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Performance of Shear Wall Building at Various Positions by Using Pushover Analysis

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Abstract- Earthquakes are the most unpredictable and devastating of all natural disasters, which are very difficult to save over engineering properties and life, against it. Hence in order to overcome these issues we need to identify the seismic performance of the building. Shear wall is the most commonly used lateral load resisting in high rise building. Shear wall is used to resist large horizontal load and support gravity load. It is very necessary to determine effective, efficient and ideal location of shear wall.

In this paper, study of G+9 storeys building in zone V are analysed by using SAP2000 by changing various position of shear wall. Pushover analysis has been the preferred method for seismic performance evaluation due to its simplicity. The main aim of this study is that the performance of the RC building is evaluated by using various parameter and guidelines from as per IS 1893 (part-1):2000.

Index Terms- Pushover analysis, Performance point, and Different position of shear wall.

1. INTRODUCTION

Earthquakes are the most destructive and life damaging phenomenon of all the times. Earthquakes are caused due to the large release of strain energy by the movement of faults, which causes shaking of ground. About 60% of the land area of our country is susceptible to damaging levels of seismic hazard. We can't avoid future earthquakes, but safe building construction practices can certainly reduce the extent of damage and loss. To evaluate the performance of framed building under future expected earthquakes, Shear wall system is one of the most commonly used lateral load resisting system. Shear wall are usually used in tall building to avoid collapse of buildings. Shear wall may become imperative from the point of view of economy and control of lateral deflection. By providing shear wall the structure become safe and durable and also more stable the function of shear wall is to increase rigidity for wind and seismic load resistance. When shear wall are situated in advantageous positions in the building they can form an efficient lateral force resisting system.

Reinforced concrete (RC) buildings often have vertical plate-like RC walls called Shear Walls in addition to slabs, beams and columns.[4] These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150mm, or as high as 400mm in high rise buildings. The overwhelming success of buildings with shear walls in resisting strong earthquakes is summarized in the quote, "We cannot afford to build concrete buildings meant to resist severe earthquakes without shear walls." as said by Mark Fintel, a noted consulting engineer in USA. [9]

1.1 Objectives of Study

The objectives of the study are as follows:

1) To study the Optimum location of shear wall having uniform thickness throughout the building.

2) To study the Performance of the building with shear wall provided at different locations.

3) To study the effect of providing shear walls, in RC framed building, using pushover analysis.

4) Determination of performance point of buildings.

2. PUSHOVER METHODOLOGY

2.1 *Pushover Analysis*

Nonlinear static analysis, or pushover analysis, has been developed over the past twenty years and has become the preferred analysis procedure for design and seismic performance evaluation purposes as the procedure is relatively simple procedure. Pushover Analysis option will allow engineers to perform pushover analysis as per FEMA 356 and ATC-40. Pushover analysis is a static, nonlinear procedure using simplified nonlinear technique to estimate seismic structural deformations. It is an incremental static analysis used to determine the force-displacement relationship, or the capacity curve, for a structure or structural element. The analysis involves applying horizontal loads, in a prescribed pattern, to the structure incrementally, i.e. pushing the structure and plotting the total applied shear force and associated lateral displacement at each increment, until the structure or collapse condition. Pushover analysis can provide a significant insight into the weak links in seismic performance of a structure.

The performance criteria for pushover analysis are generally established as the desired state of the building given a roof-top displacement. Static Nonlinear Analysis technique, also known as sequential yield analysis, or simply "pushover" analysis has gained significant popularity during the past few years. Proper application can provide valuable insights into the expected performance of structural systems and components. Pushover analysis can be performed as either force-controlled or displacement controlled depending on the physical nature of the load and the behaviour expected from the structure. Force-controlled option is useful when the load is known (such as gravity loading) and the structure is expected to be able to support the load. Displacement controlled procedure should be used when the magnitude of the applied load is not known in advance, or where the structure can be expected to lose strength or become unstable. Many methods were presented to apply the nonlinear static pushover (NSP) to structures.

