 https://doi.org/10.1051/e3sconf/202338704014

AN EXPERIMENTAL EVALUATION OF THE IMPACT OF MOULDING MOISTURE CONTENT ON THE COMPRESSIVE STRENGTH OF UNSTABILISED COMPRESSED EARTH BLOCKS

A.Kandasamy[1], *P.Priya Rachel*[2]

[1] Research Scholar,Department of Infrastructure Engineering,Saveetha School of Engineering,Chennai, India
[2] ***Professor,****Department of Infrastructure Engineering,Saveetha School of Engineering,Chennai,India*

Abstract—The purpose of this study is to evaluate the compressive strength and moulding moisture content (MMC) of unstabilized compressed earth blocks (USCEB) made from two locally accessible soil types, Than Mann (TM) and Karambai (KB). In accordance with IS 2720 (parts 4 and 5) and IS 383 standards, the physical characteristics of TM and KB are also determined. Using the ITGE VOTH machine, 24 sets of 3 USCEB, each measuring 230 x 190 x 100 mm, are cast using TM & KB in the following ratios: 80:20, 70:30, 60:40, and 50:50. The moisture contents (in %) of each mixture are 5, 6, 7, 8, 9, and 10 accordingly. For a minimum of 10 days, the created USCEB is stored outside in normal weather conditions. Based on the findings, it can be shown that in all of the mixes, the dry density rises as MMC increases up to a certain moisture content before beginning to fall. This is termed as "optimal moisture content" (OMC). Additionally, it has been found that the mixture corresponding to a 60:40 ratio produces the highest dry density for a given MMC. The maximum dry density for this mixture is also known as the maximum dry density. The compressive strength test for the 60:40 mixture was then conducted. The USCEB's maximum compressive strength of 9% moisture content was obtained. This study will enable us to determine how much water should be supplied to the soil mixtures in the USCEB for proper compaction during moulding. This research provides evidence for the contribution of MMC to USCEB's dry density. It is also proved that the proportion of clay and sand in a particular soil influences the OMC at which is to be conducted.

Keywords—Unstabilised compressed earth blocks, Optimum moisture content, Moulding moisture content, Compressive strength, Dry density

---

1Correspondingauthor: *kandasamya9032.sse@saveetha.com, priyarachelp.sse@saveetha.com*

I. INTRODUCTION

Similar to food and clothing, housing is a basic human requirement. India currently has a population of close to 1400 million people. The population of our nation has expanded by about 370 million over the past three decades. 30% of the population resides in urban regions, compared to 70% in rural areas. The disparity between housing demand and supply is growing. The cost of building supplies has multiplied ten times, while the cost of building sites has multiplied one hundred times. According to estimates, 30 million people do not have a place to live. It is quite challenging for low- and middle-income groups to construct their own homes. In order to reduce the time and expense of building, it is necessary to implement.

Low cost housing is defined as the building of a home at a substantially lower cost without compromising strength and quality. Inferior price is seldom a sign of low quality. In the current period, we should speak of economic structures whose costs have been decreased without compromising the standard of living of an individual. As a result, rural housing, which is a major source of low cost housing technology, should be planned according to the living conditions of that particular area. The challenge of how to advise a financially sound residence then emerges. The utilization of materials starts to dominate the conversation. 70% to 80% of the overall cost of construction is made up of building materials. The cost of a structure can be reduced by carefully choosing and using the right building materials. They are essential to the house's functionality, elegance, and economy.

Earth is being used as a building material (especially for walls) from time immemorial. In many regions of North Africa, the Middle East, India, China, and South America, it is still the typical low-cost building material despite the fact that it is no longer used in Europe and North America in any significant capacity. It is the perfect material for the world's hot, arid regions due to its great thermal insulation and heat storage capacity. Through its numerous specialized organizations, the United Nations has made significant contributions to helping nations encourage the use of soil as a building resource.

It has been reported that a well stabilized soil wall does not always need a rendering and hence it should not necessarily require more attention than a wall built of burnt bricks of average quality. By employing soil stabilization methods it is possible to build houses even in the humid areas of the tropics, which have high annual rainfalls and where burntbricks are scarce. The strength and resistance to weathering of almost all soils increase when treated with stabilizers like cement, lime, fly ash etc. The improvement of these properties increases with increasing percentage of stabilizers. For every soil there exists a minimum stabilizer requirement for a specific purpose. This minimum amount of stabilizer depends on several factors. They are grain size distribution, type and quantity of stabilizer, moulding moisture content, type and intensity of compaction and age. It is also likely that physical-chemical properties of the soil affect the strength development to a considerable degree.

