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Study of Seismic Behaviour of Staggered Opening Shear Wall in Multistorey Building

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Abstract – *Now a day, the population is increasing day by day and is biggest problem in India, also at the same time land problem is also increasing so to minimize this, there is need of vertical development instead of horizontal development. And therefore there is a demand of vertical structures rather than horizontal structures. As the height of structures increases vertical structures are subjected to lateral loads as well as seismic loads also. Structural frame only are not sufficient to resist against various loading act on the building. In RC building, Shear wall is the effective solution over this which improves structural behavior in multi-storied buildings. Shear wall may be provided with and without openings but staggered opening shear wall reduces dead weight and improves the seismic behavior of buildings. Shear wall also gives ductile failure. In this study the seismic behavior of the R.C. building with conventional opening shear wall and staggered opening shear wall is analyzed by Static and dynamic analysis of the shear wall and the resultant parameters like displacement, time period, stiffness etc. are compared by using structural software ETABS.*

Key Words: Displacement, Lateral Loads, Opening, R.C. Building, Shear Wall,

1. INTRODUCTION

The use of shear wall structure has gained popularity in high rise building structure, especially in the construction of office/ commercial tower. R.C.multistoried building with shear wall is most common method to satisfy the population needs and for safety of the structure under any loading conditions as well as earthquake .Shear wall may be defined as structural elements, which provide strength, stiffness and stability against lateral loads gaining strength and stiffness. Shear walls can effectively resist horizontal forces. Behavior of such type of R.C. building with provision of shear wall is different than the common R.C. structures. So it is necessary to analyses the structure with provision of shear wall. Shear walls are one of the most efficient lateral force resisting elements in multi-storied buildings. Many modern constructions use shear wall as main source for lateral force resistance and can also be used for seismic rehabilitation of existing buildings. Shear walls are one of the most efficient lateral force resisting elements in multi-storied buildings. Many modern constructions use shear wall as main source for lateral force resistance and can also be used for seismic rehabilitation of existing buildings.

The high structures are monuments of power and prestige, superior to all others achievements in engineering construction, design and analysis. But Major hazards caused by seismic loads, winds in recent years have created awareness among structural engineers and construction professionals to design these high rise structures for these lateral forces. In building construction, a rigid vertical member capable of transferring lateral forces from exterior walls, floors, and roofs to the ground foundation in a direction parallel to their planes, is the reinforced-concrete wall. Lateral forces caused by wind, earthquake, and uneven settlement loads, in addition to the weight of structure and occupants; create powerful torsional forces, These forces can literally tear or shear a building apart. Providing a rigid wall inside frame system structure increases the stiffness of the frame and prevents rotation at the joints. Shear walls are especially important in high-rise buildings subject to lateral forces. Shear walls generally start at the foundation level and are continuous throughout the building height. They are generally provided along both length and width of the building and are located at the sides of the buildings or arranged in the form of core. Shear walls may have one or more openings for functional reasons. The size and location of shear walls is extremely critical. They must be symmetrically located in plan to reduce the effect of twisting in buildings. Properly designed and detailed buildings with shear walls have shown good performance in past earthquakes. The behavior of shear walls depends on many factors some of them are, Reinforcement detailing, Aspect ratio, Material properties, Presence of openings for door and windows.

The advantages of provision of shear wall in R.C. frame structures are,

1) Resist lateral forces in its own plane.

2) Shear wall are quite stiff in its own plane and flexible in the perpendicular plane.
3) It can transfer force in its own plane by developing movement and shear resistance.
3) Shear walls increase the stiffness of the building so that horizontal deflections due to earthquake forces are minimized.
4) Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation.

2. PROBLEM DEFINTION

The main objective of this study is to study the seismic behaviour of staggered opening shear wall comparing with conventional opening shear wall in a high rise structures under lateral load due to earthquake. The performance and response of building with conventional and staggered opening l are carried out. Dynamic analysis is carried by using response spectrum method. Modelling and analysis is done by using the finite element models in ETABS software package. RC Frame of G+ 22 stories has been taken for analysis The following points are studied in this work.

