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Influence of Mesh Size in Deformability and Stress State of Shear Walls.

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Abstract
The way of shear-walls modeling is very important issue for static and dynamic behavior of the whole structure. Based on finite element method, the utilization of planar or linear element can both be used. For the planar element, the finite element formulation must be clearly understood. Modeling the shear walls with frame elements are extensively used in structural analysis due to their simplicity and capability to perform linear and nonlinear analysis. The planar elements are more convenient, but it doesn't mean that the result have to differ essentially. The behavior of shear walls, modeled using planar element, is governed by mesh size and finite element formulation. In this study, these influences are shown by numerical examples using computer software. The accuracy of analysis will be given as a function of mesh size.

Keywords: *shear wall, mesh, frame element, planar element, linear analysis.*

1. INTRODUCTION

To resist to lateral forces, shear walls (SW) structural elements are commonly used by the design civil engineers. In now days is widely spread the analyses of 3D models using the finite element method. There are different possibility to model SW as frame, planar or solid element. The planar element has shown a convenient and reliable result representing an adequate correlation with real behavior. The accuracy of analyses is function of mesh size and finite element formulation. In this study will be shown the influence of mesh size using quadratic shell finite element with six degree of freedom per node to model SW. Also the influences of opening and SW type are observed. The SW are taken with simple rectangular cross-section or squat walls. For squat walls three different contouring are taken. To have a clear understanding of SW, they are study as a part of a whole structure consists of 14 storeys. The main outcome parameters chosen from the analysis are: natural period of fundamental mode of vibration, top displacement, base forces and stress distribution. Based on this parameters and results comparison the case conclusions and comments are given.

2. MODELING AND ANALYSIS

The shear walls are model as parts of 14 storey building with typical storey height of 3m and the first 4m high. The structure is taken with 3 bays for each direction with span of 7m. The frame elements are taken according to preliminary dimensioning as they are not part of this study. Shear walls are positioned in external axis in symmetric way. The results are derived through modal and response spectrum analyses. In fig.1 is shown the structural plan of the building.

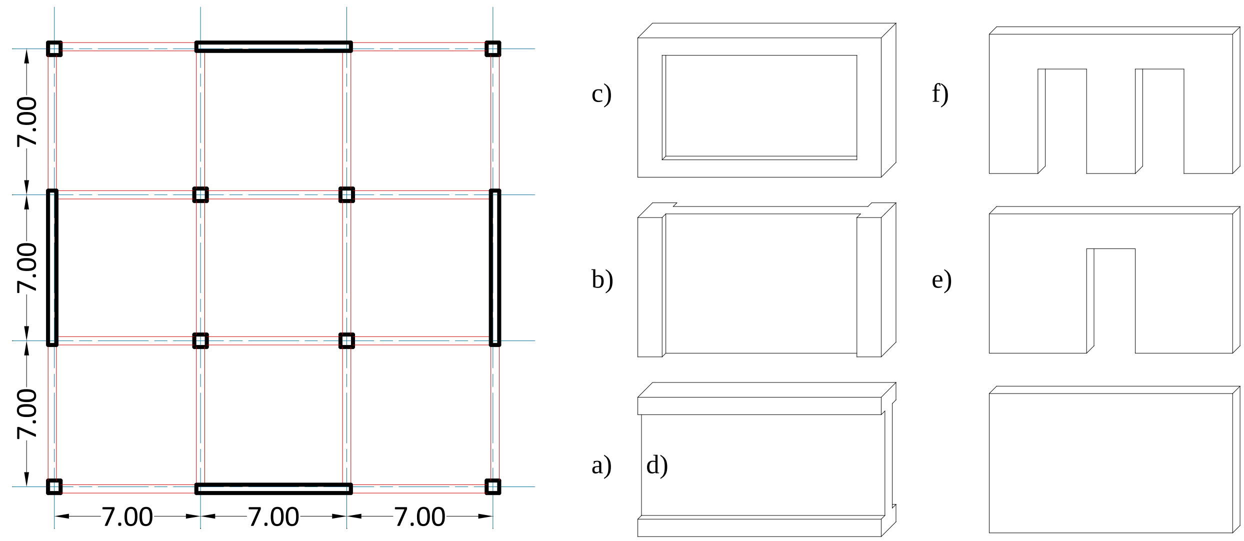


Figure-1. Typical Structural Plan
a) SW-B, b) SW-C, c) SW-BC, d) SW-simple, e) SW-1opening, e) SW-2opening

