International Journal of Research Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 12

Pushover Analysis of Multi-Storeyed Concrete Building with and Without Shear Wall UsingEtabs Software

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Earthquake, a natural fury cannot be ignored as far as the stability of a structure is concerned. All structures should be made seismic resistant to prevent loss of life and infrastructural damage. The Pushover Analysis is conducted to find out the seismic response of the structure In performance based seismic analysis evaluates how building is likely to perform. It is an iterative process with selection of performance objective followed by development of preliminary design, an assessment whether or not the design meets the performance objective; In the present study pushover analysis has been done an two multistoried R.C. frame building; In which plan of 2 buildings was taken symmetrical 10 storey and it consist of 5 bays in x direction & 5 bays in y direction and second building having 15 storey. The shear wall is providing for studying their resisting lateral forces. The building has an overall plan dimension of 20m x 20m.The M25 grade of concrete and Fe 415 grade of steel is considered for design. In this highlight the effect of shear wall on R.C frame building when shear wall providing along the longer and shorter side of the building Pushover analysis is carried out using commercially available software ETABS and behaviour of RC frames is studied.

Key words*: Pushover analysis, Capacity M25, shear wall, ETABS software.*

1 Introduction

Seismic analysis is a subset of structural analysis and is the calculation of the response of a building (or non-building) structure to earthquakes. It is part of the process of structural design, earthquake engineering or structural assessment and retrofit in regions where earthquakes are prevalent.As seen in the figure, a building has the potential to 'wave' back and forth during an earthquake (or even a severe wind storm). This is called the 'fundamental mode' and is the lowest frequency of building response. However, most buildings have higher modes of response, which are uniquely activated during earthquakes. The figure just shows the first and second mode, but there are higher 'shimmy' (abnormal vibration) modes.

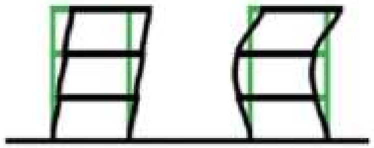


Figure1 First and second modes of buildings eismic response

Structural analysis methods can be divided into thefollowing five categories.

a) Linear static analysis

b) Linear dynamic analysis

c) Non linear static analysis

d) Non linear dynamic analysis

Linear static analysis

In a linear static procedure the building is modelled as an equivalent single-degree of freedom (SDOF) system with a linear elastic stiffness and an equivalent viscous damping. The seismic input is modelled by an equivalent lateral force with the objective to produce the same stresses and strains as the earthquake it represents. Based on an estimation of the first fundamental frequency of the building using empirical relationships or Rayleigh's method, the spectral acceleration is determined from the appropriate response spectrum which, multiplied by the mass of the building, results in the equivalent lateral force These linear static procedures are used primarily for design purposes and are incorporated in most codes. Their expenditure is rather small. However, their applicability is restricted to regular buildings for which the first mode of vibration is predominant.

Linear dynamic analysis

Static procedures are appropriate when higher mode effects are not significant. This isgenerally true for short, regular buildings. Therefore, for tall buildings, buildings with torsion irregularities, or non-orthogonal systems, a dynamic procedure is required. In the linear dynamic procedure, the building is modelled as a multi-degree-of-freedom (MDOF) system

The seismic input is modelled using either modal spectral analysis or time history analysis but in both cases, the corresponding internal forces and displacements are determined using linear elastic analysis. modes can be considered. Only linear properties are assumed. The analytical method can use modal decomposition as a means of reducing the degrees of freedom in the analysis. If the linear dynamic procedure (LDP) is selected for seismic analysis of the building, the design seismic forces, their distribution over the height of the building, and the corresponding internal forces and system displacements shall be determined using a linearly elastic, dynamic analysis in compliance with the requirements. Buildings shall be modeled with linearly elastic stiffness and equivalent viscous damping values consistent with components responding at or near yield level.

Non-linear static analysis

In general, linear procedures are applicable when the structure is expected to remain nearly elastic for the level of ground motion or when the design results in nearly uniform distribution of nonlinear response throughout the structure. As the performance objective of the structure implies greater inelastic demands, the uncertainty with linear procedures increases to a point that requires a high level of conservatism in demand assumptions and acceptability criteria to avoid unintended performance. This approach is also known as "pushover" analysis. Basically, a pushover analysis is a series of incremental static analysis carried out to develop a capacity curve for the building. Based on the capacity curve, a target displacement which is an estimate of the displacement that the design earthquake will produce on the building is determined. The pushover analysis of a structure is a static non-linear analysis under permanent vertical loads and gradually increasing lateral loads. The equivalent static lateral loads approximately represent earthquake induced forces. Consequently, at each event, the structures experiences a stiffness change as shown in Figure 1.2 where IO, LS and CP stand for immediate occupancy, life safety and collapse prevention respectively.

