Nonlinear Finite Element Analysis of Shear Wall with Different Slit Shapes

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***Abstract* - The reinforced concrete shear walls are important structural elements that are placed in multistorey buildings from seismic zones, because they have a high resistance to lateral earthquake loads. Structural reinforced concrete shear walls represents a system that provides lateral resistance, high stiffness and strength to a building. Reinforced concrete shear walls must have sufficient ductility to avoid brittle failure under the action of strong lateral seismic loads. The overall ductility of the structure increases, considering the energy dissipation solution, resulting a supplementary safety for the building. By placing vertical slits in the wall structure a substantial increase in ductility is obtained, and with this solution the degradation in the shear wall are greatly reduced. In this project, the static nonlinear analysis of shear wall is performed. The influence of the slit in shear wall with varying the shapes of slit is evaluated.**

***IndexTerms* - Ductility, Finite element method, Reinforced concrete shear wall, Static nonlinear analysis, Shear slit walls.**

I. INTRODUCTION

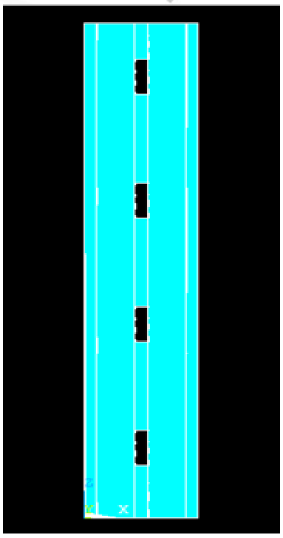
Shear walls are vertical elements of the horizontal force resisting system.The use of shear wall-buildings is quite common in some earthquake prone regions. Usually, architectural design leads to the existence of doors and windows within shear walls. Shear walls, which are quite common in earthquake resisting structural systems, may have openings for doors, windows and building services or other functional reasons. Much research in finite element analysis of shear walls with openings has been undertaken. The objective of this study is to investigate the behavior of shear walls with slit with nonlinear finite element analysis.

II. SHEAR WALL DIMENSIONS

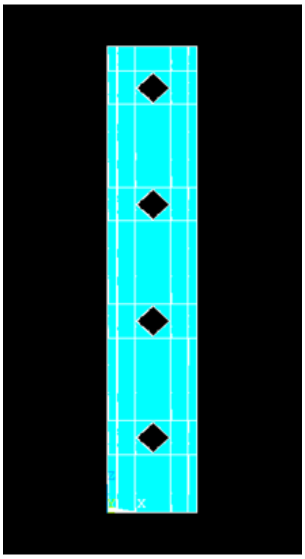
The adopted shear wall is 14 m high, representing 4 stories each of 3.5m height. The horizontal length of wall is 2.5 m, and it is 0.3m thick. The openings are located in all stories at the mid length of shear walls.

III. STRUCTURE MODELS

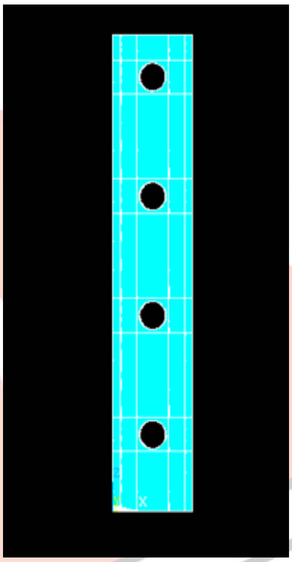
ANSYS finite element software is used to model reinforced concrete shear walls with different shapes, the rectangular openings is 0.3mx1m. And circular slit and diamond shape slit are taken such that the perimeter of the circular slit shapes and diamond shape slit are same to the perimeter of the respective rectangular slit. The dimension of the circular slit and diamond shape slit with respect to the rectangular slit dimension (0.3mx1m) is 0.40m radius and 0.65m each side.



a) Model Of Rectangular Slit With 0.3mx1m



b) Model Of Diamond Shape Slit With 0.65m Side



c) Model Of Circular Slit With Radius 0.40 m

IV. FINITE ELEMENT MODELING

ANSYS provides a threedimensional eight noded solid isoparametric element, SOLID65, to model the concrete. This element has eight nodes with three degrees of freedom at each node translations in the nodal x, y and z directions. This element is capable of plastic deformation, cracking in three orthogonal directions and crushing.

