

One Egyptian Brick Types in Construction: An In-Depth Survey and Experimental Study

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Abstract

This study presents an extensive investigation into the use of Egyptian clay bricks in construction, focusing particularly on New Aswan City. The research is divided into two key components: a detailed survey and an experimental analysis. The survey catalogs various brick types commonly used in local construction projects, and two older brick types sourced from the region, to offer a comprehensive understanding of the materials in use. Following this, an experimental analysis is conducted using the WDW 300 Testing machine, where stress-strain values and maximum forces are meticulously measured to evaluate the structural performance of these bricks under load. This approach provides valuable insights into the mechanical behavior of both contemporary and older brick varieties, contributing to the optimization of construction practices in New Aswan City. The findings from this study are particularly relevant for improving construction strategies in regions susceptible to seismic activity, ensuring that the structural integrity of buildings is maintained. The experimental results revealed significant differences in load-bearing capacities and deformation behavior between older and contemporary bricks. This highlights the importance of considering these performance variations in modern construction, particularly for seismic safety.

Keywords: Clay bricks, Compressive strength, Experimental Results, and Universal Testing Machine.

1. INTRODUCTION

The Egyptian construction sector is a major consumer of bricks, with clay bricks constituting a significant portion of this demand. This extensive use has considerable environmental implications [1]. Bricks, primarily manufactured from soil, are the most prevalent building material in both historical and modern contexts. The high consumption of clay bricks contributes to the depletion of clay soil resources [2]. To address the environmental impact of clay use, various studies have investigated the potential for substituting some of the clay with alternative materials [3]. Additionally, the thermal conductivity of wall materials plays a vital role in determining both the total cost and life cycle cost of buildings, affecting energy consumption required to maintain internal environmental comfort [4]. Globally, the construction industry is one of the most resource and energy-intensive sectors, utilizing materials such as wood, stone, bricks, iron, water, and plastic. For example, in Aswan, Egypt, the Nubians have historically used mud bricks to construct homes adapted to the region's extreme heat. These structures, often featuring domes for natural ventilation and sustainability, continue to be built using this traditional method. Similarly, in Bangladesh, the hot and humid climate has led to the use of climate-resilient buildings made from locally available materials.

Historically, these buildings were constructed from a specific type of soft mud. During the Pala Empire Dynasty (8th-12th centuries), the scarcity of stone led to the widespread use of bricks, which were frequently embellished with intricate terracotta designs. The Salban Vihara in Comilla exemplifies this architectural style. Today, bricks remain a crucial building material in Bangladesh due to the limited availability of more durable alternatives [5].

Despite their widespread use, significant challenges persist in the manufacturing of clay bricks. These challenges include variability in material quality, inconsistencies in stress strength, and differences in manufacturing sources, which can lead to substandard production and unstable stress resistance in bricks.

Addressing these manufacturing challenges is essential for ensuring the structural integrity and longevity of buildings. High-quality, reliable bricks are necessary to maintain safety standards and reduce maintenance costs, particularly in regions with harsh environmental conditions or seismic activity.

Previous research has explored various aspects of clay brick performance, including strength comparisons and construction techniques. However, gaps remain in understanding the specific local specifications and variations of Egyptian bricks, which can influence their performance in construction.

This research aims to fill the knowledge gap regarding the local specifications and performance of Egyptian bricks. By examining different types and qualities of Egyptian bricks, this study will provide valuable insights that are currently underexplored in the literature.

The study will employ a combination of field surveys and laboratory tests to assess the performance of Egyptian bricks in construction. This approach seeks to identify both strengths and weaknesses in current manufacturing practices and suggest potential improvements. The primary objectives are to evaluate the performance of various Egyptian brick types and to develop guidelines for their effective use in building design, ultimately improving construction practices and achieving better environmental and structural outcomes.

2. METHODOLOGY

The methodology of this research is structured to provide a thorough evaluation of the clay brick types prevalent in New Aswan City, utilizing a dual approach that incorporates both a survey and experimental analysis. The survey component was meticulously designed to collect comprehensive data on the various types of bricks currently employed in the region's construction projects, as well as older varieties that have become less common over time. This approach ensured that the sample selection was representative of the diverse construction practices within the city. Each brick sample was carefully selected based on its relevance to both contemporary and historical building methods. In the experimental phase, the selected brick samples were subjected to rigorous testing using the WDW 300 Universal Testing Machine, a precision instrument equipped with strain gauges and internal force sensors. This testing phase focused on generating detailed stress-strain curves and determining the maximum forces that each brick type could withstand. By combining these methods, the study offers a holistic understanding of the material properties and performance of clay bricks, which is critical for optimizing construction practices in regions where structural integrity is a priority.

