Pseudo Static Analysis of RC Structure With Shear Wall Under Seismic Excitation

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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+8 storeys building in zone V are analyzed by using MIDAS-GEN 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.*

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

I. INTRODUCTION

Earthquakes are the most destructive and life damagingphenomenon of all the times. Earthquakes are caused dueTo the large release of strain energy by the movement of faults, this causes shaking of ground. About 60% of theLand area of our country is susceptible to damaging levels of seismic hazard. We can't avoid future earthquakes, butSafe building construction practices can certainly reduce the extent of damage and loss. To evaluate the performanceOf framed building under future expected earthquakes, Shear wall system is one of the most commonly usedLateral 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 inresisting strong earthquakes is summarized in the quote,"We cannot afford to build concrete buildings meant toresist severe earthquakes without shear walls." as said by Mark Fintel, a noted consulting engineer in USA. [9]

II. OBJECIVE OF THE 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 shearwall provided at different locations.
3) To study the effect of providing shear walls, in RCframed building, using pushover analysis.
4) Determination of performance point of buildings.

III. PUSHOVER METHODOLOGY

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 FEMA356 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 behavior expected from the structure. Force-controlled option is useful when the load is known (such as gravity loading) and thestructure 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).

3.1*Non-linear Plastic Hinge*

The building has to be modeled to carry out nonlinear static pushover analysis. This requires the development ofThe force - deformation curve for the critical sections of beams, columns. The ATC-40 and FEMA-273 documentsHave 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 pointsLabeled 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.

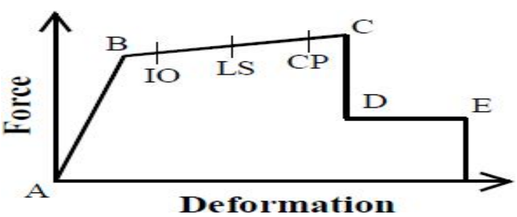


Fig. 1.1 Force-Deformation for Pushover Hinge (Habibullah. et al., 1998)

Point A corresponds to unloaded condition and point B represents yielding of the element. The ordinate at C corresponds to nominal strength and abscissa at C corresponds to the deformation at which significant strength degradation begins. The drop from C to D represents the initial failure of the element and resistance to lateral loads beyond point C is usually unreliable. The residual resistance from D to E allows the frame elements to sustain gravity loads. Beyond point E, the maximum deformation capacity, gravity load can no longer be sustained.

3.2 BUILDING PERFORMANCE LEVEL-

The combination of a Structural Performance Level and a Nonstructural Performance Level to form a complete description of an overall damage level.

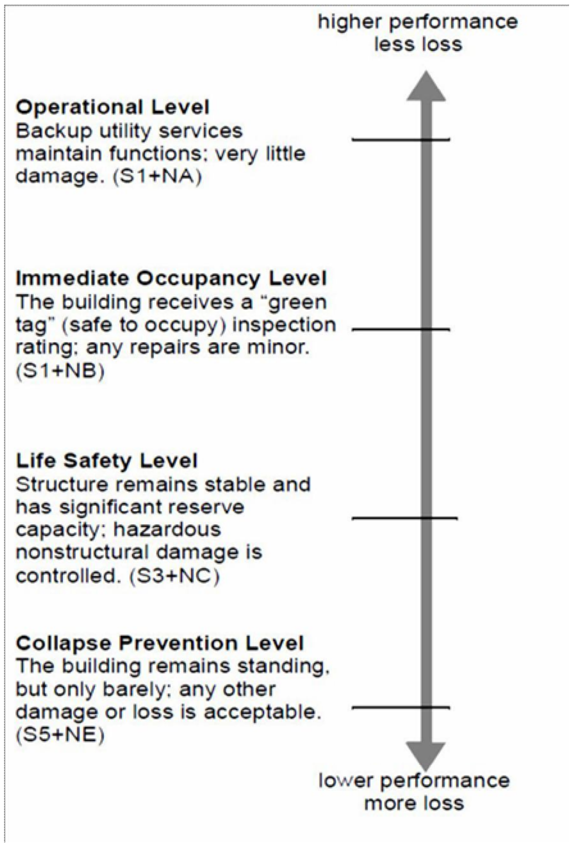


Fig. 1.2 Building Performance Levels (ATC, 1997a)

