Experimental Investigation on Mechanical Properties of Concrete Blended With Calcined Clay And Lime Stone

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Abstract- *Concrete is the world's second most widely used commodity. The production of concrete results in a wide range of environmental problems. The major problem faced is the production of CO2 by the cement industry. To decrease the impact of concrete on environment and climate, various researches are being conducted across globe, the most suitable and beneficial way is to diminish the percentage of clinker used in cement and replacement with various supplementary cementitious material (SCMs) such as slag, Fly ash, GGBS, Metakolin RHA etc, with the decrease in quantity of fly ash supply from the power sector, thermal power plants , new pozzolanic additives for cement and concrete production have become required. The issues is now being resolved with use of common SCMs which are available to meet the demand of cement to be produced. In latest ongoing research it is found that low quality calcined clay in addition with limestone have abilility to substitute of clinker. The only type of material which is available in sufficient and good quantities for meeting up the global demand is the clay containing kaolinite, which can be under go calcinations to produce an effective and efficient SCM. In the current work, the partial replacement of cement with optimum percentage of calcined clay and limestone had good results in increasing the strength properties.*

Keywords- Calcined clay, Lime stone, Co2 reduction, Efficient SCM.

I. INTRODUCTION

Cement industry is one of the largest pollution causing industry which accounts for the release of large amount of carbon dioxide which is about 8% of the emission by humans, contributes to 40% by chemical process and 30% from burning fuel. From the Manufacture of structural concrete it accounts to 410 kg/m3 of Carbondioxide emission. Manufacture of cement contributes to greenhouse gases. Concrete is currently most widely used construction material as it can be casted to any form and shape at site very easily. Cement is responsible for production of major amount of CO2. The production of Portland cement in the industry release the large amount of carbon dioxide to the atmosphere.To conserve the availability of limited resources, reduction in use of OPC was in practice based on numerous researches carried out in the field of blending of supplementary cementitious material (most commonly Calcined clay) in OPC. Commercial PPC production, on the other hand, is the result of blended cement production. It was recently revealed, based on studies conducted by a few scholars, that even while using blended cement concrete, by using pozzolanic content such as calcined clay as a partial substitute for OPC, the proportion of cement may be minimised. Keeping in the view of the above mentioned concept this experimental investigation was proposed to work out the suitability of addition of calcined clay and limestone as partial replacement of OPC in concrete. These two materials decreases green house gas emission proportionately and result in a more green concrete, through decreasing of energy. Consumptions (energy required to produce cement) and put off the depletion of natural resources. Calcined clay is formed when pulverised coal is burned, Mechanical and electrostatic separators extract pulverized coal from the fuel gases in thermal power plants. Where coal is used as a source of energy The limestone used in this experimental study is low grade and hence it is available in nature very often and very cheap in economic point of view low grade lime stone. Additional benefits include minimization of waste disposal in case of calcined clay and limestone calcined clay is commonly used in concrete in replacement ranging from 0% to 30% by weight of the total cementitious material.

II. OBJECTIVE

The objective of the present work is to study the effect of partial replacement of cement by clay and limestone as they are industrial wastages. Eight percentage levels of replacements i.e., 0%, 5%, 10%, 15%, 20%, 25%, 30% and 35% are taken for partially replacement cement with calcined clay & limestone. M30 grade mix is initially designed without replacement and subsequently cement is partially replaced with calcined clay and limestone in two different stages. The concrete mix proportions of M30 grade is obtained as per IS: 10262:2009. To study the compressive strength, split tensile strength and flexural strength of concrete at the age of 7, 28 and 56 days.

III. MATERIALS USED

- Ordinary Portland cement 43 grade (SAGAR cement) with specific gravity of 3.14
- Locally available river sand with bulk density of 1757 kg/m3 and specific gravity of 2.67 and confirming to zone-2 of IS:383
- Coarse aggregate with bulk density of 1709 kg/m3 and specific gravity of 2.74.
- Calcined clay, limestone.

IV. EXPERIMENTS CONDUCTED

150x150x150 mm cubes and 150x300mm cylinders and 500x100x100mm cubes are casted and cured for 7,28,56 days and examined for strength and physical properties. Cubes are used to check compressive strength, Cylinders are used to check split tensile strength and prisms are used to check flexural strength.

V. STRENGTH TESTS

5.1 Mechanical Properties

Mechanical properties of concrete are mainly related to the calculation of its strength. The calculation of mechanical properties includes the testing of concrete and its performance in Compressive strength, Split tensile strength and modulus of rupture. The procedures and calculations of these three tests are confirmed by the standard specification IS 516 –1959.