In fig.2 are given some representative models using the finite element computer program. Columns and beams are model as frame element with 6 DOF per node. Slabs and SW are model as shell elements with 6 DOF to insure the compatibility among the elements. SW and slabs have the same mesh size to insure the adequate connection between them.

The SW thickness it taken equal for each storey (tw=30cm). The corner columns are uniform with cross-section 60x60 cm. The internal ones vary in height, first two storey with cross-section 75x75, storey 3&4 70x70 and the others 60x60. Slab thickness is taken 20 cm and beams 30x60 for each level. Structures are assumed fixed in the base.

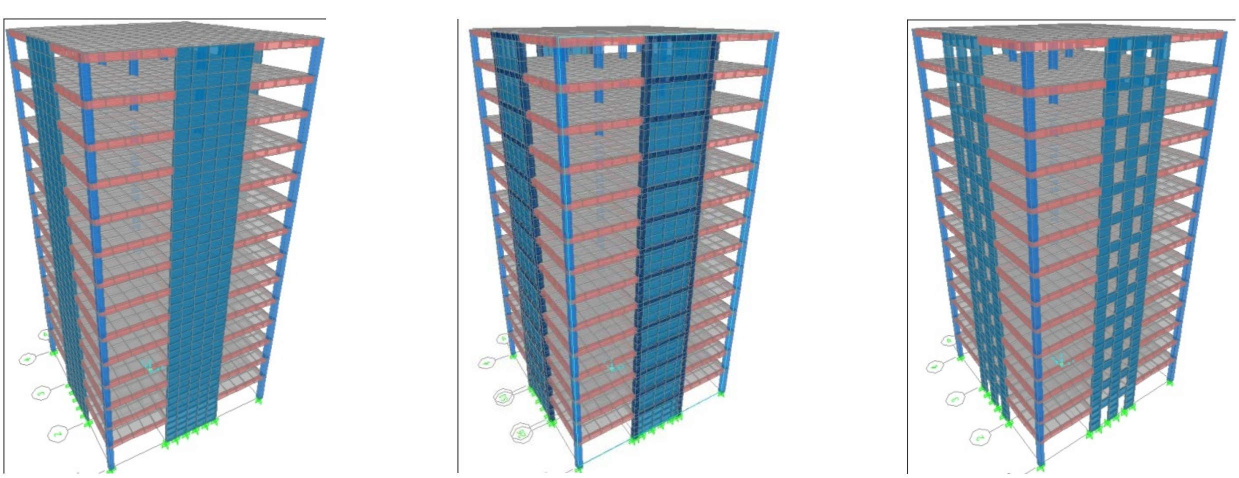


Figure-2. Typical 3D finite element structural models
a) SW-simple, b) SW-squat, c) SW with opening

To see the SW response due to lateral forces, the dynamic analysis are perform using the response spectrum procedure based on response spectra for PGA=0.3g, soil condition of class “B” as described in EC-8. The structure behavior factor is assumed q=4.5.

