A STUDY ON EFFECT OF RICE GRUEL AND CARBON DI-OXIDE CURING ON LIME MORTAR

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ABSTRACT

This paper presents a study on lime mortar of 1:3ratio with lime & rice gruel as binder and sand as aggregate. Rice gruel is added in various percentages such as 0%, 2%, 4%, 6%, 8%, 10% for manufacturing the samples. Curing of all the samples are done by two methods viz. Traditional Curing Method and Accelerated carbon dioxide (CO_2) curing method. The samples were tested for the various properties such as compressive strength, water absorption, durability and unit weight. The results showed increase in compressive strength with increase in rice gruel. The CO_2 cured samples showed three times more strength than traditionally cured samples. The cubes which are cured by accelerated method showed lesser water absorption characteristic.

Keywords: *Amylopectin, Accelerated-curing, Carbon di-oxide, carbonation, Durability, Lime, mortar, Rice gruel.*

I. INTRODUCTION

1. 1. Lime

It is traditionally used binder from ancient times. But with advent of cement and cement based concrete technology, lime and lime mortar has become obsolete. Lime has a peculiar environmental advantage over cement, it absorbs the same amount of carbon di oxide (CO_2) that was released during manufacture of lime, when it hardens in mortar.Cement cannot fully absorb the CO_2 during hydration or strengthening period due to calcium silicate hydrates which form major portion of cement paste.

Lime used in building construction is produced from calcium carbonates in the form of limestone, seashells, coral, kankar, etc. When they are burnt mixed with fuel such as coal, carbon dioxide is given off as gas, and the resulting product is calcium oxide or quicklime.

$$CaCO_3 \rightleftharpoons CaO + CO_2 \quad (1)$$

Lime is manufactured in temporary clamps which are intermittent or in kilns which are continuous in their working. Quicklime is not a stable product. If it is left exposed to air, it absorbs carbon dioxide from air and reverts back to carbonate. Hence, quicklime should be slaked to calcium hydroxide (hydrated lime or slaked lime) as early as possible to make the material stable. This is done by pouring water over quicklime. Then it swells and falls into a powder form with a hissing and cracking sound. The product is called slaked lime or hydrated lime. Chemical combination of quicklime with water is called slaking of lime. The term ‘lime’ when used in civil engineering for describing lime mortar, etc., it is understood to refer to slaked lime and not quicklime. The reaction in slaking of lime is: -

$$CaO + H_2O \rightarrow Ca(OH)_2 \text{ (Slacked or hydrated lime)} \quad (2)$$

The cementing action associated with lime is produced by carbonation is Calcium Carbonate which has cementing properties. The reaction is as follows: -

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O \quad (3)$$

Sand is added in lime mortar not only to make it increase in bulk (thus leading to economy) but also, of much more importance to make the mortar porous so that air can circulate freely through the mass to assist the carbonation. Because of the nature of the above reaction, lime does not set without access to atmospheric air such as in conditions under water.

1.2. Rice gruel

Chinese scientist Dr Zhang[1] found that the use of sticky rice was one of the greatest technical innovations of the time workers built the Ming dynasty sections of the Great Wall about 600 years ago by mixing together a paste of sticky rice flour and slaked lime, the standard ingredient in mortar. The sticky rice mortar bound the bricks together so tightly that in many places weeds still cannot grow.The ancient mortar is a special kind of organic and inorganic mixture.The inorganic component is calcium carbonate, and the organic component is amylopectin, which comes from the sticky rice soup added to the mortar. This amylopectin helped create a compact microstructure, giving the Great Wall more stable physical properties and greater mechanical strength.

1.3. Carbon di oxide (CO2) Chamber

CO_2 chambers are usually used to study carbonation of cement concrete. But in our research, the CO_2 Chamber is constructed with cheap materials and used for curing of lime mortar. This accelerates the strengthening process and reduces the time.Lime mortar/ concrete achieves its maximum strength in 60 days in ambient conditions. This results in the increase in construction time which in turn results in higher construction cost.

