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Technical Evaluation for Some Commercial Brick Types in Egypt

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Abstract

This study aims to assess the technical performance of commercial bricks production in Egypt. This evaluation is important for Egyptian construction industry sector. The technical evaluation focused on bricks properties such as bricks dimensions, bricks density, compressive strength, and water absorption to determine each brick's suitability for various applications, including structural load-bearing and energy-efficient building. The results revealed that, the maximum red clay brick length was 22.04 ± 0.114 cm for Albadr company, while the minimum red clay brick length was 16.243± 0.355 for Alhoda company. The greatest red brick density was 1.856 ± 0.096 gram/cm^3 for Alhoda Company, while the least brick density was 1.312± 0.054 gram/cm^3 for Albadr Company. Additionally, the maximum water absorption rate was 15.139 ± 3.177 % for Alhoda Company, while the minimum water absorption rate was 7.6± 0.548 % for Banha Company. Finally, the greatest compressive strength was 1.458 ± 0.590 kN/cm^2 for bricks produced by Alhoda company, while the least compressive strength value was 0.491± 0.041 kN/cm^2 for Mashour company. The maximum price was 2000 EGP for bricks produced by Mashhour Company, while the minimum price value was 1600 EGP for Alhoda Company.

Keywords: Red Bricks, Concrete Bricks, Bricks dimensions, Bricks density, Compressive Strength, Water Absorption.

Introduction

The Egyptian construction industry relies heavily on a variety of brick types due to the country's urban expansion and increasing demand for durable, cost-effective building materials. The main types of bricks used include red clay bricks, cement bricks, fly ash bricks, and AAC (Autoclaved Aerated Concrete) bricks. These materials serve diverse functions depending on load-bearing requirements, environmental impact, and cost-efficiency **(El-Gendy et al., 2019)**.

Research demonstrates that red clay bricks, due to their high compressive strength, are primarily used in load-bearing applications. A study by **Ahmed & Mahmoud (2021)** emphasizes the longevity of red clay bricks, making them a traditional favorite in Egypt, although their production is energy-intensive and environmentally impactful. Meanwhile, cement bricks are increasingly popular for partition walls because of their cost-effectiveness and simpler manufacturing processes, reducing both costs and energy requirements **(Construction Economics Journal, 2018)**.

Fly ash bricks, made using industrial by-products, have gained attention as a sustainable alternative that promotes waste reduction, aligning with global shifts toward sustainable construction practices **(Ibrahim, 2021)**. AAC bricks stand out for their lightweight and insulation properties, which make them suitable for energy-efficient buildings, despite higher initial production costs **(Hassan et al., 2020)**. While earth bricks have a good insulation specially when reinforced with natural fibres **(Ashour et al., 2010, Ashour and Wu 2010, Ashour et al., 2015, Zak et al., 2015)**.

This study aims to provide construction companies, manufacturers, and policymakers with the data needed to make informed material choices that optimize structural performance, cost, and sustainability **(Abdelrahman, 2021)**. Understanding the specific benefits and limitations of each brick type will help guide the construction industry toward more effective, environmentally-friendly building solutions.

Previous studies emphasize the need to select materials that balance technical, economic, and sustainability factors. For example, **Ahmed et al. (2019)** identified red clay bricks as ideal for structural applications due to their compressive strength but highlighted their environmental impact due to the kiln-firing process. Cement bricks, in contrast, were found to be cost-effective for high-volume projects but were noted to be unsuitable for heavy structural uses **(Construction Economics Journal, 2018)**. Fly ash bricks and AAC bricks have been identified as sustainable options due to their environmental benefits. Fly ash bricks reduce landfill waste and utilize recycled materials, while AAC bricks offer energy savings through insulation properties **(Abdullah et al., 2021)**. So, this research evaluates each brick type's technical performance which focus on compressive strength, bricks dimensions, bricks density, and water absorption.

2. Materials and Methods

To perform a comprehensive technical evaluation of the primary brick types used in Egyptian construction. Laboratory testing provided objective, quantitative data on the bricks properties, compressive strength, water absorption properties of each brick type.

