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Effect of using agricultural wastes in cement blocks production

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ABSTRACT

The disposal of agricultural wastes is a serious environmental problem. Use of agricultural wastes in the production of cement block may reduce the global environmental pollution. This study analyzes the feasibility of using agricultural waste like cotton stalks and corn stems as a partial volumetric replacement in the manufacture of cement blocks. For each residue, the replacement percentages of 5, 10, 15 and 20% (V/V) were evaluated (separately), in addition to a formulation without the use of agricultural residues. The mixture used was 1: 6 (cement: sand). The experiments have been conducted to determine some physical properties as bulk density and water absorption percentage (%) and some mechanical properties as compressive strength for the produced cement blocks. Test results show that cement blocks with agricultural waste were satisfied the strength requirement according to the standard. Cement blocks with cotton stalks and corn stems shows reasonable strength properties. Corn stems showed a greater potential for its use as reinforcement in cement blocks than cotton stalks. The formulation using 15% corn stems offered the best results in compressive strength in vertical direction (2.98 MPa) at low bulk density (1930 kg/m3). The water absorption was higher in cement blocks made from agricultural wastes than the cement blocks made without agriculture wastes, but it was in normal range.

1. Introduction

The disposal of agricultural waste is one of the most pressing environmental problems in many countries. Finding an economic use of these wastes by incorporating them into a product is the approach commonly used to overcome the associated environmental problems.

In recent years, the interest in the possible use of agricultural residues as a raw material for the production of structural reinforcement fibers for building materials has increased due to ecological and economic aspects. The environmental impact increases with the increase in population due to the generation of waste and the unlimited consumption of raw materials. Open landfilling of agricultural waste is becoming a major problem. Because open damping destroys the aesthetic appearance of nature and is harmful to health and environment, agricultural residues have to be converted into valuable materials (Tomas, 2013). Agricultural plants don't seem to be inherently waste materials; however, the good importance hooked up to edible part of the plant overshadows the employment of remaining plant material. Here in Egypt, the plants cultivated on an oversized scale. Once harvested, the plants stalks burned in several areas, clean air laws prevent this combustion. The targeted use of plant stalks for creating materials is more and more possible. During this context, its value noting that the employment of agricultural waste as a supply of biomass poses expensive and difficult issues for crop producers. For instance, cotton stalks (CS), the agricultural byproduct of cotton production that continues to be within the field once harvest (Mythili and Venkatachalam, 2013), is a plentiful waste with a world estimate of 79.5 million tons annually in 2019–20 (Johnson et al., 2020).

