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Examination of Compressive Strength and Water Absorption of Adobe Blocks prepared using Black Cotton Soil and Granite Sludge

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Abstract
Brick is one of the most commonly used conventional masonry units in construction industry prepared using red earth. Unlike red earth, Black Cotton soil (BC soil) has limited applications due to poor shear strength and high swelling & shrinkage. On the other hand, mushrooming of granite industry (cutting and polishing units) to obtain thin slices of granite for flooring, daddoing etc., from huge blocks of granite rock results in granite sludge as by product. Attempt is made in the present work to utilize granite sludge along with BC soil in the production of low cost adobe blocks along with the stabilizers. The stabilizers used in the preparation of adobe blocks are a combination of cement and lime. Six series of adobe blocks are prepared by varying the percentage of BC soil and granite sludge along with two different proportions of stabilizers. The adobe blocks prepared using 30% of BC soil and 60% of granite sludge along with admixtures are suggested for load bearing walls. Hence, sustainable low-cost housing can be achieved if adopted practically.

Keywords: Adobe blocks; Black cotton soil; Granite sludge.

Introduction

General

Affordable housing is needed in many developing countries of the world. Due to the increasing population growth in developing countries, temporary settlements and growth of slum areas are the hindrances for the infrastructural development in these countries. India being one of the developing countries, demand for housing has increased substantially. But the cost of construction materials has increased exponentially within a decade. This increase in the cost may be due to the scarce natural resources utilized in the production of conventional building blocks such as burnt clay bricks or concrete blocks. Hence attempts are made by various researchers from past three decades to find alternatives to these scarce natural resources which can be utilized in producing the building blocks without compromising on the quality of thus prepared blocks. Hence, in the present work attempt has been made to utilize black cotton soil whose weak shear strength has resulted in its limited utilization in construction industry. In order to create employment in backward districts of North Karnataka (India) where the black cotton soil is abundantly available, attempt is being made to promote the utilization of black cotton soil along with granite sludge in varied proportion in the preparation of adobe blocks along with the admixtures.

Object of Study

The present study is to find the suitability of black cotton (BC) soil along with granite sludge, an industrial by-product obtained from granite cutting and polishing units in the preparation of load bearing, good quality and low-cost adobe blocks. Also to find the bulk utilization of granite sludge with required quantity of stabilizers to prepare adobe blocks so as to reduce the burden at the dumping sites. This will create the employment opportunity to the unskilled youths living in the vicinity of Black Cotton soil deposit areas.

Scope of Study

In the present study, six series of blocks were prepared having 50%, 40%, 30% of black cotton soil with 40%, 50%, 60% of granite sludge respectively designated as A, B and C, with cement and lime as stabilizers in two different proportions namely; Series 1A, 1B and 1C contains 8% of cement and 2% of lime and Series 2A, 2B and 2C contains 6% of cement and 4% of lime. Thus prepared blocks were tested for its compressive strength and water absorption at different curing periods of 7, 14, 21 and 28 days and initial rate of water absorption (IRA) test at 28 days of curing period.

Literature Review

The conventional building blocks are the burnt clay bricks which constitutes the materials such as red earth and river sand along with water in required quantity. As red earth and river sand are the excessively utilized scarce natural resources, there is a need to replace it by alternate materials without compromising on the end results. This study is an attempt in the direction to prepare adobe blocks using BC soil and Granite Sludge along with chemical stabilizers.
The first patent for a clay working machine was granted in the year 1619. Karthikeyan et al, [1] found that the addition of textile sludge with cement and hydrated lime showed better performance. Sukhadia et al, [2] compared the compressive strength and water absorption of BC soil brick to that of normal brick. Shekar [3] prepared three series of blocks combining black soil, fly ash and granite sludge in varying proportions and tested for their compressive strength, water absorption, efflorescence and weight density. Thus it was possible to manufacture good quality bricks by using locally available materials and industrial by-products.

Lokeshwari et al., [4] casted adobe blocks in varying proportions of 8%, 46% and 46% of cement, quarry dust and granite sludge respectively for two varying water contents i.e; 18% and 19%. It was concluded that the adobe blocks showed higher compressive strength in comparison to that of normal brick. The strength was found to be increased for about 135%. Thus these blocks can be used as energy efficient building blocks. Virendra Kumara et al., [5] aimed to prepare the granite sludge blocks with varying proportions of granite sludge powder and sand with 8% and 2% of lime and gypsum.