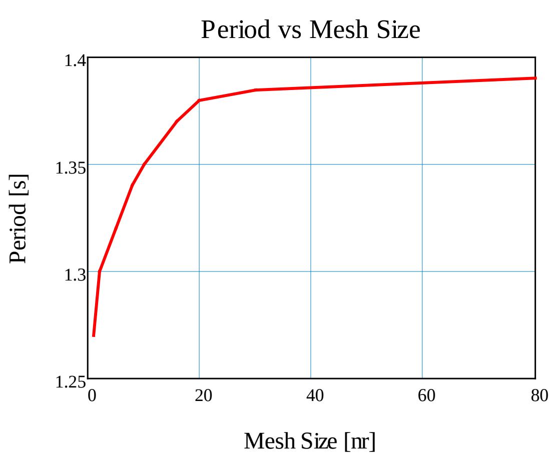
To observe the mesh influence four meshing size are taken. The cross-section are taken simple rectangular. The first model assume shear wall as one panel for each floor. The second model divides the panel of each story in five vertical strips. The third and fourth model divides the SW panel in 5x4 and 10x8 rectangular respectively. In table-1 are given the corresponding results derived from analyses depending from the mesh size.

Table-1: First modal periods and top displacement in function of mesh size.

Building Type	**Load Combination**	**First Mode Period** [s]	**Deflection** [cm]
SW-1x1	UDCON3	1.27	4.73
SW-5x1	UDCON3	1.32	4.90
SW-5x4	UDCON3	1.38	5.14
SW-10x8	UDCON3	1.39	5.16

With the increasing of mesh number, the periods and deflections are increased too. The differences will be present in a diagram as function of mesh size.

In fig.3 is given the relation between the fundamental period and top displacement versus the mesh size. It can be seen that above a certain number of division, the response is not so sensitive.



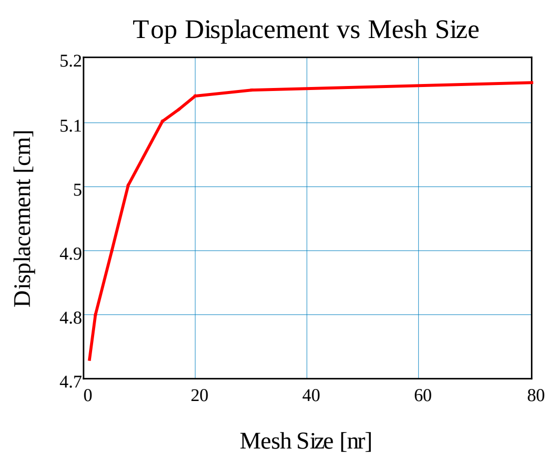


Figure-3. Periods and Displacements as Function of Mesh Size

In fig.4 is shown the stress distribution of vertical stressing as function of mesh size. As it can b seen the mesh size is of a very important factor.