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Cotton is one amongst, the most money crops fully grown in Egypt, covering a district about 375,000 fad., and it's manufacturing producing about 330,300 Mg of cotton seeds. According to (A.E.B., 2016), the yield and therefore the quantity of cotton waste were determined to be around 500,000 Mg/year. Corn stalks are agricultural by-products and currently have no economic value. The disposal of agricultural waste is currently a major economic and ecological problem. However, the abundance and availability of corn stalks as an agricultural by-product makes them a good source of raw materials for many purposes. Egypt produces 3.12 million tons of cornstalk by-products per year (Husseien et al., 2009). By volume, corn is the most produced grain in the world, resulting in large amounts of waste. Despite this, little research has been published on the use of corn stalk residue fibers in fiber-cement manufacture and data characterizing these fibers is completely lacking. The growing demand for a clean environment has led to the use of natural resources to develop innovative green materials (Sair et al., 2019). Reinforced composites are utilized in applications wherever good mechanical and alternative properties are needed, such as: Engineering and construction applications. The utilization of natural fibers offers many benefits, as an example the surface of the product, it's a natural look, a quicker production cycle is feasible, even savings on chemical compounds and therefore, natural fibers have smart properties and are simple to get and manufacture (Jamrichova and Hejdukova, 2013). Considering the environmental problem due to waste materials and the increasing demand for building materials, much research has been done to study the possibility of using waste materials in the manufacture of wall blocks. Recycling waste materials by incorporating them into building materials is a practical solution to pollution problems. This waste can be divided into three categories: construction and demolition waste, industrial waste and agricultural waste (Navaratnarajah and De Zoysa, 2018). Concrete blocks are one of the most commonly used materials in the construction industry with unique properties such as: molding in different shapes, densities, thicknesses and resistances for different applications in construction industry (Dominguez Santos et al., 2019; Scholz and Grabowiecki, 2007). However, its production consumes huge amounts of natural resources such as cement and aggregates, for this reason there is urgency for producing more environmentally sustainable products (Liu et al., 2020; Mo et al., 2016). In this sense, the use of lignocellulosic waste can lead to a reduction in the use of traditional aggregates and represents a suitable solution for eliminating large amounts of non-recycled waste (Yang et al., 2011; Xuan et al., 2018). Accordingly, the production of cement matrix compounds with plant fibers or particles has been examined in various studies looking for the technical feasibility and the most suitable formulations for the use of agro-industrial waste (Soto Izquierdo et al., 2017; Torkaman et al., 2014). It would enable proper attribution, add value to waste, and add new properties to composites (Murthy and Madhava Naidu, 2012; Dos Santos et al., 2014). In addition to high availability in many emerging markets, agricultural residues have the advantages of high tensile strength and low elastic modulus, and can be used to reinforce the cement matrix, improving the properties of the final product in terms of controlling the crack opening, reducing the density of the composite material and consequently high thermal insulation efficiency (Ardanuy et al., 2015; Teixeira et al., 2020). Raut et al. (2011) stated that enhanced performance in terms of achieved lighter density, lower thermal conductivity and higher compressive strength of the various waste-create bricks gives an economical option for designing green buildings. A varied variety of industrial waste materials for manufacturing of building blocks have been studied, including ash of coal bottom (Singha and Siddiqueb, 2016), fly ash (Kumar, 2012), wastes of sawing granite (Menezes et al., 2005), powder of glass (Turgut, 2008), wastes of marble powder (Bilgin et al., 2012), wastes of paper mills (Raut et al., 2012), husks of rice (Rauta et al., 2013), crumb of rubber (Turgut and Yesilata, 2008), butts of cigarettes (Aeslina et al., 2010) and cotton waste (Rajput et al., 2012). In these studies, compressive strength and water absorption rate are two common parameters that are considered. A study of the published literature shows that the use of these industrial waste materials as a partial replacement for sand enables the production of wall blocks with compressive strengths comparable to those obtained in the control wall blocks. While there have been several studies on the manufacture of masonry blocks from construction and industrial wastes, only a very limited study has been carried out on the manufacture of masonry blocks from agricultural wastes. Various researchers have investigated the use of waste materials such as processed waste tea for bricks (Demir, 2006), straw fiber for adobe bricks (Parisi et al., 2015) and sawdust (Turgut and Algin, 2007) for manufacturing masonry blocks. Gunasekaran et al. (2011) studied mechanical characteristics such as compressive strength, splitting tensile strength, flexural strength and impact strength of coconut shells concrete as coarse aggregates. The authors concluded that coconut shells can be used as lightweight aggregates for producing lightweight concrete. Parisi et al. (2015) reported the production of adobe bricks using a mixture of soil, water and straw fibers. The adobe bricks under study reinforced by straw fiber of 100 × 200 × 400 mm^3 in size and had a mean unit weight equal of 16.80 kN/m^3. Based on the test results, the compressive strength, tensile strength and Young's secant modulus of straw fiber reinforced clay bricks fall into the ranges under compression of

0.2–2.5 MPa, 0.17–0.75 MPa and 15–287 MPa, respectively. Kanagalakshmi et al. (2015) conducted a series of tests to determine the suitability of peanut shells for the manufacture of cement blocks. Compressive strength is considered the main parameter of these tests. It ensures that the compressive strength decreases as the proportion of nuts in the peanut shell increases. The previous works (Khedari et al., 2001; Mannan and Ganapathy, 2002; Madurwar et al., 2013) indicate that with using plant residues, which are abundant in rural areas, buildings may be cheaper to construct and of good build quality. For the manufacture and use of masonry blocks from agricultural residues, further investigations into the strength and durability properties of these blocks are required. Adding to that, there was no comparative research on waste materials. Therefore, you cannot find the most suitable waste material to use in the crafting of blocks. With this in mind, this study focuses on finding the most suitable agricultural waste materials for production of cement blocks. The present study focuses on the possibility of using agricultural waste as a partial quantity replacement in the production of cement blocks. While these waste materials can be used as fertilizer, insulation material or fuel; yet a large amount of this waste is discarded to overcome a large accumulation. This waste is usually dumped on land or incinerated in the open air, leading to land abandonment problems and water pollution. To solve this problem, a decision must be made to use agricultural waste as an alternative to sand in the manufacture of cement blocks. Cotton stalks and corn stalks are considered bulk substitutes. The effects of these agricultural waste materials on the density, water absorption percentages and compressive strength of the cement blocks were studied.

2. Materials and methods

The experiments of this work were carried out in summer of 2021 at Faculty of Agricultural Engineering, Al-Azhar Univ., Cairo, Egypt.

2.1. Material used

2.1.1. Cement

Ordinary Portland cement used as a cementing material in the experiments was obtained commercially and produced from Egyptian company in high quality of 52.5 N and compliant with Portland cement EN 1971CEMII 52.5 N, ASPER.CE certificate of conformity 0755-CPD-C02/23 which it was issued by SACHSEN-ANHALT. The cement chemical composition is given in Table 1. To calculate the bulk density of the cement used, five random samples were taken, which resulted in an average bulk density of 1.133 g/cm3 with a CV of 2.064 (%).