1. Time period
2. Base shear
3. Displacement
4. Drift

3. MODEL SPECIFICATION

A G+22 storeyed reinforced concrete building with conventional and staggered opening shear wall in Seismic Zone-II as per [IS: 1893, 2002] has been considered for the present work. Shear wall locations are taken at periphery and centre.

Fig 01: Shows the Plan of the Building

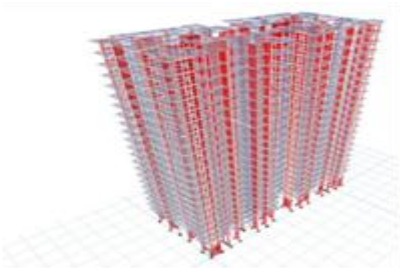


Fig 03: Shows the Conventional Opening at Periphery

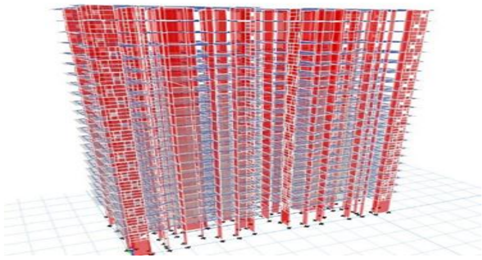


Fig 02: Shows the Staggered Opening at center

Preliminary Data Considered for the Analysis:

- Area covering = 27.2m x 57 m.
  (As shown in fig 01)
- Total Height of the building = 63.8 m
- Floor to Floor Height = 2.9m

Shear wall details

- Building with Conventional shear wall =450 mm thick
- Building with Staggered shear wall at corners =450 mm thick
- Building with Staggered shear wall at center =450 mm thick

Beam details

- Building with Conventional shear wall =230x450
- Building with Staggered shear wall at corners =230x450
- Building with Staggered shear wall at center =230x450

4. FOLLOWING ARE CODES CONSIDERED FOR THE ANALYSIS:

- R.C.C. design : IS 456: 2000
- Earthquake design : IS1893: 2016
- Code for Dead load : IS875: Part 1
- Code for Live load : IS875: Part 2

- ZONE :II(AURANGABAD)
- ZONE FACTORE :0.16
- IMPORTANCE FACTOR : 1.5
- TIME PERIOD IN STATIC X :1.21
- TIME PERIOD IN STATIC Y :0.83

5. RESULTS

Table1. Time Period for conventional Opening at Periphery and Centre

SR.NO	MODE	Conventional opening at periphery	Conventional opening at center
1.	MODE 01	3.27	3.28
2.	MODE 02	2.75	2.76
3	MODE 03	2.15	2.16

The model time period indicates that the Conventional opening is less in all three modes as compared with conventional opening at center

Table2. Time Period for Staggered Opening at Periphery and Centre

SR.NO	MODE	Staggered opening at periphery	Staggered opening at center
1.	MODE 01	3.51	3.28
2.	MODE 02	3.27	2.76
3	MODE 03	2.75	2.15

The model time period indicates that the staggered opening is less in mode 1& 3 but less in mode 2

Table3. Base shear (conventional opening at periphery and center)

	Conventionl opening shear wall at peripheri	FIG NO	Convensional opening shear wall at centre	FIg NO
BASE SHEARFOR STATIC EQX	13350 KN	01	13371 KN	15
BASE SHEAR FOR STATIC EQY	12975 KN	02	12995 KN	16
BASE SHEAR FOR DYNAMIC SPECX	4866.33 KN	03	4823.68 KN	17
BASE SHEAR FOR DYNAMIC SPECY	3324.35 KN	04	3302.77 KN	18

Base Shear is more in case of conventional opening at center in static x and y direction but less in dynamic x and y direction.

Table4. Base shear (Staggered opening at periphery and center)

	Staggered opening shear wall at peripheri	FIG NO	Staggered opening shear wall at centre	FIG NO
BASE SHEARFOR STATIC EQX	13357 KN	01	13371 KN	15
BASE SHEAR FOR STATIC EQY	12982 KN	02	12995 KN	16
BASE SHEAR FOR DYNAMIC SPECX	4668.2KN	03	4836.79 KN	17
BASE SHEAR FOR DYNAMIC SPECY	3315.30 KN	04	3290.96 KN	18

Similarly Base Shear is more in case of conventional opening at center in static x and y direction but less in dynamic x and y direction.

