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Sand Brick Using Perlite As A Cement Replacement

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Abstract: Brick is a group or masonry or building material used for the construction of a building structure as a partition wall for a building or as a brick fence. At that time, almost no uses of perlite in the construction industry made perlite very uncommon. Perlite is commonly used in the agriculture or crop industry because of it has moisture content properties. The perlite material contains characteristics of light weight in the lightweight aggregate class. In this study, 0.0 %, 1.0 %, 3.0 % and 5.0 % of perlite material were used in sand brick mixing. In addition, three samples per test were performed to determine the optimal percentage. A total of 2 laboratory tests were carried out to achieve the planned objectives such as brick density and water absorption test. The inclusion of perlite had resulted in the lighter density of sand brick, yet higher water absorption rate.

Keywords: Expanded Perlite, Light-weight, Porosity, Raw material

1. Introduction

Brick is one of the most commonly used building materials in the construction of a building structure, and some even use this brick as the aesthetic value of the building they wish to exhibit [4]. No wonder many people out there love to use bricks as a key component in building a more comfortable and conducive home despite costing up of money [7]. At the same time, the features and features of the bricks showcase their unique uniqueness in terms of shape, colour or size. In addition, the quality of bricks also plays a very important role in the selection of bricks as a building material, as the quality of bricks is measured by the degree of bricks burning in the cracks so it cannot be destroyed again when immersed in water [7].

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In addition, demand for building materials is increasing today due to high market demand to meet the construction sector in particular [11]. As such, high market demand needs to be aligned with production in order to compete with the regional economy [2]. Therefore, various initiatives and innovations have been taken up by researchers to produce better brick and mortar inventions from various sources of materials [13]. The brick manufacturing process heating rate, soaking time and firing schedule were constant. The firing temperatures used are varied, from 800 °C to 1250 °C from [9] for brick improvement. The continuous extraction of clay and the removal of the topsoil for brick manufacturing cause substantial depletion of virgin resources [12].

Therefore, in this project the study focused on characteristic of sand brick and perlite as another replacement in building materials. Perlite in the industry is used as agricultural material because it has a material that can provide water content to the soil. Then every use of perlite needs to be replaced because all the perlite has not been used and only discarded. Perlite is one of the categories as fine aggregates is a volcanic surface with a glassy surface, water content of perlite is between 2.0 % and 6.0 % with weigh 30 kg/m^3 to 240 kg/m^3. Perlite contains relatively high silica of about 75.0 % [1]. Silica can also increase the bond strength of cement mortars in bricks indirectly improves the compressive strength of the brick product. In many developed countries, the use of perlite has been widely applied in the brick industry and as a heat resistant insulator in buildings and housing [5]. This is because the perlite material has a lower relative weight than the usual aggregate.

1.1 Objective

The purpose of this research is to assess the potential of perlite as a new alternative material to substitute cement content in a sand brick through water absorption,and weight performance. Water absorption are two major physical properties of brick that are good predictors of brick's ability to resist cracking of face [10].

This was performed at different perlite mix, which are 1.0 % 3.0 % and 5.0 %. The objective of this research is to evaluate sand brick physical properties by density test and to investigate the water absorption of sand brick. This research was carried out to address two main problems, which are cement content in the production of sand brick and perlite. Hence, the holistic study was performed to develop sand brick by perlite to the Construction sector. This research's leading scope is limited to the aspect.

1.2 Scope Study

This study uses perlite material as a major ingredient in the manufacture of sand bricks. The perlite material was chosen as the main medium for this sand brick material because the perlite material is readily available for the use of crops as additives to improve soil structure. In addition, this research also to study the density and water absorption of sand brick by using perlite as a replacement to cement by percentage. In fact, this research also identifies the quantities used in mixing sand bricks using perlite as well as studying and analysing the comparison between sand bricks (control) and sand bricks using perlite.

In addition, a test will be performed on perlite sand bricks to test of perlite sand bricks using molding 215 mm x 102.5 mm x 65 mm for each molding percentage [16]. Three percent will be used in this study were perlite comprising 1.0 %, 3.0 % and 5.0 %. This research will used 3 different percentage perlite of sand bricks test, this research will calculate the difference in mass between the three types of brick, this research to calculate dry density of the specimen and water absorbtion of brick.

2. Materials and Methods

Two type of material mainly used throughout this research, which are Perlite and sand. Both materials were mixed to produce perlite sand brick for sustainable construction.

2.1.1 Sand

Sand is naturally occurring granular material which is composed of mineral particles and finely material [6]. Natural river sand was used as fine aggregate is passed through 4.25 mm sieve size [15]. From the specific gravity test using pyknometer the result show the specific gravity of sand is 2.58.