5.2 Compressive Strength

Compressive strength or crushing strength is the main property observed in testing the cubes .Cubes are tested to find Compressive strength by applying gradual loading in Compression Testing Machine. The reading of the failure load is occurred on the top of the machine in the indicator.

Cubical specimens are put on a compression strength measuring system after 28 days of curing. The dial gauge reading records the maximum load at which the cubical specimen fails. Compressive strength is obtained by applying crushing load on the cube surface the test results are presented here for the Compressive strength of 7 days, 28 days and 56 days of testing.

Compressive strength = P/A N/mm$^{2.}$

5.3 Split Tensile Strength

Cylinder specimens are mounted on a tension strength measuring system after 28 days of curing by inserting two steel plates below and above the cylinder in a horizontal direction. Ultimate load at which cylinder specimen fails is noted down the dial gauge reading. The cylindrical specimens are also tested in compression testing machine. The cylinders are placed in axial direction by facing cylindrical face to the loading surface.

Split tensile strength $f_{cr} = \frac{2P}{\pi DL}$

5.4 Flexural Strength

Prismatic specimens are mounted on a flexure strength system with a maximum capacity of 100 kN after 28 days of curing, with the two point loading placed 13.3cm from both ends.

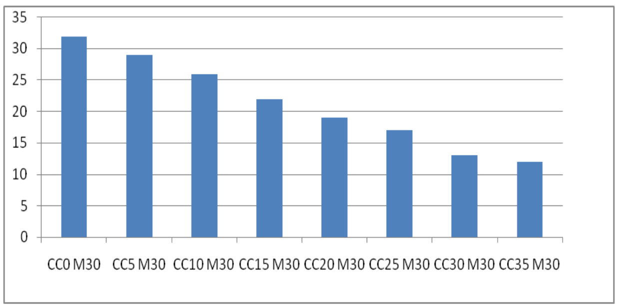
Flexural Strength fcr = PL/bd2

The modulus of rupture is denoted by “f_{cr}“.
The f_{cr} value is mainly based on the shortest distance of line fracture “a”.
If 110mm < a < 133mm, f_{cr} = 3PL/bd2
If a > 133mm, f_{cr}= PL/bd2
If a < 110mm, the test shall be discarded

VI. TABLES AND GRAPHS

Table 6.1 Workability in terms of slump(mm)

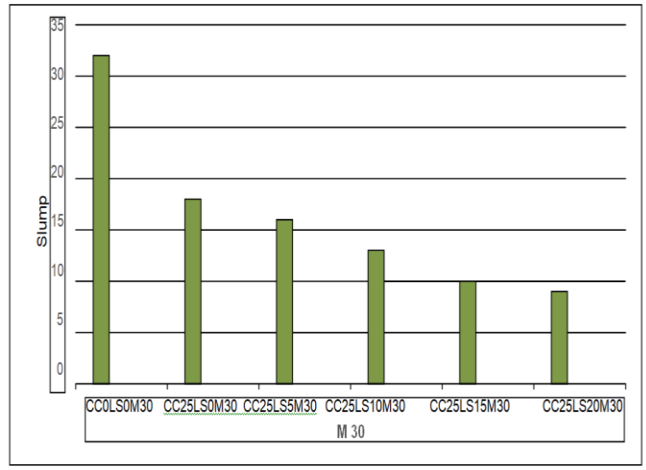
S.NO.	M30 Mix ID	calcined clay (%)	Slump (mm)	Admixture
1	CC0 M30	0	32	0.3%
2	CC5 M30	5	29	0.3%
3	CC10 M30	10	26	0.3%
4	CC15 M30	15	22	0.3%
5	CC20 M30	20	19	0.3%
6	CC25 M30	25	17	0.3%
7	CC30 M30	30	13	0.3%
8	CC35 M30	35	12	0.3%



Variation of Slump for different percentages of calcined clay.

