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Evaluation of Coupled Shear wall in High-Rise Building

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Abstract -*Shear wall is a basic important structural component. These walls can be utilized for giving more strength & safety to the structure, when the structures are subjected to external loads, such as earthquake loads, wind loads etc. these type of walls, basically play the main role for the construction of a tall structure. Provision of a shear wall is the structural system composed of braced panels (also known as shear panels) to counter the effect of the lateral load acting on a structure. It will act as vertical cantilevers to give the essential stiffness in a building.*

In this paper, four different models were considered for analysis of coupled shear. These all models have modelled in E-Tabs 2015 software by considering all geometric property are same. For equivalent static analysis and response spectrum analysis E-TABS 2015 software is used. In the result Storey displacement, storey shear, storey stiffness, storey drift is studied for all models.

Key Words: *Coupled shear wall, Coupling beams, E-TABS 2015, Storey shear, Stiffness, Storey displacement, Storey drift, lateral load, Natural period.*

1. Introduction:

The growth of population and land shortage in fast growing city areas are the two major problems for all developing cities as well as countries. In order to mitigate these problems, the structural designer's choice to high rise building, which is rapidly growing in number, with various architectural configurations and use of structural materials. Due to the earthquake large amount of damage occurred in high rise buildings. So, this particular incident has shown that designers should provide adequate earthquake resistant provision to the high-rise buildings in terms of planning, designing and detailing in buildings to withstand the effect of an earthquake. The use coupled shear wall in one the possible option in high rise building.

1.2 Coupled shear wall:

When two shear walls are interconnected by beams along their height then it is called as a coupled shear wall (as shown in fig.1). Coupling beams are the main key parameter in the coupled shear wall. These coupling beams are to be designed for ductile inelastic behaviour in order to dissipate energy and provide damping during the earthquake. So, use of coupled shear wall is one of the potential options in comparison with special moment resisting frame(SMRF) and shear wall frame combination system in buildings. Shear and flexural behaviour are controlled by shear wall frame combination and SMRF systems whereas, the behaviour of coupled shear walls governed by flexural behaviour. However, behaviour of coupling beams is coupled shear wall is governed by shear capacity and behaviour of the conventional beam both SMRF and shear walls frame combination systems is governed by flexural capacity.

1.3 Coupling beams:

In multi-storey buildings, the lateral loads are resisted by shear walls due to their strength and stiffness. These walls have several openings such as windows, doors, elevators etc. which divide the whole shear wall into slender walls. To increase shear capacity these walls are interconnected by short beams along their height. These beams are called as coupling beams. Coupled shear wall system will give more economical as well as efficient structure systems than single shear wall systems also these systems possess higher stiffness, strength and energy dissipation. Design of coupling beam, there types and advantages are discussed as per ACI 318-11.

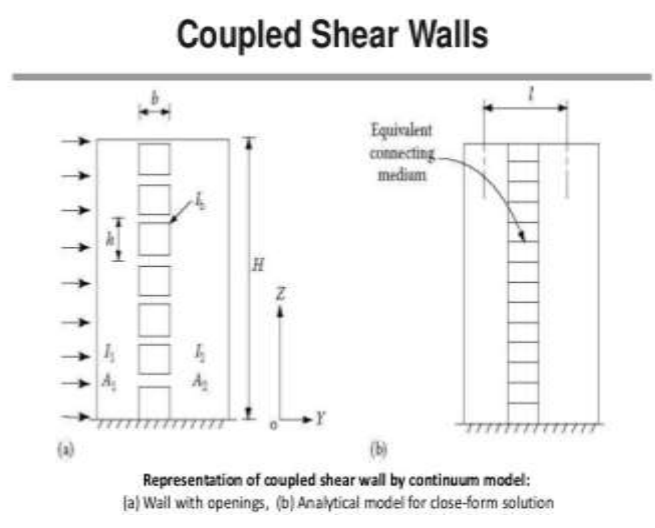

Fig.1) Coupled shear wall

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1.4 Need of Coupled Shear wall In Multi-storey Buildings:

