

FINITE ELEMENT ANALYSIS OF BRICK MASONRY STRUCTURES WITH OPENINGS

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ABSTRACT

This research investigates the influence of openings on the structural performance of brick masonry walls using finite element analysis (FEA) in ABAQUS software. Openings, often introduced for functionality and aesthetics, compromise the structural integrity of masonry walls by reducing load-carrying capacity and altering stress distributions. The study examined rectangular and circular openings under axial and lateral loads. Results indicate that openings significantly diminish the load-carrying capacity and compressive stress, with rectangular openings causing greater reductions compared to circular openings of equivalent areas.

Practical insights for optimizing masonry design, retrofitting strategies, and future research directions are provided.

Keywords: Finite Element Analysis, Brick Masonry, Openings, Structural Performance, Load Reduction, Stress Distribution.

1. INTRODUCTION

Brick masonry has been a cornerstone of architectural design due to its durability, cost-effectiveness, and thermal properties. Openings such as windows and doors are essential but compromise structural stability. Understanding how openings affect load-carrying capacity and stress distribution is crucial for designing resilient masonry structures.

2. OBJECTIVES OF THE STUDY

1. Develop an FEA model of masonry structures with openings.
2. Investigate the impact of opening size, shape, and location on structural performance.
3. Provide guidelines for optimizing masonry design with openings.

3. METHODOLOGY

Material Properties

Property	Value
Compressive Strength (Brick)	20 MPa
Tensile Strength (Brick)	2 MPa
Young's Modulus	21600 MPa
Poisson's Ratio	0.15

Finite Element Modeling

- **Software Used:** ABAQUS 6.14
- **Wall Dimensions:** Standard brick masonry wall
- **Opening Configurations:**
 - Rectangular: 400×300 mm, 600×400 mm
 - Circular: Diameter 100 mm, 200 mm
- **Mesh Setup:**
 - Fine mesh near openings
 - Coarser mesh elsewhere for computational efficiency
- **Boundary Conditions:**
 - Fixed supports at the bottom
 - Roller supports along lateral edges

- **Loading:**
 - Uniform axial load applied at the wall top

4. RESULTS AND DISCUSSION

1. Load-Carrying Capacity

Results Summary

Type of Masonry	Load (kN)	% Reduction in Load
Solid Brick Masonry	341.57	0.00
Rectangular (400×300)	13.36	96.09
Rectangular (600×400)	2.40	99.30
Circular (100 mm dia)	212.68	37.73
Circular (200 mm dia)	13.82	95.95

