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Analytical investigation on interlocking brick masonry with RC frame

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***Abstract*---**Bricks, which are constructed of sand, lime, concrete, and fly ash, are the traditional materials used in masonry construction. Traditional bricks, of course, come with high insulation and fire-resistant characteristics. There is a demand for traditional bricks around the world, which must be cost, energy, and time-efficient. Mortarless interlocking brick is now being used in this alternate quest for the mortar revolution. These interlocking bricks have protrusions on their surface and look like regular bricks. The goal of interlocking bricks is to create a beautiful perspective with continuous patterns in masonry walls while also allowing construction in rural regions without the use of trained personnel. To achieve suitable structural strength, interlocking bricks do not require mortar to join the individual brick components. As a result, mortarless masonry walls will save 35 percent on construction costs, or 20 to 40% on labour costs. Naturally, earthquakes are widespread these days, however, unlike normal bricks, interlocking bricks are seismic-resistant materials that can withstand earthquake stresses. The lateral load in the analytical research and preliminary testing were completed in the first phase. The RC Frame with Interlocking Bricks will be included in the analytical investigation. The Brick Masonry analysis and brick masonry frame were also completed for the purpose of comparison.

***Keywords*---**Interlocking Brick Frame, Brick Masonry Frame, Displacement, Stiffness.

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1. Introduction

Bricks are the conventional materials that are used in masonry construction which are made up of sand, lime, concrete, and fly ash. Naturally, conventional bricks are incorporated with good insulation and fire-resistant properties. An adequate strength, stability, and long-lasting bricks are obtained by properly consolidated and well-graded solids which are mixed and cured sufficiently. Conventional bricks are low cost-efficient and widely used for construction mostly preferred in rural areas. The 10% usage of Waste Marble Powder in interlocking bricks satisfies the local building code requirements and on the other hand, it exhibits a 43% increase in load-carrying capacity compared to conventional bricks. The bricks are bonded using mortar in masonry construction to give continuous and proper binding between the individual masonry work. Usage of mortar in construction will increase the cost of construction. In the world, for demand in construction material, there is a need for conventional bricks which have to be cost, energy, and time-efficient. In this alternate search for mortar revolution, mortarless interlocking brick is under usage now. These interlocking bricks are look-alike conventional bricks but with projections on their surface. So that the bricks can be interlocked conveniently with the use of the projections. The interlocking bricks are constructed without using mortar, which is a 20 to 40% reduction in labor cost and is more time-efficient compared to conventional bricks. These bricks are also used in load-bearing masonry walls. Interlocking bricks are available with different materials, shapes, and dimensions. These bricks reduce the cost by up to 35% compared to conventional bricks. Interlocking bricks are the improvised material of conventional bricks made up of cement, fly ash, and clay. The objective of interlocking bricks is to provide an aesthetic view with continuous patterns in masonry walls and to construct in rural areas without any skilled laborers. Interlocking bricks do not need mortar to bind with the individual brick units to attain appropriate strength to the building. So mortarless masonry walls will reduce 35% of the cost of construction which is 20 to 40% of labor cost. Naturally, earthquakes are common these days but interlocking bricks are seismic-resistant materials that can resist earthquake loads, unlike conventional bricks. The conventional bricks after completion of a structure need plastering for a smooth finish but interlocking bricks do not need any plastering works for their appearance, just a paint layer is enough for a better look. The interlocking bricks are 3 times faster to construct than conventional bricks considering their self-locking nature. The interlocking bricks do not conduct thermal energy as conventional bricks do, so they maintain the room temperature cooler compared to
conventional bricks.

2. Methodology

The specimen was modeled in Autocad according to the base paper scale down size, with relevant adjustments made to allow it to be used in future investigations. Below are the dimensions as well as 2D modeling. For further validation, a 1/2 ratio scale was used. The RC Frame with Interlocking Bricks will be included in the analytical investigation. The masonry brick frame study was also completed for the sake of comparison.

