Seismic Analysis of Multistorey Building With Coupled Shear Wall Using Etabs Software

Akhila Prasad, Aparna K A, Ashni Thomson, Nikha Santhosh

Abstract— Coupled shear wall are one of the systems commonly used to resist lateral forces in medium to high rise buildings located in seismically active regions. In this paper, four models with coupled shear wall placed at different location were considered for the analysis. These models have modeled in Etabs vs 2018 software according to IS codes and time history analysis were conducted. Storey displacement, storey stiffness, storey drift and quantity of concrete is studied for all models.

Keywords— Coupled shear wall, Coupling beam, Etabs software, Lateral forces, Storey displacement, Storey drift, Storey shear, Storey stiffness

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1 INTRODUCTION

This paper study the seismic performance of multistorey building with coupled shear wall (CSW) placed at different locations. Coupled shear wall is a type of shear wall that are constructed to resist the lateral forces acting on a building such as wind, earthquake etc. Coupled shear wall is two or more shear wall are interconnected by a system of beam or slab. This beam is called coupling beam. It transfers vertical forces between adjacent walls which creates coupling action that resist a portion of total overturning moment induced by the seismic action.

For these reasons, coupled shear walls must have high strength, high ductility, high energy capacity and high shear stiffness to limit lateral deformations. Coupled shear wall provide large lateral stiffness and strength due to coupling effect and also coupling beams provide an ideal energy dissipiation mechanism. The structural behavior of components including coupling beams and shear wall affects the lateral behavior of system.

2 METHODOLOGY

G+9 building modeled using Etabs software vs 2018 with and without coupled shear wall provided at different locations. Four models are modeled and time history analysis is conducted by using El-centro earthquake data. Parameters such as maximum storey displacement, maximum storey drift, storey stiffness and material quantity were studied. Coupled shear walls are provided at centre of the periphery bay (Model 1), CSW provided in the alternate bays (Model 2), CSW provided at corners (Model 3) and CSW provided throughout the periphery wall except corner (Model 4) are the models used for this study.

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3 BUILDING CONFIGURATION

The following shows the building configuration of all buildings,

Height of the building = 30m
Number of stories = 10
Thickness of slab = 140mm
Beam dimension = 350mm x 350mm
Column dimension = 450mm x 450mm
Grade of steel = Fe500
Grade of concrete = M30

3.1 Determination of optimum opening size

In order to analyse the seismic performance of multistory building with CSW optimum opening size is used and the coupled shear wall placed in different location [1]

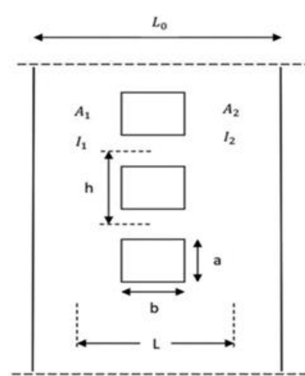


Fig. 1 Coupled shear wall parameter

Based on Fig.1, each wall area has been shown by A1 and A2 and their momet of inertia by I1 and I2. Also, each storey height has been demonstrated by h, the whole wall height by H, the opening height by a, the opening length by b and n is the number of stories. Furthermore, by adding the area factor in the equation, a non-dimensional parameter, U, was used as opening area percent. R and S which respectively represent the wall dimenions and opening dimesions, have been defined as shown in equations equation 1, equation 2, equation 3

$$U=\frac{ab}{hl_o}=\frac{nab}{HL_o} \quad (1)$$

$$R=\frac{H}{L_o} \quad (2)$$

$$S=\frac{b}{L_o} \quad (3)$$

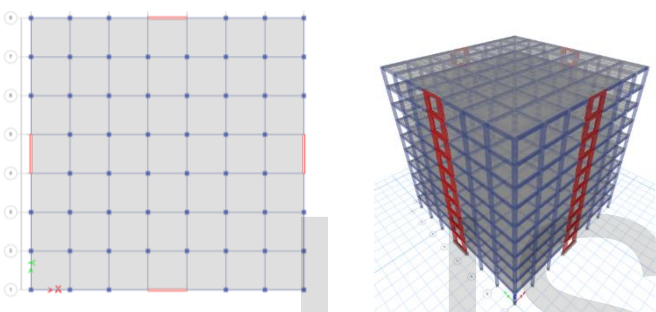
Using the above equations size of opening of CSW is calculated as 1.8mx2m

4 MODELING

Here a 10-storey symmetric plan building is modeled using Etabs software vs 2018 with 7 bays 4m each in both X and Y direction.

4.1 Model 1

Here coupled shear wall is provided at the center of the periphery wall. Plan and 3D model is shown below.



