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A Comparative Study Of The Mechanical Properties And Water Absorption Of Different Masonry Bricks In Egypt

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ABSTRACT

To evaluate existing structures and guide future strengthening initiatives, as well as to comprehend the mechanical characteristics and percentage of water absorption of different masonry bricks that are often utilized in Egypt. The experimental program encompassed ten distinct types of brick units included: first-class perforated clay bricks, second-class perforated clay bricks, first-class cement bricks, second-class cement bricks, autoclaved aerated concrete (AAC) brick, sand-lime bricks, engineered perforated clay bricks with horizontal holes, and engineered perforated load-bearing clay bricks., with a total of one hundred and fifty brick units investigated. These brick units were meticulously examined to measure their compressive strength, flexural strength, and water absorption properties. The findings of this study highlighted that solid sand-lime emerge as an optimal choice for constructing load-bearing walls in Egypt according to its remarkable compressive strength. As well as second-class perforated clay bricks has higher flexural strength and its cost-effectiveness make it particularly an optimal choice for constructing masonry elements subjected to flexure. These insights provide valuable guidance for builders, engineers, and architects alike.

KEYWORDS. *Masonry bricks; Compressive Strength; flexural Strength; Water Absorption*.

INTRODUCTION

Masonry brick holds a significant place in the world of construction and architecture. Its enduring presence dates back to ancient civilizations, where it was meticulously crafted and employed to create structures that have withstood the test of time. From the grand pyramids of Egypt to the majestic temples of Greece,[1] masonry brick has left an indelible mark on human history. There are various types of bricks that are used worldwide.

Brick masonry is a highly durable form of construction that involves placing bricks in mortar in a systematic manner to create solid structures capable of withstanding loads. The different types of bricks used in brick masonry:

- Common Burnt Clay bricks: these are the most popular type of bricks. Clay is fired in kilns to make them. They are easily recognized by their rectangular shape and reddish-brown tint.
- Concrete Bricks: Cement, sand, and aggregate are combined to make these bricks. They provide good durability and strength.
- Sand Lime Bricks (Calcium Silicate Bricks): A mixture of sand, lime, and water is used to make these bricks. They undergo autoclaving to increase their strength. Sand lime bricks have a smooth surface and are lightweight.
- Fly Ash Clay Bricks: Fly ash, a byproduct of burning coal, is combined with clay to make these bricks. They offer strong thermal insulation qualities and are environmentally beneficial.

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- Engineered Bricks: These strong, dense bricks are made for load-bearing applications. Their compressive strength is high and their water absorption is low. Other Brick Types: There are additional specialized brick types, including bullnose, channel, coping, cownose, and hollow bricks.

In Egypt, the most common types of masonry bricks are perforated clay bricks, cement bricks, autoclaved aerated concrete (AAC) bricks, autoclaved aerated concrete (AAC) blocks, sand-lime bricks, engineered perforated clay bricks with horizontal holes, and engineered load-bearing perforated clay bricks. Each type has its unique properties and applications.

According to Hilsdorf in 1969 and Roca et al. in 2010, the mechanical reaction of masonry structures as a composite material is settled by the properties of its elements and the complex interaction, the analysis of masonry constructions' behavior became a challenge. The compressive strength of masonry is regarded by obtainable standards as an essential design parameter.[1], [2]

As a result, Grimm makes sure that the axial compressive strength of typical brick masonry prisms serves as a reliable indicator of the compressive strengths of brick and mortar as well as the level of quality of workmanship. The compressive strength of brick, however, is dependent on the unit size and shape, raw material, manufacturing process, and degree of burning.[3]

Additionally, Wilson et al.'s 1999 study found that calculating a brick's water absorption is regarded as a key factor in determining the durability of the material, including the bricks' degree of burning quality and weathering behavior. Any masonry material's total porosity affects both its permeability to liquid flow and its compressive strength in a particular way. Therefore, low porosity and highly durable bricks fall within the category of engineering bricks. [4]

Moreover, Thomas, and Kaushik et al. explain that the conventional design practice affirms that masonry structures are designed to sustain only compressive forces, therefore it is principal to determine the compressive strength accurately.[5], [6]

In 2013, Shakir and Mohamed emphasize the importance of adopting sustainable practices in brick manufacturing. They advocate reducing the reliance on natural resources like clay, sand, and shale during production. Rather, they suggest using industrial waste products as the main raw materials for brick manufacture, including as quarry dust, fly ash, bottom ash, and billet scale. Additionally, they support brick factories that use conventional manufacturing techniques in their exploration of alternative fuels and adoption of renewable energy sources.[7]

