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Mechanical and Physical Properties of Compressed Earth Brick Incorporation with Quarry Dust as Sand Replacement Material

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Abstract: The global sand issue is a major issue these days, and it has had a significant impact on the world in a variety of ways, including all the industry building. In terms of cost of materials in concrete mix including coarse aggregate is increasing from year to year. These study objectives are about use the quarry dust to produce brick as sand replacement. By reducing the quarry dust, definitely bring a good vibe to the environment. For the next objective to determine the optimum content of quarry dust as sand replacement material by percentage 0%, 25% and 50% of quarry dust. In this project, the product based on ratio 1: 4: 4 which is cement, sand and soil and total of 36 pieces of CEB sample have been design size of 250mm x 125 mm x 100mm. The test conducted on CEB are density test, water absorption and compressive strength have been tested at Laboratory of Brick and Concrete, University Tun Hussein Onn, Johor, Malaysia. As a result of the quarry dust after added 25% and 50% replacement, the percentage of density test was reduced. While, for 25 % and 50% replacement of quarry dust, the percentage of compressive strength and water absorption increased. Throughout the study, brick containing 50% quarry dust was shown to be the best mix design, with the highest percentage of compressive strength and the lowest percentage of water absorption when compared to other mix designs. Quarry dust has the potential to be used as a secondary source of natural fine aggregate and to decrease quarry dust waste in Malaysia.

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Keywords: Sand Issue, Quarry Dust, Compressed Earth Brick, Compression Strength, Density, Water Absorption

1. Introduction

This study is on an Industrialized Building System block type technology called an interlocking block or interlocking brick. The modular and rectangular sizes of the typical brick (0.1 m high, 0.125 m wide, and 0.25 m long). The interlocking materials are formed of soil, cement, and water, and the optimum soil composition for the bricks is sandy soil with 30% clay content and 70% soil content. Interlocking bricks are made out of soil, sand, and 10% cement. If the clay percentage in the soil is too significant, extra sand is applied to improve the proper proportions [1]. Following that, the mixture is squeezed in a hydraulic press machine, producing a firmly compacted brick. The bricks are stacked after 21 days of curing to allow the cement to set and connect with the sand, hardening the brick. The material's density and hardness are increased when the soil compresses. Because the bricks are joined and avoid horizontal movement between them, this interlocking brick is unlike ordinary bricks in that it does not require mortar for masonry building. The walling process may be accelerated and needs less skilled labor because the bricks are put dry and lock into place.

The construction industry's pace of development has increased the usage for construction materials such as sand and bricks. This sort of brick may be produced cheaper by substituting compressed earth brick for some of the quarry dust. One of the most common forms of garbage in the solid waste stream is rubbish, which poses a severe hazard to all countries. Its composition is not unique and is determined by construction techniques, building type, country, and a variety of other factors. Depicts the breakdown of waste across around countries into demolition waste, renovation waste, and construction waste. The existence of quarry waste will cause a lot of problems to country and the environment. This is due the breeding sites from mosquitoes which can cause disease such as there are numerous other connections between erosion, climate, and topography. When using quarry waste, it can be recycled to become a new product. This also can ensure the eco-friendly product was produce and apply 3R (Reduce, Reuse and Recycle) in construction. The CEB is a contemporary descendant of the adobe block, also known as the mold earth block. The concept of compacting earth to increase the quality and performance of molded earth blocks is not modern, and the first compressed earth blocks were made with wooden tamps [2]. If it is now shown that bonding CEB with binders and bitumen enhances mechanical strength and water resistance, the utilization of natural fibers as a construction material brings unique difficulties to science and technology [3]. The natural fibers sector has the issue of creating new technologies to make natural fibers easier to employ in the construction industry, where their inherent advantages allow them to compete effectively with synthetics.