Methods and design criteria to achieve several different levels and ranges of seismic performance are defined. The four Building Performance Levels are Collapse Prevention, Life Safety, Immediate Occupancy, and Operational. These levels are discrete points on a continuous scale describing the building's expected performance, or alternatively, how much damage, economic loss, and disruption may occur**.**Each Building Performance Level is made up of a Structural Performance Level that describes the limiting damage state of the structural systems and a Nonstructural Performance Level that describes the limiting damage state of the nonstructural systems. Three Structural Performance Levels and four Nonstructural Performance Levels are used to form the four basic Building Performance Levels listed above.Other structural and nonstructural categories are included to describe a wide range of seismic rehabilitation intentions. The three Structural Performance Levels and two Structural Performance Ranges consist of:

•S-1: Immediate Occupancy Performance Level
•S-2: Damage Control Performance Range (extends between Life Safety and Immediate Occupancy Performance Levels)
•S-3: Life Safety Performance Level
•S-4: Limited Safety Performance Range (extends between Life Safety and Collapse Prevention Performance Levels)
•S-5: Collapse Prevention Performance Level

In addition, there is the designation of S-6, Structural Performance Not Considered, to cover the situation where only nonstructural improvements are made.

The four Nonstructural Performance Levels are:

•N-A: Operational Performance Level
•N-B: Immediate Occupancy Performance Level
•N-C: Life Safety Performance Level
•N-D: Hazards Reduced Performance Level

In addition, there is the designation of N-E, Nonstructural Performance Not Considered, to cover the situation where only structural improvements are made.

3.3 LIFE SAFETY PERFORMANCE LEVEL (S-3)

Structural Performance Level S-3, Life Safety, means the post-earthquake damage state in which significant damage to the structure has occurred, but some margin against either partial or total structural collapse remains. Some structural elements and components are severely damaged, but this has not resulted in large falling debris hazards, either within or outside the building. Injuries may occur during the earthquake; however, it is expected that the overall risk of life-threatening injury as a result of structural damage is low. It should be possible to repair the structure; however, for economic reasons this may not be practical.

3.4 COLLAPSE PREVENTION PERFORMANCE LEVEL(S-5)

Structural Performance Level S-5, Collapse Prevention, means the building is on the verge of experiencing partial or total collapse. Substantial damage to the structure has occurred, potentially including significant degradation in the stiffness and strength of the lateral force resisting system, large permanent lateral deformation of the structure and to more limited extent degradation in vertical-load-carrying capacity.

3.5 DAMAGE CONTROL PERFORMANCE RANGE(S-2)

Structural Performance Range S-2, Damage Control, means the continuous range of damage states that entail less damage than that defined for the Life Safety level, but more than that defined for the Immediate Occupancy level. Design for Damage Control performance may be desirable to minimize repair time and operation interruption; as a partial means of protecting valuable equipment and contents; or to preserve important historic features when the cost of design for Immediate Occupancy is excessive.Acceptance criteria for this range may be obtained by interpolating between the values provided for the Immediate Occupancy (S-1) and Life Safety (S-3) levels

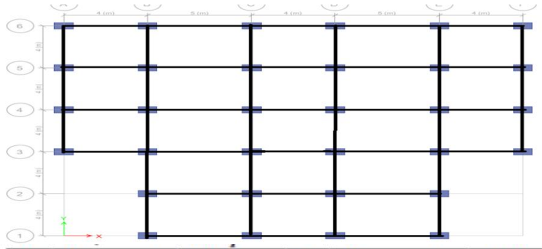
3.6 LIMITED SAFETY PERFORMANCE RANGE(S-4)

Structural Performance Range S-4, Limited Safety, means the continuous range of damage states between the Life Safety and Collapse Prevention levels. Design parameters for this range may be obtained by interpolating between the values provided for the Life Safety (S-3) and Collapse Prevention (S-5) levels.

IV. DESCRIPTION OF RC BUILDING

For the analysis and Design work, Use high rise building G+ 8 stories are made to know the realistic behavior of building during earthquake. The length of the building is 22m and width is 20 m with each 4.0m floor height. The totalheight of building is 32m, 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. Slab thickness is 150mm, 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 applied in both X and Y direction.

