Performance of Mud Bricks with Shred Tires as Sustainable Construction Materials

Hamed Niroumand, Khairul Anuar Kassim
University Technology Malaysia

Abstract

This paper presents a survey on the role of the shred tires in the mud brick compressive strength. Mud brick construction is very compatible with the laws of ecology and harmonizing with the environment. Mud brick consists of clay, water and other different materials. The massive implementation of mud bricks in construction can make an evolution due to its low cost and its high compressive strength compared to concrete blocks, which are massively used nowadays. Many experiments have been recently conducted on mud blocks without additional materials, and they resulted in weak compressive strength. Therefore, many testing in mud bricks with different material were needed. Experiments on the role of shred tires in the compressive strength of the mud bricks were performed. The survey used this cheap material in the experiments, since it's considered as part of the environmental pollution and is not very used after the consumption in the automotive industry. The results showed an increase in the compressive strength of the mud bricks with shred tires.

Keywords *Shred Tires, Kaolin, Mud Bricks, Sustainable Materials, Recycle*

1 Introduction

Mud architecture is a traditional natural as a construction material, has a worthy status in terms of environmental impact. Due to the environmental friendly design, mud architecture gains advantages in saving natural resources such as mountains and forest, by using neither cement nor rock and sometimes only little wood. It saves the usage of other building materials, since it mainly consists of mud mixed with water. Mud construction offers durability and recycling ease, due to the subordinate materials that are mostly garbage for recycling (bottles, cans and newspapers). As a sustainable material, it has minimal energy demand, due to the cool interiors offered during the summer, by obtaining temperatures approximately 24°c to 26°c. Automatic temperature, which create warm interior in the winter are controlled by a passive cooling system. Minimal financial needs and an ease in construction makes it affordable for everyone. On the other hand, humidity is a crucial factor that causes damage and sometimes even fungus to the mud construction.

Mud bricks should be prepared in ideal conditions by using mud, which contains clay content in a percentage of not more than 80% and not less that 50%, while the rest consists of sand and granular material. The crystal structure of clays is very important to be understood, since it affects directly the performance of the mud brick resistance. Clay minerals are the hydrated aluminum silicates, which are classified into three main groups: the kaolin group, the montmorillite group and the illite group. Generally clay is characterized by an expanding crystal structure. The montmorillite group and the illite have an expanding crystal structure, while the kaolin clays do not have this kind of structure. Clays with expanding crystal structures expand in volume, when water is added to them and after water is evaporated, drastic shrinkage and cracking occurs. Thus, the mud bricks made of mud that contain kaolin clay (even in a high percentage) can cause only little cracking, since they don't have an expanding crystal structure. They are also very strong and offer a high heat resistance. Due to its not expanding structure it can show only little water damage, even if they get wet shortly after they have been made. Pure kaolin is white and usually is found at the subsurface of clay.

Mould consists in four boards nailed together with handles attached at either end. Firstly a selection should be done between a single and a multiple mould. The first choice is the single brick moulds, because it offers the possibility to tramp the soil very firmly. A special consideration should be given also to the size of the brick. In this research the brick used for the tests and experiments, were 0.1m high, 0.1m long and 0.1m wide.

Tire shreds are typically shaped and they have size variations that range from 0.01m to 0.25m long. The shredding process usually exposes the tire's internal steel belt or bead, particularly along the edges of the shreds. The average loose density of the tire shreds typically ranges from 39.88 kg/ to 55 kg/ . The

average compacted density ranges from 63.39 kg/ to 87.8 kg/ . Shred tires, are linked together by earth and they support the tensile strength in the mud bricks. Figure1 shown shred tires that used in tests.

