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Finite Element Modelling of Wall-Frame Connection for Confined Masonry Structure

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Abstract: - *Confined masonry structures in recent times have found its popularity due to its behaviour against horizontal ground motion and economic construction. These structures although economical require special design consideration for its effective behaviour under seismic forces. In the current paper modelling of confined masonry wall representing simple house wall panel is subjected to in-plane lateral load and finite element analysis is conducted for different connection details between vertical RC member and masonry walls. The effectiveness of connection shall be determined based on stress analysis of the joint using standard Finite element package.*

KEYWORDS: **-** CONFINED MASONRY WALL, WALL-FRAME CONNECTIONS, FINITE ELEMENT ANALYSIS, LATERAL LOAD, *EQUIVALENT STRESS IN MASONRY*

I. INTRODUCTION

Confined masonry is building innovation that uses the same essential materials found in unreinforced masonry construction and RC frame construction with brickwork infills, however with an alternate development arrangement and framework. [1] In Confined masonry construction walls are built first and the columns and beams are poured in afterwards to enclose the wall. [2] Confined masonry construction comprises of masonry wall made up of clay bricks and horizontal and vertical RC confining element built on every one of the four sides of a masonry wall. [2] Vertical individuals called tie-columns and horizontal individuals called tie-beams. [3]

The confinement plays a significant role in maintaining the wall integrity to develop optimum lateral resistance of the structure. [4] Generally, tie columns have a rectangular section whose dimensions normally match up to the wall thickness. [4] For tie beams, both wall thickness and floor type impact the decision of the measurements. [4] This type of construction is most commonly used in one-to-two storey housing in developing countries like India. [5] The establishment of wall-frame connections on a confined masonry wall has been introduced to preserve the frame confinement to the wall and to enhance the general seismic execution of the structure. [4] The economy, proficiency, quality and firmness of confined masonry make it an alluring material for an extensive variety of basic applications. [2] Hence, an analytical study on wall-frame connections on a masonry wall confined by reinforced concrete frame was conducted.

II. MATERIAL PROPERTIES

The studies dealing with analysis of Connection between confining column and masonry wall. The properties of brick masonry, concrete element, and steel considered in the study are shown in table. [6]

Table I: Concrete Properties

CONCRETE	
Density	2300 kg/m^3
Young's Modulus	25000 MPa
Poisson's Ratio	0.2
Tensile Ultimate Strength	3.5 MPa
Compressive Ultimate Strength	25 MPa

Table II: Masonry Properties

MASONRY	
Density	2000 kg/m^3
Young's Modulus	5000 MPa
Poisson's Ratio	0.2
Compressive Ultimate Strength	4.5 MPa

Table III: Structural Steel Properties

STRUCTURAL STEEL	
Density	7850 kg/m^3
Young's Modulus	2 x 10^5 MPa
Poisson's Ratio	0.3
Tensile Ultimate Strength	550 MPa
Compressive Ultimate Strength	0
Tensile Yield Strength	415 MPa
Compressive Yield Strength	415 MPa

III. ANALYSIS

A brick wall confined by concrete elements on all the three sides is considered for analysis. The clear dimension of the model is 2.46m long, 3.1m high and thickness provided is 0.23m. The vertical and horizontal RC member has dimensions of 0.23m x 0.23m considering the characteristic strength of concrete equal to 25 N/mm^2.

Bonding / connection between wall and RC tie column is an important feature of confined masonry construction. [3] There are three types of connection considered for analysis as shown in figure.

