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**icse@bwu.edu.ly ترسل الورقات كاملة علي***

# Comparison of opening deep beam shapes under concentrated load

First Author[a].Ashraf M.L.Milad Second Author[b]Nori.S.A.Ateig
Third Author Juhaynah .S.Alshukri Fourth Author Nooralden.A.Abubakr
[a]Department of civil Engineerin , College of Engineering /Bain Waleed-University, Libya
*Crosspnding author: nuriwerfali@gmail.com

**Abstract:** The objective of this study is to examine the deep beam opening behavior of lightweight reinforced concrete beams (LWC) with and without web openings, analyzed by the ansys 19 s oftware. The analysis included five samples of various shapes, a solid deep beam, a deep beam containing two square holes with sides length of 80 mm, a deep beam containing two circular holes with a diameter of 80 mm, a deep beam containing two vertical rectangular holes with dimensions of 140 * 80 mm, and a deep beam with two horizontal rectangular holes with dimensions of 80 * 140 mm. And each sample was subjected to a single point load. The effect of different gap shapes on the behavior of the sample was analyzed and compared. The results indicated that the shapes of the holes greatly affect the behavior of the deep beam, as it was found that the deep beams with circular gaps were the closest in terms of behavior to the deep solid beams among the four samples, and the deep beams with vertical rectangular gaps were the farthest for the behavior of the deep solid beams.

## Introduction

Lightweight foam concrete is a new type of lightweight concrete, as it has the advantages of normal density concrete, aerated concrete and self-pressure concrete, by partially replacing the natural weight aggregates with polystyrene foam, which leads to reducing the weight of the concrete unit while maintaining the required strength. This, in turn, reduces the dead load by 15 to 20% and results in a reduction in the size of columns, bases and other bearing elements and reduces the total cost. Deep beams are members that are loaded on one side and supported on the opposite face so that pressure supports can develop between loads and abutments, and have either pronounced extensions (Ln), in, equal to or less than four times the depth of the total member (h). Or have areas of concentrated loads (A) within twice the depth of member (D) from the support face. In some facilities, deep beams with gaps of various shapes are needed, and these gaps affect the behavior of the deep beams and the basic services of the deep beams. In such cases, it is important to know the behavior of these beams and their ultimate strength. Many studies have investigated the effect of different gaps shapes on the behavior of the cameras, including that: (Nishitha Nair, Kavitha PE ), University of Kerala, India, studied the effect of loads on seven different samples of deep beams (Deep beam without hole, deep beam with a circular hole one at centre, deep beam with a rectangular hole one at centre, deep beam with one circular hole one at side, deep beam with one square hole one at side, Deep beam with circular hole at two sides and Deep beam with rectangular hole at two sides) with ansys 14. It was found that the maximum tolerance was in the deep beam without hole, and the lowest tolerance was in the deep beam with rectangular hole at two sides [2]. Haider M. Alsaeq studied the effect of shapes and locations of gaps on the ability of endurance of deep beams. Haidar tested four gaps (circular, square, rectangular long sides in the horizontal and long rectangular from the vertical) .When investigating the effects of the shape of the gaps and its location on the structural behaviour of the hollow reinforced concrete beams, it was concluded that the use of a rectangular gap, long sides in the horizontal is considered to be the best among other forms of gaps, but it is often undesirable and does not do some purposes required [3]. Khattab Saleem Abdul-Razzaq, Hayder I. Ali and Mais M. AbdulKareem studied the effect of aperture shape on deep beams. Experiments were conducted to test thirteen deep beams under two point loads with square, circular, horizontal and vertical rectangular openings. Two holes were placed, one in each cut period. The creation of square, circular and horizontal and vertical rectangular openings slots reduced the final capacity by about 20.5%, 18.3%, 24.7% and 31.7%, respectively, compared to the reference solid beam. In general, the opening size was found to be inversely proportional to the maximum capacity of the deep beam and the mid-section deviation because the reduction of the opening size resulted in less interruption in the compressive support connecting the loading and support points [4].