Table 6.2 Slump cone values for optimized calcined clay with different percentages of Lime stone

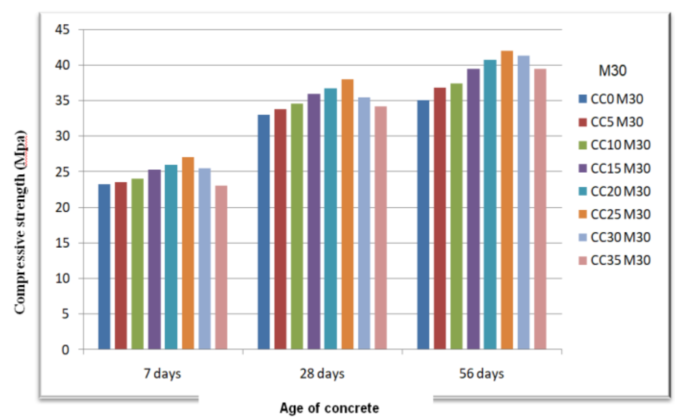
S.NO.	M30 Mix ID	calcined clay (%) + Limestone (%)	Slump (mm)	Admixture (%)
1	CC0LS 0M30	0 + 0	32	0.3
2	CC25LS0M30	25 + 0	18	0.3
3	CC25LS5M30	25 + 5	16	0.3
4	CC25LS10M30	25 + 10	13	0.3
5	CC25LS15M30	25 + 15	10	0.3
6	CC25LS20M30	25 + 20	09	0.3



Variation of Slump for optimized calcined clay with Limestone percentages

Table 6.3 Compressive strength of M30 Grade concrete with different proportions of calcined clay

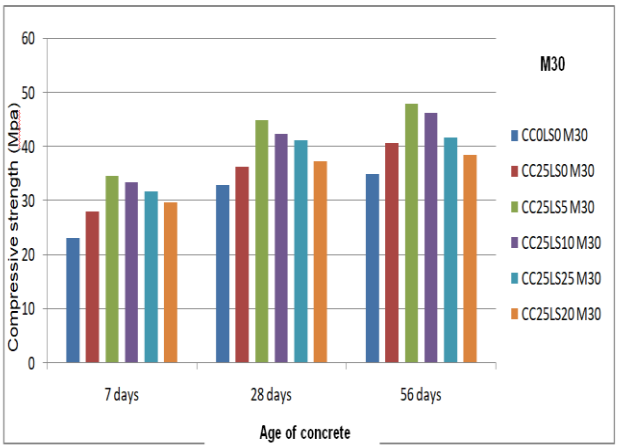
	CC0M30	CC5 M30	CC10M30	CC15M30	CC20M30	CC25M30	CC30M30	CC35 M30
%CC	0	5	10	15	20	25	30	35
7 days	23.2	23.5	24	25.3	26	27	25.5	23
28 days	33	33.8	34.6	35.9	36.7	38	35.4	34.2
56 days	35	36.8	37.4	39.4	40.7	42	41.3	39.4



Graphical representation for the variation of compressive strength for various percentage of calcined clay for different time periods.

Table 6.4 Compressive strength for M30 grade concrete with different proportions of balanced cement with optimized calcined clay and limestone

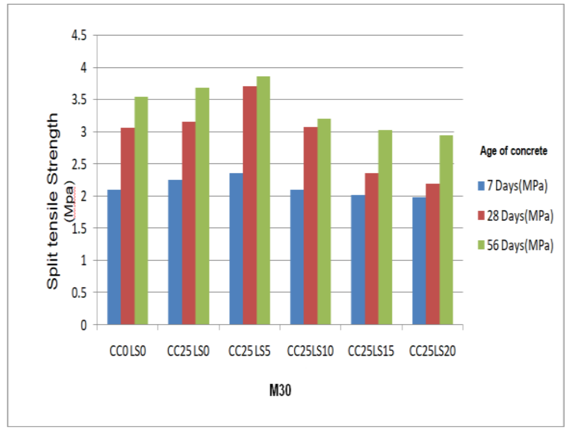
MIX ID	CC0LS0M30	CC25LS0M30	CC25LS5 M30	CC25LS10M30	CC25LS25M30	CC25LS20M30
CC (%)	0	5	10	15	20	25
7 days	23.2	28	34.7	33.5	31.8	29.8
28 days	33	36.4	45	42.4	41.3	37.3
56 days	35	40.8	48	46.3	41.8	38.6



Graphical Representation for the variation of compressive strength for various percentage of calcined clay and lime stone for different time periods.

Table 6.5 Split tensile strength for M30 grade concrete with different proportions of balanced cement with optimized calcined clay and limestone.

