Study of Geosynthetic Clay Liner Reinforced Mud Blocks

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Abstract - In the present investigation attempt has been made to improve the strength of the black cotton soil mud bricks mixed with different content of lime by reinforcing the geogrid. The soil is collected from Naragund area of Bagalkot District. The circular (100mm diameter and 200mm depth; 150mm and 100mm depth) and rectangular (200mm x 100mm x 100mm) mud bricks are prepared with soil treated with 10, 12, 14 and 16 percent lime with the geogrid reinforcement at the middle depth of the brick. The compressive strength of the mud bricks is obtained by laboratory compression test apparatus. Considerable improvement in the compressive strength is observed in rectangular mud bricks with14% and 16% of lime content reinforced with geogrid and for circular mud bricks, the maximum compressive strength is observed at 12% lime content with geogrid reinforcement.

Keywords—Black Cotton Soil, Lime, Geo-grid, Compressive strength, Rectangular blocks.

I. INTRODUCTION

The providing affordable housing is a challenge around the world, especially in developing countries. The impediments to solving the housing problem are scarcity of land and high cost of building materials. Ideally, low-cost housing must rely on locally available raw materials. Furthermore, such materials must be abundantly available and be renewable in nature. Local soil has always been the most widely used material for earthen construction in India, Approximately, 55 percent of Indian homes still use raw earth for wall constructions [9]. Bricks are masonry units composed of inorganic, non-metallic material and are widely used as building components all over the world. The bricks could be sun-dried or burnt. Burnt bricks are usually stronger than sundried bricks, especially if they are made of clay or clayey material. Clay paver design considerations including traffic, site conditions, drainage and appearance. Sand-set pavers are the most cost-effective method of constructing a pavement made with clay pavers. Pavers are used as follows;

i. For most residential, pedestrian and light duty vehicular applications, such as driveways, entranceways and passenger drop-offs use clay pavers.

ii. For heavy duty vehicular applications, such as streets, commercial driveways and industrial applications use clay pavers.

II. MATERIALS USED IN THE STUDY

Different materials like black cotton soil, lime, geogrid were used in the present study and they are discussed below.

Manuscript Received on May 09, 2015.

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2.1 BLACK COTTON SOIL

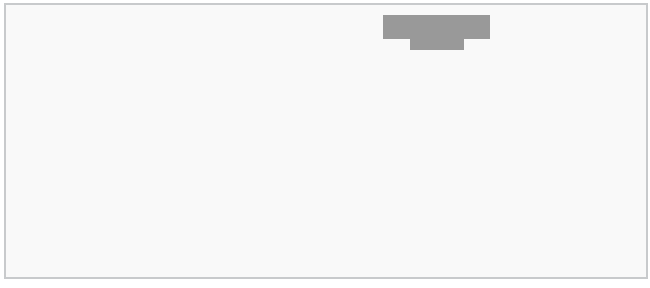
The B.C. soil used for the present work is collected from Naragund, Bagalkot district. At the time of collection of sample sufficient care has been taken to avoid the mixing of unwanted materials like wastes, roots and minerals. The soils is collected at a depth of 1m from ground level at the sites. The index property of the collected soil is studied by conducting various laboratory tests conforming to Indian Standard codes. The location of the site with latitude and longitude 15° 43' 0"E and longitude 75° 23' 0" N where the black cotton soil collected.

2.1 Physical properties of black cotton soil

Properties	*Tests carriedout as per IS*	*Results*
Liquid limit w_L(%)	**IS 2720 part V,1985 [23]**	91.2
Plastic limit w_P(%)		45
Optimum moisture content, w_{OMC}(%)	IS: 2720, Part VII—1980 [25]	35
Maximum dry density, γ_{dmax}(gm/cm^3)		1.3gram/cc
Specific gravity (G)	IS 2720 part III/Sec-1,1980 [22]	2.5

IS Sieve No	*% of passing by weight*
4.75mm	99.6
2mm	96.6
1mm	91.4
425micron	86.6
300micron	72
75micron	69.2

2.1(a) Sieve analysis results



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2.1(b) gradation curve of black cotton soil

2.2 GEOGRID

In the recent years, the geosynthetic clay liners are commonly used in landfill liners, landfill covers, liquid impoundments, canal liners, secondary containment, heap leach pads and transportation uses.