Prisms or wall panels are tested in a lab to determine the compressive strength of masonry, as stated by Jagdish et al. in 2008 and Thaickvil and Thomas in 2018. Prisms are short wall specimens of many layers with a width of three or more units, whereas prisms are samples of masonry units with a thickness of one to three units. Masonry wall samples have higher heights than prisms and resemble real walls. Nevertheless, it is more cost-effective to test prisms rather than masonry wall samples for examining the compressive strength of the material. Additionally, the characteristics of the masonry's components and the quality of workmanship of have an impact on prism testing. [8], [9]

In 2020, Baez et al. investigates water absorption and porosity of handmade and solid fired clay bricks from Paraguay, finding that handmade bricks have a higher degree of porosity and absorb water at a faster rate, leading to accelerated decay.[10]

Additionally, Shahreza in 2021, the study carried out an experimental investigation on water absorption and penetration in clay brick masonry exposed to cyclic water spraying, and discovered that mortar joint profiles have no effect on water absorption, while the amount of absorbed water depends on the water absorption coefficient and absorption capacity of the bricks.

As well as, at water content levels corresponding to 50%–60% of full saturation level, the specimens' backsides showed the first noticeable dampness patches. Furthermore, because

there were no known defects and no differential air pressure, no detectable amounts of penetrated water were collected at the backside.[11]
When Abdulhussain (2021) examined the physical characteristics of perforated clay bricks from several manufacturers, he discovered differences in the bricks' compressive strength, efflorescence rates, and water absorption.[12]
Additionally, Da Silva et al. in 2022 discovered that varying the ratios of raw ingredients, such as sand, coal tailings, and hydrated lime, can maximize the compressive strength of sand-lime bricks.[13]
Moreover, AAC blocks, also known as Autoclaved Aerated Concrete blocks, are a type of innovative material used in masonry construction. According to Krishnan, and Bhattacharjya, AAC Blocks have gained popularity due to their eco-friendliness, durability, and cost-effectiveness. Compared to traditional clay bricks, AAC blocks have superior properties such as thermal insulation, acoustic absorption, fire resistance, and insect resistance. [14], [15]
Finally, Bayisenge et al. found that an increase in the number of perforations in clay bricks led to a reduction in weight loss and increased abrasion resistance. [16]

The objective of the experimental study is to understand the mechanical properties of different brick types is crucial for assessing existing buildings and designing effective strengthening measures. This research aims to comprehensively characterize compressive strength, flexural strength, and water absorption for various masonry bricks to gain insights into the performance of different brick units. These findings have practical implications for builders, architects, and engineers in Egypt and beyond

EXPERIMENTAL WORKS

- **EXPERIMENTAL PROGRAM**

The objective of the experimental investigation was to measure the mechanical characteristics of brick units—such as their compressive and flexural strengths and percentage of water absorption—that are often used in Egypt's building industry. One hundred and fifty brick units were arranged in three groups. Each group includes fifty brick units.
Group (1): Ten types of brick units (first-class clay brick units, second-class clay brick units, first-class cement brick units, second-class cement brick units, autoclaved aerated concrete (AAC) brick units, autoclaved aerated concrete (AAC) block units, sand-lime bricks, engineered perforated clay brick with horizontal holes, and engineered load-bearing clay brick) were tested, where five bricks of each type were taken as a sample to make a compression test on them. The results provide valuable insights into the load-bearing capacity of different brick materials.
Group (2): Ten types of brick units (first-class clay brick units, second-class clay brick units, first-class cement brick units, second-class cement brick units, autoclaved aerated concrete (AAC) brick units, autoclaved aerated concrete (AAC) block units, sand-lime bricks, engineered perforated clay brick with horizontal holes, and engineered load-bearing clay brick) were tested, where five bricks of each type were taken as a sample to make a tension test on them. Understanding the tensile strength of these bricks is crucial for assessing their performance under various forces.
Group (3): Ten types of brick units (first-class clay brick units, second-class clay brick units, first-class cement brick units, second-class cement brick units, autoclaved aerated concrete (AAC) brick units, autoclaved aerated concrete (AAC) block units, sand-lime bricks, engineered perforated clay brick with horizontal holes, and engineered load-bearing clay brick) were weighted, where five bricks of each type were taken as a sample and immersed for 24 hours to calculate the Absorption percentage. The absorbed water content was calculated, providing investigation about the bricks’ susceptibility to moisture.