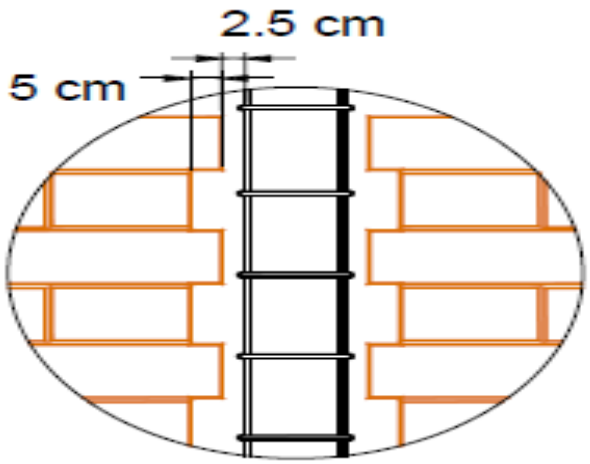

Fig.1: Rectangular toothing

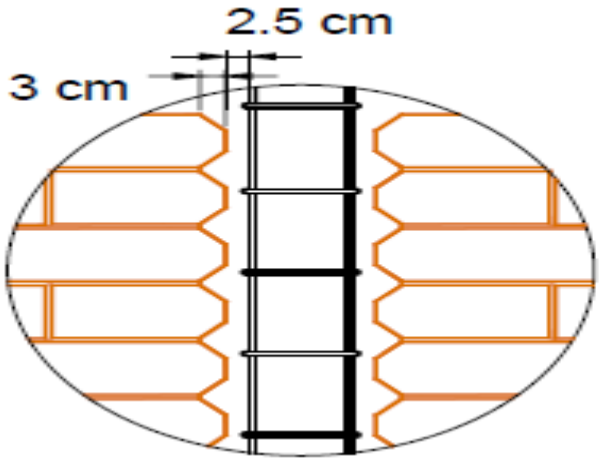

Fig.2: Hexagonal toothing

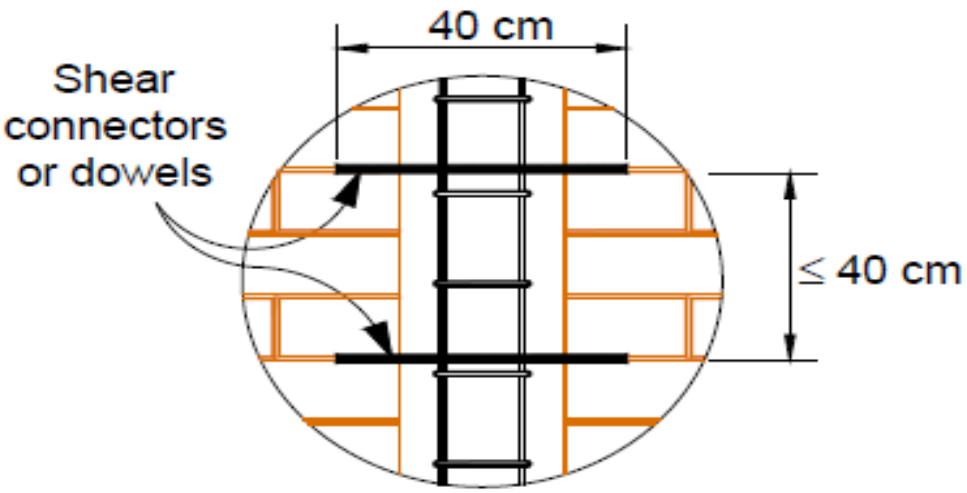

Fig.3: Provision of dowels when toothing is not possible

Analysis of connection between RCC frame and confined masonry wall by using ANSYS Workbench. Geometry of wall-frame connection of confined masonry wall is created by the use of AUTOCAD and NX software. If geometry is created by the use of AUTOCAD/NX than *.dwg file then export it in to the *.iges or *.igs file because ANSYS supports *.sat,*.step,*.igs and *.iges file. [7]

a. MODELLING IN AUTOCAD

i. Rectangular Connection
ii. Hexagonal Connection
iii. Provision of dowels when toothing is not possible
iv. Provision of L shape dowels

b. MODEL GENERATED IN ANSYS WORKBENCH

When the geometry is in the form of *.igs or *.iges get imported in ANSYS and in program schematic window by double clicking on model cell, model will get generate as shown in figure shown below.

Rectangular and hexagonal connection model has been generated ANSYS which is shown in figure 4 and 5 respectively. For providing straight dowel bars connection, 10mm diameter dowel bar having 400mm length, has been chosen which is provided at 300mm c/c distance from bottom of the geometry as shown in figure 6a & 6b.