These methods can be listed as: (1) Capacity Spectrum Method (CSM) (ATC), (2) Displacement Coefficient Method (DCM) (FEMA-356), (3) Modal Pushover Analysis (MPA). [13]

2.2 Non-linear Plastic Hinge

The building has to be modeled to carry out nonlinear static pushover analysis. This requires the development of the force - deformation curve for the critical sections of beams, columns. The ATC-40 and FEMA-273 documents have developed modeling procedures, acceptance criteria and analysis procedures for pushover analysis. These documents define force-deformation criteria for hinges used in pushover analysis. As shown in Figure 1.1, five points labeled A, B, C, D, and E are used to define the force deflection behavior of the hinge and three points labeled IO, LS and CP are used to define the acceptance criteria for the hinge. (IO, LS and CP stand for Immediate Occupancy, Life Safety and Collapse Prevention respectively.) The values assigned to each of these points vary depending on the type of member as well as many other parameters defined in the ATC-40 and FEMA-273 documents.

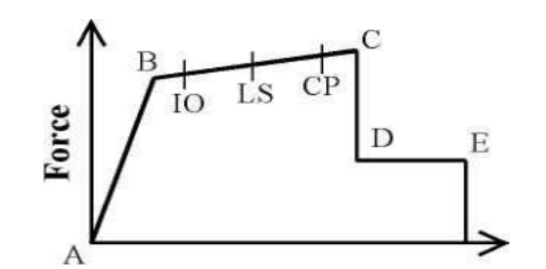

Fig.1 Force-Deformation Relationship

ii) Point B represents yielding of the element.

iii) The ordinate at C corresponds to nominal strength and abscissa at C corresponds to the deformation at which significant strength degradation begins.

iv) The drop from C to D represents the initial failure of the element and resistance to lateral loads beyond point C is usually unreliable.

v) The residual resistance from D to E allows the frame elements to sustain gravity loads.

3. CAPACITY SPECTRUM METHOD

Seismic Evaluation and Retrofit of Concrete Buildings commonly referred to as ATC-40 was developed by the Applied Technology Council (ATC) with funding from the California Safety Commission. Although the procedures recommended in this document are for concrete buildings, they are applicable to most building types.

The overall capacity of a structure depends on the strength and deformation capacities of the individual components of the structure. The building performance level can be determined by target displacement using the capacity spectrum method (ATC 40). The capacity spectrum method allows for a graphical comparison between the structure capacity and the seismic demand. The pushover curve represents the lateral resisting capacity and the response spectrum curve represents the seismic demand. Ground motion during an earthquake produces complex horizontal displacement patterns which may vary with time. Tracking this motion at every time step to determine structural design requirements is judge impractical. For a given structure and a ground motion, the displacement demands are estimate of the maximum expected response of the building during the ground motion. Demand curve is a representation of the earthquake ground motion. It is given by spectral acceleration (Sa) Vs Time period (T).[10]

The capacity spectrum method, which is given in figure 2, is started by producing force-displacement curve that consider inelastic condition. The result is then plotted to ADRS (Acceleration Displacement Response Spectrum). Demand is also converted into ADRS format so that capacity curve and demand curve are in the same format. The performance point is obtained by superimposing demand spectrum on capacity curve into spectral coordinate or ADRS format.

The capacity spectrum method has been built in SAP2000 program. According to ATC 40, the capacity spectrum method are shown in fig 2 and performance levels of buildings are as shown in Table 1[6]

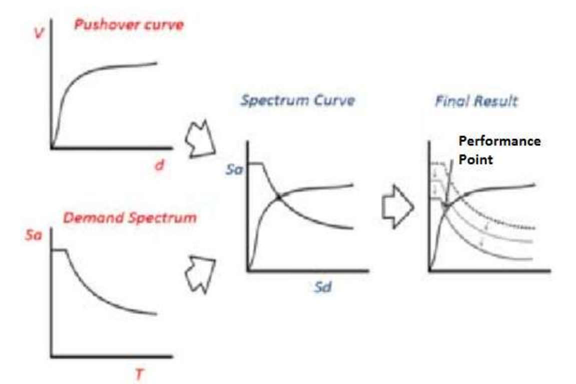

Fig. 2 Capacity Spectrum Method

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Level	Description
Operational	Very light damage, no permanent drift, structure retains original strength and stiffness, all system are normal
Immediate Occupancy	Light damage, no permanent drift, structure retains original strength and stiffness, elevator can be restarted, fire protection operable
Life Safety	Moderate damage, some permanent drift, some residual strength and stiffness left in all stories, damage to partition, building may be beyond economical repair
Collapse Prevention	Severe damage, large displacement, little residual stiffness and strength but loading bearing column and wall function, building is near collapse

Table 1 performance Levels of Building

4. DESCRIPTION OF RC BUILDING

For the analysis and Design work, Use high rise building G+ 9 stories are made to know the realistic behaviour of building during earthquake. The length of the building is 24m and width is 16m with each 3.0m floor height and also 3.0m ground floor height. The total height of building is 30m, so only static method is use to design the RC building. The building considering in the seismicity zone ‘V’. The soil is considered as medium II types. The columns are assumed to be fixed at the ground level. The section for column and beam uses 300mm 600mm and 300mm 450mm and the shear wall thickness is 300mm use. Slab thickness is 125mm, Z is 0.36, importance factor is 1 and fixed support is use. Type-II medium soil as per IS 1893 and R is % (SMRF) use. The lateral load acted on both X and Y direction. The lateral load is increase with height of building.