II. LITERATURE SURVEY

A. Yodger.E.J

Based on his test results Yoder was able to propose the following (in 1963):

a) Unconfined Compressive Strength (UCC strength) increases with increases with increase in compacted dry density for a soil stabilized with cement.

b) The rate of increase of UCC strength with respect to compacted dry density increases with increase in percentage of cement.

c) The UCC strength increases very steeply for the first week of curing and then rather moderately for the second week and after that mildly up to the end of four weeks. Beyond that the increase in UCC strength is not appreciable.

B. Rosenak. S

During 1957 Rosenak did the testing and development work in Burma on behalf of the United Nations Technical Assistance Administration, for the National Housing Town and Country development Board, Union of Burma. Part of the work was done along with R. Fitzmaurice. In 1949, a large stabilized soil housing project comprising the construction of 4000 houses by the rammed earth technique in the East Punjab, India was carried out under the guidance of Rosenak. Based on his experience, he gave the following conclusions:

a) The method (soil stabilization) is found to be too expensive compared to, say, ordinary brick-material, if an addition of cement much in excess of 5% is required.

b) Soil having liquid limit below 25%, clay content up to 20%, a minimum sand content of 35% and plasticity index between 8.5 and 10.5 is found to be suitable for stabilization with 5% cement.

c) Power operated machine produced blocks under 7 N/mm^2 and the blocks had crushing strength twice as high as that of blocks made by the hand operated machine which exerted a pressure of 2.8 N/mm^2

d) Increased density of blocks results in increased compressive strength.

C. Mukherjee. S.C.

In his paper Mukherjee states that for successful stabilization of soil with cement content of 3 to 4% by weight of soil , the soil should be composed of 60% silica and 40% alumina. His statement is based on exploratory experiments.

D. Nambiar. K.K.

He gives a simple test for the suitability of a sample of soil to be stabilized with cement in his paper submitted for a symposium on economy in construction conducted in March 1974.The soil sample is to be slightly moisturized and a ball made out of it by hand. This ball is to be dropped from a height of one metre. If it splits up into small pieces and scatters, the clay content is low. On the other hand, if it flattens without any other damage. It means that the sample is too clayey. If the sample develops cracks, but does not disintegrate, it may be taken to be suitable for making soil stabilized cement blocks

III. OBJECTIVES AND SCOPE OF THE PRESENT WORK

The objectives and scope of the present work are limited to

❖ Find the Optimum moisture content for different ratios of the mixes of soils ("Than Mann" and "karambai") by making unstabilised mud blocks.

❖ Find the maximum of maximum dry density from those mud blocks.

❖ Determine the compressive strength of the blocks for those particular mix of soil, yielding the maximum of maximum dry density.

IV. DETERMINATION OF PHYSICAL PROPERTIES

The first step in the block making process is to study the properties of soil by conducting various lab tests on those soils which are used for the experimental investigation of mud blocks. The test results for those soils are given below.

A. Soil 1 (Brown soil locally known as "Than Mann")

a) Fraction of sand = 68 %
b) Fines(finer than 75 microns) = 32 %
c) Liquid limit & plastic limit (Non-plastic)
d) Soil classification : SM (Silty sand)

B. Soil 2 (Black soil locally known as "Karambai")

a) Fraction of sand = 29 %
b) Fines (finer than 75 microns) = 71 %
c) Liquid limit = 29%
d) Plastic limit = 10%
e) Soil classification : CL (clay with compressibility)

V. EXPERIMENTAL PROGRAM

A. Materials Used in this Experimental Programme:

- Soil 1 - Brown in color locally known as "Than Mann"
- Soil 2 - Black in color locally known as "Karambai"
- Water

B. Schedule of Experimental Programme

The unstabilised soil blocks are cast by mixing soil 1 and soil 2. The ratios of the soil 1 and soil 2 that are taken during this investigation are 80:20, 70:30, 60:40, 50:50. The total amount of soil taken for casting one mud block is 8 Kg. Each mix is prepared with moisture contents of 5,6,7,8,9 and 10 respectively. For each combination three number of blocks are cast.

