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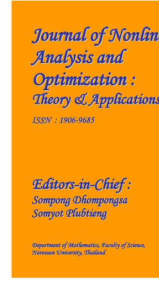

EVALUTION OF STABILIZED EARTH BLOCK IN CONSTRUCTION

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ABSTRACT

Earth as a building material has already known for centuries started with plain mud and strawutilized sun dried producing brick adobe with low strength and durability until its evolved to become fired clay brick with mass rapid production in the kiln[1,2,3]. In the growing concern ofawareness regarding sustainable building material and environmental issue, Stabilized EarthBrick (SEB) give the view of energy efficient, cost reduction and environmental friendly building materials, overall contribution on the sustainable development. It turned out that SEB properties can be very easy bear comparison with other materials such as concrete block ornormal fired brick.Stabilized earth is an alternative building material that is significantly cheaper than usingconventional brick and concreteVarious compositions of lime and cement were used with different soil Types as additives inearth block molding and then were pressed with a pressed to provide Compaction and a definiteshape in solid form. Drying and curing was done before the blocks were tested for strength[4,5,6].Although the strength yielded by the blocks was not comparable to that of fired clay brick, it produced rewarding results regarding the reduction of GHG emission, energy consumption andoverall cost of production.

INTRODUCTION

Fire-burnt clay brick has been the main building material of construction industry in India forquite a long time due to the unavailability of stone aggregate or other alternative buildingmaterials at comparable cost in the country[7,8,9].This rapid proliferation of Fixed Chimney Kiln (FCK) in North Cluster has resulted in anelevated concentration of CO2,SO2, and fine particulate matter in the air of North Indiaespecially during dry season.SEB technology is an alternative to the conventional burnt brick technology and is relatively lessexpensive, uses local resources and consumes less energy with reduced carbon emission at the production stage. However, SEB needs systematic approach for ensuring the consistency of themethod applied to manufacture such building block. The percentage of sand and clay in soil is animportant factor that governs the selection of the type and amount required of the stabilizer for particular type of SEB production Stabilization of soil by lime is achieved mainly through cation exchange, flocculation andagglomeration, and reaction. Cation exchange, flocculation and agglomeration reactions takes place rapidly and bring immediate changes in soil properties such as strength, plasticity andworkability, whereas,reactions are time dependent[10,11,12]. The cation exchange starts to take place between the monovalent metallic ions associated with the surface of the clay particles (Na+, K+etc.) and that are surrounded by a diffuse hydrous double layer (H+), which is modified by theion exchange of calcium, because of which there is alteration in the density of the electricalcharge around the clay particles, that leads to the flocculation and agglomeration of soil particles .[13,14]This process mainly takes place within the lime fixation point and is mainly responsible for themodification of the engineering properties of soils treated with lime. In addition to cationexchange,reaction occurs between the silica and some alumina of the lattices of the clayminerals.

The effectiveness of the treatment depends on the quality and quantity of lime as well as the chemical and mineralogical composition of the soil.[15,16] The strength developed is obviously influenced by the quantity of cementitious gel produced and consequently by the amount of lime consumed. SEB that will reduce emission and energy requirement and thus replace part of the traditional fired bricks which are mainly used as non-load bearing purpose in household construction sector in India.

Literature reviews

Stabilized Earth Blocks (SEB) is considered to be an important step in the manufacture of SEBs, and is aimed at improving the performance of a soil as a construction material. Amongst the variety of soil stabilizers used, cement has been the most popular stabilizer in the manufacture of SEBs. However, compared to cement, utilization of lime as a stabilizer in the preparation of SEBs has not found popularity[17,18,19]. Stabilized earth blocks (also called adobe earth blocks) are made from soil mixed with stabilizing material such as Portland cement, formed into blocks and dried in the sunlight. Researchers have showed that stabilized earth bricks demonstrate many advantages compared to conventional burnt bricks. This study focuses on the comparative performances of earth blocks using different stabilizer.