BEAM188 is suitable for analyzing slender to moderately thick beam structures.BEAM188 has six or seven degrees of freedom at each node. These include translations in the x, y, and z directions and rotations about the x, y, and z directions. A seventh degree of freedom (warping magnitude) is optional. This element is well-suited for linear, large rotation, and/or large strain nonlinear applications. The element includes stress stiffness terms, by default, in any analysis with large deflection. The provided stress-stiffness terms enable the elements to analyze flexural, lateral, and torsional stability problems (using eigen value buckling). Elasticity, plasticity, creep and other nonlinear material models are supported. A cross-section associated with this element type can be a built-up section referencing more than one material.

V. SECTIONAL PROPERTIES (REAL CONSTANTS)

The reinforcement bars in the shear wall is given as smeared reinforcement and so the real constant values for solid 65 are required. For this model, parameters to be considered are material number, volume ratio and orientation angle (θ and Φ) in *X*- and *Y*-directions respectively. Real constant values is given as in table (1)

TABLE 1 Real Constant Values For Solid 65

Real constant set	Element type	Particulars	Real constant for rebar 1	Real constant for rebar 2	Real constant for rebar 3
1	Solid 65	Material number	2	2	2
		Volume ratio	0.009	0.00785	0.00349
		Orientation angle THETA 1	90	0	0
		Orientation angle THETA 2	0	90	90

VI. Specimen Geometry

The solid65 element and beam 188 is used in the nonlinear response of reinforced concrete model. Solid 65 is used for the beams and beam 188 is used to give the reinforcement. Table (2) lists concrete properties for beam 188, beyond that concrete properties for Solid65 element, in Table (3). Solid65 element is capable of cracking in tension and crushing in compression.

Table 2 Material Properties of beam 188

Linear Isotropic	
Ex	$2.1x10^{11} N/m^2$
PRXY	0.3

Table 3 Material Properties of solid 65

Shear transfer coefficients for an open crack	0.2
Shear transfer coefficients for a closed crack	0.9
Uniaxial tensile cracking stress	$3.78\ e^6\ N/m^2$
Uniaxial crushing stress.	$40\ e^6\ N/m^2$

VII. MESHING

All the models are meshed into very fine meshes to get very accurate result in ANSYS software.

VIII. LOADS AND BOUNDARY CONDITIONS

The supporting conditions of the shear wall is given as fixed at the bottom. Dead load of 3500N/m is given to every floor. An assumed load is given increasingly to each floor as going to the top floor.

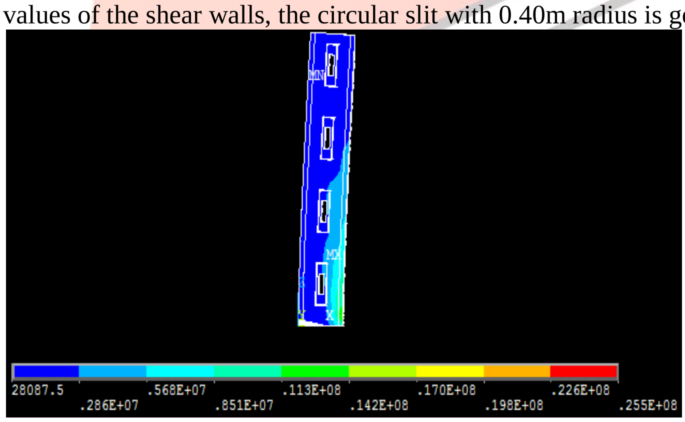
IX. RESULT AND DISCUSSIONS

The carried out analysis stimulates the whole load deformation curve, inclusive of elastic deformation, initiation of cracking, as well as tension and shear cracks until ultimate concrete crushing. The load was gradually increased, employing non-linear, large deflection analysis, until a load level was found whereby the structure became unstable. The deflection values and the Von Mises stress diagram are the results obtained from the analysis of shear wall.

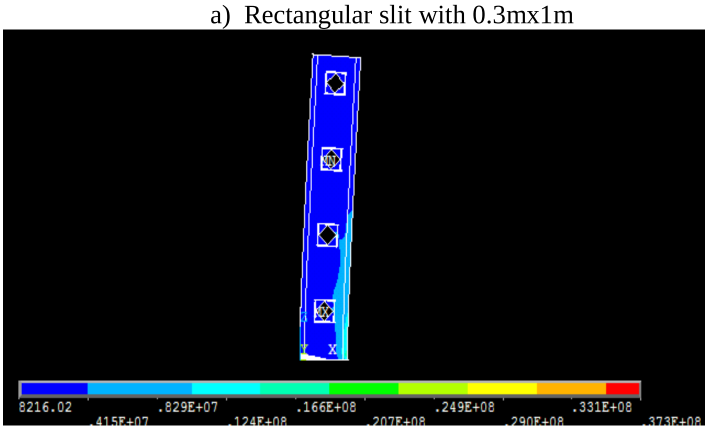
Table 4 Deflection Values

Slit dimension	Deflection value
Rectangular slit with 0.3mx1m	0.021155m
Diamond shape slit with 0.65m side	0.029645m
Circular slit with radius 0.40m	0.014853m