- **DESCRIPTIONS OF THE TEST SPECIMENS**

Utilizing locally produced materials, brick units comprised two classes of clay bricks, two classes of cement bricks, autoclaved aerated concrete (AAC) brick units, autoclaved aerated concrete (AAC) block units, sand-lime bricks, engineered perforated clay brick with horizontal holes, and engineered load-bearing clay brick as shows in Table.1.

Type	Specimen	Description	
Clay brick-Class 1	**B1**	**Hand-molding perforated clay bricks has eight holes with high quality standards**	
Clay brick- Class 2	**B2**	**Hand-molding perforated clay bricks has eight holes with medium quality standards**	
Cement brick-Class 1	**B3**	**Machine-molding solid cement bricks with high quality standards**	
Cement brick-Class 2	**B4**	**Hand-molding solid cement bricks with medium quality standards**	

			
Autoclaved aerated concrete (AAC) brick	**B5**	**Autoclaved aerated concrete (AAC) brick consists of quartz sand, calcined gypsum, lime, Portland-cement, water, and aluminum powder**	
Autoclaved aerated concrete (AAC) block	**B6**	**Autoclaved aerated concrete (AAC) block consists of quartz sand, calcined gypsum, lime, Portland-cement, water, and aluminum powder**	
Sand-lime brick	**B7**	**Solid sand-lime bricks made by combining lime, sand, and water through a chemical reaction**	
Engineered perforated clay brick with horizontal holes	**B8**	**Machine-molding perforated clay bricks with twelve horizontal holes, its dimensions 50*30 mm^2**	

			
	B9	Machine-molding perforated clay bricks with ten horizontal holes, its dimensions 30*35 mm^2	
Engineered load-bearing clay brick	B10	Machine-molding perforated clay bricks with sixteen vertical holes, its diameter 25 mm	

Table 1. Description for the different bricks

Furthermore, the specifications of the different bricks are shown in Table.2 including the dimensions, the cost, the average weight, and the average density of each brick.

Type	Specimen	Dimensions (mm^3)	Cost (EGP/Brick)	Cost (EGP/m^3)	Average Weight (N)	Average Density (N/m^3)	CO2 Emissions (kgCO2/kg)
Perforated clay brick-Class 1	B1	210*100*60	1.35	1071.43	18.4	14365	0.213

Perforated clay brick-Class 2	**B2**	**200*80*60**	**1.10**	**1041.67**	**13.34**	**13895.8**	**0.213**
Cement brick-Class 1	**B3**	**240*120*60**	**1.90**	**1099.54**	**35.91**	**20781.3**	**0.097**
Cement brick-Class 2	**B4**	**245*105*50**	**1.75**	**1360.54**	**25.51**	**13885**	**0.097**
Autoclaved aerated concrete (AAC) brick	**B5**	**200*100*60**	**2.65**	**2208.33**	**7.34**	**6116.7**	**0.026**
Autoclaved aerated concrete (AAC) block	**B6**	**600*100*200**	**23.50**	**1958.33**	**69.75**	**5812.5**	**0.026**
Sand-lime brick	**B7**	**250*120*60**	**3.14**	**1744.4**	**32.76**	**18200**	**0.196**
Engineered perforated	**B8**	**260*120*250**	**6.10**	**782**	**47.27**	**6060.25**	**0.213**
clay brick with horizontal holes	**B9**	**260*100*200**	**4.60**	**884.61**	**38.74**	**16103.8**	**0.213**
Engineered load-bearing clay brick	**B10**	**250*120*130**	**3.40**	**871.8**	**38.15**	**9782**	**0.213**

Table 2. The specifications of each brick

- **Test Setup**

The testing process you described involves subjecting the brick specimens to vertical top loading until they fail. Hydraulic jacks with 1000 kilonewton capacity were employed to apply the load. Each specimen experienced progressively increasing loads until reaching the point of failure.

