Optimum Location of Lift Core Walls in RC Framed Buildings under Different Seismic Zones

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Abstract- *The shear walls are the walls in the building which resist the lateral loads develop from the wind or earthquake. The large portion of the lateral load acting on a building and the horizontal shear force resulting from the load are often allowed to structural elements made of RCC. The shear walls are added singly to resist the horizontal forces. The concrete walls enclosing staircase, elevated shafts, and utility cores will serve as the shear walls. The shear walls have large in plane stiffness and due to the large in plane stiffness they resist the lateral load acting on the building. The shear walls are very efficient in the deflection control. The shear walls help in the formations of the plastic hinges in the entire structure preceding to failure. The shear walls are used in the high raised buildings in order to control the inter-storey drift caused by the lateral loads. The shear walls are not provided with large openings and such type of shear walls are called as coupled shear walls. The shear walls which are well designed provide safety to the structural and non structural damage during the earthquake. The location of shear walls at exterior perimeter of the building will increase the strength of the building to resist the seismic forces. The shear walls are defined as the vertical plate reinforced concrete walls. The shear walls are the structural elements which resist the horizontal forces parallel to the plane of wall. The shear walls are provided to control the displacement due to horizontal lateral loads. The lateral loads caused due to the earthquake, wind force, and due to the uneven settlement loads causes the twisting of building which causes change in the shape of the frame and rotation at the joints. The provision of shear walls reduces the tear of building and prevents the rotation at the joints. The shear walls are the good means of providing the resistance to the earthquake and the total collapse of the building is prevented. The shear walls are very easy to construct and in cost controllable. The special ductile detailing should be provided for the shear wall provision in the high raised buildings. The shear walls carry lateral load downwards to the foundation. The shear walls are provided with the thickness of 150mm. The thickness of 400mm is provided in case of high raised buildings. The shear walls are commonly used in the construction of residential buildings in which 100 to 500 people can live per building.*

Keywords- Lift core wall, Linear Static method, Linear Dynamic method.

I. NEED OF CONSTRUCTION OF SHEAR WALLS

The shear walls gives the three dimensional stability to the building systems. The shear walls are provided in the structural spectrum to provide resistance to the gravity loads and the lateral loads due to earthquakes. The shear walls are structurally unified with the roof or diaphragm and with the transversely laterally running walls at right angles. The structural system with shear wall is more stable. The shear walls support the total plan area of the building very largely when compared to the RCC framed structures.

The shear walls are provided to resist the push the wall in and pull of the wall away due to the lateral force caused due to wind. The shear wall provided should resist the lift up forces caused due to the wind pull. The shear walls are provided to resist the shear force pushing the wall over.

1.1 PURPOSE OF PROVISION OF SHEAR WALL

The shear walls are provided in the structural system to give the sufficient lateral strength to resist the lateral earthquake forces. When the strength of the shear wall is more they transfer the lateral load to the next element in the load path below them. The shear wall transfer the load to the components such as slabs, floors, foundation walls or other shear walls so that the structural system will be safe against twisting and displacement. The provisions of shear wall make the structural system stiffer and prevent the floor above from the excessive sideways. The shear wall cause less damage to the non structural elements. The movement of the floor and the roof frame from their supports is prevented by the implantation of the shear wall in suitable location of the building.

1.2 PERFORMANCE OF SHEAR WALL

In the high rise building the shear wall behave as the vertical cantilever beams and the strength of the shear wall is controlled by flexure rather than the shear. The shear walls with low height-to-length ratios, may fail in shear just as deep beams. Confinement is obtained by running the other walls at right angles to the shear walls. Depending on the point of contra flexure along the wall height and proportions of the wall the shear wall behave as low shear wall when the portion of shear wall interacts with the frames.

The ductility in the shear wall is increased due to the additional compression flanges. The shear wall sections are thin. The reversed cyclic yielding is danger and causes section instability. The boundary elements resist the lateral loads due to seismic forces. In high raise structures the shear capacity is sufficiently provided hence the shear failure will not precise a flexural failure. The behavior of shear wall depends on the particular mode of failure. The failure of shear wall is as in the case of beams influenced by the proportions and support conditions.

