International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 04 | Apr 2019 www.irjet.net p-ISSN: 2395-0072

# IMPACT ON COMPRESSIVE STRENGTH OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH LIME POWDER

**Prashant**

*Student, M.Tech Structural Engineering, Department of Civil Engineering, R.N. College of Engg. & Technology, Panipat (India)*

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**Abstract:** *This research work is done to find out the impact on the compressive strength of concrete when cement is partially replaced with lime powder which is taken from 0% to 30% in a division of 10%. In this research, M25 grade of concrete is used by adopting slump of 75 mm. The compressive strength of cubes having size 150mmX150mmX150mm is carried out at 7, 14 and 28 days at room temperature. After getting result, it has been observed that the grater compressive strength is achieved at 30% replacement of cement by lime powder.*

**Keywords:** Concrete, Lime powder, Cement, Compressive Strength, M25 grade

## 1. INTRODUCTION

Concrete is one of the materials of present as well as future. The wide use of it in structures, from buildings to factories, houses, from bridges to airports, makes it one of the most experimentally material of the 21st century. Due to the rapid population explosion and the technology boom to cater to these needs, there is an urgent need to improve and develop the strength and durability of concrete. Out of the various materials used in the creation of concrete, cement plays a major role due its particle size and adhesive property. So, to produce concrete with improved properties, the chemical mechanism of cement hydration has to be studied properly and better substitutes to it have to be suggested. Different materials known as subsidiary cementeneous materials or SCMs are added to concrete improve develop its properties. Some of these are lime, surkhi, fly ash, blast furnace slag and rice husk ash etc.

### LIME-USED IN CONCRETE

From the ancient period, human is using lime as a binding material. Due to its binding property, it is also known as natural cement. Egyptian and roman used this material in ancient period very effectively. If we talk about the ancient period of India many engineering structures i.e. Quila, Raj palace, Bridges, Temples and other structures are in very good condition that were build in Indian ancient time. Lime is very useful in comparison of cement which is as-

1. Lime is to cheaper than cement.
2. Workability and plasticity of lime is good as compare to cement.
3. Shrinkage of lime is less with respect to cement on hardened state.
4. Lime is generally available locally.

Due to calcinations of limestone, the moisture and carbon dioxide are removed from it. The product which remains thereafter is known as lime. The chemical reaction is as follows-

$$CaCO_3 \xrightarrow{\text{calcination}} CaO + CO_2$$

And the heating of limestone to redness in contact with air is known as calcinations.
If the lime is obtained from the calcination react with water it convert into hydraulic lime and liberate some heat. The reaction for hydrate lime or slake lime is as-

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

### Classification of Lime-

Lime obtained from lime burning may be classified into two categories-

***A.*** **Fat Lime** is also known as pure lime or white lime. Slaking of this lime is due to strengthening. After slaking the volume of slaked lime is increased by 2 to 2.5 %. It is generally obtained by pure lime stone. It has 95% of calcium oxide and less than 5% of impurities in it.

**Merits-**

a. It gets hardened very slowly.
b. Its plasticity is very high.
c. It is soluble in water.
d. It colour is pure white.
e. It settles down very slowly by air.

***B.*** **Hydraulic Lime** which has ability to get hardened in water is known as hydraulic lime. It generally contains 11% to 20% of clay impurity and rest of calcium hydroxide. It is used in mortar. It settles down or hardened in water after one week and is slaked after 2 to 3 hours.

### Uses of Lime

1. It is used as the chemical raw material to purify the water and for sewerage treatment.
2. It is used as flux in metallurgical industry.
3. It is used in concrete and mortar.
4. It is used in the production of glass.
5. It is used for making the mortar for masonry work.
6. It is used for plastering of wall and ceilings.
7. It is used for soil stabilization.

## 2. LITERATURE REVIEW

**Bell** indicates that with Increase in liquid limit and plasticity index lime has increased the plasticity of the soils treated with. This is suggested due to the action of hydroxyl ions modifying the water affinity of the soil particles. Besides, increase in lime content, beyond a certain limit, is found to have reduced the strength.