Technically, quarry dust is used to make bricks, tiles, and premix. Quarrying plays an important role in a country's development because it provides raw materials for the construction sector [4]. Quarry dust has the benefits of being economical, easily available, decreasing pollution in the environment, and being a good substitute for river sand. As demand for these materials develops and resources become scarce, quarry dust might be a solution or alternative to natural sand in the construction industry [5]. Utilizing 50 percent quarry dust as a sand replacement better than using natural sand to make blocks [6]. Quarry dust has a similar strength characteristic to sand, in that both materials chemical compositions exhibit consistent strength qualities. The silica content is greater than 80%, resulting in excellent strength comparable to sand. The specific gravity and sieve analysis investigation indicates that quarry dust can be utilized as a sand replacement when the specific gravity of all crusher samples is between 2 and 2.7 (satisfies the sand conditions) [7]. In addition, using local materials in general, and earth blocks in particular, in the construction of dwellings is one of the ways to support the planet's long-term growth [8]. Numerous scientific studies on compressed earth blocks have translated this tendency toward earth building. The compressive strength of CEB is the most significant characteristic to consider when assessing its load-bearing qualities [9]. As a result, the physical properties of this parameter have received a lot of interest. The impact of compacting pressure and optimal manufacturing water content on the dry density and compressive strength of CEB. The impacts of binding CEB with a pozzolan binder [10] and lime [11] were investigated. It should always be observed that when the material is not exposed to water, stabilization is not required (protected walls, walls coated, interior walls, etc.). In fact, uncompacted compressed earth bricks have been found to have sufficient mechanical strength to be employed in building [12]. CEB's thermal characteristics have been researched, albeit only to a limited extent. Thermal conductivity and thermal diffusivity are affected by cement stabilization and water content [13]. The effect of replacement natural pozzolan and wood sawdust to stabilized compressed earth blocks on their thermophysical characteristics.

2. Methodology

The material preparation such as clay soil, sand or gravel, quarry dust, Ordinary Portland cement (OPC), and water were the components applied in this production. The clay soil was sourced from the Batu Pahat quarry. Quarry dust was produced from a granite quarry in Minyak beku, Batu Pahat, Johor, in the meantime. The quarry dust was dried in an oven at 100°C for 24 hours before sieving to pass the 1.2 mm sieve. Only quarry dust with a particle size of less than 1.2 mm was collected and stored in an airtight container.

The compressed earth brick was tested for material qualities and engineering properties as part of the experimental investigation. Prior to the creation of the compressed earth brick (CEB), the particle size distribution (sieve analysis) river sand and quarry dust were determined. The CEB's mix ratio is 1: 4: 4 (cement, sand, and soil), with a constant water to clay and cement ratio. Quarry dust was used to substitute river sand variable percentage 50% and 100% of the time in CEB production. The CEB with sand was utilized as a control brick. CEB is produced by thoroughly mixing a specified amount of dry quarry dust and cement, then continuously adding water until the mixture reaches a uniform texture. The liquid was then placed into a greased molds measuring 250mm x 125mm x 100mm and compressed at a pressure of 43 kN using a compression machine. CEB samples were placed at room temperature for 24 hours with a lid on to avoid moisture loss. To control the valuable of the produced CEB, all samples were tested for the compressive strength (BS 3921:1985), density (ASTM 6140), and water absorption test (ASTM90).

3. Results and Discussion

The performance of CEB is conducted in this experiment by analyzing at its density, water absorption, and compression value. Various tests were carried out to obtain this result, including sieve analysis to establish CEB workability and density testing to determine CEB density. Compressive strength to obtain compression value and water absorption tests are used to detect amount of moisture content in CEB.

3.1 Sieve analysis on quarry dust

According to figure 3.1, sieve analysis was used in this study to determine the size appropriation of granular material by passing it through a sieve with a dynamically smaller particle sizes and measuring the quantities of materials kept at every sifter as a tiny percentage of the total mass. Fine aggregate sieves are microscopic in size and have different aperture sizes at each level, such as 10mm, 5mm, 2.36mm, 1.18mm, 600um, 300um, 150um, and 75um. This material's grading has been verified to determine that it falls within the overall grading limit of BS 882:1983.

