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Experimental Study on Compressive Strength of Brick Using Natural Fibres

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ABSTRACT

Despite the use of modern materials, clay bricks are reasonably preferable materials nowadays. However, the moo fetched and flexibility of clay bricks are not related with tall natural and feasible values, particularly with regard to crude fabric sources and fabricating processes. Agricultural world is growing fast, with increased rural arrive development and land cultivation leading to massive development of the agro-based industry leading to expansive amount of agrarian squanders which are not recycled. Therefore, these wastes can be reused by reviving fibres obtained from disposed leaves and fruit bunches, which can be used in brick-making. This research investigated the mechanical properties of clay bricks built by including two naturally existing fibres to a clay-water blend, in heated and non-heated conditions. The fibre samples were sourced from pineapple leaves (PF), Coconut at the range of 0.5-1.5 % with length 5mm and 10mm. To that mixture, cement was mixed at 5 %, as it is a binder. It was observed that the two fibres had distinct after effects on the bricks produced and the presence of cement dominated the compressive strength. The non-baked bricks disintegrated when immersed in water and the baked ones exhibited cement-dependent qualities in water-absorption and density variations. Interestingly increase in fibre content did not cause significant density reduction in both the baked and non-baked bricks.

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1. INTRODUCTION

Evolution of befitting technologies for the yield of low-cost building substances of beneficial nature will improve the stipulation of affordable urban housing in growing countries. The devastating natural calamities around the world resulted in masonry walls collapsed which caused loss of many lives. The major research in civil engineering is to solve the issue of insufficiency of materials. The expansion of industries to boost the usage of locally available building material is one of the successful methods. Use of synthetic fibre has now augmented the markets due to its better performance [1]. But, the cost of synthetic fibres and the availability for common man usage has led to the research on natural fibres. Natural fibres which are the renewable resources can be reared and formed quickly when compared with conventional glass and carbon fibres [2, 3]. Fibres act as thermal and acoustic insulators; however, the resistance of the material is taken into consideration. The energy required for the production of fibre composite is less and the cost of fabrication is lower when compared with common synthetic reinforcing fibres [4]. Natural fibre composites have good mechanical properties with a low specific mass [5]. The quality of the fibre-bricks was based on the cement (binder) proportions [6]. The advantage of using fibre in the non-heated specimens proved that the strength gain exceeded that of non-heated cement-added only specimens (i.e. at cement content ≥ 15 %) [7]. Also the strength is depended on fibre volume fraction [8]. As the fibre volume fraction increased, the tensile strength of composite also increased and the compressive strength reduced [9]. The natural fibres are environmentally advantageous but it has less strength and durability. But research says using some aritficial treatment the durability of fibres would be enhanced [10]. The present study was conducted to observe the

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compressive strength and ductility behaviour of brick using different natural fibres.

1. 1. Fibre Characteristics and Properties It is known that vegetable fibres made from natural composites have a cellular arrangement. Various quantities of cellulose and lignin set up the various layers (Table 1). Naturally available fibres have lower Young's modulus and higher tensile strength [11-13].

1. 2. Sisal Fibre Sisal fibre acts as an effective reinforcement of polymer. It has many applications such as ropes, carpets, mats, etc [3, 14]. Based on the test condition, age and source of sisal fibre, the properties may vary, also the stiffness and strength of fibres vary with spiral angle and cellulose proportion. The tensile properties of sisal fibre may vary with its length [15-17]. The tensile strength and the effects of fibre diameter were studied by Mukherjee and Satyanarayana at the break of sisal fibres. It was observed that there was no major variation in instinctive properties of the fibre with the change in diameter [18, 19]. When the fibre length increases the Young's modulus also increases and the tensile strength decreases respectively [20].

1. 3. Coir Fibre The elements of coir fibres are cellulose, hemicelluloses, lignin, and many crucial substances. The fibre is very tough and stiff when referred to other natural fibres. Coir fibres are high in weight, strong, elastic and has low density, height degree of retaining water, strong and elastic, have a low light resistance, a high durability and also rich in micronutrients.

2. EXPERIMENTAL SETUP

2. 1. Brick Proportion The clay soil is taken and it is sieved under the 500 microns. The necessary soil is needed for the brick mold size 190*90*90 mm is taken.