**Hwang, Noguchi & Tomosawa** based on their experimental results concerning the compressive strength development of concrete containing Lime, the authors concluded that the pores in concrete reduce by addition of Lime as replacement of sand.

**Rogers et al** investigated that cementation is primarily attributable to pozzolanic reactions and can significantly improve the long-term performance of the stabilized soils.

**Petry and Little** observed that High plastic soils generally contain clay minerals such as montmorrilonite, which has large affinity for water. Therefore, such soils undergo large swelling, leading to severe distress and damage to the overlying structures.

**Kumar et al** reported that increase in lime content beyond a certain limit was found to decrease the strength gain Because lime itself has neither appreciable friction nor cohesion, excess of lime is postulated to reduce its strength. However, soil-lime stabilization is dependent on several factors such as soil type, its mineralogy, lime content, and curing period, and is a complex problem that needs careful re evaluation.

## 3. EXPERIMENTAL WORK

**MATERIAL USED FOR TEST**

**A. CEMENT-**

The main raw material for the production of cement is clinker. Clinker is an artificial rock made by heating lime stone and other raw material in specific quantity to a very high temperature in a kiln. Ordinary Portland cement is hydraulic cement made by finely pulverizing the clinker produced by calcining to incipient fusion a mixture of argillaceous and calcareous material.

**Table showing Chemical composition of ordinary portland cement**

| S.NO. | OXIDE COMPOUND | PERCENTAGE | |
|---|---|---|---|
| | | LIMIT | AVERAGE |
| **1** | CaO | 60-65 | 63 |
| **2** | $SiO_2$ | 20-25 | 22 |
| **3** | $Al_2O_3$ | 4-8 | 7 |
| **4** | $Fe_2O_3$ | 2-4 | 3 |
| **5** | MgO | 1-3 | 2 |
| **6** | $SO_3$ | 1-2 | 2 |

**Test of cement-**
**a. Laboratory test-**

Following are the tests performed in laboratory to find out the properties of cement-

a. Fineness test.
b. Consistency test.
c. Setting time test.
d. Soundness test.
e. Compressive strength test.
f. Tensile strength test.

**b. Field test-**

Following are the tests performed at field-

a. Gray colour with a light greenish shade.
b. Cement should fell smooth when touched between fingers.
c. If a small quantity of cement is thrown in a bucket of water, it should sink and should not float on the surface.
d. Cement should be free from lump.
e. If hand is inserted in a bag of cement it should feel cool.

**Table showing properties of ordinary Portland cement has been taken for the mix design-**

| S.NO | PROPERTY | VALUE |
|---|---|---|
| **1** | Grade | 53MPa |
| **2** | Specific gravity | 3.15 kg/m$^3$ |
| **3** | Initial setting time | Less than 30 min |
| **4** | Final setting time | Not more than 10 hours |
| **5** | Fineness | 10% residue by weight |
| **6** | Normal consistency | 33 to 35 mm from top of the mould |
| **7** | Com.stre. at 28 days | 53Mpa |
| **8** | Tensile strength | 10% to 15% of com.str. |

**B. AGGREGATES-**

Aggregates are the major ingredients of concrete. They constitute 70-75% of the total volume, provide a rigid skeleton structure for concrete, and act as a and act as economical space filler IS:383 defines the requirement of aggregates. They are inert and broadly classified into 2 categories on the basis of their shape-

**Coarse aggregate** are those whose size is greater than 4.75mm and on passing through 4.75mm sieve, retained on 4.75mm sieve.

**Fine aggregate** are those whose size is equal to or less than 4.75mm and does not retained on 4.75 mm sieve.

**Table showing Properties of aggregate taken for test-**

| S.NO. | TYPE OF AGG. | FINENESS MODULUS | SIZE OF AGG. | SPECIFIC GRAVITY | WATER ABSORBTION |
|---|---|---|---|---|---|
| **1** | Coarse agg | 6.93 | 20 mm | 2.71 kg/m$^3$ | 0.6% by weight of c.agg. |
| **2** | Fine agg. | 3.05 | - | 2.67 kg/m$^3$ | 1% by weight of f.agg. |

**C. WATER**

The quality of water used must be checked for ensuring good quality of concrete. Water used for curing and mixing should be free from oil, acid, alkali, salt, and organic matter. It should be potable quality. There are three types of impurities present in water which are chemical, physical, and biological impurities. The value of Ph should lie between 6-8.

