taken to study the strength behaviors of LC^3 Concrete in comparison to OPC concrete.

3. Need for study

1. To find on alternative for OPC in all respects
2. To reduce Co_2 emission & produce eco-friendly concrete.
3. To develop a cost efficient product
4. To provide high strength concrete than OPC Concrete

4. Objectives and scope

1. To make a concrete using LC^3
2. To study the compressive strength of LC^3 concrete over OPC Concrete
3. To study the split tensile strength of LC^3 Concrete over OPC Concrete
4. To study the flexural strength of LC^3 Concrete over OPC Concrete
5. To analyze & compare the results of LC^3 concrete with OPC Concrete.

5. Methodology and materials used

Methodology

Figure 1: Methodology Used

6. Materials Used

The different materials used in production of concrete obtained from construction sites in Rohtak. The basic ingredients of OPC Concrete & LC^3 concrete used in this research study are:

- Ordinary Portland Cement
- Limestone calcined Clay Cement
- Aggregates
- Fine aggregates
- Coarse aggregates
- Water

Ordinary Portland Cement (OPC)

Ordinary Portland Cement's is one of the most widely used type of Portland Cement was given by Joseph Aspdin in 1824 due to its similarity in color & its quality when it hardens like portland stone.

The OPC of grade 43 conforming to IS12267 is used to carry out the research. The physical properties of OPC are given in table below

Table 1: Physical Properties of OPC

Proportion	Values
Specific gravity	3.10
Normal Consistency	30%
Initial setting time	75min
Final setting time	280 min
Fineness M^2/kg	310
Compressive strength	43 N/mn^2
Color	Dark Grey
Soundness, mm	2.50

Limestone Calcined Clay Cement (LC^3)

Limestone calcined clay cement (LC^3) from a trial industrial production in Bhuj, Gujrat, India is used. The composition of Clinker: calcined clay: Limestone: Gypsum is 50: 31: 15: 4 for LC^3 blends used in this research. The Clinker used in LC^3 in the study is different compared to OPC Clinker.Table shows the physical properties of LC^3

Table 2:- Physical Properties of LC[3]

Physical Characteristics	Values
Standard consistency	30%
Blaine's fineness (m2/kg)	440
Initial setting time (min)	95
Final setting time (min)	350
Loss on ignition	6.7%
Insoluble residue	
3 days strength (MPa)	25.0
7 days strength (MPa)	36.9
28 days strength (MPa)	46.8

Coarse Aggregates

The Coarse aggregates used in this study were also locally supplied aggregates having size within range of 10 mm – 20mm conformed to IS: 383: 1970 were mixed in 50:50 proportion. The properties of coarse aggregates are given below.

Table 3:- The Physical Properties of Coarse Aggregates

S. No	Characteristics	Value
1	Type	Crushed
2	Sp. Gravity	2.68
3	Bulk density	1765 kg/m^3
4	Fineness modulus	6.56
5	Max. Size	20 mm
6	Water Absorption	0.50
7	Moisture Content	Nil

Fine Aggregates

The Fine aggregates used in this study were locally available river sand & conformed to grading Zone as per IS: 383:1870. It was sieved through 4.75 mm sieve to remove larger sized particles. Properties of fine aggregates are summarized in table below.

Table 4: Physical Properties of Fine Aggregates

S. No.	Characteristics	Values
1	Types	Uncrushed
2	Sp. Gravity	2.54
3	Bulk density	1668 kg/m^3
4	Fineness modulus	2.96
5	Grading zone	Zone II
6	Water Absorption	1.78
7	Moisture Content	0.50

Water

The mixing water should be clean, fresh & potable. The water should be relatively free from organic water. Water as available from the tap in the laboratory was used for mixing the ingredients of concrete & curing the specimens.

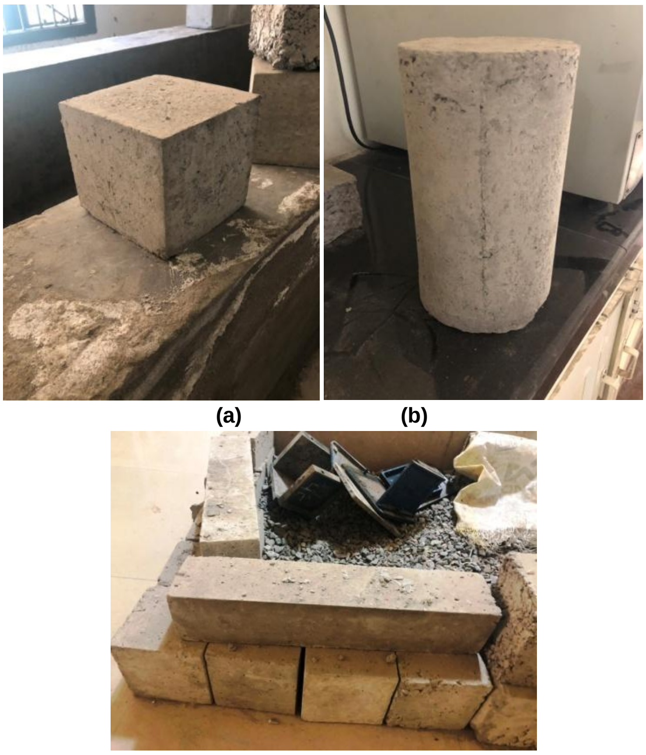
7. Casting of test specimens

The concrete grade M25 was proportioned by adopting IS method of mix design with water binder ration 0.4. The test specimens were divided into four series as 3 days, 7 days, 14 days and 28 days.