2.1 Materials

2.1.1 Manufactory process

The brick materials were mixed in a ratio of 2 brown clay : 1 yellow clay : 1 sand. The water is added to the mixture and then goes to a mixer for thorough blending of the components. After then, it passes through a press in a mold to determine the brick's dimensions and height before being cut to the desired length and width. The bricks are left to dry in the sun (open air) for 5 to 6 days, depending on the weather temperature. After drying, bricks are placed in a gas-fired kiln. The kiln doors are sealed with clay. The kiln operates by arranging the bricks properly and then covering them with clay. Finally, red powder is sprinkled on the surface. There are openings on the surface that lead inside the kiln, where gas pipes are inserted to provide the required heat for firing the bricks. Inside the kiln, there are tunnels that absorb the rising smoke, which is then expelled through an exhaust as showed in Fig.1.

Fig.1. Industry process steps of bricks preparation.

2.1.2 Brick dimensions

Brick dimensions were measured by using a tabular tap.

2.1.3 Brick weight

Brick weights were measured by weighing the brick on a balance with an accuracy of ± 0.005 kg.

2.1.4 Compression test device

Compression test was done according to ASTM C 109/C109M. Fig.2 illustrates photograph of the compression test machine.

Fig. 2: Compressive strength testing machine.

2.2 Methods

Samples of each brick type were collected from certified manufacturers in Egypt to ensure uniformity and adherence to the standards outlined in the Egyptian Building Code. Tests were conducted on 5 samples of clay bricks as replicates from different companies. The laboratory test includes bricks dimensions (length, width and height), weight, density, water absorption and compressive strength.

2.2.1 Bricks dimensions and weight

Five bricks were used to measure length, width and height as shows in Fig.3.

Fig.3. Measuring the dimensions of bricks.

The bricks volume was then determined using the following equations.

$$\text{Brick volume } (V) = L.B.T$$

Where,

L: brick length (cm)

B: brick width (cm)

T: brick height (cm)

2.2.2 Bricks density

The brick density was calculated using the following formula:

$$\rho = \frac{W}{V}$$

Where,

ρ : Density (kg/m^3)

W : Weight of the brick (kg)

V : Volume of the brick (m^3)

2.2.3 Water absorption of brick

The water absorption test assesses a brick's ability to resist moisture, which is crucial for durability, especially in humid or coastal environments. Bricks with high water absorption can experience structural deterioration over time due to water retention and freezing-thawing cycles.

Brick samples were initially oven-dried and weighed to establish a baseline dry weight. Each brick was fully submerged in water for 24 hours according to ASTM C140 standards. After the soaking period, samples were removed, surface-dried, and weighed to determine the wet weight. Water absorption was calculated using the formula:

$$\text{Water Absorption (\%)} = \left(\frac{\text{Wet Weight - Dry Weight}}{\text{Dry Weight}}\right) \times 100$$

Water absorption rates indicate each brick type's suitability for humid conditions. Fly ash bricks, with low water absorption, demonstrated better moisture resistance, making them ideal for humid or coastal regions, as supported by **Abdullah et al. (2021)**. Red clay bricks and AAC bricks exhibited higher absorption rates, necessitating additional treatments for use in moisture-prone environments **(Ahmed et al., 2019)**.

2.2.4 Compressive strength

The compressive strength test measures a brick's ability to withstand loads, an essential property for bricks used in load-bearing applications. Higher compressive strength indicates that, the brick can endure greater loads, making it suitable for structural applications. Samples of each brick type were collected from certified manufacturers in Egypt to ensure uniformity and adherence to the standards outlined in the Egyptian Building Code. Laboratory methods followed international standards according to ASTM (American Society for Testing and Materials). Brick samples were dried and prepared according to **ASTM C67** to ensure uniformity.

The compressive strength test used a universal testing machine to measure each brick's load-bearing capacity. The compressive strength of the bricks was measured on five brick samples as replicates as showed in the following figure**:-**

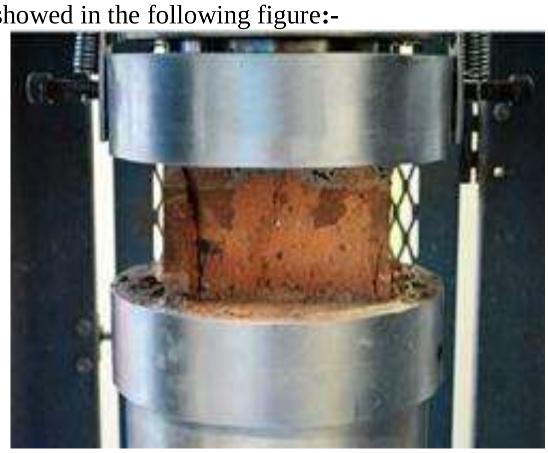


Fig. 4. Compression test machine.