Dr. Bell and Coulthard, 1990; Little, 1995; Mallela et al., 2004; Amu et al., 2011; Herrier et al., 2012 reported Lime has been used in stabilizing clayey soils, and has been found to impart long-term strength gain..

Herrier et al. (2012)as reported that An outstanding testimonial of the durability of the lime-stabilized soils is the Friant-Kern irrigation canal in California[20,21]. In the recent past, attempts to independently utilize lime instead of cement in the preparation of SEBs and compare their properties with those prepared with cement has been reported in the literature **Raheem et al. (2010)** have reported the 28 days wet compressive strength of compressed stabilized interlocking earth blocks prepared with lime and cement alone as stabilizers added in varying quantities from 5% to 25%, with an increment of 5%. [22] For maximum amount of stabilizer content namely 25%, the strength gain of the blocks is found to be 3.2 MPa and 1.2 MPa for blocks prepared with cement and lime respectively

Guettala et al., 2002; Raheem et al., 2010; Miqueleiz et al., 2012). Guettala et al. (2002) have tried to use various quantities of lime namely, 5%, 8% and 12% to improve the durability of the blocks. [23,24] The evaluated dry strength of blocks reported by them is around 9.4, 14.2 and 16.2MPa respectively for 5%, 8% and 12% of lime. Similarly, when tested under humid state, the strength of the blocks was found to be 4.4, 8.2 and 9.8 MPa respectively for 5%, 8% and 12%lime. From their study, it is clear that after an optimum value of lime content, any further increase in lime will not be so beneficial in the strength gain of the blocks

Guettala (2002) describes the durability of lime stabilized earth blocks. They conducted urability test and freeze-thaw test on earth blocks using clay soil and sand and lime asstabilizer. They concluded that by increasing the compacting stress from 5 to 20 MPa, it will improve the compressive strength up to 70%[25,26]. They also found that water absorption and weight loss decrease with increasing of compacting stress and lime content.

Miqueleiz (2012) have reported the advantage of using lime towards the development ofunfired clay bricks. From the results of tests conducted on cylindrical specimens of 65 mdiameter and 30 mm height prepared with use of 18% lime, they have found that, at the end of 90days of ageing the maximum compressive strength of the cylindrical specimens wasnearly 13MPa, and the strength of cylindrical specimens prepared with 18% of cement were around18mpa . However, attempts to utilize lime in combination with cement as a stabilizer to achieve

desirable properties of SEBs have not been studied and reported. As lime is known to impart strength in the long term, its utilization in some proportion as a replacement to cement may be beneficial[27,28,29]. This paper reports the attempts made to understand the role of lime in combination with cement as a stabilizer in improving the long-term properties of SEBs, optimize the use of stabilizers and maximize the strength of the blocks. Any effort tooptimize the quantity of stabilizers used in combination would help in reducing the cost of the blocks.[30] This work is thus aimed at contributing towards improvising the existing technology of manufacture of unfired earth blocks. This would be a good contribution towards sustainable development

Material USEDCement:

In building, a cement is a binder—a chemical that binds other materials together by setting, hardening, and adhering to them. Cement is primarily used to bond materials, like as sand, together. It is rarely used alone. Masonry mortar is made from cement combined with fine aggregate, and concrete is made from cement combined with sand and gravel. When regular Portland cement of grade 53 was utilized, IS 269-1969 requirements were met.

Because of its excellent compressive strength, OPC 53 grade cement is the recommended variety. The phrase "53 Grade" refers to the cement's minimum compressive strength, which it reaches after 28 days of curing, of 53 MPa.

Composition and Properties of OPC 53 Grade :

Materials containing silica, alumina, iron oxide, calcareous and argillaceous particles make up the majority of OPC 53 grade cement[31,32]. After the components are heated to high temperatures, a nodule known as clinker is produced, which is subsequently crushed into a fine powder. We call this fine powder cement. One of the most popular types of cement is Portland cement. Ordinary Portland Cement is created by grinding Portland clinker with gypsum. The particular ratio and combination of these ingredients affect the cement's characteristics.