TABLE I. SCHEDULE OF EXPERIMENTAL PROGRAMME

Proportion of Soil 1 : soil 2	Mass of Soil 1 (in Kg)	Mass of Soil 2 (in Kg)	Moulding Moisture content (in %)	No of blocks cast
80 : 20	6.4	1.6	5	3
80 : 20	6.4	1.6	6	3
80 : 20	6.4	1.6	7	3
80 : 20	6.4	1.6	8	3
80 : 20	6.4	1.6	9	3
80 : 20	6.4	1.6	10	3
70 : 30	5.6	2.4	5	3
70 : 30	5.6	2.4	6	3
70 : 30	5.6	2.4	7	3
70 : 30	5.6	2.4	8	3
70 : 30	5.6	2.4	9	3
70 : 30	5.6	2.4	10	3
60 : 40	4.8	3.2	5	3
60 : 40	4.8	3.2	6	3
60 : 40	4.8	3.2	7	3
60 : 40	4.8	3.2	8	3
60 : 40	4.8	3.2	9	3
60 : 40	4.8	3.2	10	3
50 : 50	4.0	4.0	5	3
50 : 50	4.0	4.0	6	3
50 : 50	4.0	4.0	7	3
50 : 50	4.0	4.0	8	3
50 : 50	4.0	4.0	9	3
50 : 50	4.0	4.0	10	3

VI. METHODOLOGY

It consists of the following:

- *A. Mixing of soil 1 and soil 2 and moisture content*
- *B. Mud block pressing*
- *C. Drying of mud blocks*
- *D. Testing of mud blocks*

A. Mixing of soil 1 and soil 2 and water

As already discussed 8 kg is used for making one mud block. Soil 1 and soil 2 are weighed according to the value given in the table 6.1. Then both the soils are thoroughly mixed using hand or trowel. Then the water is added as given in the table 6.1. Soil mix and water are mixed well using hand, such that no wet lumps having excess water are present in the mix.

B. Mud block pressing

The following steps are to be followed in a sequence for pressing a stabilised soil block:

a) The machine should be firmly on a level ground correctly in position.

b) Open the lid of the mould completely and hold the compacting lever in vertical position. The lever should be held as close to the mould as possible. Insert the thin base plate (3mm thick) in to the bottom of the mould. Smear the sides of the mould with lubricating oil. Do not apply lubricating oil to the lid and bottom plate. The lubrication may be repeated once after 8 to 10 blocks are made.

c) The prepared soil mix is weighed out in the scoop and poured into the mould. The narrower end of the scoop must be pushed deep in to the mould and the soil emptied by an up and down motion.

d) Now close the lid of the mould with a slight impact and tighten the screw jack (locking system of the mould) such that the lid is held down tightly.

e) The compaction is now carried out by pulling the lever down till it reaches the stopper. During this operation maximum compaction pressure applied by the ITGE VOTH machine is 3.0 N/mm^2.

f) The lid is now opened by loosening the screw jack. The compaction lever is pushed further down forcing the compacted block out of the mould. The ejected block is removed by sliding it horizontally along with the thinner base plate. The lever must be held down while the block is removed from the machine.

g) The block is now weighed and is termed as wet mass of the mud block.

h) The block is now kept for drying on its side and the base plate is brought back to the mould for the next block. The process is repeated.

C. Drying of mud blocks

The mud blocks are kept in a place where there is no direct sunlight. It should be kept there for a minimum of 10 days.

D. Testing of mud blocks

i. Determination of dry density of mud blocks

After the drying period the block is weighed and is termed as dry mass of mud blocks. Then the dry density of the mud blocks can be found out using the formulae given below.

Dry density = dry mass/ Volume

ii. Determination of compressive strength of mud blocks

For each mix the optimum moisture content (OMC) and the corresponding maximum dry density are determined. Based on these results, the optimum mix proportion and the moulding moisture content corresponding to the maximum of maximum dry density are identified. The compressive strength of this mix is determined.