TABLE 1. Natural fibres properties

Fibre Name	Tensile Strength (MPa)	Density (kg/m^3)	Water absorption (%)	Modulus elasticity (GPa)
Reed	70-140	490	100	37
Sisal	268	700-800	56	15
Coir	180-200	145-380	130-180	19-26
Roselle	170-350	750-800	40-50	10-17
Date Palm	125-200	463	60-65	70
Bamboo	73-505	500-800	145	10-40
Banana	384		407	20-51

30 % water of the weight of the soil is added and the mix is put in the mold and compressed well and then taken out to form a clay brick. Note that this water content is approaching the liquid limit of the clay (see Table 2). Then Sisal and coir fibre is cut into the size of 10mm and 0.5% fibre is added to the clay soil and brick is made. For the next specimen, the sisal and coir fibre is cut into size of 5mm and 0.5% fibre is added to the clay soil and brick with fibre is made. Sisal and coir fibre is cut into a length of size 10mm and 0.5% fibre is added to the clay soil and 5% of cement is added as a binding material and brick with fibre is made. Sisal and coir fibre is cut into a length of size 5mm and 0.5% fibre is added to the clay soil and 5% of cement is added as a binding material and brick is made.

Sisal and coir fibre is cut into a size of 5mm and 1 and 1.5% fibre is added to the clay soil and brick is made (see Figures 1 and 2).

TABLE 2. Physical Properties of Clay

Percentage passing 63 µm sieve	43.67%
Specific gravity, Gs	2.71
Liquid limit, wLL	32.38%
Plastic limit, wPL	17.19%
Plasticity Index, PI = wLL - wPL	15.19%
Soil description	Brownish clay with medium plasticity

Figure 1. Mixing the fibre with clay soil

Figure 2. Moulding of brick

Then these bricks are air-dried for 2 days. Bricks are oven-dried for 5 days at 200ºC (Figures 3 and 4). After this these bricks are kept in the furnace and heated to a process temperature of 900ºC (Figure 3). The specimens tested are shown in the Table 3.

2. 2. Testing of Specimen Compression tests of bricks are carried out on UTM (Figure 5) of 100T capacity and load-deflection curve is plotted for all the specimens. The standard used for compressive strength is displacement control. Where each 1 mm displacement occurs in 10 seconds for all specimens. The top plate thickness is 10 mm.

Figure 3. Heating the brick using furnace

Figure 4. Heating the brick using Hot air Oven

TABLE 3. Specimen Casted

Specimen	Size	Materials Added
1	190x90x90 mm	Chamber brick
2	190x90x90 mm	Clay soil + 30% water
3	190x90x90 mm	Clay soil + 30% water +0.5%10 mm sisal fibre
4	190x90x90 mm	Clay soil + 30% water +0.5%10 mm coir fibre
5	190x90x90 mm	Clay soil + 30% water+0.5% 5 mm sisal fibre
6	190x90x90 mm	Clay soil + 30% water+0.5% 5 mm coir fibre
7	190x90x90 mm	Clay soil + 30% water+5% cement
8	190x90x90 mm	Clay soil + 30% water +0.5%10 mm sisal fibre+5% cement
9	190x90x90 mm	Clay soil + 30% water +0.5%10 mm coir fibre+5% cement
10	190x90x90 mm	Clay soil + 30% water+ 0.5% 5 mm sisal fibre+5% cement
11	190x90x90 mm	Clay soil + 30% water+0.5% 5 mm coir fibre+5% cement
12	190x90x90 mm	Clay soil + 30% water+1% 5 mm sisal fibre
13	190x90x90 mm	Clay soil + 30% water+1.5% 5 mm sisal fibre
14	190x90x90 mm	Clay soil + 30% water+1% 5 mm coir fibre
15	190x90x90 mm	Clay soil + 30% water+1.5% 5 mm coir fibre

Figure 5. Testing of brick using 50T Universal Testing machine (UTM)

Table 4 shows the compressive strength of the brick with different proportions. It is observed that 5mm sisal fibre and coir fibre has more compressive strength.