Input data for the building



S.N	Parameters	Values	S.N	Parameters	Values
1	Earthquake Load	As per IS-1893 (part-1)	4	Floor finish load	1K N/m2
2	Live load on terrace	1.5 KN/m^2	5	Water proofing load	2K N/m2
3	Live load at typical floor	3KN/m2	6	Terrace finish load	1K N/m2

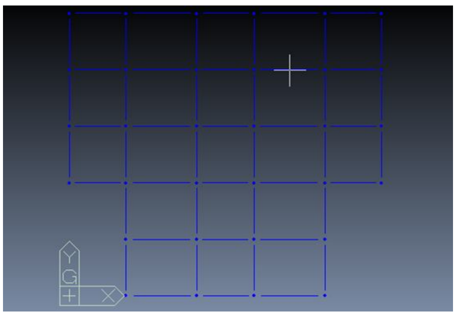
Fig 1.3 plan of the building (Mallika.K1 ,Nagesh Kumar.G2)

4.1 Geometric parameters for the 3 shear wall buildings ((Mallika.K1 ,Nagesh Kumar.G2)

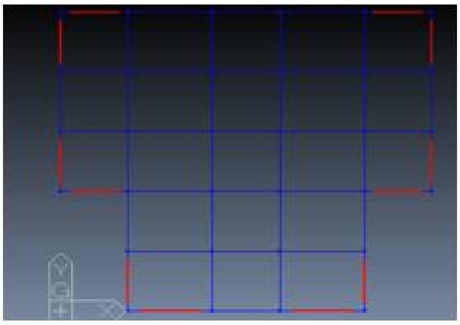
column dimension (1-5) floor mm	500*500 mm
column dimension (6-8) floor mm	400*400mm
beam dimension mm	300*500mm
shear wall thickness mm	230 mm
height of each storey m	4m
total no floors	8 nos
length of shear wall	4 m
aspect ratio of shear wall	8

V. DIFFERENT LOCATION OF SHEAR WALL IN RC BUILDING

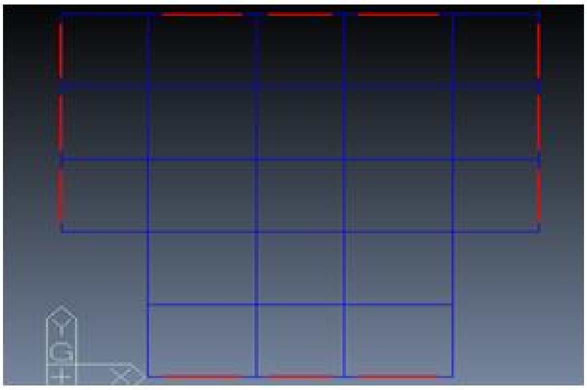
Here three different location of shear wall is provided in the RC frame structure building and plan are shown in below figure.



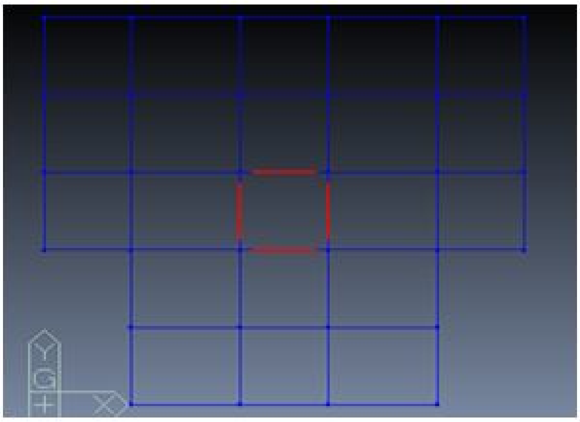
Model 1: without shear wall as shown



Model 2: shear wall at corers as shown



Model 3: shear wall parallel to x and y axis as shown in fig



Model 4: shear wall at interior as shown in fig

VI. 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 behavior. After the analysis of the different model the graph shows the performance point of the structure.

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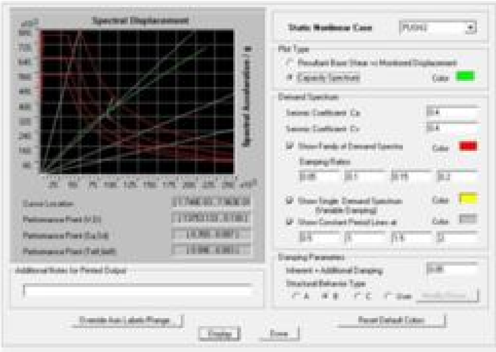
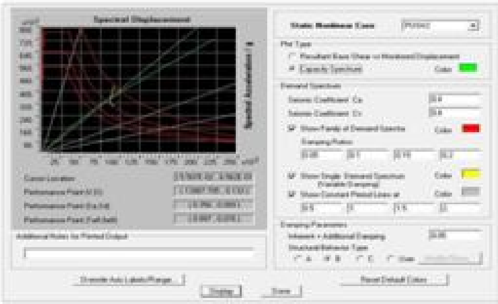
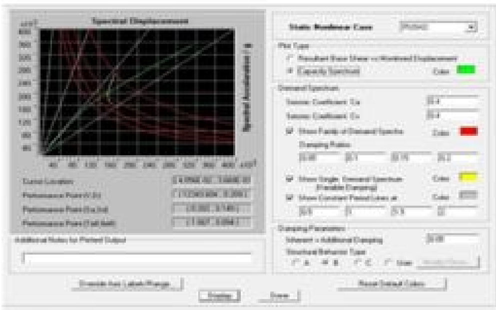