VII. RESULTS AND DISCUSSION

Based on the findings, it can be shown that in all of the mixes, the dry density rises as MMC increases up to a certain moisture content before beginning to fall. This is termed as "optimal moisture content" (OMC). Additionally, it has been found that the mixture corresponding to a 60:40 ratio produces the highest dry density for a given MMC. The maximum dry density for this mixture is also known as the maximum dry density. The compressive strength test for the 60:40 mixture was then conducted. The USCEB's maximum compressive strength of 9% moisture content was obtained. This study will enable us to determine how much water should be supplied to the soil mixtures in the USCEB for proper compaction during moulding. This research provides evidence for the contribution of MMC to USCEB's dry density. It is also proved that the proportion of clay and sand in a particular soil influences the OMC at which is to be conducted.

TABLE II:Soil 1: Soil 2 (80:20)

Moisture content(%)		Wet mass of the blocks (in gm)	Dry mass of the blocks (in gm)	Density of the blocks (gm/cc)	Average density (gm/cc)
5	T1	7650	6850	1.567	1.563
	T2	7655.	6850	1.567	
	T3	7650	6800	1.556	
6	T1	8450	7450	1.704	1.700
	T2	8455	7550	1.704	
	T3	8400	7400	1.693	
7	T1	8050	7400	1.693	1.697
	T2	8050	7450	1.704	
	T3	8055	7400	1.693	
8	T1	8100	7350	1.681	1.677
	T2	8150	7350	1.681	
	T3	8105	7300	1.670	
9	T1	8300	7200	1.647	1.651
	T2	8300	7250	1.659	
	T3	8100	7200	1.647	
10	T1	8500	7150	1.636	1.631
	T2	8300	7100	1.62	
	T3	8150	7150	1.636	

TABLE III: Soil 1: Soil 2 (70:30)

Moisture content(%)		Wet mass of the blocks (in gm)	Dry mass of the blocks (in gm)	Density of the blocks (gm/cc)	Average density (gm/cc)
5	T1	8050	7550	7550	1.723
	T2	8050	7550	1.727	
	T3	8000	7500	1.716	
6	T1	8450	7800	1.784	1.784
	T2	8450	7800	1.784	
	T3	8400	7800	1.784	
7	T1	8450	7816	1.788	1.788
	T2	8400	7820	1.789	
	T3	8450	7816	1.788	

8	T1	8500	7820	1.789	1.790
	T2	8500	7820	1.790	
	T3	8550	7824	1.790	
9	T1	8550	7880	1.803	1.803
	T2	8500	7880	1.803	
	T3	8500	7884	1.804	
10	T1	8500	7312	1.673	1.672
	T2	8300	7312	1.672	
	T3	8350	7310	1.672	

TABLE IV: Soil 1: Soil 2 (60:40)

Moisture content(%)		Wet mass of the blocks (in gm)	Dry mass of the blocks (in gm)	Density of the blocks (gm/cc)	Average density (gm/cc)
5	T1	8150	7458	1.706	1.705
	T2	8150	7458	1.706	
	T3	8100	7450	1.704	
6	T1	8350	7624	1.744	1.744
	T2	8350	7624	1.744	
	T3	8300	7620	1.743	
7	T1	8250	7630	1.759	1.752
	T2	8200	7640	1.748	
	T3	8200	7630	1.749	
8	T1	8550	7892	1.805	1.805
	T2	8500	7890	1.805	
	T3	8540	7892	1.805	
9	T1	8650	7928	1.814	1.814
	T2	8655	7928	1.814	
	T3	8660	7940	1.816	
10	T1	8600	7688	1.759	1.752
	T2	8650	7688	1.759	
	T3	8600	7600	1.739	

TABLE V : Soil 1: Soil 2 (50:50)

Moisture content(%)		Wet mass of the blocks (in gm)	Dry mass of the blocks (in gm)	Density of the blocks (gm/cc)	Average density (gm/cc)
5	T1	8200	7440	1.702	1.702
	T2	8210	7445	1.703	
	T3	8200	7440	1.702	
6	T1	8150	7506	1.717	1.717
	T2	8140	7500	1.716	
	T3	8120	7506	1.717	
7	T1	8200	7650	1.750	1.750
	T2	8150	7655	1.751	
	T3	8200	7650	1.750	
8	T1	8250	7680	1.757	1.757
	T2	8250	7685	1.758	
	T3	8150	7680	1.757	
9	T1	8450	7710	1.764	1.764
	T2	8430	7712	1.764	
	T3	8445	7710	1.764	
10	T1	8450	7595	1.737	1.737
	T2	8440	7600	1.739	
	T3	8450	7600	1.737	

 https://doi.org/10.1051/e3sconf/202338704014

FIGURE 1:Average Density vs. Moisture content

(80:20)