2.1. SURVEY OF BRICK TYPES

The survey component of this study plays a vital role in cataloging and analyzing the various types of clay bricks commonly used across the construction landscape of New Aswan City. Brick samples were meticulously gathered from a range of construction sites throughout the city, ensuring a representative selection that includes both widely used modern bricks and older types that, while less common today, still provide valuable comparative insights. The survey carefully documented key physical attributes such as size, weight, and color of each brick type, contributing to a detailed understanding of the materials employed in local construction practices. Additionally, the survey investigated the distribution patterns and usage frequencies of these bricks, providing a nuanced view of how different brick types are applied in various building projects.

The findings from this survey are illustrated through a series of detailed figures and tables that visually depict the prevalence and characteristics of each brick type. Figure 1 shows the field survey area, highlighting the locations where samples were collected. Figure 2 presents illustrative samples of the different brick types, providing a visual reference for the variety observed. Figure 3 depicts the pre-test storage conditions of the samples, ensuring the integrity of the materials prior to testing. Additionally, Table 1 offers a summary of brick characteristics, including physical attributes and distribution patterns. These visual aids not only enhance the clarity of the survey findings but also establish a foundation for the subsequent experimental testing, which further explores the mechanical properties of these essential construction materials.

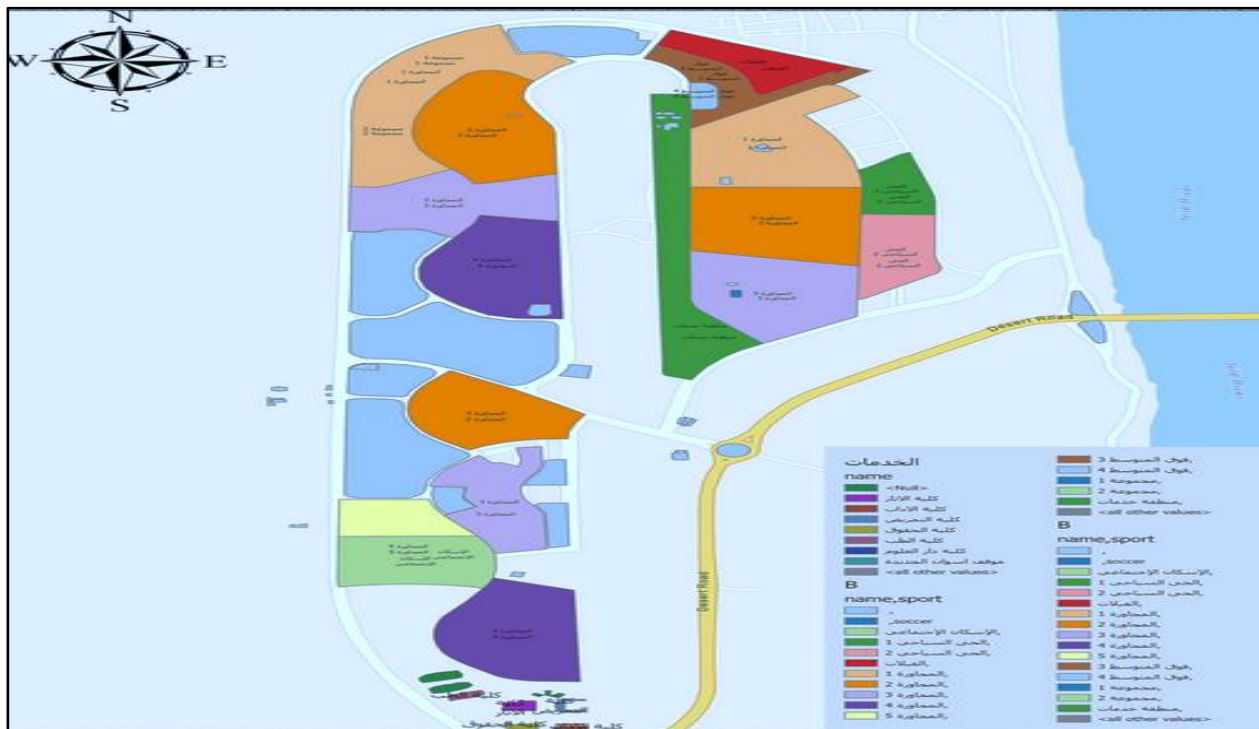


Figure 1: Field Survey Area: Detailed Map of Selected Region in New Aswan City













Figure 2: Illustrative Samples of Private and Affordable Housing Developments in New Aswan City





