International Journal of Engineering

Journal Homepage: www.ije.ir

Experimental Investigation of Brick-Slabs: Evaluation of the Performance and Ductility of Various Brick Materials

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PAPER INFO

Paper history:
Received 24 May 2023
Received in revised form 09 July 2023
Accepted 10 July 2023

Keywords:
Brick Slab
Perforated Brick
Gpsum Mortar

ABSTRACT

In this study, five one-way brick slab specimens were manufactured to investigate the behavior of brick slabs composed of various types of bricks (solid bricks, perforated bricks, and cellular concrete blocks (thermostone). The span ranges from 600 to 800 mm, while the camber ranges from 0 to 30 mm. Previously, cellular concrete blocks, solid and perforated clay bricks were employed as the building materials. These samples were tested by being subjected to flexural three-point loading. The results revealed that increasing camber by 30 mm for solid brick specimens increased ductility, and ultimate strength, by 5.5% and 77.62, respectively. Increasing the span from 600 to 800 mm for solid brick specimens decreased the ultimate strength and ductility by 37.96% and 6.83%, respectively. Cellular concrete blocks can be used in the construction of slabs due to their lightweight and acceptable structural response when compared to solid brick specimens. Due to their good structural performance and lightweight, perforated bricks can be used to build brick slabs. Brittleness and the sudden collapse of the brickwork arch characterized the failure mode in all samples.

doi*: 10.5829/ije.2023.36.09c.07*

NOMENCLATURE

f_{fb}	Flexural bonding strength in Mpa	W	Weight of brick in Newton
l_b	Length of a brick unit in mm.	w_b	Width of brick unit in mm
l_{mj}	Length of mortar joint in mm	Δu	Ultimate Deflection
P	Failure load in Newton	Δy	Yield Deflection
t_{bar}	Thickness of steel bar in mm		

1. INTRODUCTION

Brick slabs are composed of I-section steel beams that stand on bearing walls with span centers that vary from 70 to 90 cm. Gypsum mortar is utilized to bind together clay brick units and form the spans between steel I-section beams because of the quick setting time of gypsum (See Figure 1). For aesthetic reasons, the brick slab's bottom face may not be plastered with mortar. The brick slab was developed in the late nineteenth century by Victorian architects in Britain. The brick slab eventually reached the majority of nations, including India, Eastern Europe, and North America. It had gained popularity as a flooring system in various Middle Eastern nations by the mid-20th century, especially in Iran and Iraq. Brick slabs were a well-known technique that was extensively utilized in Iraq. Brick slabs are still utilized in construction in spite of the widespread use of reinforced concrete in the majority of Iraq's regions because of their reasonable cost, speed of construction, lack of need for skilled labor, suitability for narrow areas, and avoidance of forms, casting, reinforcement, and curing. Those from limited-income families commonly use the arch brick slab. It was recently found that ceramic panels and cellular concrete block units are being used in their construction due to the cellular concrete block's

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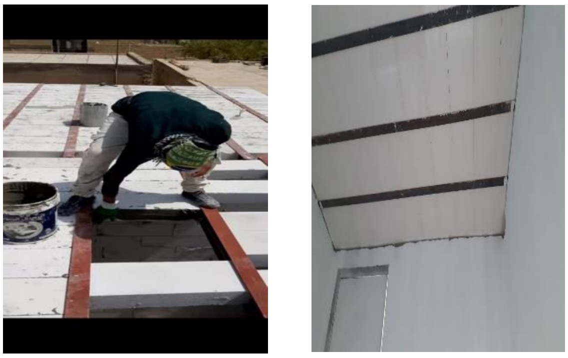
Please cite this article as: A. Hatif Obaid, A. A. Jaafar, E. Noroozinejad Farsangi, Experimental Investigation of Brick-Slabs: Evaluation of the Performance and Ductility of Various Brick Materials, ***International Journal of Engineering, Transactions C: Aspects***, Vol. 36, No. 09, (2023), 1636-1644

Figure 1. Brick slab after construction

speed of work, thermal insulation, and lightweight (see Figure 2). Brick slabs have significant drawbacks despite their general benefits. In particular, it uses gypsum mortar, which has low moisture resistance and is vulnerable to seismic loadings as a primitive construction technique.

