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BEHAVIOUR OF CONCRETE BY PARTIAL REPLACEMENT OF LIME IN CEMENT

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Abstract - The present paper has investigated the compressive strength and shear bond strength behaviour of hydraulic lime cement concrete and mortar. Concrete of M-30 was made using Ordinary Portland cement, which was partially replaced by hydraulic lime at varying percentages ranging from 0%,25%,50%,75% in concrete and 0%,25%,50%,75%,100% in mortar. There is critical issue with this type of cement replacement i.e. the change in physical properties of concrete and mortar. This research looks at the change in physical properties of concrete when cement is replaced by lime with respect to compressive strength in concrete and shear bond strength in mortar. The results from this research study show a linear diminution in strength with linear increase in the relative % age of lime to cement. The shear bond strength of triplet specimen was increased with increase in lime content in mortar. The compressive strength of lime concrete cube specimens were increases when the replacement of lime up to 15% and with higher percentage, strength decreases considerably.

Key Words: Lime concrete, Lime mortar, Compressive strength, Shear bond strength etc..,

1. INTRODUCTION

1.1 General

An artificially built up stone hardening of a mixture of cement, sand, aggregates and water with or without a suitable admixture, is generally known as “concrete”. Concrete is used for made of building components like beam, column, slab etc. Mortar is mixture of cement, sand and water which is used to bind bricks or stones in wall of buildings, plaster on walls, concrete masonry units . Mostly concrete and mortar are made with cement but sometimes cement replace by few amount of other admixture like hydraulic lime, fly ash, red mud, silica fume, glass etc. to enhancement of mechanical properties of concrete and mortar . These properties are such as compressive, tensile, flexure and shear bond strength etc. Lime is used as the primary binder in many mixes such as a lime putty or hydraulic lime. Lime is a durable, abundant and versatile binder that has been used extensively in construction like Lime concrete, lime mortar etc. for thousands of years. Lime is calcium containing inorganic material in which carbonates, oxides and hydroxides predominate. It is derived from limestone or chalk. They may be crushed, cut or pulverized and chemically altered. Lime improves the workability, plasticity, cohesion, adhesion, air content and water content. Broadly lime is classified into three categories fat lime, hydraulic lime, poor lime etc. In this study, they have to use the hydraulic lime as admixture by replacement of cement in concrete and mortar. Hydraulic lime has hydraulic property so it can set under water and it is also known as water lime. Natural hydraulic lime is made from a limestone which naturally contains some clay. Artificial hydraulic lime is made by adding forms of silica and alumina such as clay to the limestone during firing, or by adding a pozzolana to pure lime. Hydraulic lime are classified by their strength, moderately and eminently lime. It contains some amount of ferrous oxide and clays also. Depending upon the clay particle it may be further divided into following categories (a) Eminently hydraulic (b) Semi hydraulic (c) Non hydraulic lime. Mostly hydraulic lime is used for mortar and plaster. Concrete’s compressive strength mostly depends on the concrete mix design. It is also affected by other factors such as mixing of concrete, placing of concrete, curing of concrete as well as quality of concrete ingredients. Compressive strength is the maximum compressive stress that, under a gradually applied load, a given solid material can sustain without fracture. Measurements of compressive strength are affected by the specific test methods and conditions of measurements. The shear bond strength in masonry is the force in shear required to separate the units from the mortar. The shear bond strength is the bond strength between the brick mortar and interface of brick. The bond development in masonry is on account of mechanical interlocking of hydrated cement product into the pores of the bricks.

1.2 OBJECTIVES

The aim of the investigation is to investigate the behavior and durability properties of concrete and mortar by the influence of lime as partial replacement of cement.

1.3 SCOPE

- The scope of the present investigation can be summarized as follows:
- To study the effect of behaviour and durability properties of concrete and mortar with there placement of cement by lime powder.
- To achieve 28 days characteristic compressive strength of 30 MPa.

- To compare the variation of compressive strength at 7 days ,14 days and 28 days strength between normal concrete and lime concrete.
- In the present investigation more emphasis is given to study the lime concrete. So as to achieve better concrete composite and to encourage the use of lime to overcome the environmental impacts caused cement.