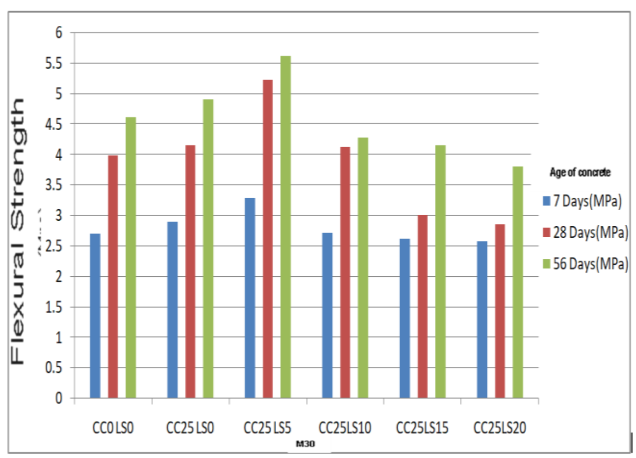
MIX ID	CC0 LS0	CC25 LS0	CC25 LS5	CC25LS10	CC25LS15	CC25LS20
% Limestone	0	0	5	10	15	20
7 Days(MPa)	2.1	2.25	2.35	2.1	2.02	1.98
28 Days(MPa)	3.06	3.15	3.7	3.07	2.35	2.19
56 Days(MPa)	3.54	3.68	3.85	3.2	3.02	2.94



Graphical representation for the variation of split tensile strengths for various percentages of calcined clay and limestone for different time period.

Table 6.6 Flexural strength for M30 grade concrete with different proportions of balanced cement with optimized calcined clay and limestone.

MIX ID	CC0 LS0	CC25 LS0	CC25 LS5	CC25LS10	CC25LS15	CC25LS20
% Limestone	0	0	5	10	15	20
7 Days(MPa)	2.7	2.9	3.29	2.71	2.62	2.58
28 Days(MPa)	3.98	4.15	5.23	4.12	3.01	2.85
56 Days(MPa)	4.61	4.91	5.62	4.28	4.15	3.81



Graphical representation for the variation of Flexural strengths for various percentages of calcined clay and limestone for different time period.

VI. CONCLUSIONS

A study was done on concrete blended with Calcined clay and Lime stone. Results were analyzed to derive useful conclusions regarding the strength characteristics of cement with calcined clay and also optimized calcined clay with limestone for M30 concrete has been used as reference mix. Based on the test results, the following conclusions were drawn:

1. The workability of concrete measured from slump cone test, as the percentage of calcined clay increases in mix, the slump value decreases. Hence it can be concluded that with the increase in the calcined clay content workability decreases.
2. From the experimental results, the optimum percentage recommended is 25% calcined clay for achieving maximum benefits in compressive strength, split tensile strength and Flexural strength.
3. The compressive strengths obtained from the calcined clay percentages CC05, CC10, CC15, CC20, CC25, CC30 and CC35 are increased by 2.4%, 4.84%, 8.78%, 11.2%, 15%, 7.2% and 3.6% respectively over the conventional concrete for 28 days.
4. The compressive strengths obtained from the optimized calcined clay with lime stone percentages CC25LS0, CC25LS5, CC25LS10, CC25LS15 and CC25LS20 are increased by 10.30%, 36.36%, 28.48%, 22.12% and 13.03% respectively over the conventional concrete for 28 days.
5. The compressive strength for optimized calcined clay with lime stone percentages at CC25LS5 was incremental level when compared to conventional base concrete.
6. The split tensile strengths obtained from the optimized calcined clay with lime stone percentages for CC25LS15 and CC25LS20 are decreased by 23% and 28.43% respectively over the conventional concrete for 28 days.
7. The split tensile strength for optimized calcined clay with lime stone at CC25LS5 was incremental level when compared to conventional base concrete.
8. The split tensile strengths obtained from the optimized calcined clay with lime stone percentages CC25LS0, CC25LS5 and CC25LS10, are increased by 2.941%, 20.916%, 0.32% respectively over the conventional concrete for 28 days.
9. The Flexural strength for optimized calcined clay with lime stone at CC25LS5 was incremental level when compared to conventional base concrete.
10. The Flexural strengths obtained from the optimized calcined clay with lime stone percentages for CC25LS15 and CC25LS20 are decreased by 24.37% and 28.39% respectively over the conventional concrete for 28 days.
11. The Flexural strengths obtained from the optimized calcined clay with lime stone percentages CC25LS0, CC25LS5 and CC25LS10, are increased by 4.27%, 31.40%, 3.51% respectively over the conventional concrete for 28 days.

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