In order to conduct this analysis, the following actions were taken.

1. Modelling of specimen in 2D
2. Modeling the specimen in Abaqus for finite element analysis
3. Application of properties to the materials
4. Application of load
5. Final analysis and results

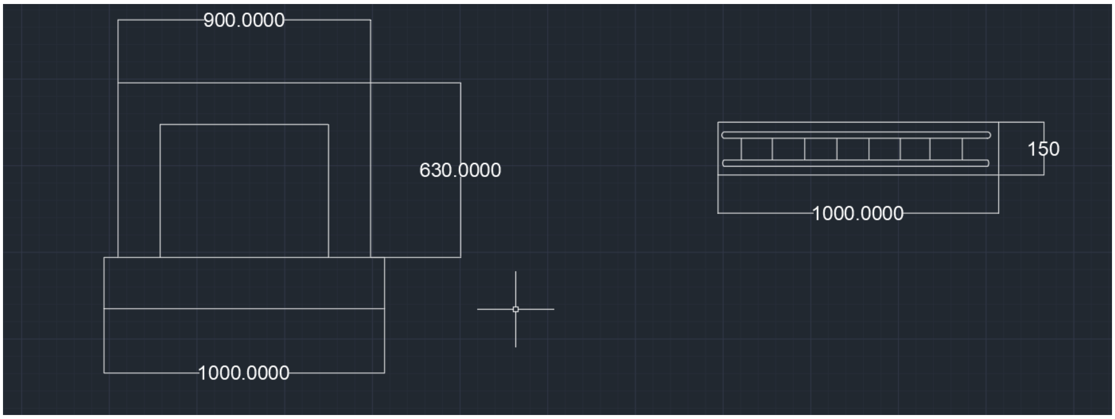

Fig 1. 2D model of Frame

Table 1. Dimensions adopted

Beam Dimension	177x150 mm	1/2 scale adopted
Column Dimension	127x150 mm	1/2 scale adopted
Infilling dimension	610x453x150 mm	1/2 scale adopted
Frame height	780 mm	1/2 scale adopted

Note: Reinforcement consists of an 8mm main bar and 6mm stirrups at 100mm c/c. These details were scaled down and optimized as per min ast required.

3. Analytical Program
3.1 Overview

The analysis is carried out using Abaqus software and the Finite Element Method. The interlocking brick panel and masonry infill portions of the analytical work are separated. The mechanical component is modeled as well as analyzed. Beams, columns, foundations, whole bricks, and half bricks are used to make the model's parts. The total deflection and stiffness achieved while axially loading the specimens will be determined. The purpose of the finite element analysis is to find the stiffness variation between the frames. This section takes the load and displacement graphs and discusses the stiffness values.

3.2 Interlocking Brick Panel

Interlocking bricks are makeshift versions of traditional cement, clay, and fly ash bricks. The goal of interlocking bricks is to create a beautiful perspective in masonry walls with continuous patterns and to construct in rural regions without the use of experienced employees. To achieve suitable structural strength, interlocking bricks do not require mortar to join with the individual brick components. As a result, mortarless masonry walls will save 35 percent on construction costs, or 20 to 40% on labour costs. Naturally, earthquakes are widespread these days, however, unlike normal bricks, interlocking bricks are seismic-resistant materials that can withstand earthquake stresses. Because of their self-locking nature, interlocking bricks are 3 times faster to build than traditional bricks. Because interlocking bricks do not conduct thermal energy like traditional bricks, the room temperature remains lower.