In the provision of L shape dowel bars connection 10mm diameter dowel bar having a length of 400mm, has been provided at 300mm c/c distance from bottom of the geometry having developing length of 250mm c/c as shown in figure 7.

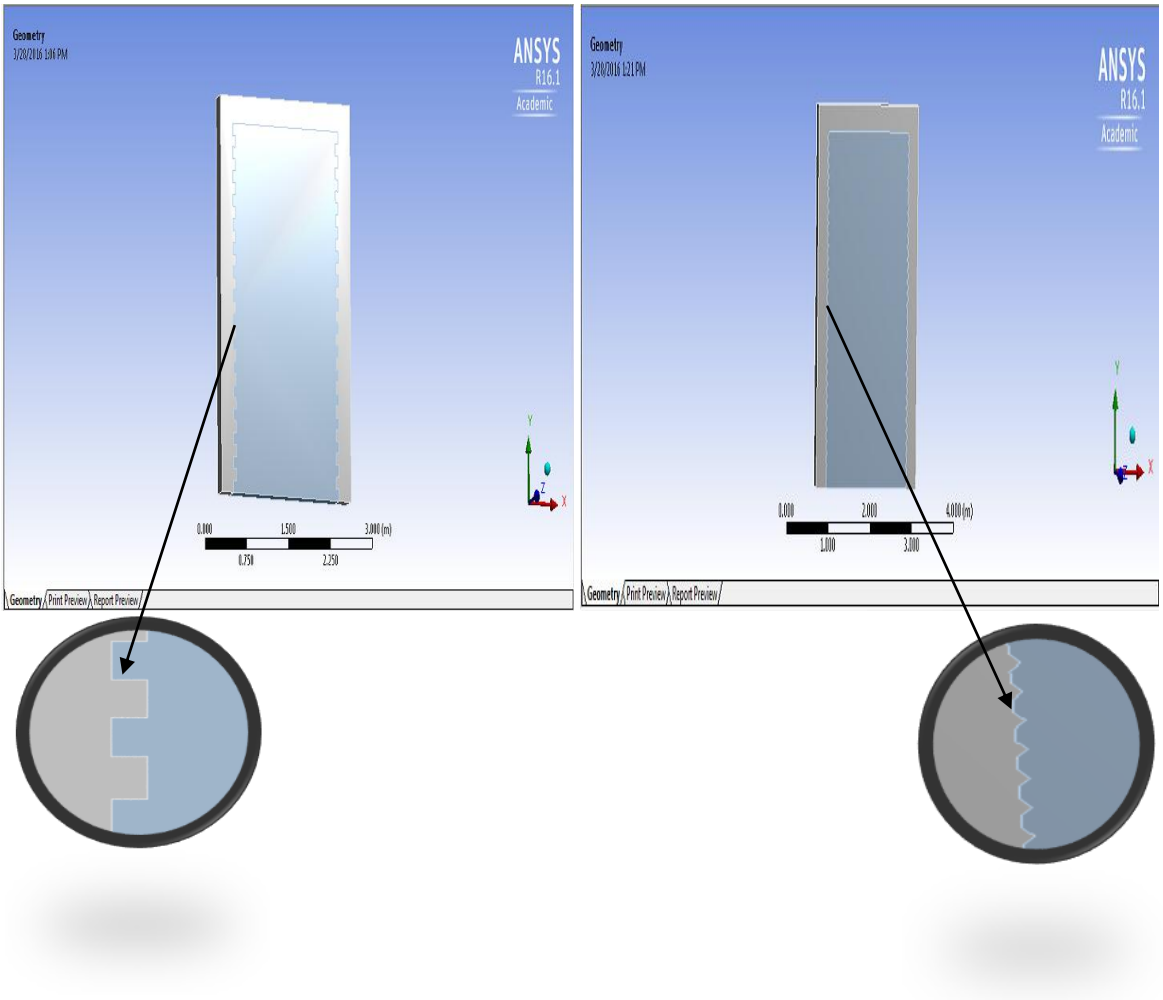

Fig.4: Rectangular connection

Fig.5: Hexagonal connection

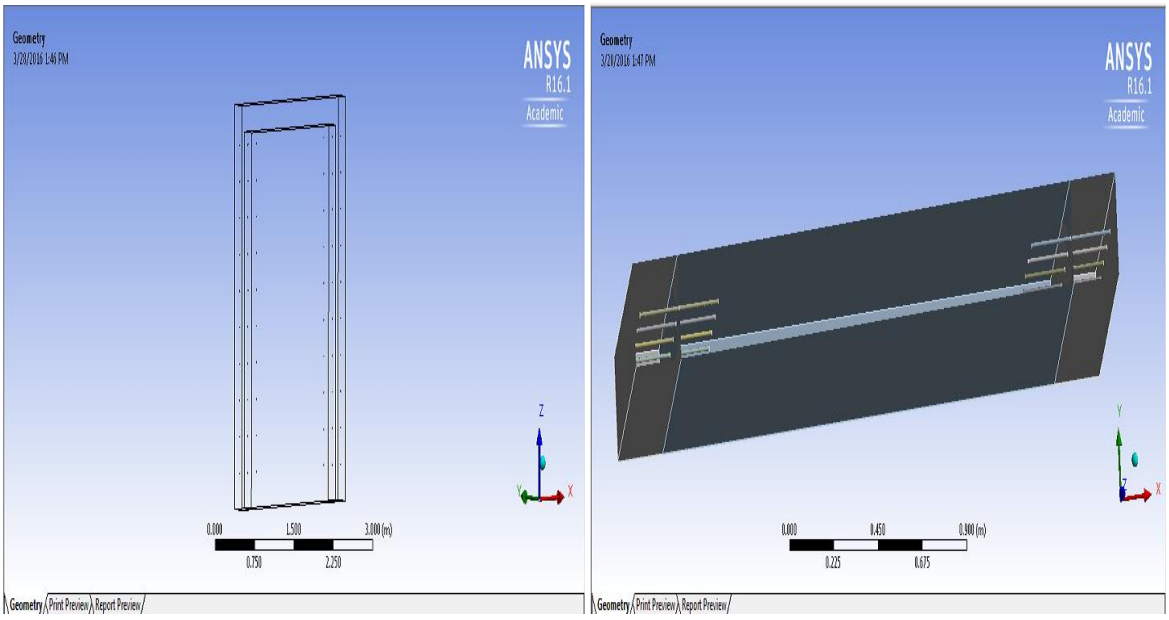

Fig.6a: Provision of straight dowels when toothing is not possible
Fig.6b: Sectional view of geometry in ANSYS

