Experimental Investigation on Strength Characteristics of Controlled Low Strength Material Bricks

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Abstract **- Controlled Low Strength Material (CLSM), is a flowable fill which has been used as a trench backfill, sub base preparation etc. As material used in CLSM has a low strength, ingredient materials percentage is varied to prepare bricks in order to achieve more strength. Materials used are cement, Flyash, M- sand and Laterite soil with 0.7 w/c ratio. By varying material percentages 16 trial mix proportions were tested. Based on compressive strength test results bricks were casted by selecting four mix proportions. Strength parameters of CLSM bricks were tested. Brick having 20% cement shows high strength and all the bricks of different mixes satisfying IS standards and recommendation.**

Index Terms – CLSM, **Bricks, Compressive Strength Test**

I. Introduction

CLSM is neither a soil cement nor concrete but it has properties similar to both. It is a fluid mixture made of Cement, Water, Fine aggregate, Fly ash and GGBS or both. CLSM is a cementitious backfilling material which is flowable fill used for filling trenches, voids etc. The consistency of CLSM is like slurry after the material placing hardens to support moving loads without undergoing any settling. It is a non-segregating, self-consolidating, easily-flowing material which results in a non-settling fill. Many terms are used to explain CLSM including flowable fill, un-shrinkable fill, controlled fill, flowable mortar, K-Crete, and other different names.

A brick is a building material used to make walls, pavements and other elements in masonry construction. A brick can be composed of different materials. Bricks are produced in numerous classes, types, materials and sizes which vary with region and time period and produced in bulk quantities. Here in this study an effort is made to produce a brick by using controlled low strength material and tried to increase the strength of brick by varying the materials proportion.

II. Need For The Study

Lots of research is required to be done increase the strength of bricks by using locally available low cost materials and also reuse of waste materials in the preparation of bricks also reduces the pollutions and helps to go green. Many research works has been done on the cement stabilization which indicates strength of soil increases by the use of cement. Further study is required to use the Flyash as a replacement material for cement. Flyash which is a pulverised fuel ash and is a product that is composed of the particulates that are driven out of coal fired boilers together with the flue gases. There are many studies are done for the replacement of river sand with M Sand. Laterite soil and M Sand are low cost materials, to achieve the low cost bricks as a construction material to make the construction economically sound.

III. Objectives Of The Study

- To determine the properties of lateritic soil, M-sand, Cement and Flyash.
- To determine the quantity of water required for the workability based on Flow Test.
- Selection of best CLSM mixes for the production of bricks by varying the material percentage based on Compressive strength.
- To determine the strength characteristics of CLSM bricks.

IV. Literature Review

Naik et. al (2004) carried out experimental investigation on CLSM mix using cement, wood ash, sand, fly ash. Mix contain with 80% of wood ash, 15% of sand and 5% of cement showed strength of 0.8 N/mm2 in 28 days and attained 1.4N/mm2 after a year. The researchers observed the reduction in permeability of CLSM with the age.

Lissy and Sreeja (2014) carried out experimental investigation on manufactured bricks using Textile industry Sludge (6.66%), red soil (56%), clay (4.4%), fine-sand (33%) and water. Bricks were casted, sundried for 4 days and burnt at 500°C for 3 days in furnace. The compressive strength of bricks performed better compared to normal burnt clay bricks.

Gaurav and Karna (2015) conducted a study on Laterite soil Bricks using Cement and Fly ash along with the Laterite soil. The bricks were prepared with fly ash (20%), cement (5-10%) and soil (70-75%). The CLSM bricks with fly ash 20% and cement 10% show a compressive strength of 9.5 N/mm2 higher than Laterite bricks.

IV. MATERIALS USED

A. *Cement*

Ordinary Portland cement of 53 grade (ACC) confirming the Indian standard IS 12269:2013 was used. The various properties of cement are given in the Table I

TABLE I
PROPERTIES OF CEMENT

SL No	Properties		Test results	Requirements As Per IS 12269:2013
1	Specific Gravity		3.1	-
2	Normal Consistency		33%	-
3	Initial Setting Time (min)		55	>30
4	Final Setting Time (min)		300	<600
5	Compressive Strength (N/mm^2)	3 Days	32	>33
7 Days		40	>43	
28Days		54	>53	

B. *Manufacture sand (M –Sand)*

Manufacture sand procured from RMC Mangalore. Sand passing through 4.75 sieves was used in manufacture of bricks. Table II gives the properties of M-Sand

TABLE II
PROPERTIES OF M-SAND

Properties	Results
Specific gravity	2.68
Water absorption	0.2%
Fineness modulus	3.84

C. *Flyash*

Flyash collected from RMC Mangalore, Karnataka Confirming to IS 12089:1981 and used as partial replacement material for cement. The Table III gives the properties of Flyash.