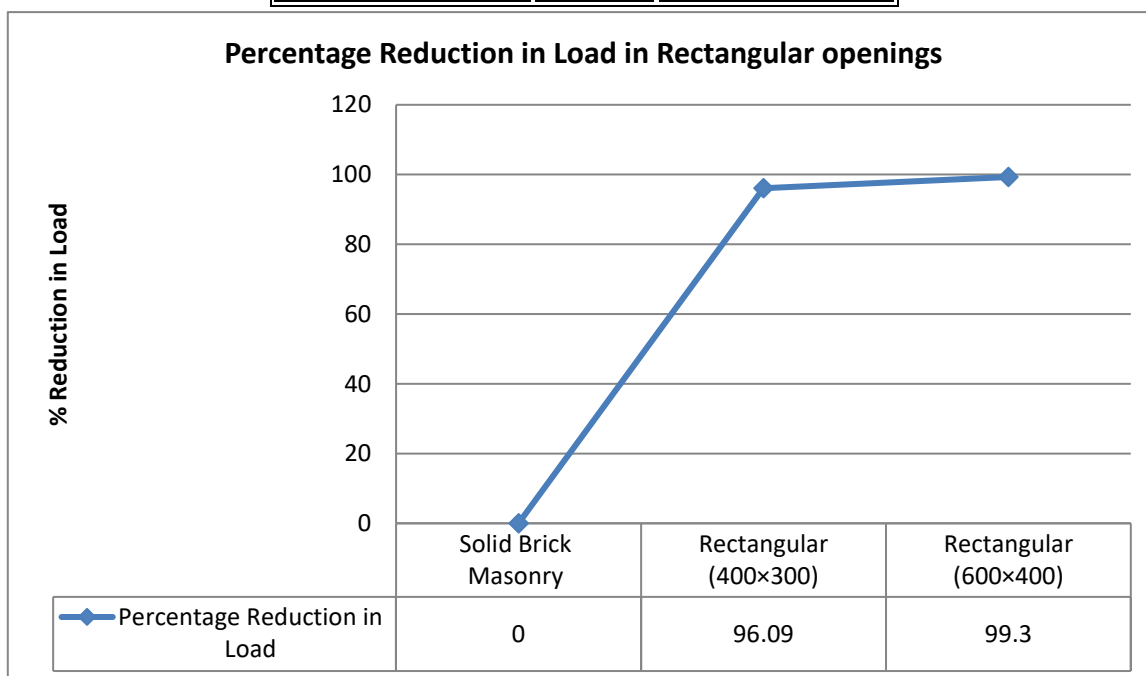


Figure 1: Load reduction for Rectangular openings

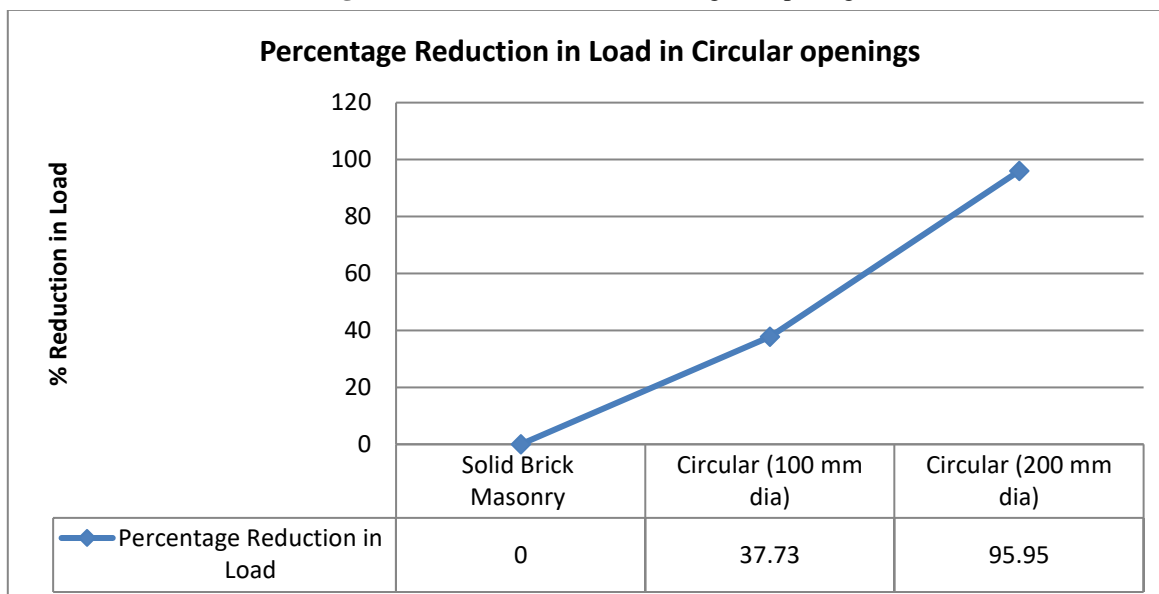


Figure 2: Load reduction for circular openings

Observations

- Rectangular openings cause more load reduction compared to circular openings.
- Larger openings lead to a dramatic decrease in load-carrying capacity.

2. Stress Analysis

Maximum Compressive Stress

Type of Masonry	Stress (MPa)	% Reduction in Stress
Solid Brick Masonry	68.37	0.00
Rectangular (400×300)	30.43	55.49
Rectangular (600×400)	16.00	76.60
Circular (100 mm dia)	41.00	40.03
Circular (200 mm dia)	24.00	64.90