According to a procedure carried out using Pycnometer equipment that complies with IS12269 - 1987, the specific gravity of cement is 3.15 .

LIME:

Lime is an inorganic material composed primarily of calcium oxides and hydroxides, usually calcium oxide and/or calcium hydroxide. It is also the name for calcium oxide which occurs as a product of coal-seam fires and in altered limestone xenoliths in volcanic ejecta.

Description of lime utilized in this project:

Byadding lime to the soil for stabilisation, four basic reactions are believed tooccur:cationexchange, flocculation and agglomeration, carbonation, and pozzolanic reactions. The pozzolanic reaction is believed to be the most important and it occurs between lime and certainclay minerals to form a variety of cementitious compounds which bind the soil particles together.Lime can also reduce the degree to which the clay absorbs water, and so can make the soil lesssensitive to changes in moisture content and improve its workability. Lime is a suitable stabiliserfor clay soils[33,34]. Lime is more widely available than Portland cement in Sudan and is producedlocally in traditional kilns. However, some improvements still need to be made in its productionand processing.The advantages that lime has over Portland cement are that it requires less fuel to manufactureand requires relatively simple equipment to make. It is therefore more suitable for village scale production and use.

Water:

This project uses portable water. The term "water-cement ratio" refers to the weight-based ratio of water to cement. This ratio determines the concrete's strength and quality.IS 456-2000 Table 5 shows that the maximum water-cement ratio for designing M50 grade concrete is 0.45.For this project, the chosen w/c ratio is 0.44.

CALCULATIONS

Specific gravity = (W2-W1)/ (W2-W1)-(W3-W4)

Bottle No.	1	2	3
Mass of empty bottle W1 (gm)	31.10	31.10	31.10
Mass of bottle + dry soil W2{gm}	41.34	45.48	43.49
Mass of bottle + dry soil + water W3{gm}	88.16	91.04	89.02
Mass of bottle + water W4{gm}	81.92	82.32	81.39
Specific Gravity	2.61	2.62	2.61
Avg. Specific Gravity	**2.61**		

Sample: Narava Bank
Table1 , Specific Gravity determination

Sample: mechanical pit

Table 2 , Specific Gravity determination

Bottle No.	1	2	3
Mass of empty bottle W1 (gm)	31.28	31.28	31.28
Mass of bottle + dry soil W2{gm}	40.34	40.42	40.39
Mass of bottle + dry soil + water W3{gm}	87.65	87.67	87.60
Mass of bottle + water W4{gm}	82.10	82.10	82.01
Specific Gravity	2.60	2.62	2.61
Avg. Specific Gravity	**2.61**		

IP= WL – WP

Atterberg's limit

	Liquid Limit				Plastic Limit	
Container No.	18	58	21	8	114	2
Mass of empty container	16.58	15.91	15.28	16.35	16.19	45.42
Mass of container + wet soil	33.64	33.19	31.56	30.80	19.14	49.77
Mass of container + dry soil	28.33	29.74	26.64	26.59	18.59	48.93
Mass of dry soil	11.75	12.03	11.36	10.24	2.4	3.51
Mass of water	5.31	5.25	4.92	4.21	0.55	0.84
Water content (%)	45.19	43.64	43.309	41.11	22.91	23.93
No. of blows	14	21	29	35		
	LL=43.1%				PL=23.42%	
	PI=19.82				I f=8.8	
	I_t=2.66				P_{IA}=16.86	
	P_{iu}=31.59					
	Types of soil**- Intermediate clay(CI)**					

METHODOLOGY

The proposed methodology involves stages to full fill the objectives of the present research work.

A) Material Selection and Characterization:

Identify and characterize the raw materials, including soil types, stabilizers, aggregates, and any other additives[35,36].

Conduct tests to determine the properties of the materials, such as particle size distribution, plasticity index, organic content, and moisture content.

B) Mix Design:

Develop a mix design based on the desired properties of the SEBs, considering factors like strength, durability, and workability.

Determine the optimal proportions of soil, stabilizers, and water to achieve the desired properties.