Figures 6 and 7 show the load vs Deflection curve for the bricks made by sisal and coir fibre with the length 5mm and 10 mm, compared with baked and Non-Baked bricks. From the figure it is observed that 5mm coir fibre is has more compressive strength and more ductility. Figure 8 shows that same with length, 5 % of cement is added to get good bond between the fibre and clay. But additional amount of cement is decreasing the compressive strength of brick. Figures 9 and 10 show the load vs Deflection curve for the bricks made by the 5mm length of sisal and coir fibre at different percentage. It is observed that the percentage of fibre is increasing it decrease the compressive strength and ductility.

TABLE 4. Compressive Strength of Bricks

Specimen No	Material Added	Compressive Strength
1	Chamber brick	2.678 N/mm²
2	Clay soil + 30% water	3.357 N/mm²
3	Clay soil + 30% water +0.5% 10 mm sisal fibre	2.015 N/mm²
4	Clay soil + 30% water +0.5% 10 mm coir fibre	4.088 N/mm²
5	Clay soil + 30% water+0.5% 5 mm sisal fibre	5.246 N/mm²
6	Clay soil + 30% water+0.5% 5 mm coir fibre	6.292 N/mm²
7	Clay soil + 30% water+5% cement	2.614 N/mm²
8	Clay soil + 30% water +0.5% 10 mm sisal fibre+5% cement	1.614 N/mm²
9	Clay soil + 30% water +0.5% 10 mm coir fibre+5% cement	1.848 N/mm²
10	Clay soil + 30% water+0.5% 5 mm sisal fibre+5% cement	1.792 N/mm²
11	Clay soil + 30% water+0.5% 5 mm coir fibre+5% cement	2.018 N/mm²
12	Clay soil + 30% water+1% 5 mm sisal fibre	2.283 N/mm²
13	Clay soil + 30% water+1.5% 5 mm sisal fibre	2.218 N/mm²
14	Clay soil + 30% water+1% 5 mm coir fibre	2.304 N/mm²
15	Clay soil + 30% water+1.5% 5 mm coir fibre	3.288 N/mm²