2.1.2 Perlite

All this time industrial perlite waste is not been used as material. Perlite has high contain of silicate, which can be used as mixture material of sand brick. Application of lightweight brick for the wall is a substitution technique to reduce self weight of normal brick when using normal sand or aggregate. Perlite is one of lightweight aggregate which as lightest density [7].

According to [1] it can be used as insulator owing to its low heat conductivity. Perlite is a substance that contains 70.0 % to 75.0 % silicon dioxide, and 12.0 % to 16.0 % alumina. Other components are sodium oxide, potassium oxide, ferro oxide, manganese oxide, titan oxide and sulphide. Chemical components and weight batching ratios are given in Table 2.1.

Table 1: Physical properties of perlite [1]

Physical properties of perlite	
Components	Weight ratio (%)
SiO_2	71.0 - 75.0
Al_2O_3	12.5 - 16.0
Na_2O	2.90 – 4.00
K_2O	4.00 – 5.00
CaO	0.20 – 0.50
Fe_2O_3	0.50 – 1.45
H_2O	3.05 – 5.16
MgO	0.03 – 0.50
TiO_2	0.03 – 0.20
MnO_2	0.00 – 0.10
Cr	0.00 – 0.10
Ba	0.00 – 0.05
PbO	0.00 – 0.30
S	0.02 – 0.04

Expanded perlite is fire, heat and chemical resistant material that have porous structure. Porosity is determined as the average ratio between volume of pores and total volume of perlite grains. Porous structure gives perlite volumetric and surface absorption capability [3]. To prevent water pollution and to ensure insulation, water absorption is involuntary, because pores filled with water increase heat conductivity. Porous structure gives perlite surface absorption and lightweight property.

The unit weight of perlite depends on gradation and expansion. Generally, perlite is used in prefabricated constructions as filler owing to its lightweight property. The heat conductivity of dry

perlite that has unit weight of 90 kg/m^3 is calculated as 0.04 W/mK according to dry unit weight method. Fiberglass has heat conductivity of 0.037 W/mK at same temperature, in this manner perlite is a good insulator compared to fiberglass at same temperature. Perlite materials have advantage on sound absorption and insulation. A 5 cm thick perlite fill insulate 13 dB at 1000 Hz of sound. This is 12 dB for fiberglass and 13 dB for Styrofoam at same thickness. Some properties of expanded perlite are given in Table 2.

Table 2: Physical properties of expanded perlite [1]

Physical Properties of expanded perlite	
Colour	White
Melting point	1300 °C
Specific heat	0.20 kcal/kg °C
Unit weight	2.2 – 2.4 g/cm^3
Rough density	30 – 190 kg/m^3
Heat conductivity	0.034 – 0.040 kcal/m h °C
Sound insulating	18 db (125 Hz)

2.2 Methodology

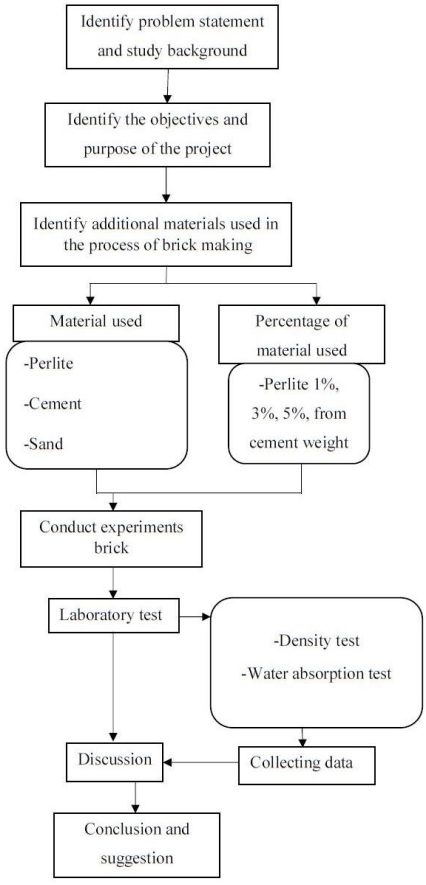

Figure 1: Methodology flowchart

2.2.1 Procedure

Work procedures are the steps or procedures to be followed when handling tools and materials used during the sand brick mixing process. Preparation for the work steps is done before the mixing work is done.

Figure 2: Planetary ball mill machine grinding Perlite to small particle

Sand and cement are weighed according to the calculations made for brick mixing. Before inserting the mix bricks of sand into the mold, the mold must be rubbed with oil to prevent lumps from sticking to the surface during the molding process. The well mixed compound is then inserted into a three-layer compressor mold, the top layer is flattened using scrapper. After 24 hours, the mold was removed and the bricks were taken and dried before the laboratory tests were performed on the bricks [8]. Repeated for brick mixing for 0.0 %, 1.0 %, 3.0 %, 5.0 % percentages of perlite.