Table 1
The chemical composition of the used cement.

Oxide	SiO_2	AL_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	The Other components
OPC (%)	12.25	3.06	2.35	67.02	2.2	3.1	1.8	8.22

2.1.2. Water

The water used in the cemented mixture for cement blocks making and processing must be clean, free of impurities, salts, organic matter and chlorides, and free of oils, grease, acids, alkalis and clay materials, so that these impurities and harmful substances do not affect the quality of the produced cement blocks or bricks. Tap water was used in the preparation of the mix to form the cement blocks. Some samples of used tap water were analyzed at Soil, Water and Environment Research Institute, Cairo University Street, Giza, Egypt. The properties of the tap water used in this work were, pH 6.9, Sulfate content 21 mg/l and hardness 500 (as $CaCo_3$).

2.1.3. Sand

The sand used in the cement blocks mixture was obtained commercially, a sieve analysis was carried out in order to determine the used sand, the screening was by using a sieve to desired size. The size of fine sand used was ≤ 1 mm. Table 2 illustrates sieve analysis for a 100 g random sample for the used sand. It is classified as silica and supplied as bulk. To calculate bulk density for it, five samples were selected randomly; its mean was found to be 1.567 g/cm3 with CV of 0.789 %.

Table 2
The sieve analysis of the used sand.

Test sieve (mm)	>1.6	>1.0	> 0.8	> 0.63	> 0.50	> 0.25	> 0.125	> 0.08	< 0.08	Total
Weight (g)	0	2.88	34.81	20.85	21.81	15.82	3.31	0.52	0	100
(%)	0	2.88	34.81	20.85	21.81	15.82	3.31	0.52	0	100

2.1.4. Agricultural wastes

Based on availability of waste materials in Egypt, two types of agricultural wastes were selected as cotton and corn stalks (TS and CS). This waste was recovered from a field in Kafer Elshiekh Governorate; it was prepared for experiments by cutting it into small pieces, each 200 mm long. Mean values of its diameter of 11 and 19 mm, respectively, were recorded. The stalks have been dried naturally before preparation by placing them in the open sun during the intense hours of sunshine of the day. After drying, the moisture content on a wet basis was approximately ± 9.75% and ± 7.25%, respectively.

2.1.4.1. Agricultural wastes preparation

Cotton stalks and corn stems were washed in boiling water at 100 °C for 1 hour and naturally dried in the sun for 8 hours, then mercerized by immersing in an aqueous solution of 1.5 % w/w sodium hydroxide (NaOH) and hydrogen peroxide 30.0% w/w at room temperature for 48 hours. Afterword, the cotton stalks and corn stems were washed with water to remove excess NaOH. Finally, the cotton stalks and corn stems were dried naturally in the sunshine for 6 hours and stored for the next using.

2.1.4.2. Specimen's preparation mold

In this work, a rectangular plywood mold with inner dimensions of (300 × 200 × 50 mm) was used to mold the blocks for the next testing. The plywood used to manufacture the mold was wooden residues received from a furniture workshop inside the El-Gharbia Governorate, Egypt. The mold was constructed to be removed and installed by connecting the wooden sides by metal screws. Its top (300 x 50 mm) was opened to place the stalks or stems and pouring the cement mixture through. The wooden underside which had metal pins of (1.0 mm) in diameter, to help even out the placement of stalks or stems while pouring the cement mixture, the underside was facing the opened side. After pouring the cement mixture on the stalks, sufficient time is allowed to fully set, the mold was removed and the reinforced cement blocks removed for testing.

2.1.5. A *pressing apparatus*

For studying some mechanical and physical properties of the composite made from cement blocks and agricultural waste: The hydraulic press which was used to test the composites made from mixing cement blocks and agricultural stems is shown in Fig. 1. Pressure on the manufactured blocks was achieved by a press which was using double-acting pump with manual reset. The technical data of the hydraulic press are as follows, according to the manufacturer's catalogue, model: pm, press max.: 20 Mg, year of industry: 1996, caliber: 0.60 MPa, resolution: 2 MPa and the hydraulic press was manufactured by company SICMI sa., Trecasali (Parma), Italian.

