



Manufacturing of Tiles from Kieselguhr Sludge /Diatomaceous Earth/

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Abstract. Diatomaceous earth sludge this has a negative impact on the ecosystem because kieselguhr has some heavy metals which poison the environment and it has cementing behavior that cause desertification. But kieselguhr is able to produce the simplest unit of tiles and becomes beneficial for the process economy of the factories. The objective of this project was to prepared floor tiles from the brewery filtration by product so-called kieselguhr. The primary one was pretreatment of the brewery by product by the help of bases (NaOH) in order to make it neutralize. The next task was mixing of the raw materials (kieselguhr, sand, fifty percent cement water and aggregate) using their standard ratio. After this molding and drying of bricks has done. The required tiles must be with the require shape, so in this project the task of molding was done to give the shape for the bricks. Later, the tiles were dried using sun light from 1428 days to remove its moisture. The parameters which were checked during this project work were Compression strength, percentage water absorption, moisture content and density. The experimental result showed that it was not as expected to produce floor tiles from pure 100%kieselguhr in the replacement of cement, but by mixing through the percentage ratio of 50% of kieselguhr with the remaining percentage of cement was used to produce floor tiles. As the result showed the compression strength and the percentage water absorption mainly depends on the porosity.

Keywords: Aggregate · Cement · Floor tiles · Kieselguhr · Manufacturing · Sand · Tiles · Water

1 Introduction

The brewing spent kieselguhr is an industrial by product, in the sludge form, that is mainly composed by diatom frustules, yeast (fungi) and other organic matter (hop and malt) restrained in the filtration phase of the beer production process [2]. Kieselguhr also called diatomaceous earth or diatomite, is a non-metallic, soft, friable, fine grained and siliceous sedimentary rock that can be easily crumbled in to a white to off-white powder [3]. This powder shows a granular feel, and it is very light due to its high porosity [4]. Diatomaceous deposits are formed by sedimentation from silica bearing waters of unicellular algae called diatoms, [5] whose skeletons are made of cryptocrystalline silica associated to clay minerals and quartz as accessory components. Diatoms have quite complex structure showing numerous fine pores, cavities and

channels, reason why this material has low specific weight, low heat conduction, high specific surface area and high adsorption capacity [2]. As a filter medium, kieselguhr is currently used to separate very fine particles that otherwise pass or clog the filter net. This geometrical can be used as filter medium for water, juice wine, sprits, syrups, gelatin, sugar and several chemical substances [6]. Recently diatomite powder was sinterized around 1000% to manufacture ceramic monoliths with bimodal porosity and high strength. Scientists have studied the use of diatomaceous earth mixed with lime and gypsum to make autoclaved light weight bricks [2]. The beer industry has to find sustainable solution to prevent the environmental impact of kieselguhr waste deposition which carries sanitary and economic implication. The current eliminations of this by product is either its deposition on land fill or its spread over agricultural fields [7]. The procedures referred are not satisfactory with regard to sustainable development and environmental care. This study aims to manufacture floor tiles with recycled brewing spent kieselguhr in order to achieve a sustainable solution for the Environment and or for the byproduct incorporation without significant impact on the physico-mechanical properties of the floor tile material.

2 Methodology

Treatment of kieselguhr sludge: -For determining pretreatment of kieselguhr sludge 1.5 kg of kieselguhr sludge was mixed with 1000 mL of the NaOH under heating system in order to neutralize with holding time of 30 min and maximum cross pending temperature of 62.5° centigrade (boiling condition), the alkaline activation is carrying out on a stirrer. Afterward the sample solution is filtered and washed sequentially with deionized water five times to remove the salt ions and other residues. The resulting solid which is separated by the process of settling is finally dried at 105° centigrade for 24 h (Fig. 1).



Fig. 1. Treated kieselguhr powder after it discharges

Mixing process:- The washed and screend through three milimeter sand, aggregate, 50%kieselghure and cement together were mixed in a vessel folowed the standard values of C25 2:3:1 respectively (where C stands for compression). The mixing mechanisim was electricaly and it was processed at the standard values of temprature and pressure for 15minutes in the precence of slowly adding 2 liters of water.Genarally the mixing time and the amount of water to be used is depend on on the size of the part taken.