For the casting of concrete cubes, pre-oiled moulds of 150mm x 150mm x 150mm size are used. Totally 24 concrete cubes were cast for compressive strength of concrete cured at 3, 7, 14, 28 days. Also 24 cylinder specimens of 150mm diameter and 300mm length for split tensile strength test and 24 beams of 100mm x 100mm x 500mm size for flexure strength test were cast and cured for 3, 7, 14, 28 days. All the specimens were demoulded after 24 hours from casting time and cured in water. Pond curing was adopted. The specimens were dried in air for one day before testing. Table shows the details of test specimen.

Table 5: Details of Test Specimen

Sr. No.	Name of the Test	Size of Specimen (mm)	No. of Specimen
1.	Compressive Strength Test	150 X 150 X 150	24
2.	Split Tensile Strength Test	100 X 300	24
3.	Flexural Strength Test	500 X 100 X 100	24
		Total	72



(a) (b)

(c)

Figure 2: (a) cube specimen, (b) cylinder specimen, (c) beam specimen

8.

9. Tests for concrete

1. Test for compressive strength of concrete cubes

To calculate the compressive strength of concrete cubes the universal testing machine (UTM) having capacity of 300 tonne was used. In this test the strength obtained in tone. The measured compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test by the cross sectional area calculated from mean dimensions of the section and shall be expressed to the nearest N/mm^2.

Compressive strength = Maximum load/ Area

= P/A

2. Test for Split tensile strength of concrete cylinders

As we know that the concrete is weak in tension. Tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure. The usefulness of the splitting cube test for assessing the tensile strength of concrete in the laboratory is widely accepted the usefulness of the splitting cube test for assessing the tensile strength of concrete in the laboratory is widely accepted and the use fullness of the above test for control purpose in the field is under investigation. The standard has been prepared with a view to unifying the testing procedure for this type of test for tensile strength of concrete. The load at which splitting of specimen takes place shall then be recorded. The universal testing machine (UTM having capacity of 300 tonne was used for the splitting strength of the concrete cylinders.

The split tensile strength of the specimen calculated from the following formula

$T = [2P/(\pi dL)]$

3. Test for Flexural strength of concrete beams

For this test the beams of dimension 100mm×100mm×500mm were casted. Flexural strength, also known as modulus of rupture, bond strength, or fracture strength, (dubious – discuss) a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a road specimen having either a circular or rectangular cross- section is bent until fracture using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. The beam tests are found to be dependable to measure flexural strength.

The value of the modulus of rupture depends on the dimension of the beam and manner of loading. In the investigation, to find the flexural strength by using third point loading. In symmetrical two points loading the critical crack may appear at any section enough to resist the stress with in the middle third, where the banding moment is maximum, Flexural modulus of rupture is about 10 to 20 percent of compressive strength depending on the type, size and volume of coarse aggregate used.

The flexural strength of concrete can be calculated with the following formula:

$F = PL/bd^2$

10. Result and discussion

Table 6: Comparison of compressive strength test results

Mix Design	3 Days Avg. Comp. St.	7 Days Avg. Comp. St.	14 Days Avg. Comp. St.	28 Days Avg. Comp. St.
OPC Concrete	10.5	17.7	22.0	25.7
LC^3 Concrete	11.1	18.6	24.2	30.2

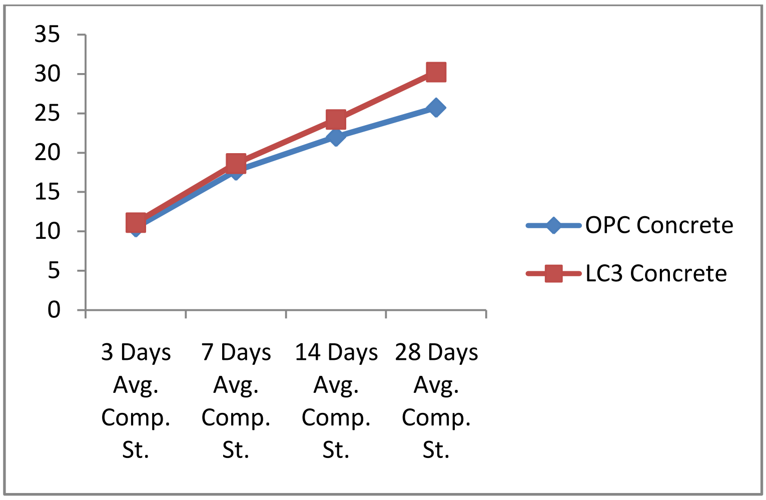


Figure 3: Comparative Graph of compressive strength test

Table 7: Comparison of Split Tensile Strength Test Results

Mix Design	3 Days Avg. Split Tensile St.	7 Days Avg. Split Tensile St.	14 Days Avg. Split Tensile St.	28 Days Avg. Split Tensile St.
OPC Concrete	2.17	2.66	3.37	3.56
LC^3 Concrete	2.71	2.89	3.59	3.99