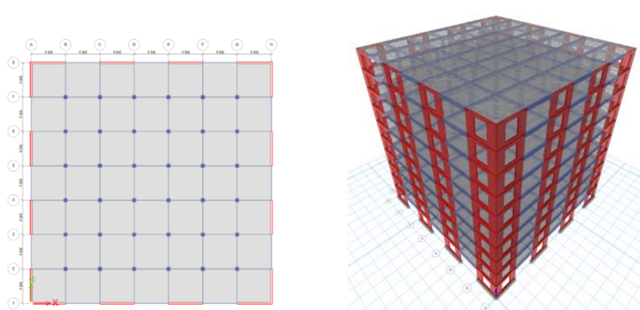
(a) (b)

Fig. 2 (a) Plan and (b) 3D model of CSW placed at center

7 bays are provided in both X and Y direction. CSW is provided at the central bay.

4.2 Model 2

In this model CSW provided alternately throughout the periphery wall. Fig. 3.a and Fig.3.b, shows the plan and 3D model of model 2.



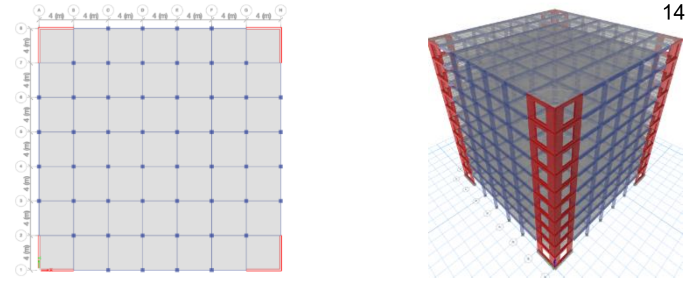
(a) (b)

Fig. 3 (a) Plan and (b) 3D model of CSW provided alternately

Here CSW provided alternately including the corner. Distance between each bay is 4m.

4.3 Model 3

Here CSW are located at the corner of the building.



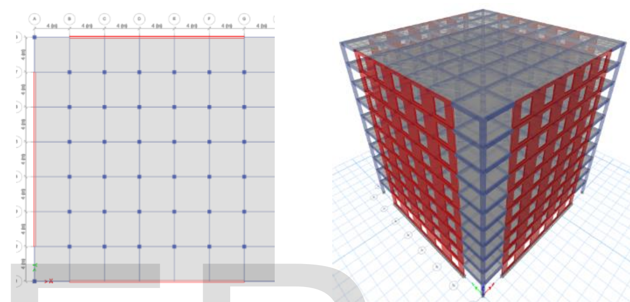
(a) (b)

Fig.4 (a) Plan and (b) 3D model of CSW placed at corner

Fig.4 a shows plan and Fig.4 b shows 3D model.

4.4 Model 4

In this model CSW provided throughout the periphery of the building except corners



(a) (b)

Fig.5 (a) Plan and (b) 3D model of CSW except corner

Figure above shows the plan, and 3D model of the building.

5 ANALYSIS

Time history analysis is an important technique for seismic analysis especially when the evaluated structural response is non linear. To perform such an analysis, a representative earthquake time history is required for a structure being evaluated. Time history analysis is a step-by-step analysis of the dynamic response of a structure to a specified loading that may vary with time.

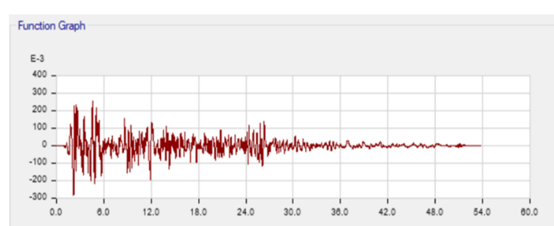


Fig. 6 Time history function graph

Time history analysis is used to determine the seismic response of a structure under dynamic loading of representative earthquake. For the analysis El Centro earthquake is used as representative earthquake. It had a moment magnitude of 6.9 and a maximum perceived intensity of X (extreme). It was the strongest recorded earthquake to hit the Imperial Valley

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and caused widespread damage to the irrigation system and led to the death of nine people. The fig.2 shows the time history function graph

5.1 Parameters studied

- Maximum storey displacement

  It is total displacement of its storey with respect to the ground and there is maximum permissible limit prescribed in IS code for buildings.
- Maximum storey drift

  It is defined as the ratio of displacement of two consecutive floors to height of that floor. It is very important term used for the research purpose in earthquake engineering.
- Storey stiffness

  Storey stiffness is estimated as thelateral force producing unit translational lateral deformation in that storey, with the bottom of storey restrained from moving laterally.
- Material quantity

  Material quantity helps to get an idea about costing and plan accordingly to complete the project efficiently. The project becomes uneconomical when the quantity of material increases.

6 ANALYSIS RESULTS

6.1 Storey displacement

The graph below shows the storey displacement graph. Displacement obtained for four models are shown in this graph.