**Table showing permissible limit of impurities in water used for curing and mixing**

| Solids | Permissible limits in mg/l |
|---|---|
| **Organic** | 200 |
| **Inorganic** | 3000 |
| **Sulphates** | 400 |
| **Chlorides** | 2000 for PCC |
| | 500 for RCC |
| **Suspended matter** | 2000 |

**MIX DESIGN FOR SAMPLE PREPRATION**

The mix design for M25 grade of concrete is described below in accordance with Indian Standard Code IS: 10262-2009.

**a. Target strength for mix proportion:**

Characteristic compressive strength at 28 dayss: fck = 25 MPa
Assumed standard deviation (Table 1 of IS 10262:2009): sd = 4 MPa
Target average compressive strength at 28 days: ftarget = fck + 1.65sd =31.6 MPa

**b. Selection of water cement ratio:**

From Table 5 of IS: 456-2000, maximum water-cement ratio = 0.50. To start with let us assume a water-cement ratio of 0.475.

**c. Selection of water content:**

Maximum water content per cubic metre of concrete (refer Table 2 of IS: 10262-2009): Water max = 186L (for 25mm to5 mm slump).
Since, the slump was 75mm, then
=186+(3/75)*186=193.33

**d. Calculation of cement content:**

Mass of water selected per cubic metre of concrete = 193.33 kg. Mass of cement per cubic metre of concrete = 193.33/0.475 = 407.242 kg/$m^3$.
Minimum cement content = 300 kg/$m^3$ (for moderate exposure condition, Table 5 of IS 456:2000)
Maximum cement content = 450 kg/$m^3$ (Cl. 8.2.4.2 of IS 456:2000)
So, the selected cement content is alright.

**e. Proportion of volume of coarse and fine aggregate:**

Volume of coarse aggregate per unit volume of total aggregate (Table 3 of IS: 10262-2009) = 0.66
(This is corresponding to 20 mm size aggregate and Zone IV fine aggregate for water-cement ratio of 0.50)
As the water-cement ratio is lowered by 0.05, the proportion of volume of coarse aggregate is increased by 0.01 (ref. Table 6 of IS: 10262-2009)
Corrected volume of coarse aggregate per unit volume of total aggregate = (0.66+0.005) = 0.665
Volume of fine aggregate per unit volume of total aggregate= 1-0.665 =0.335

**f. Mix design calculation**

a. Volume of concrete = 1 $m^3$
b. Volume of cement = 407/(3.15×1000) = 0.129 $m^3$
c. Volume of water = 193.33/1000 = 0.193 $m^3$
d. Volume of all aggregates = 1-0.129-0.193 = 0.678 $m^3$
e. Mass of coarse aggregate = 0.665×0.678×2.71×1000 = 1221.85 kg
f. Mass of fine aggregate = 0.335×0.678×2.67×1000 = 606.44 kg
So the mix design,
407.242: 606.44: 1221.85 which is,
1: 1.489: 3.00

**PREPRATION AND TESTING OF SMAPLE FOR TEST**

Standard Cubes of concrete of size 150mm X 150mm X 150mm was prepared for testing in universal testing machine. In samples designation A0, A1, A2, A3 (each sample designation contain 3 cubes) concrete was prepared with 0%, 10%, 20% and 30% replacement of cement with lime powder in a mix proportion of 1: 1.489: 3.00 and poured and casted in mould cubes after drying, concrete cubes were removed from mould and place in 4 water tanks of designation A0, A1, A2, A3 of water for curing at 7,14, and 28 days after curing compressive strength test was done on universal testing machine according to the IS 10262: 1982 code. The test result obtained after compressive strength is shown in the table-