Table 2. Interlocking Bricks Mechanical Properties

Density (Kg/m^3)	2014.8
Poisson's ratio	0.2
Compressive Strength (N/mm^2)	18.02
Tensile Strength (N/mm^2)	2.79

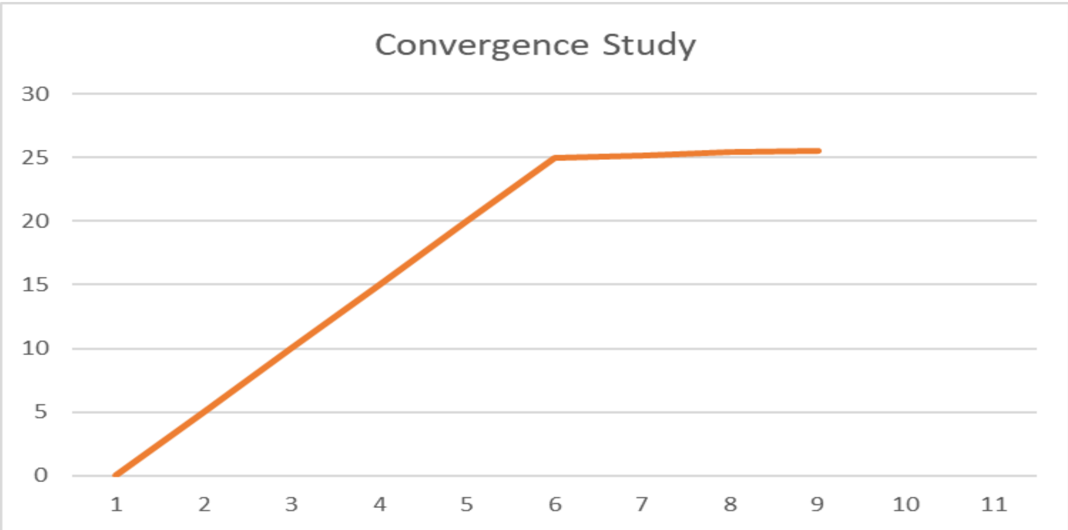

Fig 2. Convergence Study

The entire specimen is modeled in the manner shown in fig3. Tables 1 and 2 provide the dimensions and attributes that were used.

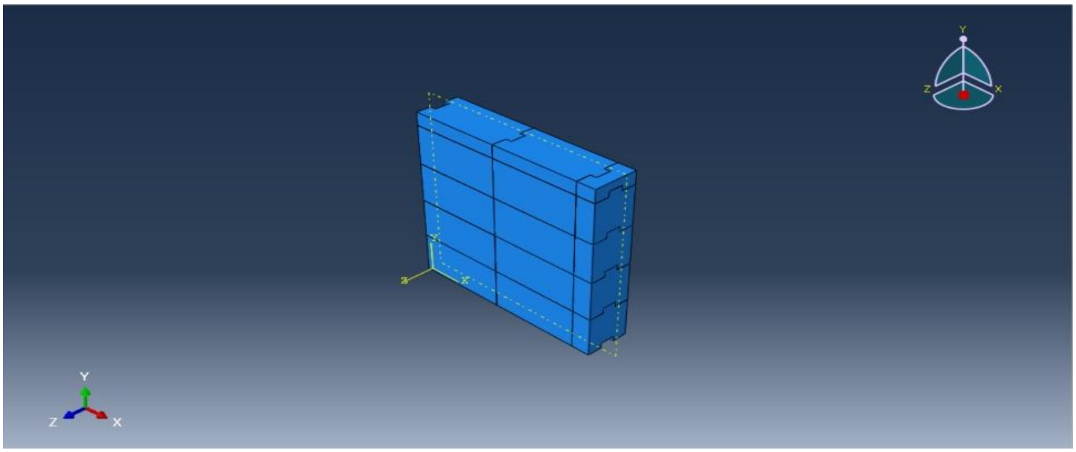

Fig 3. Interlocking Brick panel

The study was analyzed by applying the size of the mesh with the same load. The mesh size of 25 mm was applied and analyzed for convergence. By taking the results of load and displacement for each size the convergence graph is drawn. By the graph when the linear pattern of the line moves the value is noted and a global mesh size of 25 was established (see fig 4).