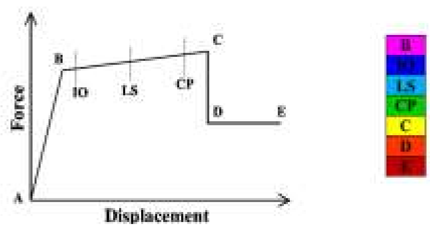


Figure 2 Hinge performance levels

The plastic deformation curve is characterized by the following points:

• Point A represents the origin.

• Point B represents the yielding state. No deformation occurs in the hinge up to point B, regardless of the deformation value specified for point B. The displacement (rotation) at point B will be subtracted from the deformations at points C, D, and E. Only the plastic deformation beyond point B will be exhibited by the hinge.

• Point C represents the ultimate capacity for pushover analysis.

• Point D represents the residual strength for pushover analysis.

• Point E represents total failure. Beyond point E the hinge will drop load down to point F (not shown) directly below point E on the horizontal axis.

Non-linear dynamic analysis

Nonlinear dynamic analysis utilizes the combination of ground motion records with a detailed structural model, therefore is capable of producing results with relatively low uncertainty. In nonlinear dynamic analyses, the detailed structural model subjected to a ground-motion

In non-linear dynamic analysis, the non-linear properties of the structure are considered as part of a time domain analysis. This approach is the most rigorous, and is required by some building codes for buildings of unusual configuration or of special importance.

About Etabs

ETABS is a sophisticated, yet easy to use, special purpose analysis and design program developed specifically for building systems. ETABS Version 9 features an intuitive and powerful graphical interface coupled with unmatched modeling, analytical, and design procedures, all integrated using a common database. Although quick and easy for simple structures, ETABS can also handle the largest and most complex building models, including a wide range of nonlinear behaviours, making it the tool of choice for structural engineers in the building industry.

Need For Investigation

The widespread damage especially to RC building during Bhuj earthquake exposed the construction practices being adopted in India and generated a great demand for seismic evaluation and up-gradation of RC buildings. The RC building can become seismically deficient since seismic design modal requirements are constantly revised due to extensive experimental investigations in the research fields. Performance-based design is experiencinga rapid development in recent years. This concept provides a new approach for establishing design objectives and desired performance levels for new and existing buildings. Seismic deficient buildings are being upgraded using performance-based design.

Aims And Objectives Of The Study

1) To analyze the seismic behaviour of 10 and 15 storied RC framed building using pushover analysis procedure.

2) To compute the seismic response of a building in terms of storey drifts and roof displacements.

3) Determination of performance point of the building to suggest retrofitting techniques.

4) To study the effect of shear walls as a method of retrofitting.

Scope Of The Study

The scope of the present study is limited to building the model, generating the load cases and to carry-out the analysis for 10 and 15 storied buildings both symmetrical in plans and are carried out with shear walls and without shear walls using ETABS Version 9.7.3.

Summary

In this chapter, various types of analysis and importance of ETABS are discussed. The scope and objective is also been discussed. Based on the objective of the present study, research papers were collected and studied thoroughly. The review of research papers is discussed in the chapter named as literature review

2 Literature Review

Chattopadhyaya and Sengupta (2011) studied on a 4-storyed regular RC building was considered for comparative study of the options of modeling a shear wall for pushover analysis. The modeling of shear wall was studied for seismic loads along one direction. He concluded that modeling of tall and solid shear wall using column element is adequate for pushover analysis, provided the hinge properties are defined properly. Modeling a shear wall using fiber-based wall element is rigorous. Since it is computationally intensive, it need not be used for pushover analysis of a building with a solid shear walls.

Chandrasekaran and Gupta (2013) focuses on pushover analysis of multistory RC framed buildings subjecting them to monotonically increasing lateral forces with an invariant height wise distribution until the preset performance level (target displacement) is reached. The studies conducted highlight the superiority of MPA while bringing out the significant higher mode participation in evaluating the seismic demands. The results also show that MPA agrees closely with that of the response behavior obtained through nonlinear response history analysis (NLRHA). The study conducted lead to some main conclusions: i) the MPA results closely agree with that of NLRHA and hence shall be looked upon as a reliable alternative, ii) MPA brings out the significant contribution of higher modes in seismic demand estimation,

iii) MPA shows conservative results compared to NLRHA.