The laboratory testing phase allowed for a direct comparison of technical performance indicators across the brick types, providing data critical for assessing each type's suitability in structural and climate-specific applications. This method has been validated by similar studies, such as those conducted by **Hassan et al. (2020)** and **Ahmed et al. (2019)** on the compressive strength of red bricks.

2.2.5 Bricks price

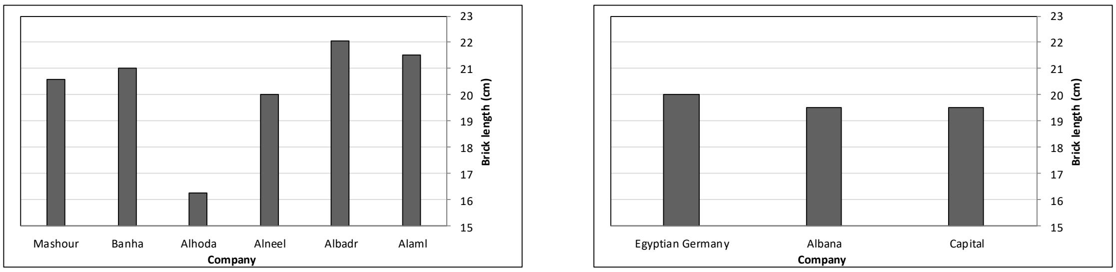
In this parameter, the price of 1000 bricks for different companies were collected. The bricks price was in EGP (Egyptian pound).

3. Results and Discussions

3.1 Brick length

Fig.5a shows the average of red bricks length for different companies. The maximum length was 22.04 ± 0.114 cm for Albadr company, while the minimum red brick length was 16.243± 0.355 for Alhoda company. The red bricks length were 21.5± 0, 20±0, 21±0 and 20.6±0.418 cm for Alaml, Alneel, Banha and Mashour companies respectively.

On the other hand, the results revealed that, the maximum length of cement bricks was 20 ± 0 cm for Egyptian Germany company, while the minimum brick lengths was 19.5± 0 for Capital company (Fig.5b).

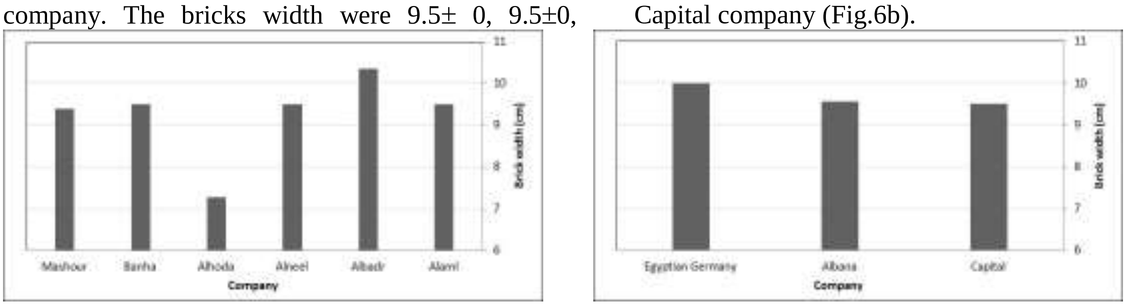


a) **b)**

Fig. 5. Bricks length distibution for differen companies, a) red bricks, b) concrete bricks.

3.2 Brick width

Fig.6a illustrates the average of red bricks width for different companies. The highest red brick width was 10.36 ± 0.167cm for Albadr company, while the least red brick width was 7.271± 0.229 for Alhoda company. The bricks width were 9.5± 0, 9.5±0, 9.5±0 and 9.4±0.224 cm for Alaml, Alneel, Banha and Mashour companies respectively. While, the results revealed that, the highest width of cement bricks was 10 ± 0 cm for Egyptian Germany company, while the least brick width was 9.5± 0 for Capital company (Fig.6b).

