Scientific Journal of Impact Factor (SJIF): 5.71

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 5, Issue 09, September -2018

STABILIZATION OF SOIL USING CEMENT AND BALE STRAW

Asad Khan[1], Muhammad Adil[1], Afnan Ahmad[1], Raza Hussain[1], Haider Zaman[2]

[1]*University of Engineering and Technology, Peshawar, Pakistan*
[2]*Imperial College of Business Studies, Lahore, Pakistan*

Abstract -- *In developing countries, raw earth used as a construction material is the most cost effective, easily handled and abundantly available ingredient for housing construction. Mud construction have a great affinity for water but it is badly affected when intercourse with water. In order to make the earthen buildings water resistant and durable, different stabilizers such as cement, lime, fly ash etc. are widely used. This research aimed at finding out the 28 days compressive strength of locally available soil stabilizer with cement and reinforced with bale straw in different percentage. For this purpose soil sample (taken from Zangali, Khyber Pakhtoon Khwa) is stabilized with 10% cement by dry weight of soil and reinforced with bale straw. Different samples were tested varying bale straw percentage from 1% to 4% by dry weight of soil keeping the cement content up to 10% in all samples except the controlled samples. Tests were conducted on these samples revealing a decreased in compressive strength using 10% stabilizer and 1% straw bale while an increase in compressive strength have been observed when more straw bale were added to the soil samples.*

Key Words: *Ingredient, Water resistant, Stabilizers, Compressive Strength.*

Introduction and background

Among other necessities, proper shelter for living is one of the important need of human beings. Now a days, most of the developing countries are suffering from providing sufficient and affordable housing (Satprem, n.d.). In order to provide affordable low cost housing, we must rely on the locally available materials such as raw earth.

Since mud construction is transformed by modern construction materials like concrete, steel etc. which have high engineering properties as compared to raw earth but still it is important construction material in developing countries like Pakistan, India, Nepal etc. While rammed earth construction is broadly used in building constructions in Western Australia and the south-west area of America (Hall & Djerbib, 2004). Furthermore, raw earth is one of the oldest, economical and easily accessible construction material known for voluminous years. Also, earthen shelters is currently used by approximately 60% the world's population (Daniel Adom, 2008). Moreover, earthen buildings have the ability to absorb thermal and sound energy. Likewise, earthen construction construction is environmentally friendly as compared to other construction constituent in term of reduced CO_2 emission, reduced pollution, reduced embodied energy, humidity regulation and possible reuse of earthen materials (Mike Lawrence, 2008). A part from that soil as a construction material can reduce transportation cost and fasten building construction. But on the other hand, earthen construction is related with number of undesirable problems, spalling, worsening, and lower strength, and reduction in durable when intercourse with water and shrinkage cracking are some of the grave shortcomings of earthen constructions. In recent year, numbers of different techniques are employed to make the soil resilient to abrasion and disintegration such using fibers or bale straw used as reinforcement to minimize shrinkage cracks while additives such as cement, lime etc. have been used to overcome the durability issue (Ms. Karlene Fine, 2000).

Portland cement is commonly used additive in unfired clay to enhance their engineering properties (P.J.Walker, 1995). Ngowi in his research (Ngowi, 1997), discover that bricks with cement stabilizer are about 70% stronger than lime used as stabilizer in bricks because cement mortar is three times stronger than lime mortar. Atzine et al. estimate in his research (Cirillo, et al., 2008), 0.9Mpa compressive strength for samples without stabilizers, while a compressive strength of 5.1Mpa, an increase have been observed using stabilizers. In Papua New Guinea, a compressive strength from 0.39Mpa to 3.1Mpa have been observed when raw earth is mixed locally available stabilizers like finely ground natural lime, cement, volcanic ash and their various combinations and. Therefore, investigating and evaluating the strength of locally available soil with multiple stabilizers and additives in varying proportion is mandatory before using it as a construction material.

Scope of research

Since Pakistan is a tropical country, earthen construction maintain a suitable living environment insides the houses as it resist heat conduction. Therefore, the significance of this research work intend to find low cost alternative to the existing building material other than concrete.

Objectives of research

This research aimed at finding out the following prime objectives:

1. To evaluate the compressive strength of locally available soil, stabilized with Portland cement and reinforced with straw bales.

2. To investigate experimentally the effect of altering the cement and straw contents on the properties and compressive strength of soil used.
3. To find out the effective percentage of stabilizer and straw for the chosen soil sample.

Methodology

1. Soil for sampling

Locally available soil was tested. A deep excavated soil sample were collected from Zangali of Khyber Pakhtoon khwa province with an index properties came from laboratory tests are enlisted in table 1. The soil sample were properly dried in oven for 24 hours and proportions were made on the basis of dry samples. Sieve analysis were performed after drying to get different fractions of gravel, sand, silt and clay. Hydrometer analysis test was performed on the soil sample that were passed on sieve# 200. The amount of water added for sampling was based on the dry weight to shrinkage limit.