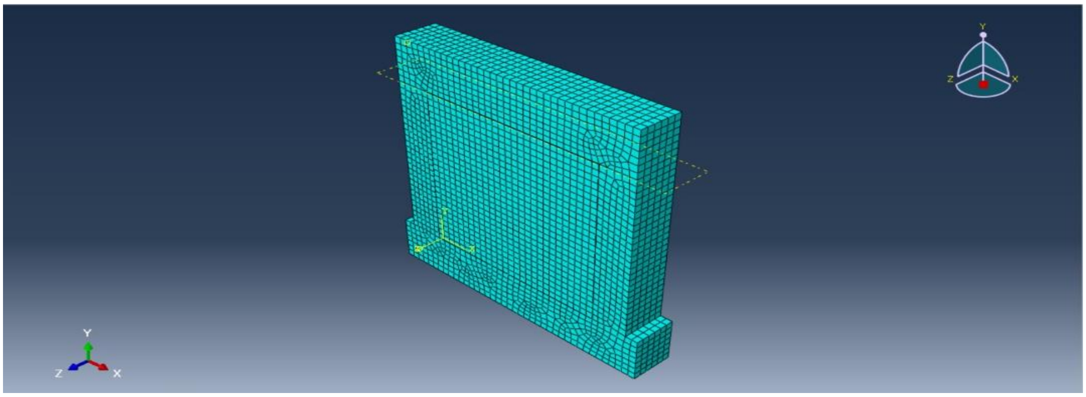

Fig 4. Interlocking Brick mesh

3.2.1 Application of load

The interlocking brick panel and the frame were subjected to a lateral load of 10 to 50 kN when it came to the loading and boundary conditions. Because of the symmetry of the panels and stress circumstances, and in order to reduce analysis time, just a quarter of the structure was simulated in the single panel and jointed panel cases. Even in this phase, the 1/2 scale ratio was used to provide the best results.

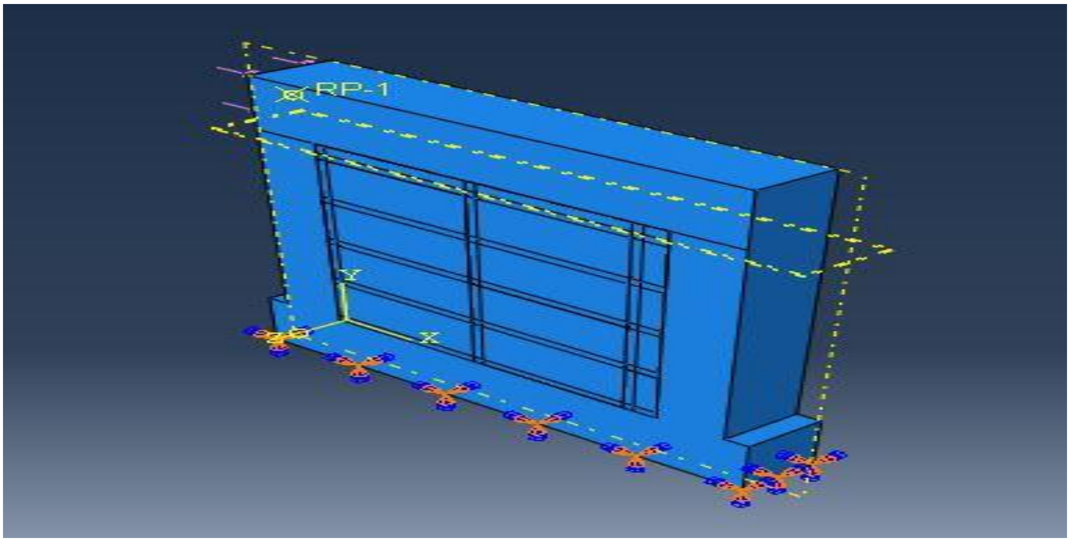

Fig 5. Loading of Frame

3.3 Brick Masonry Model

Numerous studies show that infill alters the behavior of framed structures under lateral pressures; nonetheless, the contribution of panels is frequently neglected in normal structural analyses. When constructing columns and other structural components in most RC frame designs, the structural influence of brick infill is overlooked. The brick walls provide high in-plane stiffness, which helps the frame withstand lateral loads. The lateral deflection of the infilled frame is considerably reduced when compared to the deflection of the frame without infill. Frames with infill produce much lower deflections than frames without infill. The mesh global seed size is the same as the mesh global seed size of 25.