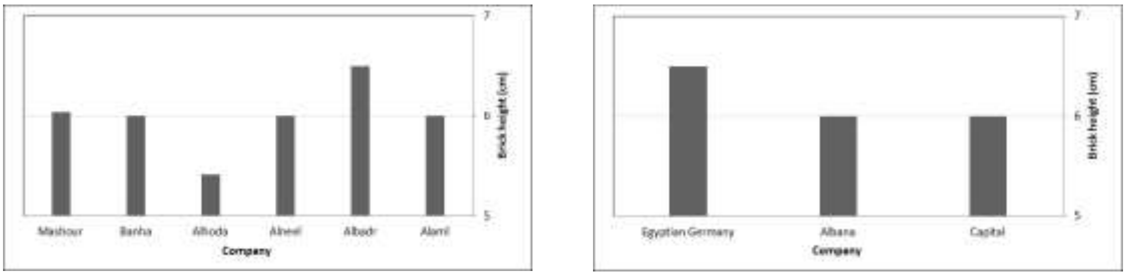


a) **b)**

Fig.6. Bricks width for different bricks production , a) red bricks, b) concrete bricks.

3.3 Brick height

Fig.7a illustrates the average of red bricks height for different companies. The maximum red brick height was 6.5 ± 0.071cm for Albadr company, while the minimum brick height was 5.414± 0.324 for Alhoda company. The bricks height were 6±0, 6±0, 6±0 and 6.04±0.089 cm for Alaml, Alneel, Banha and Mashour companies respectively. In addition to, the results revealed that, the maximum height of cement bricks was 6.5 ± 0 cm for Egyptian Germany company, while the minimum brick height was 6± 0 for Capital company (Fig.7b).

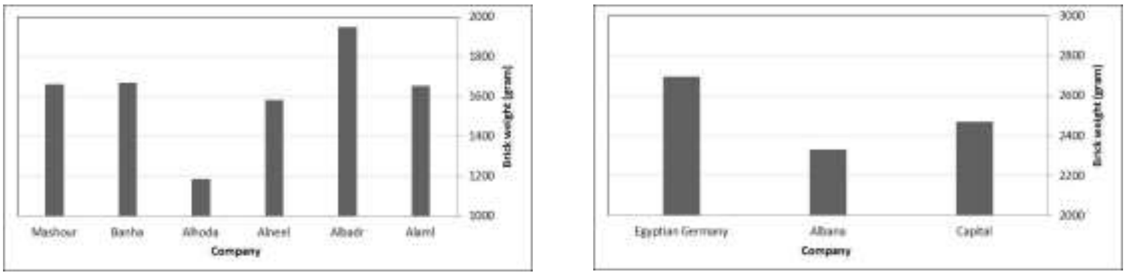


a) b)

Fig. 7. Bricks height dimension for different companies, a) red bricks, b) concrete bricks.

3.4. Bricks weight

Fig.8a showed the average of red bricks weight for different companies. The maximum red brick weight was 1947.236 ± 32.67 gram for Albadr company, while the minimum brick weight was 1186.429± 88.962 gram for Alhoda company. The bricks weight were 1654.667± 31.66, 1584 ± 17.088, 1668.33 ± 8.505 and 1663±0.011 gram for Alaml, Alneel, Banha and Mashour companies respectively. While, the maximum weight of cement bricks was 2697 ± 38.01gram for Egyptian Germany company, while the minimum brick weight was 2331.7± 25.146 for Albana company (Fig.8b).

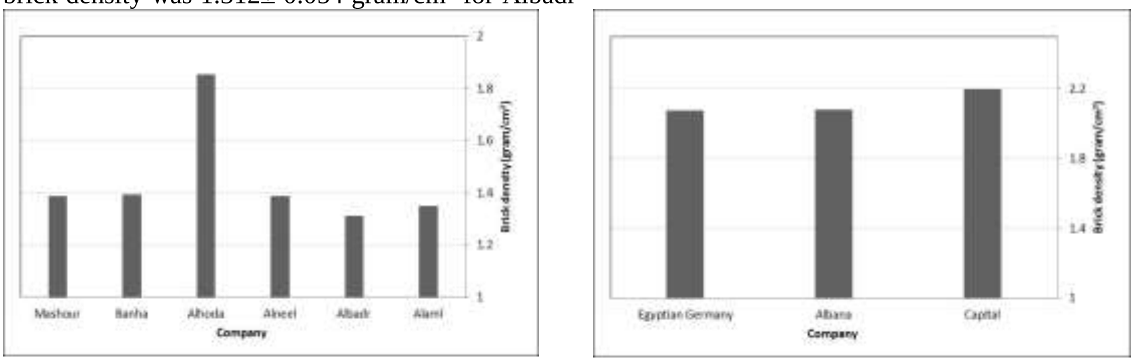


a) b)

Fig.8. Bricks weight for different brick companies, a) red bricks, b) concrete bricks.