3Shear Walls

Introduction

Shear walls are vertical elements of the horizontal force resisting system. The reinforced concrete shear wall is important structural elements placed inmulti-storey buildings which are situated in seismic zones because they have a highresistance to lateralearthquake loads. RC shear walls must have sufficient ductility to avoid brittle failure under the action of strong lateral seismic loads. In residential construction, shear walls are straight external walls that typically form a box which provides all of the lateral support for the building. When shear walls are designed and constructed properly, and they will have the strength and stiffness to resist the horizontal forces.

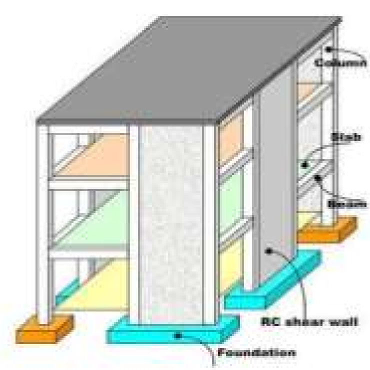


Figure 3. Reinforced concrete shear walls in buildings

Classification Of Shear Walls

- Simple rectangular types and flanged walls
- Coupled shear walls
- Framed walls with in filled frames
- Core type shear walls

Types Of Shear Walls

- RC Shear Wall
- Plyood Shear Wall
- Mid ply Shear Wall
- RC Hollow Concrete Block MasonrWall
- Steel Plate Shear Wall

RC shear wall

RC Shear Wall consists of reinforced concrete walls and reinforced concrete slabs. Wall thickness varies from 140 mm to 500 mm, depending on the number of stories, building age, and thermal insulation requirements. In general, these walls are continuous throughout the building height; however, some walls are discontinued at the street front or basement level to allow for commercial or parking spaces. Usually the wall layout is symmetrical with respect to at least one axis of symmetry in the plan.

Figure 4 R.C shear wall

Plywood shear wall

Plywood is the traditional material used in the construction of Shear walls. The creation of prefabricated shear panels have made it possible to inject strong shear assemblies into small walls that fall at either side of a opening in a shear wall.

Figure 5 Plywood shear wall

Midply shear wall

The midply shear wall is an improved timber shear wall that was developed by redesigning the joints between sheathing and framing members, so that the failure modes observed in standard wall testing are virtually eliminated at lateral load levels high enough to cause failures in standard wall.

RC Hollow concrete block masonry walls

RHCBM walls are constructed by reinforcing the hollow concrete block masonry, by taking

advantage of hollow spaces and shapes of the hollow blocks. It requires continuous steelrods(reinforcement) both in the vertical and horizontal directions at structurally critical locations of the wall panels, packed with the fresh grout concrete in the hollow spaces of masonry .

Steel plate shear wall

In general, steel plate shear wall system consists of a steel plate wall, boundary columns and horizontal floor beams. Together, the steel plate wall and boundary columns act as a vertical plate girder. The columns act as flanges of the vertical plate girder and the steel plate wall acts as its web. The horizontal floor beams act, more-or-less, as transverse stiffeners in a plate girder.

International Journal of Research Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 12
April 2018

Figure 6Plate shear wall

4 Methodology

The use of the nonlinear static analysis (pushover analysis) came in to practice in 1970" s but the potential of the pushover analysis has been recognized for last two decades years. This procedure is mainly used to estimate the strength and drift capacity of existing structure and the seismic demand for this structure subjected to selected earthquake. This procedure can be used for checking the adequacy of new structural design as well. The effectiveness of pushover analysis and its computational simplicity brought this procedure in to several seismic guidelines (ATC 40 andFEMA 356) and design codes (Euro code 8 and PCM 3274) in last few years.

Role Of Pushover Analysis

Performance based approach requires a non-linear lateral load verses deformation analysis.

The pushover analysis is a static method of non-linear analysis. The pushover analysis is an elegant method to observe the successive damage states of building states of a building both in the existing condition and a proposed retrofit scheme. It addresses the deficiencies of an elastic analysis by the following features.

- The analysis considers the inelastic deformation and ductility of the members.
- The sequence of yielding of sections in the members and subsequent redistribution of loads in the building are observed.

Purpose Of Pushover Analysis

The purpose of pushover analysis is to evaluate the expected performance of structural

systems by estimating performance of a structural system by estimating its strength and deformation demands in design earthquakes by means of static inelastic analysis, and comparing these demands to available capacities at the performance levels of interest. The evaluation is based on an assessment of important performance parameters, including global drift, inter story drift, inelastic element deformations (either absolute or normalized with respect to a yield value), deformations between elements, and element connection forces (for elements and connections that cannot sustain inelastic deformations). The inelastic static pushover analysis can be viewed as a method for predicting seismic force and deformation demands, which accounts in an approximate manner for the redistribution of internal forces that no longer can be resisted within the elastic range of structural behavior.