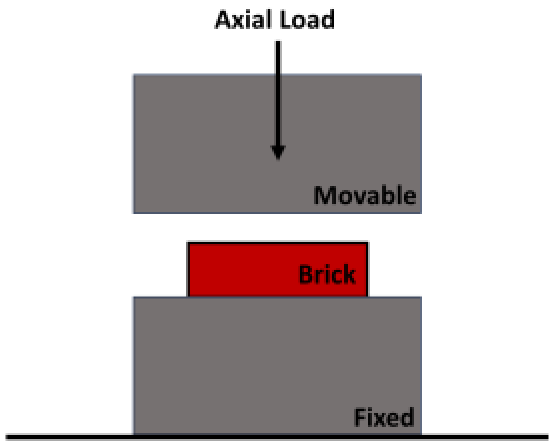

Figure 1. Compressive strength test setup.

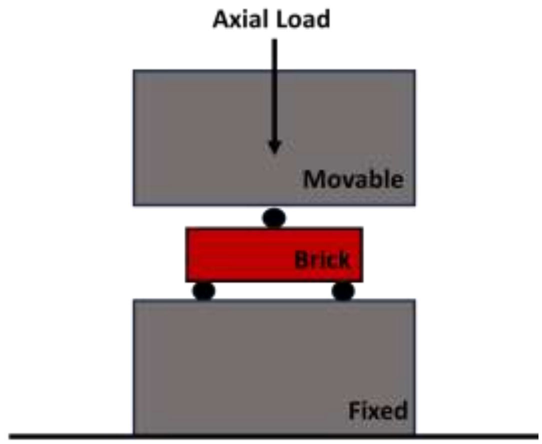

Figure 2. Flexural strength test setup.

- **Experimental Results and Discussion**

Compressive strength of brick units

Compressive strength was tested on a series of single bricks. This rigorous testing provides crucial data on the load-bearing capacity and structural integrity of the brick units. Understanding how these materials behave under stress is essential for safe and reliable construction practices.

a) first-class perforated clay brick unit subjected to compression test

b) Engineered perforated clay brick unit with horizontal holes subjected to compression test

c) Solid sand-lime brick unit subjected to compression test

Figure 3. Compressive strength test for different bricks

Five units of each brick type were tested in a compression test, the results of the specimens are shown in the table.3. First-class perforated clay brick units had an average compressive strength of 9.43 N/mm^2, second-class perforated clay brick units had an average compressive strength of 7.69 N/mm^2, first-class cement brick units had an average compressive strength of 10.83 N/mm^2, second-class cement brick units had an average compressive strength of 9.87 N/mm^2, autoclaved aerated concrete (AAC) brick had an average compressive strength of 2.75 N/mm^2, autoclaved aerated concrete (AAC) block had an average compressive strength of 2.28 N/mm^2, sand-lime brick had an average compressive strength of 26.47 N/mm^2, and engineered perforated large clay brick with horizontal holes had an average compressive strength of 0.54 N/mm^2, the average compressive strength of engineered perforated large clay brick with horizontal holes was 0.87 N/mm^2, the average compressive strength of engineered load-bearing clay brick was 3.70 N/mm^2.

Type	Specimens	Dimensions (mm^3)	Failure Load (kN)	Comp. Strength (N/mm^2)	Average Comp. Strength (N/mm^2)
Perforated clay brick-Class 1	**B1**	**210*100*60**	**175**	**8.33**	**9.43**
			215	**10.24**	
			215	**10.24**	
			185	**8.81**	
			200	**9.52**	
Perforated clay brick-Class 2	**B2**	**200*80*60**	**115**	**7.19**	**7.69**
			120	**7.5**	
			125	**7.81**	
			130	**8.13**	
			125	**7.81**	
Cement brick-Class 1	**B3**	**240*120*60**	**270**	**9.38**	**10.83**
			410	**14.24**	
			240	**8.33**	
			330	**11.46**	
			310	**10.76**	
Cement brick-Class 2	**B4**	**245*105*50**	**250**	**9.72**	**9.87**
			305	**11.86**	
			200	**7.77**	
			270	**10.50**	
			245	**9.52**	
Autoclaved aerated concrete (AAC) brick	**B5**	**200*100*60**	**40**	**2**	**2.75**
			65	**3.25**	
			45	**2.25**	
			55	**2.75**	
			70	**3.5**	
Autoclaved aerated	**B6**	**600*100*200**	**120**	**2.00**	**2.28**
			145	**2.42**	
			130	**2.17**	

concrete (AAC) block			**140**	**2.33**	
			150	**2.50**	
			880	**29.3**	
			720	**24.0**	
Sand-Lime Brick	**B7**	**250*120*60**	**810**	**27.0**	**26.47**
			760	**25.3**	
			800	**26.7**	
			20	**0.64**	
			22	**0.71**	
	B8	**260*120*250**	**10**	**0.32**	**0.54**
Engineered perforated clay brick with horizontal holes			**15**	**0.48**	
			18	**0.58**	
			20	**0.77**	
			15	**0.58**	
	B9	**260*100*200**	**25**	**0.96**	**0.87**
			28	**1.08**	
			25	**0.96**	
			125	**4.17**	
			100	**3.33**	
Engineered load-bearing clay brick	**B10**	**250*120*130**	**110**	**3.67**	**3.70**
			130	**4.33**	
			90	**3.00**	

