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Low alkaline Lime Mortar with Surkhi and Red Soil

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A B S T R A C T

This paper envisages application of alkali activated materials(AAM) with lime as rural technology. The AAM is similar to Geopolymer but it has lot of differences. Low Mole AAM is manufactured using sodium hydroxide of 2, 3, 4 and 5 moles and sodium silicate as double the weight of Sodium hydroxide. The low mole solutions are easy to manufacture and ease of handling. The solution is used instead of water in lime- Surkhi and lime-red soil blocks. The blocks manufactured are tested for weight, water absorption and compressive strength. The results showed increase in density, decrease in water absorption and increase in strength with increase in moles of alkaline solution.

Keywords: *AAM, Lime, Surkhi, Red soil, rural technology*

1. Introduction

The Geopolymer invented by Davidovits is mineral polymer binder made from metakaolin (MK-750) with blast furnace slag and alkali silicates of sodium or potassium. Sodium Hydroxide is not involved in manufacture of geopolymer. Alkali activate materials (AAM) are manufactured using alkaline materials of Sodium Hydroxide or Potassium Hydroxide along with sodium silicate or Potassium silicate as alkaline activators used in conjunction with waste materials or industrial wastes of high amorphous silica content. The industrial wastes such as fly ash (both high and low calcium), ground granulated blast furnace slag(GGBS), rice husk ash(RHA), red mud, etc. are some of the materials containing amorphous silica.

Low temperature geopolymeric Setting (LTGS) created with siliceous materials such as Fly ash of C class or GGBS. Small amount of Lime can be added to mix if calcium is absent in the mix. The lime helps in setting at ambient temperature as compared to geopolymer which requires 60 ºC -80ºC.

Lime [1] is an ancient cementitious material before advent of cement. It is obtained by calcining the calcium carbonate or lime stone. The calcium oxide thus obtained is lime when comes in contact with moisture or water becomes calcium hydroxide called slaked lime. Slaked lime is commonly used for white washing, making lime mortar and lime concrete.

Surkhi [1] is a siliceous material obtained from crushing of burnt clay bricks or by calcining local soil. Surkhi itself is not a binding material but when combined with lime becomes binding materials hence it is also a puzzolanic material.

Local red soil [2] is widely available in India in Tamil nadu state. It is formed due to wreathing of sedimentary or metamorphic rocks rich in iron oxides. The red soil when used in concrete reduced the permeability of concrete.

The alkaline activator solution consists of various moles of sodium hydroxide solutions with sodium silicate. The Sodium silicate is taken as twice the amount of sodium hydroxide. The low alkaline solutions of 2,3,4 and 5 moles were used as compared to minimum 8 moles for AAM.

2. Literature review

Davidovits [3], inventor of geopolymer, states that geopolymers are not AAM as it doesn't contain sodium hydroxide or potassium hydroxide in its ingredients. Geopolymer is a Nano material with size in terms of 10nm. But fly ash or other puzzolanic materials used in AAMs have dimensions in micrometers. Geopolymers are macromolecules or polymers while AAM is based on small molecules and not polymers. AAMs are also not Hydrates of Sodium or Potassium. No evidence of gel or hydrate was found in AAM as compared to calcium alumino silicate hydrate (CASH) or calcium silicate Hydrate CSH gels in cement.

AAM [4] are projected as alternative to cement for its sustainability factor because of less CO_2 emission and usage of industrial wastes such as fly ash, GGBS, red mud in large scale. One-part AAM consists of a dry mix that has a solid aluminosilicate , solid alkali, and admixtures to which water is added, similar to the preparation of OPC or PPC concrete.

AAM[5] works by Alkali-activation of solid aluminosilicate precursor and an alkaline source or activator, importantly it can occur at room temperature to produce a hardened product.