5Numerical Study

Building Description

In the present work, a 10 storied and 15 storied reinforced concrete frame building situated inzone V, is taken for the purpose of study. The plan area of building is 20 x 20m with 2m as plinth level and 3m as height of each typical storey. It consists of 5 bays in X-direction and 5 bays in Y-direction. The total heights of the buildings were 32m and 47m.

Structural System Of The Building

The column, beam and wall dimensions are detailed in the below tables:

Table 1 & 2 Structural dimensions of 10 storied and 15 storied buildings

Specifications	10 storey	15 storey
Slab Thickness	165mm	165mm
Beam dimensions	300x450mm	300x450mm
Plinth beam dimensions	380x380mm	380x380mm
Column dimensions	400x400mm 450x450mm	400x400mm 450x450mm 500x500mm 550x550mm 600x600mm
Exterior wall	230mm	230mm

Specifications	10 storey	15 storey
Interior wall	115mm	115mm
Grade of concrete	M20	M20
Grade of steel	Fe-415	Fe-415
Unit weight of concrete	25kN/m^3	25kN/m^3
Thickness of shear wall	150mm	200mm

Table 3Design variables for analysis

Design variable	Value	Remarks
Dead loads		
(a) Masonry	20kN/m^3	IS 875:1987(Part-1)
(b) Concrete	25kN/m^3	
Live loads		
(a) Floor load	2kN/m^2	IS 875:1987(Part-1)
(b) Roof load	1.5kN/m^2	
(c) Floor finishes	1.0kN/m^2	
Importance factor	1.0	IS 1893:2002
Seismic zone factor	0.36	IS 1893:2002
Response reduction factor	5	IS 1893:2002

Pushover Analysis Using Etabs V9.7.3

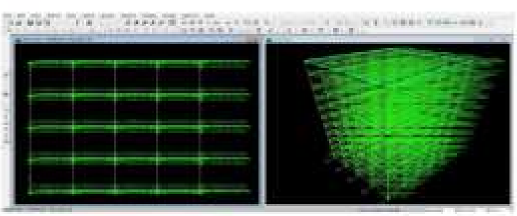


Figure 7 Pushover Analysis

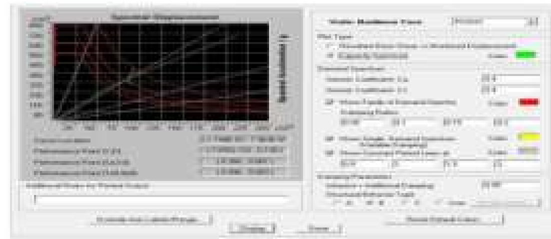


Figure 8 Displacement spectrum curve of symmetrical 10 storied building with shear walls for 1% drift

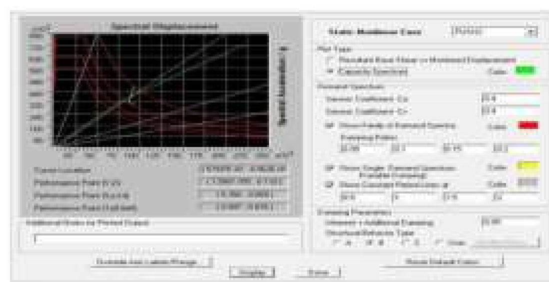


Figure 9 Displacement spectrum curve of symmetrical 10 storied building with shear walls for 2% drift

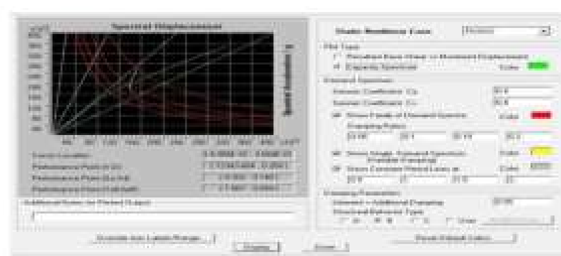
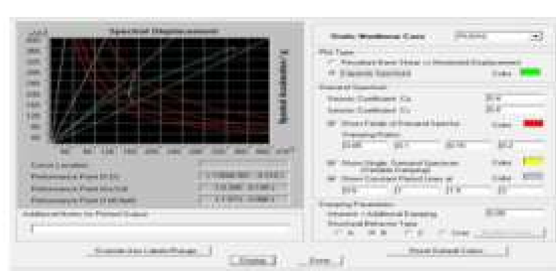


Figure 10 Displacement spectrum curve of symmetrical 15 storied building with shear walls for 1% drift



International Journal of Research Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
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Figure 11 Displacement spectrum curve of symmetrical 15 storied building with shear walls for 2% drift

6Results And Discussions

General

In this chapter, the structure is modelled for 10 and 15 storied building considered in zone V which is symmetrical in plan. A non-linear static analysis is performed in ETABS v9.7.3 and the results are generated in the form of pushover curveswhich are presented here. The same building is analyzed by taking symmetric condition and analyzed after applying retrofitting.