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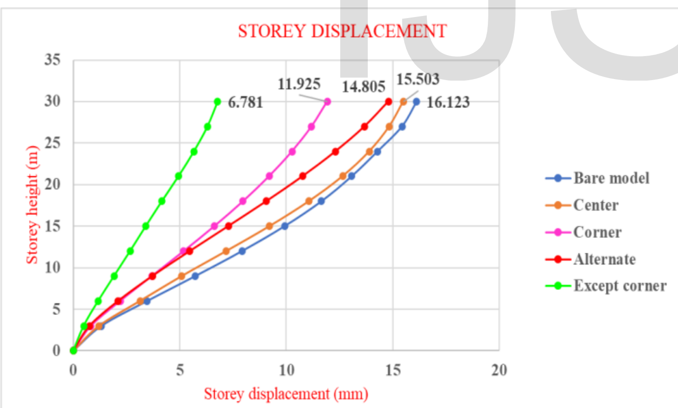

Fig. 7 Storey displacement graph

It is clear that displacement decreases with the increase in height. Minimum displacement is obtained for model with CSW provided except corner.

6.2 Storey drift

The Fig 8 shows the storey drift graph. Storey drift obtained for four models with CSW provided at different location is shown in this graph.

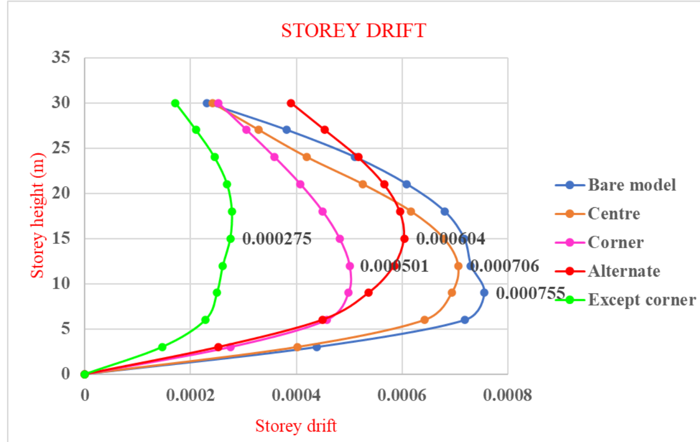

Fig. 8 Storey drift graph

Minimum value for storey drift is obtained for the model with CSW provided except corner.

6.3 Storey stiffness

The graph below shows the storey stiffness graph. Storey stiffness is plotted along X direction and stoey height plotted along Y direction.

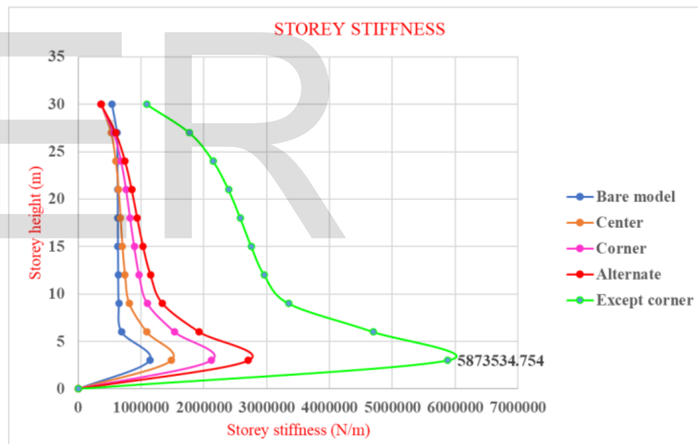

Fig. 9 Storey stiffness graph

Storey stiffness increased when CSW provided. Maximum storey drift is obtained for the model with CSW provided except corner.

7.CONCLUSIONS

CSW location has significant effect on behavior of structure. The parametres such as storey displacement, storey drift. Storey stiffness is varied according to locations of CSW. Loading was done according to standard specification of various codes to the possible extend. As height increases displacement increases and minimum storey displacement is obtained for the model 4 where CSW provided throughout the periphery wall except corner and storey displacement is 57.94 % lesser than that of bare model.

TABLE 1
SUMMARY OF RESULT OF ALL MODELS

MODEL	STOREY DISPLACEMENT	STOREY DRIFT	STOREY SHEAR	STOREY STIFFNESS	MATERIAL QUANTITY
BARE MODEL	14.52 mm	0.00068	1234.79 k N	1139.373 kN/m	5027.72
CSW CENTRE	13.59 mm	0.00063	2046.45 k N	1909.767 kN/m	5197.157
CSW CORNER	13.57 mm	0.00055	2066.42 kN	2754.450 kN/m	5366.59
CSW ALTERNATE	7.98 mm	0.00033	1928.43 kN	4227.782 kN/m	5702.01
CSW EXCEPT CORNER	4.33 mm	0.00021	3219.66 kN	6938.156 kN/m	5868.00

In model 4, Storey drift get reduced by 63.17% compared to bare model and quantity of concrete required for CSW4 model is 5.50% greater than that of bare model. The summary of result is shown in table 1 given below

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