3.5 Brick density

Brick density is directly proportional to the weight and inversely proportional to volume of the brick. Brick density was determined by calculating the brick volume and then dividing the mass by the volume to get the brick density. Fig.9a illustrates the average of red bricks density for different companies. The highest red brick density was 1.856 ± 0.096 gram/cm^3 for Alhoda Company, while the minimum brick density was 1.312± 0.054 gram/cm^3 for Albadr Company. The bricks weight were 1.35± 0.026, 1.389 ± 0.015, 1.394 ± 0.007 and 1.389±0.009 gram/cm^3 for Alaml, Alneel, Banha and Mashour companies respectively. For cement bricks, the maximum bricks density was 2.2 ± 0.007 gram/cm^3 for Capital Company, while the minimum bricks density was 2.075± 0.03 gram/cm^3 for Egyptian Germany Company (Fig.9b).

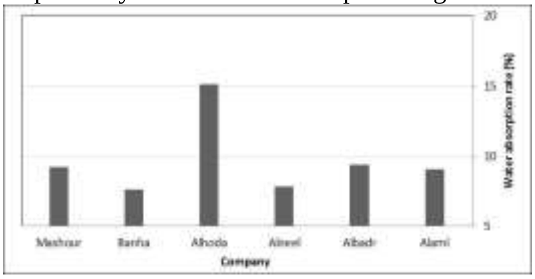


a) b)

Fig.9. Bricks density for different companies, a) red bricks, b) concrete bricks.

3.6 Water absorption rate

Fig.10a illustrates the average of water absorption rates for red bricks produced from different companies. The highest water absorption rate for red brick was 15.139 ± 3.177 % for Alhoda Company, while the minimum water absorption rate was 7.6± 0.548 % for Banha Company. The percentages of water absorption rates for bricks produced from different companies were 9.041± 0.812, 7.856 ± 0.279, 9.4 ± 0.828 and 9.22± 1.686 % for Alaml, Alneel, Albadr and Mashour companies respectively. The maximum percentage of water absorption rate for cement bricks was 6.3± 0.456% for Capital company, while the minimum water absorption rate was 2.218± 0.374% for Egyptian Germany company (Fig.10b).



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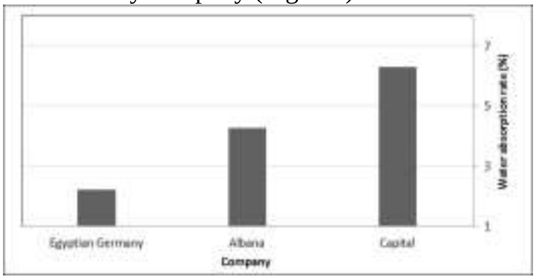


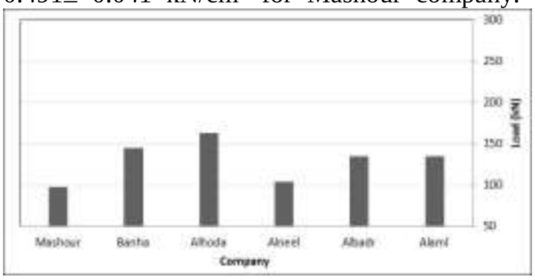
b)

Fig.10. Percentage of water absorption rate for bricks produced from different companies, a) red bricks, b) concrete bricks.

Water absorption is a key property affecting a brick's durability, especially in humid or rainy climates. High water absorption can lead to structural deterioration, reduced thermal efficiency, and increased vulnerability to mold growth and freeze-thaw cycles. This test is important to assess their suitability in humid environments and identify their long-term durability.