Photograph of coated yarn

Physical properties	Coated yarn geogrid
Aperture size	50.8 mm
Thickness	2 mm
Density	1.12 gram/cm^3
Mass per unit area	0.1 g/cm^2

2.2 Physical properties of Geogrid (supplied by the manufacturer)

2.3 LIME

In present work different percentage of lime is used as admixture. The physical and chemical properties of the lime are given in table 2.3. Physical and chemical properties of lime (Fisher scientific chemicals private limited, Mumbai, India)

Properties	Results
Appearance	White or off white (beige) fine powder
Odour	Slight earthy odour
pH	12.4Ca(OH)$_2$saturated solution at 25^{0}C
Solubility in water	1850mg/l at 0^{o}C
	1650mg/l at 20^{0}C
	770mg/l at 100^{0}C
Solubility	Soluble in ammonium salts, acids and glycerine.
	Insoluble in alcohol.
Melting point	Decomposition at 580^{0}C, to formCaOand H_2O
Boiling point	Not applicable
Specific gravity	2.24
Bulk density	200-800 kilo-gram/m^{3}at 20^{0}C
Vapour pressure	Non volatile

2.3. Physical and chemical properties of lime

III. PREPARATION OF RECTANGULAR AND CIRCULAR SHAPE TESTING SPECIMANS

The soil collected from the site was pulverized with a wooden mallet to break lumps and then air dried. It was then sieved through 2mm IS sieve, the 10 percent by quantity of lime in the form of powder were added to soil and mixed thoroughly. A thin coat of mould release oil was applied with brush onto the interior surface of the mould so as to prevent adhesion of the mixture of soil-lime. Compact the soil using the rammer of mass 4.98kg and fall 45cm in five layer being given 25 blows. The specimens for the determination of compressive strength were prepared by soil lime mixtures at their optimum moisture content *(OMC).* The soil specimens cured for 3, 5, 7 and 14days in desiccator at 100 percent relative humidity. Same preparation follows on 12, 14, 16percent lime content for rectangular and circular mud bricks. The dimensions of rectangular and circular shape bricks are 200mm x 100mm x 100mm and (100mm diameter and 200mm depth; 150mm and 100mm depth) shows in fig 3.6 and fig 3.7 respectively. Reinforcement of geogrid in mud bricks, soil is sieved through 2mm IS sieve, the lime powder of 10percent mixed thoroughly. A thin coat of mould release oil was applied with brush onto the interior surface of the mould so as to prevent adhesion of the mixture of soil-lime. same preparation follows on 12, 14, 16percent lime content with reinforced single layer of geogrid of thickness 2mm and size as per rectangular and circular brick required is placed in middle of each mould and mixtures of soil-lime (clay) above the geo-synthetic clay liner. The specimens for the determination of compressive strength are prepared by soil lime mixtures at their optimum moisture content *(OMC).* [5]

Photograph shows rectangular and circular mud bricks

3.1 TESTING OF MUD BRICK SAMPLESFOR COMPRESSIVE STRENGTH TEST.

The compressive strength tests conducted on the stabilized black cotton soil bricks. The brick size used for the experiments is 200mmx100mmx100mm of rectangular mud brick, and 100mm diameter 200mm depth, 150mm diameter 100mm depth of circular brick. Universal testing machine conforming to IS 516-1959, is used for carrying out the test.

Photograph shows compression tests on rectangular mud bricks using UTM

IV. RESULTS AND DISCUSSION

4.1 COMPRESSIVE STRENGTH OFRECTANGULAR MUD BRICK (200mmx100mmx100mm) WITHOUT GEOGRID REINFORCEMENT

The results of the compression tests conducted on rectangular mud blocks with the addition of 10, 12, 14 and

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16 percent lime without geogrid reinforcement were plotted.

Rectangular mud brick (200mm x 100mm x 100mm) 10%, 12%, 14%, 16%lime and unreinforced geogrid for curing period of 3, 5, 7 and 14 days.

From the Fig 4.1 observed that;

i. The compressive strength of the geogrid un reinforcement rectangular mud brick for 10 percent lime content and 3, 7 and 14 days curing period is 3.2, 3.6, 4.7 and 6.0kg/cm^2 whereas for 12, 14 and 16 percent lime is (i) 5.3, 6.4, 8.4 and 10.5kg/cm^2 (ii) 6.4, 8.2, 10.8 and 12.8 kg/cm^2 respectively.

ii. The strength of rectangular mud brick is continuously increasing with curing period for 10, 12, 14 and 16 percent addition of lime content.

iii. The rate of increase in the gain of strength is greater between 12 to 14 percent of lime and the rate is increase with increase in lime content. Similar results were reported by sujit kumar et.al (2012), Nilo et.al (2011).