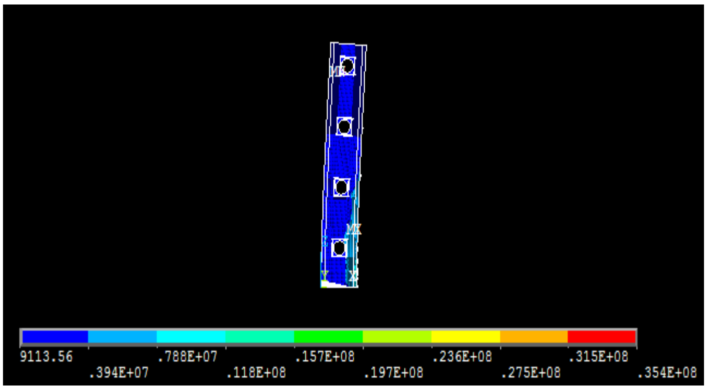
When comparing the deflection values of the shear walls, the circular slit with 0.40m radius is getting the smaller value



a) Rectangular slit with 0.3mx1m



b) Diamond shape slit with 0.65m side

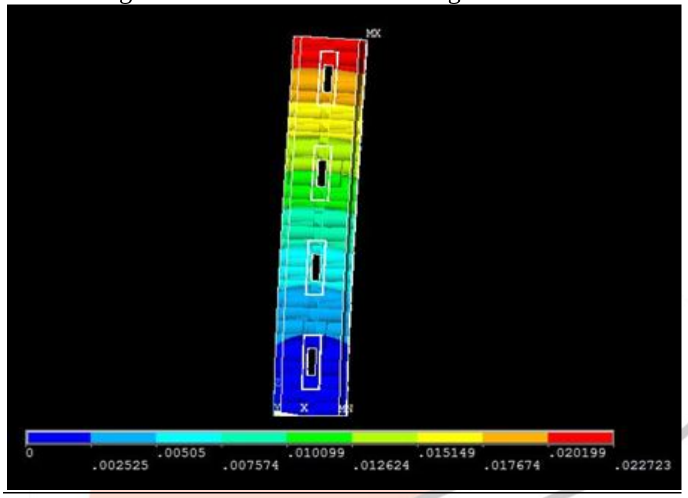


c) Circular slit with radius 0.40 m

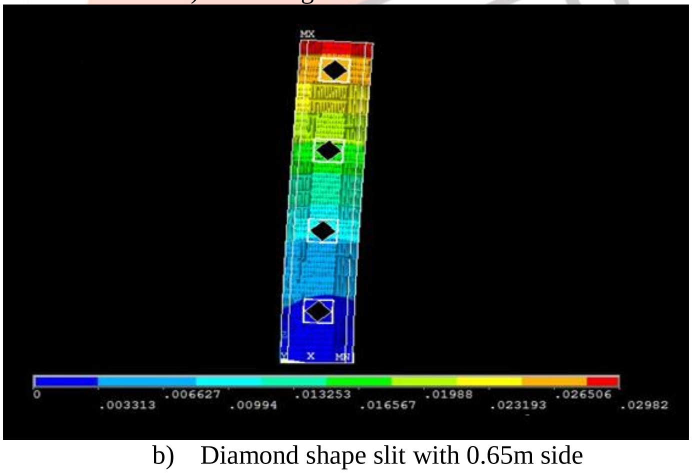
Fig 1: Von Mises stress diagram

X. SEISMIC ANALYSIS OF SHEAR WALL

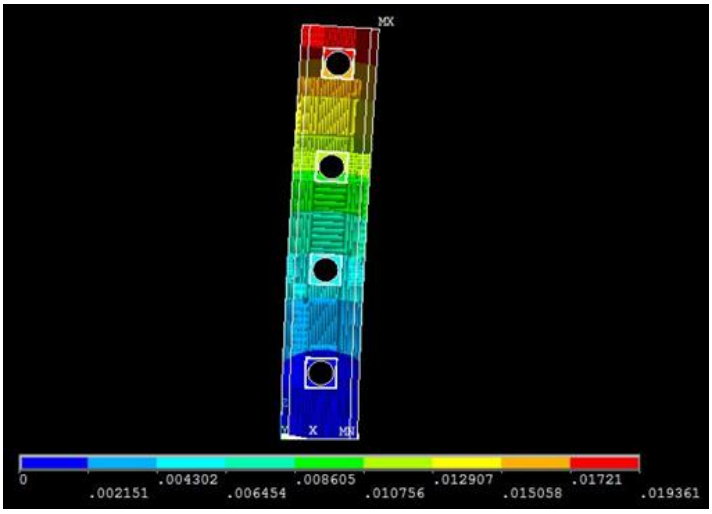
The seismic analysis of shear wall with varying slit shapes is done by giving the time and acceleration of earthquake as the input and the results are obtained as deflection diagram and Von Mises stress diagram. The obtained results are given below.