3.7 Compressive Strength

Fig.11a shows the average of failure loads for red bricks produced from different companies. The maximum load for red clay brick was 163.33 ± 66.078 kN for bricks produced by Alhoda company, while the minimum failure load value was 97.9± 9.462 kN for Mashour company. The failure loads for bricks produced by different companies were 134.67± 14.468, 104.167 ± 16.251, 145 ± 28.62 and 134.7± 37.715 kN for Alaml, Alneel, Banha and Albadr companies respectively. On the other hand, the results revealed that the maximum load of cement bricks was 398.8± 79.512 kN for Egyptian Germany company, while the minimum load was 195.07± 79.46 kN for Albana company (Fig.11b). While, Fig. 12a shows the average of compressive strength for red bricks produced from different companies. The maximum compressive strength was 1.458 ± 0.590 kN/cm^2 for bricks produced by Alhoda company, while the minimum compressive strength value was 0.491± 0.041 kN/cm^2 for Mashour company. The compressive strength for bricks produced by different companies were 0.659± 0.071, 0.548 ± 0.086, 0.727± 0.143 and 0.592± 0.176 kN/cm^2 for Alaml, Alneel, Banha and Albadr companies respectively. The results revealed that, the maximum compressive strength of cement bricks was 1.994± 0.398 kN/cm^2 for Egyptian Germany company, while the minimum compressive strength was 1.045± 0.427 kN/cm^2 for Albana company (Fig.12b). Red clay bricks are widely used in Egypt's construction industry for multi-story buildings due to their robustness and ability to endure significant loads. The findings of this study align with **Ahmed & Mahmoud (2021)**, who identified red clay bricks as an excellent option for load-bearing structures in residential and commercial buildings. Although red bricks are strong and durable, they are resource-intensive to produce due to kiln firing, which contributes to higher CO_2 emissions. Nevertheless, their high compressive strength makes them indispensable for projects requiring long-term stability and durability. These phenomena may be due to the compressive strength is assumed at the end of the linear regime. The increased porosity of the composite material as a result of fiber addition is the major factor responsible the reduction in compressive strength **(Zak *et al.*, 2016).**



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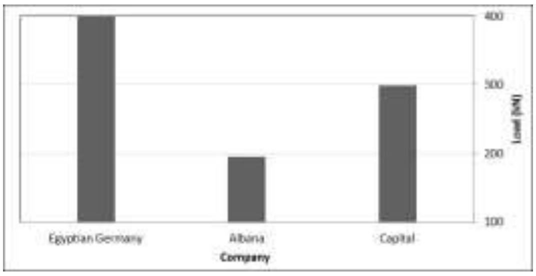

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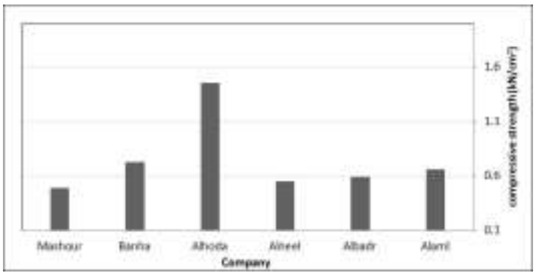
Fig.11. Failure load of compression test for bricks produced from different companies, a) red bricks, b) concrete bricks.



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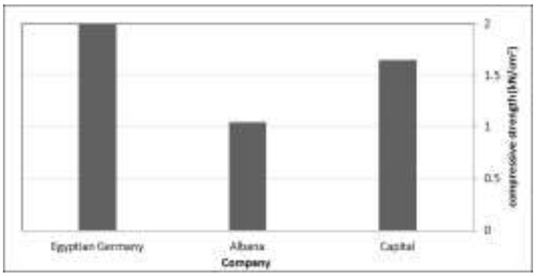


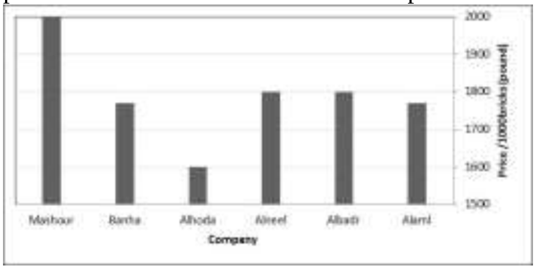
b)

Fig.12. Compressive strength of bricks produced from different companies, a) red bricks, b) concrete bricks.

Cement bricks are frequently used in interior walls and partition applications where load-bearing requirements are lower. They are suitable for single-story structures or as secondary support in buildings where other materials bear the primary load. Their cost-effectiveness makes them a popular choice in projects where budget constraints are a primary concern.

3.8 Brick prices

Fig.13a shows the average of red clay bricks price for 1000 bricks for bricks produced from different companies. The maximum price was 2000 EGP for bricks produced by Mashhour Company, while the minimum price value was 1600 EGP for Alhoda Company. The Prices for red clay bricks price produced by different companies were 1770, 1800, 1770 and 1800 EGP for Alaml, Alneel, Banha and Albadr companies respectively. On the other hand, the results revealed that the maximum price of cement bricks was 2000 EGP for Capital Company, while the minimum price was 1850 EGP for Albana Company (Fig.13b).