Table 3. Compressive strength for different samples

The figure 4 shows that the compressive strength of sand-lime brick (B7) is higher than the other bricks, the compressive strength of perforated clay brick with horizontal holes with dimensions 260*120*250 mm^3 (B8) is the lowest value among the bricks, and the results proved that the sand-lime brick is the best masonry brick can used for the load-bearing walls.

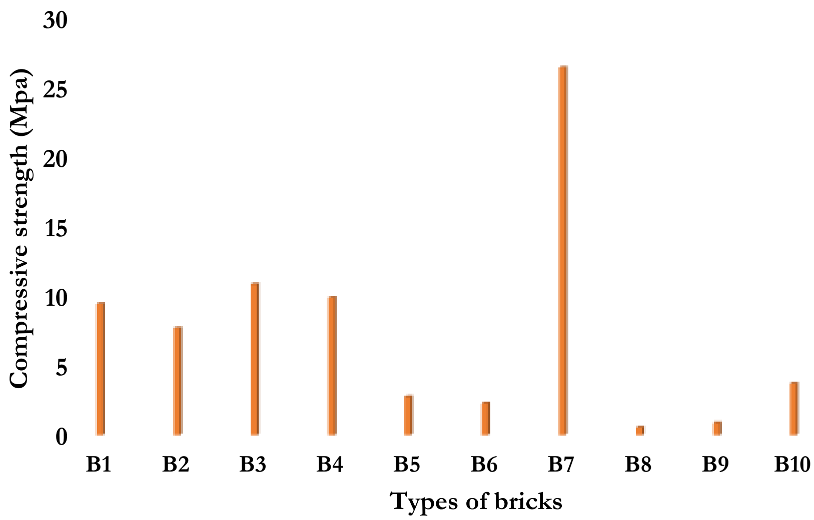

Figure 4. Average compressive strength of the specimens

According to Egyptian code for designing and constructing of the masonry works ECP 204-2005, For perforated clay bricks with vertical holes, the acceptable minimum average compressive strength is 8 N/mm^2 for load-bearing walls and 4 N/mm^2 for non-load-bearing walls. Similarly, for perforated clay bricks with horizontal holes, the acceptable minimum average compressive strength is 8 N/mm^2 for load-bearing walls and 3 N/mm^2 for non-load-bearing walls. This refers to engineered perforated clay brick with horizontal holes (B8), (B9), and engineered load-bearing clay brick (B10) would not be satisfy the specification and would be not acceptable. Also, the acceptable minimum average of compressive strength for solid cement bricks is 7 N/mm^2 for load-bearing walls, and 2.5 N/mm^2 for non-load bearing walls that means the two classes would be satisfy the specifications. As well as, the acceptable minimum average of compressive strength for solid sand-lime bricks of density exceeds 2000 N/mm^3 is 15 N/mm^2, and the acceptable minimum compressive strength for one unit of solid sand-lime bricks of density exceeds 2000 N/mm^3 is 12 N/mm2 that means the sand-lime brick (B7) would be satisfy the specifications. Finally, the specification of compressive strength of autoclaved aerated concrete (AAC) bricks and blocks does not be mentioned in the Egyptian code.

Failure of specimens under compression test

a) Failure of Autoclaved aerated concrete (AAC) blocks

b) Failure of solid sand-lime bricks

Figure 5. Failure of bricks under compression test.

Flexural strength of brick units

A set of single bricks supported on by steel roller bearings—a simple beam system—were used to determine the flexural strength. Applying a gradual load through the steel rod on top of the bricks created the effect of a concentrated load. This test on bricks is essential for understanding their ability to withstand bending forces.