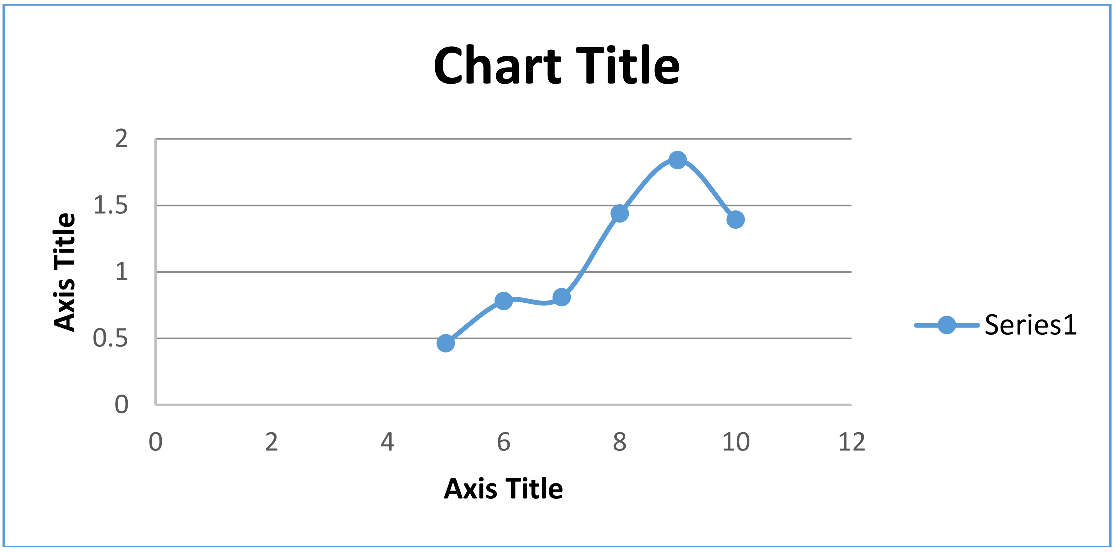


FIGURE 2: Average Density vs. Moisture content

(70:30)

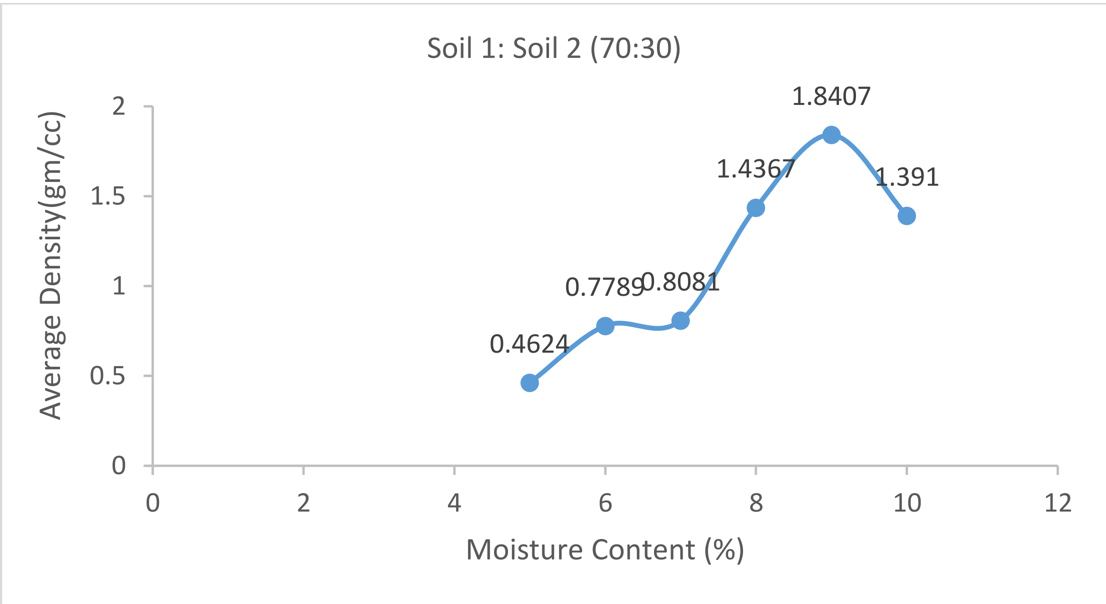


FIGURE 3: Average Density vs. Moisture content

(60:40)