The brick slab system is stable under typical static loading because the arches of the brick slabs predominantly transmit stress loads along the archway to the beams, then transfer stresses to the supporting beams or walls. Due to its geometric shape, the brick slab structure is often described as a one-way slab [1]. As suggested a revolutionary two-way method in 2003, the vulnerabilities of conventional one-way brick slabs are Investigated. A steel grid was created by the suggested technique, in which a series of steel transversal beams that crossed through the main I-beams were used. The disjointed steel transversal beams will subsequently be an element of a steel grid that enables the distribution of applied loads in two-way directions. The brick slab system, which was developed and constructed, was found to improve the diaphragm's action and resistance to gravity and seismic stresses [2]. A research investigation was conducted on how the existing structures performed during the 2003 Bam earthquake. The result demonstrates that brick slabs with the supporting two X bracings that are welded at the end of the slab corner as indicated in Figure 3 performed well when subjected to lateral loads [3]. Pourfalah et al. [4] conducted research on the experimental study of placing a layer of concrete on the top of brick slab in 2009. The result demonstrated that strength, ductility, and seismic performance had all



(a) cellular concrete blocks (b) ceramic panels

Figure 2. Construction of a brick slab

Figure 3. Sample with two X-bracings on the floor slab during construction [4]

increased. Experimental research has been done on the in-plane seismic response of traditional and strengthened brick slab diaphragms. The findings indicate that the seismic response, integrity, and ductility of end arch spans were improved by using simultaneous diagonal bracing and steel tension ties [5]. The ferrocement layer and the brick slab's corresponding effects increased stiffness, ductility and flexural strength, without considerably adding to the weight of the slabs [6]. According to finite element analysis, a brick slab in southern Iraq's seismic performance was examined, and the results demonstrated that flexural forces rather than membrane stresses dominate behavior of the brick slab. The tensile stresses were high, but the slab's compressive stresses were smaller than the allowable stress. In steel support beams, displacement, stress, and strain were generally within acceptable limits [7]. An historic American boarding school for girls in Merzifon, Turkey, with a one-way masonry brick slab, has been evaluated for its seismic sensitivity and structural behavior. The top of the structure and the connection areas between steel beams and brick arches exhibited the highest compression and tension loads, based on the results of the static tests [8]. Slant-jack arch masonry slabs are considered semi-rigid roofs, and improving them can make them more rigid. A layer of reinforced concrete can be poured on masonry buildings to increase their seismic performance after being retrofitted with slant-brick slabs. The results demonstrate that the most economical method for jack arch retrofitting is to add a concrete layer [9]. According to the result of an experimental investigation of standard and retrofitted brick slabs in a single-story 3D steel building, the double X strapping approach can greatly improve the other two techniques in regards to stiffness in plane, capacity, and even energy dissipation [10]. Flexural failure was the main mode of failure for the cellular concrete block (thermostone) roof structure. There was no evidence of cellular concrete block crushing through the test at the point where the unit of cellular concrete block split almost entirely in the center [11]. The proposed ferrocement sandwich slab is a possible replacement for the conventional brickwork slab [12]. The suggested approach and its use are validated by achieving a good correlation between the analytical findings and the observed fragility features in field testing [13]. It is noted that a significant factor in the structural damage anticipated for the Fertek building is slab discontinuities on the gallery floor [14]. The severe damage that out-of-plane accelerations cause to masonry infill walls makes load-bearing masonry structures extremely vulnerable to seismic damage and potential collapse. Largely enhanced accelerations occur on the face of the laden infill wall as a result of the dynamic interaction between the vibrating structure, slab diaphragms, and the infill wall loaded out-of-plane, leading to significantly increased inertia forces [13]. The use of new lightweight materials in building applications is encouraged by their increased thermal and mechanical properties [15]. In all combinations, the early age strength is reached, but the dosage of 10% alcooline results in a stronger effect [16]. With 10% waste glass and 20% waste clay brick, the flexural strength at 400ºC increased by 56% and 69%, respectively. All combination mixes also demonstrated greater strength than the control [17]. According to the feedback earlier in this section, no in-depth research has been done on the behavior of brick slabs constructed from various types of bricks (solid, and perforated bricks), cellular concrete block units (thermostone), and mortar made with gypsum, which are the majority of regularly used materials in their construction, particularly in Iraq. As a result, the purpose of this study is to gather information and provide statistics about how the brick slabs made of solid bricks, perforated bricks, and cellular concrete blocks behave. Five one-way brick slab specimens were manufactured in order to demonstrate the effects of span length, camber, and brick types utilized on the structural behavior of brick slabs and were experimentally tested.