Table -05 Displacement details (conventional opening at periphery and center)

DIRECTIONS	Convensional opening at peripheri	FIG NO	Convensional opening at centre	FIG NO
Max storey displacement for EQX	0.081 M	05	0.082M	19
Max storey displacement for EQy	0.147M	06	0.148M	20
Max storey displacement for SPEC X	0.021M	07	0.019M	21
Max storey displacement for SPEC Y	0.027M	08	0.031M	22

Displacement of static x and y in conventional opening at center is more and less in case on dynamic x while compared with conventional opening at periphery.

Table -06 Displacement details (Staggered opening at periphery and center)

DIRECTIONS	Staggered opening at peripheri	FIG NO	Staggered opening at centre	FIG NO
Max storey displacement for EQX	0.813 M	05	0.081M	19
Max storey displacement for EQy	0.147M	06	0.148M	20
Max storey displacement for SPEC X	0.019M	07	0.018M	21
Max storey displacement for SPEC Y	0.023M	08	0.031M	22

Displacement of static x and y in conventional opening at center is more and less in case on dynamic x while compared with conventional opening at periphery.

Table -07 Drift details (conventional opening at periphery and center)

DIRECTIONS	Convensional opening at peripheri	FIG NO	Convensional opening at centre	FIG NO
Max storey Drift for EQX	0.0013	11	0.0013	25
Max storey Drift for EQy	0.0024	12	0.002	26
Max storey Drift for SPEC X	0.00035	13	0.00035	27
Max storey Drift for SPEC Y	0.00051	14	0.00050	28

In case of Drift values the values are almost similar in both static and dynamic earthquake in conventional opening at periphery and center.

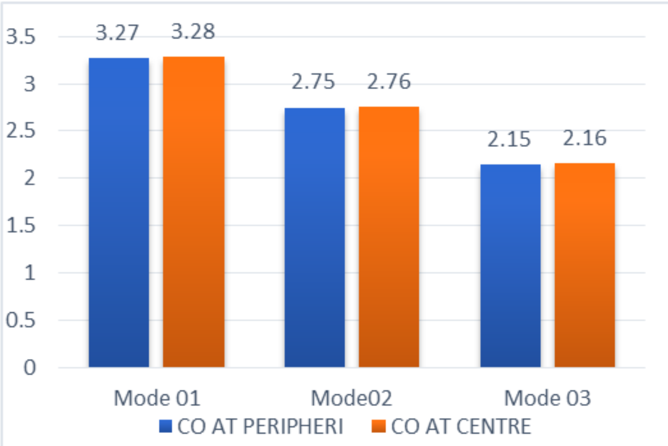
Table -08 Drift details (Staggered opening at periphery and center)

DIRECTIONS	Staggered opening at peripheri	FIG NO	Staggered opening at centre	FIG NO
Max storey Drift for EQX	0.0013	11	0.0013	25
Max storey Drift for EQy	0.0023	12	0.0024	26
Max storey Drift for SPEC X	0.00034	13	0.00035	27
Max storey Drift for SPEC Y	0.0005	14	0.0005	28

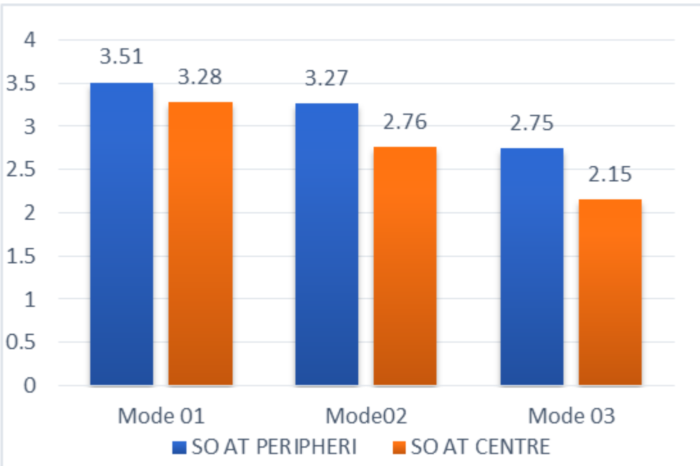
In case of Drift values the values are almost similar in both static and dynamic earthquake in staggered opening at periphery and center.