The purpose of curing chamber is to achieve the full strength in a reduced period of time with the help of carbonation. Carbonation is known to improve surface hardness, strength, and durability of cement-based products. However, for reinforced cement/lime-based products, as the pH of carbonated cement/lime paste reduces due to carbonation, reinforcing steel loses its passivity and becomes vulnerable to corrosion.

Cengiz Duran Atiş[2] studied accelerated carbonation of fly ash (FA) concrete. The process of carbonation was accelerated using a controlled environment. He found that FA concrete made with 70% replacement ratio was carbonated more than that of 50% FA replacement concrete and normal Portland cement (NPC) concrete

Cheng-FengChang&Jing-WenChen[3] did the experimental investigation of concrete carbonation depthusing the thermalgravimetric analysis (TGA) method, which tests the concentration distribution of $Ca(OH)_2$ and $CaCO_3$, and the X-ray diffraction analysis (XRDA) which tests the intensity distribution of $Ca(OH)_2$ and $CaCO_3$. They found that depth of carbonation front is twice of that determined from phenolphthalein indicator.

The equipment used in the research consists of a rectangular chamber, consisting of supports, acrylic sheet base, PVC pipes used as a pillar, and beams, a polythene cover is used to make the chamber as to make it air-tight. A simple CO_2 gas manufacturing unit is placed inside the chamber. It consists of Hydrochloric acid with

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marble stones. The marble stones react with hydrochloric acid to produce calcium chloride and CO_2 gas. The CO_2 gas is bubbled through the water, so that production of gas can be visibly seen and also to eliminate hydrochloric acid fumes from entering the chamber. CO_2 Cylinders are avoided to reduce cost of manufacturing. Weight of Marble pieces and hydrochloric acid is maintained same in each set of curing.

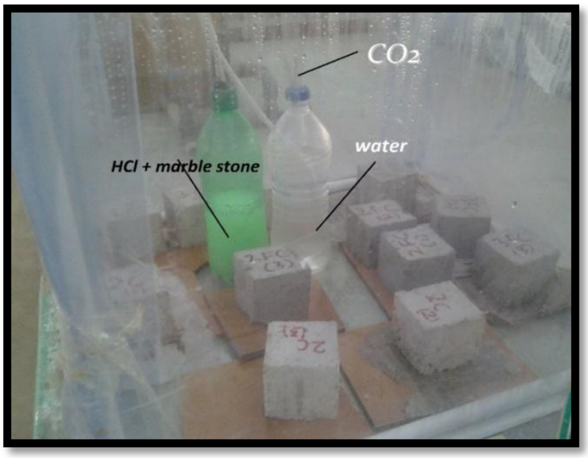
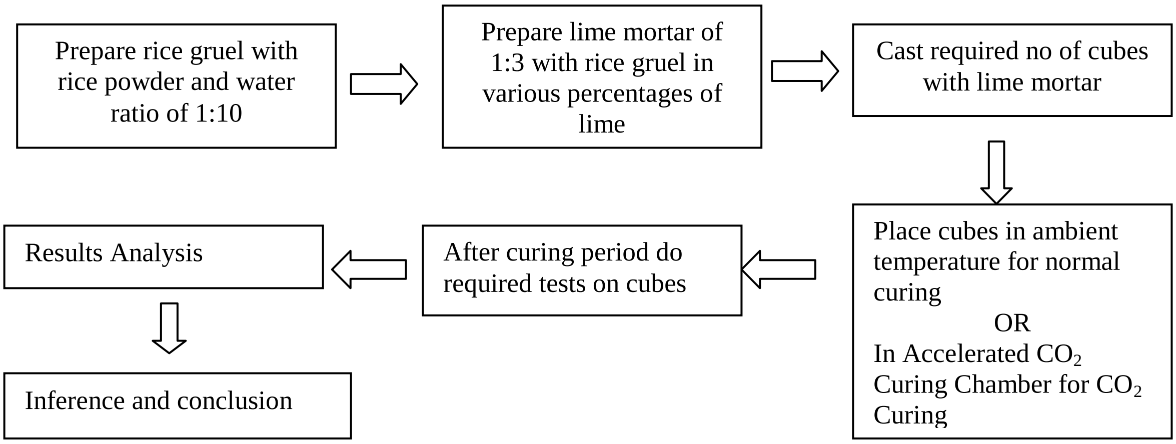


Fig. 1 CO_2 Chamber for accelerated curing

Fig. 2 Inner arrangements of CO_2 Chamber

II. METHODOLOGY



III. PROPERTIES OF MATERIALS USED

3.1. Property of sand.

Specific gravity of sand used is =2.73. Natural Graded sand passing through 2.4mm and retained in 1.2mm sieve and sand passing through 1.2mm and retained in 0.6mm sieve are added in equal proportions in mortar.