Molding and Drying: molding oftiles isthe mechanisims of giving shape for the tiles by letting the time from 24 to 72 h after puting the mixed ingradients on the molding box and then vibrating 26 min. Water was added durin mixing to increase wokability of the mixture and also after molding to sterngthn or to decrease its porosity by creating the hydrogen bond initially. So to remove this water drying mehanisim with 1428 days at the standard temprature and presure was recomended up to the calculated moisture content will be 10%. Then in this study the tiles had dried using sun light for 21 days (weight of tile at the end of the third week) at which the moisture content of the tiles was less than 10%.

$$\text{percentage moisture content} = \frac{W1 - W2}{W1} * 100 \quad (1)$$

Weight Composition of the Produced Tiles:- was the percentage composition of the raw materials which existed in the final produced tiles. This can be calculated using the following formula.

$$\text{Weight percentage composition} = \frac{\text{Component mas of each raw material}}{\text{Total mas of produced tiles}} * 100 \dots \quad (2)$$

Compression Strength test for Floor Tiles:- the mandatory strength for floor tile is compression strength. This is the resistance of the tiles to the compression force which was applied by compression mechanism, until the first cracking occurs. This was determined by putting the sample on the compression machine and reading the values (Fig. 2).



Fig. 2. Compression strength test

Density of Tiles:- was determined by dividing the weight of the sample to equivalent weight of water or volume of the sample. Then the dispersed volume of water due to the sample was 698 ml or 0.000698 m³.

$$\text{Density of the tile} = \frac{\text{mass of tile}}{\text{volume of tile}} \tag{3}$$

Determining Water Percentage Absorption Capacity of Tiles:- The produced tiles were dried in oven for 48 h at a temperature of 112° centigrade and cooling for 4 h at a room temperature and pressure in order to weigh (W1 of it). Then after it was immersed in clean water at a water bath with a temperature of 25° centigrade for 24 h. Finally it was removed from the water bath and the moisture was swept by clean cloth then and weighed in three minutes (W2). The percentage water absorption capacity of tiles was calculated by using the following formula (Fig. 3).

$$\text{Water percentage absorption} = \left(\frac{W2 - W1}{W1} \right) * 100 \tag{4}$$

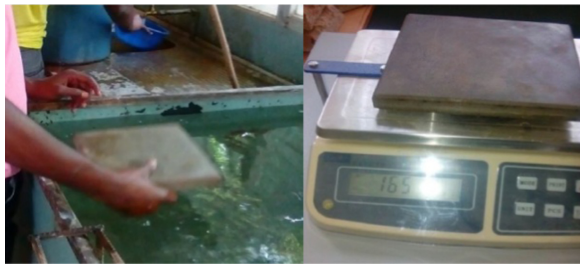


Fig. 3. Water absorption and weighing balance of the tile.

3 Characterizations of the Produced Floor Tiles

Table 1. Characterizations of the produced tiles

	Checked parameter	Obtained value	Recommended values
Ratio of kieselguhr (50% over cement)	Compression strength	4653.19 N	10005000 N
	% water absorption	5%	<20%
	Density	2177.7 kg/m ³	20002300 kg/m ³

The above Table 1 indicates that all the parameters were within the range of the standard values. Therefore, the floor tiles made up of this waste was acceptable in the aspect of those parameters.

Generally the methods that followed to produce the tiles from the byproduct of the brewery filtration so called kieselguhr sludge was as follows (Fig. 4).