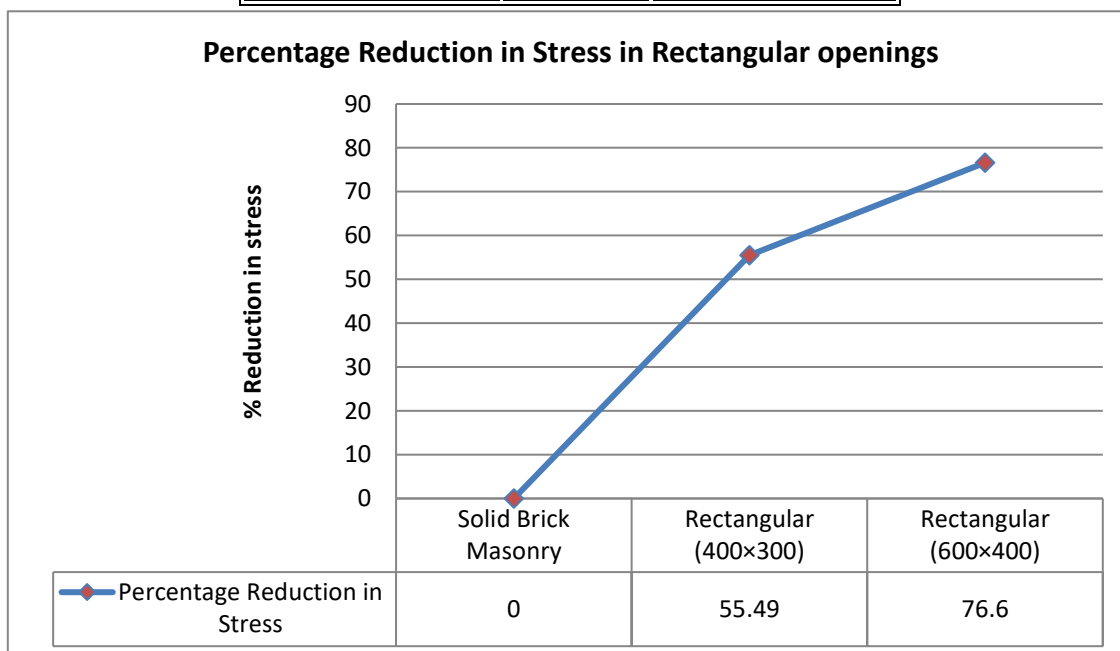


Figure 3: Stress reduction for rectangular openings

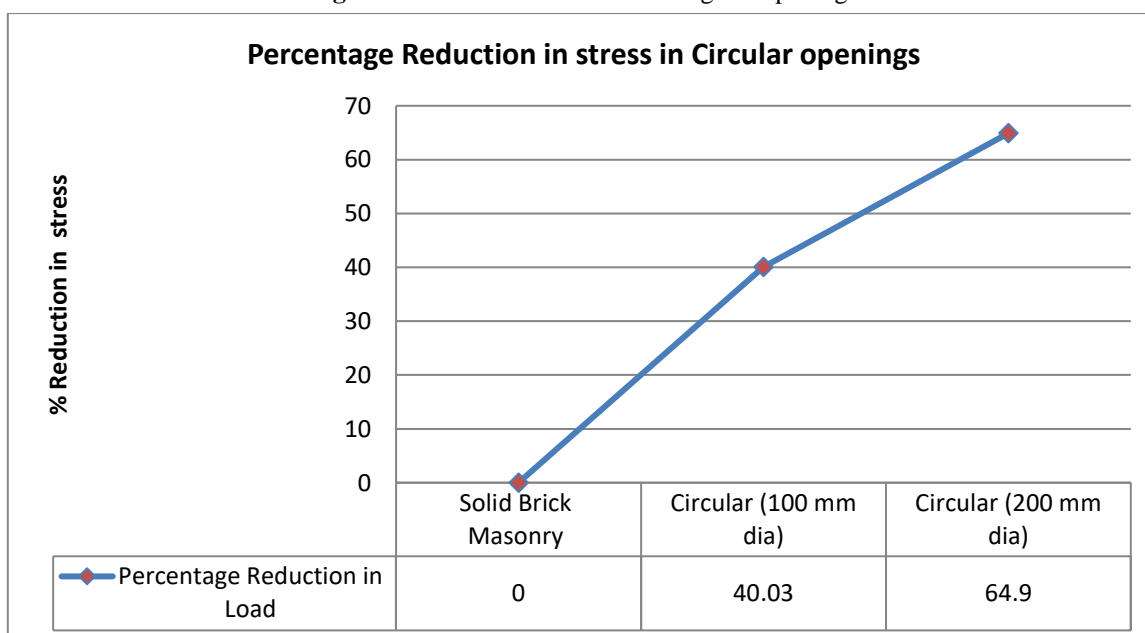


Figure 4: Stress reduction for circular openings

Observations

- Stress concentration occurs around the corners of openings.
- Rectangular openings exhibit more significant stress reductions compared to circular ones.

Relation Between Opening Area and Load Reduction

Rectangular Openings

% Area Reduction	% Load Reduction
0.00	0.00
5.55	96.09
11.11	99.30

Circular Openings

% Area Reduction	% Load Reduction
0.00	0.00
0.36	37.73
1.45	95.95

5. CONCLUSION

1. Openings significantly reduce the load-carrying capacity and stress resistance of brick masonry.
2. Rectangular openings have a greater impact than circular ones.
3. The reduction in capacity is proportional to the area of the opening but exhibits nonlinear behavior for larger openings.

6. FUTURE WORK

- Extend the analysis to dynamic loading conditions, including seismic effects.
- Study reinforcement techniques to mitigate the impact of openings.
- Explore advanced materials for improved masonry resilience.

7. REFERENCES

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