II. RESPONSE SPECTRA GENERATION

The factors like earthquake mechanism, local site conditions, and the medium through which the seismic waves propagate. The earthquake causes the ground vibrations and lead to the damage of the structures. The ground vibrations cause damage to the human life and lead to the loss of property. The low encumbrance of the soft soil layer's near the earth's surface leads to the increase in the amplitude of the seismic waves. This phenomenon is called as the site amplification process. The factors such as type of the bed rock, depth of the bed rock, and the thickness and property of soil layer above the bed rock influence the magnitude of the amplitude of the seismic waves. The above factors have to be considered in the determination of the ground vibrations due to earthquake at the site.

The steady state response of series of oscillators having different natural frequency is forced into motion by means of providing same vibration at the base. Response spectrum is the plot of the steady state response of the oscillators that are forced into the motion by the means of providing shock at the base. The linear system with the given natural frequency of oscillation gives the response of the linear system from the response spectrum plot. The response spectrum plot is used to determine the response of the structural system to the earthquake. The ground response spectrums values are used by the strong ground motion to counterpart the seismic damages.

The steady state values can be recorded by using the steady state periodic input for the calculation of the response spectrum. The damping must be present to get the response values. If the damping is not provided the response obtained will be infinite. The damping should be taken for the certain level. The response results are obtained without damping. The response spectra values will be accurate only for the low level of damping. For multi degree of freedom systems the response for the linear system is determined by using the response spectra values. The modal analysis results show the different modes of the building. The response at particular mode is determined by response spectrum results. The total response of the structure is determined by the combination of the peak response results. The term SRSS is a square root of the sum of the squares and it is the characteristic combination method which is used when the modal frequencies are not close. The results obtained will be different because the particular information is lost in the generation of response spectrum. The results will be different compared to the results obtained from the direct input method. The major disadvantage of the response spectrum is they are globally applicable in the case of linear system. The efforts have been made to develop the seismic design spectra for the non linear systems with the extensive wider applications. The response spectra can be generated for non linear systems only when the system is having same non-linearity. The results of the non linear system with the same non-linearity cannot be directly combined for the different mode responses.

III. DETAILS OF THE MODELS

I have considered regular building, irregular symmetric building in x and y direction, irregular asymmetric building in x and y direction and irregular building asymmetric in x direction. The modeling and analysis is done by the ETABS 2015 software by considering the zone II, zone III, and zone V for all buildings with 20 storeys having 5 bays in x and y direction. The height of each floor is 3m and the type of shear wall used in the modeling is box type which is closed at three faces. The type of building selected is office and business buildings with a live load of 4kN/m2 and 2kN/m2 on floor and roof. The beam size of 230 x 500mm and column size of 300 x 900mm with a slab thickness of 150mm is considered for the modeling. The grade of concrete used is M35 for the beam, column, slab and shear wall. The spacing of bays in x and y direction is 4m for all models considered. The shear wall is placed at centre, diagonal corner, four corner, and middle edge and at four edges for the particular type of building. The modeling involves defining of beam, column, slab, shear wall and load patterns and assigning them. The models are performed to run analysis to obtain maximum storey displacement and maximum inter storey drift

IV. LINEAR STATIC METHOD

The linear static method is the simplest method of finding the design lateral forces. The calculation is done according to the formula given in the code of practice and calculations are less. Linear static method is also known as equivalent static method or seismic coefficient method. In this method the design base shear is calculated for the entire building system. The obtained base shear is distributed along the height of the building. For the individual lateral load resisting elements the lateral force obtained for each floor are distributed. In the building the total shear in any horizontal plane is distributed to the various vertical elements of the lateral force resisting system, when the floors in the horizontal plane are assumed to be infinitely rigid. When the floor in the building system cannot be treated as infinitely rigid in their own planes the lateral shear force at each floor is distributed to the vertical elements resisting the lateral force and this results in the in- plane flexibility of the diaphragms.