Results Obtained For A 10-Storied Building Initial Drift 1%

Table 4 Pushover curve for a 10-storied symmetrical building for drift 1%

Displacement	Base Force	A-B	B-IO	IO-LS	LS-CP	CP-C	C-D	D-E	>E	TOTAL
0	0	1430	0	0	0	0	0	0	0	1430
0.032	3912.9153	1428	2	0	0	0	0	0	0	1430
0.049	5996.7573	1303	127	0	0	0	0	0	0	1430
0.082	9715.2539	1112	316	2	0	0	0	0	0	1430
0.116	12678.0195	1025	359	46	0	0	0	0	0	1430
0.1503	15329.2900	984	361	85	0	0	0	0	0	1430
0.1835	17782.1875	956	255	181	38	0	0	0	0	1430
0.2213	20519.7461	914	244	212	60	0	0	0	0	1430
0.256	22988.8496	892	231	235	72	0	0	0	0	1430
0.2898	25346.0898	870	222	240	96	0	2	0	0	1430
0.3144	27061.7246	870	220	241	97	0	0	2	0	1430
0.3144	27014.4805	868	217	232	111	0	0	2	0	1430
0.32	27438.5098	1430	0	0	0	0	0	0	0	1430

Table 5 Capacity spectrum curve for a 10-storied symmetrical building for drift 1%

Step	Teff	Beff	Sd(C)	Sa(C)	Sd(D)	Sa(D)	ALPHA	PF*Ø
0	0.932	0.05	0	0	0.093	0.429	1	1
1	0.932	0.05	0.021	0.099	0.093	0.429	0.699	1.496
2	0.932	0.05	0.033	0.152	0.093	0.429	0.699	1.496
3	0.947	0.058	0.055	0.246	0.091	0.407	0.699	1.496
4	0.983	0.078	0.077	0.322	0.087	0.362	0.697	1.5
5	1.016	0.09	0.1	0.391	0.086	0.336	0.695	1.501
6	1.04	0.096	0.122	0.454	0.087	0.323	0.694	1.503
7	1.063	0.098	0.147	0.525	0.088	0.314	0.693	1.504
8	1.079	0.098	0.17	0.589	0.089	0.308	0.692	1.504
9	1.092	0.098	0.193	0.65	0.09	0.305	0.691	1.505
10	1.1	0.098	0.209	0.694	0.091	0.303	0.69	1.505
11	1.101	0.098	0.209	0.693	0.091	0.302	0.69	1.505
12	1.102	0.097	0.213	0.704	0.091	0.303	0.69	1.505

Results Obtained For A 10-Storied Building Initial Drift 2%

Table 6 Pushover curve for a 10-storied symmetrical building for drift 2%

Step	Displacement	Base Force	A-B	B-IO	IO-LS	LS-CP	CP-C	C-D	D-E	>E	TOTAL
0	0	0	1428	2	0	0	0	0	0	0	1430
1	0.049	5996.7573	1122	308	0	0	0	0	0	0	1430
2	0.1136	12485.339	992	356	82	0	0	0	0	0	1430
3	0.1781	17386.731	934	235	203	58	0	0	0	0	1430
4	0.2446	22191.331	872	226	240	92	0	0	0	0	1430
5	0.3099	26748.695	870	222	240	96	0	2	0	0	1430
6	0.3144	27061.723	870	220	241	97	0	0	2	0	1430
7	0.3144	27014.744	868	206	228	122	0	4	2	0	1430
8	0.3258	27645.662	868	204	226	120	0	0	12	0	1430
9	0.3256	27538.035	864	204	204	140	0	6	12	0	1430
10	0.3365	28189.729	864	204	204	138	0	0	20	0	1430
11	0.3359	27688.354	1430	0	0	0	0	0	0	0	1430

Table 7 Capacity spectrum curve for a 10-storied symmetrical building for drift 2%