6. GRAPH:

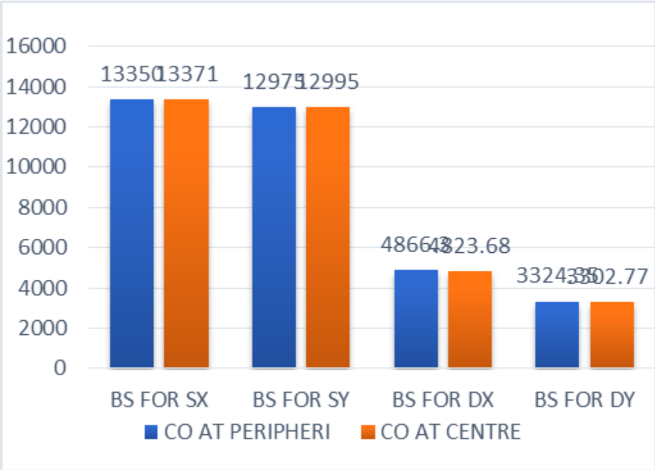
01] Time period :(Conventional opening at periphery and center)



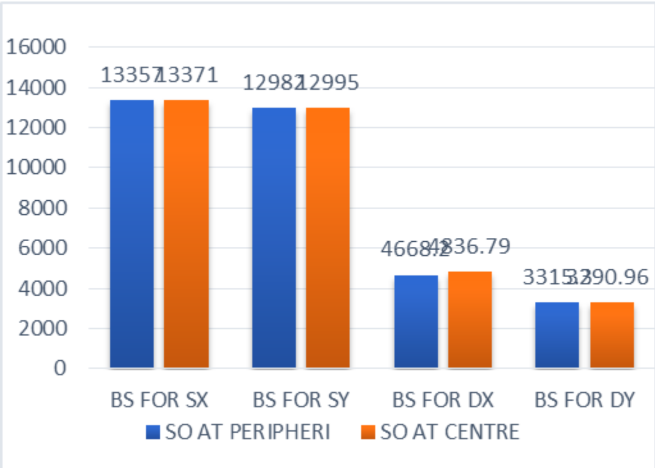
02] Time period :(Staggered opening at periphery and center)



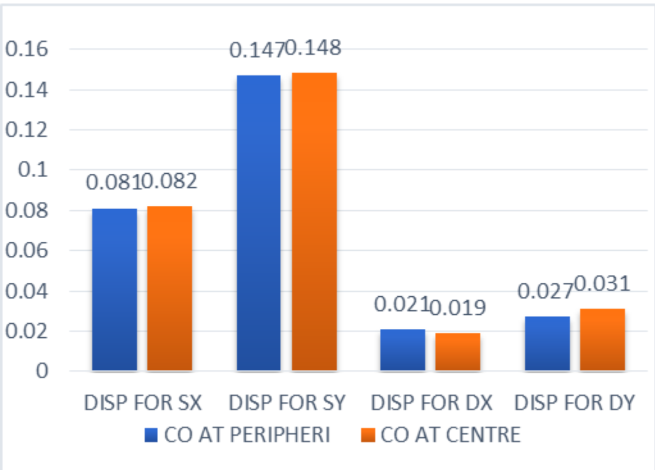
03] Base shear :(Conventional Opening at periphery and center)