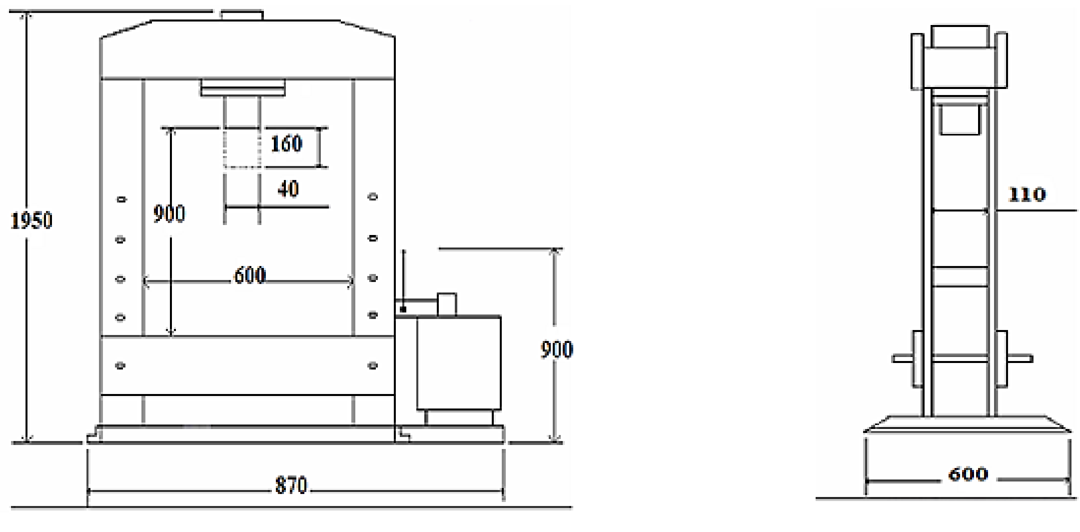

Fig. 1. Schematic diagram of pressing apparatus (dimensions in mm).

2.1.5.1. Pressing apparatus dial gauge calibration

The calibration of hydraulic press was carried out in the Research Center, Faculty of Agricultural Engineering, Al-Azhar University. The reference standard load cell and recording unit were used in the calibration process; the calibration process was carried out by the Force and Materials Metrology Department, Optical and Mechanical Metrology Division, National Institute for Standards, Ministry of Scientific Research and Technology, Cairo, Egypt. Table 4 shows the calibration results of the dial gauge reading of pressing apparatus, the pressing apparatus was calibrated and become adjusted to test the produced cement blocks (El-Bessoumy, 2005).

Table 4
Applied load (kN) related to dial gauge reading (El-Bessoumy, 2005).

Dial gauge reading MPa (bar)	2 (20)	4 (40)	6 (60)	7 (70)	8 (80)	10 (100)	12 (120)	14 (140)	16 (160)	18 (180)	20 (200)	21 (210)	22 (220)
Applied load (kN)	10.23	24.79	41.61	48.68	57.83	73.66	89.54	105.74	122.10	137.95	155.36	162.31	169.89

2.2. Mix design

The suitable ratio of each of the cement and sand to form the cemental mixture of CS mixture was choose based on volumetric percentages, the cement to the sand ratio in the CS mixture was cement: sand (1:6). While, the suitable proportion of water was used in the mixture formation which is ranged from 20-25 % of each mixture total volume. Since the main aim of this work was investigated for using agricultural wastes as a partially replacement in mixture of cement and sand as reinforcement materials in cement blocks manufacturing in developing country as Egypt. The usual mixture of cement-to-sand for sand-cement blocks is 1:6 as used with (Navaratnarajah and De Zoysa, 2018). Therefore, for control blocks, the cement and sand only proportion (1:6) in volume was used. Added to it, cement blocks that made with the four different percent volume ratios of replacement were investigated in that comparison. In each agricultural waste case, four different volumetric ratios of (5, 10, 15 and 20 %) were replaced by the same ratio from cement and sand mixture CS mixture.

2.3. Test procedures

Four replacement volumes of each cotton stalks and corn stems (TS and CS) were replaced with mixture of cement, sand and water (CS mixture) to investigate bulk density "Bd, kg/cm^3", the water absorbed ratio "Wa, %" and compressive strength "P, MPa" of composites made from cement blocks added with agricultural residues, which was influenced by the following variable: percent volume of replacement "PVR, %" and type of agricultural residues used.

2.3.1. Percent volume of replacement "PVR, %"

The mixture (CS mix) ratios by volume were added to four reinforcement ratios of each (TS) and (CS) by volume. The cotton stalks and corn stems volumetric ratios were 5, 10, 15 and 20 (%), in addition that ratio of (0 %) was without adding (TS) or (CS) as a control. Samples of 200 mm in length for each were taken from about 100 cotton stalks and corn stems; the average diameter of each of them was 19 and 11 mm, respectively. Depending on its average diameter and length, the volume of one stalk or stem was calculated for both (CS) and (TS), which the average volume of sample for each (CS) and (TS), were 56,677 and 18,997 cm^3, respectively. Four volumes of 5, 10, 15 and 20 % from the total mold volume used in the sample's preparation were calculated. The volumes of 150,300,450 and 600 cm^3 of TS or CS were required to achieve the replacement volumetric ratios of 5, 10, 15 and 20%, respectively. For achieving these previous replacement volumetric ratios, the total required number of stalks or stems was calculated to be used with each volumetric ratio. And it was clear that the corn stems required numbers were 3, 5, 8 and 11, respectively. While the required number of cotton stalks were 8, 16, 24 and 32, respectively.