Step	Teff	Beff	Sd(C)	Sa(C)	Sd(D)	Sa(D)	ALPHA	PF*Ø
0	0.932	0.05	0	0	0.093	0.429	1	1
1	0.932	0.05	0.033	0.152	0.093	0.429	0.699	1.496
2	0.98	0.07	0.076	0.318	0.089	0.375	0.697	1.499
3	1.037	0.091	0.139	0.484	0.088	0.328	0.694	1.502
4	1.074	0.096	0.163	0.568	0.089	0.312	0.692	1.504
5	1.099	0.096	0.206	0.686	0.091	0.305	0.691	1.505
6	1.1	0.096	0.209	0.694	0.092	0.304	0.69	1.505
7	1.101	0.097	0.209	0.693	0.091	0.303	0.69	1.505
8	1.103	0.095	0.216	0.715	0.092	0.305	0.69	1.505
9	1.114	0.104	0.223	0.725	0.091	0.296	0.689	1.506

Results Obtained For A 15-Storied Building Initial Drift 1%

Table 8 Pushover curve for a 15-storied symmetrical building for drift 1%

Step	Displacement	Base Force	A-B	B-IO	IO-LS	LS-CP	CP-C	C-D	D-E	>E	TOTAL
0	0	0	2080	0	0	0	0	0	0	0	2080
1	0.047	3309.6047	2078	2	0	0	0	0	0	0	2080
2	0.0760	5393.2124	2002	78	0	0	0	0	0	0	2080
3	0.1238	8644.6484	1658	422	0	0	0	0	0	0	2080
4	0.1724	10965.5186	1537	509	34	0	0	0	0	0	2080
5	0.2227	12875.3594	1450	512	118	0	0	0	0	0	2080
6	0.273	14653.3711	1424	437	187	32	0	0	0	0	2080
7	0.3211	16247.833	1400	316	288	76	0	0	0	0	2080
8	0.3740	18087.8535	1340	322	318	100	0	0	0	0	2080
9	0.4267	19780.9395	1311	287	316	166	0	0	0	0	2080
10	0.47	21196.9844	2080	0	0	0	0	0	0	0	2080

Table 9Capacity spectrum curve for a 15-storied symmetrical building for drift 1%

Step	Teff	Beff	Sd(C)	Sa(C)	Sd(D)	Sa(D)	ALPHA	PF*Ø
0	1.536	0.05	0	0	0.151	0.26	1	1
1	1.536	0.05	0.032	0.054	0.151	0.26	0.660	1.468
2	1.536	0.05	0.051	0.088	0.151	0.26	0.664	1.468
3	1.547	0.053	0.083	0.14	0.151	0.255	0.667	1.488
4	1.612	0.079	0.116	0.179	0.142	0.219	0.664	1.491
5	1.686	0.1	0.149	0.211	0.139	0.196	0.662	1.494
6	1.749	0.111	0.182	0.24	0.139	0.183	0.66	1.496
7	1.796	0.117	0.214	0.268	0.141	0.176	0.659	1.498
8	1.839	0.119	0.25	0.298	0.143	0.171	0.657	1.499
9	1.873	0.12	0.284	0.326	0.146	0.167	0.656	1.5
10	1.899	0.12	0.313	0.35	0.149	0.165	0.656	1.5

Results Obtained For A 15-Storied Building Initial Drift 2%

Table 10 Pushover curve for a 15-storied symmetrical building for drift 2%

Step	Displacement	Base Force	A-B	B-IO	IO-LS	LS-CP	CP-C	C-D	D-E	>E	TOTAL
0	0	0	2078	2	0	0	0	0	0	0	2080
1	0.0766	5393.2124	1658	422	0	0	0	0	0	0	2080
2	0.1724	10965.5186	1457	517	106	0	0	0	0	0	2080
3	0.2671	14447.7393	1440	319	247	74	0	0	0	0	2080
4	0.364	17727.9805	1513	298	213	135	0	0	0	0	2080
5	0.4676	21120.7344	1293	286	287	208	0	4	0	0	2080
6	0.4886	21116.791	1280	274	297	216	0	0	10	0	2080
7	0.4886	21090.1895	1287	271	292	213	0	4	10	0	2080
8	0.5028	21456.4551	1262	273	293	213	0	0	16	0	2080
9	0.5025	21216.3301	1280	271	295	211	0	3	16	0	2080
10	0.5044	21283.4176	2080	0	0	0	0	0	0	0	2080

Table 11 Capacity spectrum curve for a 15-storied symmetrical building for drift 2%

Step	Teff	βeff	Sd(C)	Sa(C)	Sd(D)	Sa(D)	ALPHA	PF*Ø
0	1.538	0.05	0	0	0.133	0.26	1	1
1	1.538	0.05	0.051	0.088	0.133	0.26	0.666	1.488
2	1.653	0.069	0.116	0.179	0.147	0.228	0.664	1.491
3	1.742	0.105	0.178	0.237	0.141	0.187	0.66	1.496
4	1.831	0.116	0.243	0.292	0.144	0.173	0.658	1.499
5	1.897	0.117	0.312	0.349	0.149	0.166	0.656	1.5
6	1.914	0.117	0.332	0.365	0.15	0.163	0.655	1.501
7	1.95	0.135	0.333	0.355	0.146	0.153	0.654	1.501
8	1.96	0.139	0.336	0.352	0.145	0.152	0.654	1.501