Table 2 Load Details of Building

S. N	Parameters	Values	S. N	Parameters	Values
1	Earthquake Load	As per IS-1893 (part-1)	4	Floor finish load	1KN/m^2
2	Live load on terrace	1.5 KN/m^2	5	Water proofing load	2KN/m^2
3	Live load at typical floor	3KN/m^2	6	Terrace finish load	1KN/m^2

5. DIFFERENT LOCATION OF SHEAR WALL IN RC BUILDING

Here six different location of shear wall is provided in the RC frame structure building and plan are shown in below figure.

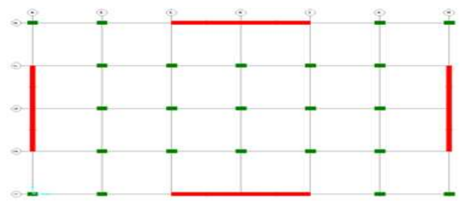


Fig. Model-I Shear wall at center

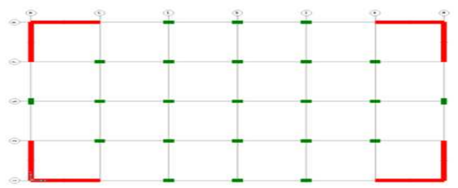


Fig. Model-II Shear wall at corner

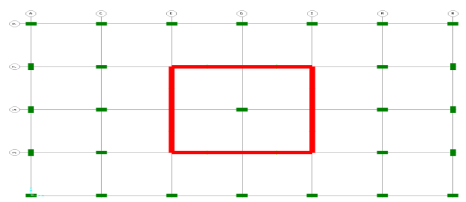


Fig. Model-III Shear wall at middle core

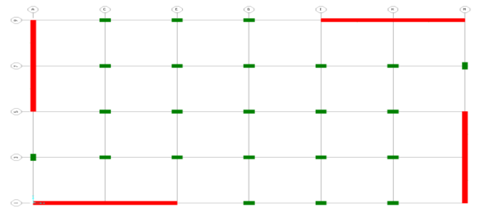


Fig. Model-IV Shear wall at outer side opposite corner

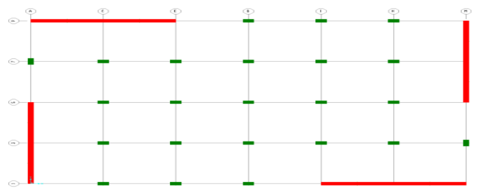


Fig. Model-V Shear wall at outer side opposite corner

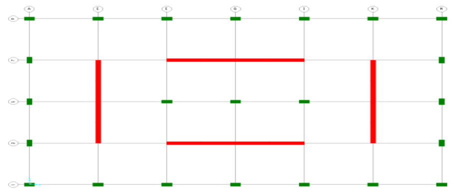
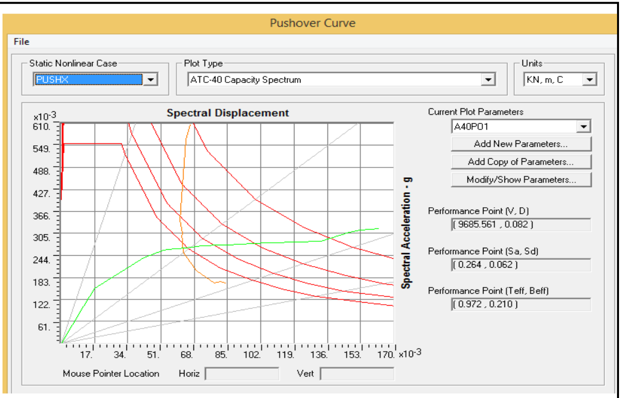


