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Partial replacement of cement with rejected lime from industry

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Abstract - *The demand for materials is increasing and the availability of the materials are decreasing presently. Because of these factors, the reuse of solid waste products such as lime powder was considered to study.*

In this study, the compressive strength of lime cement concrete was examined. C25 concrete was made with Ordinary Portland cement which was partially replaced with quick lime got as a waste product from company in proportions ranging from 10% to 30% by weight.

There is a fundamental problem with this sort of cement replacement, the alteration of the physical properties of concrete. This study investigates the effect of substituting lime for cement on the compressive strength of concrete, as well as its other physical qualities. With a 10% substitution of lime, the compressive strength of lime concrete cube specimens increased significantly, whereas with a higher proportion, the strength decreased significantly.

***Key Words*: Lime powder, Waste, Concrete, Compressive strength**.

1. INTRODUCTION

1.1 General

Concrete is a binding material composed of calcium, silicon, aluminium, iron, and a variety of other materials. It is mostly utilised as a binding material throughout the world due to properties like having strong compressive strength, setting time, and so on. Calcium hydroxide (also known as slaked lime) is an inorganic substance having the formula $Ca(OH)_2$. Quicklime or calcium oxide when mixed with water produces a powder white in colour or translucent crystals. These materials, limestone products, cement, concrete, and mortar, are still widely utilised in Engineering and Construction. Lime improves the fresh and hardened properties of mortars when mixed. It enhances water retention and workability, increases utilisation efficiency, and allows for high-quality work on fresh concrete. Increases resistance to natural movement without experiencing severe cracking or debonding, such as thermal expansion and contraction and creep, increases resistance to frost, increases overall toughness, decreases the likelihood of efflorescence (staining caused by salt deposits) on hardened concrete.

Lime has been utilized in building construction for many years, and it may be utilized as a strong, long-lasting substance that reduces its environmental impact. However, in circumstances where curing time is of the utmost, cement may be required. Cement and lime are frequently used in concrete applications to take advantage of their unique qualities. Natural limestone is converted into lime by heating the rock in a kiln until only quicklime — calcium oxide — remains. The quicklime is then combined with small quantities of water to produce hydrated lime, which can be added to cement or used as a binder when combined with water. Cement comprises of compounds containing silica that, when combined with water, rapidly harden. Lime becomes harder over time by slowly absorbing carbon dioxide and reverting to limestone.

1.2 Objectives

The aim of the investigation is to investigate replacing cement with lime in the production of normal weight concrete in order to reduce greenhouse gas emissions produced by Portland cement manufacturers.

1.3. SCOPE

The study includes the following:

- To know the importance of physical properties of materials used in concrete by some tests on fine aggregate, coarse aggregate, and cement.
- To study the behaviour of lime concrete by conducting series of experiments to compare the quicklime-added concrete to conventional concrete and examine the impact of replacing cement with quicklime at percentages of 10%, 20%, and 30%.

2. LITERATURE REVIEW

Hemanshu Veram et al. (Maurya, N. K., Faldu, S., & Thakur, R. 2019), this study examined the hydraulic lime cement concrete and mortar's compressive strength and shear bond strength. M-30 concrete was partially replacing Ordinary Portland cement with hydraulic lime in quantities ranging from 0% to 35% in concrete and from 0% to 100% in mortar. It also studies the effects of replacing cement with lime on the compressive strength and shear bond strength in mortar. The strength of the shear bond of a triplet specimen

increased as the lime content of a mortar increased. When lime was replaced by up to 15%, the compressive strength of cube specimens of lime concrete increased, but rapidly decreased as the quantity increased.

Omar M. Omar et al. (Abd Elhameed, G.D., Sherif, M.A. and Mohamadien, H.A 2012), refers to a study conducted to determine the changes in the qualities of concrete change when sand is substituted with limestone waste and marble powder is added. 25%, 50%, and 75% of the sand in the concrete mixtures was substituted with waste limestone. In addition, the concrete mixes contained 5%, 10%, and 15% powdered marble. The effects of employing waste limestone as fine aggregate on various concrete characteristics, both fresh and cured, were investigated. As part of the investigation, the material's compressive strength, indirect tensile strength, flexural strength, elastic modulus, and permeability were all assessed. There were no changes to the unit weight of concrete. However, good results were observed when limestone waste and marble powder were used as the fine aggregate.