2. LITERATURE REVIEW

A Costigan et al. (A & S, 2009) discussed the strength behaviour of hydraulic and non-hydraulic lime mortars in clay brick masonry bond. They used two masonry types under lateral and vertical load. Authors concluded that compressive and flexural strength of NHL5 mortar increases by 60-65% between 28 days and 56 days while its flexural bond strength increases by 80%. However, the compressive strength of the NHL5 bound masonry only increases by 11%, after 56 days the NHL 5 mortar is stronger in compression than the NHL5 masonry whereas the CL90-s mortar / masonry shows the opposite trend.

C. Freeda Christy et al. (Christy, Shanthi, & D. Tensing, 2012) investigated shear bond strength of small burnt clay brick masonry samples. They have been received shear bond strength from three brick triplets. In this paper, the authors concluded that © 2019 JETIR May 2019, Volume 6, Issue 5 www.jetir.org (ISSN-2349-5162) JETIR1905K43 Journal of Emerging Technologies and Innovative Research (JETIR) www.jetir.org 327 shear bond strength of unreinforced clay brick masonry in the ratio of 1:6 cement mortar with 20% replacement of fine aggregate with fly ash was 1.45 times more than the unreinforced clay brick masonry in the ratio of 1:6 cement mortar, shear bond strength of reinforced clay brick masonry in the ratio of 1:6 cement mortar with 20% replacement of fine aggregate with fly ash was 1.5 times more than the unreinforced clay brick masonry, shear bond strength of reinforced fly ash brick masonry in the ratio of 1:6 cement mortar with 10% replacement of fine aggregate with fly ash was twice than the unreinforced fly ash brick masonry.

Awodiji Chioma Temitope Gloria et al. (Gloria, Ogbonnaya, & Olujide, 2017) investigated the flexural strength and tensile strength of hydrated lime cement Concrete. In the present study, they used hydrated lime replace by cement from 5% to 30%. Authors concluded that the highest flexural strength and tensile strength at 13.83% replacement of hydrated lime by cement in concrete for 28 days of curing, flexural strength higher than split tensile strength of concrete.

N. Suneel et al. (Kumar N., Kumar, M. Thirupathamma, D. Sasikala, & Sarada, 2017) discussed the experimental study of concrete strength when cement replace by lime powder from 0% to 30%. They used M-20 grade of concrete for study. In this study, the authors concluded that compressive and tensile strength is maximum on 30% replacement of cement by lime with high workability.

Dr. A. Anbuchezian et al. (A. Anbuchezian & Kumar, 2018) discussed experimental work on Split Tensile Strength, Flexural Strength and Compressive Strength of concrete. They used groundnut shell replacement of fine aggregate and lime powder replacement of cement in concrete. In this paper, the authors have been partially changed fine aggregate as groundnut shell in the percentage of 5,10,15,20 and lime powder partly replaced in general ratio of 20 percentages. They concluded that groundnut shell concrete achieves more strength at 5% to 10% than normal concrete and lime concrete achieve more strength at 20% than normal concrete.

B. T. Sapna et al. (B. T. Sapna & M. Aravindhraj, 2018) discussed the compressive, split tensile, flexural strength of concrete when cement replaced by 0%, 5%, 10%, 15%, 20% of red mud and 5% hydrated lime. They concluded that compressive strength of the concrete achieved up to 17% for the replacement of red mud with cement by 15% and 5% of hydrated lime compared to normal concrete, split tensile strength of concrete achieved up to 23% replacement of red mud with cement by 15% and 5% of hydrated lime compared to normal concrete, the Authors saw that compressive strength of cubes and split tensile strengths of cylinder the optimum percentage of replacement of red mud with cement was 15% and 5% of hydrated lime.

S. Pavia et al. (Pavia & R. Hanley, 2010) measured flexural bond strength of natural hydraulic lime mortar (NHL) with mortar hydraulicity, water content, workability and water retention. They concluded that NHL5 mortar strongest bond with medium flow concurrently providing the highest water retention and best workability. However, NHL 2 and NHL 3.5 mortars are achieve lower bond strength with optimum workability but it is the highest flow values that provide the NHL2 and NHL3.5 mortars with the strongest bond comparison to other.