**EXPERIMTAL PROGRAM**

The pilot study consisted of five simply supported reinforced concrete girders with mesh and no openings, and made of lightweight concrete. The packages were tested under the influence of a single concentrated payload by applying them to ANSYS19 software. All tested samples have the same geometry and the main upper and lower longitudinal reinforcement. The research sample was taken from the study (Amr Hassan Zahir, Wael Montaser and Muhammad Ramadan) entitled (An experimental study of the behavior of lightweight reinforced concrete deep beams with mesh holes)[1].

**Geometry of the Deep Beam**

The geometry of the full size beam is 1100mm x 400mm x 80mm. The beam is supported simply by providing a plate support on both sides. Single point loads are applied at the center of the beam. The concrete grade was 28.9 MPa and yield strength 550 MPa.

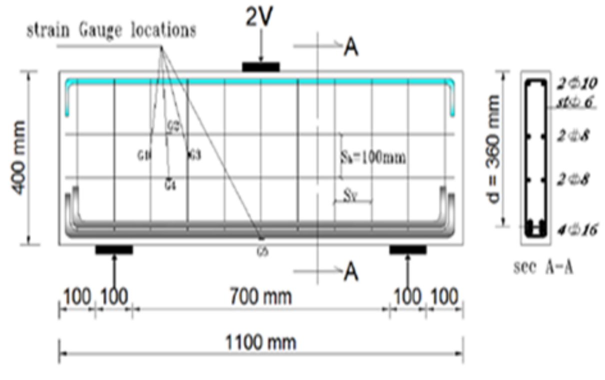
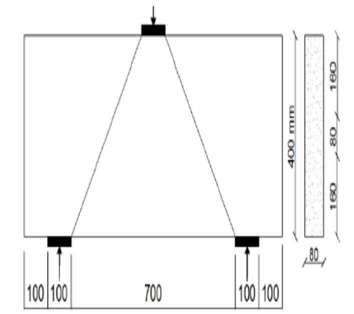
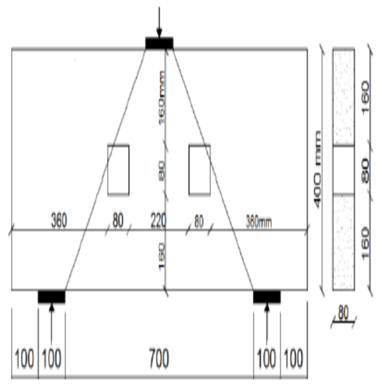


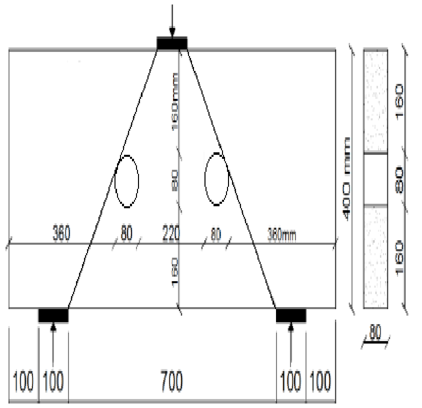
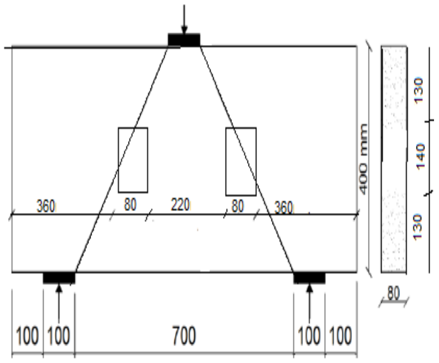
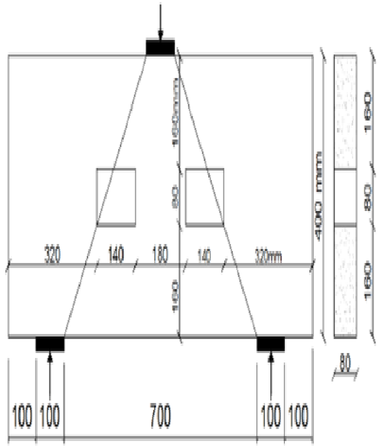

**Figure (1):** Reinforcement detail

**Test Specimens**

**Table (1)** shows samples of deep beams for treatment by research, its dimensions and the dimensions of the gaps in it.