Figure 3: Pre-Test Storage of Selected Bricks in the Laboratory

Table 1: Summary of Area, Volume, Weight, Density, and Visual Color Representation for Surveyed Brick Samples

Sample No.	Code	Type	Dimension (cm)			Volume (cm ³)	Area (cm ²)	Avg. Weight (Kg)	Density (Kg/m ³)	Figure
			L	B	H					
1	KAS	Hollow Single	24	10.5	7	1764	252	2.537	1439	
2	DKS	Hollow Single	18	8.5	6.5	994.5	153	1.286	1294	
3	AZS	Hollow Single	19.5	9.5	6	1111.5	185.25	1.6428	1479	
4	MAS	Hollow Single	18.5	8	6	888	148	1.18	1329	
5	OKS	Solid Single	20	10	6	1200	200	1.6882	1407	
6	MHS	Hollow Single	17.5	8.5	6	892.5	148.75	1.1598	1300	
7	MHD	Hollow Double	24	10.5	12	3024	252	3.908	1293	
8	ASD	Hollow Double	23.5	10.5	12	2961	246.75	3.579	1209	
9	HAD	Hollow Double	24.5	10.5	12	3087	257.25	4.162	1349	
10	HUD	Hollow Double	19	9	11.5	1966.5	171	2.607	1326	

2.2. EXPERIMENTAL STUDY

2.2.1. Materials and Methods

Brick Samples:

- **Selection Criteria:** Brick samples were meticulously chosen based on their widespread use in construction projects in New Aswan City. The selection included both commonly used contemporary bricks and older types to ensure a comprehensive analysis [6]. Details of the samples are provided in Table 1.
- **Sample Preparation:** Each brick sample was cleaned to remove any surface debris and then stored in a controlled environment to maintain consistent experimental conditions [7].

Testing Equipment:

- **WDW 300 Universal Testing Machine:** The primary equipment used for testing was the WDW 300 Universal Testing Machine Figure 4, equipped with advanced strain gauges and internal force sensors. This machine is capable of applying compressive loads while precisely measuring the resulting deformation, allowing for the accurate determination of stress-strain characteristics [8].

Testing Procedure:

The testing procedure was conducted with a focus on precision and consistency. Each brick was meticulously positioned in the testing machine, ensuring proper alignment to avoid any uneven distribution of the applied force [9]. The machine then incrementally applied a compressive load to the brick until failure occurred, with the maximum force sustained by the brick before failure being carefully recorded [10]. Throughout the test, continuous monitoring

and recording of stress-strain data captured the brick's response to the applied load, including key parameters such as compressive strength, maximum force, and strain at failure [11]. To ensure the reliability of the results, each brick type was subjected to multiple tests. The results from these tests were averaged to provide a representative value for each brick type, thereby enhancing the accuracy and the findings [12].



Figure 4: Universal Testing Machine Setup

3. RESULTS ANALYSIS

3.1. Compressive Strength Behavior:

The compressive strength of each brick type was calculated by dividing the maximum force sustained by the brick by its cross-sectional area. These values were then compared to the standards set by the Egyptian Organization for Standardization (EOS) and international benchmarks such as ASTM C62 [13].

3.2. Stress-Strain Behavior:

HAD

The stress-strain curves generated from the experiment provide valuable insights into the elastic and plastic deformation behavior of the bricks, allowing for the determination of the modulus of elasticity. Significant differences were observed between the mechanical responses of older and contemporary brick types. Figure 5, which presents stress-strain curves for ten samples, requires further discussion to better understand these variations. Additionally, Table 2 highlights stress-strain values across two ranges, underscoring the relevance of these findings in the context of construction, especially for seismic safety. [14].