4.2 COMPRESSIVE STRENGTH OF CIRCULAR MUD BRICK (100mm diameter and 200mm depth) WITHOUT GEOGRID REINFORCEMENT

Fig. 4.2 Circular mud Brick (100mm diameter and 200mm depth) 10%, 12%, 14%, 16%lime and Unreinforced Geogrid for curing period of 3, 5, 7 and 14 days.

From the Fig 4.2 , it is observed that;

i. For unreinforced geogrid in circular mud brick, the compressive strength for 10 percent lime content and 3, 5, 7 and 14 days curing period is 1.78, 2.03, 2.29 and 2.54kg/cm^2 whereas for 12, 14 and 16 percent lime is (i) 2.29, 2.54, 2.80 and 3.05kg/cm^2 (ii) 2.54, 2.80, 3.31 and 3.56 kg/cm^2 (iii) 3.05, 3.31, 3.56 and 4.07 kg/cm^2 respectively.

ii. Continuously increasing the compressive strength of circular mud bricks is increasing with curing period for 10, 12, 14 and 16 percent addition of lime content.

iii. The rate of increase in the maximum gain of strength is greater between 10 to 16 percent of lime and the rate is increase with increase in lime content.

4.3 COMPRESSIVE STRENGTH OF CIRCULAR MUD BRICK (150mm diameter and 100mm depth) WITHOUT GEOGRID REINFORCEMENT

Circular mud bricks (150mm diameter and 100mm depth) 10%, 12%, 14%, 16%limeandunreinforced Geogrid for curing period of 3, 5, 7 and 14 days.

From the Fig 4.3 it is observed that;

i. The compressive strength of the geogrid un reinforcement circular mud brick for 10 percent lime content and 3, 5, 7 and 14 days curing period is 0.79, 0.90, 1.01 and 1.05kg/cm^2 whereas for 12, 14 and 16 percent lime is (i) 0.90, 1.1, 1.10 and 1.14kg/cm^2 (ii) 1.01, 1.13, 1.20 and 1.24 kg/cm^2 (iii) 1.13, 1.20, 1.25 and 1.30 kg/cm^2 respectively.

ii. The strength of circular mud brick is gradually increasing with curing period for 10, 12, 14 and 16 percent addition of lime content.

iii. The rate of increase in the gain of strength is greater between 10 to 12 percent of lime and the rate is increase with increase in lime content.

4.4 COMPRESSIVE STRENGTH OF RECTANGULAR MUD BRICK (200mm x 100mm x 100mm) WITH GEOGRID REINFORCEMENT

The compressive strength of the geogrid reinforced rectangular mud brick for the curing period of 3, 5, 7 and 14 days and for different lime content is shown in Fig 4.4. The compressive test results for geogrid reinforcement for different days of during and varying lime content are tabulated in Table 4.4.

Rectangular mud brick (200mm x 100mm x 100mm) 10%, 12%, 14%, 16%limeand Reinforced geogrid for curing period of 3, 5, 7 and 14 days.

From the Fig 4.4 it is observed that;

i. The compressive strength of the geogrid reinforcement rectangular mud brick for 10 percent lime content and 3, 7 and 14 days curing period is 5.3, 8.6, 10.5 and 8.8kg/cm^2 whereas for 12, 14 and 16 percent lime is (i) 7.2, 9.8, 11.5 and 10.8kg/cm^2 (ii) 9.9, 13.9, 16.5 and 15.8 kg/cm^2 respectively.

ii. The strength of rectangular mud brick is continuously increasing with curing period for 10, 12, 14 and 16 percent addition of lime content.

iii. For the 14 percent lime content, the maximum compressive strength of the mud brick is observed

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as 10.5kg/cm2, 11.5kg/cm2 and 16.5kg/cm2 for 3, 7 and 14 days curing period. The optimum lime content for the mud brick is 14 percent.

iv. The rate of increase in the gain of strength is greater between 10 to 12 percent of lime and the rate is decreasing with increase in lime content.

v. The optimum lime content for the mud brick is 14 percent. Similar results were reported by Kabiraj et.al (2012), Asish et.al (2102).