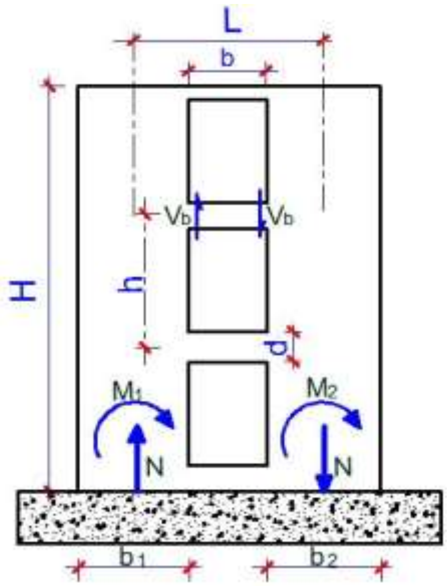


Fig.2) Section view of the coupled shear wall structure

In reinforced concrete high-rise structures, coupled wall structures as shown in Fig.2) can provide an efficient lateral load resisting system against wind and earthquake effects. When such structures are subjected to horizontal loading, the total overturning moment is divided into two components: primary bending moments, *M*1 and *M*2 taken by the individual walls and an axial bending moment *Tl* which is the axial force, *T* induced in the walls by the shear forces in the coupling beams, multiplied by a distance l between the neutral axes of the walls. The relationship between these two types of bending moment is given by single parameter. The degree of coupling (*DOC)* of coupled shear walls (CSW) is defined by the axial bending moment at the base of the structure, expressed as a fraction of the total overturning moment

$$DOC = \frac{Tl}{Tl + M1 + M2}$$

Obtaining the different types of bending moment requires a full analysis of the structure as the relationship between these actions is dependent on the stiffness of the coupling beams. The continuous medium theory as applied to high-rise coupled shear wall structures allows a rapid assessment of the horizontal deflections when subjected to lateral loading. This makes it possible to derive expressions for the shear forces in the coupling beams in MSW structures. Establishing the maximum shear force, *Vbmax* in the critical coupling beam and its location up the height of the structure will yield a relationship between this peak shear force and an average shear force, *V*b, average which is called the peak shear demand (PSD.

2. Related work:

Hoenderkamp [1]: This paper presents a simple method of analysis to determine the influence of single shear walls (SSW) on the degree of coupling(DOC) and on the peak shear demand (PSD) for beams of coupled shear walls (CSW) in mixed shear wall structures (MSW).

Harries et.al [2]: An extensive parametric analysis of coupled wall behavior was conducted. using elastic analysis and gross section properties**,** the role of representative geometric parameters in the response of coupled structures has been illustrated. The effect of using various code-prescribed reduced section properties is also discussed.

Subedi et.al [4]: In this paper three basic modes of failure can be identified in reinforced concrete coupled shear wall structures, depending on the degree of interaction and the behavior of the coupling beams.

Rangolli and Hosur [11]: The growth of population and shortage of land in town areas are two major problems for all developing countries. In order to mitigate these two problems, the designer's choice to high-rise buildings, which are rapidly increasing in number, with various architectural configurations and use of structural materials. Due to frequent earthquakes occurring around the world, cause considerable damage to the large number of RCC high-rise buildings. This particular incident has shown that designers and structural engineers should ensure to offer adequate earthquake resistant provisions with regard to planning, design, and detailing in high rise buildings to withstand the effect of an earthquake. As an earthquake resistant system, the use of Coupled shear walls is one of the possible options.

3. Building parameter for modelling:

In this paper four different cases considered for analysis. Considering all geometric properties are same for all models and these models are modelled in E-tabs 2015 software as per structural details are given in Table.1

Table.1) Structural Details of RC Building

1	Type of structure	Multistory rigid jointed plane frame
2	Number of stories	G+10
3	Floors height	3.5m
4	Size of column	550x550 mm
5	Size of beam	230x550 mm
6	Depth of slab	150 mm
7	Live load	1.On roof=1.5 KN/m^2 2.On floor = 4 KN/m^2
8	Shear wall(thick)	230 mm

9	Material	M20 and Fe500
10	Grid lines (X)	5
11	Grid lines (Y)	5
12	Spacing along X and Y axis	5 m
13	Size of Coupling beam	230x1000 mm
14	Zone considered	II
15	Importance factor	1
16	Response reduction factor	5
17	Damping Factor	0.05
18	Type of soil	Hard
19	Wall load	17KN/m
20	Floor Finish	1.5 KN/m^2
21	Response Spectra	As per IS1893(Part1):2002

4. Modelling of Structure:

The given frame structure is modelled in four different ways and it is analysed by using E-TABS2015. Response spectrum analysis and equivalent static analysis are carried out for all models.

Model 1: Normal Building with Column beam joint.

Model 2: Building with opening in shear wall.

Model 3: Building with four side shear walls.