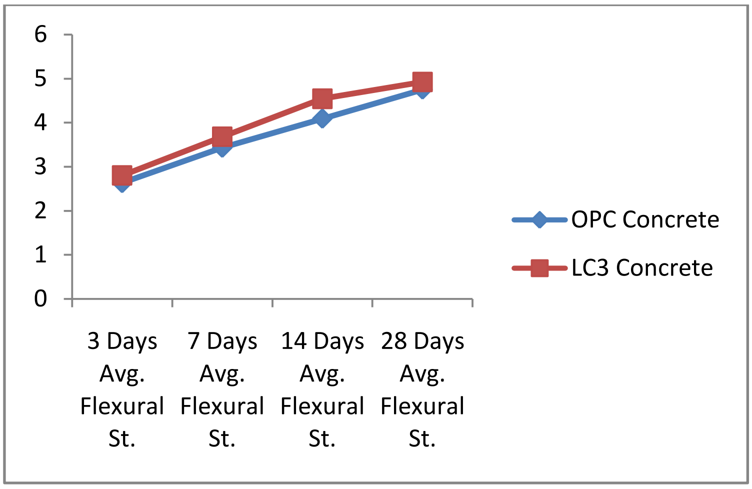


Figure 4: Comparative Graph of Split Tensile Strength test

Table 8: Comparison of Flexural Strength Test Results

Mix Design	3 Days Avg. Flexural St.	7 Days Avg. Flexural St.	14 Days Avg. Flexural St.	28 Days Avg. Flexural St.
OPC Concrete	2.63	3.43	4.09	4.75
LC^3 Concrete	2.80	3.68	4.54	4.92

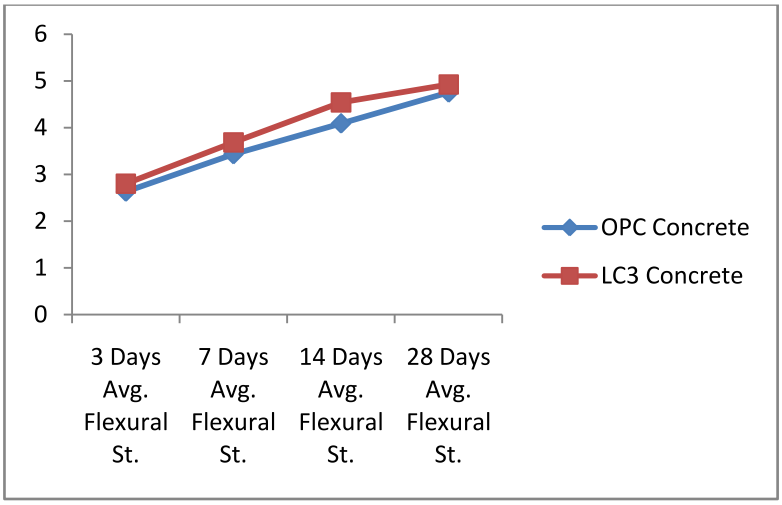


Figure 5: Comparative Graph of Flexural Strength test

11. Conclusions

Based on the experimental investigations done on the strength parameter of OPC Concrete LC^3 concrete as Per IS Code, the following facts on concluded:

1. LC^3 Concrete has 5.71%, 5.08%, 10.0%, 17.5% more compressive strength than OPC Concrete at 3days, 7days, 14days and 28days respectively.
2. LC^3 Concrete has 4.88%, 8.64%, 6.52%, 12.07% more Split Tensile strength than OPC Concrete at 3days, 7days, 14days and 28days respectively.
3. LC^3 Concrete has 6.46%, 7.28%, 11.0%, 3.57% more Flexural strength than OPC Concrete at 3days, 7days, 14days and 28days respectively.
4. Use of LC^3 Concrete in place of OPC Concrete proves to be economical.
5. LC^3 will preserve the resources particularly Ordinary Portland Cement & thus makes construction industry sustainable
6. It will solve the problem of Co_2 emission during production of cement, upto great extent. Hence, it will prove to be environmental friendly.

12. Future scope

1. Effect of different curing periods on LC^3 concrete.
2. Effect on the mechanical properties of LC^3 concrete by using different water cement ratio for the design mix concrete.
3. For the use of LC^3 concrete as a structural material, it is necessary to investigate the behavior of reinforced LC^3 concrete under flexure, shear, torsion and compression.
4. The logistics of implementing the use of LC^3 concrete in developing country construction should also be investigated to ensure that this low cost and environmental friendly material is helping the people who need it most.

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