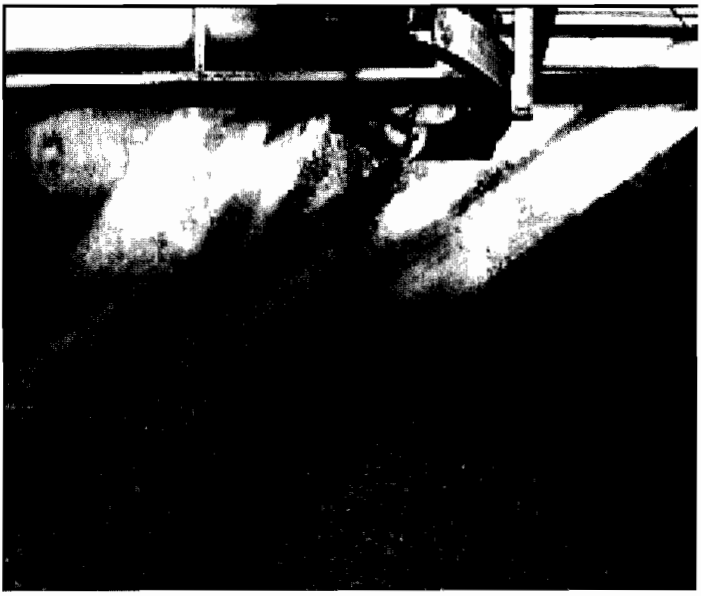

Figure1.View of Shred Tires

This research tested on compressive strength of shred tires reinforced mud architecture with moisture content of 20% in pure kaolin due to compaction tests on kaolin with different water content in geotechnical laboratory that they shown in Figure2.

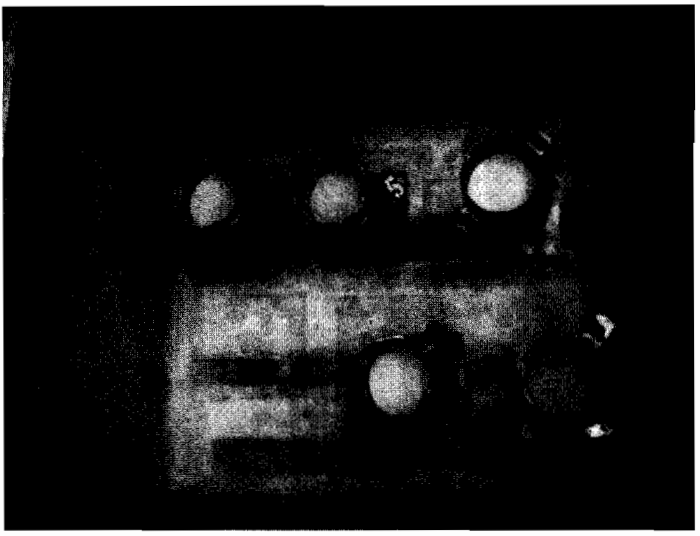

Figure2.Compaction Test of Kaolin

2 Experimental Test

2.1 Materials

The materials used in the test, conducted in this research were: pure kaolin, shred tires and water.

The Shred tires used were of the same size, since they were cut by a shredder tire. The shred tires were obtained from deterioration tires that are used in the vehicles, mainly cars. They consisted of cotton, which can be used for the tension condition in mud bricks. Tire recovery is the process of the recovery of the vehicle tires that cannot be used any more, due to the wear or any irreparable damage. These tires are among the largest and most problematic sources of waste, due to the large volume produced and their durability. The same characteristics that make waste tires so problematic also make them one of the most re-used waste materials, as the rubber is very resilient and can be reused in many other products. Approximately one tire is discarded per person on one year.

Most of the cost of these scrap tires were used to make automotive and truck tire re-treads with landfills, minimizing their acceptance of whole tires and the health and environmental risks of stockpiling tires. Thus many new markets have been created for scrap tires. Growing markets exists for a majority of scrap tires produced every year and they are supported by the State and Local Government [2]. Tires are also often recycled for use on basketball courts and new shoe products. However all the material recovered from the waste tires, known as "shred" is generally only a cheap "filler" material and is rarely used in high volumes.

The tire crumb in applications such as basketball courts could be better described as reused" rubber rather than "recycled".