V. LINEAR DYNAMIC METHOD

This method gives the peak response can be obtained for the design of the structure. The dynamic analysis for the structural system can be done by time history method or response spectrum method. This method gives the peak response of the structure during earthquake directly from the earthquake response spectrum. The different modes of response of the structure to the earthquake are considered. The total response of the system can be computed by the modal combination methods. Depending on the modal mass and modal frequency the response for the each mode can be obtained from the design spectrum. The design lateral force at each floor can be computed by using the modal mass method. Modal analysis method is the alternative method to the equivalent lateral procedure. The dynamic analysis for the tall and irregular buildings cannot be applied according to the code IS 1893 (Part 1): 2002. The dynamic analysis of the steel and RCC buildings is performed by using 2% and 5% damping value for the buildings. The dynamic analysis is not necessary for the buildings in zone II and zone III with less than 40m height.

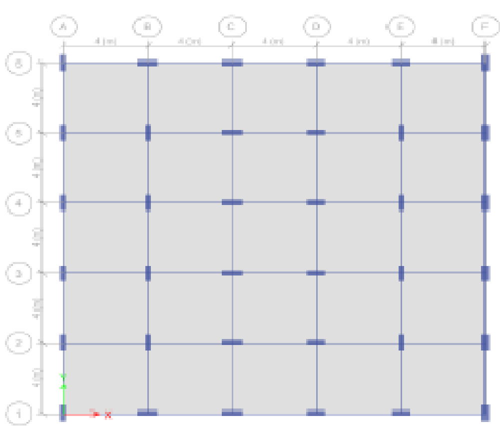

Fig 5.1 2D view of Regular building

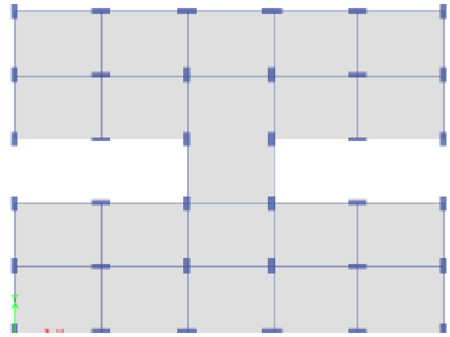

Fig 5.2 2D view of Irregular symmetric building

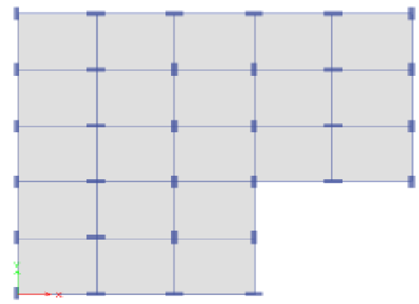

Fig 5.3 2D view of Irregular asymmetric building

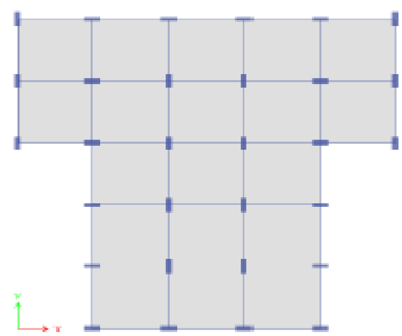

Fig 5.4 2D view of Irregular asymmetric building in x direction

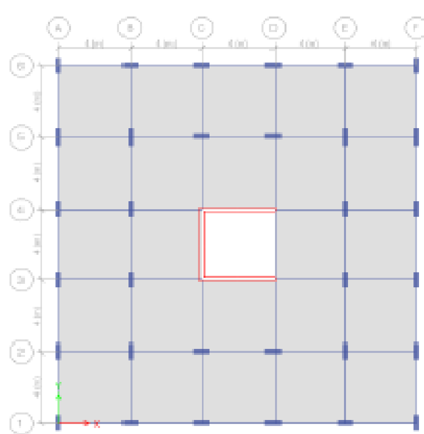

Fig 5.5 Regular building with centre shear wall

VI. RESULTS AND DISCUSSIONS

The modeling is done by ETABS by considering the regular building, irregular building symmetric in both direction, irregular building asymmetric in both direction and irregular building asymmetric in x direction. The analysis of the building is done by the linear static method and linear dynamic method by the software ETABS 2015. The results are taken for the maximum storey displacement and maximum inter storey drift. Two types of comparison are done namely TYPE A and TYPE B. The graphs obtained for maximum storey displacement and maximum inter storey drift are merged. Maximum storey displacement and Maximum storey drift are considered as parameters for results and discussions. Graphs are plotted from the result obtained from E – TABS 2015. These graphs are merged according to their Zones are related according to the models prepared.