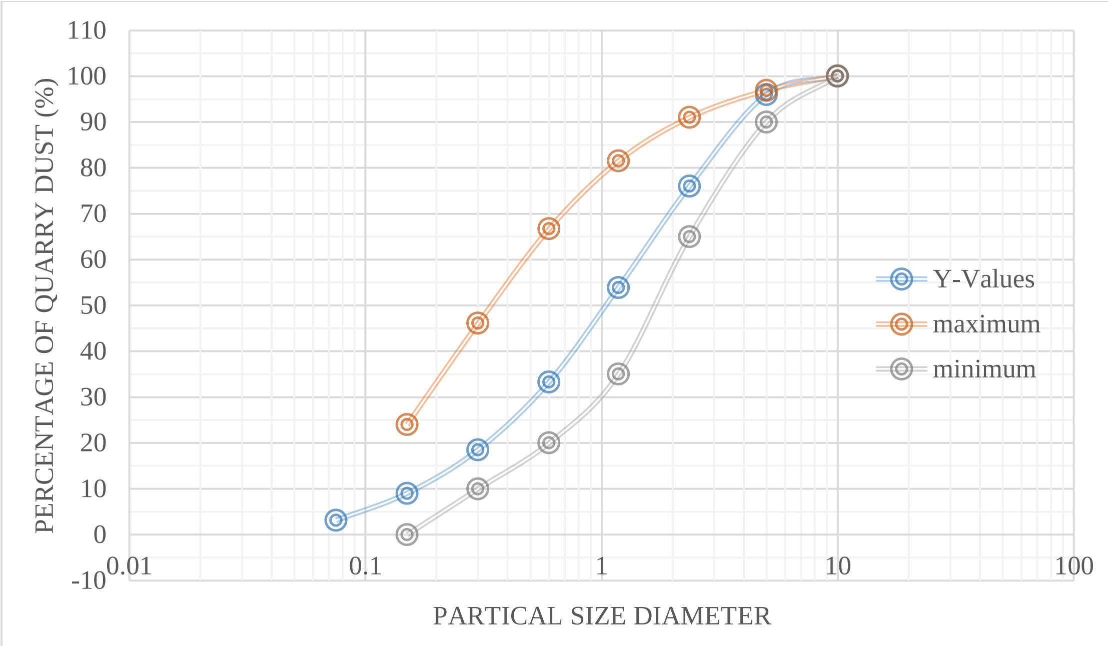

Figure 3.1: The grading curve for cumulative percentage passing

3.2 Density test

Figure 3.2 shows the density of the compressed brick. It was observed that the control brick sample had a greater density at all curing days than the fully-compressed earth brick at 25% and 50% quarry dust. According to the ASTM 6140 density test standard, all of the samples satisfy the specifications. Because there are fewer holes in the sample, a density brick has a higher strength. Because of their decreased water absorption, they have more strength and durability.