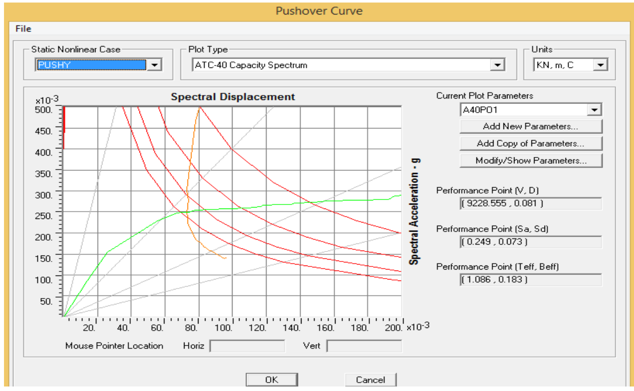
Fig. Model-VII Shear wall at mid span

6. PERFORMANCE POINT GRAPH

The buildings are pushed to a displacement of 4% of height of the building to reach collapse point as per ATC 40 (Applied Technology Council). Tabulate the nonlinear results in order to obtain the inelastic behaviour. After the analysis of the different model the graph shows the performance point of the structure in both direction X and Y.

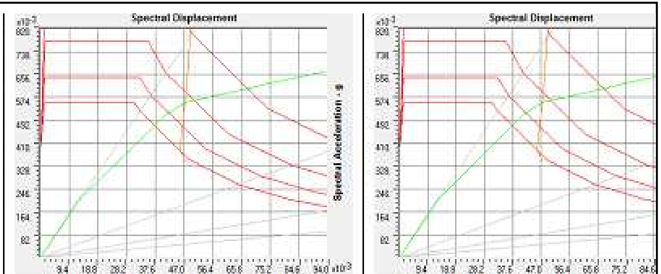
Model-I





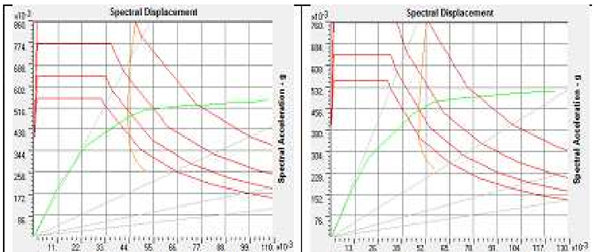
Capacity –Demand Spectrum for Y Direction

Model-II



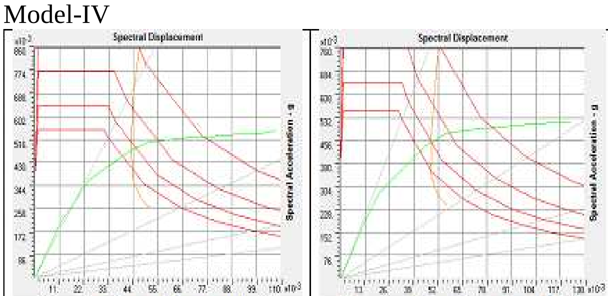
Capacity –Demand Spectrum for X Direction | Capacity –Demand Spectrum for Y Direction

Model-III



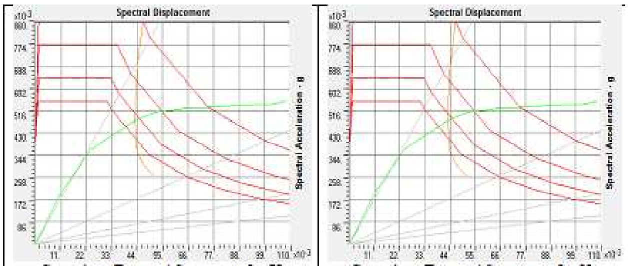
Capacity –Demand Spectrum for X Direction | Capacity –Demand Spectrum for Y Direction

Model-IV



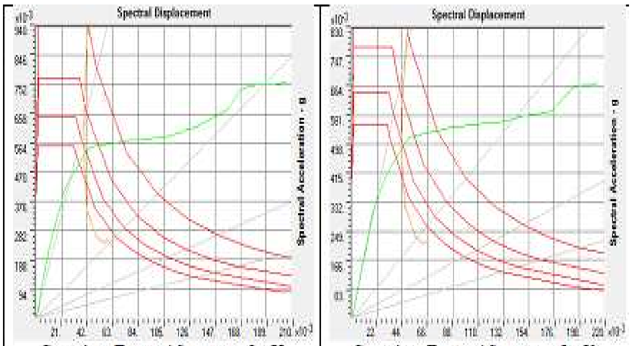
Capacity –Demand Spectrum for X Direction | Capacity –Demand Spectrum for Y Direction