2.3.2. Preparations for testing

The wooden rectangular mold was used for preparing cement blocks for next step. About 5, 10, 15 and 20% of cotton stalks and corn stems TS and CS by volume respectively, were arranged inside and placed vertically in the wooden mold. The mixture of CS mix was pouring inside the mold to take a place between and around stalks or stems and by placing the cement and sand mixture by volume in the bottom of the mold immediately after mixing. After about 8 hrs, the composite of CS mix and TS or CS was removed from mold. The produced composite of cement: sand mixture (CS mix) and TS or CS were removed from the wooden mold to be ready for testing. In this work, a total of 27 specimens were prepared which were 3 for control cement blocks and 24 for agricultural wastes materials added to cement blocks (12 cement blocks for each agricultural waste type). Three cement blocks each were used to determine the compressive strength, bulk density and water absorption percentage.

2.4. Experimental design

A combination of two types each of cotton and corn stalks and four proportions of each, added to the cement-sand mixture (1:6) resulting in eight treatments. Each treatment was replicated three times to give three replicates, resulting in 24 samples, plus three replicates for the control, resulting in 27 samples or blocks.

2.5. Measurements

All the cement blocks were left under an open shed for curing up for 28 days before they were taken to laboratory for testing. All the following measurements were carried out at a room temperature of 28°C and a relative humidity of 76 %. These measurements were achieved for each cement block.

2.5.1. Bulk density "Bd, kg/cm³"

The weight "M" and dimensions of each cement block were recorded. The block length "L" of 200 mm and the surface area "A" of 300 × 50 mm were used to calculate the bulk density "Bd" at various replacement ratios above according to the following equation:

$$\text{Bulk density (Bd)} = \frac{M}{v} \quad \ldots [1]$$

2.5.2. Water absorption percentage "Wa, %"

To obtain the water absorption of the cement blocks, the weight and dimensions of the cement blocks and those containing different agricultural waste were measured according to ASTM C140 (2017). Cement blocks which have 28 days' time, were dried in an oven at 100 °C for 24 h. Then, the cement blocks were stored indoor the laboratory until the surface temperature of the specimen becomes room temperature. The dried blocks are immersed completely in clean water at room temperature for 24 h. After removing the blocks from the water, the surface water wiped off and the weight of the cement blocks was recorded. The water absorption percentage was calculated by Eq. (2)

$$\text{Water absorption "Wa" (\%)} = \frac{M_w - M_d}{M_d} \times 100 \quad \ldots [2]$$

Where:

M_W: is the weight of the specimen at the fully saturated condition (g).

M_d: is the weight of the oven-dried specimen (g).

2.5.3. Compressive strength "P, MPa"

After 28 days, the compressive strength of cement blocks has been measured. The pressing apparatus with the previous technical specifications was used to carry out the test. Cement blocks, having the size of 300 × 200 × 50 mm, were tested in two directions, according to stalks position in the blocks, under vertical and parallel loading. A pressing apparatus was used by manual displacement control method to carry out the measurements. The load was applied to the cement blocks until failure occurred and the ultimate load was recorded. The cement blocks were tested with applied force to the parallel and vertical direction of the stalk's length. The values of applied force "F, kN" and compressive strength "P, MPa" were recorded; the data were analyzed after that, according to the device conditions.

3. Results and discussions

3.1. Percent volume of replacement "PVR, %" via bulk density "Bd, kg/m³"

Fig. 2 indicates, the relation between "RVR, %" and bulk density "Bd, kg/m³" for each TS and CS. It shows that bulk density is affected by percent volume of replacement (%). The bulk density decreased with increasing percent volume of replacement (%) for each TS and CS. The obtained data illustrated that, the bulk is decreased from 2230 to 2100 kg/m³ and from 2230 to 1840 kg/m³ by increasing percent volume of replacement (%) from 0 to 20 % for TS and CS, respectively. The percentages of reduction in bulk density for cement blocks made from cement mixture (CS mixture) and cotton stalks were about 1.79, 3.14, 4.93 and 5.83 % for replacements ratios of 5, 10, 15 and 20 %, respectively. Whilst the percentages of reduction in bulk density for cement blocks made from cement mixture (CS mixture) and corn stems were about 4.48, 9.41, 13.45 and 17.48 % for replacements ratios of 5, 10, 15 and 20 %, respectively. The reduction ratios of bulk density for corn stems are higher than the reduction ratios of bulk density for cotton stalks at different percent volume of replacement (%) and it is may be because of the differences in the average diameter of each TS and CS.

