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Adobe, Stabilizers, Black Cotton Soil, Local, Low Cost

Adobe Bricks Stabilized with Different Local Materials

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ABSTRACT

This study aimed to identify the stabilizers which could help increase the strength of adobe blocks made of black cotton soil. The objectives were to find out the different stabilizers which have already been explored and find out the suitable ones for making adobe blocks of black cotton soil. The adobe blocks cast out of black cotton soil and different local stabilizers were tested for compressive strength, as they are used for the construction of walls, where the important property is to withstand the compressive load. The conclusions of the study were that out of all the compositions tried the best block composition for making the blocks was black cotton soil 66% + Sand 25% + lime 8% + plastic fibers 1%, as they have compressive strength 1.17N/mm^2, they are good in aesthetics and also prevent the growth of fungus. Adobe blocks cost less than burnt bricks and further savings can be achieved if they are self-made.

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Introduction

Today the demand for building materials is increasing leading to the increased cost. The cheapest available material is soil. At most of the places in Maharashtra black soil is present abundantly. Tasgaon, located in the Sangli district is one of the areas. But black cotton soil is considered unfit for mud construction because of its property to undergo a volumetric change due to variation in moisture content. So, the intent of this study is to test the adobe blocks made of black cotton soil and locally available stabilizing materials. Such blocks could be used for low-cost housing, housing in rural areas, small-scale constructions, and temporary structures. All of the materials used for the study were from Tasgaon, Sangli, Maharashtra. All the materials used for block-making were cheap and easily available.

About Adobe

The word “Adobe” is used generally to describe different earth materials employed in building construction and the method in which they are used. *(Abdulhalim et el., 2020).*

Adobe blocks are generally understood as rectangular prisms small enough that they can quickly air dry individually without cracking. They can be subsequently assembled, with the application of adobe mud to bond the individual bricks into a structure. There is no standard size, with substantial variations over the years and in different regions.

From different research papers the conclusions were made that for mixing materials, dry mixing by weight is preferable. To improve the strength and binding of soil, addition of cement or lime is mandatory. Lime acts as a better binder than cement with black cotton soil. The black cotton soil which is dug from deeper areas has better compressive strength. Polypropylene fibers work as better binders than polythene fibers. Polypropylene waste of 40mm in length from cement bags is preferable.

Material and Methodology

The study was quantitative and pilots of different blocks were made on-site to find out the strength of the blocks. The results of this evaluation are presented as findings.

Material selection and collection

Black cotton soil: The black cotton soil is the main ingredient of the block. The soil was collected from a construction site where the soil was excavated to construct the foundation. The soil which was dug at a depth of about 1.5m was collected.

Sand: Sand, silt, clay, and gravel are the main components of soil. They are segregated based on the size of their particle. The clay has a grain size of less than 0.002mm. Black cotton soil is clayey soil i.e. it has more content of clay than other ingredients. The property of clayey soil is that it holds moisture and after its evaporation cracks are formed. To avoid this problem, sand was added. The waste sand fallen on the ground was brought from the construction site. The sand type used was sea sand.

Plastic sacks: To create adobe blocks, binder materials are very essential. Binder materials have thread-type properties. They bind the bricks together and allow them to shrink without cracking. Used cement bags were collected and brought from the construction site. The bags were shredded manually and the pieces were cut into the length between 40 to 50 mm each. One bag took about 5 mins to shred and weighed around 100g.

Sugarcane bagasse: Another locally available natural and biodegradable binder was sugarcane bagasse. In the summer season when the blocks were cast, sugarcane bagasse was available widely. So, it was collected from the local juice makers. Considering that it is a local crop, the sugarcane bagasse was the most preferable option to use.

Lime: Lime and cement act as binder materials in the block. To make the block more cost effective, lime was selected. Also, from the studies it was noted that lime works better as a binder with clayey soils and the sandy clays act better when cement is added as a binder. The Lime was bought from the market costing Rs.170 for a sack of 15kg.

Sawdust: Sawdust was used to lay down on the ground so that the blocks won't get deformed. The sawdust was brought from the local carpenter's workshop for free.

Mould: the mould was made from the MS channels as it was the cheapest process available. Also, MS is a durable material, requires less maintenance, and is easy to handle. The leftover pieces of MS were used for making the mould. The cost of MS mold making was lesser than wood or plywood mould. The size of the mould was 200 X 100 X 75 mm which was decided from the waste parts available in the shop.

Figure1 shows all the materials used for the block making.