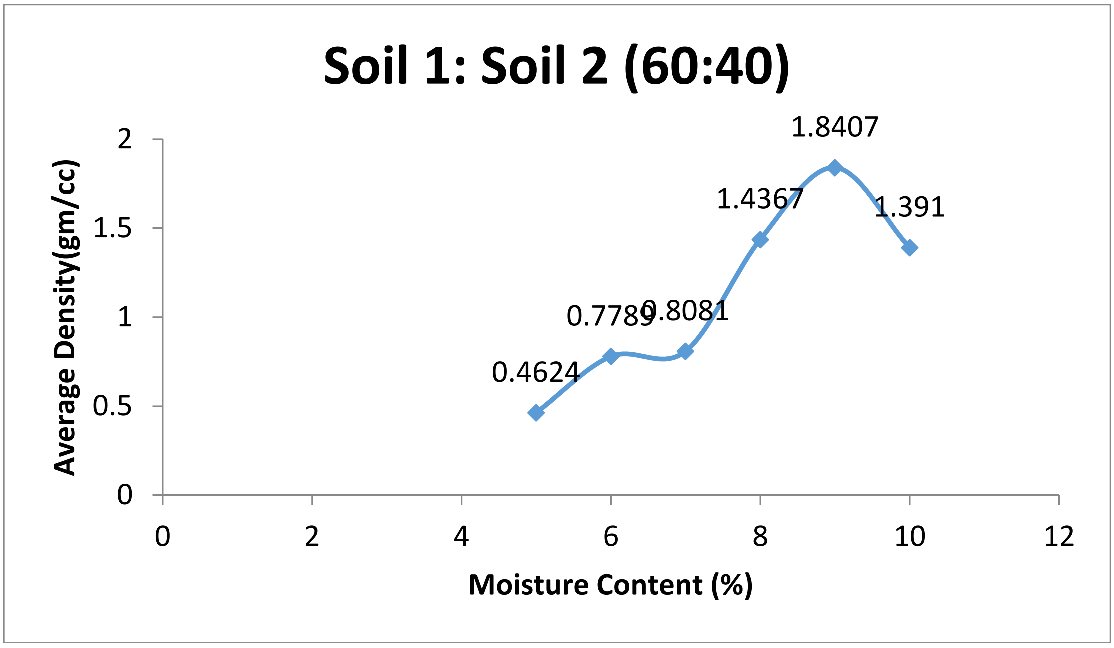


FIGURE 3: Average Density vs. Moisture content

(50:50)