AAMs [6] having recycled PVC and glass aggregates are better than the ordinary Portland cement (OPC)-based composite in terms of mechanical properties, energy absorption, thermal conductivity, and carbon footprint estimation

AAM [7] can be used to create high performance concrete and lightweight concrete. The high performance AAM has rapid strength gain with high ultimate strengths. AAM can produce materials with density as low as 1200 kg/m3 and compressive strengths from 2 to 65 MPa. AAM have far better environmental resistance than Portland cement concrete, resisting acid attack of synthetic and organic acids. AAMs resists freeze–thaw attack and high abrasion, possesses low chloride permeability and does not exhibit alkali silica reactivity.

AAMs [8] with seawater and sea sand has economic and ecological advantages, such as utilization of industrial wastes/byproducts, reduction in CO2 emission, and the reduction of the freshwater usage.

AAMs [9] can be designed to have abrasion and fire resistance, acid and chemical attack resistance, alkali-silica reaction resistance, excellent compressive and flexural strength, low permeability and low cost.

A smaller amount of limestone [10] can increase the compressive strength of Alkali activated concrete [10]. The benefits are increase in pore refinement, higher particle packing, intensified reaction, increase in gel products by nucleation effect.

The conventional lime mortar [11] mix of air lime, alccofine with alkali activation is a sustainable material in the fresh and hardened states.

sustainable structural mortars[12] can be produced by using Construction Demolition Waste mixture with mainly concrete waste mixed with brick waste and slag and activated by powdered Ca(OH)2 which is alkaline material.

In low concentration of NaOH [13] of less than 1 Mole, the pozzolanic reaction was dominant while the zeolitic reaction and geopolymerization became dominant at medium NaOH concentration of greater than 1Mole and at high NaOH concentration.

When surkhi [14] is mixed with lime to form mortar mix, interlocking hydraulic crystals are formed. This gives mortar a hydraulic property and improves the strength hence it is used in construction of many historic buildings since ancient times.

The red soil [15] blended cement is better than normal concrete in toughness and impermeability. Red soil mixed cement concrete has an excellent strength.

2. Manufacturing Procedure

Alkali Activation (AAM) solution is prepared by mixing sodium hydroxide in various moles 2,3,4 and 5 with sodium silicate (water glass). The ratio of sodium hydroxide to sodium silicate is maintained as 1:2 in the solution. This solution is used instead of water in the mortar mix. Sodium hydroxide and sodium silicate are easily available chemicals for soap and detergent manufacturing. Hence they can be used safely in low molarity without much problems of fumes or skin problems.

Surkhi is made by crushing burnt clay bricks and sieving through 300-micron sieve. Red soil is also prepared by sieving through 300-micron sieve. The powders thus obtained are used along with lime, with lime 1 part and powder 3 parts to create binder. The binder to M-sand ratio is maintained as 1:5 for all blocks.

The mix is prepared by dry mixing M-Sand, Surkhi or red soil and lime. Then water or solution is added and mixed thoroughly to make mortar paste. The mortar is molded in to blocks in mould of size 50 sq. cm. The blocks are cured in ambient conditions without water sprinkling or water curing.