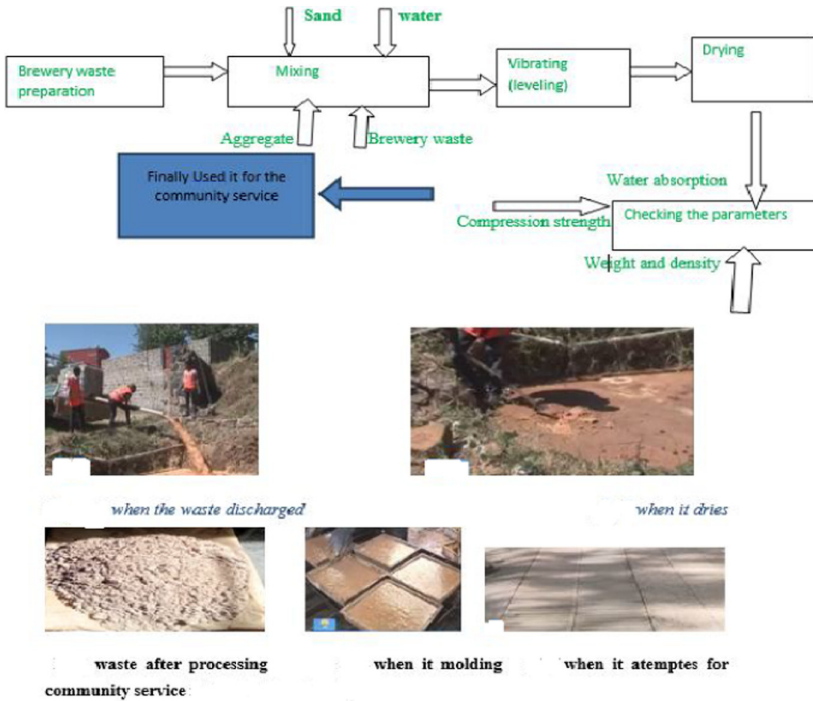


Fig. 4. General flow diagram of the entire process

4 Results and Discussion

The %moisture content of the produced tiles with respect to time was as follows.

W_1 (weight of tile at the beginning of the first week) = 1845 g

W_2 (weight of tile at the end of the second week) = 1652 g

W_3 (weight of tile at the end of the third week) = 1520 g

W_4 (weight of tile at the end of the fourth week) = 1416 g

Then the drying time at which the moisture content is less than 10% was calculated by using Eq. (1) (Fig. 5).

$$\text{Percentage moisture content (W2)} = \frac{1845 \text{ g} - 1652 \text{ g}}{1845 \text{ g}} * 100 = 10.46\%$$

$$\text{Percentage moisture content (W3)} = \frac{1652 \text{ g} - 1520 \text{ g}}{1652 \text{ g}} * 100 = 7.99\%$$

$$\text{Percentage moisture content (W4)} = \frac{1520 - 1416}{1520} = 6.8\%$$

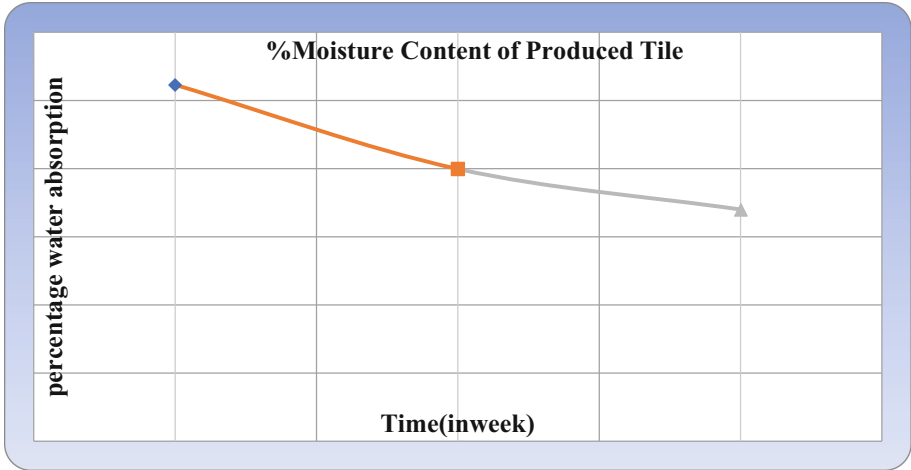


Fig. 5. Percentage moisture content of the tile

As it was seen from the graph when the time increased, the moisture content of the floor tile was decrease. This was due to the drying temperatures of sun light which makes to vaporize the water content. on the other hand, the weight of the tiles also observed to have inversely proportional with the drying time. This means when the drying time increases from week one to week four the weight of he produced tiles were decreasing from 1845 g to 1416 g.