C) Block Production:

Prepare the mixture according to the mix design, ensuring thorough mixing and homogeneity.

Form the mixture into blocks using appropriate molds or presses.

Implement curing methods such as air curing or moist curing to enhance strength development and durability.

D) Quality Control:

Establish quality control measures to monitor the production process and ensure consistency and compliance with specifications.

Conduct regular inspections and tests on the raw materials, mixtures, and finished blocks to detect any variations or defects[37,38,39].

E) Testing Procedures:

1 Specific gravity of soil, Determination of soil index properties (Atterberg'sLimits), Liquid limit by Casagrande's apparatus, Plastic limit, Particle size distribution by wet sieve &hydrometer analysis, Determination of the maximum dry density (MDD) and the corresponding optimum moisture content (OMC) of the soil by Proctor compaction test, Unconfined compressive test.[40]

F) Structural Performance Evaluation:

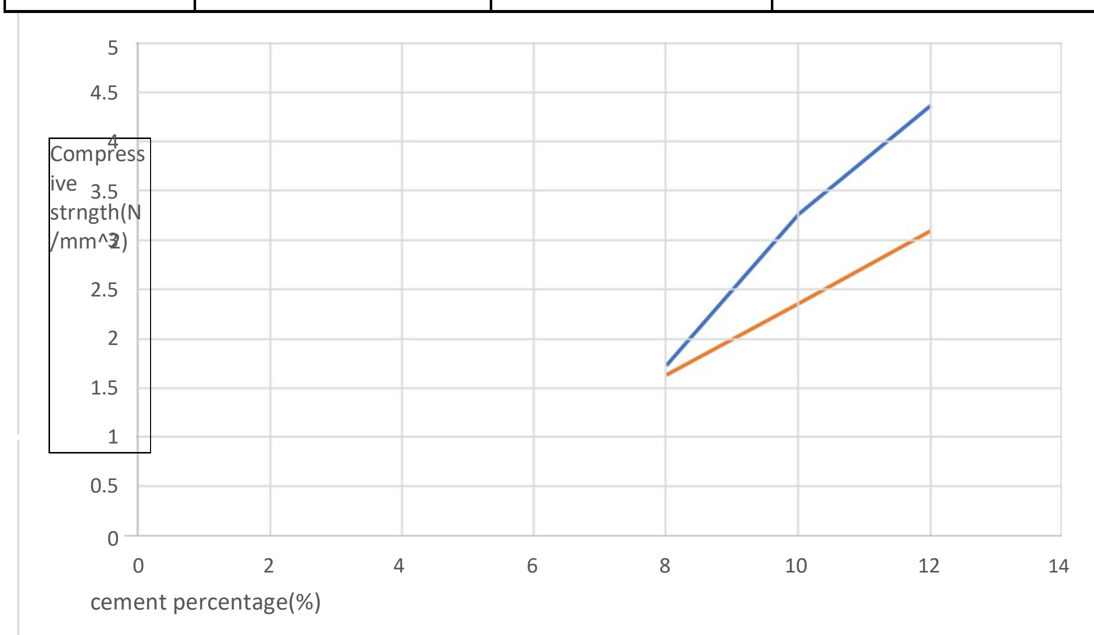
Conduct structural tests, including load tests and seismic performance tests, to assess the suitability of SEBs for different construction applications.

Analyze the blocks' behavior under various loading conditions and compare the results with applicable design standards and criteria.

Test Results :