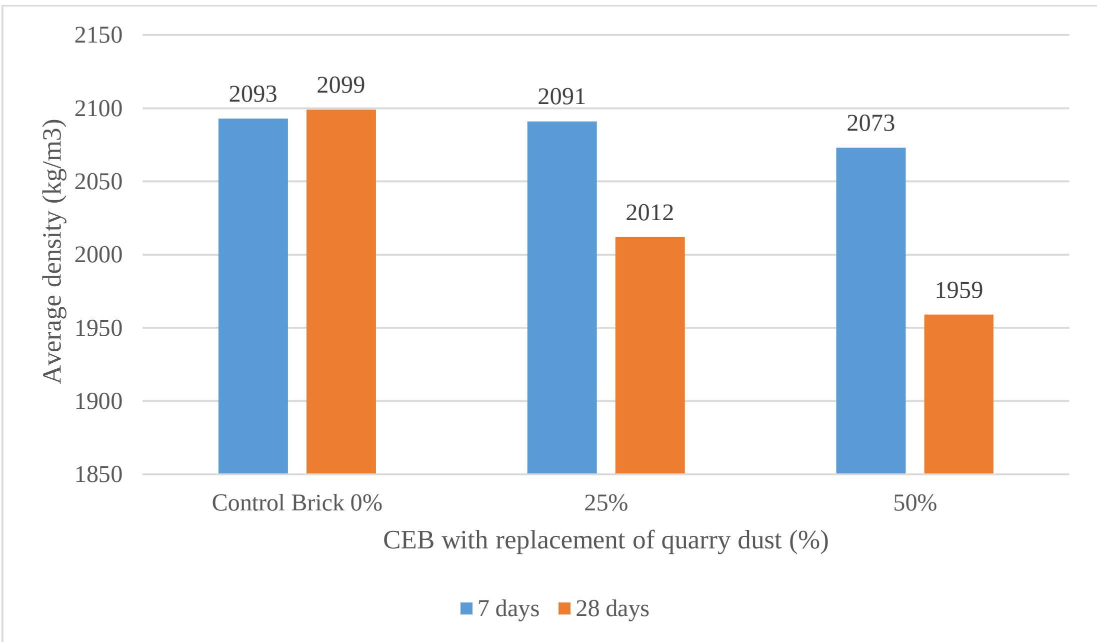

Figure 3.2: Bar chart of density test for 7 days and 28 days

3.3 Water Absorption

The amount of water absorbed by brick has a significant impact on its long-term durability. The material's quick disintegration would be accelerated by the significant water absorption. The water absorption values for control bricks are lower than for quarry dust bricks. This demonstrates that the amount of quarry dust in the mix has an effect on the resultant water absorption. However, the higher sand replacement with quarry dust reflected in enhanced water absorption by the brick. For a 28-day curing period, the highest amount of moisture absorption was found to be 15% for brick with a 25% quarry dust replacement.

Water absorption of bricks with different replacements of quarry dust reduces significantly from 7 to 28 days of curing, as shown in Figure 3.3. Due to the general curing process, the hydration process of cement has increased. Calcium oxide (CaO) combines with water to form calcium silicate hydrate (CSH), which fills the spaces between the particles in brick and renders it impervious to moisture after the hydration process is complete. Because of this, water absorption into the bricks was impeded. The brick had the lowest water absorption rate when sand was replaced with quarry dust at 50% for a 28-day curing time, and this was 11% lower than the control brick, which had a 10% water absorption rate. On the authority of the standard ASTM 90 which is not over more than 15% water absorption [14].