The Kaolin used in the tests was pure one, without any addition material. It consists of a clay mineral with the chemical composition Al2Si2O5(OH)4. Kaolin is a layered silicate mineral, with one tetrahedral sheet linked through oxygen atoms to one octahedral sheet of alumina. Kaolin-type clays undergo a series of phase transformations upon thermal treatment in the air at atmospheric pressure. Endothermic dihydroxylation (or alternatively, dehydration) begins at 550-600 °C to produce disordered metakaolin, Al2Si2O7, but continuous hydroxyl loss (-OH) is observed up to 900 °C and has been attributed to gradual oxolation of the metakaolin. Because of historic disagreement concerning the nature of the metakaolin phase, extensive research has led to general consensus that metakaolin is not a simple mixture of amorphous silica (SiO2) and alumina (Al2O3), but rather a complex amorphous structure that retains some longer-range order (but not strictly crystalline) due to stacking of its hexagonal layers.

$$2\ Al2Si2O5(OH)4 \rightarrow 2\ Al2Si2O7 + 4\ H2O$$

Further heating to 925-950 °C converts metakaolin to a defect aluminuim-silicon spinel, Si3Al4O12, which is sometimes also referred to as a gamma-alumina type structure:

$$2\ Al2Si2O7 \rightarrow Si3Al4O12 + SiO2$$

Upon calcination to ~1050 °C, the spinel phase (Si3Al4O12) nucleates and transforms to mullite, 3 Al2O3 • 2 SiO2, and highly crystalline cristobalite, SiO2:

$$Si3Al4O12 \rightarrow 2\ Si2Al6O13 + 5\ SiO2$$

2.2 Mixing of Different Materials

The Figure3 shown combination of dry kaolin with the optimum moisture content, due to compaction test in different tests and then it is mixed by kneading until cohesive soil is reached.

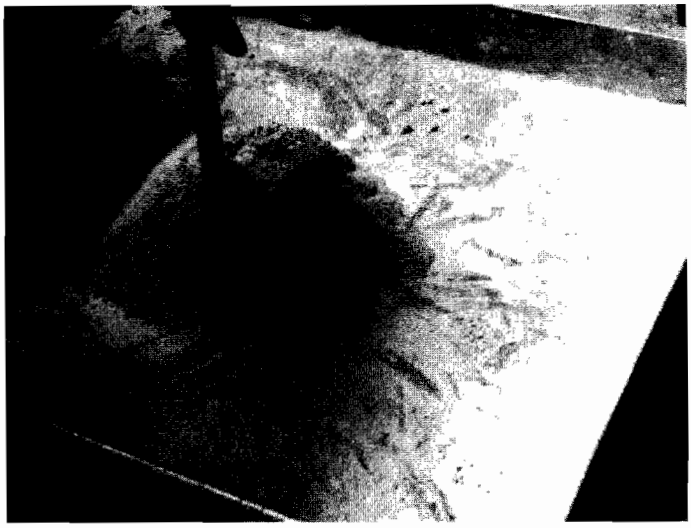

Figure 3.Mixing of Kaolin with optimum moisture content

2.3 Preparation of Mud Bricks

The dimensions of the bricks used for the test were 0.1m × 0.1m × 0.. The mixture prepared before, is placed in three layers in steel moulds. It consists of two layers of shred tires that are placed at the height 1/3 and 2/3 in the brick. The Figure4, Figure5 and Figure6 shown prepare procedure of mud bricks with shred tires.