Table 1: Index properties of soil sample

Particle Size/Properties	Value
Clay	1.1%
Silt	78.8%
Sand	20.1%
Shrinkage Limit	18%
Classification	Sandy Loam Soil

2. Stabilizers selection

Different types of stabilizers are used in combination as well as alone. This study particularly focus on the performance of cement stabilizer with different proportion of bale straw in soil sample as a reinforcement. The fraction of cement and straw bale are enlisted in table 2.

Table 2: Stabilizers Proportion

S. No	SELECTED PROPORTION	DESCRIPTION
1	S	Soil only
2	SCS_1	Soil+10% Cement+1% Straw
3	SCS_2	Soil+10% Cement+2% Straw
4	SCS_3	Soil+10% Cement+3% Straw
5	SCS_4	Soil+10% Cement+4% Straw

3. Molds Size

In order to perform compression test, a standard 5cm×5cm×5cm (2 cubic inch) mold were prepared. The same size mold is also used for the compression test of concrete samples.

4. Sample preparation

To find out the amount of water for sampling, shrinkage limit of Zangali soil has been find out according to D4943-08. Based on the shrinkage limit soil the soil, water were specified for the soil sample. Stabilizers should be thoroughly mixed with soil before adding water otherwise their benefit will be lost. In this work, 10% by weight of dry soil cement is used as stabilizer while bale straw proportion vary from 1% to 4%. Three different molds were tested for each set of stabilizers and the final result is the average of the three individual data.

5. Grain size distribution

To get the grain size distribution of the soil sample used, sieve analysis and hydrometer analysis tests are used. The sieve analysis test is performed according to ASTM C136/C136-M14 while the hydrometer analysis test was carried out according to D7928-17.

The aim of sieve analysis is to get the percentage of different grain size in the soil sample used for the sampling. This test comprises of filtering the soil through a series of standard mesh sieve placed one above the other descending order i.e. the largest sieve is placed at the top as shown in figure 1 (Vinu Prakash, 2016). The end result gives a full quantitative proportion of grain size distribution within the soil sample. For the soil particle of size 0.075mm to 0.0002mm, it is not practical to design sieves, therefore hydrometer analysis is done for grain size analysis of fine grained soil.

Figure 1: Sieves arranged for Sieve analysis

6. Compression test

This test indicate the capacity of a soil sample to resist the axial demand. According to ASTM C109 specification, compression test should be conducted on a specimen of at least 50mm (2in) height and 1:1 ratio of its height to length. Specimen of lateral dimension and height of 50.8mm were prepared for the compression test. Universal testing machine (UTM) was used to get the displacement with respect to time data as shown in figure 2 and steel pad were placed above and below the specimen to ensure uniform loading over the entire area.


Figure 2: Cubic specimen placed in UTM for compression test

Results

1. Grain Size Distribution:

The end result of sieve analysis and hydrometer analysis is shown in figure 3. The graph is formed by combining sieve analysis and hydrometer analysis results. Graph plotted on the left side of the red vertical line (showing silt) came from sieve analysis while to the right side, hydrometer analysis data were plotted. The results revealed that the soil sample consist of 20.1% of sand while 79.9% of silt and clay were found. Moreover, no gravel exist in the soil samples.