Figure 1: *Materials selected for block making*

Figure 2: *Process of Block Making*

Ingredients	Ingredients by weight in %						
Composition No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Black cotton soil	66.5	66	65	66	65	66.5	66
sand	25	25	25	25	25	25	25
lime	8	8	8	8	8	8	8
straws	0	0	0	0.5	1	0.5	1
Plastic fibers	0.5	1	2	0.5	1	0	0

Table 1: *Composition of different blocks*

Process of Block Making

In our experiment, for making the blocks, firstly, all the ingredients were weighed and dry mixed in 7 different compositions. Then, after adding water, they were mixed by stamping method. Separate heaps of mixtures with 7 different proportions were created and left to rest for 6 days, where they were watered 3 times a day. This allowed soaking of all the ingredients and helped in softening and dissolving all lumps. The mixture became homogeneous and soft. From each of the mixtures, the blocks were cast manually with the mould described above. **Table 1** shows the information of percentage of ingredients by weight that were present in all 7 types of blocks.

The base was prepared by laying plastic sacks and sawdust on top of it. The blocks were kept in a shaded place protected from sun and rain. The blocks were cured for 28 days and kept for rest for 7 days. Then they were tested for compressive strength on the 35th day of casting. **Figure 2** shows the step-wise process of block-making followed on-site.

Results and Discussion

According to the Australian standards, minimum compressive strength required of adobe blocks is 1.15 N/mm^2. This threshold was crossed by blocks number 2, 5, and 7 having compositions as follows,

Block No 2 - Black Cotton Soil 66% + Sand 25% + Lime 8% + Plastic Fibers 1%

Block No 5 - Black Cotton Soil 65% + Sand 25% + Lime 8% + Plastic Fibers 1% + Straws 1%

Block No 7 - Black Cotton Soil 66% + Sand 25% + Lime 8% + Straws Fibers 1%

Though these blocks had fulfilled the code's requirement, their compressive strength was very close to the borderline. So, one can conclude that the compositions used are not suitable to make the adobe blocks from the particular black cotton soil. The minimum

Criteria **Block numbers**	Size (mm) (l X b X w)	Weight (gram)	Edges on a scale of 5, (1 - worst, 5 - best)	Cracks while drying on a scale of 5, (1 - maximum cracks, 5 - minimum cracks)
1. (Black Cotton Soil 66.5% + Sand 25% + Lime 8% + Plastic Fibers 0.5%)	195 X 95 X 65	1751	3	1
2. (Black Cotton Soil 66% + Sand 25% + Lime 8% + Plastic Fibers 1%)	195 X 95 X 65	1767	5	4
3. (Black Cotton Soil 65% + Sand 25% + Lime 8% + Plastic Fibers 2%)	195 X 95 X 65	1773	4	4
4. (Black Cotton Soil 66% + Sand 25% + Lime 8% + Plastic Fibers 0.5% + Straws 0.5%)	195 X 95 X 65	1710	4	2
5. (Black Cotton Soil 65% + Sand 25% + Lime 8% + Plastic Fibers 1% + Straws 1%)	195 X 95 X 65	1597	4	3
6. (Black Cotton Soil 66.5% + Sand 25% + Lime 8% + Plastic Fibers 0.5% + Straws 0%)	195 X 95 X 65	1745	5	3
7. (Black Cotton Soil 66% + Sand 25% + Lime 8% + Straws Fibers 1%	195 X 95 X 65	1743	2	2
Criteria **Block numbers**	Difficulty in making on a scale of 5 (1 - simplest to make, 5 - hardest to make)	Compressive Strength (N/mm2)	Comments	
1. (Black Cotton Soil 66.5% + Sand 25% + Lime 8% + Plastic Fibers 0.5%)	3	1.09	A lot of cracks. Edges are breaking easily while handling	
2. (Black Cotton Soil 66% + Sand 25% + Lime 8% + Plastic Fibers 1%)	4	1.17	Sharper ages and fewer cracks, best blocks concerning aesthetics	
3. (Black Cotton Soil 65% + Sand 25% + Lime 8% + Plastic Fibers 2%)	5	1.06	Sharp edges and least cracks but it is more time-consuming to make	
4. (Black Cotton Soil 66% + Sand 25% + Lime 8% + Plastic Fibers 0.5% + Straws 0.5%)	3	1.1	visible cracks and fungi growing on sugarcane fibers	
5. (Black Cotton Soil 65% + Sand 25% + Lime 8% + Plastic Fibers 1% + Straws 1%)	4	1.21	Lesser cracks than all blocks with sugarcane fibers and lesser fungi	
6. (Black Cotton Soil 66.5% + Sand 25% + Lime 8% + Plastic Fibers 0.5% +Straws 0%)	2	1.13	Good in form and aesthetic but growing fungi	
7. (Black Cotton Soil 66% + Sand 25% + Lime 8% + Straws Fibers 1%	1	1.41	Worst in aesthetics and edges falling apart.	