Acharya, P.K. et al. (Patro, S.K., 2015), this study investigates incorporating Ferrochrome ash (FA) as a partial replacement for traditional Portland cement in the production of concrete. FA was substituted for Ordinary Portland Cement (OPC) at four different substitution rates (10%, 20%, 30%, and 40%), whereas lime was substituted at a rate of 7%. Lime and FA were examined for their water permeability, splitting tensile strength, elastic modulus, compressive strength, and ultrasonic pulse velocity. At 28 days, the properties of control concrete and concrete made with 40% FA and 7% lime in place of 47% OPC were identical. It was discovered that a combination of up to 40% FA and 7% lime can be used efficiently in concrete preparation without affecting or even boosting concrete performance. Petrography analysis promotes the improvement of concrete properties having FA and lime.

Adesina, P.A. et al. (Olutoge, F.A., 2019) in this work, Rice Husk Ash (RHA) and lime were used to replace ordinary cement in varying proportions to produce RHA-Lime concrete. According to the findings of the strength tests, RHA-Lime concrete exhibited greater early strength than the control concrete. RHA-Lime cement combinations were also shown to be appropriate for usage in structural concrete, having the capacity to substitute up to 25% of conventional cement. RHA-Lime mixtures can serve as a viable alternative to conventional cement in concrete.

Borinaga -Treviño, R et al. (Cuadrado, J., Canales, J. and Rojí, E., 2021), this study shows the use of lime mud, a by-product of the paper industry, as a partial replacement for cement in mortar to lessen its environmental impact. For this, mortars containing 10%, 20%, 30%, and 40% lime mud being replaced with cement by weight are compared to a typical cement mortar. Physical, thermal, mechanical showed that lime mud could replace up to 20% of cement while still maintaining the mortar's thermal properties. Studies conducted in the laboratory on radiant floor heating slabs has revealed that 20% lime mud mortar has same stationary behaviour as that of reference mortar.

3. METHODOLOGY

The following methodology was used to study of strength behaviour of concrete with lime. Here, the basic properties like specific gravity of fine aggregates, sieve analysis of coarse aggregates, consistency and setting time of cement were done. C25 mix was designed and for the concrete samples, weight-based batching was used. Mixture mixing was used to mix aggregates, cement and water. Vibration compacting was used for compacting concrete samples. Curing of concrete specimen was done by keeping samples inside the water tank. Testing of compressive strength test was done using the Compressive strength testing Machine. Cement was partially replaced with 10%, 20%, and 30% by weight with the Lime powder. Compressive strength tests for C25 grade concrete with varied amounts of lime powder were done after 7 and 28 days of curing. The strength results obtained were compared to those of standard concrete and the results for compressive strength were studied. The tests were done in the laboratory and the results are tabulated given.

Figure -1: Specific gravity test

Figure -2: Sieve Analysis

Figure -3: Consistency test on cement

Figure -4: Setting time test on cement

Table – 1: Properties of Aggregates and Cement

S. No	Tests done in Lab	Result
1	Specific gravity of fine aggregates	Specific gravity = 2.449
2	Sieve Analysis of coarse aggregates	Fineness Modulus = 4.5
3	Consistency test on cement	% of water = 34%
4	Setting time test on cement	Initial setting time of cement = 37 minutes

Materials: In this research study, the 53 grade of ordinary Portland cement (OPC) was used. The coarse aggregate used in this study was angular shaped because angular aggregate provides more strength. C25 grade concrete design mix was done. The aggregate sizes used in the test were in the range between 10mm and 20mm. Fine aggregate was having a specific gravity of 2.449. Locally available transportable water was used.

Table – 2: Quantities of materials used

S. No.	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	W/C
1.	10.44	18.06	25.5	0.55

In In this study, Rejected Lime from Majan industry, Salalah, Oman was used as a partial replacement of cement to prepare lime concrete. The cement used in this study was replaced 10%, 20% and 30% by weight with lime powder for making concrete and results compared with Normal concrete.

Table – 3: % Replacement of lime with cement

S. No.	% Replacement of lime with cement	Lime added (kg)	Cement (kg)
1	0	0	10.44
2	10	1.044	9.396
3	20	2.088	8.352
4	30	3.132	7.308

Testing: Compressive strength - Compressive strength tests are performed on cubes, 150 mm 150 mm 150 mm specimens. The compressive strength of concrete is depending on the concrete mix design used, concrete quality, cement strength, water cement ratio, curing, and other factors. It is also influenced by other elements such as concrete mixing, concrete placement and concrete curing. By compressive testing machine, the compressive strength of concrete was found.