TABLE III
PROPERTIES OF FLYASH

SL No	Characteristics Chemical Requirements	Test Results	Requirements As Per BS:6699
1	Fineness(m^2/kg)	350	275(min)
2	Specific gravity	2.92	-

D. *Laterite Soil*

Table IV shows the laterite soil properties determined after testing the collected laterite soil

TABLE IV
PROPERTIES OF FLYASH

Sl No.	Properties	Laterite soil
1	Specific gravity	2.29
2	Grain size distribution (%)	
	a) Gravel	5
	b) Sand	52
	c) Silt and clay	43
3	Consistency limits (%)	
	Liquid limit	53.95
	Plastic limit	30.48
	Plasticity index	23.47
5	IS Soil Classification	CH
6	Engineering Properties	
	Light Compaction	
	a) MDD, γdmax (g/cc)	1.99
	b) OMC (%)	7.91
	Heavy Compaction	
	a) MDD, γdmax(g/cc)	3.06
	b) OMC (%)	8.35
7	Soaked CBR Value (%)	
	Light Compaction	0.47
	Heavy Compaction	0.67
8	Unconfined compression test	
	Light Compaction (kN/m2)	236.13
	Heavy Compaction (kN/m2)	320.42

Tests like grain size analysis, LL, PI, PL, specific gravity, water content, compaction, UCC and CBR were conducted and the result were tabulated to compare with properties of stabilized soil.

E. *Water*

Potable water confirming to IS 456-2000 was used.

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V. METHODOLOGY

Step.1 Collection of required materials which generally includes, Laterite soil, Cement, Flyash and M-sand.

Step.2 Flow ability test to fix the water consistency for mix.

Step.3 CLSM moulds were casted for fixed W/C ratio and tested for compressive strength of different mix proportion by varying material percentages.

Step.4 The mix proportions were selected based on compressive strength parameter of CLSM moulds and CLSM bricks were casted and cured in potable water for 7, 14 28 days.

Step.5 Different bricks tests such as Compressive strength test, Water absorption test, Impact test, Soundness test, Structure of brick, Brick column test, Durability test (NaCl) were conducted.

VI. RESULTS AND DISCUSSIONS

A. *Flowability test*

The flow-table test is conducted to determine the flow ability of the given mix. It generally involves mould of base of 10 mm dia placed on horizontal plate which is oiled for both mould and plate. By fixing the W/C as 0.7, we got flow value in between 100% to 118 % with the approximate 25 number of blows using vibrator. The Table V gives the results of Flow ability test.

TABLE V
FLOWABILITY TEST RESULTS

Trial No	Cement (%)	Flyash (%)	M-Sand (%)	L-Soil (%)	W/C ratio	Base Diameter of Mould In Cm	Average Diameter of Mortar In Cm	Flow Value=((Average Dia-Base Dia)/ Base Dia)*100
1	5	25	40	30	0.7	10	20	100
2	5	25	35	35	0.7	10	20.2	102
3	5	25	30	40	0.7	10	20.4	104
5	10	20	40	30	0.7	10	20.4	104
6	10	20	35	35	0.7	10	21	110
7	10	20	30	40	0.7	10	21.6	116
9	15	15	40	30	0.7	10	20.2	102
10	15	15	35	35	0.7	10	20	100
11	15	15	30	40	0.7	10	21	110
13	20	10	40	30	0.7	10	21.6	116
14	20	10	35	35	0.7	10	22	120
15	20	10	30	40	0.7	10	21.8	118

B. Compressive Strength Test:

The Different Mixes are Casted using 70.7mm x 70.7mm x 70.7mm size mould and Tested for 3 and 7days of curing. The Compressive Strength Results are shown in Table VI

TABLE VI
FLOWABILITY TEST RESULTS

Trial No	Cement (%)	Flyash (%)	M-Sand (%)	L-Soil (%)	W/C ratio	Compressive Strength (MPa)
1	5	25	40	30	0.7	2.12
2	5	25	35	35	0.7	1.56
3	5	25	30	40	0.7	1.48
5	10	20	40	30	0.7	6.12
6	10	20	35	35	0.7	5.58
7	10	20	30	40	0.7	5.18
9	15	15	40	30	0.7	11.79
10	15	15	35	35	0.7	7.08
11	15	15	30	40	0.7	5.8
13	20	10	40	30	0.7	10.80
14	20	10	35	35	0.7	7.76
15	20	10	30	40	0.7	6.65

Based on the Compressive Strength results four Mix Designs selected for the manufacture of CLSM Bricks. Table VII gives the selected mix designs and details.

TABLE VI
SELECTED MIX DESIGNS AND DETAILS

Mix	Mix Proportion (%)	Cement (%)	Flyash (%)	M-Sand (%)	L-Soil (%)	w/c ratio	Compressive Strength (MPa)
Brick A	15:15:40:30	15	15	40	30	0.7	11.79
Brick B	20:10:25:45	20	10	25	45	0.7	10.80
Brick C	10:20:40:30	10	20	40	30	0.7	6.12
Brick D	20:10:35:35	20	10	35	35	0.7	7.76

C. Tests on Bricks:

Tests Such As Compressive Strength Test, Water Absorption, Soundness, Impact, Hardness, Structure of Brick, Efflorescence, Durability and Brick Column Test Were Conducted On CLSM Bricks.