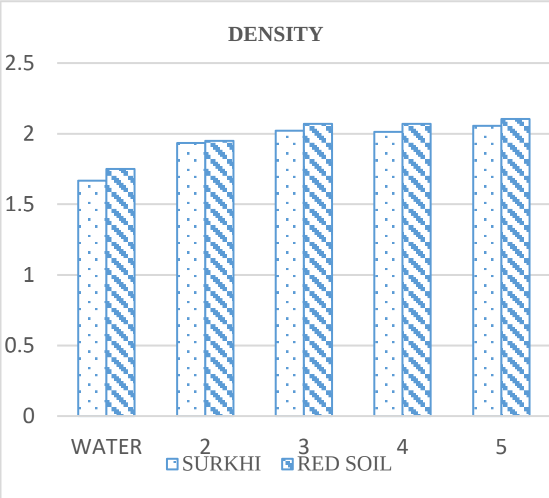
2. Tests and Results

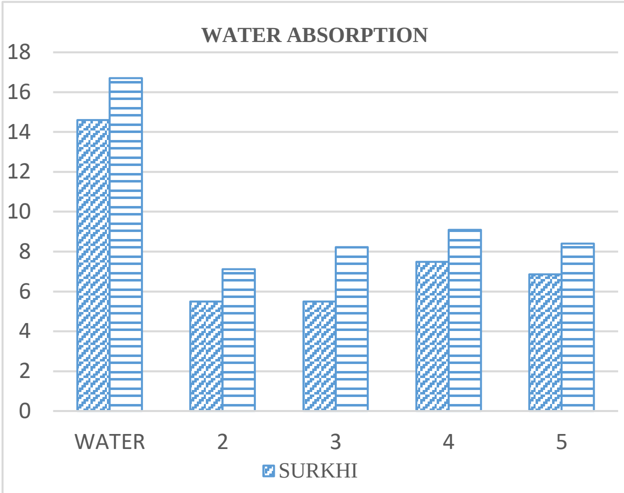
The blocks are tested for density water absorption and compressive strength as per Indian Standards. The results are enumerated as follows.

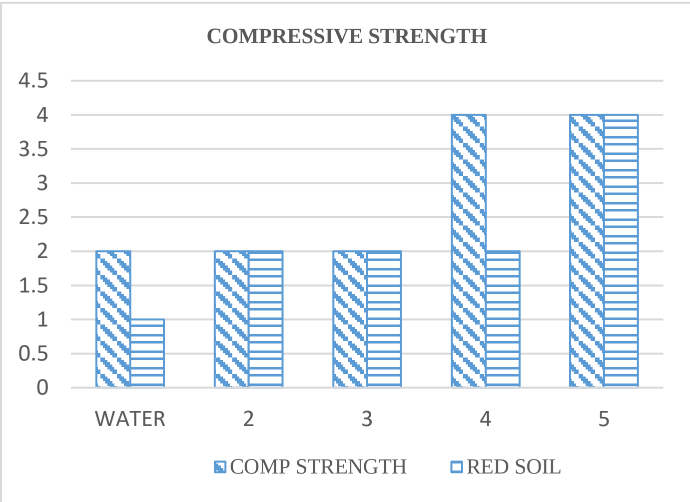
Table 1 – Comparison of results

	Surkhi			**Red soil**		
Mix	**Density**	**Water absorption**	**Comp. Strength**	**Density**	**Water absorption**	**Comp. Strength**
WATER	1.667	14.6	2	1.74	16.7	1
2 MOLE	1.934	5.49	2	1.94	7.11	2
3 MOLE	2.021	5.49	2	2.07	8.22	2
4 MOLE	2.012	7.48	4	2.07	9.1	2

5 MOLE	2.055	6.86	4	2.104	8.4	4







2.1. Discussion of Results

The density of surkhi and red soil cubes goes on increasing with increase in moles.

2. Maximum density is for 5 mole mixes of surkhi and red soil.

3. The water absorption for mixes with alkaline mixes are less than 10 and much lower the cubes made with water.

4. The compressive strength of the cubes re lower for red soil, but comparitively higher for surkhi cubes.

5. Maximum compressive strength is for 5 mole cubes of both surkhi and redoil

6. The lower moles added as replacement for water increases the compressive strength and density and lowers water absorption.

7. Low moles of sodium hydroxide in combination with sodium silicate of 2.3.4 and 5 moles are suitable as rural technology than 8 mole or higher solutions for lime based cubes.

8. Low moles of sodium hydroxide in combination with sodium silicate of 2.3.4 and 5 moles are having low handling hazard as compared to higher mole mixes.

3. Conclusion

The experimental studies show constant improvement in density, reduction of water absorption and increasing compressive strength with increase in moles of sodium hydroxide. The low mole solutions along with lime can act as replacement for Cement. Lime is abundantly available in rural areas. Sodium hydroxide and sodium silicate and available chemical sales companies even in small towns. The low mole solution of AAM is viable and sustainable alternative to cement when used along with lime, Surkhi and red soil. This mortar thus created is more environment friendly and can be locally sourced. Hence such technologies must be taught to local masons and they can be trained so that our earth suffers less pollution due to reduction in cement consumption. Since water curing is totally absent, the amount of fresh water required for curing is also reduced in manufacturing mortar and blocks.

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