Compressive Strength = P/A where, P = Compressive load in kN and A = Area of cube in mm^2.

Figure -5: Compressive strength test

The 7 days and 28 days average compressive strength of 6 specimens were taken and results are shown below in Table - 4.

Table -4: 7 days and 28 days Compressive strength test

% Replacement of lime with cement	Strength in 7 days (N/mm^2)	Strength In 28 days (N/mm^2)
0	20.7	26.8
10	23.8	30.3
20	19.8	24.7
30	18.6	21.8

4. RESULT AND DISCUSSION

The 7 days and 28 days average compressive strength of 6 specimens were taken and results are shown below in figure 6 and figure 7.

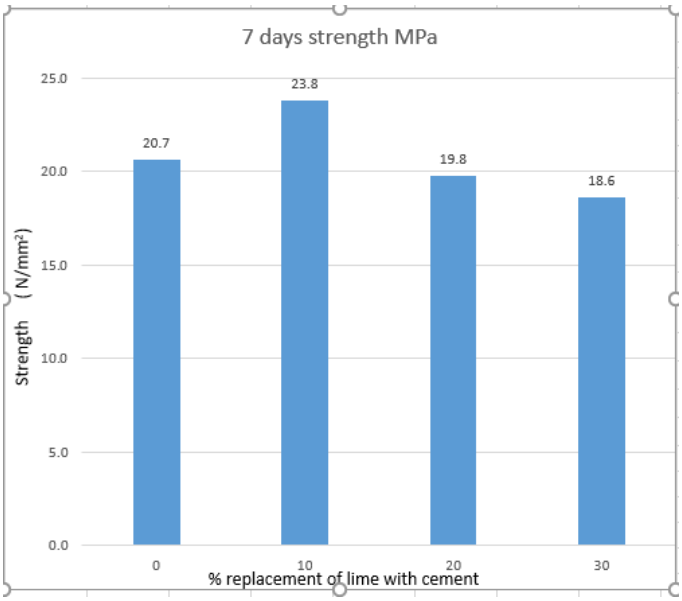

Figure -6: 7 days Compressive strength (MPa)

From the above Figure 6, the compressive strength of lime concrete at 7 days strength can be studied. According to the graph above, when lime is added up to 10% by weight of cement, lime concrete has an optimum compressive strength of 23.8 MPa. When lime content exceeds 10%, compressive strength gradually falls.

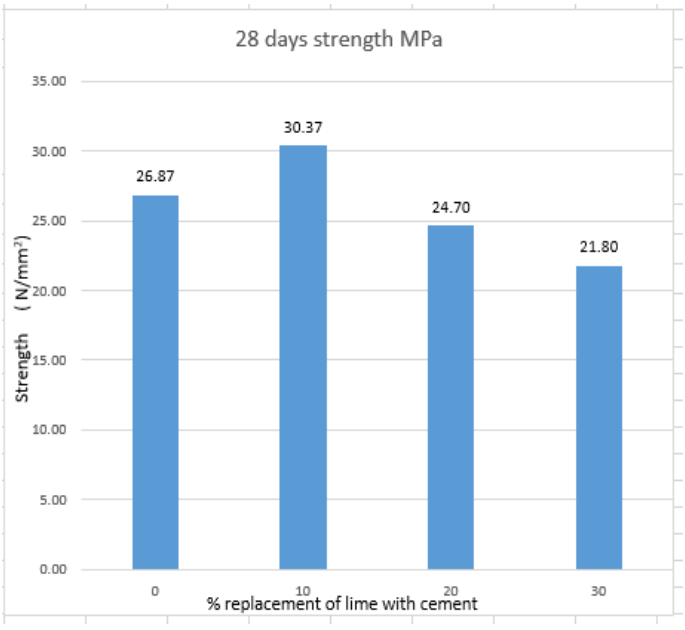

Figure -7: 28 days Compressive strength (MPa)

From the above Figure 7, the compressive strength of lime concrete at 28 days strength can be studied. According to the graph above, when lime is added up to 10% by weight of cement, lime concrete has an optimum compressive strength of 30.37 MPa. When lime content exceeds 10%, compressive strength gradually falls.

5. CONCLUSION

1. The compressive strength of lime concrete cubes increased until lime was added to 10% by weight of cement. When the amount of lime used exceeds 10%, the compressive strength of the lime concrete cube decreases significantly.

2. As the lime concentration increased, the compressive strength increased more rapidly at earlier stages.

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