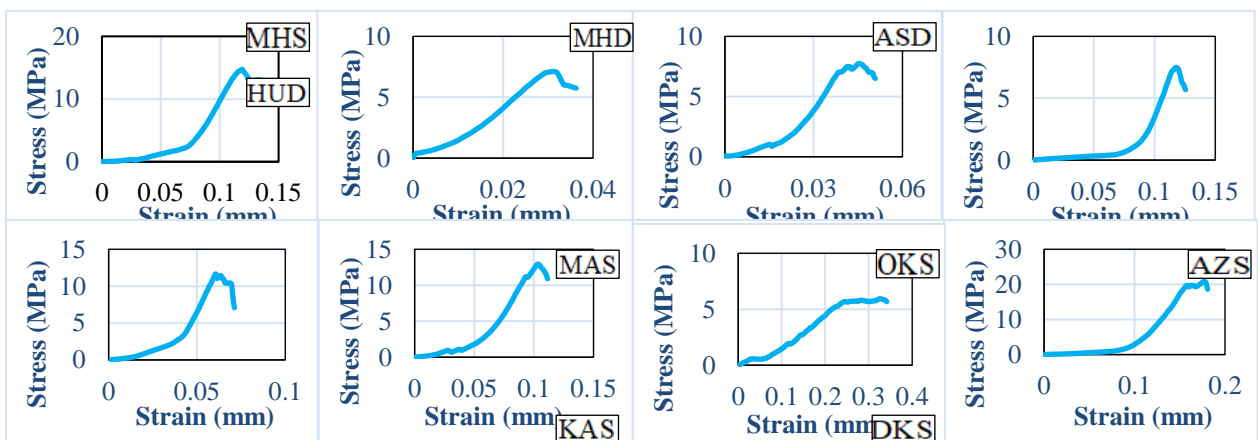


Figure 5: Representative Stress-Strain Curves of Selected Brick Types**Table 2:** Stress-Strain Values for Ten Samples across Two Ranges

Sample No.	Code	Type	Dimension (cm)			Stress Values (MPa)
			L	B	H	
1	KAS	Hollow Single	24	10.5	7	5.1 - 7.75
2	DKS	Hollow Single	18	8.5	6.5	9.02 - 10.45
3	AZS	Hollow Single	19.5	9.5	6	12.47 - 20.8
4	MAS	Hollow Single	18.5	8	6	11.71 - 12.92
5	OKS	Solid Single	20	10	6	3.38 - 5.94
6	MHS	Hollow Single	17.5	8.5	6	9.05 - 14.73
7	MHD	Hollow Double	24	10.5	12	6.07 - 7.34
8	ASD	Hollow Double	23.5	10.5	12	6.1 - 7.74
9	HAD	Hollow Double	24.5	10.5	12	5.08 - 7.48
10	HUD	Hollow Double	19	9	11.5	8.69 - 11.64

4. CONCLUSION

This study offers a comprehensive evaluation of Egyptian clay bricks, focusing on their types, manufacturing processes, and performance characteristics. The combination of field surveys and rigorous experimental testing has yielded several important findings:

- **Variation in Brick Quality:** The research identified significant variability in the compressive strength of Egyptian clay bricks. While some bricks met or exceeded the standards set by the Egyptian Organization for Standardization (EOS), others fell short. This inconsistency underscores the need for improved quality control in the manufacturing process, as variations in raw material quality and production techniques directly impact the structural integrity of the bricks.

- **Influence of Manufacturing Methods:** The study highlights that bricks produced under controlled manufacturing conditions—such as consistent raw material composition and regulated firing temperatures—demonstrated superior compressive strength and overall performance. This finding emphasizes the importance of standardizing manufacturing practices to ensure the production of high-quality bricks that meet industry standards. By adopting more precise and uniform manufacturing techniques, brick producers can enhance the durability and reliability of their products.
- **Environmental Impact:** The environmental analysis revealed considerable impacts associated with traditional brick production methods, including the depletion of clay resources and high energy consumption during the firing process. The study also identified brick types that meet performance standards while requiring less energy, suggesting a pathway for reducing the environmental footprint of brick manufacturing. By optimizing the use of raw materials and adopting energy-efficient practices, the construction industry can contribute to more sustainable building practices.

Overall, the findings of this research underscore the critical need for refining brick manufacturing practices in Egypt. By improving quality control, standardizing production processes, and embracing sustainable practices, the construction industry can produce higher-quality bricks that not only meet performance standards but also reduce environmental impact. Future research should focus on exploring innovative manufacturing techniques, evaluating the long-term performance of bricks in various environmental conditions, and investigating the potential for incorporating recycled materials into brick production. These efforts will further advance the sustainability and effectiveness of construction practices in Egypt and beyond.

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