2. EXPERIMENTAL PROGRAM

2. 1. Materials Properties

2. 1. 1. Clay Bricks The most common type of brick used in brick slab construction is clay brick. According to IQS 24-1989 the bricks were subjected to testing, and the findings are summarized in Table 1.

2. 1. 2. Gypsum Mortar Gypsum and water are mixed to form the gypsum mortar. Gypsum mortar testing is done in accordance with the Iraqi Reference Guide (1042-2011). Table 2 illustrates the test results.

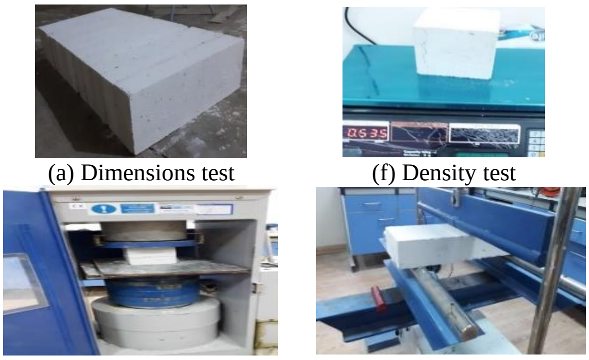
2. 1. 3. Cellular Concrete Blocks Thermostone, an instance of a precast lightweight cellular concrete block, is made of cellular concrete. As stated in Figure 4, its mechanical and physical characteristics have been evaluated in accordance with the Iraqi Reference Guide (810-2009). The results satisfy Iraqi standards (IQS 1441-2013). Table 3 demonstrates the test results.

TABLE 1. Test results for clay brick properties

Type of brick		Solid clay Bricks	Perforated clay Bricks	Limit of IQS No.25 /1988
Per. of Perforated [%]		0	24.44	25% Max
Density [kg/m^3]		1500	1207	-
Dimension [mm]		233.0×113.0×72.0	235.20×114.63×73.46	L*, W* =± 3%
Rupture Modulus [MPa]		2.0	1.2	-
Efflorescence		Light	Light	-
Water Absorption [%]	10 units	25	22	26
	1 unit	25	23	28
Average Compressive Strength [MPa]	10 units	9	7	9
	1 unit	8	6	7

TABLE 2. Properties of gypsum mortar

Property	Test Result	Limit of IQS No.28/2010 [20]
Fineness [%]	5	8 % Maximum
Time Setting [Minute]	13	(for brick slab using 15 max) [8-25]
Compressive Strength [MPa]	3	3 [MPa] Minimum
Rupture Modulus [MPa]	0.7	-
Gypsum / Water	0.39	-



(a) Dimensions test (f) Density test

(d) Compressive strength test (e) Modulus of rupture test

Figure 4. Cellular concrete block tests

2. 1. 4. Cement, Aggregate, and Water The bottom faces of the specimens used in this study are plastered with cement mortar. This mortar was produced using sand (S) and ordinary Portland cement (C). The C:S ratio for this mix was 1:2 with a W/C of 0.5. Ordinary Portland cement mechanical and physical characteristics have been tested in accordance with the Iraqi Reference Guide (No. 198-1990). The test findings are given in Table 4, while chemical properties are tested according to the Iraqi Reference Guide (472-1993). The results of

TABLE 3. Test results of cellular concrete blocks

Dimension Test	Standard Dimension [mm]	Test Result [mm]	Limit of IQS 1441/2013	
Length	600	+2	± 3 mm for any dimension	
Height	200	-0.5		
Thickness	100	+1		
Specimen [mm]	Average weight for 2 cubes [kg]	Average volume for 2 cubes [m^3]	Density [kg/m^3]	Class according to Limit of IQS 1441/2013
	0.51	0.00095	536.80	0.50
(100×100×100)	Compressive strength [MPa]			Limit of IQS 1441/2013
	One unit		2.16	1.60
	Average for two cubes		2.20	2
600×200×100	Modulus of rupture [MPa] average for two unit			-
	600×200×100			

the tests are shown in Table 5. Sand is available as natural silica sand. Its grading is tested according to Iraqi standards (IRQ No. 30/1984). Test results are satisfactory by Iraqi standards (IQS No. 45/1984) as shown in Table 6. Drinking water is used for mixing all the cement and gypsum mortar, as well as curing specimens and other testing of the materials. Drinking water satisfied the Iraqi standard (IQS 1703/2018).