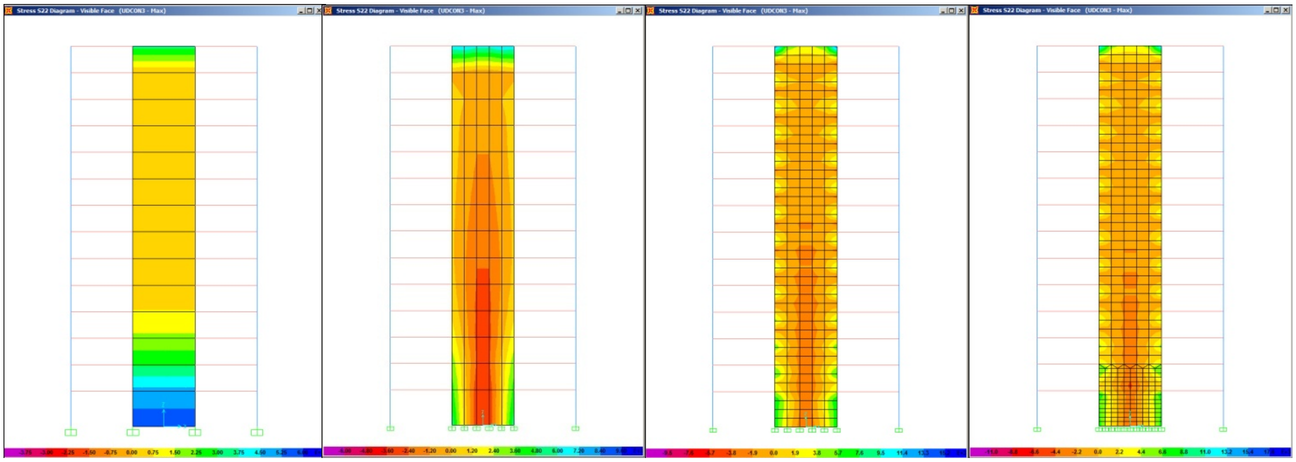


Figure-4. Distribution of vertical stresses as Function of Mesh Size

In table -2 is given the base forces depending on mesh size. The base forces decrease with the increasing of mesh size in intend to a constant value. Although the differences are less then 2%.

Table-2: Base forces in function of mesh size.

Building Type	**Load Combination**	**Global FX** KN	**Global MY** KN-m
SW-1x1	UDCON3	4568.376	120744.1173
SW-5x1	UDCON3	4502.512	117522.3191
SW-5x4	UDCON3	4405.873	112791.6354
SW-10x8	UDCON3	4411.132	112761.7815

To see the influence of boundary elements in shear walls, four type of SW are used. First type is with simple rectangular cross=section of shear wall. The edge columns are taken with cross-section 60x60 and boundary beams are 60x50 cm. The second type is a SW with boundary beams (fig.1-a), the third with boundary columns (fig.1-b) and a squat wall (fig.1-c). for each of these cases the outcome results are given in preceding tables:

Table-3: Periods and top displacements as function of boundary elements

Building Type	**Load Combination**	**First Mode Period** [s]	**Deflection** [cm]
SW-7x5	UDCON3	1.44	5.34
SW-7x5-B	UDCON3	1.40	5.20
SW-7x5-C	UDCON3	1.27	4.70
SW-7x5-BC	UDCON3	1.28	4.78

Table-4: Base forces as function of boundary elements

Building Type	**Load Combination**	**Global FX** KN	**Global MY** KN-m
SW -7x5	UDCON3	4215.860	107957.0801
SW -7x5-B	UDCON3	4393.427	113524.8279
SW 7x5-C	UDCON3	4721.212	123853.4976
SW -7x5-BC	UDCON3	4735.572	124403.5406

As it can be seen the column edges have a major influence in SW behavior. In fig.5 is given the stress distribution for each case of boundary.

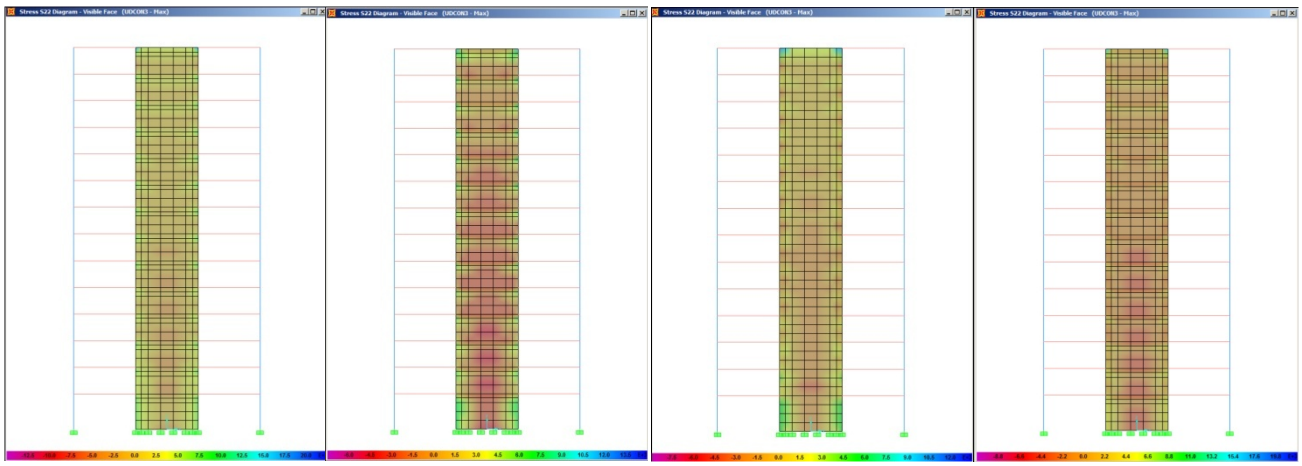


Figure-5. Stress distribution
a) SW-simple, b) SW-B, c) SW-C, d) SW-BC

In fig.6 are given the stress distribution in SW depending of openings. Dimension of openings are taken 1.4x3 m for the first storey and 1.4x2 m for the others storey.