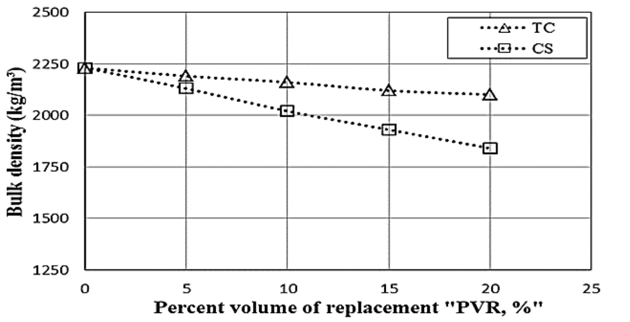

Fig. 2. Effect of percent volume of replacement "PVR, %" on bulk density at for (TS and CS).

3.2. Percent volume of replacement "PVR, %" via water absorption "Wa, %"

Fig. 3 shows the relation between "RVR, %" and water absorption "Wa, %" at different percent volume of reinforcements "PVR, %" for TS and CS. The figure shows that water absorption percentage is affected by percent volume of replacement (%). The water absorption percentage "Wa, %" increased by increasing percent volume of replacement "PVR, %" for TS and CS. The obtained data indicated that, water absorption percentage "Wa, %" increased from 1.28 to 5.06 % and from 1.28 to 12.04 % by increasing the percent volume of replacement (%) from 0 to 20 % for TS and CS, respectively. The percentages of increasing in water absorption "Wa, %" for cement blocks made from cement mixture (CS mixture) and cotton stalks were about 42, 57, 70 and 75 % for replacements ratios of 5, 10, 15 and 20 %, respectively. While, the percentages of increasing in water absorption "Wa, %" for cement blocks made from cement mixture (CS mixture) and corn stems were about 80, 84, 87 and 89 % at replacements ratios of 5, 10, 15 and 20 %, respectively. The increasing ratios of water absorption for corn stems are higher than the increasing ratios of water absorption for cotton stalks at different percent volume of replacement (%). From the previous results, it is clear that cotton stalks had lowest value of water absorption than corn stems, it is may be because of the porosity of cotton stalks are lower than corn stems.

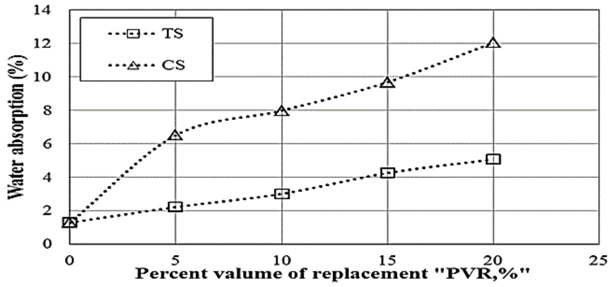

Fig. 3. Percent volume of replacement "PVR, %" via water absorption "Wa, %" for (TS and CS).

3.3. *Compressive strength "P, MPa" via "PVR, %"*

Figs. 4 and 5 show the relation between percent volume of reinforcement "PVR, %" and compressive strength "P, MPa" at two directions parallel and vertical "P and V" for TS and CS. The figures indicate that the compressive strength "P, MPa" is affected by percent volume of reinforcement "PVR, %" at the two directions for each TS and CS. Compressive strength increases with increasing percent volume of reinforcement "PVR, %" from 5 to 15 % and it decreased at 20 % at both two directions for each TS and CS. The obtained data in Fig. 4 illustrated that, the compressive strength is increased from 0.83 to 1.75 and from 1.58 to 2.26 "P, MPa" with increasing the percent volume of reinforcement "PVR, %" from 5 to 15 % at the two directions P and V, respectively. The compressive strength is decreased at 20 % in both of the two directions. The results showed that the lowest value of "P, MPa" was 0.83 and the highest value was 1.75 with increasing ratio of 53 % at parallel direction, while the lowest value of compressive strength "P, MPa" was 1.58 and the highest value was 2.26 with increasing ratio of 30 % at vertical direction for cotton stalks. On the other hand, Fig. 5 depicted that the compressive strength is increased from 1.05 to 1.65 and from 2.26 to 2.98 "P, MPa" with increasing percent volume of reinforcement "PVR, %" from 5 to 15 % at the two directions P and V, respectively. The compressive strength is decreased at 20 % at both of the two directions. The results showed that lowest value of "P, MPa" was 1.05 and highest value was 1.65 with increasing ratio of 36 % at parallel direction, while lowest value of compressive strength "P, MPa" was 2.26 and highest value was 2.98 with increasing ratio of 24 % at vertical direction for corn stems. From the previous results, it is clear that corn stems had highest value of compressive strength at vertical direction at 15 % and lowest value of compressive strength in parallel direction at 20 %.