Compressive strength due to cement stabilize

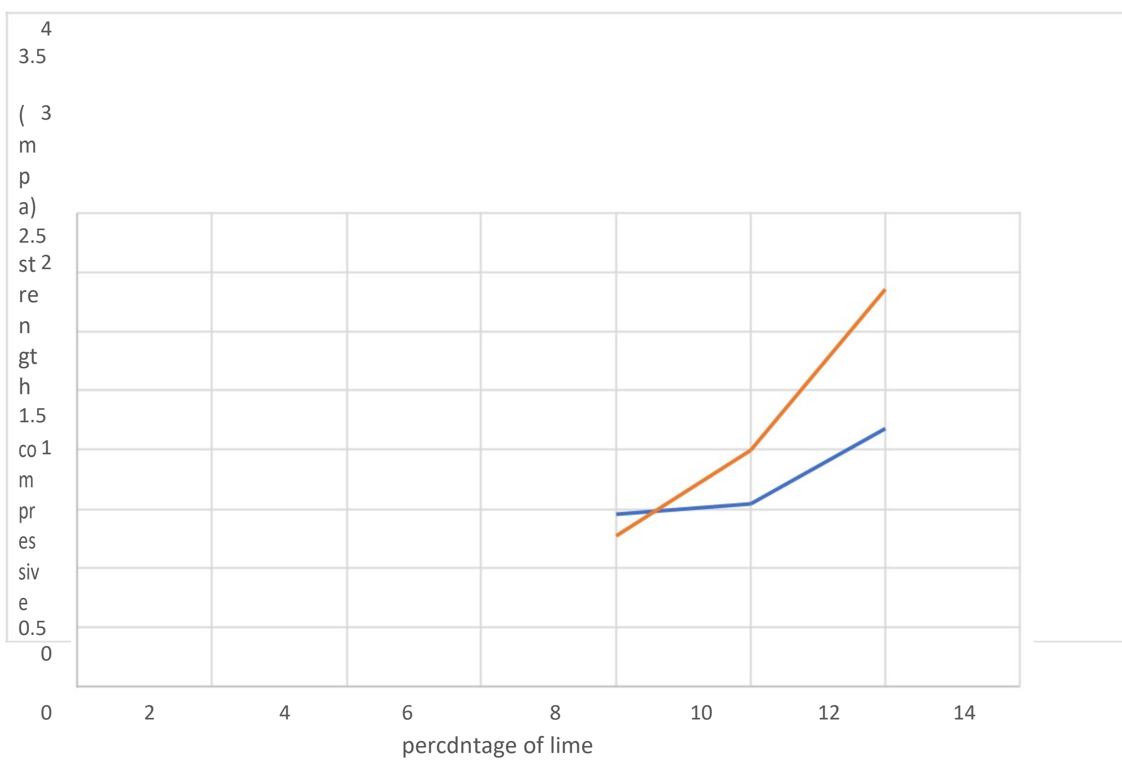
Soil sample	Percentage (%)of cement	Load(KN)	Compressive strength(Mpa)
Mechanical Pit	08	95	1.7241
	10	180	3.2666
	12	240	4.3555
Narava bank	08	90	1.6333
	10	130	2.3555
	12	170	3.0855



Cement percentage vs Compressive strength sample 1

sample 2 **compressive strength due lime stabilizer**

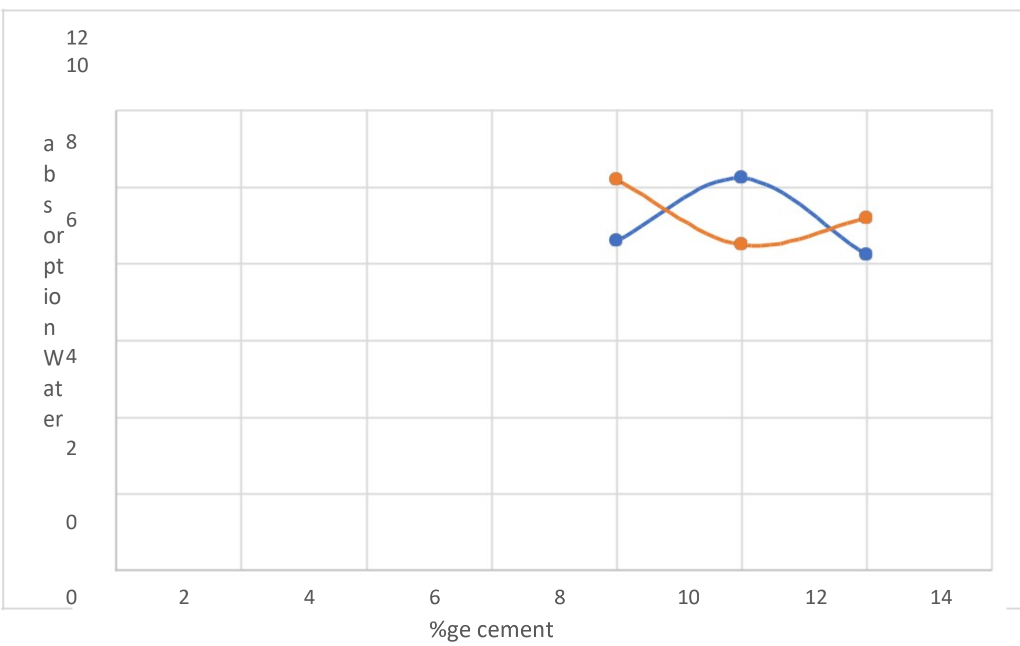
Soil sample	Percentage (%)of lime	Load(KN)	Compressive strength(Mpa)
Mechanical Pit	08	80	1.451
	10	85	1.542
	12	120	2.177
Narava bank	08	70	1.270
	10	110	1.995
	12	185	3.357