Table 3. Brick Masonry Mechanical properties

MATERIAL	DENSITY(Kg/m^3)	YOUNG'S MODULUS(N/mm^2)	POISSON'S RATIO
BRICK	1900	3878	0.3

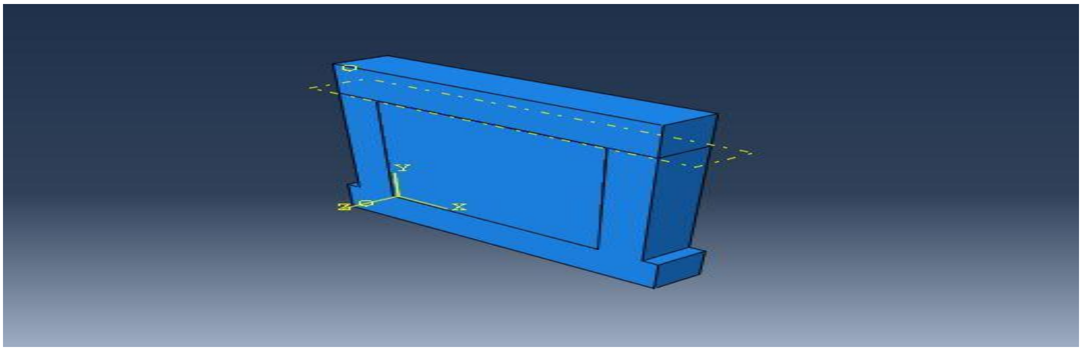

Fig 6. Masonry Brick Frame

4. Results and Discussion

The finite element study findings are presented in two portions and then compared to highlight the difference in stiffness between the two models. The stiffness of the models was determined using the deflection and load to time graphs that were obtained. The stiffness was calculated using the load/displacement method and cross-checked with the findings of the Abaqus finite element analysis.

4.1 Interlocking Brick Infill In Rc Frame

To determine the load vs displacement graph, the loading conditions discussed and calculated previously were applied, and a finite element analysis was performed. The obtained deflection when the frame was subjected to lateral stress as shown in fig 5 is shown in fig 7. The stiffness of the RC frame with interlocking bricks is also determined once the lateral load is applied on it. This also results in stress Deflection. The interlocking brick panel infill showed 0.29mm deflection under a 10 kN load.