3.2. Properties of water

Table 1. Properties of water

Property	Total Dissolved Solids	Chlorides	pH
Values	73 ppm	42 ppm	7

The quantity of water is 55% of lime for all mixes.

IV. MANUFACTURING OF MORTAR

Plain mortar is prepared by mixing 1200gm.lime, 1800gm.of sand passing through 2.4mm and retained in 1.2mm sieve and 1800gm. of sand passing through 1.2mm and retained in 0.6mm sieve. The dry lime and sand are mixed properly. Then 660 ml of (55% of lime) water is taken using measuring jar. The water is added on the dry mix and mixed properly to form mortar paste. Put the oil inside the cube mould. The mortar is put inside the mould and compacted using tamping rod in three layers.

Rice gruel is manufactured by mixing 1-part rice flour and 10 parts water. It is mixed thoroughly and placed in oven at 200^{o}C for 30minutes. It is added in various percentages of lime viz. 2%, 4%, 6%, 8% and 10% to each sample lime mortar.

Lime mortar prepared is cast in cubes of 50 sq cm surface area, with hand compaction. The cast cubes are then cured in two methods viz. Traditional method i.e. water sprinkling and Accelerated CO_2 curing method

V. TEST RESULTS

5.1. Figures and Tables

Fig.3 After compressive strength test, cubes sprayed with phenolphthalein indicator to know depth of carbonation. Depth of carbonation not measured.

Fig. 4 Durability test on cube sampleswith 2% H_2SO_4 Solution

Table 2. Weight comparison of samples

S.No	Cubes with % of rice gruel	I Batch		II Batch (Durability tested)	
		Traditional Curing (wt. in gram)	Accelerated Curing (wt. in gram)	Traditional Curing (wt. in gram)	Accelerated Curing (wt. in gram)

1	0	697	733	735	793
2	2%	677	706	725	790
3	4%	668	723	728	788
4	6%	663	718	724	778
5	8%	601	675	668	730
6	10%	644	710	701	776

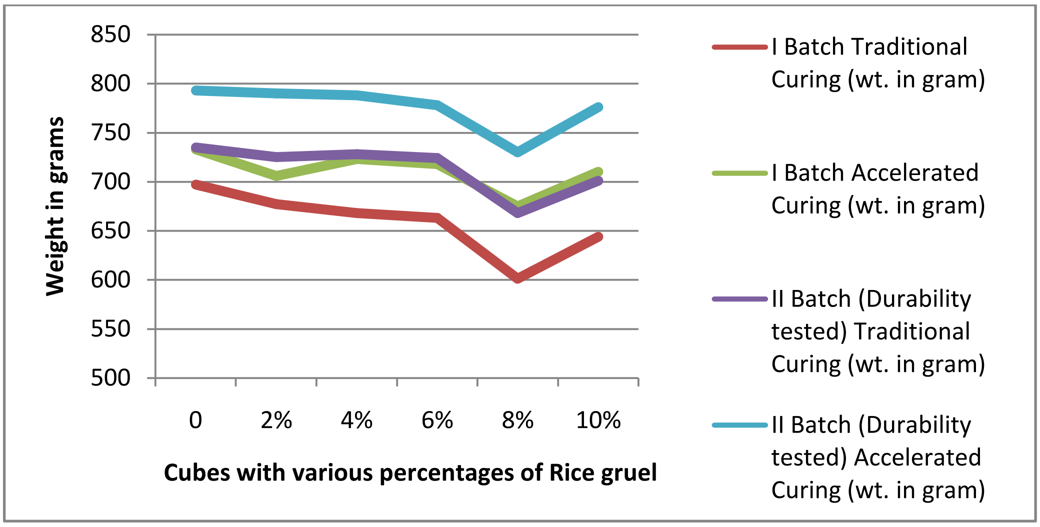


Fig. 5. Weight comparison of samples

Table 3. Water absorption comparison of samples

S.No	Cubes with % of rice gruel	I Batch Water absorption in Percentage	
		Traditional Curing	Accelerated Curing
1	0	9.7	8.7
2	2%	10.3	9.2
3	4%	9.4	7.4
4	6%	10.3	8.2
5	8%	10.8	8.8
6	10%	8.8	8.2