a) Rectangular slit with 0.3mx1m

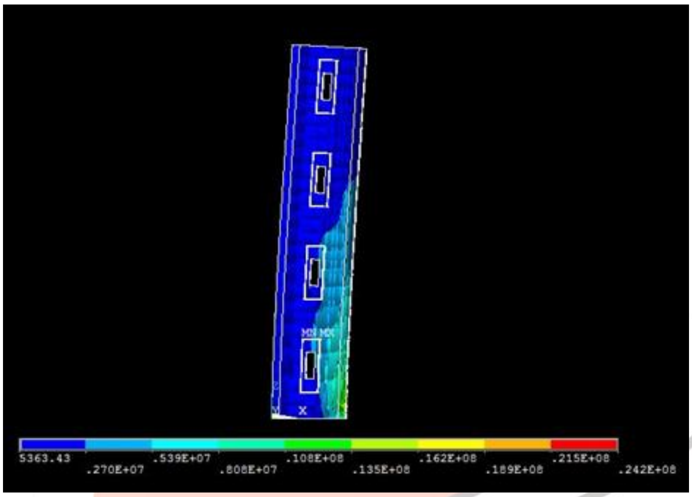


b) Diamond shape slit with 0.65m side

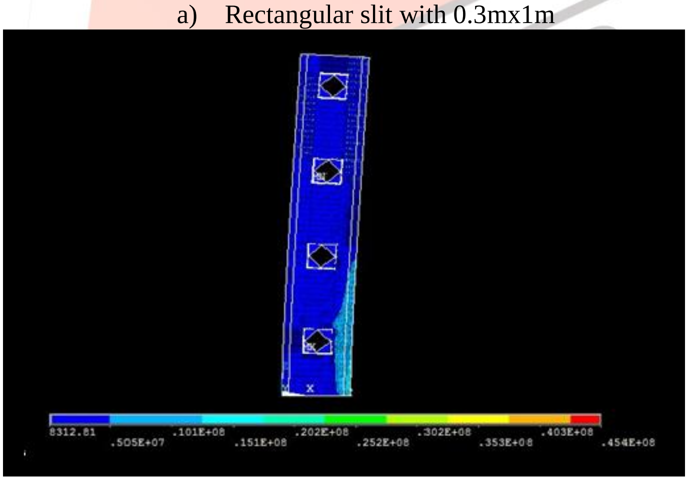


c) Circular slit with radius 0.40 m

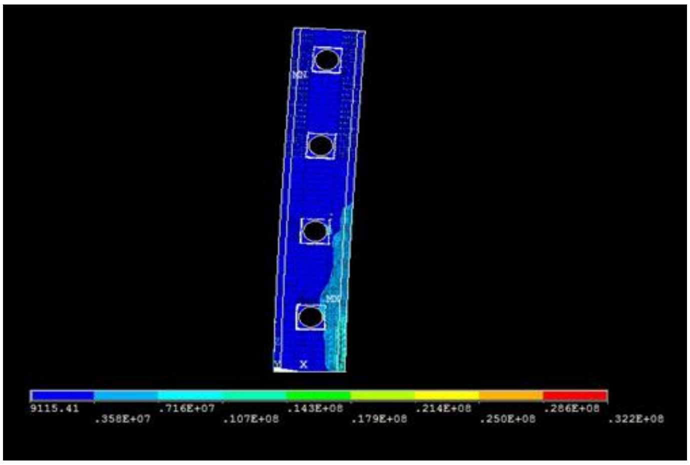
Fig 2: Deflection Diagrams Of Shear Wall



a) Rectangular slit with 0.3mx1m



b) Diamond shape slit with 0.65m side



c) Circular slit with radius 0.40 m

Fig 3: Von Mises Stress Diagram Of Shear Wall

XI. CONCLUSIONS

The shear wall with different slit shapes is modeled using ANSYS software. From the results obtained it can be concluded that the shear wall with circular slit of radius 0.40m is having lesser deflection than the rectangular slit shape and diamond shape slit of shear wall. The seismic analysis of shear wall with different shapes of slit is done. From the results, it could be concluded that the shear wall with circular slit could resist maximum seismic load and attain maximum stability in all the cases.

XII. ACKNOWLEDGMENT

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