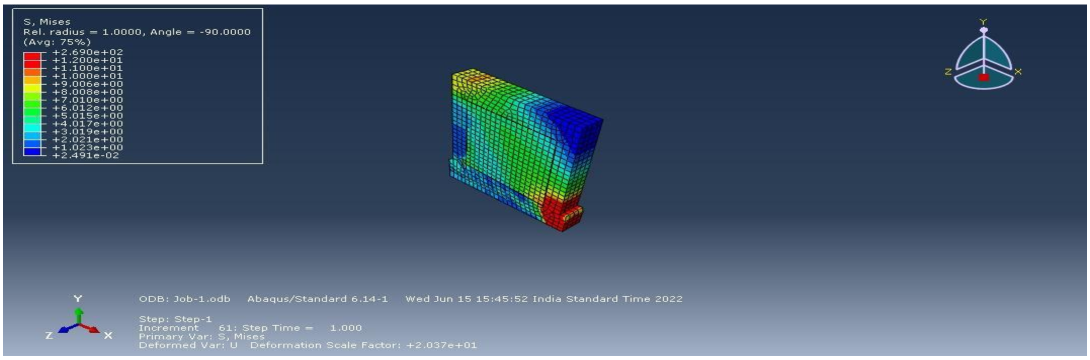

Fig 7. Interlocking Brick Panel

4.2 Masonry Infill In Rc Frame

The circumstances of loading To determine the load vs displacement graph, previous talks and computations were used, along with finite element analysis. When subjected to cyclic loading, the behavior of the frame with an infill masonry wall, both partially and fully, was examined, as shear and ductile failures are the most typical in this type of loading condition. When the frame was exposed to lateral load as shown in fig 6, the deflection was achieved. The brick infill frame exhibited 0.33 mm deflection under a 10 kN load.