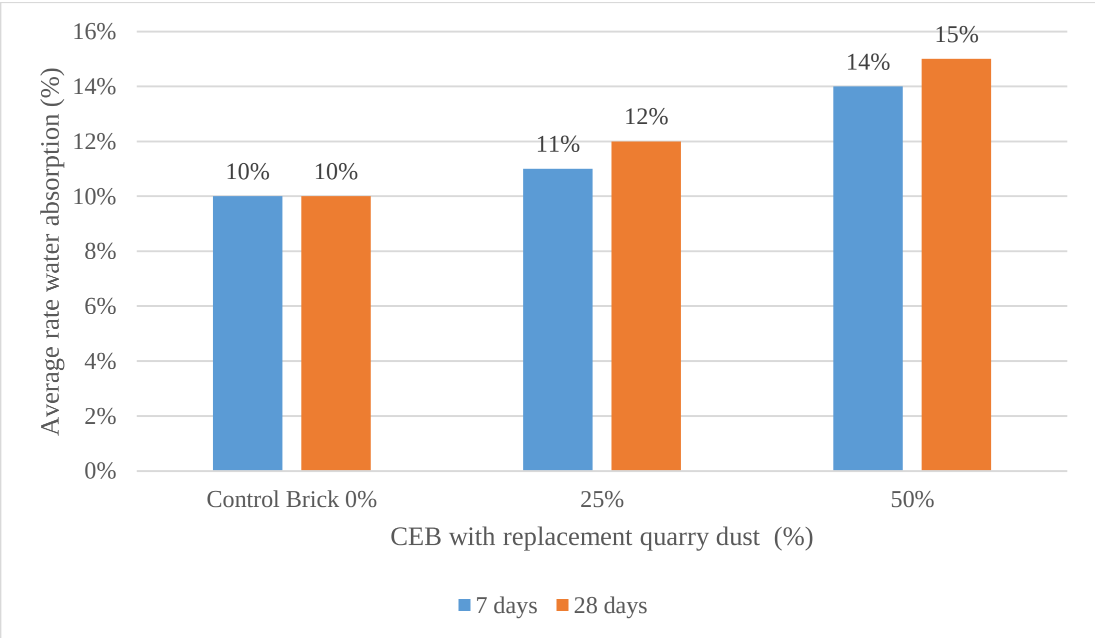

Figure 3.3: Water absorption for 7 days and 28 days

3.4 Compression strength

Based on figure 3.4, compressive strength for 25% and 100% replacement levels recorded higher compressive strength than control bricks for all curing ages. At 7 and 28 days, however, all products contain 50% quarry dust had greater compressive strength, with 2903.2 kN/m^3 and 4752.7 kN/m^3, respectively. This shows that a larger percentage of quarry dust replacements sand, resulting in a lower compressive strength. Furthermore, the improvement in compressive strength after 28 days for the samples containing 50% quarry dust suggested that the development of hydration products had resulted in a stronger bonding between the particles, which enhanced the pore structure of the specimen to have reduced absorption.

Generally, the compressive strength of a compressed earth brick does not support a heavy load because it is non-load bearing, according to the BS 3921-1985 standard [15].

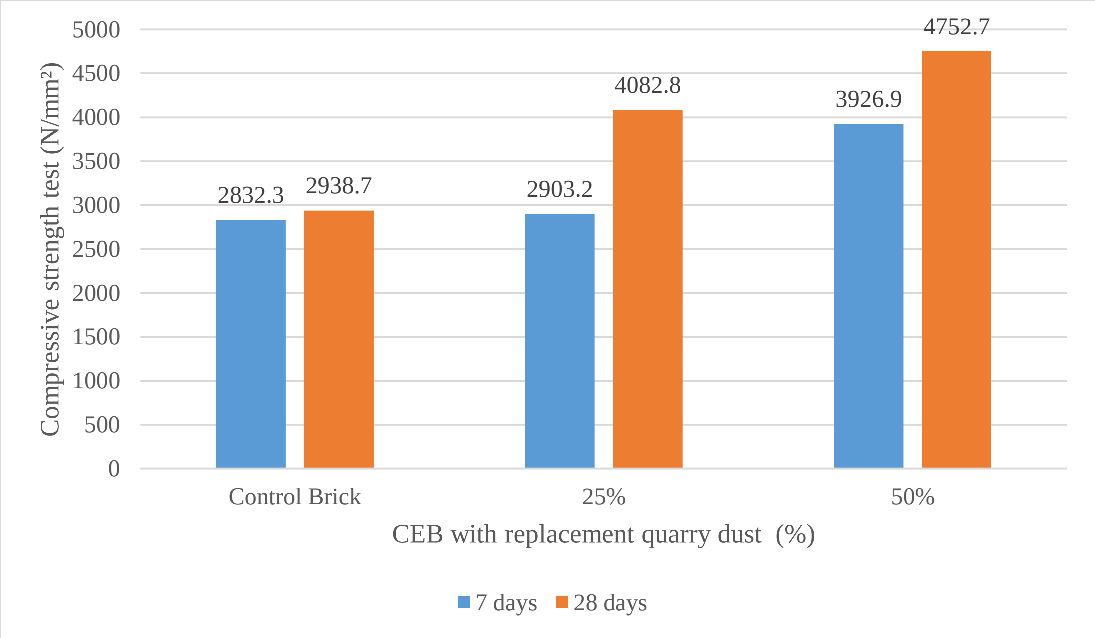

Figure 3.4: Compression strength for 7 days and 28 days.

4. Conclusion

The major findings obtained from the examined data were to establish the appropriate quarry dust replacement ratio in compressed earth brick. After the results of brick testing, such as density, compressive strength, and water absorption, the estimation must be taken into account. According to the results of the experiments performed in this study, the greatest percentage of quarry dust replacement to be applied to compressed earth brick was 50%. It's because the compressive strength of the bricks surpassed control bricks and other mix designs. This is the preferable criteria, which is based on standards.

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