Model 4: Building with coupled shear wall

MODEL 1:

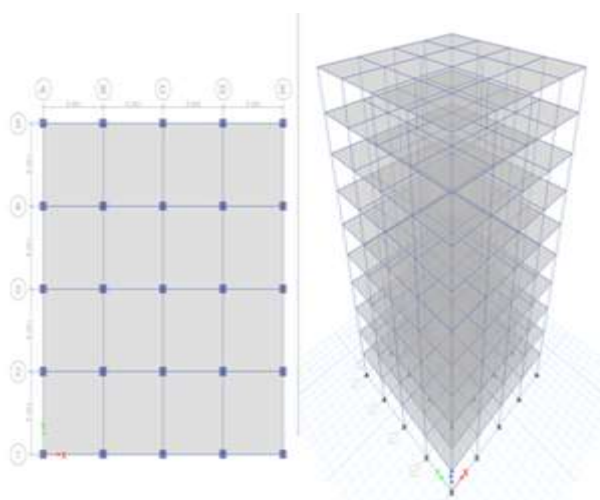


Fig.3) Normal Building with Column beam joint

MODEL 2:

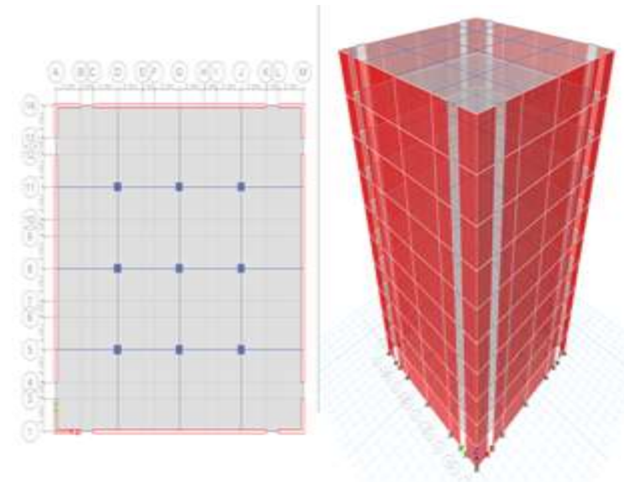


Fig.4) Building with opening in shear wall

MODEL 3:

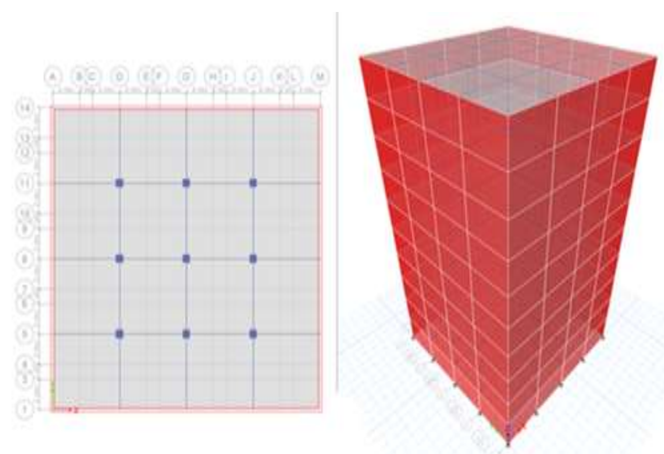


Fig.5) Building with four side shear walls

MODEL 4:

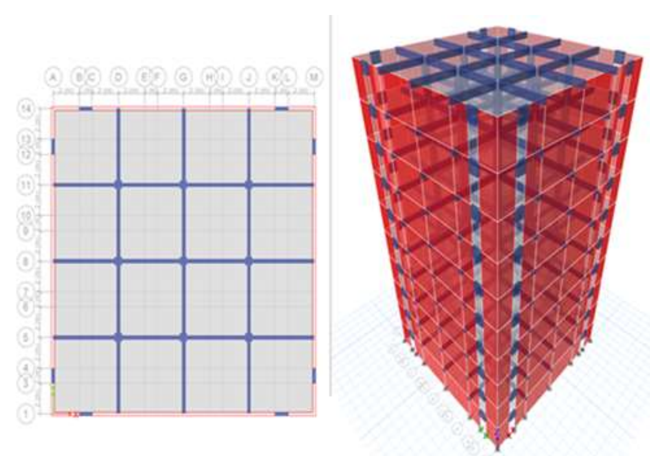


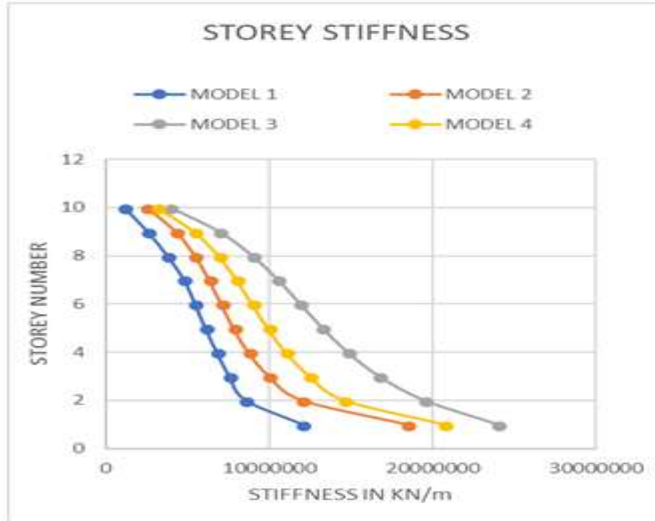
Fig.6) Building with Coupled Shear.

