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NON-LINEAR PUSHOVER ANALYSIS OF RCC BUILDING WITH BASE ISOLATION SYSTEM

Asst Prof. Noor Mohammed, Mohammed Huzaifa Yaman, Shaik Mohammed Siddiq
* Department of Civil Engineering NSAKCET, India

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ABSTRACT

Buildings are designed as per the code regulations meeting all specific requirements of code and assuming a linear elastic behaviour for the structural members. Moreover, it is also necessary to know the behaviour of a building that were designed with older codes or which may not have been designed for earthquake forces. During the seismic excitation the building responds well beyond its elastic and linear capacity and enters into non-linear stage.

So, the present work is intended to provide a systematic procedure to assess the behaviour of a structure during the seismic excitation. For studying the behaviour a non-linear static analysis procedure known as pushover analysis is used. The literature pertaining to pushover analysis is reviewed.

A Nine storey residential building located in the Hyderabad city, which was designed and constructed for gravity loads alone, was considered for analysis. The present structure is studied using the evaluation procedures provided in ATC-40 and FEMA-273 documents. Under detailed evaluation a target displacement for Immediate Occupancy, Life Safety, Collapse Prevention was given and the performance is checked in accordance with IS 1893:2002

INTRODUCTION

Natural hazards bring many damages to man-made interventions such as habitat and infrastructural facilities causing loss to life and property. Earthquakes are one of those hazards with the sudden violent movement of earth's surface with the release of energy. According to the revised provisions of IS 1893 (Part 1): 2002, the seismic zones of India become more vulnerable and reduced to four zones. So it is important to design the structures with seismic resistance. Recent earthquakes in the Indian subcontinent, India-Pakistan earthquake on October 8, 2005 with a magnitude of 7.4 on Richter scale, Gujarat earthquake on January 26, 2001 with a magnitude of 7.6 on Richter scale have led to an increase in the seismic zoning factor over many parts of the country. Buildings are designed as per the building code regulations, aptly termed as prescriptive based design. It ismethodology based upon meeting all of the specific requirements of the code. In prescriptive based design, the normal engineering practice is to assume linear-elastic behaviour for structural members, which fails to account for redistribution of forces due to member non-linear behaviour and dissipation of energy due to material yielding.

The present work aims at the study of following objectives:

- How the seismic evaluation of a building should be carried out.
- To study the behavior of a building under the action of seismic loads with and without rubber base isolator.
- To find the performance of a building so as to suggest some retrofitting techniques, if required.

GENERAL

The seismic evaluation process consists of two phases, namely preliminary evaluation phase and detailed evaluation phase. After the building is preliminary evaluated using rapid visual screening, the detailed evaluation is carried out using 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 a building both in the existing condition and under a proposed retrofit scheme. The concept of protecting a building from the damaging effects of an earthquake by introducing some type of support that isolates it from the shaking ground is an attractive one, and many mechanisms to achieve this result have been proposed. Although the earlier proposals go back hundred years, it is only in recent years that base isolation has become a practical strategy for earthquake resistant design. It is a passive control device that is installed between the foundation and the base of the building. The base isolation system introduces a layer of low lateral stiffness between the structure and the foundation. With this isolation layer the structure has a natural period which is much longer than its fixed base natural period. This lengthening of the period can reduce the pseudo-acceleration and hence the earthquake induced forces in the structure

MODELLING PARAMETERS

Building Description:Reinforced Concrete Frame of 9 storeys, with plan size 21mx21m, with heights of 21m respectively are modeled.

S.No.	*Description*	*Information*	*Remarks*
1.	*Plan size*	*21 m x 20 m*	----
2.	*Building height*	*30m*	----
3.	*Number of storeys above ground*	*9*	----
4.	*Number of basements below ground*	*0*	----
5.	*Type of structure*	*RC frame*	----
6.	*Open ground storey*	*Yes*	----
7.	*Type of building*	*Regular frame with open ground storey*	*IS 1893:2002 Clause 7.1*
8.	*Grade of concrete and steel used*	*M25, Fe415*	----
9.	*Software used*	*SAP2000 V16*	----

S. No.	Specifications	G+9 storey
1.	Slab Thickness	150mm
2.	Beam dimensions	300x230mm
3.	Column dimensions	400x400mm,
4.	Unit weight of concrete	$25kN/m^3$
5.	Live loads	$3kN/m^2$
6.	(a) Sdl	$1.5kN/m^2$
7.	Importance factor	1
8.	Seismic zone	V
9.	Response reduction factor	5