Storey Drifts For 10 & 15 Storied Building

Table 12 Storey drifts of various storey levels

Storey level	Storey drifts without shear wall	Storey drifts with shear wall
Terrace	13.22	3.936
Storey 9	14.66	4.059
Storey 8	14.98	4.128
Storey 7	14.92	4.125
Storey 6	14.8	4.023
Storey 5	13.4	3.81
Storey 4	12.6	3.468
Storey 3	12.8	2.988
Storey 2	11.27	2.349
Storey 1	1.027	1.563
Ground level	1.250	0.726

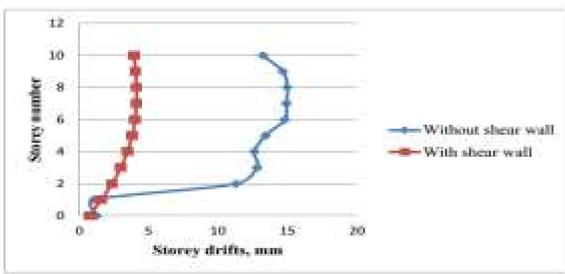

Figure 12 Drifts of 10-storied building in x-direction

Table 13 Drifts of various storey leve

Storey level	Storey drifts without shear wall	Storey drifts with shear wall
Terrace	14.41	5.421
Storey 14	14.62	5.568
Storey 13	15.33	5.763
Storey 12	15.45	5.763
Storey 11	15.23	5.811
Storey 10	15.21	5.802
Storey 9	14.8	5.727
Storey 8	14.46	5.562
Storey 7	14.56	5.34
Storey 6	14.22	5.01
Storey 5	13.83	4.581
Storey 4	13.42	4.044
Storey 3	13.22	3.393
Storey 2	13.02	2.61
Storey 1	1.22	1.695
Ground level	1.1	0.771

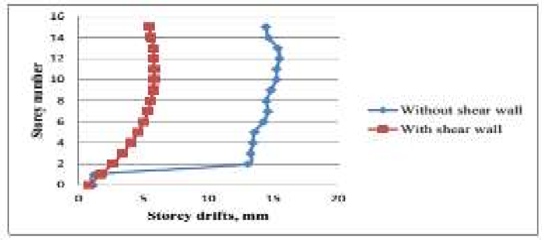

Figure 13 Drifts of 15-storied building in x-direction

DISPLACEMENTS FOR 10 & 15 STORIED BUILDING

Table 14Roof displacements of various storey levels

Storey level	Displacements without shear wall	Displacements with shear wall
Terrace	161.295	34.93
Storey 9	156.054	30.995
Storey 8	146.856	26.935
Storey 7	134.102	2.808
Storey 6	118.537	18.684
Storey 5	100.861	14.661
Storey 4	81.691	10.852
Storey 3	61.549	7.385
Storey 2	40.983	4.397
Storey 1	21.859	2.047
Ground level	0.4930	0.484

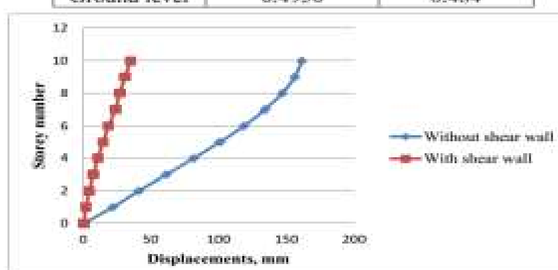

Figure 14 Displacements of 10-storied building in x-direction

Table 14 Roof displacements of various storey levels

Storey level	Displacements without shear wall	Displacements with shear wall
Terrace	271.576	72.526
Storey 14	264.576	67.106
Storey 13	251.881	61.538
Storey 12	233.966	55.862
Storey 11	211.593	50.099
Storey 10	191.289	44.289
Storey 9	170.145	38.488
Storey 8	149.788	32.761
Storey 7	129.767	27.185
Storey 6	110.167	21.846
Storey 5	90.068	16.835
Storey 4	70.251	12.254
Storey 3	51.659	8.209
Storey 2	33.668	4.817
Storey 1	16.774	0.208
Ground level	3.532	0.0514