TABLE 4. Properties for cement and plastering mix

Physical and Mechanical Properties	Test Result	Limit of IQS No.5/2019
Fineness [m^2/kg]	254.30	≥ 250
Time Setting Initial [Hour: Minute]	0: 59	≥ 45 Minutes
Final [Hour: Minute]	8: 2	≤ 10 Hours
Compressive Strength [MPa]		
2- Days	19.0	≥ 10
28- Days	34.2	≥ 32.5

TABLE 5. Chemical properties of cement

Chemical Property	Content [%]	Limit of IQS No.5/2019
MgO	2.65	≤ 5 %
SO_3	2.20	≤ 2.8 %
Loss of Ignition	3.11	≤ 4 %
Insoluble Materials	1.15	≤ 1.5 %
Lime Saturation Factor	0.86	0.66 – 1.02

TABLE 6. Sand test result

Sieve Size [mm]	Cumulative Retained [%]	Cumulative Passing [%]	Limit of IQS No.45/1984- Zone No.2
10 [mm]	0	100	100
4.75[mm]	0	100	90-100
2.36 [mm]	10	90	75-100
1.18 [mm]	16	84	55-90
600 [Micron]	45	55	35-59
300 [Micron]	72	28	8-30
150 [Micron]	94.5	5.5	0-10
Material Finer Than 75 Micron	1.1		5 % Max
Fineness Modulus	2.375		[2.3-3.1] ASTM C33M/13 [18]

2. 1. 5. Flexural Bonding Strength According to Khalaf, tests and calculations were done to determine the flexural bond strength between solid, perforated clay brick, cellular concrete block units, and gypsum mortar. A new test procedure was proposed by Khalaf. According to this approach, three-point loading caused a flexural bond failure parallel to the bed joint when bricks were manufactured using two brick units arranged in a Z-shape. Two assumptions are made for calculating the values of the flexural bond strength (f_{fb}). The first is a linear stress distribution, and the second type of stress distribution is a parabolic distribution. In this study, flexural bond strength values based on two assumptions were determined by using Equation 1 for linear stress distribution and, Equation (2) for parabolic stress distribution. The results of the tests are summarized in Table 7.

$$f_{fb} = \frac{(0.5l_b^2 - l_b t_{bar} + 0.5t_{bar}^2)P + (0.75l_b^2 - 1.25l_b t_{bar} + 0.5t_{bar}^2)W}{(0.333l_{mj}^2 w_b)(1.5l_b - t_{bar})} \quad (1)$$

$$f_{fb} = \frac{(0.5l_b^2 - l_b t_{bar} + 0.5t_{bar}^2)P + (0.75l_b^2 - 1.25l_b t_{bar} + 0.5t_{bar}^2)W}{(0.42l_{mj}^2 w_b)(1.5l_b - t_{bar})} \quad (2)$$

2. 2. Specimen Manufacturing The experimental program emphasizes one-way testing of brick slab specimens. Five samples are fabricated using perforated, solid clay bricks, and cellular concrete blocks with a workable gypsum mixture to bind units together and fill gaps between them. Cement mortar as plastering of 10 mm in thickness is applied on the bottom face of the specimens. The compressive strength of cement paste used for plastering is (50×50×50) mm cubes and (160×40×40) mm prisms, whereas the flexural strength is35.7 MPa and 7 MPa, respectively. After 28 days of

TABLE 7. Test Results of flexural bonding strength according to Khalaf [22]

Specimen Type	Test Result	
	Average (Two Samples) by Linear Stress Distribution [MPa]	**Average (Two Samples) by Parabolic Stress Distribution [MPa]**
Solid Clay Bricks	0.321	0.253
Perforated Clay Bricks	0.410	0.324
Cellular Concrete Blocks	0.254	0.200

plastering five samples with cement mortar, to prepare the samples for testing and to have a good overview of the cracks during the test, a white coating layer is put over the plastering coating. The main variables that are considered for these samples are span length (600-800) mm, camber height (30) mm, and brick types (solid bricks, perforated bricks, cellular concrete blocks (thermostone) are used in construction of specimens to show their effects on the behavior of the brick slab. Table 8 summarized the specimens' details and Figure 5 shows the construction process of brick slab specimens.