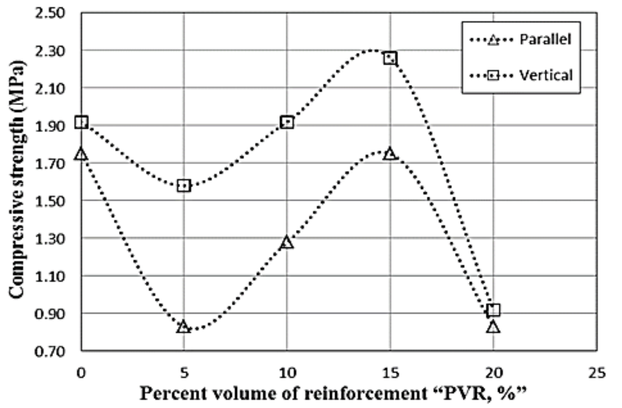

Fig. 4. Effect of "PVR, %" on compressive strength in two directions (P and V) for TS.

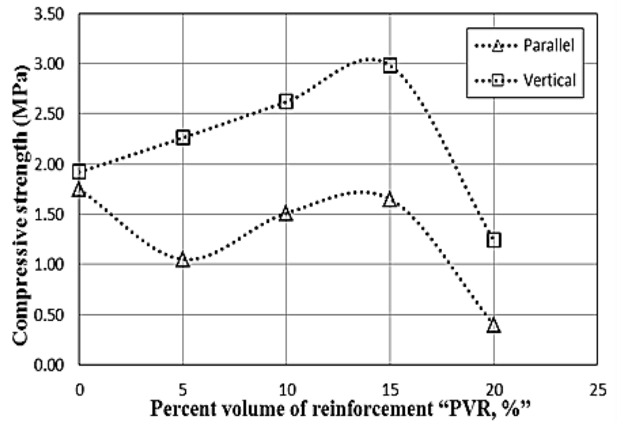

Fig. 5. Effect of "PVR, %" on compressive strength in two directions (P and V) for CS.

3.4. *Compressive strength "P, MPa" via bulk density "Bd, kg/m³"*

Figs. 6 and 7 show the relation between bulk density "Bd, kg/m^3"and compressive strength "P, MPa" at two directions parallel and vertical "P and V" for TS and CS. The figures indicate that compressive strength "P, MPa" is affected by bulk density "Bd, kg/m^3" at two directions for TS and CS. Compressive strength increases with decreasing bulk density "Bd, kg/m^3" from 2190 to 2120 and the compressive strength decreased at bulk density of 2100 kg/m^3 in both two directions for TS and CS. The obtained data in Fig. 6 illustrated that, the compressive strength is increased from 0.83 to 1.75 and from 1.58 to 2.26 "P, MPa" with decreasing bulk density "Bd, kg/m^3" from 2190 to 2120 at the two directions P and V, respectively. The compressive strength is decreased at decreased bulk density of 2100 kg/m^3 in both of the two directions. The results showed that lowest value of "P, MPa" was 0.83 and highest value was 1.75 with increasing ratio of 53 % in parallel direction, while lowest value of compressive strength "P, MPa" was 1.58 and highest value was 2.26 with increasing ratio of 30 % in vertical direction for cotton stalks. On the other side in Fig. 7, the compressive strength is increased from 1.05 to 1.65 and from 2.26 to 2.98 "P, MPa" decreasing bulk density "Bd, kg/m³" from 2130 to 1930 at the two directions P and V, respectively. The compressive strength is decreased at bulk density of 1840 kg/m³ in both of the two directions. The results showed that lowest value of "P, MPa" was 1.05 and highest value was 1.65 with increasing ratio of 36 % in parallel direction, while lowest value of compressive strength "P, MPa" was 2.26 and highest value was 2.98 with increasing ratio of 24 % in. From the previous results, it is clear that corn stems had highest values, better, of compressive strength at vertical direction and lowest bulk density values than cotton stalks; the highest value of compressive strength was 2.98 MPa at vertical direction and bulk density of 1930 kg/m³.

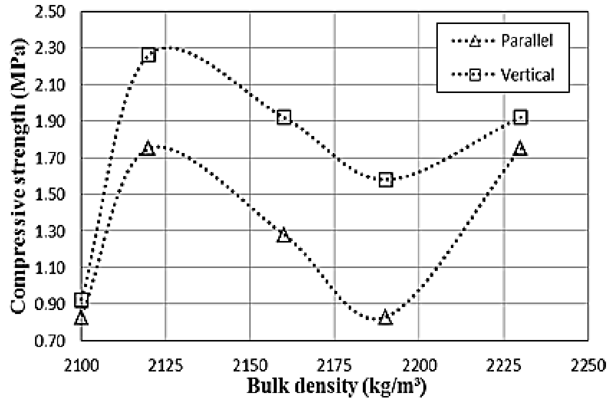

Fig. 6. Effect of bulk density on compressive strength in two directions (P and V) for TS.