Figure 6. Flexural strength test for specimens

A flexural test was conducted on five units of each type of brick; the specimens' findings are displayed in the table.4. First-class perforated clay brick units had an average flexural strength of 1.41 N/mm^2, second-class perforated clay brick units had an average flexural strength of 2.61 N/mm^2, first-class cement brick units had an average flexural strength of 1.39 N/mm^2, second-class cement brick units had an average flexural strength of 1.99 N/mm^2, autoclaved aerated concrete (AAC) brick had an average flexural strength of 2.18 N/mm^2, autoclaved aerated concrete (AAC) block had an average flexural strength of 0.63 N/mm^2, sand-lime brick had an average flexural strength of 2.26 N/mm^2, and engineered perforated large clay brick with horizontal holes had an average flexural strength of 0.36 N/mm^2.

, Engineered perforated large clay brick with horizontal holes had an average flexural strength of 0.36 N/mm^2, engineered load-bearing clay brick had an average flexural strength of 1.04 N/mm^2, and engineered perforated large clay brick had an average flexural strength of 0.82 N/mm^2.

Type	**Specimens**	**Dimensions** (mm^3)	**Failure Load (kN)**	**Flexural Strength (N/mm^2)**	**Average Flexural Strength (N/mm^2)**
Perforated clay brick-Class 1	**B1**	**210*100*60**	**2**	**1.58**	**1.41**
			1.5	**1.19**	
			1.7	**1.35**	
			1.8	**1.43**	
			1.9	**1.50**	
Perforated clay brick-Class 2	**B2**	**200*80*60**	**3**	**2.81**	**2.61**
			2.5	**2.34**	
			2.8	**2.63**	
			2.7	**2.53**	
			2.9	**2.72**	
Cement brick-Class 1	**B3**	**240*120*60**	**2**	**1.53**	**1.47**
			2	**1.53**	
			1.7	**1.30**	
			1.9	**1.45**	
			2	**1.53**	
Cement brick-Class 2	**B4**	**245*105*50**	**1.7**	**2.14**	**1.99**
			1.6	**2.01**	
			1.6	**2.01**	
			1.5	**1.89**	
			1.5	**1.89**	
Autoclaved aerated concrete (AAC) brick	**B5**	**200*100*60**	**4**	**3.00**	**2.18**
			2	**1.50**	
			2.5	**1.88**	
			3	**2.25**	
			3	**2.25**	
Autoclaved aerated concrete (AAC) block	**B6**	**600*100*200**	**2**	**0.42**	**0.63**
			3	**0.63**	
			4	**0.84**	
			3	**0.63**	
			3	**0.63**	

			2.5	**1.82**	
			3.5	**2.55**	
Sand-Lime Brick	**B7**	**250*120*60**	**3**	**2.19**	**2.26**
			3	**2.19**	
			3.5	**2.55**	
			8	**0.38**	
			7	**0.34**	
Engineered perforated clay brick with horizontal holes	**B8**	**260*120*250**	**7**	**0.34**	**0.36**
			8	**0.38**	
			7	**0.34**	
			11	**1.24**	
			9	**1.01**	
	B9	**260*100*200**	**8**	**0.90**	**1.04**
			10	**1.13**	
			8	**0.90**	
			5	**0.85**	
			4	**0.68**	
Engineered load-bearing clay brick	**B10**	**250*120*130**	**6**	**1.02**	**0.82**
			5	**0.85**	
			4	**0.68**	

Table 4. Tensile strength of different specimens

The figure.5 shows that the flexural strength of perforated clay brick-class2 (B2) is higher than the other bricks, the flexural strength of engineered perforated clay brick with horizontal holes with dimensions 260*120*250 mm^3 (B8) is the lowest value among the bricks, and the results proved that the perforated clay brick-class2 (B2) is the best masonry brick can used for elements subjected to flexural. Also, as masonry wall not masonry bricks, the results can be different due to the bond between bricks and mortar.