2. 3. Procedure Testing

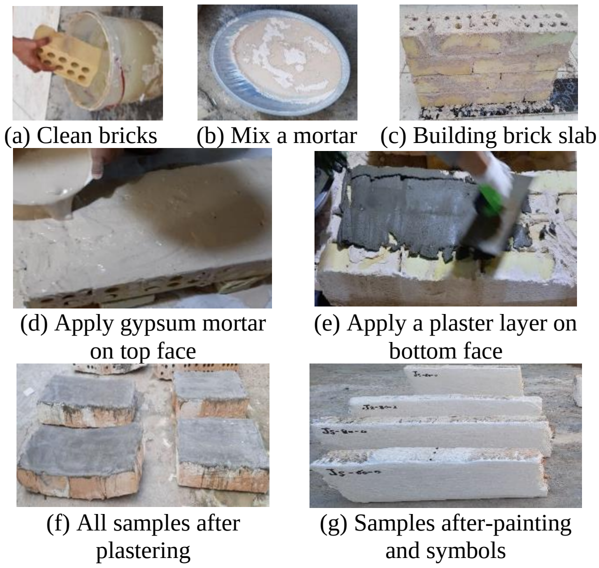
All five specimens are subjected to a line load with three-point bending. Brick slabs are tested using a hydraulic piston with a 10-ton capability. At each load step, the load is progressively increased and applied monotonically in equal increments. Two steel rods support the slab specimen on either side. A dial gauge with a 50-mm capacity is used to measure the displacement at the midpoint of the span. A crack microscope is used to view the cracks. The applied load at a slab's midspan is measured using a calibrated load cell. Figure 6 depicts an image of the test setup, and Figure 7 shows a plan of the test setup.

3. RESULTS AND DISCUSSIONS

The main objectives of this study are to investigate behavior of brick slabs made of various bricks (solid clay bricks, perforated clay bricks and, cellular concrete blocks (thermostone)) subjected to flexural three-point loading (line load). The results of the tests are presented regarding the ultimate load, load-deflection at the slab's mid-span, ductility index, and failure mode.

TABLE 8. Specimens' details

No.	Specimens Symbol	Span Length [mm]	Width [mm]	Camber Height [mm]	Type of Bricks Used
1	Js-60-0	600	320	0	Solid brick
2	Js-80-0	800	320	0	Solid brick
3	Js-80-3	800	320	30	Solid brick
4	Jv-60-0	600	320	0	Perforated brick
5	Jc-60-0	600	320	0	Cellular concrete block



(a) Clean bricks (b) Mix a mortar (c) Building brick slab
(d) Apply gypsum mortar on top face (e) Apply a plaster layer on bottom face
(f) All samples after plastering (g) Samples after-painting and symbols

Figure 5. Steps for preparing brick slab specimens

Figure 6. Test setup image

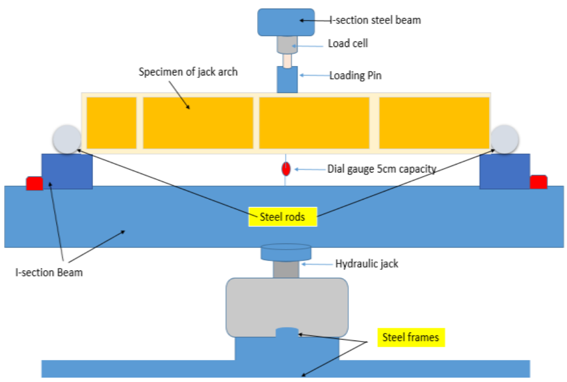


Figure 7. Test setup strategy

3. 1. Ultimate Strength The results of ultimate load for brick are shown in Table 9 and Figure 8. The effects of the type of bricks used in the construction of the brick slab on ultimate loads are studied by using three brick types. These are solid, perforated clay bricks, and cellular concrete blocks with a span length of 600 mm. The results indicate that the specimen with perforation bricks Jv-60-0 has a greater ultimate load than the specimens with solid clay bricks Js-60-0 and cellular concrete blocks Jc-60-0 by 37.4 and 41.07%, respectively. These results are due to the fact that the flexural bonding strengths between brick units and gypsum mortar are higher than those between cellular concrete block units as mentioned in the flexural bonding tests in the previous section. Also, the poor mechanical properties of cellular concrete blocks compared to clay bricks are expected. To study the effect of span length on the ultimate loads of brick slabs are considered for samples made with solid bricks. The selected span is between 600 and 800 mm. The results show a clear decrease in the ultimate loads when increasing the span length for solid clay brick samples. The findings indicate that when the span was increased from 600 to 800 mm for Js-80-0 the ultimate loads decreased by 37.96%. Increasing camber has an impact on the brick slab's ultimate loads, which are tested on specimens. For this purpose, a camber of 30 mm is used for specimens made of solid clay bricks. The results show an increase in the ultimate loads for specimens when the camber is increased. Increasing camber from 0 to 30 mm for Js-80-3 improves ultimate loads by 77.62%.