Results:

Table 2. Storey Displacement					
Story level	Elevation	Model			
		1	2	3	4
	m	mm	mm	mm	mm
10	35	19.3	14.1	11.8	12.8
9	31.5	17.7	13.6	10.8	12.2
8	28	15.9	12.9	9.7	11.2
7	24.5	13.9	11.8	8.5	10.1
6	21	11.8	10.5	7.3	9.2
5	17.5	9.5	9	5.9	7.7
4	14	7.3	7.3	4.6	5.9
3	10.5	5	5.4	3.3	4.1
2	7	3	3.3	2	2.5
1	3.5	1.2	1.3	0.9	1
Base	0	0	0	0	0

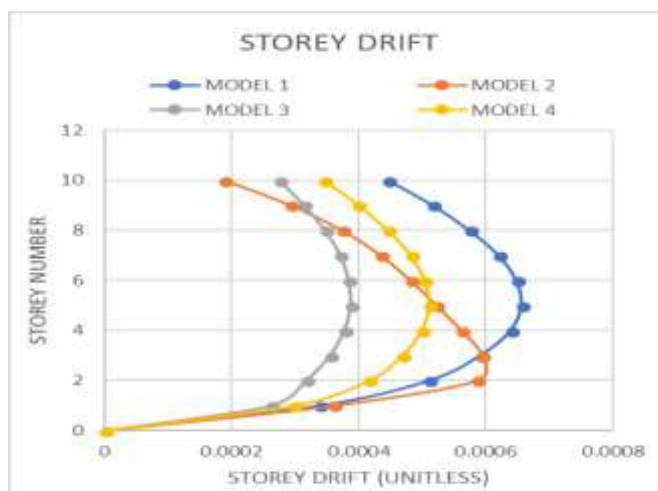
Table 3. Storey Stiffness					
Story level	Elevation	Model			
		1	2	3	4
	m	KN/m	KN/m	KN/m	KN/m
10	35	1100476.117	2469322.511	3901018.736	3119964.228
9	31.5	2523444.867	4249893.465	6889915.987	5387358.984
8	28	3731298.672	5430904.663	8932652.681	6887623.155
7	24.5	4753429.929	6296329.174	10499094	8000157.385
6	21	5435454.474	7036291.848	11867378	8952715.608
5	17.5	6054722.135	7793018.217	13234057	9909075.615
4	14	6757577.954	8699907.026	14772138	11012381
3	10.5	7524102.654	9975547.163	16696907	12470870
2	7	8533218.397	12003234	19462010	14596658
1	3.5	12003234	18412217	23959047	20671549
Base	0	0	0	0	0

Graph 1) Storey Displacement



Graph 2) Storey Stiffness

Table 4. Storey Drift					
Story level	Elevation	Model			
		1	2	3	4
	m				
10	35	0.000446	0.000188	0.000275	0.000345
9	31.5	0.000516	0.000292	0.000314	0.000399
8	28	0.000574	0.000373	0.000347	0.000445
7	24.5	0.00062	0.000434	0.000371	0.000481
6	21	0.000648	0.000481	0.000384	0.000503
5	17.5	0.000656	0.000522	0.000387	0.00051
4	14	0.000639	0.000561	0.000377	0.000499
3	10.5	0.000591	0.000594	0.000355	0.000468
2	7	0.00051	0.000586	0.000317	0.000416
1	3.5	0.000338	0.000361	0.000262	0.000299
Base	0	0	0	0	0



Graph 3) Storey Drift

Conclusions:

Coupling beams are designed to take deformations as well as capable of taking shear capacity.

1. The displacement is least for the 3rd and 4th model compared to other to models.

2. Storey stiffness is more for the 3rd and 4th model compared to other two models.

3. Storey drift for the 1st model is highest and least for 3rd model.

From the above graphical comparisons, it is concluded that model with coupled shear wall performance is same as shear wall provided all side and better performance than other two models. So, coupled shear with coupling beams is the potential option in high-rise building when there opening is provided between two shear walls in multistory buildings.

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