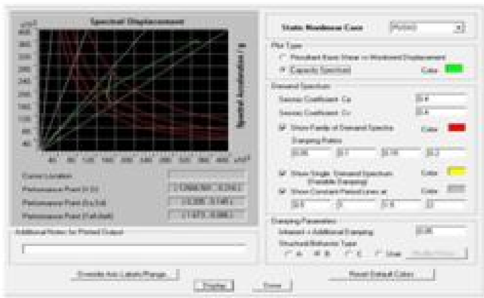
Fig; capacity demand spectrum for G+8 storey without shear wall



Fig; capacity demand spectrum for G+8 storey with shear wall at corners



Fig; capacity demand spectrum for G+8 storey with shear wall parallel to x& y dir



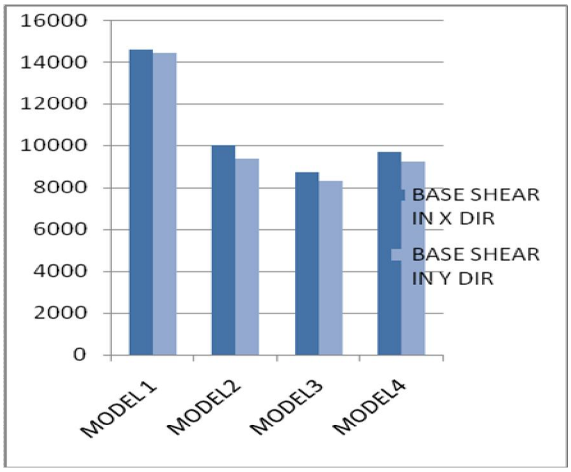
Fig;capacity demand spectrum for G+8 storey with shear wall at the interior

VII. RESULTS AND DISCUSSIONS

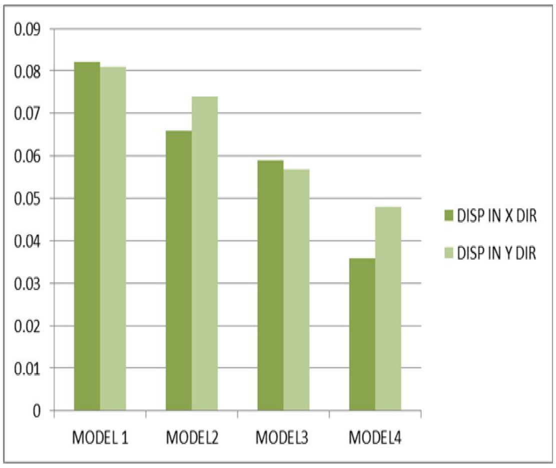
The results of pushover analysis can be obtained in the form of performance point of the building. Therefore, the performance point of different type of models is tabulated below. shows the performance point of different type of shear wall models. The shear wall models have been analyzed and tabulated 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			
	X-DIRECTION		Y-DIRECTION	
	BASE SHEAR (KN)	DISPLACEMENT (m)	BASE SHEAR (KN)	DISPLACEMENT (m)
MODEL 1	14586.270	0.082	14386.548	0.081
MODEL 2	9979.716	0.066	9370.737	0.074
MODEL 3	8742	0.059	8301.618	0.057
MODEL4	9685.561	0.036	9228.55	0.048

7.2 BASE SHEAR VALUE AT PERFORMANCE POINT



7.3 DISPLACEMENT VALUE AT THE PERFORMANCE POINT



VIII. 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 behavior of structures.
2. Performance point of shear wall model-4 is more than the other type of models, if the performance point is more for a building, then behavior such type of buildings are good than the other type of models.
3. It is observed that base shear is minimum for model-3 and maximum for model-1 building and the lateral displacement is minimum for model-4and maximum for model-I.
4. The observation of results will gives that Shear wall Model-4 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-4 (shear walls at core) is seen to perform better in all cases.

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