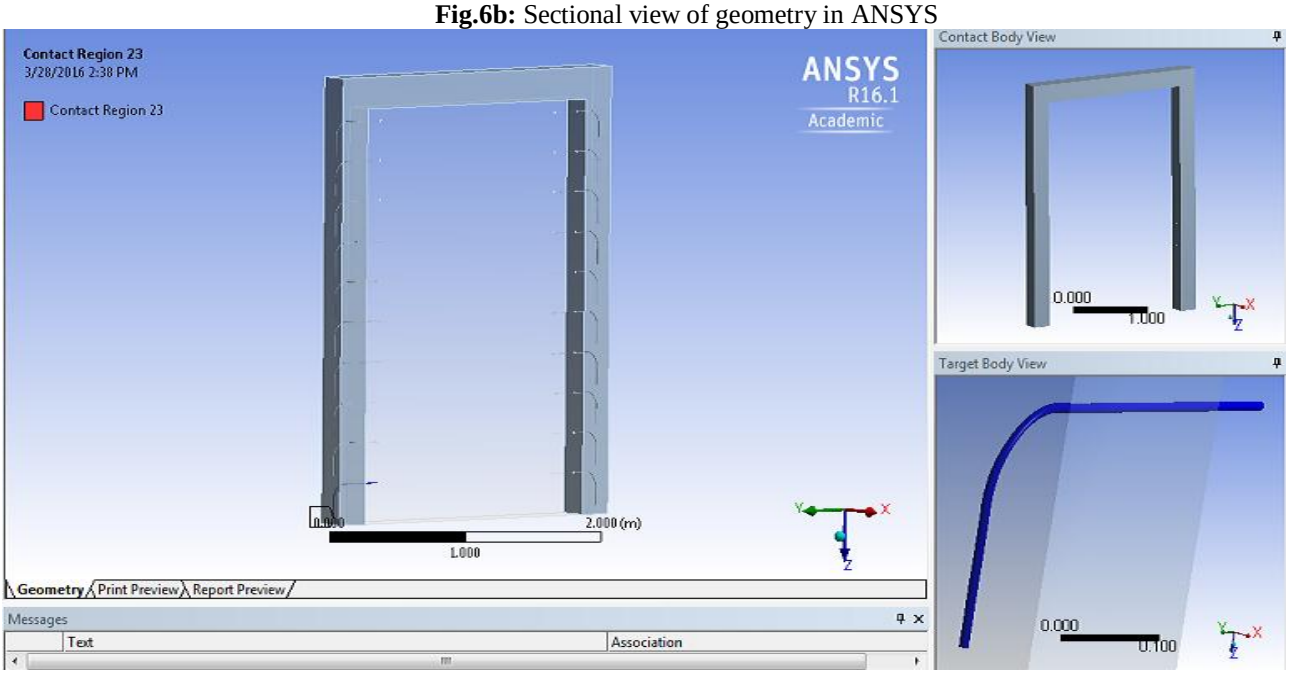

Fig.7: Provision of L shape dowels

c. ANALYSIS WITH ANSYS WORKBENCH

In Static structural tool, applying 25,000 N force in right direction and fixed support provided at the bottom of the model, which is as shown in fig 4. In Solution tool, total deformation due to horizontal force and equivalent stress in four different types of connection get computed.

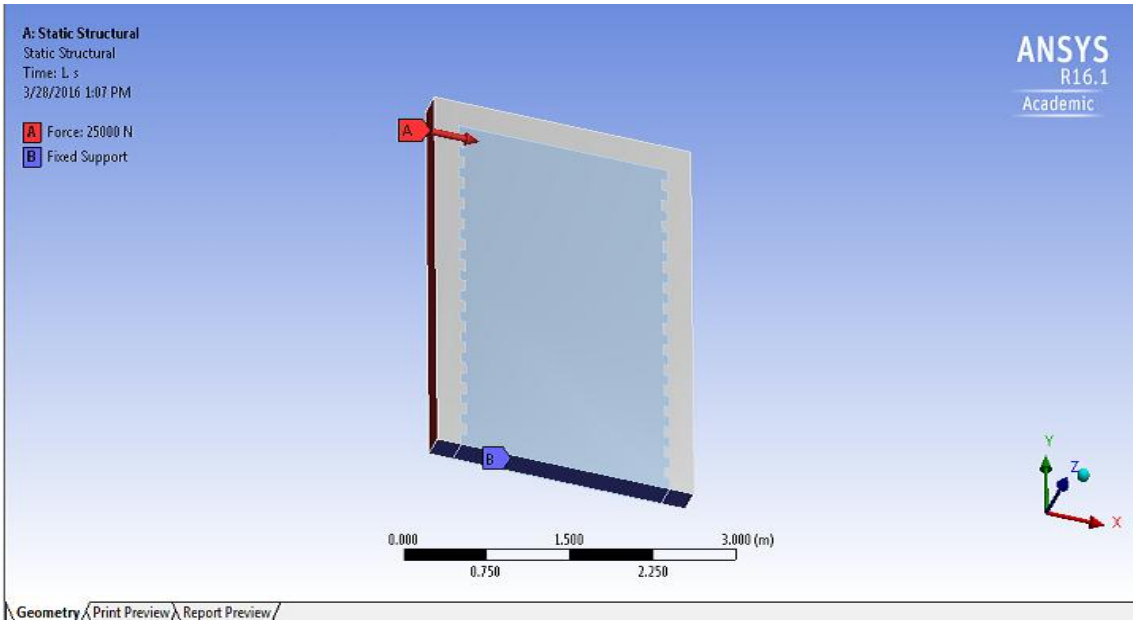

Fig.8: Force and Boundary Condition apply in ANSYS

IV. OBSERVATIONS & DISCUSSION

Deformation refers to any changes in the shape or size of an object due to an applied force, which is proportional to the stress applied within the elastic limits of the material. [5]