Figure 3: Mixture of perlite by percentage inside mould brick

2.3 Equations

2.3.1 Density Test

Bricks which have already been curing will be weighed and the data on the brick weight will be divided by the dried brick volume.

$$\text{Density } (\rho) = \frac{\text{Mass of brick}}{\text{Volume of brick}} \qquad \text{Eq. 1}$$

2.3.2 Water Absorption

Bricks should not absorb water more than 12.0 % of their own weight. Three bricks for each percent of perlite were tested by placing the bricks in the oven at 105 °C to 115 °C for all bricks and cooled to room temperature (W1) before weighing. The cooled bricks were then immersed in clean water at 20 °C to 27 °C for 24 hours. The bricks are weighed using a weighing machine (W2). After test, the data

obtain from the test will compared to the Table 3 then it will be identify weather the data is between the standard range BS 3921: 1985.

$$\text{Water absorbtion in weight} = \frac{W1-W2}{W1} \quad \text{Eq. 2}$$

3. Results and Discussion

The expected outcome in this research is the replacement of perlite by percentage in cement will improved sand brick physical properties by density test and to investigate the water absorbtion of sand brick.

3.1 Density Test

Through a density study, the addition of a percentage of perlite to the sand brick mix has shown a significant reduction in average weight of the control sand bricks. This is likely because the nature of the perlite material itself is light and has a very low density as shown in Table 3.

Table 3: Density of bricks

Perlite percentage %	Average weight of sand bricks	Density (kg/m^3)
0	2.95	2059.427
1	2.79	1947.729
3	2.68	1870.937
5	2.59	1808.107

The density test results of hardened sand bricks were 1947.729 kg/m^3, 1870.937 kg/m^3 and 1808.107 kg/m^3 for each mix of sand bricks with a percentage of perlite material of 1.0 %, 3.0 %, and 5.0 % as part of cement compared with control sand bricks of 2059.427 kg/m^3. On the other hand, the result of the calculation of the density of the sand bricks shows that the density of the sand bricks is in accordance with Malaysian standard (MS 76: 1972) which is in the range of 1300 kg/m^3 to 2200 kg/m^3 in this study found to all the sand bricks produced recording density below 2200 kg/m^3. Figure 4 shows the graph of the density of sand bricks.

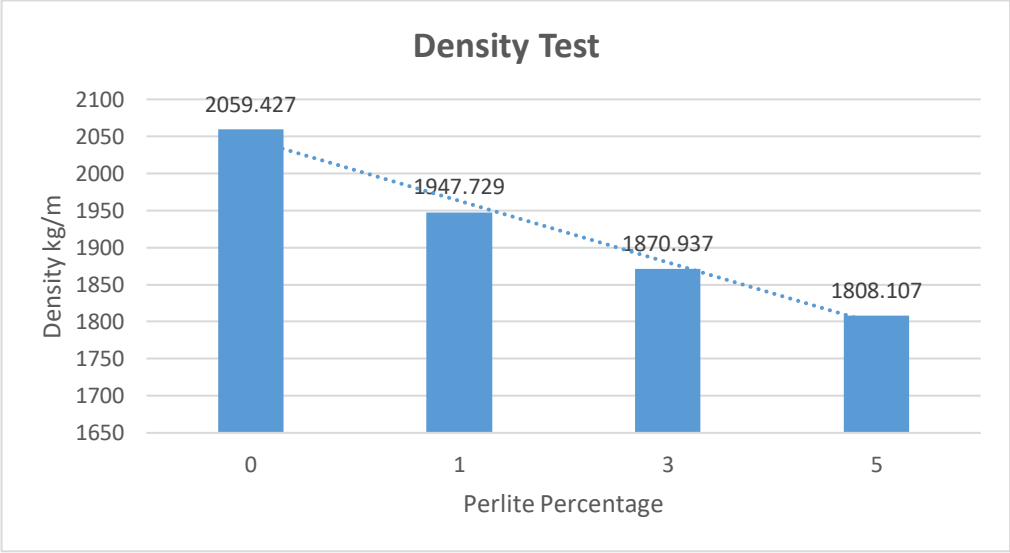

Figure 4: Relationship between Density and Perlite percentage

3.2 Water Absorption Test

The calculation of the rate of water absorption against sand brick mixed with the additives is very important because the percentages it can determine the minimum and maximum rates of water absorption allowed in the construction of a structure. Water absorption test was done based on the procedure given in MS 76:1972. This test performed with place sand brick in the oven for 24 hours at a constant temperature of 105 °C to 115 °C. Then, the sand brick was immersed in water for 24 hours. The percentage of water absorption of sand brick was obtained from each samples. Table 4 shows the result of water absorption test and the average value of four sample of the perlite ratio. Weight (B1) is taken when the brick is removed from the oven. Weight (B2) is the weight of a brick after being immersed in water for 24 hours. Table 4 shows the results of the rate of absorption of sand bricks for the additional percentage of perlite.