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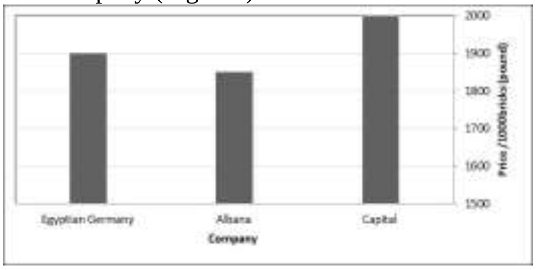

b)

Fig.13. Price of bricks produced from different companies, a) red bricks, b) concrete bricks.

Red clay bricks are kiln-fired, requiring high energy input in the form of fuel for firing. This energy-intensive process contributes significantly to production costs, as well as high CO_2 emissions, making red clay bricks less sustainable and more costly to produce **(Construction Economics Journal, 2018).**

Conclusions

This study provided a comprehensive technical evaluation of the commercial bricks produced from different companies in Egypt. The results revealed that, the maximum red clay brick length was 22.04 ± 0.114 cm for Albadr company, while the minimum red clay brick length was 16.243± 0.355 for Alhoda company. The maximum red brick width was 10.36 ± 0.167cm for Albadr company, while the minimum red brick width was 7.271± 0.229 for Alhoda company. The highest red brick height was 6.5 ± 0.071cm for Albadr company, while the least brick height was 5.414± 0.324 for Alhoda company. The greatest red brick density was 1.856 ± 0.096 gram/cm^3 for Alhoda Company, while the least brick density was 1.312± 0.054 gram/cm^3 for Albadr Company. Additionally, the maximum water absorption rate was 15.139 ± 3.177 % for Alhoda Company, while the minimum water absorption rate was 7.6± 0.548 % for Banha Company. Finally, the greatest compressive strength was 1.458 ± 0.590 kN/cm^2 for bricks produced by Alhoda company, while the least compressive strength value was 0.491± 0.041 kN/cm^2 for Mashour company. The maximum price was 2000 EGP for bricks produced by Mashhour Company, while the minimum price value was 1600 EGP for Alhoda Company.

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تقييم فنى لبعض انواع الطوب التجارى فى مصر

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تهدف هذه الدراسة إلى تقييم الأداء الفني لبعض أنواع الطوب التجارى المستخدمة في صناعة البناء في مصر، وتشمل الطوب الطفلي الأحمر، وطوب الأسمنت .يتضمن التقييم الفني تحليل خصائص الطوبة مثل أبعاد الطوبة (الطول ، العرض ، الإرتفاع) وزن الطوبة ، كثافة الطوبة قوة الضغط، ومعدل امتصاص الماء لتحديد مدى ملاءمة كل نوع للتطبيقات المختلفة، مثل البناء الهيكلي في المنشإت.

أظهرت النتائج أن أقصى طول للطوب الطفلي الأحمر هو 22.04±0.114 سم لطوبة شركة البدر ، بينما كان أقل طول للطوبة الحمراء هو 16.243±0.355سم لطوبة شركة الهدى. أقصى طول للطوبة الأسمنتية كان 20± صفرسم لطوبة الشركة المصرية الألمانية، وأقل طول هو 19.5± صفر سم لطوبة شركة كابيتال. بالنسبة لعرض الطوبة كان أقصى عرض للطوابة كان 10.36±0.167سم ، 10± صفرسم لكلا من الطوب الأحمر والأسمنتى على التوالى. أقصى كثافة للطوبة كان 1.856±0.096 ، 2.2±0.007جم/سم^3 لكل من الطوب الأحمر والأسمنتى على التوالى.

أظهرت النتائج أيضا أن أقصى معدل لتشرب المياه بلغ 15.139±3.177%، 6.3±0.456% لكلا من الطوب الطفلى الأحمرالمفرغ والأسمنتى على التوالى. كان أقصى تحمل للطوبة 1.458±0.59، 1.994±0.398ك ن/سم^2 لكلا من الطوب الأحمر والأسمنتى على التوالى. أخيرا أوضحت النتائج أن أقل سعر للطوب 1850، 1600 جنيه مصرى لكلا من الطوبة الاسمنتية والحمراء على التوالى.