In this Chapter an elaborate discussion is made regarding works done so far in this area as literature review. Going to study about the behavior and durability properties of concrete and mortar by the influence of lime as partial replacement of cement.

3. PROPERTIES OF LIME IN CONCRETE

Lime concrete provides good bases to bear the sufficient loads and also provide certain degree of flexibility. It adjusts very well when it is in contact with surface. Lime concrete also exhibits certain degree of water proofing property and thus prevents subsoil dampness in floors and walls. Lime concrete also exhibits volumetric stability. It can be made easily and can be available at much cheaper rates. It also resists weathering effects and is very durable. Lime is one of the oldest binding materials used in several ancient architectural works. A good quality lime should own the following properties:

- It should possess good plasticity.
- It should be flexible and easily workable.
- When used in mortar, it should provide greater strength to the masonry.
- It should solidify in less time and become hard.
- It should comprise of excellent binding properties which adhere to brick or stone masonry units perfectly.
- It possesses high durable properties as it is less shrinkable when used in mortar.

It should be highly resistant to moisture and can be used for pointing works

3.1 DIFFERENCE BETWEEN LIME AND CEMENT

3.1.1 CHEMICAL COMPOSITION

Lime is produced from natural limestone by burning the stone in a kiln until only quicklime calcium oxide is left behind. The quicklime is then mixed with small amounts of water to create hydrated lime, which may be included in cement or mixed with water for use as mortar. Lime hardens by slowly absorbing carbon dioxide and turning back to limestone over time. Cement consists of highly reactive silica-containing compounds when mixed with water, they harden quickly.

3.1.2 PHYSICAL PROPERTIES

Lime hardens much more slowly than cement-containing mortars, making it much more workable. Lime is also less brittle and less prone to cracking, and any cracked areas can absorb carbon dioxide and mend over time. Cement hardens very quickly, but may be too strong for some applications, e.g., working with old bricks. Cement is also prone to cracking as a structure settles, and may eventually require repair.

3.1.3 VAPOR BARRIER

Lime is also breathable, allowing vapours to pass through, which can reduce moisture and improve the environment of the home. Cement creates a waterproof barrier that does not allow vapours to escape, and can absorb water, causing moisture to accumulate -- especially in basements.

3.1.4 ENVIRONMENTAL CONCERNS

Lime production results in release of carbon dioxide into the atmosphere, but lime mortar absorbs carbon dioxide from the atmosphere over its lifetime. As a result, lime mortar is considered by environmentalists to be "carbon neutral." In contrast, cement production contributes greatly to global warming, as copious amounts of carbon dioxide are released during its production.

3.2 LIME MORTAR :

Lime mortar is composed of lime and an aggregate such as sand , mixed with water. The Ancient Egyptians were the first to use lime mortars. Which they used to plaster the pyramids at Giza. In addition ,the Egyptians also incorporated various limes into their religious temples as well as their homes. Indian traditional structures built with lime mortar, which are more than 4,000 years old like Mohenjo-darois still a heritage monument of Indus valley civilization in Pakistan. It is one of the oldest known types of mortar also used in ancient Rome and Greece, when it largely replaced the clay and gypsum mortars common to ancient Egyptian construction. With the introduction of Portland cement during the 19th century, the use of lime mortar in new constructions gradually declined. This was largely due to the ease of use of Portland cement, its quick setting, and high compressive strength. However, the soft and porous properties of lime mortar provide certain advantages when working with softer building materials such as natural stone and terracotta. For this reason, while Portland cement continues to be commonly used in new constructions of brick and concrete construction, in the repair and restoration of brick and stone-built structures originally built using lime mortar, the use of Portland cement is not recommended. Despite its enduring utility over many centuries, lime mortar's effectiveness as a building material has not been well understood; time-honoured practices were based on tradition, folklore and trade knowledge, vindicated by the vast number of old buildings that remain standing. Only

4. MATERIALS

Materials: In this research study, the ordinary Portland cement (OPC) 53 grade is used and the compressive strength of 28 days shall be minimum 53 MPa for this cement. Specific gravity of cement is 3.14. Coarse aggregate used in the present study are of crushed angular shape because angular aggregate gives higher strength. They are grey in color. The aggregates sizes vary from 10mm to 20mm. Fine aggregate sizes vary from 0.25mm to 0.06mm. Fine and coarse aggregate was used with specific gravity of 2.65 and 2.68 respectively. Locally available portable water (drinking water) having the pH value of 7.0 preferable and the pH value of water should not less than 6.