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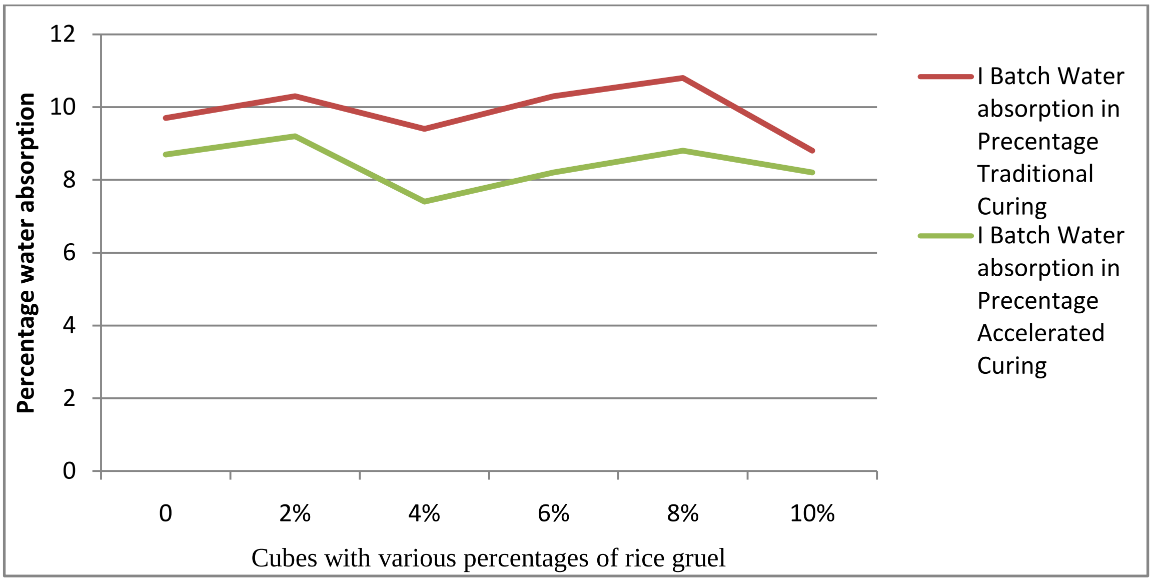

Fig. 6. Water absorption comparison of samples

Table 4. Compressive strength comparison of samples

S.No	Cubes with % of rice gruel	I Batch Compressive strength in N/mm^2		II Batch (Durability tested) Compressive strength in N/mm^2	
		Traditional Curing	Accelerated Curing	Traditional Curing	Accelerated Curing
1	0	0.21	0.98	0.08	1.05
2	2%	0.19	0.22	0.15	0.75
3	4%	0.15	0.28	0.20	0.39
4	6%	0.19	0.22	0.20	0.27
5	8%	0.14	0.26	0.29	0.90
6	10%	0.17	0.30	0.30	1.20