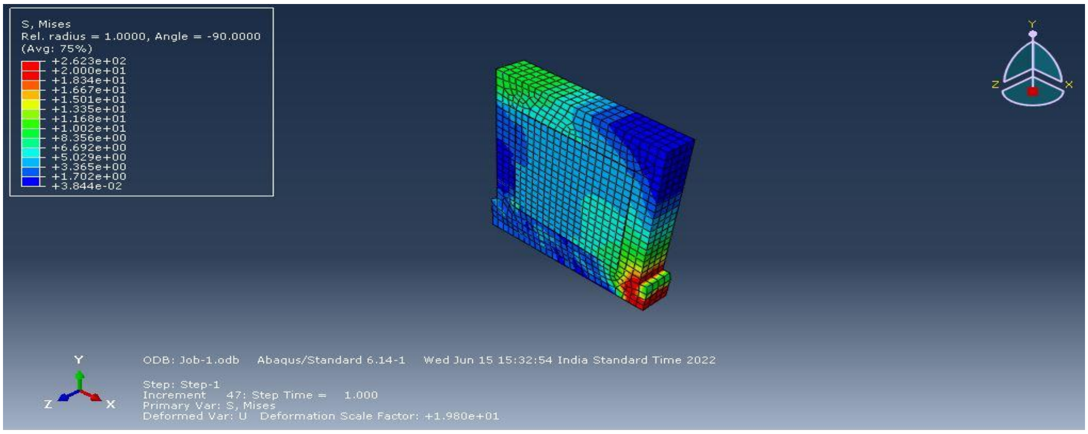

Fig 8. Masonry Brick Panel

4.3 Graph Comparison

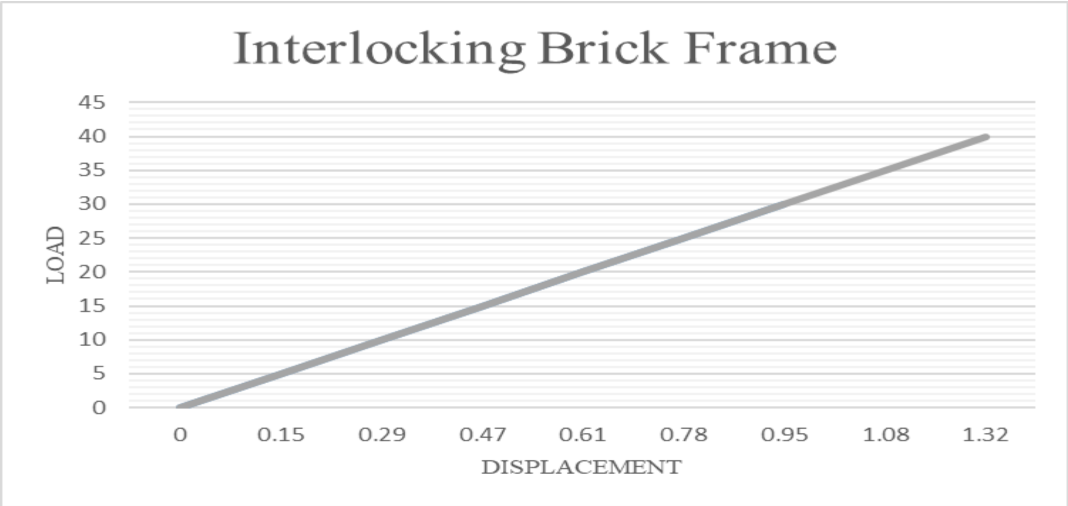

Fig 9. Load vs Displacement Interlocking Brick Frame

As shown in fig 10, the graph for Load versus Displacement for the Sandwich panel infill with RC frame was plotted. Deflection of 0.29mm was measured with a load of 10 kN.

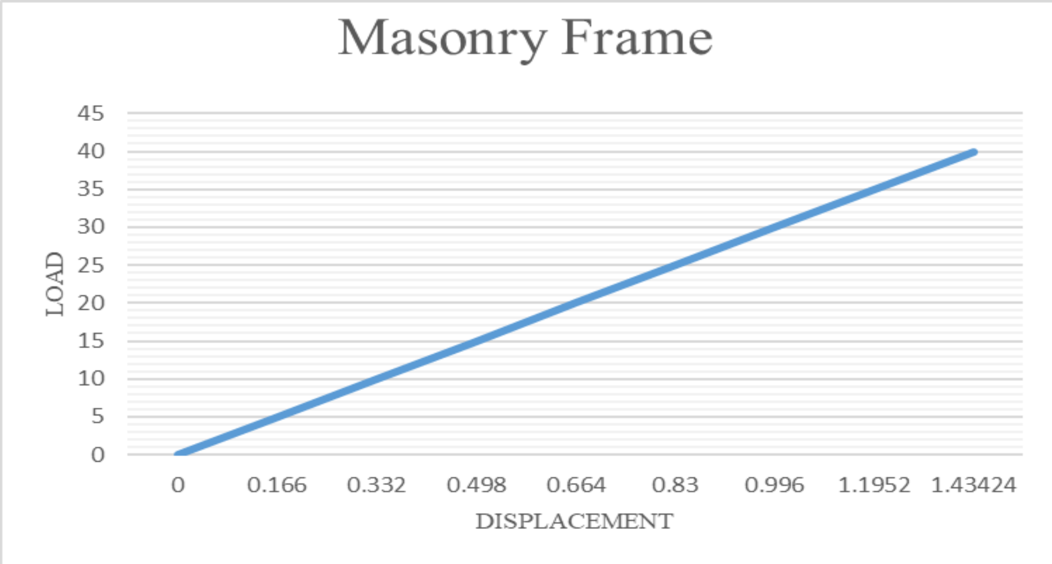

Fig10. Load vs Displacement Masonry Brick Frame

As shown in fig 11, the curve for Load versus Displacement for Masonry infill with RC frame was plotted. A 0.33 mm deflection was recorded at a 10 kN load.

5 Conclusion

The brick infill frame has a 0.33 mm deflection, whereas the interlocking brick frame has a 0.29 mm deflection. As a result, the interlocking brick panel frame's stiffness is 34.48 N/mm2, whereas the masonry infill frame's stiffness is 30.33 N/mm2. Table 5 shows the outcomes. In order to establish crack patterns and compare the two specimens experimentally, a further experimental program must be carried out.

Specimen	Load (KN)	Stiffness (N/mm^2)	Displacement (mm)
Interlocking Brick Panel	10	34.48	0.229
Masonry Panel	10	30.33	0.332

As a result, it can be summarised as follows:

- The mechanical qualities of construction will be considerably improved by using interlocking bricks.
- Interlocking Bricks might withstand the strain because they can evenly distribute the seismic load over the structure.
- When interlocking bricks are used in high-rise structures, the dead load of the structure is greatly reduced.
- The interlocking brick panel's lateral rigidity is more effective than traditional brick masonry infill.

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