Guettala et al, [6] used lime in varying proportions of 5%, 8% and 12% in order to improve the durability and strength of blocks. Raheem et al., [7] prepared compressed stabilized interlocking earth blocks in addition with lime and cement as stabilizers added in varying proportions from 5% to 25% with an increment of 5% and the result of wet compressive strength of these blocks at 28days for 25% of stabilizer content was found to be 3.2 MPa and 1.2 MPa. Miqueleiz et al., [8] in the study of unfired clay blocks found that lime is very advantageous. Walker [9] examined the durability, strength and shrinkage properties of the soil blocks that are stabilized by cement also suggested suitable guidelines for usage of cement content required for wide range of soils. Nagaraj et al., [10] studied on the long-term durability of compressed stabilized earth blocks by the effect of combination of lime and cement.

Mohammad et al, [11] attempted to prepare adobe using clay, straw, jute, hemp, gypsum and cement. Farraj et al., [12] used many materials in varying proportions of sand and mud as the main matrix, and hay, cement, lime, bitumen, steel fibers, and steel filing as fibrous materials. Habib, [13], conducted the experiment with varying proportions of 5%, 10%, 15%, 20% and 25% of stone dust with 5% of cement and it was concluded that with the use of stone dust, the compressive strength increases from 10% to 20%. Finally, it was found that the use of adobe blocks provides low cost housing.

Materials and Methods

BC soil was characterized for its specific gravity, grain size distribution and consistency limits. Granite sludge was characterized based on grain size distribution and specific gravity. Ordinary Portland cement was tested for its normal consistency, initial setting time and specific gravity. Lime was also tested as per codal provision for its reactivity in the presence of water

Experimental Study

The experimental program was planned to prepare six series of adobe blocks of size 22cmx10cmx10cm using BC soil in various proportions of 50%, 40% and 30% along with 40%, 50% and 60% of granite sludge respectively by varying the percentages of stabilizers in two different proportions, namely: 8% of cement and 2% of lime for series 1A, 1B and 1C and 6% of cement and 4% of lime for series 2A, 2B and 2C. A total number of 162 adobe blocks were cast using the mould of standard size 22cmx10cmx10cm and were subjected to compressive strength, water absorption test at various curing periods of 7, 14, 21 and 28 days, also IRA test (Initial Rate of Water Absorption) was carried out at 28 days of curing period.

Plate 1: Various stages of preparing, stacking, numbering, curing and testing adobe blocks

Results and Discussions

Adobe blocks prepared with different proportions of BC soil, granite sludge, lime and cement were subjected to compression test and the results are tabulate in the Table 5.1 for the Series S1 and S2.

Table 1 Results of Compressive strength and Water Absorption on Adobe blocks of all series

Curing Period (in Days) ↓ Series →	Compressive Strength in Kg/cm^2				Water Absorption in %			
	7	14	21	28	7	14	21	28
1A	11.84	15.45	22.42	23.94	16.4	15.8	10.4	7.83
B	8.81	14.24	28.48	36.06	15	14.05	7.13	7.23
C	8.87	15.02	23.02	28.03	19.55	18.8	10.5	8.8
2A	5.93	10.16	15.45	17.27	11.4	10.45	9.73	7.33
B	7.51	12.53	13.53	18.48	12.55	12.25	9.56	8.4
C	9.89	17.27	18.90	30.00	15.6	14.4	7.43	7.16