4.5 COMPRESSIVE STRENGTH OF CIRCULAR MUD BRICK (100mm diameter and 200mm depth) WITH GEOGRID REINFORCEMENT

Compressive strength of geogrid reinforced in circular mud brick of (100mm diameter and 200mm depth) for 10, 12, 14 and 16% lime content and 3, 5, 7 and 14 days of curing period.

From the Fig 4.5 it is observed that;

i. The reinforcement geogrid in circular mud brick for10 percent lime content and 3, 5, 7 and 14 days curing period, the compressive strength values are 2.03, 3.82, 2.95 and 2.80kg/cm^2 whereas for 12, 14 and 16 percent lime is (i) 2.54, 4.07, 3.05 and 3.05kg/cm^2 (ii) 3.31, 4.33, 3.82 and 3.82 kg/cm^2 (iii) 4.07, 4.84, 4.07 and 4.33 kg/cm^2 respectively.

ii. The reinforced circular mud bricks strength is continuously increasing with curing period for 10, 12, 14 and 16 percent addition of lime content.

iii. The optimum lime content for the mud brick is 12 percent, from the graph 12 percent lime content is having maximum compressive strength of the mud bricks and it is observed as 3.82kg/cm2, 4.07kg/cm2, 4.33 kg/cm2 and 16.5kg/cm2 for 3, 5, 7 and 14 days curing period.

iv. Increasing the rate of gain strength is greater between 10 to 12 percent of lime and the rate is decreasing with increase in lime content.

v. The12 percent lime content is optimum for the circular mud bricks.

4.5 COMPRESSIVE STRENGTH OF CIRCULAR MUD BRICK (150mm diameter and 100mm depth) WITH GEOGRID REINFORCEMENT

Compressive strength of reinforced geogrid in circular mud brick of (150mm diameter and 100mm depth) for 10, 12, 14 and 16% lime content and 3, 5, 7 and 14 days of curing period.

From the Fig 4.6 it is observed that;

i. The compressive strength of the geogrid reinforcement circular mud brick for 10 percent lime content and 3, 5, 7 and 14 days curing period is 0.905, 1.24, 1.18 and 1.09kg/cm^2 whereas for 12, 14 and 16 percent lime is (i) 1.10, 1.35, 1.28 and 1.20kg/cm^2 (ii) 1.20, 1.45, 1.36 and 1.30 kg/cm^2 (iii) 1.35, 1.58, 1.47 and 1.40 kg/cm^2 respectively.

ii. The strength of rectangular mud brick is continuously increasing with curing period for 10, 12, 14 and 16 percent addition of lime content.

iii. The 12 percent lime content, maximum compressive strength of the mud brick is observed as 1.24kg/cm2, 1.35kg/cm2, 1.45 kg/cm2 and 1.58kg/cm2 for 3, 5, 7 and 14 days curing period. The optimum lime content for the mud brick is 12 percent.

iv. The rate of increase in the gain of strength is greater between 10 to 12 percent of lime and the rate is decreasing with increase in lime content.

v. The optimum lime content for the mud brick is 12 percent.

V. CONCLUSIONS

5.1 CONCLUSION

Reinforced and unreinforced geogrid in circular (100mm diameter and 200mm depth; 150mmdiameter and 100mm depth) and rectangular (200mm x 100mm x 100mm) mud bricks results are presented in chapter 4.Based on the results, following conclusions were drawn.

i. 14% lime with geogrid reinforcement mud brick is having optimum value of compressive strength comparing to 10, 12, 16 percent lime content with reinforcement geogrid mud brick.

ii. For 10, 12, 14 and 16 percent lime with geogrid of circular mud brick (100mm diameter and 200mm depth) 12% lime with reinforced geogrid is optimum.

iii. 12% lime with geogrid is optimum for circular mud brick (150mm diameter and 100mm depth).

iv. Comparison of reinforced mud brick and normal brick 14% lime content with reinforcement geogrid is maximum.

5.2 SCOPE FOR FURTHER INVESTIGATION

i. The compressive strength test used in this study can be tried on black cotton soil to improve their strength properties and the same can be compared with non-expansive soil, red soil.

ii. By using other stabilizing agents along with geogrid, the laboratory tests can be carried in the same way.

iii. Soil specimen's blocks were prepared in this study, further it can be tried by constructing square and hexagonal blocks for compressive strength test.

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