In this study, Hydraulic Lime is used as a partial replacement of cement to prepare lime concrete and lime mortar. Amount of lime used in this study is 0, 25, 50 and 75% by weight of cement

5 Mix Design: The study uses the design mix M30 grade of concrete using 43 grades OPC in the study. The Mix design was performed as per IS 10262: 2009. The water cement ration for mix is 0.43. The following mix proportion was obtained from the mix design.

Table -1: MIX DESIGN(CEMENT;SAND;AGGREGATE)

CEMENT	SAND	AGGREGATE
368	645.5	1264.04
1	1.754	3.4

6. Casting & Curing: For compressive strength the standard size of cube mould is 150 mm × 150 mm × 150 mm used. Lime is used as a partial replacement of cement to prepare lime concrete in this study. Amount of lime used in this study is 5, 10, 15, 25 and 35% by weight of cement. After casting, each cube should be marked with a legible identification on the top of cubes. Leave the sample undisturbed for 24 hours. After the 24 hours, the moulds are opened and immersed in water for curing till the day of testing. Ponding method was used for curing. Testing is done after 3, 7, 28 days. Three cubes were prepared for each specimen.

7. Testing

7.1 Compressive Strength: Compressive strength is the maximum compressive stress that under a gradually applied load, a given solid material can sustain without fracture. Compressive strength is carried on cubes i.e. 150 mm × 150 mm × 150 mm specimens. Concrete's compressive strength mostly depends on the concrete mix design, quality of concrete, cement strength, water cement ratio, curing etc. It is also affected by the other factors such as mixing of concrete, placing of concrete, curing of concrete as well as quality of concrete ingredients. The compressive strength of concrete was found by universal testing machine of 1000 kN capacity.

Compressive Strength = P/A
Where, P = Compressive load in kN and A = Area of cube

FIGURE 1

7.2 Shear Bond Strength of Masonry: This study is to determine the shear bond strength retained by the joints of bricks and masonry. Shear bond strength is determining by the triplet specimen so that only shear stresses are developed in mortar and bricks unit. A vertical shear load is applied through hydraulic jack until shear failure occurred. Lime is replaced by cement in mortar 0%, 20%, 40%, 60%, 80% and 100%.

Bond stress = PV/2A
Where, PV = Vertical compressive load in kN and A = Cross-sectional area of triplet specimen in mm^2.

FIGURE 2

Bricks are laid in such a way that center brick is sheared and upper and lower bricks are supported. The size of specimen is 230 mm × 110 mm × 70 mm. Bricks are wetted for 10 to 15 minutes before preparation of triplet bond specimens. The First brick is laid on a horizontal surface then mortar is filled in bearing surface. No voids should remain in the horizontal area. Thickness of the first layer of mortar is adjusted to 10-12mm then extra mortar should be removed. After hardening of the first layer of mortar next unit is laid by using same procedure. Normal masonry mortar should be used within half an hour of mixing. Each specimen was tested after 28 days. The maximum amount of load taken by the specimen was used to calculate shear bond strength in universal testing machine.

8. RESULT AND DISCUSSION

Average strength of 2 specimens was taken as compressive strength at 7 days and 28 days