----------- sample 1

----------- sample 2 **Water Absorption**

Soil sample	Percentage (%)of cement	Dry weight of block(W1,gm)	Wet weight of block(W2,gm)	Water absorption(%)= {(W2-W1)/W1}*100
Mechanical Pit	08	10.4	11.3	8.6
	10	10.54	11.62	10.24
	12	10.62	11.50	8.23
Narava bank	08	9.45	10.42	10.2
	10	9.57	10.38	8.49
	12	9.38	10.25	9.2



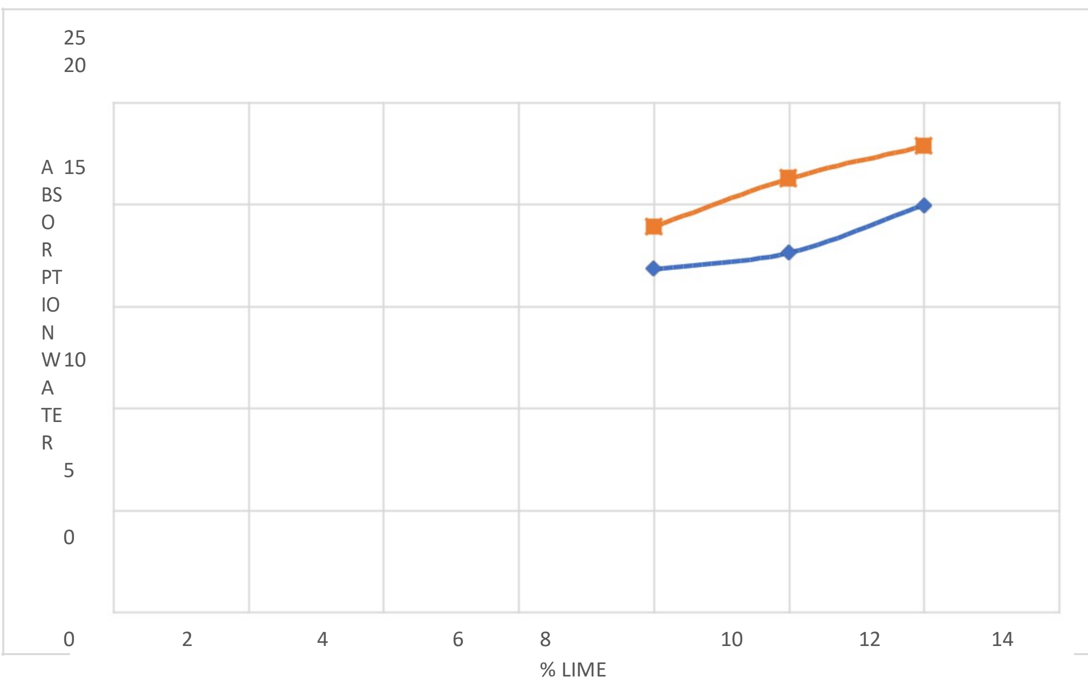
Water absoption vs percentage of cement

------------- sample 1

----------- sample 2 **Stabilizer line**

Soil sample	Percentage (%)of lime	Dry weight of block(W1,gm)	Wet weight of block(W2,gm)	Water absorption(%)= {(W2-W1)/W1}*100
Mechanical Pit	08	7.12	8.32	16.85
	10	7.53	8.86	17.66
	12	6.5	7.8	20
Narava bank	08	6.23	7.41	18.94
	10	6.43	7.8	21.3
	12	6.2	7.62	22.9