In continuum mechanics, stress is a physical quantity that expresses the internal forces that neighbouring particles of a continuous material exert on each other. [5]

i. Rectangular connection

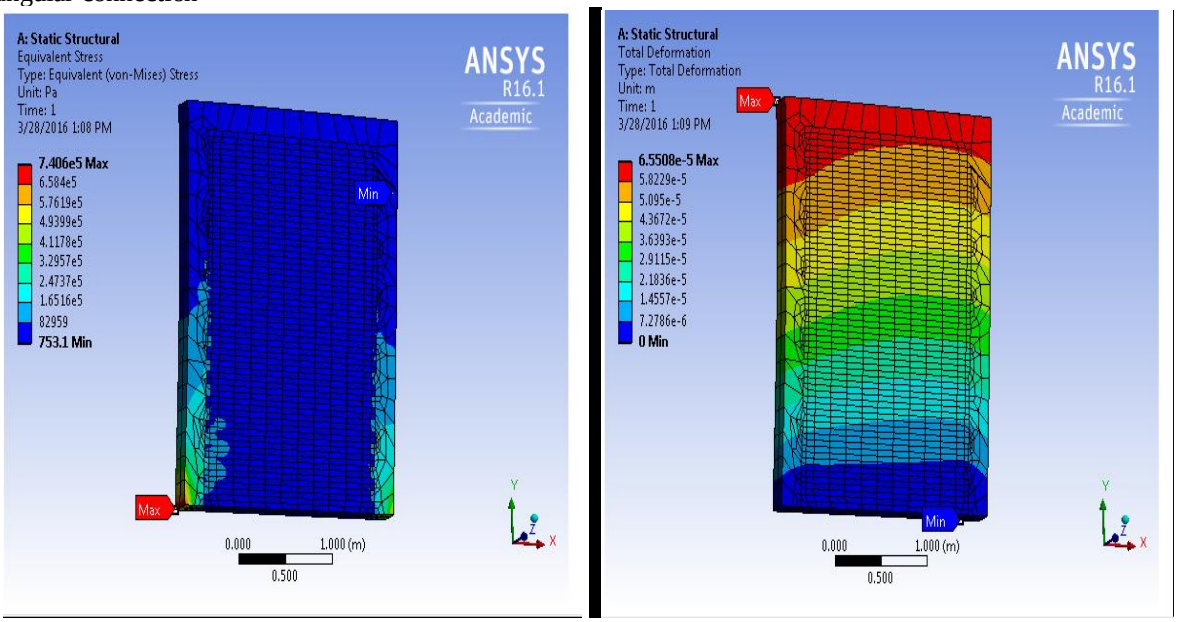

Fig.9a: Equivalent stress in Rectangular connection in ANSYS
Fig.9b: Total deformation in Rectangular connection in ANSYS

