ФИЗИЧЕСКИЕ НАУКИ

УДК 537.9
https://doi.org/10.25587/2222-5404-2025-22-1-29-36
Original article

Mechanical behaviour of compressed earth blocks reinforced with random and aligned continuous distribution corn husk fibers

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Abstract
This study aims to characterise a composite material from compressed earth reinforced with corn husks fibers. In order to achieve this objective, the work started by conducting many laboratory tests on fibers and soils. The parameters that were determined included the diameters, stress at rupture, elongation at rupture, deformation at rupture, Young modulus 1 and Young modulus 2, and constraint maximum for fibers. In addition, geotechnical parameters of soils were determined, including the water limit liquid, plastic limit liquid also determine optimal moisture for soil and is maximum dry density. It is evident that the tensile strength decreases and varies depending on the amount of corn husk fiber has increased. The results also demonstrate that the rate of water absorption of the composite increases with the increase in the fiber content, which is explained in particular by the fact that the fibers' plant origins are hydrophilic and possess a porous character, thereby enabling water absorption. Furthermore, the study also shows that there is a reduction in the density of the fiber composite with increasing fiber content. It was equally observed that an increase in the fiber ratio let to an increase in the Young's modulus of the composite.
Keywords: corn husk fiber, Earth matrix, Young's modulus, compressive stress, tensile stress, water absorption of the composite, fiber composite, fiber composite, compressed earth, hydrophilic origin of fibers
Funding. No funding was received for writing this manuscript
For citation: B. Bahel, B. B. Ngwem, F. Kenmogne, R. A. Kum, E. Yamb, Safonova M. N., Fedotov A. A., Ammosova N. E. Mechanical behaviour of compressed earth blocks reinforced with random and aligned continuous distribution corn husk fibers. *Вестник СВФУ.* 2025, Т. 22, № 1. С. 29–36. DOI: 10.25587/2222-5404-2025-22-1-29-36

Оригинальная научная статья

Механическое воздействие прессованных грунтовых блоков, армированных волокнами кукурузной шелухи с хаотичным непрерывным распределением

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Аннотация

Целью данного исследования является характеристика композитного материала, полученного на основе прессованного грунта, армированного волокнами кукурузной шелухи. Для достижения этой цели работа началась с проведения множества лабораторных исследований волокон и грунтов. Были определены следующие параметры волокон: диаметр, предел прочности при разрыве, относительное удлинение при разрыве, деформация при разрыве, модуль Юнга 1, модуль Юнга 2 и максимальное напряжение. Кроме того, были определены геомеханические параметры грунтов, включая предел текучести, предел пластичности, а также оптимальную влажность грунта и его максимальную сухую плотность. Было выявлено, что прочность на растяжение снижается и варьируется в зависимости от увеличения содержания волокон кукурузной шелухи. Результаты также показывают, что скорость водопоглощения композитного материала увеличивается с увеличением содержания волокон, что объясняется, в частности, гидрофильной природой волокон растительного происхождения и их пористой структурой, способствующей поглощению воды. Кроме того, исследование показывает снижение плотности волокнистого композита с увеличением содержания волокон. Было также отмечено, что с увеличением соотношения волокон увеличивается модуль Юнга композита.

Ключевые слова: волокно кукурузной шелухи, матрица Земли, модуль Юнга, сжимающее напряжение, растягивающее напряжение, водопоглощение композита, волокнистый композит, композитный материал, прессованный грунт, гидрофильная природа волокон

Финансирование. Исследование не имело финансовой поддержки

Для цитирования: Б. Бахель, Б. Б. Нгвем, Ф. Кенмоне, Р. А. Кум, Э. Ямб, Сафонова М. Н., Федотов А. А., Аммосова Н. Е. Механическое воздействие прессованных грунтовых блоков, армированных волокнами кукурузной шелухи с хаотичным непрерывным распределением. *Vestnik of NEFU*. 2025, Vol. 22, No. 1. Pp. 29–36. DOI: 10.25587/2222-5404-2025-22-1-29-36

Introduction

The increasing demand for housing, coupled with informal settlements constantly expanding as well as low-income household’s inability to afford decent housing, is environmentally very dangerous shown in Fig. 1. Therefore, there is an important necessity for research into methods of designing new materials and technologies to become urgent in general and on earth in particular.

a b c

Fig. 1. Pollution of the environment: a) maize farm, b) burn waste, c) smoke pollution of the air
Рис. 1. Загрязнение окружающей среды:
а) кукурузная ферма, б) сжигание отходов, в) загрязнение воздуха дымом

One of the problems associated with earth as a construction material is the issue of low durability and strength properties [1,2]. Soil in its natural state lacks the dimensional stability required for building houses [9] (Fig. 2). There are also the problems of cracking and shrinkage with the use of earth for building houses.

The principal purpose of this research paper is to study the mechanical behaviour of the composite blocks based on compressed earth reinforced with corn husks fibers.