Table 12 Water absorption



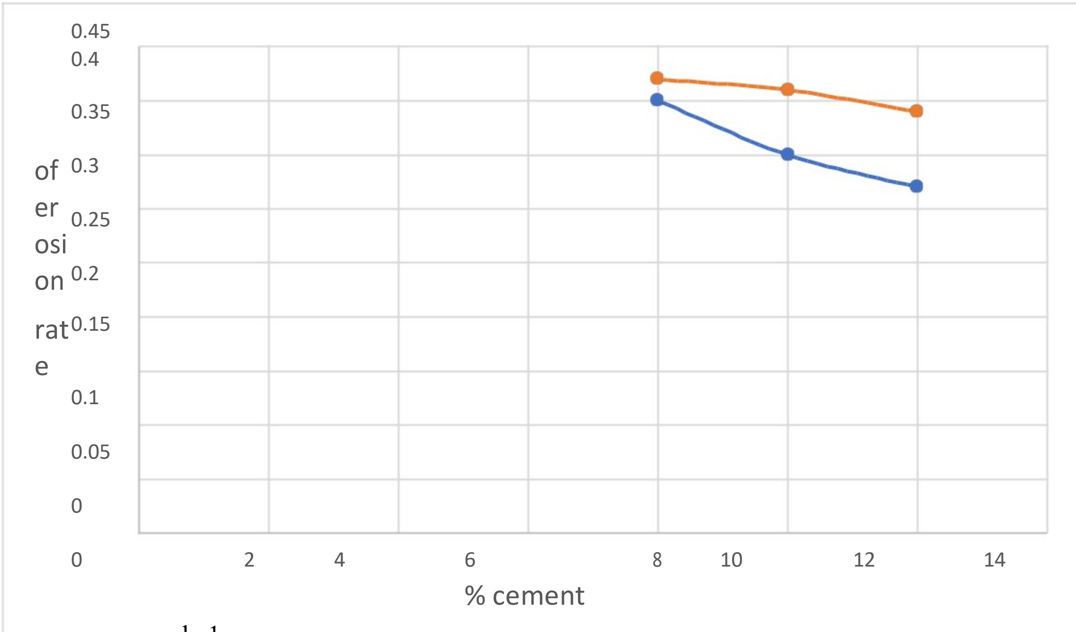
Water absorption vs %ge lime

------------- sample 1

----------- sample

Cement stabiliser

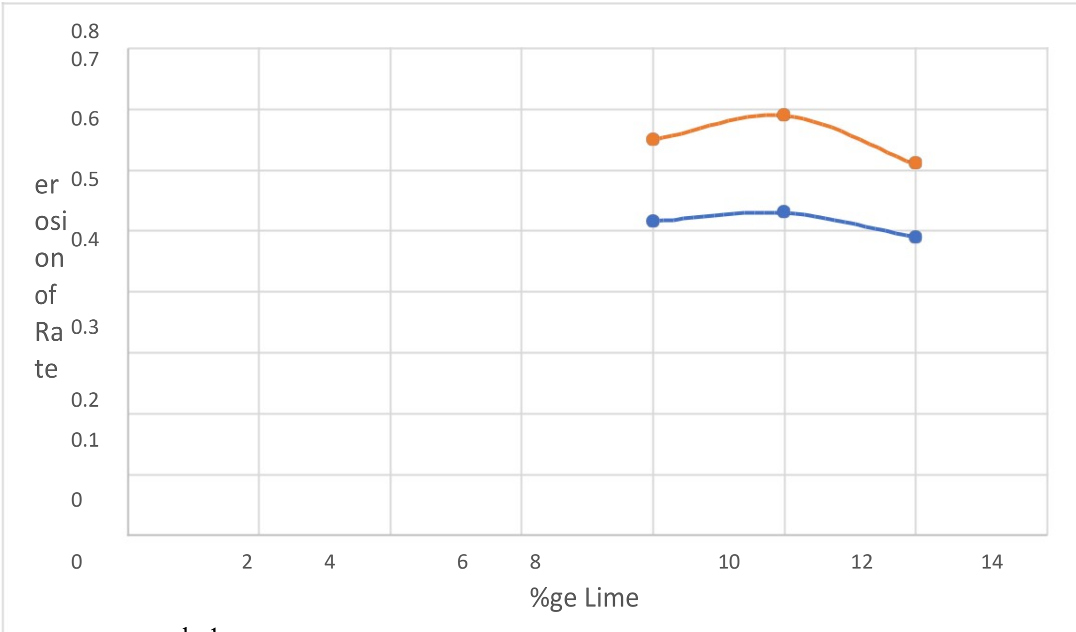
Soil sample	Percentage(%) cement	Timer(minutes)	Depth of erosion(mm)	Rate of erosion(mm/min)
Mechanical pit	08	15	16	0.40
		30	17.5	
		45	21	
		60	24	
	10	15	14	0.35
		30	15.5	
		45	18	
		60	21.5	
	12	15	13	0.32
		30	14.5	
		45	17	
		60	19.5	
Narava Bank	08	15	17	0.42
		30	19	
		45	22	
		60	26	
	`10	15	18.5	0.41
		30	20	
		45	22	
		60	25	
	12	15	19	0.39
		30	20.5	
		45	22	
		60	23.5	



------------- sample 1

----------- sample 2 **erosion due to stabilizer lime**

Soil sample	Percentage(%) Lime	Timer(minutes)	Depth of erosion(mm)	Rate of erosion(mm/min)
Mechanical pit	08	15	21	0.516
		30	24	
		45	28	
		60	31	
	10	15	22	0.53
		30	24	
		45	27	
		60	32	
	12	15	19	0.49
		30	22	
		45	24.5	
		60	29.5	
NARAVA Bank	08	15	27	0.65
		30	30.5	
		45	33	
		60	39.5	
	`10	15	29	0.69
		30	32	
		45	35.5	
		60	41.5	
	12	15	28	0.61
		30	31.5	
		45	34	
		60	37	



------------- sample 1

------------- sample 2 **Weathering rate of block without stabiliser** = 1.24 mm/min

CONCLUSIONS

Soil has been, and continues to be, the most widely used building material throughout mostdeveloping countries. It is cheap, available in abundance, simple to form into building elements.It provides adequate shelter against hot and cold weather conditions due to its high thermalcapacity and insulating properties. Despite its long proven applications, earth is sometimeslooked upon with scepticism and mistrust, and is often not recognised by authorities as anacceptable, durable building material. Its main technical disadvantage is the lack of resistance toextreme weather conditions, in particular rain. In many developing countries building standards,which often rule out applications of soil as an acceptable building material, have beenformulated[14]. Earth is mostly used for buildings that are built without formal authorisation, such asrural housing or squatter settlements around urban centresThe previous sections have demonstrated that in general, the utilization of compressed stabilized earth buildings blocks in building construction can provide a great number of advantages,especially to the Low GDP areas and developing countries in general. The development and promotion of good quality building blocks can also improve the standard of living for low-income groups in developing countries. Soil blocks are the only building material that can be produced in-situ if the proper equipment and optimum amount of stabiliser is available. Forexample, housing authorities may organize for the transport of a block making machine andsupporting equipment to the building site and assist in training of the work-force[15]. Alternatively,the equipment can be owned by a contractor within the urban areas, and/or by co-operatives inrural areas operating on a self help basis.

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