6.1. TYPES OF COMPARISONS

1 TYPE A: I have done 24 set of comparison by considering the regular and irregular buildings for the zone II, zone III and zone V. The comparison is done for the maximum storey displacement and maximum inter storey drift obtained for linear static and linear dynamic method for the zone II, zone III, and zone V. The graphs obtained for the maximum storey displacement and maximum inter storey drift for the linear static method and linear dynamic method are merged for the three zones considered of regular and irregular building with bare frames and with different location of shear wall for their corresponding methods.

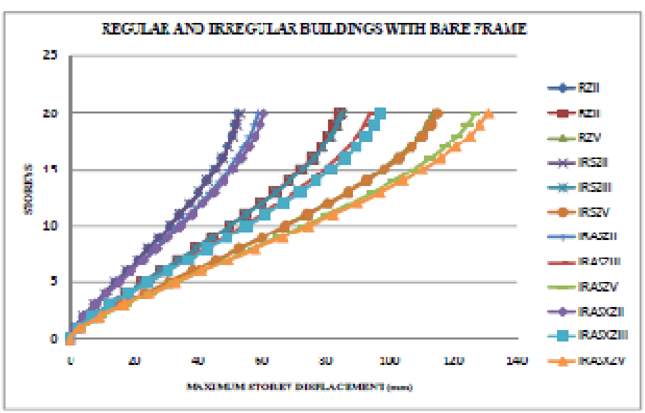

Fig 6.1 Regular and irregular buildings with bare frame (Displacement, LSM)

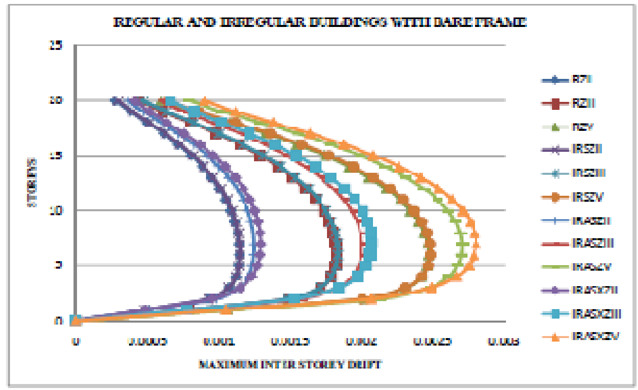

Fig 6.2 Regular and irregular buildings with bare frame (Drift, LSM)

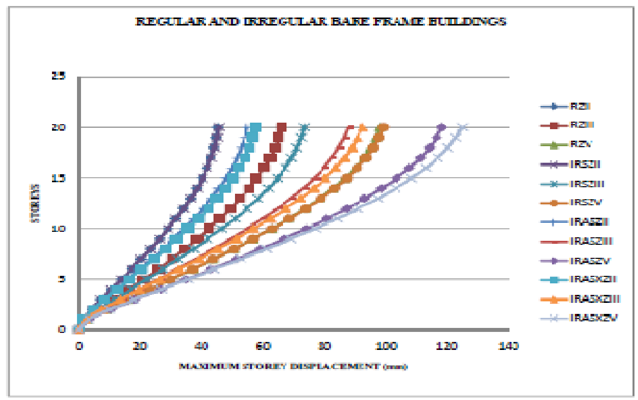

Fig 6.3 Regular and irregular buildings with bare frame (Displacement, LDM)

TYPE B: In TYPE B the comparisons is done for the regular and irregular buildings with different shear wall location for linear static method and linear dynamic method by considering the parameters such as storey displacement and inter storey drift. The models are compared for the zone II, zone III and zone V by static and dynamic method respectively. I have considered one regular and three irregular models and the comparison is done for all four bare frame models and all four models with different shear wall location for each zone by linear static method and by linear dynamic method.