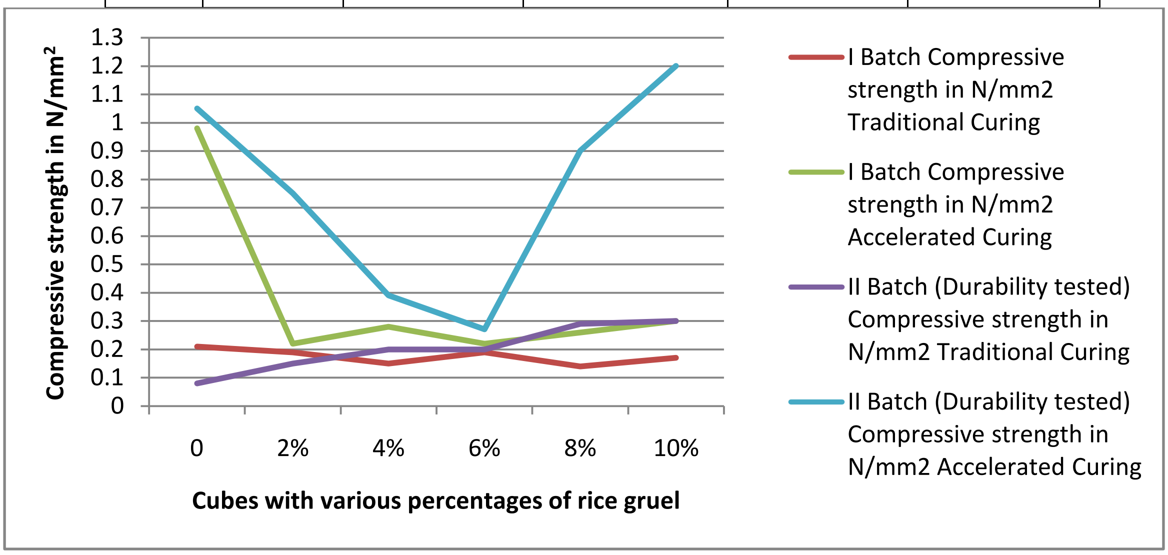

Fig. 7. Compressive strength comparison of samples

VI. CONCLUSIONS

5.1 Compressive Strength:(Curing Period For 8 Days)

In 8 days compressive strength of cubes the 8% rice gruel cubes shows higher value because of higher rice content in rice gruel.The strength of CO_2 cured cubes is almost 3 times than that of traditional cured cubes. The strength of durability tested cubes have increased when compared to non-durability tested I- Batch cubes

5.2 Water absorption:

The cubes which are cured by accelerated method show lesser water absorption characteristics. When compared to traditionally cured cubes.In all the mixes the 10% cubes show lesser water absorption characteristics.

5.3 Weight:

The weight of samples subjected to accelerated curing and durability test have increased.

5.4 Durability:

Even after keeping the cubes in 2% H_2SO_4 solution for 28days, the strength of the cubes has increased. This is in contrast to the results shown by cement based cubes referred in internals journals[4,5]. This shows that lime is a durable material, which is confirmed by the ancient monuments standing for over hundreds and thousands of years.

VII. SCOPE FOR FURTHER RESEARCH

This paper gives only a preliminary study on effect of rice gruel and CO_2 curing on lime mortar.

Further in-depth research can be done with controlled CO_2 environment withinthe chamber with various percentages of CO_2. For this a CO_2 sensor measuring the CO_2 in parts per million can be used along with CO_2 Cartridges with controlled release mechanism.

Flue gases from generators and boilers can be tried for accelerated curing.

The Depth of carbonation can be researched with increasing the period of curing or varying the percentage of CO_2 in chamber.

REFERENCES

[1]. Dr Zhanget.al (2010), “Study of Sticky Rice-Lime Mortar Technology for the Restoration of Historical Masonry Construction”, *http://pubs.acs.org Publication Date (Web): May 10, 2010 | doi: 10.1021/ar900194*

[2]. Cengiz Duran Atiş (2002), “Accelerated carbonation and testing of concrete made with fly ash”, *Elsevier - Construction and Building Materials, Volume 17, Issue 3, April 2003, Pages 147-152*

[3]. Cheng-Feng Chang &J ing-Wen Chen(2003),”the experimental investigation of concrete carbonation depth” *Elsevier - Cement and Concrete Research, Volume 36, Issue 9, September 2006, Pages 1760-1767*

[4]. Kazuyuki Torii and Mitsunori Kawamura (1994), “Effects of Fly Ash And Silica Fume On The Resistance of Mortar To Sulfuric Acid And Sulfate Attack”, *Cement and Concrete Research, Vol. 24, No. 2, pp. 361-370.*

[5]. M Vijaya Sekhar Reddy, et. al.“Durability Aspects of Standard Concrete” *ISSN 2319 – 6009 www.ijscer.com Vol. 2, No. 1, February 2013.*