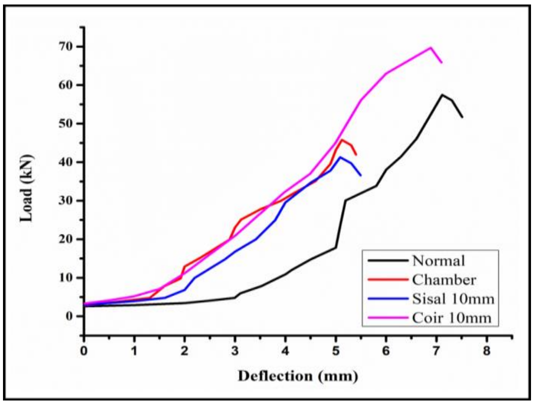

Figure 6. 10 mm Sisal and Coir

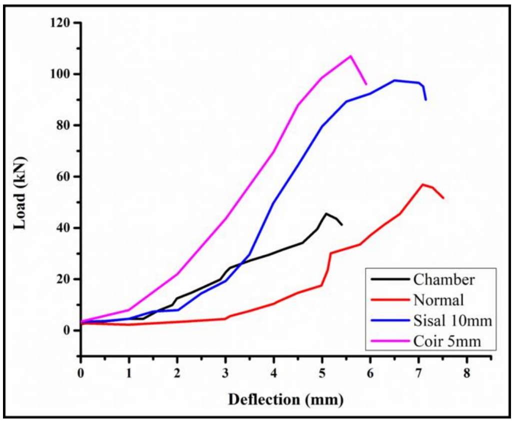

Figure 7. 5mm Sisal and Coir

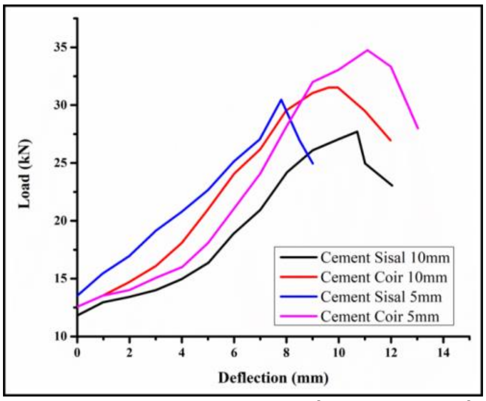

Figure 8. 10mm and 5mm Sisal , coir fibre with 5% of cement

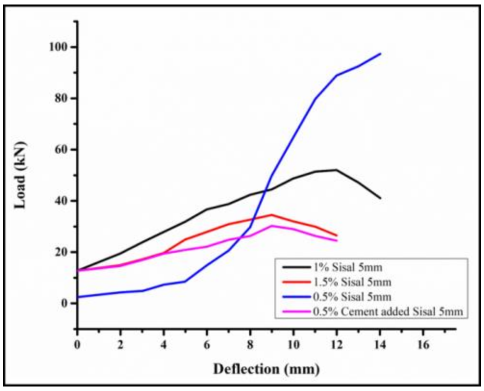

Figure 9. 5mm Sisal Fibre at 0.5, 1 and 1.5%

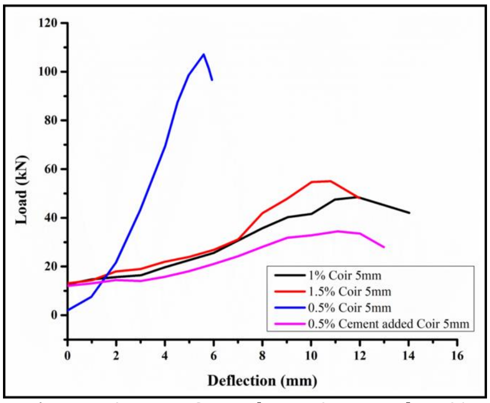

Figure 10. 5mm Coir Fibre at 0.5, 1 and 1.5%

3. CONCLUSION

From the experimental investigation, the compressive strength and ductility of the brick with natural fibre is found out and the load versus deflection behaviour is observed. The 5mm sisal clay brick and 5mm coir clay brick has more compressive strength than 10mm sisal clay brick and 10mm coir clay brick. Therefore, as the length of the fibre increases, the compressive strength of the brick decreases and also it observed that addition of sisal 5mm with 5% has more dutility compared coir and cement. Adding 5% of cement as the binding material in the sisal clay brick changes its originality of the brick to more brittle behaviour and decreases the compressive strength. Therefore, addition of cement in the brick reduces the compressive strength of the brick.

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چکیده

علیرغم استفاده از مواد مدرن، آجرهای سنگی امروزه از مواد قابل قبول تر است. با این حال، تولید و انعطاف پذیری آجرهای خاک رس با ارزش های طبیعی و قابل قبول بالا، به خصوص با توجه به منابع نفت خام و فرایندهای تولید، ارتباطی ندارد. دنیای کشاورزی به سرعت در حال رشد است، با افزایش روستاها، توسعه و کشت زمین به وجود می آید که منجر به توسعه گسترده ای از صنایع کشاورزی می شود که منجر به میزان گسترده ای از زباله های زراعتی می شود که بازنویسی نشده اند. بنابراین، این زباله ها را می توان با احیاء فیبر های به دست آمده از برگ های جدا شده و دسته های میوه ای که می تواند در ساخت آجر استفاده شود، دوباره استفاده می شود. این تحقیق خواص مکانیکی آجرهای خاک رس را که شامل دو الیاف طبیعی موجود به یک ترکیب رس–آب، در شرایط گرم و غیر گرم شده ساخته شده است، مورد بررسی قرار داد. نمونه های فیبر از برگ های آناناس ((PF، نارگیل در محدوده ۰٫۵–۱٫۵٪ با طول mm۵ و mm۱۰ بود. به این مخلوط، سیمان با ۵٪ مخلوط شده است، زیرا یک باندینگ است. مشاهده شد که دو الیاف بعد از اثرات بر روی آجر تولید شده مشخص شدند و حضور سیمان بر مقاومت فشاری تاکید داشت. آجرهای غیر پخته در هنگام غوطه ور شدن در آب تجزیه شدند و پخته شده ها ویژگی های وابسته به سیمان را در تغییرات جذب آب و چگالی نشان دادند. جالب توجه است که افزایش محتوای فیبر باعث کاهش شدید تراکم در آجرهای پخته شده و غیر پخته شده نمی شود.

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