**Table (1):** Typical dimensions of tested beams

| Name | shape of specimen |
|---|---|
| BWOH |  |
| BSHmS |  |

| | |
|---|---|
| BCmHS |  |
| BRHH |  |
| BRHV |  |







| Beam components | Selected from ANSYS library | Element characteristics |
|---|---|---|
| Reinforced Concrete Structural Solid | SOLID65 | 8-node Brick Element (3 Translation DOF per node). |
| 1-Reinforcing bars (main, horizontal and vertical stirrups). | LINK180 | 2-node Discrete Element (3 Translation DOF per node). |
| Layered Structural Solid | SOLID186 | 20-node Brick Element (3 Translation DOF per node). |

**Elements used for Modeling:**

**Table (2)**: shows the characteristics and identifications of the selected ANSYS finite element type representative of the main components for all beams.

**Table (2):** Characteristics and identifications of the selected ANSYS finite element types representative of the main components for all beams. (12)

**RESULTS**

Evolutions of Crack and Load Capacity for RC

**Deep Beam:**

The appearance of cracks begins when the samples are exposed to excessive loads or to more than they can bear, as when increasing loads more the samples reach the final breaking point and that varies from one sample to another due to the difference in the shapes of gaps, their dimensions and the distance between them.

**First Crack:**

The five samples were subjected to a single point load, and as the load increased, initial cracks appeared on the samples.

And it turned out that the BRHH sample was the one that showed the cracks first between the six hollow samples, so it started to crack when exposed to a 36.25 kN load, while the BCmHS was the one that showed the first cracks last between the four experimental samples. Where the cracks began when exposed to a load of 66 kN.

The result is closest to the BWOH reference sample that began craving under 92 kN load.

The following figure shows all the results of the seven samples in terms of the first part:

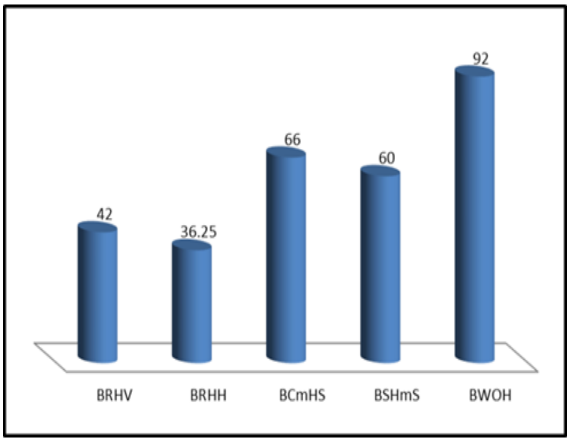



**Figure (2):** First Crack

**Final load:**

Samples reached collapse position when subjected to excessive loads. In the BWOH reference sample, it collapsed upon exposure to a load of 213 kN, the BCmHS sample was closest to the reference sample, and collapsed at a load of 205.25 kN, which means it requires a behavior very close to steel, at 96%. The BRHV sample was the furthest in behavior compared to the BWOH reference sample, and collapsed at a 110.25 kN load, this indicates that it had only 51% of the power of the reference sample.

The following figure (3) shows all the results of the five samples in terms of final pregnancy:

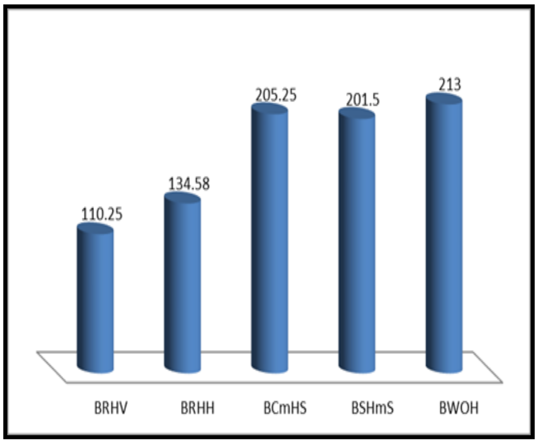
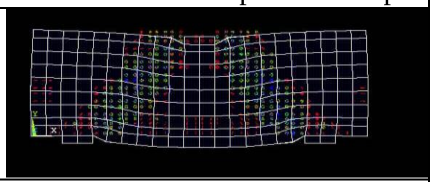
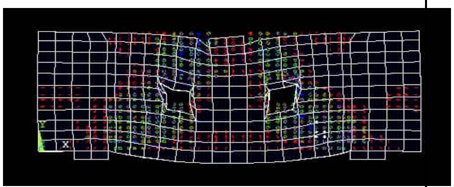
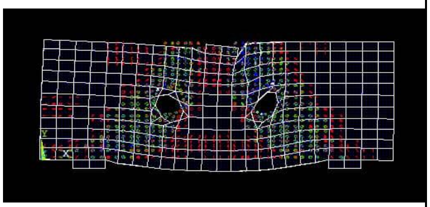
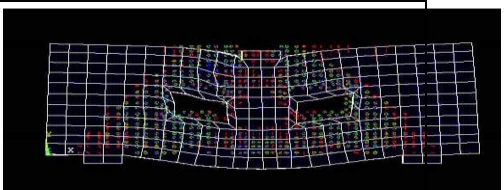
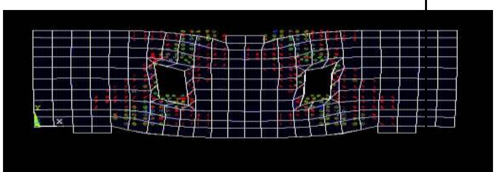



**Figure (3):** Ultimate load

**Cracking Pattern and Mode of Failure:**

The ANSYS program crack pattern records a crack pattern at each load step evolution of crack pattern developing for each beam at last loading step. ANSYS program display circles at locations of cracking or crushing in concrete elements. Cracking is shown with a circle outline in the plane of the crack, and crushing is shown with an octahedron outline the first crack at an integration point is shown with a red circle outline, second crack with green outline, and third crack with a blue outline (ANSYS manual version 10.0).

**Table (3)** shows the evolution of cracks in the five experimental samples

| | Cracks develop in the sample |
|---|---|
| BWOH |  |
| BSHmS |  |
| BCmHS |  |
| BRHH |  |
| BRHV |  |

**Load Deflection Curve:**

The following figure shows the deflection results for the five samples as a result of exposure to different loads:

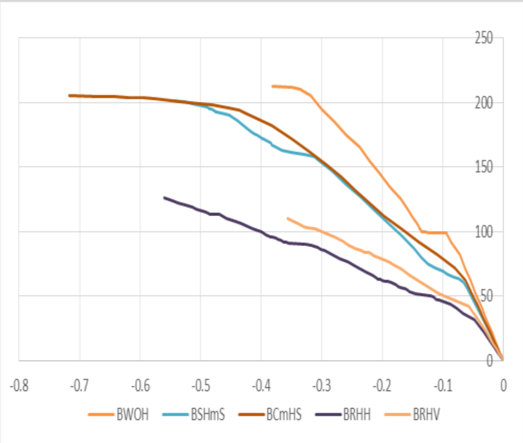



**Figure (4):** Comparison of load-deflection curve for specimens with different web opining type.

**CONCLUSION**

1- The behaviour of deep hollow beams varies with the shape of the gaps .

2- Deep beams containing a circular cavity contain the behaviour closest to the solid deep beam.

3- The deep beam which contains a vertical rectangular cavity has about 51% of the strength of the solid deep beam and this indicates its extreme weakness.

4- The deep hollow beams with a circular cavity are the best between round and square gaps.

5- The deep hollow beams with a horizontal rectangular bore are best between the horizontal rectangular gaps and the vertical rectangular gaps.

6- Deep beams with a circular cavity are the most flexible of the seven specimens.

7- The deep beams with a vertical rectangular cavity are the least flexible of the seven specimens.

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