TABLE 9. Test results

No.	Specimens Symbol	Ultimate Load [kN]	Weight [kg]
1	Js-60-0	3.53	40
2	Js-80-0	2.19	51
3	Js-80-3	3.89	52
4	Jv-60-0	4.85	33
5	Jc-60-0	3.44	14

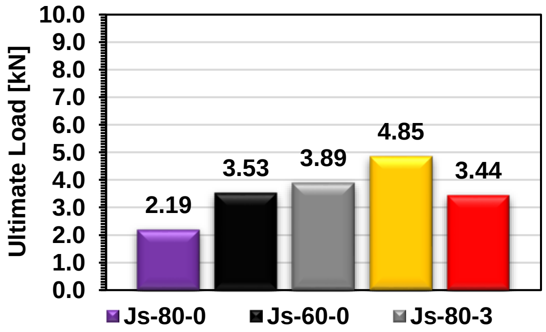


Figure 1. Ultimate loads for brick specimens

3. 2. Load–Deflection Curves and Ductility Index The ability of a material to resist plastic deformation under load is called ductility. The ductility index (μΔ) is defined as the proportion of total displacement (Δu) to elastic limit displacement (Δy) [19, 20]. The point at which strength behavior is believed to switch from elastic to plastic is the elastic limit deflection. The approach for calculating the ductility indices for each tested specimen in the current experimental study is based on Figure 9. The load-deflection curves for brick slab specimens are shown in Figure 10. This figure depicts the load-deflection curves of all five brick slab specimens, Js-60-0, Js-80-0, and Js-80-3, Jv-60-0, and Jc-60-0. It is seen clearly show that the specimens made from perforated and solid clay brick behave approximately linearly until they reach their ultimate load. A sudden failure occurs after reaching ultimate loads. The loading-deflection curve for specimen Jc-60-0, depicts a sample made with a cellular concrete block (thermostone block) and gypsum mortar that has been widely used in recent years in the construction of brick slabs. It is obvious from this figure that the samples behave similary to the behavior of brick specimens made with solid and perforated clay

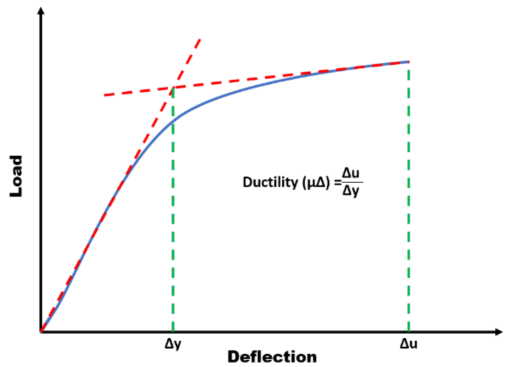


Figure 9. The ductility index calculation approach [23, 24]

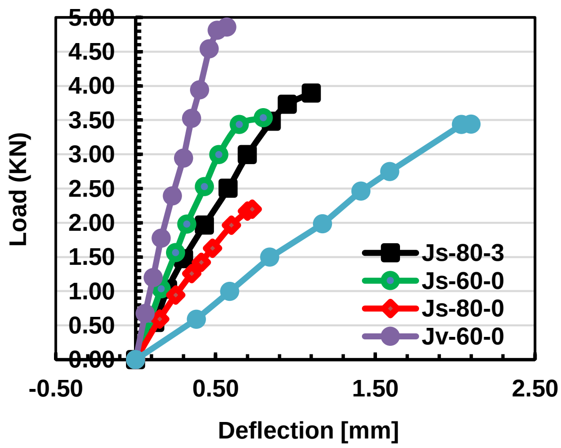


Figure 10. Load-deflection curves for specimens

bricks, where the behavior is linear until reaching their ultimate strength. As soon as the maximum load is reached, an abrupt failure occurs. This linear behavior of jack-arch slab specimens made with solid, and perforated bricks, and cellular concrete blocks bonded together using gypsum mortar is due to the fact that they are brittle materials and do not exhibit the ductility of ductile materials. From previous load-deflection curves, the specimen Jv-60-0 has a higher stiffness than the specimens Js-60-0, and Jc-60-0. The specimen Js-80-3 has a higher stiffness than Js-80-0.