Table 2: *Analysis of Physical Properties of the Blocks*

compressive strength of blocks used for temporary structures is 0.5 N/mm2. So, the blocks made could be used for temporary construction. **Table 2** discusses the results of analysing the blocks on different parameters. It took around 2 minutes to make one block. By improvising the design of the mould, three blocks could be made at a time. **Figure 3** shows the proposed mould design. So, a non-skilled worker can make 35 blocks in an hour. Considering the shift of 8 hours a person can make 280 blocks in a day. A half-brick-thick wall of 3 X 3 m would require around 600 bricks to construct.

1	Ingredients		%	Kg
	Black cotton soil		66	1.32
	sand		25	0.5
	lime		8	0.16
	straws		0	0
	Plastic fibers		1	0.02
	Size of one block		200X100X 75	mm
	Volume of block		1500000	cu. mm
	Volume of block		0.053	cu. ft
	Approximate weight of one block		2	kg
	1 brass		100	cu. ft
	Total blocks in one brass		1887	
	Let us consider the total no of blocks in one brass is		1800	
2.	Total materials and cost required to make 1 brass blocks			
	Ingredients	Kg	cost in Rs/kg	Total cost
	Black cotton soil	2376	0	0
	sand	900	2	1800
	lime	288	7	2016
	straws	0	1	0
	Plastic fibers	36	1	36
	Total Material Cost to make 1 brass blocks			3852
3.	Total labor cost required to make 1 brass blocks			
	Blocks made by one person in 8hrs shift		300	
	Total people required to cast 1 brass blocks		6	
	Weight of one plastic bag		0.1	kg
	Time required to shred one bag		5	Minutes
	Total plastic could be stranded in 8hrs shift		9.6	Kg
	Total people required to shred material required to make 1 brass block		4	
	Total people required to make 1 brass block		10	
	Per person per day payment		300	Rs.
	Total Labor Cost		3000	Rs.
4.	Total Cost to make 1 brass blocks			
	Total cost to make 1 brass block with labor cost		6852	Rs.
	Total cost to make 1 brass block without labor cost		3852	Rs.
	Cost of 1 brass burnt bricks		10000	Rs.

Table 3: *Cost Analysis*

Table 3 includes detailed calculations of the cost of blocks and their comparison with the cost of burnt brick blocks. From the calculations, it can be concluded that the cost of Adobe blocks is around 2/3rd of market cost of burnt bricks. If the blocks are self-made instead of hiring labour, this cost would further reduce to about 1/3rd.

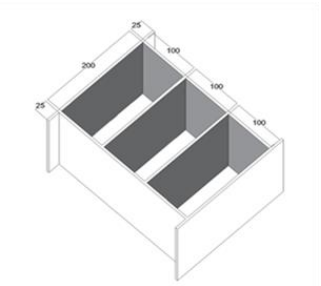

Figure 3: *Modified Design of mould for block-making*

Conclusions

From the study, it could be concluded that the adobe blocks made from black cotton soil in varying compositions as tried out in our experiment could not be used for making permanent structures due to less compressive strength. However, they could be used for temporary construction. Also, the use of sugarcane bagasse should be avoided as it is promoting the growth of fungi, instead polypropylene waste of 40mm in length is preferable to use as binder. All of the blocks have approximately the same compressive strength ranging from 1 to 1.5 N/mm^2. So, the best composition for making the blocks was 2 (Black Cotton Soil 66% + Sand 25% + Lime 8% + Plastic Fibers 1%), as they have a compressive strength of 1.17 N/mm^2, they are good in aesthetics and also prevent the growth of fungi leading to healthy indoor built areas and also increasing the life of the building.

If the blocks are made on-site by the owners, then the labor cost could reduce drastically and the cost of material would be about 1/3 of the burnt brick blocks. On the other hand, if the blocks are made by hiring labour, then the cost of the block is around 2/3 of the burnt bricks.

The adobe blocks with black cotton soil could be used as the cost-effective solution for the temporary structures and has the potential of degrading the block and being part of the earth again reducing the impact on the environment if the natural straws are used as the binding material. To solve the problem of fungi caused because of rotting of the natural fiber, researchers can explore the addition of Neem leaves and an increased amount of lime in the blocks. ■

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