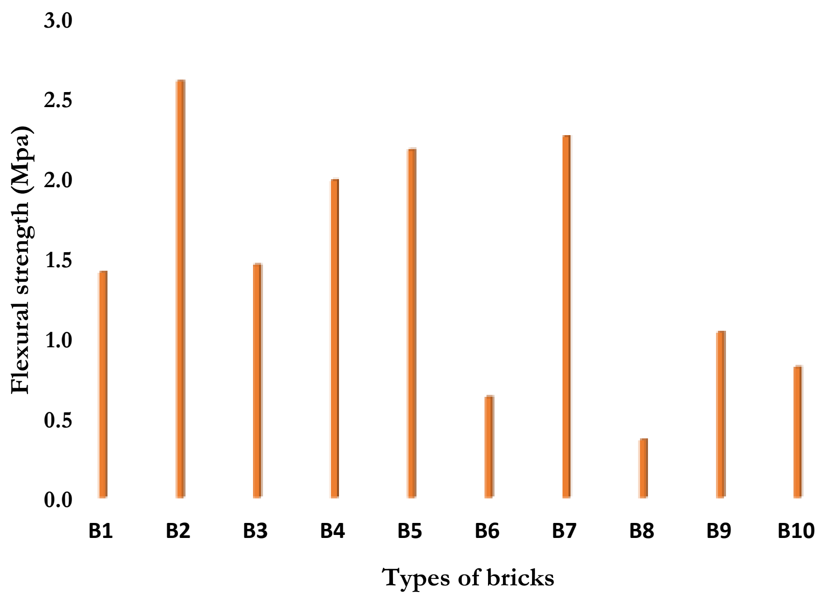

Figure 7. Average flexural strength for different specimens

Failure of specimens under flexural test

a) Failure of first-class perforated clay brick unit

b) Failure of first-class solid cement brick unit

Figure 8. Failure of specimens under flexural test

Water absorption of brick units

Water absorption and porosity also play significant roles in determining brick durability. Understanding these properties ensures the longevity and stability of masonry structures. Water absorption is observed by weighing the brick unit in a dry case and after immersing it for 24 hours and calculating the water absorption percentage.

Figure 9. Second-class perforated clay brick immersed in water for 24 hours

A compression test was conducted on five units of each type of brick; the specimens' results are shown in the table.5. The average water absorption of first-class perforated clay brick units was 10.32 %, the average water absorption of second-class perforated clay brick units was 8.51 %, the average water absorption of first-class cement brick units was 7.98 %, the average water absorption of second-class cement brick units was 4.99 %, Autoclaved aerated concrete (AAC) bricks had an average water absorption of 52.85%, whereas AAC blocks had an average water absorption of 44.30%, the average water absorption of sand-lime brick was 10.85 %, the average water absorption of engineered perforated large clay brick with horizontal holes was %, the average water absorption of engineered perforated large clay brick with horizontal holes was %, the average water absorption of engineered load-bearing clay brick was %.

Type	**Specimens**	**Dimensions** (mm^3)	**Dry Weight (gm)**	**Weight after 24 hours** (gm)	**Water Absorption Percentage (%)**	**Average Water Absorption Percentage (%)**
Perforated clay brick-Class 1	**B1**	**210*100*60**	**1826**	**2007**	**9.91**	**10.32**
			1856	**2051**	**10.51**	
			1837	**2026**	**10.29**	
			1842	**2034**	**10.42**	
			1846	**2039**	**10.46**	
Perforated clay brick-Class 2	**B2**	**200*80*60**	**1336**	**1425**	**6.66**	**8.51**
			1363	**1487**	**9.10**	
			1303	**1425**	**9.36**	
			1358	**1467**	**8.02**	
			1324	**1446**	**9.21**	
	B3	**240*120*60**	**3498**	**3762**	**7.55**	**7.98**
			3698	**4002**	**8.22**	

Cement brick-Class 1			**3591**	**3863**	**7.57**	
			3564	**3872**	**8.64**	
			3636	**3924**	**7.92**	
			2650	**2760**	**4.15**	
			2469	**2594**	**5.06**	
Cement brick-Class 2	**B4**	**245*105*50**	**2535**	**2670**	**5.33**	**4.99**
			2584	**2740**	**6.03**	
			2610	**2724**	**4.37**	
			744	**1138**	**52.96**	
			738	**1119**	**51.63**	
Autoclaved aerated concrete (AAC) brick	**B5**	**200*100*60**	**720**	**1084**	**50.55**	**52.85**
			735	**1126**	**53.2**	
			760	**1185**	**55.92**	
			6975	**9876**	**41.59**	
			7210	**10387**	**44.06**	
Autoclaved aerated concrete (AAC) block	**B6**	**600*100*200**	**7975**	**12040**	**50.1**	**46.51**
			7088	**10264**	**44.81**	
			7345	**11146**	**52**	
			3274	**3636**	**11.06**	
			3313	**3662**	**10.53**	
Sand-Lime Brick	**B7**	**250*120*60**	**3241**	**3595**	**10.92**	**10.85**
			3287	**3687**	**12.17**	
			3325	**3643**	**9.56**	
			5303	**5585**	**5.32**	
			5353	**5640**	**5.36**	
Engineered perforated clay brick with horizontal holes	**B8**	**260*120*250**	**5340**	**5610**	**5.06**	**5.22**
			5435	**5693**	**4.75**	
			5380	**5682**	**5.61**	
			4130	**4445**	**7.63**	
			3952	**4220**	**6.78**	
	B9	**260*100*200**	**4062**	**4407**	**8.49**	**7.04**
			3995	**4274**	**6.98**	
			4047	**4262**	**5.31**	
			3790	**4075**	**7.52**	
			3820	**4105**	**7.46**	
Engineered load-bearing clay brick	**B10**	**250*120*130**	**3840**	**4120**	**7.29**	**7.47**
			3785	**4063**	**7.34**	