1) Water Absorption Test: The water absorption test decides the strength and stability with time. Here test is conducted for different proportions for 24hrs and got results as 2.00%, 1.60%, 1.80%, 2.62%, which is less than 20%.so it satisfies the IS standards.

TABLE VI
SELECTED MIX DESIGNS AND DETAILS

Brick Name	Mix-Proportion	Weight Of Brick Before Soaking(Kg)	Weight Of Brick After Soaking For 24 Hrs (Kg)	Water Absorption (%)
A	15:15:40:30	4.28	4.36	1.87
B	20:10:25:45	4.18	4.26	1.92
C	10:20:40:30	4.28	4.36	1.86
D	20:10:35:35	4.18	4.29	2.63

2) Soundness Test: After 28 days of curing two CLSM bricks are struck each other to know the resistance of CLSM bricks on impact. Bricks gave clear ringing bell sound when struck each other. This shows that there is no void inside.

3) Structure of Bricks

After curing CLSM bricks for 28 days, a brick is broken into two pieces and the broken surface of the CLSM bricks are observed and found that is free from void and material lumps. This indicates the good quality of CLSM bricks.

4) Compressive strength of brick

It is carried to know the crushing strength of the CLSM bricks of dimension 20cm x 10cm x 10cm using Compression Testing Machine (CTM) is calculated.

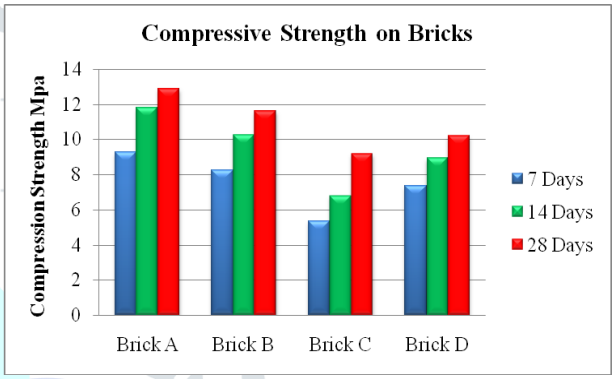

Fig. 1 Compressive Strength of CLSM Bricks

5) Efflorescence Test

This test is conducted to find the presence of soluble salts in CLSM bricks. In this test CLSM bricks are immersed in water for 24 hrs. Then are taken out and dried. After drying CLSM bricks are observed to check the presence of soluble salts. Presence of white or grey patches indicates the presence of soluble salts in CLSM bricks and not recommended for construction. In this study CLSM bricks have shown very little efflorescence. Hence conclude that the selected CLSM bricks can be used for wall construction.

6) Brick Pillar Test

Brick Pillar consists of Bricks of Dimension 20*10*10 are used For Masonry With 1:3 Mortar Proportion. All Bricks Types Satisfy IS Standards. Hence It Is Advisable To Use For Load Bearing Walls.

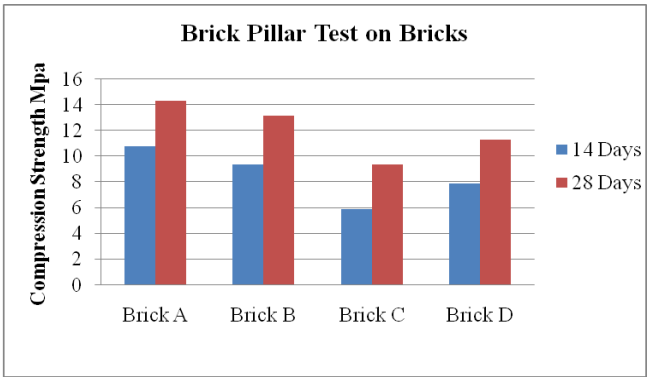

Fig. 2: Compressive Strength of Brick Using CTM

VII. CONCLUSIONS

- The soil is having specific gravity of 2.29 and it contains 5% of gravel, 52% of sand and 43% of silt and clay. Hence, the given soil is classified as High compressible clayey soil (CL).
- The best CLSM mix proportions can be selected based on the strength and flowability criteria and the w/c ratio of 0.7 gives good workability for CLSM mixes used for the brick construction.
- The proportion of CLSM mix with cement, Flyash, M-sand and laterite soil gives good strength and based on this, CLSM brick A, B, C and D are selected and all the type can be used for load bearing walls.
- Water absorption of all selected CLSM bricks are less than 3% and satisfies the IS 3495 (Part II):1992 standards and it is good to use for wall construction.
- The CLSM bricks show high resistance to Impact, soundness, hardness and efflorescence. And when tested for brick column CLSM bricks of selected ratios satisfy the IS standards
- Based on the compressive strength of brick A, B, C and D, it can be concluded that CLSM bricks can be used as construction material.

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