The following specific objectives are pursued in order to achieve this purpose: to determine the properties of earth and corn husks fibers as raw materials for the production of the composite; to determine the mechanical and physical properties of compressed earth blocks and the reinforcement; to determine and analyse the mechanical behaviour of the composite or compressed blocks reinforced by corn husks fibers.

Materials and methods

The aim of this section is to discribe the process to obtaining the soil samples and fibers that were used for manufacture the block composite (Fig. 2). It is mainly also the laboratory tests used for determining the compression blocks properties, moisture and results and analysis.

Characterisation of corn husk fibers. After sampling and prepare the fibers as shown to the Fig. 3a above different parameters of the fibers are determine as diameter (Fig. 3b), rupture stress, deformation, Young modulus, and maximum stress (Fig. 3c).

Process of manufacturing blocks.

The processes involved in preparing the samples for testing are presented in Fig. 4. The figure demonstrates the procedure that was followed in order to create the earth blocks using agricultural waste fibers. Earth blocks measuring 290 × 140 × 100 mm were made.

a b c d

Fig. 2. Materials used for the experimentation: a) corn husk waste, b) soil and corn husk fibers, c) compression moulding machine, d) block obtain after moulding for drying
Рис. 2. Использованные материалы для проведения эксперимента: а) отходы кукурузной шелухи, б) почва и волокна кукурузной шелухи, в) устройство для компрессионного формования, г) блок, полученный после формовки для сушки

a b c

Fig. 3. Fibers experimentation equipments: a) sampling and preparation of fibers, b) computer and optical microscope, c) machine of determine fibers parameters

Рис. 3. Оборудования для проведения эксперимента по изучению волокон: а) отбор и подготовка волокон, б) компьютер и оптический микроскоп, в) аппарат для определения свойств волокон

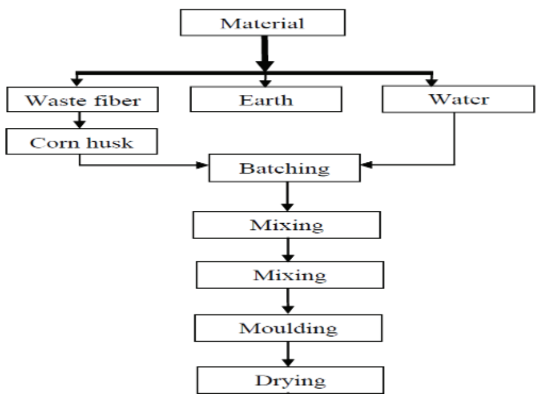


Fig. 4. Process of manufacturing blocks

Рис. 4. Процесс изготовления блоков

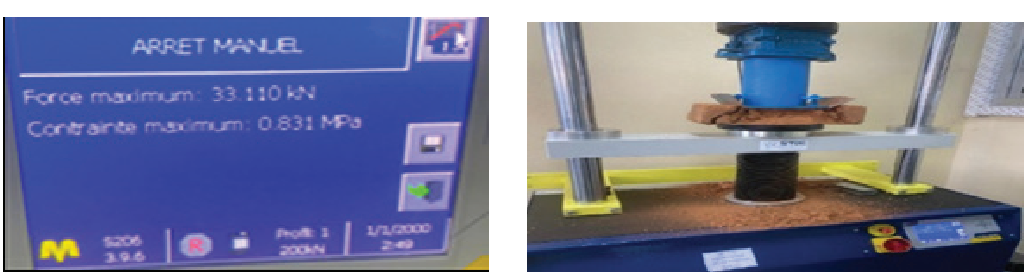
Laboratory tests.

Water absorption and swelling tests.

Water absorption and Swelling tests. Water absorption tests have been measured according to the international standard ASTMD570.

Compressive strength test and deformation of the blocks.

The test was conducted in accordance with British Standard Institute BS EN 772:1 (2011). Testing machine (CONTROLS 50-C46G2) with maximum capacity 200 kN was used for conducting the test (Fig. 5).



a b

Fig. 5. Compressive test equipment: a) screen space of data reading, b) process of compression

Рис. 5. Оборудование для испытания на сжатие: а) экранное пространство для считывания данных, б) процесс сжатия

Compressive strength of the blocks reinforced with corn husks fiber.

Base on the homogenious equation in composite with discontinuous fiber randomly distributed the Young's modulus of the composite is:

$$E_C = KV_f E_f(d) + (1 - V_f)E_m \tag{2}$$

E_c : the Young's modulus of the composite, (ii) E_f : the Young's modulus of the fiber, (iii) E_m : the Young's modulus of the matrix , (iv) V_f : the volume fraction of the fiber, (v) K : the efficiency of the corn husks fiber depending on V_f and $\frac{E_f}{E_m}$.