Table 4 : Result of water absorption test

Perlite percentage %		Weight (B1) (kg)	Weight (B2) (kg)	Water content (B2 - B1) (kg)	Water absorption percentage %	Average Water Absorption %
0	1	2.97	3.22	0.25	8.42	8.47
	2	2.93	3.18	0.25	8.53	
	3	2.95	3.21	0.25	8.47	
1	1	2.79	3.11	0.32	11.46	11.57
	2	2.85	3.15	0.30	10.53	
	3	2.75	3.10	0.35	12.73	
3	1	2.70	3.08	0.38	14.07	13.66
	2	2.70	3.05	0.35	12.96	
	3	2.65	3.02	0.37	13.96	
5	1	2.60	3.03	0.43	16.54	17.35
	2	2.58	3.05	0.47	18.21	
	3	2.60	3.05	0.45	17.31	

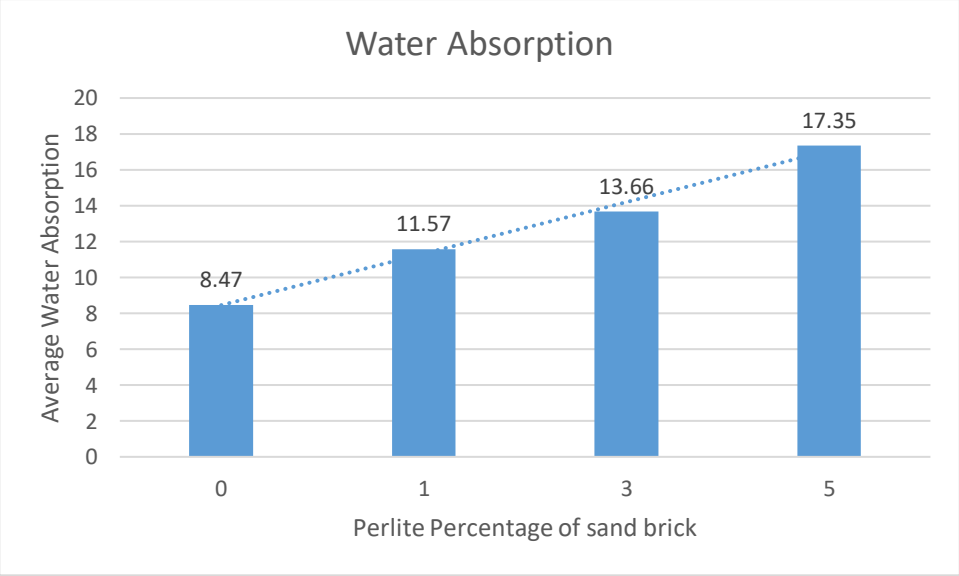

Figure 5: Relationship between average water absorption and perlite percentage

Water absorption rates for different percentages of perlite showed an average increase in water absorption rate for sand bricks compared to control sand bricks. In addition, the addition of a percentage

of perlite material in cement replacement has caused water absorption to occur on sand bricks. The mean water absorption results for the three bricks were 8.4 %, 11.5 %, 13.6 % and 17.3 % for the perlite percentage increase of 0.0 %, 1.0 %, 3.0 %, 5.0 %. Meanwhile, for the results of water absorption for sand bricks in reference to MS 76: 1972 standard shows no specific water absorption rate for sand bricks even in BS 3921: 1976 standard also indicates no specific water absorption rate classification for bricks with loadbearing features. However, the standards for Singapore Standard SS103: 197 indicate that the specification of elements as bricks must have a water absorption rate of not more than 25.0 %.

4. Conclusion

In this research, Sand Brick with perlite with differences ratio perlite and cement (1.0 %, 3.0 % and 5.0 %) were investigated.The weight of a masonry unit is very important in smoothing the ability of an employee in handling bricks to fit into an unloading vehicle. The density of the bricks was taken in the experiment to compare between mixed sand bricks with control sand bricks. The density of sand bricks shown as a result of the experimental results is low and can be said to be relatively light when compared to the weight of the control sand bricks.

Sand brick mixing design for cement replacement for the optimum percentage of 1.0 %. in the meantime, the use of perlite materials in the manufacture of sand bricks can be applied in the actual project site if able to analyze the additional minimum percentage for perlite materials as has been proven in this experiment.

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