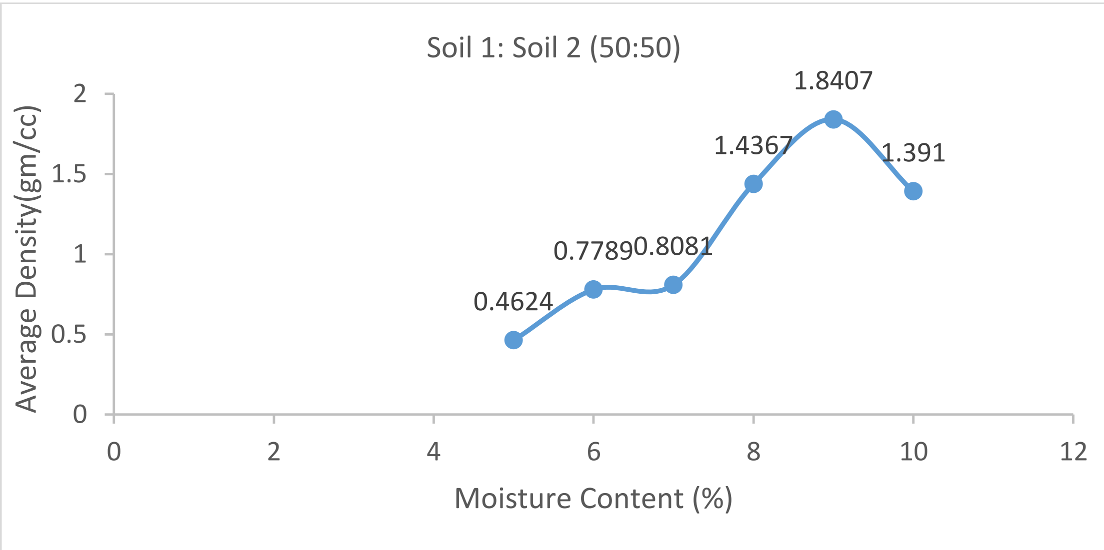
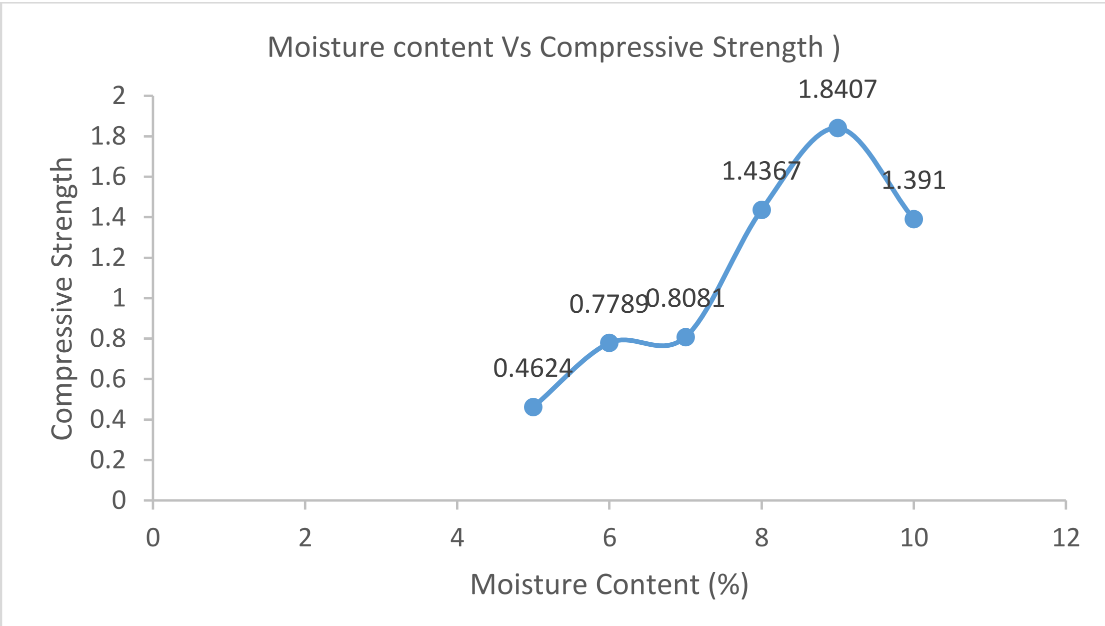


TABLE VI : Compression Test Results

Moisture content (in %)	Dry density of mud blocks (gm/cc)	Load Ton	Compressive strength in N/mm^2
5	1.705	2.060	0.4624
6	1.744	3.470	0.7789

7	1.752	3.60	0.8081
8	1.805	6.400	1.4367
9	1.814	8.2	1.8407
10	1.752	6.2	1.391

FIGURE 5 : Moisture content Vs. Compressive Strength



VIII. CONCLUSION AND SCOPE OF FURTHER STUDIES

The fact that the moulding moisture content plays a role in the dry density of mud blocks is proved by the experiments conducted. It is also proved that proportion of clay and sand in a particular soil influences the optimum moisture content at which is to be conducted.

Scope for Further Studies

On this optimum mix further investigations can be done by adding stabilisers like (cement, lime, foundary waste sand). Optimum moulding moisture content for this stabilised mix could be determined and the compressive strength of blocks made of such mix compacted at optimum moisture content could be determined.

IX. REFERENCES

[1] SENTHIL KUMAR .S.R.R M.E project work submitted in the year 1993, PSG College of technology.
[2] VENKATARAMAREDDY. B.V., SUDHAR M. RAO AND ARUN KUMAR M.K, The Indian concrete j, February / 2003, pp. 903-911.
[3] IS: 1725 - 1982 Specification for soil based blocks used in general building construction.
[4] IS: 3495 - 1973 Methods of tests of clay building bricks.

[5] ROLAND STULZ and KIRAN MUKURJI, Intermediate Technology Publications, pp. 223-227, 342-357.
[6] GRAMAVIDYA The Stabilised Mud block, User's Manual for mud block press ITGE VOTH.