Ductility index results for brick slab specimens are shown in Figure 11 and Table 10. The effects of the type of bricks used in the construction of the brick slab on the ductility index are studied by using three brick types, solid, and perforated bricks, and cellular concrete blocks (thermostone) for a span length of 600 mm. The results show that the specimen with solid bricks, Js-60-0 has a greater ductility index than the specimens with perforated clay bricks Jv-60-0 and cellular concrete blocks Jc-60-0 by 4.46 and 13.59%, respectively. To investigate how span length affects the ductility index of brick slab is also considered for samples made with solid bricks. The selected span is between 600 and 800 mm. The findings indicate that by increasing the span from 600 to 800 mm for Js-80-0 the ductility index decreased by 6.83%. Also, the effect of increasing camber height on the ductility index of the brick slab is investigated. For this purpose, one camber of 30 mm is used for specimens made of solid clay bricks.The results show an increase in the ductility index for the specimens when the camber is increased. The results showed an increase in camber of 30 mm for the specimen Js-80-3 which improve the ductility index by 5.50%. From the above results of ductility index, all-control brick slab specimens have a very low ductility index as a result of consistent materials, clay bricks, gypsum mortar, and cement (plastering), which are not ductile and brittle. Also, cellular concrete blocks do not have ductile properties.

4. FAILURE MODES

Failure modes for all brick slab specimens are shown in Figure 12 (a-e). For those specimens, failure is characterized in all brick slabs made from solid, and perforated brick specimens by the sudden collapse of brickwork slabs due to initiate cracks at the joining brick units together. Due to the fact that the bond joints between brick units are the weakest part of the element, this characterized failure in the control of conventional brick slab samples. The failure mode is characterized by a brittle failure, this is due to the brick slab constituent materials that are brittle and have low tensile strength. The observation made during the test show that the specimens' compression faces are not crushed, and the clay bricks do not break or break, see Figure 12 (a-d). For brick slab specimens made with cellular concrete blocks, the failure mode is similar to that of brick slabs made with perforated and solid clay brick specimens. The failure is characterized by brittleness and the sudden collapse of cellular concrete block. The fracture occurs in the cellular concrete block unit at mid-span instead of in the bond joint between units. This failure mechanism occurs because cellular concrete blocks have brittle and low tensile strength. During the test of this specimen, no crushing in the compression face occurred, see Figure 12 (e). From the above explanation, the flexural failure mode is dominates the brick slab specimens at mid-span for brick slab specimens made with cellular concrete block and nearer the bond joint at mid-span for brick slab specimens made with perforated and solid clay brick.

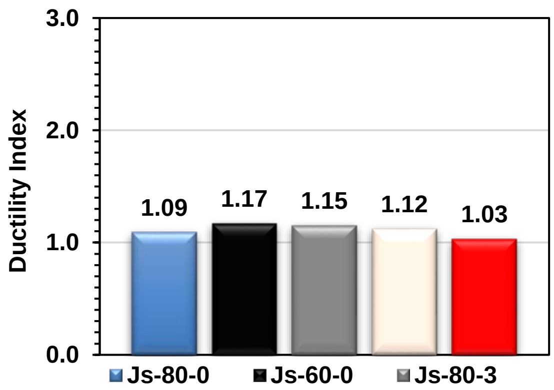


Figure 11. Ductility index results for specimens

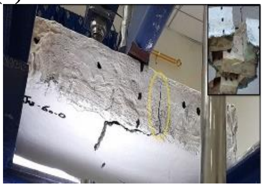
TABLE 10. Sample test results

Specimens Symbol	Ultimate Load [kN]	Ultimate Deflection [mm]	Yield Load [kN]	Yield Deflection [mm]	Ductility [Δu/Δy]	Weight [kg]
Js-60-0	3.53	0.80	3.50	0.68	1.17	40
Js-80-0	2.19	0.73	2.16	0.67	1.09	51
Js-80-3	3.89	1.10	3.73	0.95	1.15	52
Jv-60-0	4.85	0.57	4.80	0.50	1.12	33
Jc-60-0	3.44	2.10	3.43	2.03	1.03	14