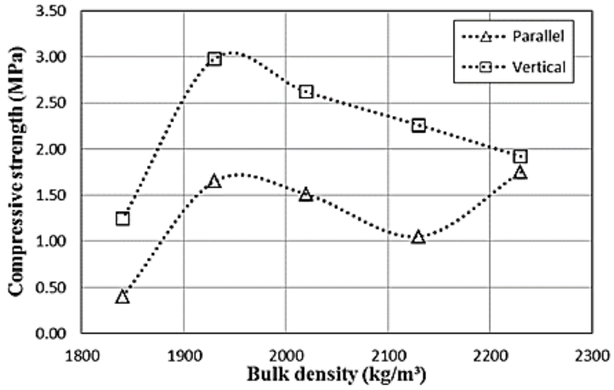

Fig. 7. Effect of bulk density on compressive strength in two directions (P and V) for CS.

4. Conclusions

This work aimed at evaluating the feasibility of producing cement blocks partially replacing the cement mixture (CS mixture) by each of cotton stalks or corn stems which, it is one of agricultural wastes. For each residue, the replacement percentages of 5, 10, 15 and 20% (V/V) were evaluated (separately), in addition to a formulation without the use of agricultural residues. Agricultural waste was treated for extractive removal and later evaluated based on their morphological, chemical and physical characterization. The cement mixture used was 1:6 (cement: sand) the quantity of used water in the mixture was about 20 – 25 % of total mixture volume. The cement blocks were evaluated for their bulk density, water absorption and compressive strength. Agricultural wastes used as reinforcement improved some physical and mechanical properties of cement blocks. Corn stems showed a greater potential for its use as reinforcement in cement blocks than cotton stalks. The formulation using 15% corn stems offered the best results, which allowed the blocks to present the lowest bulk density values, normal water absorption value and the highest compressive strength values, as well as being one of the best treatments when evaluating compressive strength, meeting all the commercialization standards criteria.

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تأثير استخدام المخلفات الزراعية في إنتاج بلوكات الأسمنت

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الملخص العربي

يعتبر التخلص من المخلفات الزراعية من أكثر المشاكل البيئية إلحاحًا في العديد من البلدان. إن العثور على استخدام اقتصادي لهذه المخلفات من خلال دمجها في منتج هو النهج المستخدم بشكل شائع للتغلب على المشاكل البيئية المرتبطة بها. ساعدت مشكلة

تراكم المخلفات الزراعية في الحقول في مصر إلى العديد من مشكلات التوازن البيئي. وقد أدى عدم تدبير كيفية استخدام هذه البقايا بطريقة تطبيقية مفيدة إلى تفاقم المشكلة مما جعلها في صدارة المشكلات البيئية. وحالياً يوجد مستويات عالية لتحويل المخلفات الزراعية بطرق مفيدة للمحافظة على البيئة والصحة العامة. ولقد أجريت هذه الدراسة في قسم هندسة المنشآت الزراعية والتحكم البيئي، كلية الهندسة الزراعية، جامعة الأزهر، القاهرة، مصر، لمعرفة مدى إمكانية استخدام سيقان القطن او الذرة في انتاج بلوكات الاسمنت لتحسين بعض الخواص الفيزيائية والميكانيكية لها. وقد تم انتاج تلك البلوكات عن طريق وضع (احلال حجمي) نسب حجمية ٢٠,١٥,١٠,٥ ٪ من حطب القطن والذرة كل على حدة والمقطع يدويا بأطوال ٢٠ سم مع خليط من الاسمنت والرمل بنسب (١:٦) وباستخدام كميه مياه من ٢٠ الى ٢٥٪ على اساس الحجم الكلى للخليط، في قالب سهل الفك والتركيب مصنوع من خشب الأبلاكاش بأبعاد ٥٠×٢٠٠×٣٠٠مم ومقارنته بمعامله بدون احلال (خليط من الاسمنت الرمل فقط). وقد أجري في هذا البحث حساب كلا من: النسبة المئوية لامتصاص الماء والكثافة الظاهرية وقياس مقاومة الانضغاط.

أظهرت نتائج الاختبار أن البلوكات الأسمنتية المصنوعة مع المخلفات الزراعية قد استوفت متطلبات القوة وفقًا للمعايير. تظهر بلوكات الأسمنت بسيقان القطن وسيقان الذرة خصائص قوة أفضل. أظهرت سيقان الذرة إمكانية أكبر لاستخدامها كمدعم في بلوكات الأسمنت من سيقان القطن. قدمت التركيبة التي تستخدم ١٥٪ من سيقان الذرة أفضل النتائج في مقاومة الانضغاط في الاتجاه العمودي (٢,٩٨ ميجا باسكال) عند الكثافة الظاهرية المنخفضة (١٩٣٠ كجم / م٣). كان امتصاص الماء في البلوكات الأسمنتية المصنوعة من المخلفات الزراعية أعلى من البلوك الأسمنتي المصنوع بدون مخلفات زراعية، لكنه كان في المعدل الطبيعي.