Weight Composition of the Produced Tiles:- The dried tile had the following composition of sand, cement, kieselguhr and aggregate when the produced tile weight was 1.52 kg. The following calculated result was obtained through applying Eq. (2) (Table 2).

Table 2. Weight percentage compositions of the produced tile.

Ratio of kieselguhr sludge (%)	Raw materials	Mass of raw materials (k.g)	Mass of produced tiles	% weight composition
50	Sand	0.433	1.52	28.5
50	Aggregate	0.575	1.52	37.8
50	Kieselguhr	0.175	1.52	11.5
50	Cement	0.175	1.52	11.5

From this one can see that the percentage weight a composition of each raw material with the remaining percentage of water was found in the unit produced tile.

Density of Tile: The unit density of the produced tile was found using Eq. (3)

$$\text{Density of tile} = \frac{1.52 \text{ kg}}{0.000698 \text{ m}^3} = 2177.7 \text{ kg/m}^3$$

The obtained density was within the range the recommended values of tiles which is 2002300 kg/m³. Then in the aspect of this parameter the tiles which is produced from the kieselguhr sludge was acceptable.

Water Percentage Absorption Capacity of the Produced Tile: by following its method which is stated in methodology part the water absorption capacity of the newly produced tile was found to be 4.73% by using the equation of (4).

$$W_1 = 1620 \text{ g.}$$

$$W_2 = 1696.6 \text{ g}$$

$$\text{Water}\% \text{ absorption of tile} = \left(\frac{1696.6 - 1620}{1620} \right) * 100 = 4.73\%$$

This result shows the absorbing capacity of the tile 4.73% was much less than the recommended value (20%). This lower value of water absorption indicates the porosity of the produced tile was decreasing and then the compression strength increase.

Compression Strength:- During the compression strength test the first cracking of the produced sample was occurred at the 3952.6 Newton at the end of the week one and continue linearly up to week four (Fig. 6).

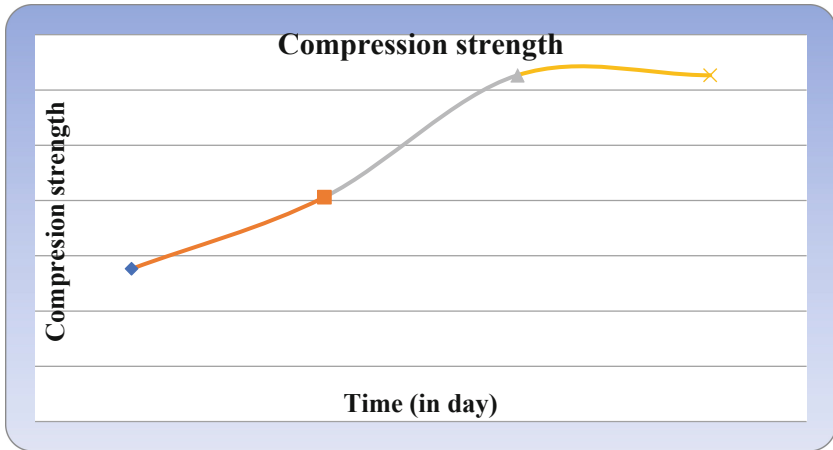


Fig. 6. Compression strength of the produced tile

As it was seen from the graph when the drying time becomes longer the compression strength also increased. This indicates that the porosity of the produced sample narrowed as the hydration bond or the particle were compacted.

5 Conclusion

Generally, the experimental result shows that it is possible to produce tiles from 50% kieselguhr over cement and use it for different services like walkways, compounds as a floor tiles.

Compression strength and percentage water absorption mainly dependent on porosity. Means the lower the porosity and %water absorption the higher the strength.

Manufacturing of tiles from brewery sludge (diatomaceous earth) can make the environment safe, increase the income of the company, create the work opportunity and minimize the cost of cement.

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