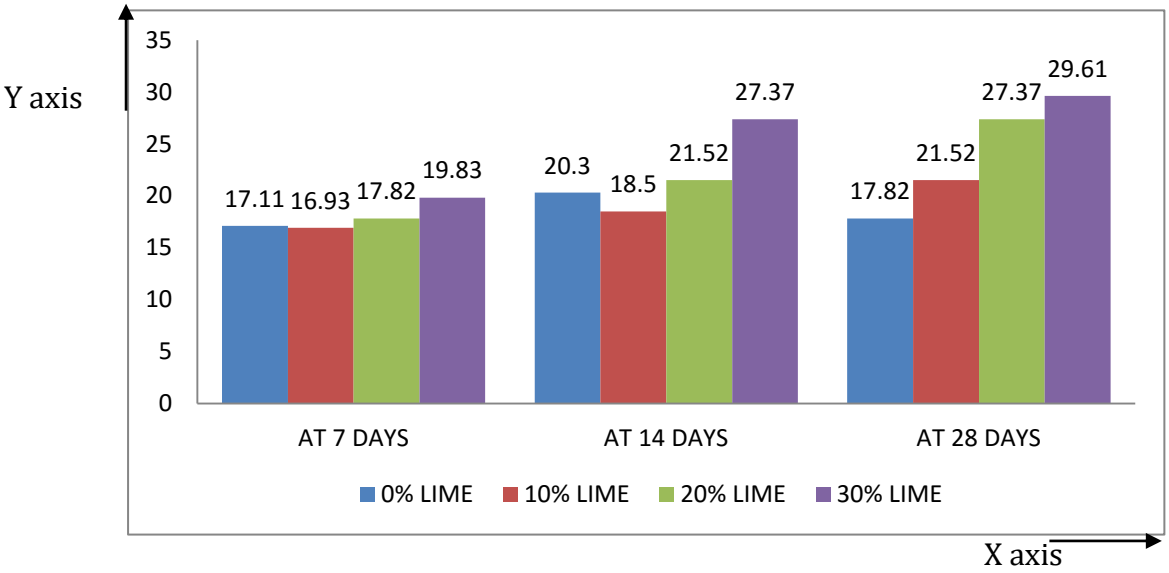
**Table showing impact of lime on compressive strength of concrete at 7,14 and 28 days of curing**

| SAMPLE NO. | % OF LIME | COMPRESSIVE STRENGTH | | |
|---|---|---|---|---|
| | | AT 7 DAYS | AT 14 DAYS | AT 28 DAYS |
| **A0** | ***0*** | 17.11 MPa | 20.30 MPa | 26.75 MPa |
| **A1** | ***10*** | 16.93 MPa | 18.50 MPa | 25.78 MPa |
| **A2** | ***20*** | 17.82 MPa | 21.52 MPa | 27.37 MPa |
| **A3** | ***30*** | 19.83 MPa | 20.58 MPa | 29.61 MPa |


Figure shows compression testing machine used for test

Figure shows casting of concrete cubes figure shows de moulding of concrete cubes

Graph is also plotted between curing days at x axis and compressive strength at y axis to know the exact variation in compressive strength of concrete when cement is partially replaced with lime powder which is taken from 0% to 30% in a division of 10%.




**Graph showing curing days at X axis and compressive strength at Y axis**

When cubes were tested on UTM after 7,14 and 28 days of curing, 30% replacement of cement with lime powder gave best result for the compression strength. 20% replacement of cement also gave satisfactory result but 10% replacement of cement with lime is slightly or nearly equal to the traditional compressive strength of the cube. Using 30% partial replacement by weight of cement in M25 grade of concrete with lime powder is economical.

## 4. CONCLUSIONS

Form the graph, it has been concluded that the partial replacement of cement (30% by weight of cement) with lime powder at 28 days of curing, when test on universal testing machine gave 29.61 MPa compressive strength for M25 grade of concrete that was highest strength among all the samples.

Lime is generally available in local palace at very cheap price as compare to ordinary Portland cement, so partial replacement of cement with lime is economical.

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