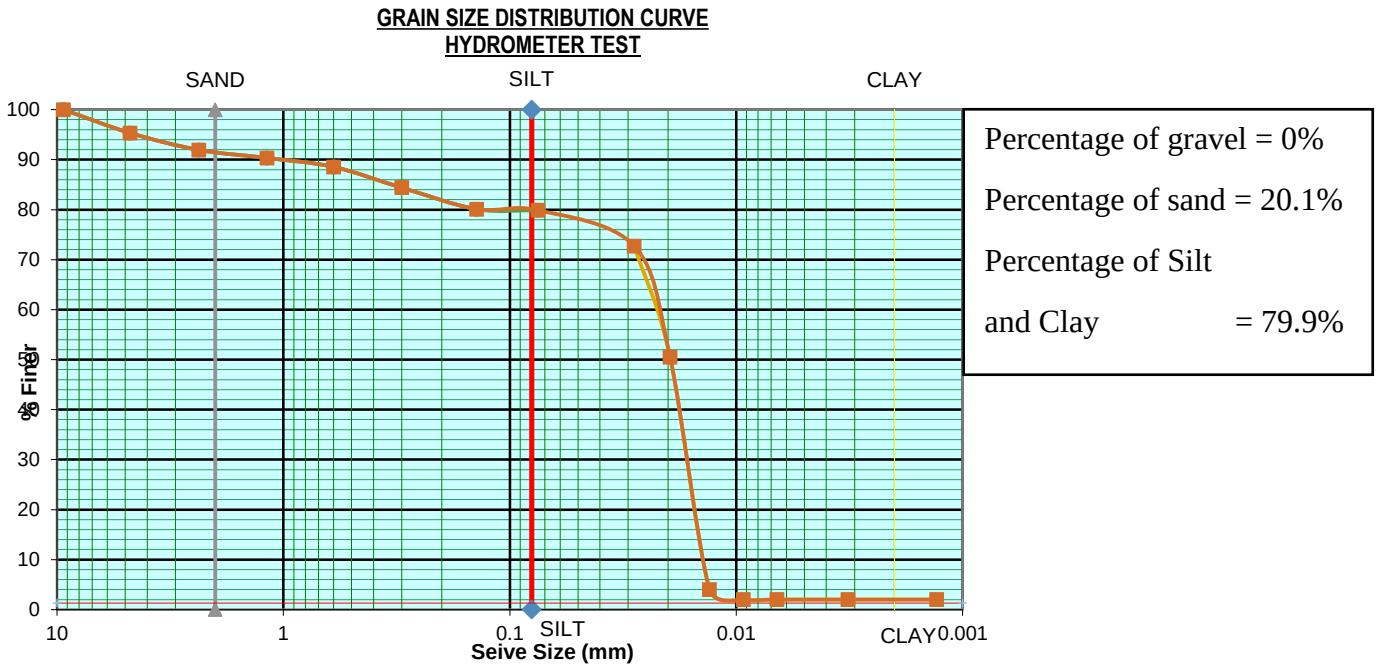

Figure 3: Sieve analysis and Hydrometer analysis result

The results obtained from the above graph is tabulated below:

Table 3: Particle size distribution

Particle Size Distribution	Percentages (%)
Gravel	0
Sand	20.1
Silt/Clay	79.9

2. Compression Test:

The compression test result shows that controlled samples (only soil) have yielded the highest strength then the rest of the samples and about double the strength gain by SCS_1 (10% cement and 1% straw). Increase in compression strength have been found from SCS_1 to SCS_3 but decreased after 10% cement and 3% straw. The lowest strength have yielded by 10% and 4% straw. The results of compression test are shown in table 3. Specimens after compression tests are shown in figure 4 and figure5.

Table 4: Average samples compressive strength

S.NO	Selected Proportion	Compressive Strength (Psi)
1	S	457.33
2	SCS_1	267.23
3	SCS_2	275.50
4	SCS_3	278.25
5	SCS_4	225.91

Figure 4 and 5: Specimens after compression tests

The results of our research correspond to most of the research work (I. Alam, 2015) . The compressive strength results of different proportion are compared in figure 6 and figure 7.