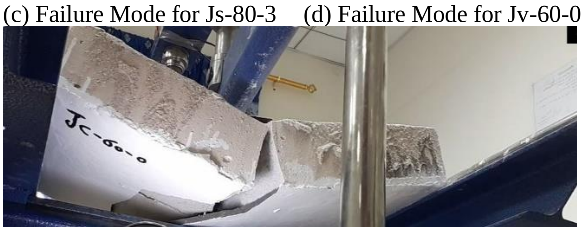
(a) Failure Mode for Js-60-0

(b) Failure Mode for Js-80-0

(c) Failure Mode for Js-80-3



(d) Failure Mode for Jv-60-0



(e) Failure Mode for Jc-60-0

Figure 12. Mode of failure for specimen

5. CONCLUSIONS

Steel I-section beams that are supported by bearing walls with span centers ranging from 70 to 90 cm make up brick slabs. The behavior of brick slabs made of different types of bricks solid bricks, perforated bricks, and cellular concrete blocks (thermostone) was examined in this study using five one-way brick slab specimens. While the camber varies from 0 to 30 mm, the span is between 600 and 800 mm. Previously, the buildings were constructed of cellular concrete blocks and solid and perforated clay bricks. Flexural three-point loading is used to test these samples. The results revealed that increasing camber by 30 mm for solid brick specimens increased ductility, and ultimate strength, by 5.5%, and 77.62, respectively. Increasing span from 600 to 800 mm for solid brick specimens decreased the ultimate strength and ductility by 37.96% and 6.83%, respectively. Conclusion based on the study's findings showed that cellular concrete blocks can be used in the construction of slabs due to their lightweight and acceptable structural response when compared to solid brick specimens. Due to their good structural performance and light weight, perforated bricks can be used to build brick slabs. Brick slab specimens generally exhibit flexural failures. Brittleness and the sudden collapse of the brickwork arch characterized the failure mode in all samples. The authors suggest adopting this kind of slab when constructing residential buildings because it is quick to construct, inexpensive, and suitable for narrow spaces when applying the required engineering techniques.

6. RECOMMENDATIONS FOR FUTURE RESEARCH

1. To increase strength, we should increase the bond strength between brick units, and mortar used.
2. Our main emphasis in this study was on experimental work. We are currently creating the empirical equations and finite element models for the methodology covered in this paper. This, in our opinion, should be covered in a different study.

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Persian Abstract

چکیده

این مطالعه، پنج نمونه دال آجری یک طرفه برای بررسی رفتار دال‌های آجری متشکل از انواع آجر (آجرهای توپر، آجرهای سوراخ‌دار و بلوک‌های بتنی سلولی (ترموستون)) ساخته شد. دامنه دهانه بین ۶۰۰ تا ۸۰۰ میلی متر است، در حالی که دامنه از ۰ تا ۳۰ میلی متر است. قبلاً از بلوک های بتنی سلولی و آجرهای سفالی جامد و سوراخ دار به عنوان مصالح ساختمانی استفاده می شد. این نمونه ها با بارگذاری سه نقطه ای خمشی آزمایش می شوند. نتایج نشان داد که افزایش کمبر به میزان ۳۰ میلی‌متر برای نمونه‌های آجر جامد، شکل‌پذیری و استحکام نهایی را به ترتیب ۵.۵ درصد و ۷۷.۶۲ افزایش داد. افزایش دهانه از ۶۰۰ به ۸۰۰ میلی متر برای نمونه های آجر جامد، مقاومت نهایی و شکل پذیری را به ترتیب ۳۷.۹۶٪ و ۶.۸۳٪ کاهش داد. بلوک های بتنی سلولی به دلیل سبک بودن و واکنش سازه ای قابل قبولی که در مقایسه با نمونه های آجری جامد دارند، می توانند در ساخت دال ها استفاده شوند. آجرهای سوراخ دار به دلیل عملکرد سازه ای خوب و وزن سبکی که دارند می توانند برای ساخت اسلب آجری استفاده شوند. شکنندگی و فروریختن ناگهانی طاق آجرکاری، حالت شکست را در همه نمونه ها مشخص می کند.