TABLE 2 : COMPRESSIVE STRENGTH OF LIME CONCRETE

MIX DESIGNATION	7 DAYS(MPa)	28 DAYS(MPa)
NORMAL	23.33	30.22
LC 25	24	31.85
LC 50	18	26
LC 75	14	20

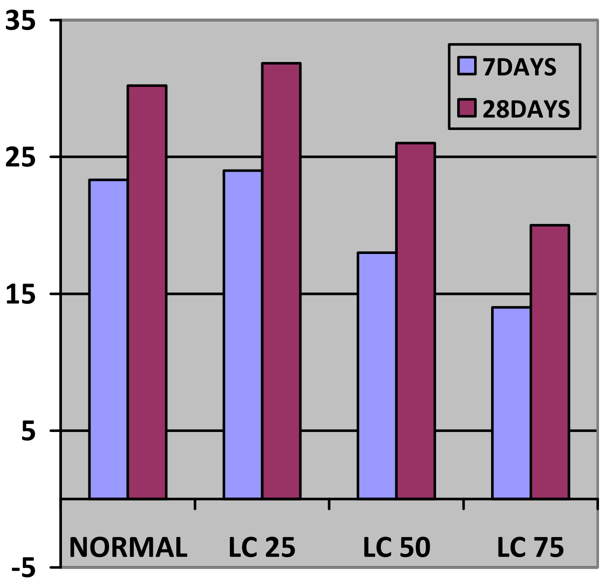

FIGURE 3

From the above Figure 3 the compressive strength of lime concrete at7 and 28 days are compared. Above graph says that optimum compressive strength of lime concrete is obtained when lime is added up to 25% by weight of cement. When lime content is increased after 25% then compressive strength decreases gradually.

Triplet specimens was prepared and tested to determine the shear bond strength of cement mortar and lime mortar

TABLE 3 SHEAR BOND STRENGTH AT 28DAYS

MIX DESIGNATION	SHEAR BOND STRENGTH
LC 0	0.11
LC 25	0.13
LC 50	0.16
LC 75	0.18
LC 100	0.23

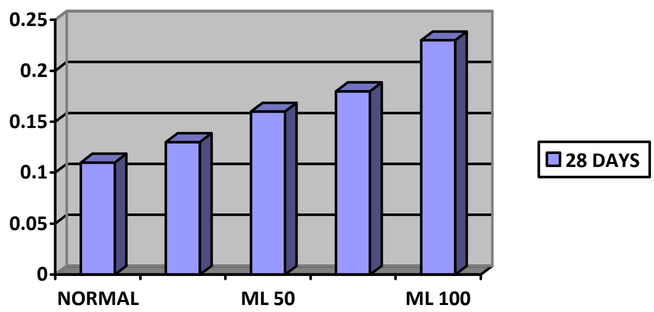

FIGURE 4

From the above Figure 4 the shear bond strength of brick masonry at 28 are the above graph says that shear bond strength of brick masonry increases as age of testing varies . The shear bond strength of brick masonry is optimum at 100% lime content and minimum at 0% lime content in mortar.

9. CONCLUSIONS

1) The compressive strength of cubes made with lime increased till lime is added to 25% by weight of cement. When amount of lime is exceeding 25 %, the compressive strength of lime concrete cube is decreasing considerably.

2) The rate of increase of compressive strength was higher at early ages as the lime content is increased.

3) Despite low compressive strengths, the lime cement achieved high tensile bond strength. Therefore, masonry walls constructed with lime mortar have better bond strength. Also, the increase in bond strength is directly proportional to increase in compressive strength for all the mixes.

4) The triplet specimen test shows why the lime mortar produces good bond strength. The lime mortar was sucked with the moisture into the bricks pores which when harden produces good bond strength.

REFERENCES

[1] A, C., & S, P. (2009). Compressive, Flexural and Bond Strength of Brick/Lime Mortar Masonry. In Mazzolani (Ed.), Proceedings of PROHITEC 09 (pp. 1609-1615). London: Taylor and Francis Group.

[2] A. Anbuchezian, & Kumar, S. (2018). An Experimental Study on Partially Replacement of cement by Lime Powder and fine Aggregate by Groundnut Shell in concrete. International Research Journal of Engineering and Technology, 5(5), 597-600.

[3] Anusha, P., & Ramya, K. S. (2018). Experimental Study on Concrete with Limestone Powder and Copper Slag. International Journal of Engineering Research and Management, 5(9), 6-12.

[4] B. T. Sapna, & M. Aravindhraj. (2018). Influence of Red Mud as a Partial Replacement of Cement With Hydrated lime. International Research Journal of Engineering and Technology, 5(8), 1282-1288.

[5] Chowdhary, M. M., Hashmi, S., Abdullah, S., Faisaluddin, M., & Ahmed, M. M. (2016). Evaluation of Masonry Mortar in which Natural River Sand is varied by Pond Ash. International Journal for Scientific Research & Development, 4(7), 121-124.