ii. Hexagonal connection

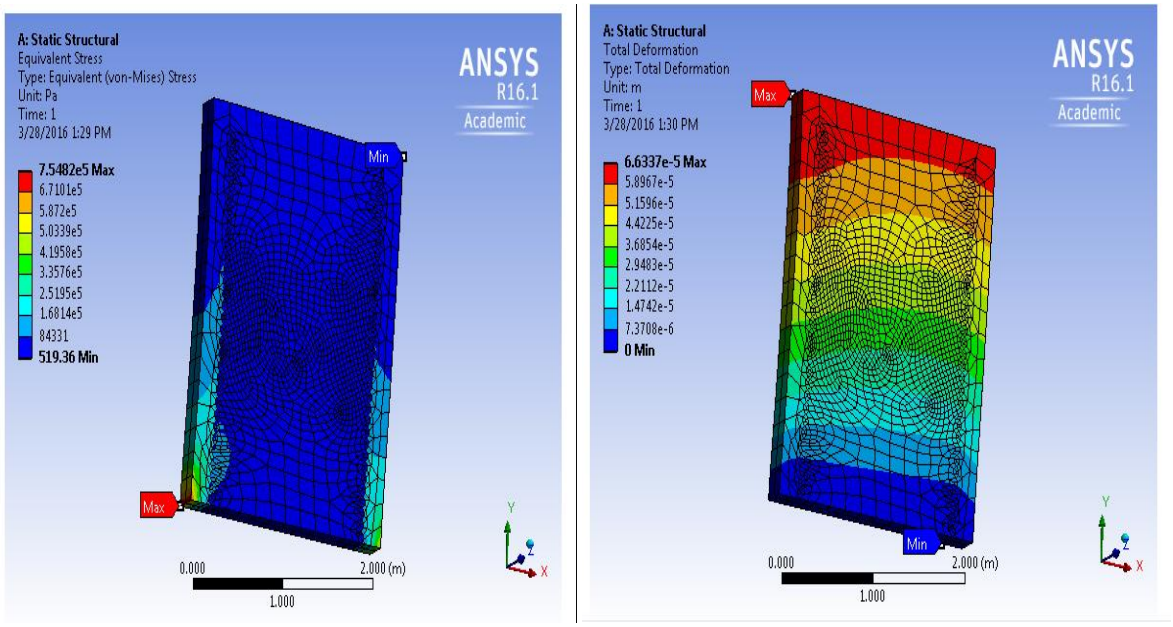

Fig.10a: Equivalent stress in Hexagonal connection in ANSYS
Fig.10b: Total deformation in Hexagonal connection in ANSYS

iii. Provision of dowels when toothing is not possible

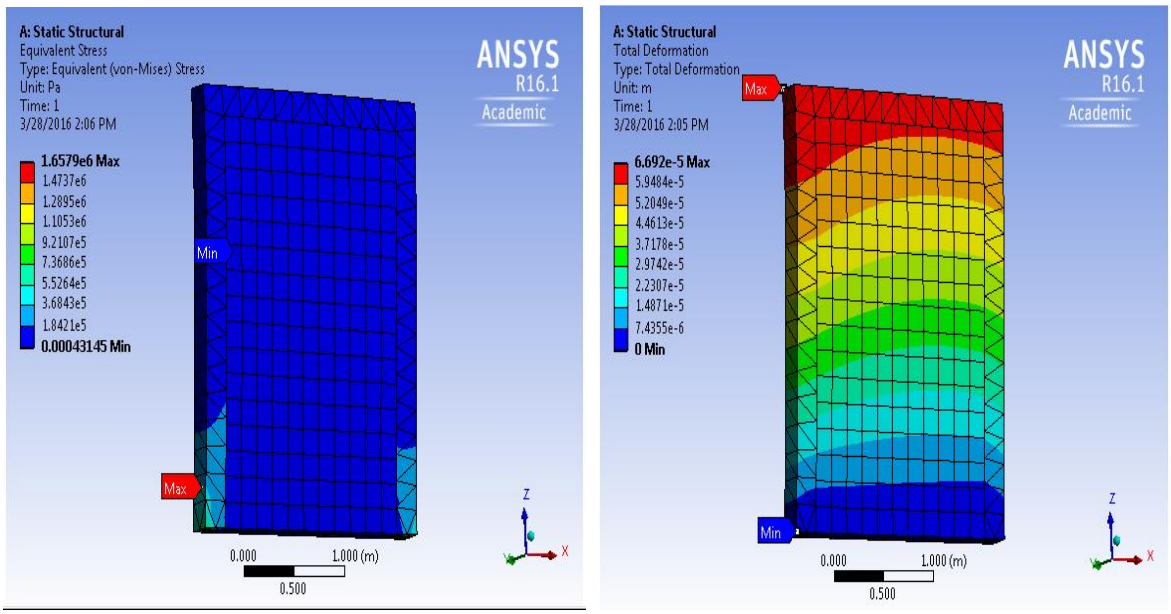

Fig.11a: Equivalent stress in Straight dowel connection in ANSYS
Fig.11b: Total deformation in Straight dowel connection in ANSYS