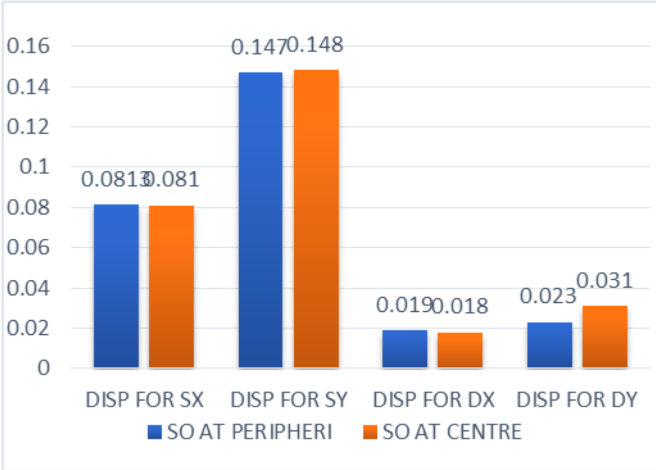
04] Base shear :(Staggered Opening at periphery and center)



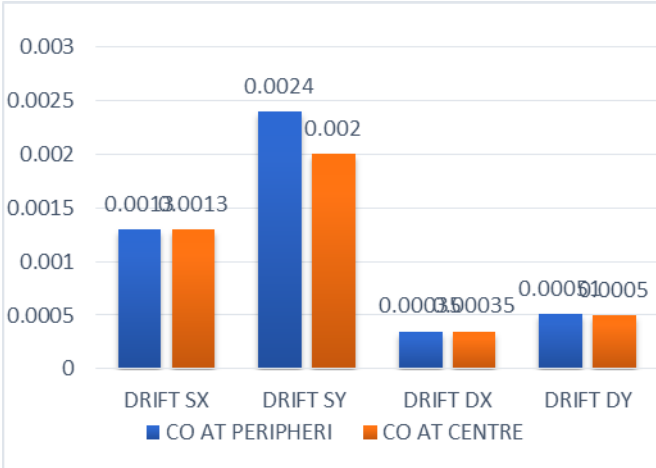
05] Displacement :(Conventional Opening at periphery and center)



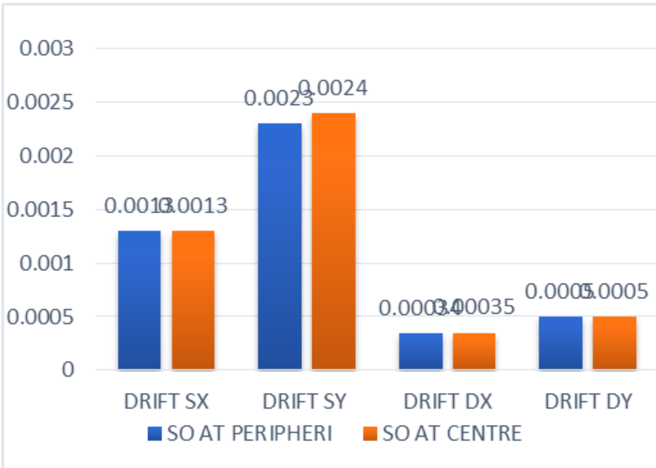
06] Displacement :(Staggered Opening at periphery and center)



07] Drift Details :(Conventional Opening at periphery and center)



08] Drift Details :(Staggered Opening at periphery and center)



7. CONCLUSIONS

Following are the conclusion we have obtained from above analysis results are:-

1. Time period
   A] In case of Time period the values where obtained is higher in conventional opening at center and less in case of conventional opening at periphery as shown in fig.
   B]] similarly In case of Time period the values where obtained is higher in Staggered opening at center and less in case of Staggered opening at periphery as shown in fig.

2. Base shear
   A] In case of Base shear the value in conventional opening at center is more in Static Earthquake x and y and less in Dynamic Earthquake x and y.
   B] In case of Base shear the value in Staggered opening at center in more in Static Earthquake x and y and less in Dynamic Earthquake x and y.

3. Displacement
   A] The displacement is more in Conventional opening at center than the conventional opening at periphery.
   B] The displacement is more in staggered opening at center than the staggered opening at periphery.

4. Drift
   A] The Drift values for both conventional and staggered opening in center as well as periphery is almost similar.

From the above conclusion it is cleared that it is better to provide opening in periphery instead of opening provided at center.

And in case of providing the opening we always have to go with staggered opening shear wall because it gives better performance against earthquake in Displacement, drift and base shear.

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