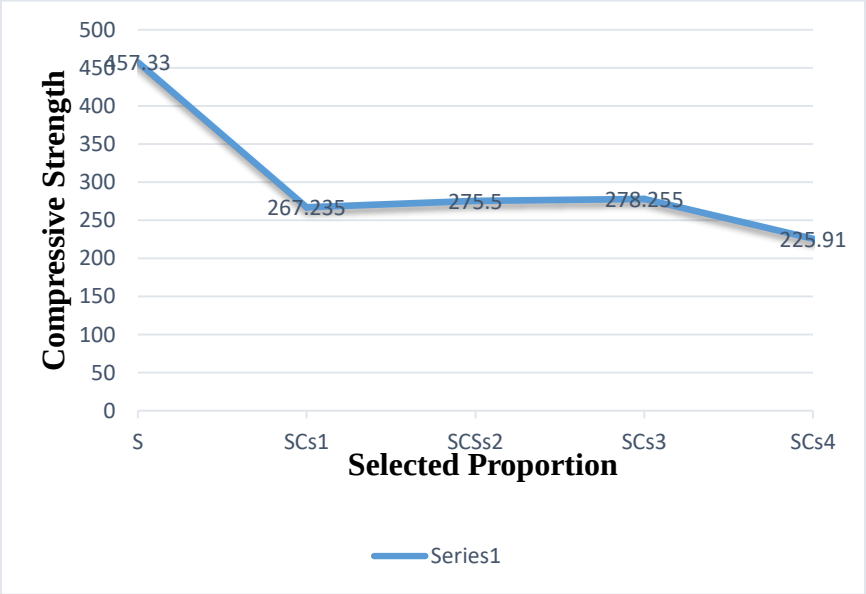

Figure 6: Comparing compressive strength

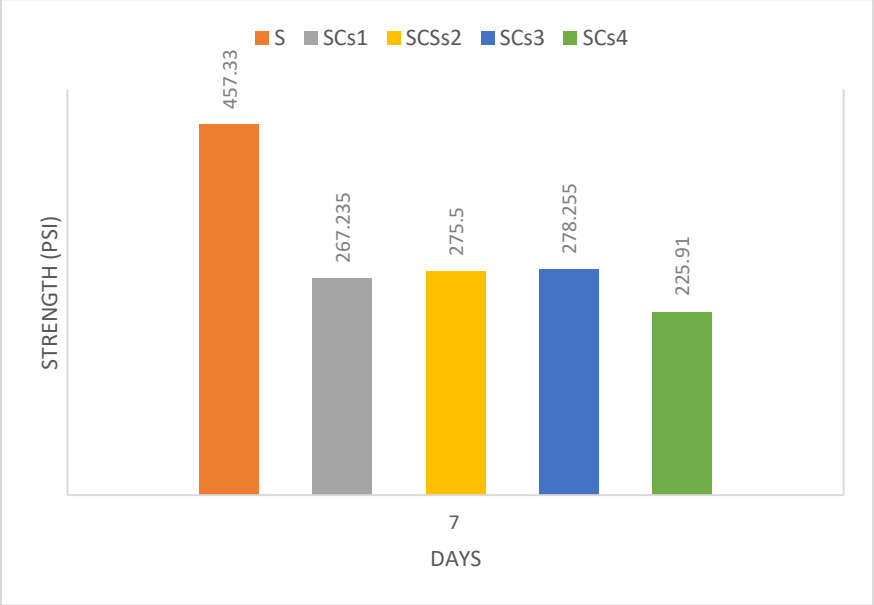

Figure 7: Comparing compressive strength

Conclusions

Pure soil without stabilizers show more strength as compared to stabilized soil because the clay particles is replaced by cement content which cannot produce any bondage with the clay particles. But due to lack of certain basic properties such as water affinity which make it non-durable, it is recommended by researcher to not use them as a construction material in pure form (Vinu Prakash, 2016) (I. Alam, 2015) (Habib, 2014) (Humphrey Danso, 2015). Since stabilized soil are durable therefore this research aimed at finding the right proportion of stabilizers and straw bales work as reinforcement. It concluded that compressive strength decreased by 41.56% using 10% cement and 1% straw. While adding 2% straw bale to a 10% stabilized soil increase its compressive strength by 1.56%. Similarly increase in compressive strength have been experienced by adding 3% straw to a 10% stabilized soil. Adding 4% straw to a 10% stabilized soil, an abrupt declination in compressive strength of about 11.40% have been found. Therefore, it could be stated on the basis of result conducted in this particular study that resulted structure will show better performance when soil used in the construction is stabilized with 10% cement and reinforced with 3% straw.

References

Cirillo, A., Giorgio, P. & Ulrico, S., 2008. Surface wear resistance of chemically or thermally stabilized earth-based materials. *Materials and structures*, 41(4), pp. 751-758.

Daniel Adom, B. A. B. A. P. B. M. F. J. F. J. F. .. B. M., 2008. Low-cost sustainable housing, materials and building technology in developing countries.. *UN Habitat.*

Habib, A., 2014. Adobe Bricks Stabilized With Cement and Natural Rubber Latex. *International Journal of Emerging Science and Engineering (IJESE),* February, 2(4), pp. 36-38.

Hall, M. & Djerbib, Y., 2004. Rammed earth sample production: context, recommendations and consistency. May, 18(4), pp. 281-286.

Humphrey Danso, B. M. M. A. a. C. M., 2015. Performance characteristics of enhanced soil blocks: a quantitative review. *BUILDING RESEARCH & INFORMATION,* 43(2), pp. 253-262.

I. Alam, A. N. A. S., 2015. Economical stabilization of clay for earth buildings construction in rainy and flood prone areas. *ELSEVIER,* Volume 77, pp. 154-159.

Mike Lawrence, A. H. a. P. W., 2008. *Mortars for thin unfired clay masonry walls.* s.l., s.n.

Ms. Karlene Fine, M. C. P., 2000. *USE OF BOTTOM ASH AND FLY ASH IN,* North Dakota: Energy & Environmental Research Center.

Ngowi, A. B., 1997. Improving the traditional earth construction: a case study of Botswana. *Construction and Building Materials,* 11(1), pp. 1-7.

P.J.Walker, 1995. Strength, durability and shrinkage characteristics of cement stabilised soil blocks. *Cement and Concrete Composites,* 17(4), pp. 301-310.

Satprem, M., n.d. Compressed stabilized earth block sand stabilized earth techniques. *Research and development by the Auroville earth institute (AVEI).*

Vinu Prakash, A. R. ,. A. S. B. M. S. V. R., 2016. STUDIES ON STABILIZED MUD BLOCK AS A CONSTRUCTION MATERIAL. *International Journal of Innovative Research in Advanced Engineering (IJIRAE),* 03(01), pp. 19-24.