3797	**4090**	**7.72**

Table 5. Water Absorption percentage for different samples.

The figure.10 shows that the water absorption percentage of second-class solid cement brick (B4) is lower than the other bricks, the water absorption percentage of autoclaved aerated concrete (AAC) brick (B5) is the highest value among the bricks, and the results proved that the second-class solid cement brick is the best masonry brick can used for the masonry works exposed to water and moisture.

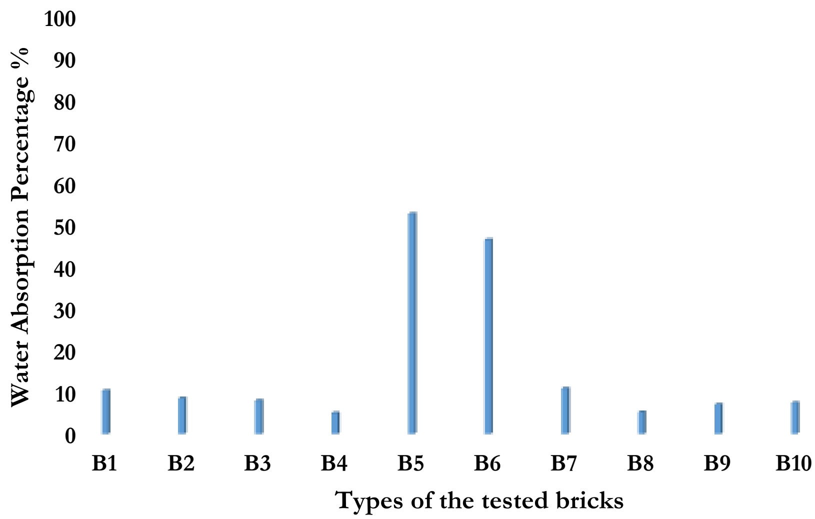

Figure 10. Average water absorption percentage of different specimens.

According to Egyptian code for designing and constructing of the masonry works ECP 204-2005, the acceptable water absorption percentage for perforated clay bricks doesn't exceed 16 % for load-bearing walls, and 20% for non-load bearing walls. Also, the specification of compressive strength of solid cement bricks, solid sand-lime bricks, autoclaved aerated concrete (AAC) bricks, and autoclaved aerated concrete (AAC) blocks does not be mentioned in the Egyptian code.

CONCLUSION

The experimental study conducted in Egypt aimed to evaluate various mechanical properties of common brick types used in construction. The key conclusions based on the tests performed:

- Engineered perforated clay brick with horizontal holes (B8), (B9), and engineered load-bearing clay brick (B10) would not be satisfy the specification of the compressive strength has been set by the Egyptian code for designing and constructing of the masonry works (ECP-204-2005) and would be not acceptable.
- The lighter type of specimens can used in masonry walls is autoclaved aerated concrete (AAC) block (B6).
- The cost-effectiveness type of bricks can used in masonry walls is considered second-class clay brick (B2).
- Among the tested brick units, solid sand-lime bricks (B7) demonstrated the highest compressive strength and considered the best masonry brick for load-bearing walls.
- Among the specimens, second-class clay bricks had the highest bending strength and considered the best masonry brick for masonry walls, and lintels.

- The average water absorption percentage of second-class cement brick units (B4) was the lowest among all specimens and considered the best masonry bricks for structures exposed to water and moisture.
- Conversely, autoclaved aerated concrete bricks (B5), and blocks (B6) had the highest water absorption percentage.

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