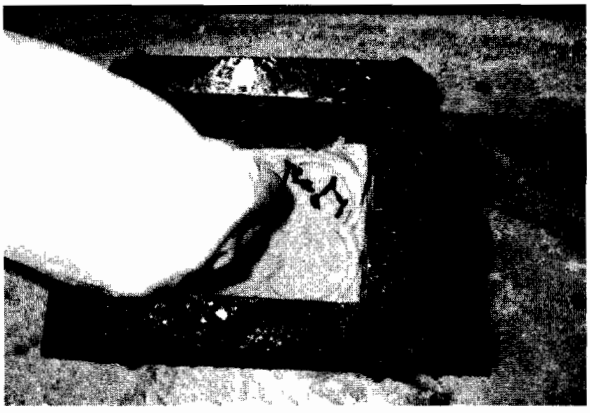

Figure4.View of Different Steps in Compressive Test

Figure5.View of 1/3 Layer of Mould

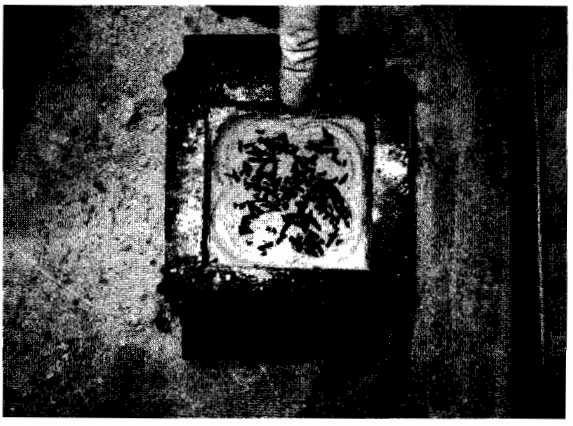

Figure6.View of Shred Tires In 1/3 Layer of Mould

2.4 Test of Mud Bricks

The mud bricks were prepared for 4 tests. After preparation, they were taken out from the moulds, and they were tested for their compressive strength in different days that tests shown in Figure7 and Figure8. The results of the tests of the compressive strength on mud bricks with shred tires obtained in days 3th, 7th, 14th and 21th are illustrated at table 1.

Table 1.The results of compressive test of mud bricks with shred tires

Type	Days				Water absorption (%)	Loss of weight (%)	
	3	7	14	21	3 days	4 - 14 days	15 - 21 days
Kaolin(10kg) + Water(2kg) +Shred Tires(0.06kg)	2.19 N/m	2.62 N/m	3.91 N/m	4.28 N/m	20.14	6.5	1.25

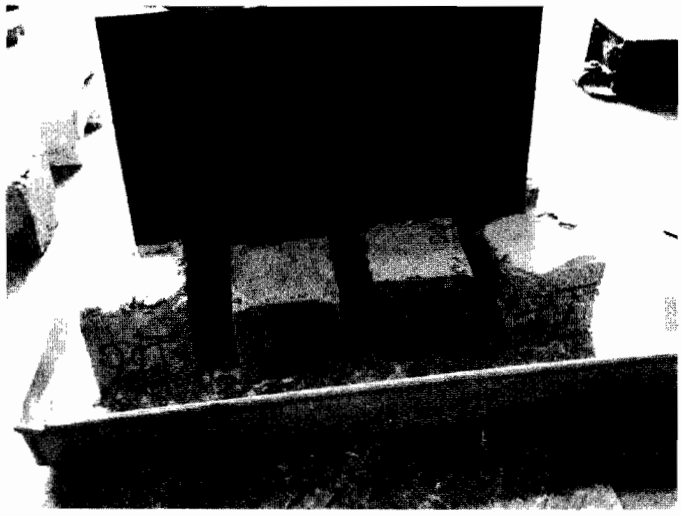

Figure 7.View of Different Cases in Compressive Test

Figure 8.View Compressive Test in Lab

3 Conclusion

The result of the compressive strength test conducted on the mud bricks with shred tires are illustrated in table 1. These results showed that the compressive strength of the mud bricks that contain shred tires increases with time. Shred tires increased the status of tension in mud bricks. In different cases shred tires increased the properties of the compressive strength of the mud bricks. It was observed that the interface layers of shred tires materials increased the compressive strength and geometrical shape gave the best result and this kind of mud bricks can be formed into different shape and size depending upon requirements, rendering it efficient as a sustainable material. The performance of the mud bricks without any additional material was very bad in the case of the earthquake that happened in Boroujerd (Iran) in 2007. We hope that the shred tires will be part of a massive implementation in the mud construction so it can offer a higher carrying out capacity in the future.

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