Model-V



Capacity–Demand Spectrum for X Direction | Capacity–Demand Spectrum for Y Direction

Model-VI



Capacity–Demand Spectrum for X Direction | Capacity–Demand Spectrum for Y Direction

7. RESULTS

7.1. *Results of Capacity Demand Curve*

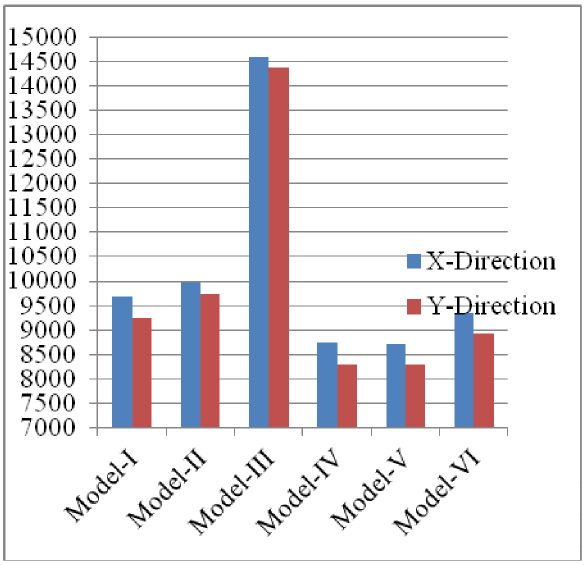
The results of pushover analysis can be obtained in the form of performance point of the building. Therefore, the performance point of different type of models is tabulated below. Table 1 shows the performance point of different type of shear models.

The shear wall models have been analyzed and tabulated similar to that of shear wall building to compare the results of considered parameters, such as base shear, lateral displacement i.e. Performance point of building.

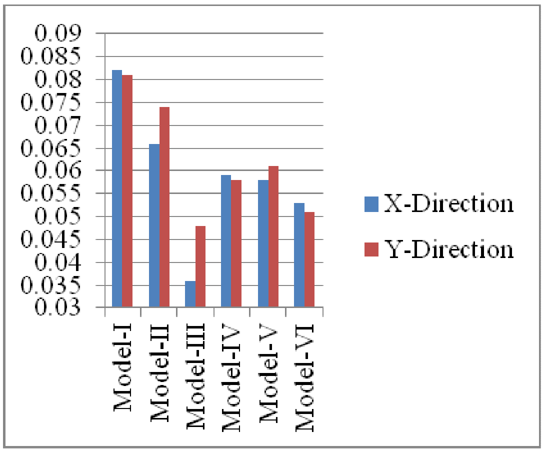
Type of Structure	PERFORMANCE POINT (V, D)			
	X-Direction		Y-Direction	
	Base shear (KN)	Displacement (m)	Base shear (KN)	Displacement (m)
Model-I	9685.561	0.082	9228.555	0.081
Model-II	9979.716	0.066	9370.737	0.074
Model-III	14586.270	0.036	14386.548	0.048
Model-IV	8742.259	0.059	8301.518	0.058
Model-V	8726.517	0.058	8292.308	0.061
Model-VI	9341.489	0.053	8930.265	0.051

7.2 Base Shear value at performance point

In this subsection we have present the base shear value X and Y direction in bar chart format



7.3 Displacement Value at performance point.



8. CONCLUSION

The present work focuses on study of seismic performance evaluation of RC buildings by using pushover analysis, which is located in seismic zone-V. The pushover analysis is very good approach to assess the adequacy of a structure to seismic loading. The analysis outputs were noted in terms Performance Point of the buildings which is an estimate of the actual displacement and base shear of the building. The following are the conclusions are drawn from the present investigation, which are as follows.

1) In medium high rise buildings provision of shear wall is found to be effective in enhancing the overall seismic capacity of the structure. The results obtained in terms of base shear and displacement which show capacity of the building and gave the real behaviour of structures.

2) Performance point of shear wall model-III is more than the other type of models, if the performance point is more for a building, then behaviour such type of buildings are good than the other type of models.

3) It is observed that base shear is minimum for model-V and maximum for model-III building and the lateral displacement is minimun for model-III and maximum for model-I.

4) The observation of results will gives that Shear wall Model-III is effective and greater in resisting the seismic force capacity than the other type of models.

5) Shear walls are definitely good mechanism for lateral loads mitigation, but the placement of shear walls should be made judiciously. In the present case, the model-3 (shear walls at core) is seen to perform better in all cases.

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