By replacing the K with it value the:

$$E_C = (V_f^{\,2} - V_f + 1)E_m \tag{3}$$

$\sigma_c = E_c \in$

The Young's modulus of the composite reinforced with continuous aligned fibers with used the formula:

$$E_C = V_f E_f(d) + (1 - V_f)E_m \tag{4}$$

Splitting tensile strength test.

The tensile splitting strength of the blocks was then calculated from the Equation below:

$$T = 0.637 \times K \times \frac{P}{S} \tag{5}$$

Where: *T* is the tensile strength (MPa), 0.637 is constant, *k* is correction coefficient of block thickness, *P* is the failure load (N), *S* is the cross sectional area of the block where the load was applied (mm2).

Results and discussion.

Some corn husks fibers characteristics.

Table

Characteristics of corn husks fibers

Таблица

Характеристики волокон кукурузной шелухи

Average interval fibers diameter µm	Stress at rupture Mpa	Deformation at rupture	Young modulus GPa	Maximum stress Mpa
[0,20 -0,30]	0.802 – 34.65	0.0392–0.260	374.46 – 2068	0.802 – 34.65
[0,30 -0,40]	7.699 – 32.24	0.0775 – 0.1947	165.41–899.219	9.83 – 32.44
[0,40 -0,50]	0.466 –11.686	0.044 – 0.114	234.979 – 750.277	7.62 – 23.493
[0,50 -0,60]	7.09 – 12.71	0.090 – 0.167	234 – 334 .640	6.94 – 17.12
[0,60 -0,70]	1.623	0.109	74.394	1.88
[0,70 -0,80]	4.39 – 22.326	0.0525 -0.139	165.416 – 773.141	7.6 – 22.15
[0,80 -0,90]	3.575 – 6.79	0.1113 – 0.1563	175.01 – 221.404	6.60 – 7.228

Some geotechnical parameters of the soils.

The Atterberg limits are the basic measure of the water contents of a fine-grained soil: its shrinkage limit, plastic limit, and liquid limit. Depending on its water content, the soil may appear in one of four states: solid, semi-solid, plastic, and liquid. The results of the liquid limit (LL), plastic limit (PL), and plasticity index (PI).

Tensile and compressive stress of the compressed earth blocks reinforced with corn husks fibers.

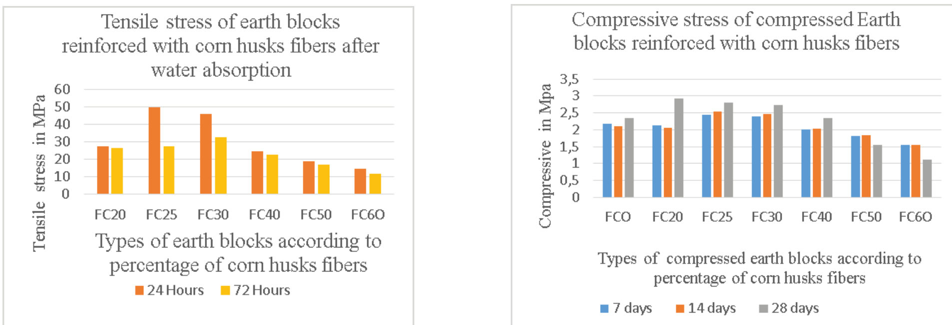


Fig. 6. Diagram of stretching and compression of earth blocks reinforced with corn husk fibers

Рис. 6. Схема растяжения и сжатия блоков, армированных волокнами кукурузной шелухи

Comparative compressive stress of the compressed earth blocks reinforced with random and continuous aligned corn husks fiber.

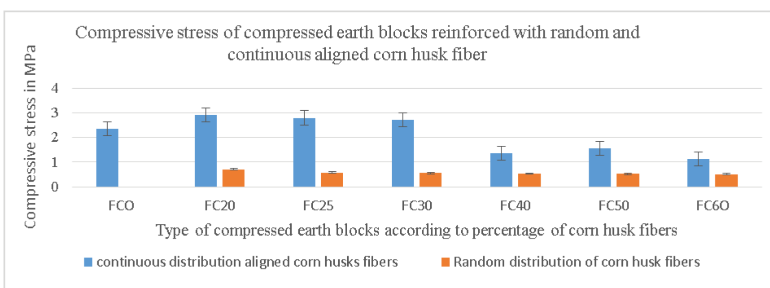


Fig. 7. Diagram of the comparative compression stress of compressed earth blocks reinforced with corn husk fibers

Рис. 7. Схема сравнения напряжения при сжатии спрессованных блоков, армированных волокнами кукурузной шелухи

Conclusion

The combine of earth and corn husks fibers to obtain sustainable and good mechanical behavior of compressed earth blocks is when the fibers are continuous and aligned on earth block closer to the Tsai-pagano model.

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(указывается в журнале с 2025 года)

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Conflict of interests

The authors declare no relevant conflict of interests

Конфликт интересов

Авторы заявляют об отсутствии конфликта интересов

Submitted / Поступила в редакцию 24.09.24
Accepted / Принята к публикации 14.10.24