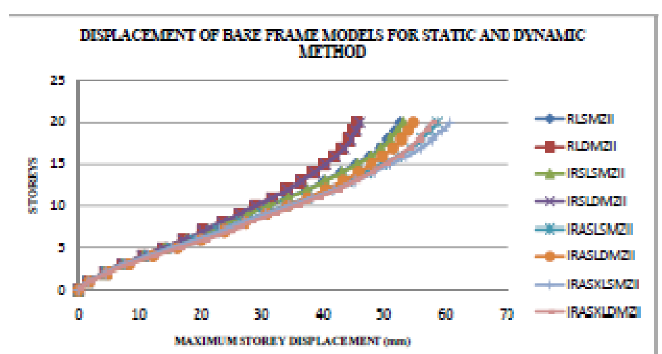

Fig 6.4 Regular and irregular models with bare frame by LSM and LDM (Displacement, Z II)

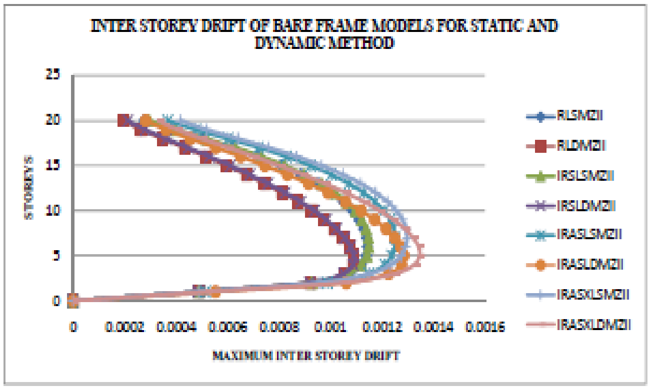

Fig 6.5 Regular and irregular models with bare frame by LSM and LDM (Drift, Z II)

VII. CONCLUSIONS

1) In regular and irregular buildings with bare frame by linear static method it can be observed that the behavior of regular and irregular symmetric are same with almost similar stiffness and their performance is good compared to the irregular asymmetric buildings. In irregular asymmetric buildings the displacement is more which indicates low stiffness.
2) In centre shear wall buildings it can be observed that performance of irregular symmetric buildings is good in all zones considered compared to the other buildings.
   Regular and irregular asymmetric buildings show almost similar displacement and their values are higher when compared to other buildings which indicates that they have low stiffness when compared to the other buildings.
3) According to the plans considered the diagonal shear wall cannot be used in the case of irregular asymmetric building in x direction. The diagonal shear wall considered in the other buildings shows the similar behavior which indicates that they have almost same stiffness irrespective of zones considered.
4) According to the plans considered the four corner shear walls can be used in the regular and irregular symmetric building when compared to the other types of location for the shear wall considered the four corner shear wall gives less displacement for regular and irregular symmetric building which indicates maximum stiffness for the buildings considered.
5) In the middle edge shear wall irregular symmetric building shows less displacement when compared to the other type of buildings. The middle edge location of shear wall is good for all types of shear wall considered.
6) According to the plans considered four edge shear wall is applicable only for the irregular asymmetric building in x direction. For all types of location of shear wall considered this location is very good for the irregular asymmetric building in x direction.
7) For the graphs plotted for the drift we can observe similar conclusion as made for the displacement.
8) Linear dynamic method is the accurate method compared to the linear static method because linear static method has the factor of safety in it hence the values obtained is more in this method. The graphs obtained for both displacement and drift has less deflection in linear dynamic method when compared to linear static method. The linear dynamic method is carried out to find the accurate values of the parameters like inter-storey drift, displacement, storey shear and overturning moment.
9) It is better to use the lift core wall at the four corners in regular and irregular symmetric building which increases the seismic resistance capacity of the building and reduces the drift and displacement of the building.
10) In irregular asymmetric building provision of lift core wall at middle edge reduces the displacement and drift with increase in the seismic resistance of the building. In irregular asymmetric building provision of lift core wall at the outer periphery of the building reduces the displacement of the building.
11) The use of bare frame building scale factor values in the buildings with different location of shear walls for the zones considered gives lesser displacement and drift.

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