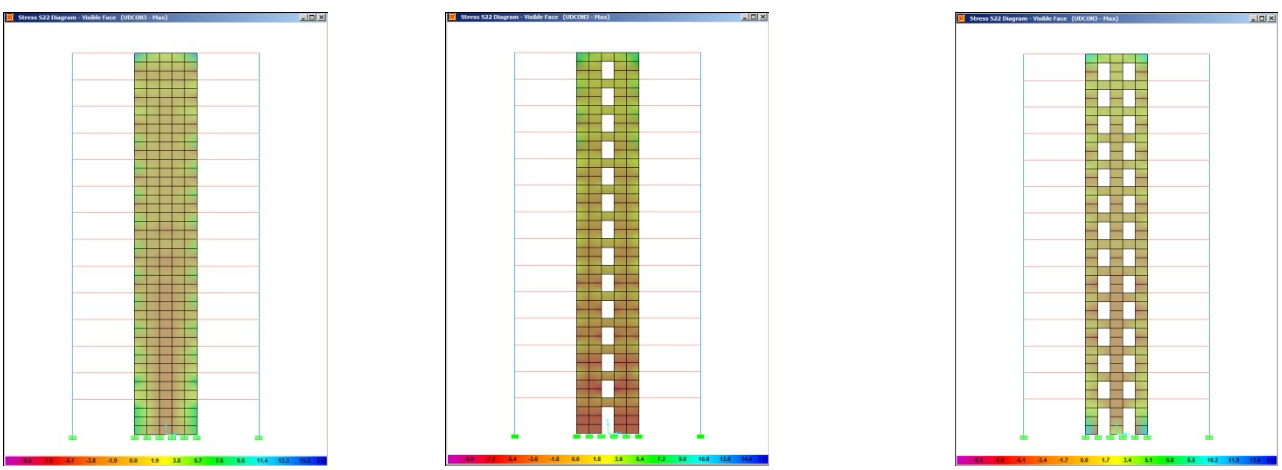


Figure-6. Stress distribution
a) SW-simple, b) SW-1 opening, c) SW-2 opening

the values for the fundamental period, top displacement and base forces are given in tables nr.5&6. It's obvious that the opening decrease the stiffness of shears walls and reduces the base forces.

Table-5: Periods and top displacements as function of openings

Building Type	**Load Combination**	**First Mode Period** [s]	**Deflection** [cm]
M-5x4	UDCON3	1.38	5.14
M-5x4-1 OPN	UDCON3	1.40	5.20
M-5x4-2 OPN	UDCON3	1.47	5.41

The stress stage of SW walls depends on size, number and placement of openings.

Table-6: Base forces as function of openings

Building Type	**Load Combination**	**Global FX** KN	**Global MY** KN-m
SW-5x4	UDCON3	4405.873	112791.6354
SW-5x4-1 OPN	UDCON3	4341.606	110228.0647
SW-5x4-2 OPN	UDCON3	4191.255	104272.4784

3. CONCLUSIONS

The mesh size has a great influence in analysis accuracy of the calculated model. Although, above a certain level of meshing, the differences are too smalls. The size of meshing is not influencing significantly the values of higher modes. When large number of meshing is used, the model become more complicated. So, for design purposes a reasonable meshing can be used. The behaviors of squat walls are governed mainly by edge columns. The influence of boundary beams is not so sensitive. The openings in shear walls influence in their rigidity and in the pattern of stress distribution.

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