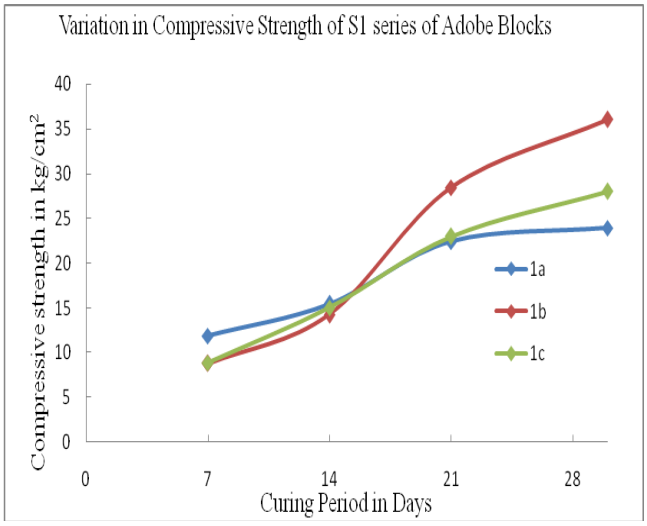

Fig 1: Result of compressive strength of Adobe Blocks of S1 series

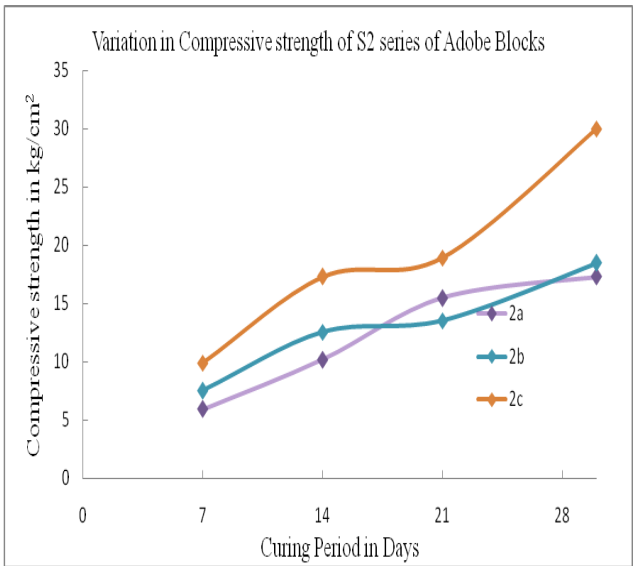

Fig 2: Result of compressive strength of Adobe Blocks of S2 series

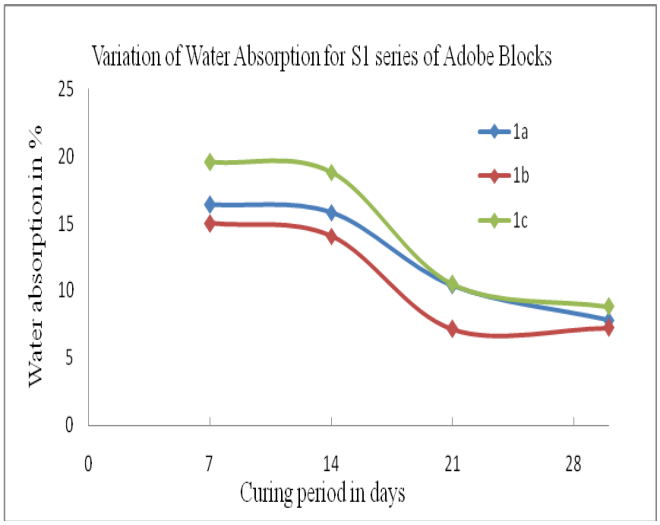

Fig 3: Result of water absorption of Adobe Blocks of S1 series

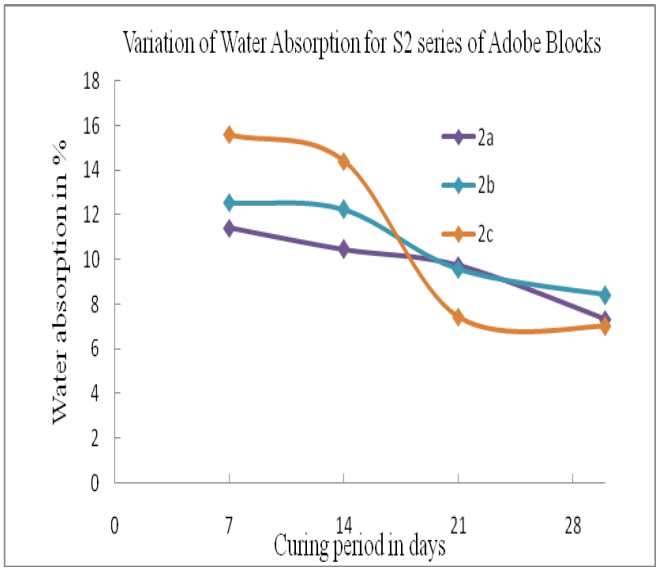

Fig 4: Result of water absorption of Adobe Blocks of S2 series

Table 2: Results of IRA test on Adobe blocks of all series

Series	1A	1B	1C	2A	2B	2C
IRA Values (kg/m^2/min)	0.87	0.39	0.72	0.42	1.07	1.20

The adobe blocks designated as Series 1B, 1C and 2C have gained compressive strength of 36.06, 28.03 and 30 Kg/cm^2 at 28 days of curing period which is more than the desired strength of 25 Kg/cm^2 for unfired clay bricks. This increase in strength may be due to better binding between the constituent materials in the presence of sufficient percentage of stabilizers. It can be observed that water absorption exhibited by adobe blocks of all series after 14 days of curing period are within the prescribed value of 18% for good quality unburnt bricks as per IS:1725,2013 (October) [14]. This also compliments to the observed increase in compressive strength of adobe blocks of few series namely, 1B, 1C, 2B and 2C series. From the values of IRA test it can be observed that the series 1A, 1C, 2B

and 2C have exhibited the IRA values between the prescribed range of 0.8 Kg/m^2/min to 3.0 Kg/m^2/min.

Conclusions

Series 1B, 1C and 2C have gained required strength after 28 days of curing period along with prescribed range of water absorption and IRA values which qualify these blocks to be suggested for utilization in constructing load bearing walls.

Future Scope of Work

However durability studies are to be made for blocks of series 1B, 1C, 2B and 2C before utilizing them practically.

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