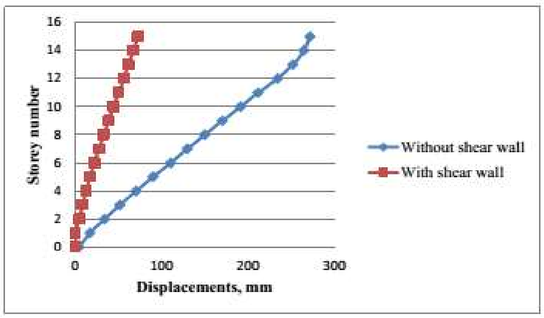

Figure 15 Displacements of 15-storeied building in x-direction

7. Conclusions

- When a 10 and 15 storied buildings are pushed to 1% transient drift (0.32m,0.47m), the performance of the building lies between Immediate Occupancy and Life Safety levels even with increase in the storey height. In the present case study, both the buildings have moderate resistance.
- The drift index of 10 and 15 storied buildings are 0.00406 and 0.00415 which is below the permissible index value of 0.005(for no damage as per ATC-40). It infers that the lateral displacement of the structure is well within permissible limits and no damage occurs as a whole.
- When a 10 and 15 storied buildings are pushed to 2% transient drift(0.64m,0.94m), the performance of the building lies between Life Safety and Collapse Prevention levels even with increase in the storey height. In the present case study, both the buildings have poor resistance.
- The drift index of 10 and 15 storied buildings are 0.00445 and 0.00459 which is
- below the permissible index value of 0.005(for no damage as per ATC-40). It infers
- that the lateral displacement of the structure is well within permissible limits and no
- damage occurs as a whole.
- The observed displacements at terrace level for a 10 storied building without shear wall were 161mm. When shear wall was introduced to the structure displacement was drastically reduced to 34.9mm. It infers that the structure is well within permissible
limits and no damage occurs as a whole.
- The observed displacements at terrace level for a 15 storied building without shear wall were 271mm. When shear wall was introduced to the structure displacement was drastically reduced to 72.5mm. It infers that the structure is well within permissible
- limits and no damage occurs as a whole.

Scope For Future Study

The Study can be extended to a non-linear time history analysis of the building. Modeling of shear walls with openings, coupled shear walls, flanged walls and core walls can also be studied.

Summary

This Chapter, details the discussions drawn based on the present work and the scope of the further study and Investigation based on the present study was discuss

References

1. Habibullah and Stephen Pyle (1998), "Practical Three Dimensional Nonlinear Static Pushover Analysis", Published in Structure Magazine, winter.

2. Kadid A and Boumrkik A (2008), "Pushover Analysis of Reinforced Concrete Framed Structures", At Department of civil Engineering, University of Banta, Algeria, Asian journal of civil engineering Vol. 9(1),pp. 75-83.

3. Monavari B, Massumi A, Kazem A (2008), "Estimation of Displacement Demand in RC Frames and Comparing with Target Displacement" Provided by FEMA-356, 15th World Conference on Earthquake Engineering, 24th to 28th, Lisbon, Portugal.

4. Onur Merter and Taner Ucar (2010), "A Comparative Study on Nonlinear Static

and Dynamic Analysis of Frame Structures", Journal of civil Engineering and Science, Vol. 2(3), pp. 155-162.

5. Sudipta Chattopadhyaya and Alman K Sengupta (2011), "Modeling of Tall Shear Walls for Non-linear Analysis of RC Buildings under Cyclic LateralLoading", The Indian Concrete journal, Vol. 85(8), pp. 38-40.

6. Mitchalis Fragiadakis, Dimitrios Vamvatsikos, Mark Ascheim (2011), "Application for Seismic Assessment of Regular RC Moment Frame Buildings", Department of Civil and Environmental Engineering, University of Cyprus. Vol. 5(4), pp. 20-29.

7. A. Cinitha, P.K. Umesha, Nagesh R. Iyer (2011), "Non linear Static Analysis to Assess Performance and vulnerability of Code-Conferring RC buildings", wseas transactions on applied and theoretical mechanics, Vol.7(1), pp. 39-48.

8. S.I. Khan and P.O. Modani (2012), "Seismic Evaluation and Retrofitting of RC Building by Using Energy Dissipating Devices", International Journal of Engineering research and Applications, Vol. 3(3), pp. 1504-1514.

9. Chopra, A.K and Rakesh K.G (2012), "Capacity-Demand-Diagram Methods Based on Inelastic Design Spectrum", Earthquake Spectra, Vol. 5(4), pp. 45-52. 57

10. Satpute S.G and Kulkarni D. B (2013), "Comparative Study of Reinforced Concrete Shear Wall Analysis in Multi Storied Building with Openings by Nonlinear Methods", International Journal of Structural and civil Engineering Research,Vol.2(3), pp.183-193.