iv. Provision of L shape dowels

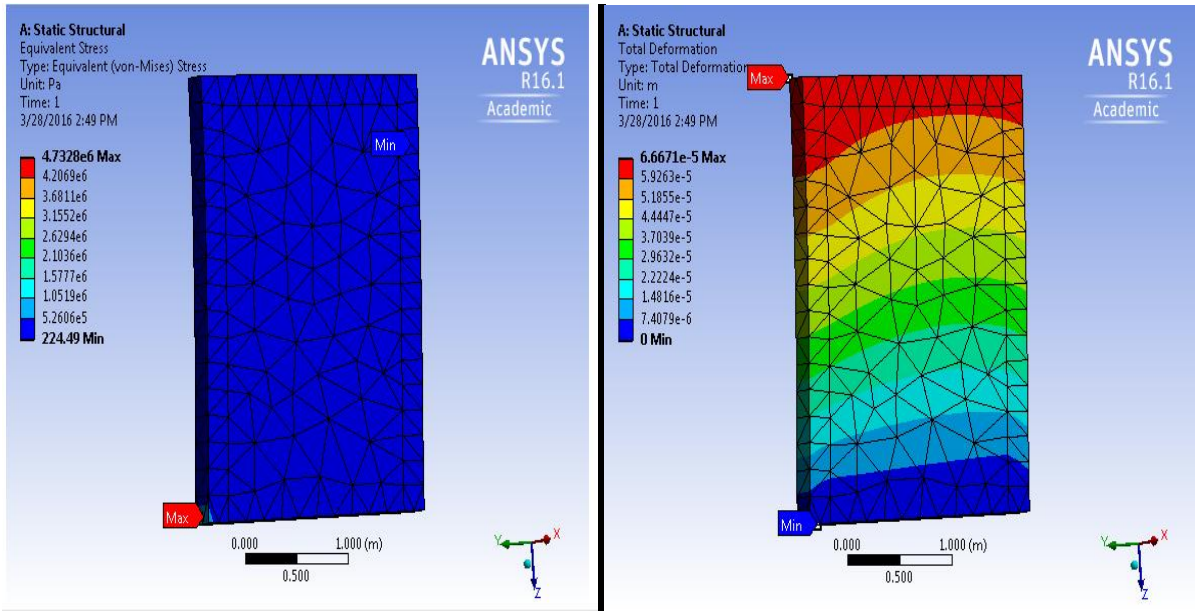

Fig.12a: Equivalent stress in L shape dowel connection in ANSYS
Fig.12b: Total deformation in L shape dowel connection in ANSYS

Table IV: Results of Various Connections

Sr No.	Rectangular Toothing Connection	Hexagonal Toothing Connection	Provision of Straight Dowel Bars	Provision of 'L' Shape Dowel Bars
Total Deformation (Maximum)	0.065508 mm	0.06637 mm	0.06692 mm	0.066677 mm
Equivalent Stress (In RC frame)	0.7406 MPa	0.75482 MPa	0.76077 MPa	1.875 MPa
Equivalent Stress (In Wall)	0.11373 MPa	0.11151 MPa	0.11862 MPa	0.24078 MPa
Stress in Steel Dowel bars	--	--	1.6579 MPa	4.7328 MPa

V. CONCLUSIONS

As per the results obtained mentioned in table: ___ the overall deformation is not affected to a great deal by providing any kind of joint assembly. The stresses induced in the RC element and masonry element reduces a bit in rectangle groove joint between masonry and RC element. The stresses induced in the dowel bar are due to load transfer between the RC element and steel reinforcement which provides a much better bonding. It can be concluded from the analytical study that the rectangular groove and dowel bars if connected properly with masonry can give better lateral load resistance to the confined masonry structure.

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