TABLE 1: DATA OF RC FRAME CONSIDERED IN STUDY

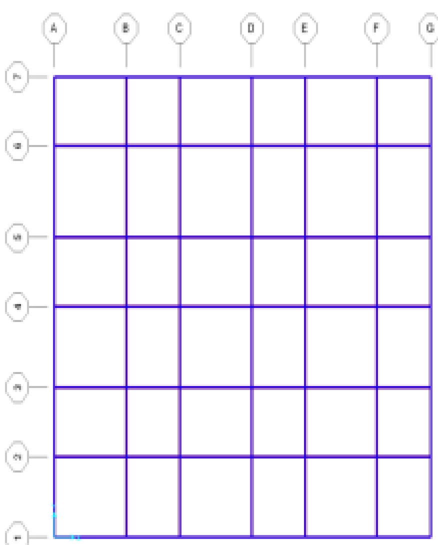

Fig 1: Plan Of Rcc Frame Model

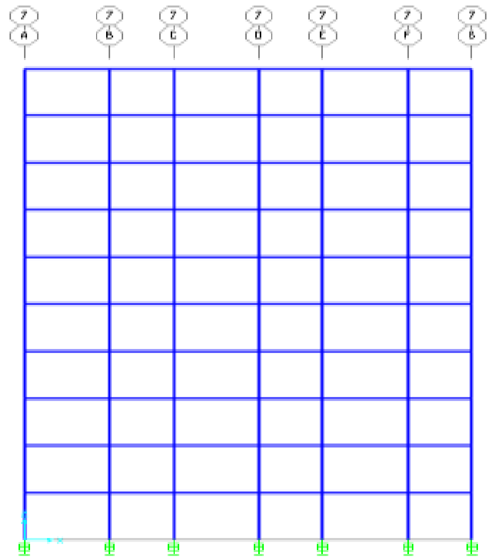

Fig 2: Elevation View Of Rcc Frame Model

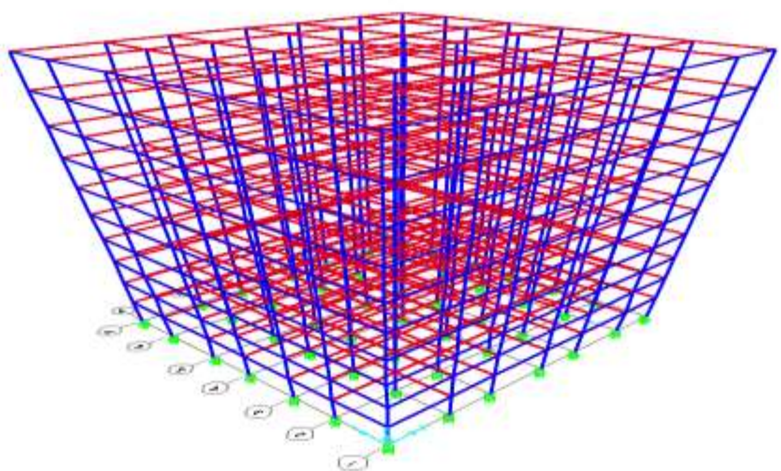

Fig 3: Isometric View Of Rcc Frame Model

BASE ISOLATION

The concept of protecting a building from the damaging effects of an earthquake by introducing some type of support that isolates it from the shaking ground is an attractive one, and many mechanisms to achieve this result have been proposed. As buildings with longer time periods attract less seismic force the isolation system deflects the seismic energy. In particular, high energy in the ground motions at higher mode frequencies are deflected .In buildings, the base isolator protects the structure from earthquake forces in two ways:

(i) By deflecting the seismic energy and

(ii) By absorbing the seismic energy. The seismic energy is deflected by making the base of the building flexible (instead of fixed) in lateral directions, thereby increasing the fundamental time period of the structure.

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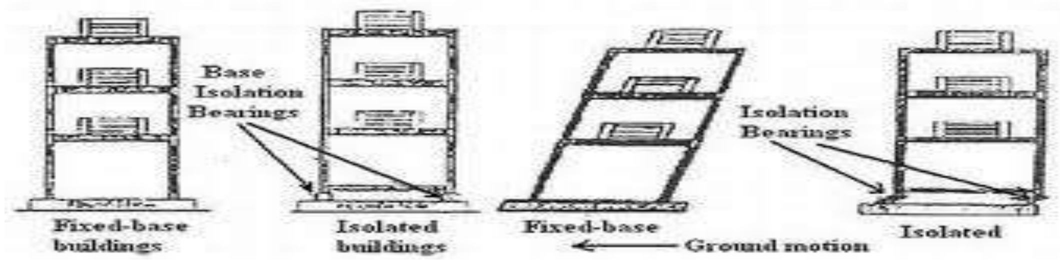

The effective stiffness of the isolator is calculated by, $K_{eff} = \frac{4\pi^2 R}{g T_b^2}$

The yield force is given by $F_y = K_u D_y$.

ANALYSIS RESULTS

The Results obtained are of different parameters such as Storey displacement, Modal Periods etc. The results obtained by carrying out Non-linear static analysis for Buildings as listed.

Result For Non-Linear Static Analysis Of 9 Stories Building

PUSHOVER FOR 9 STOREY			
STOREY LEVEL	**LOAD CASE**	**STOREY DISPLACEMENT ISOLATOR WITHOUT IN mm**	**STOREY DISPLACEMENT WITH ISOLATOR IN mm**
9	PUSH-X	431.9	604.7
8	PUSH-X	429.9	604.4
7	PUSH-X	426.9	603.7
6	PUSH-X	422.6	602.7
5	PUSH-X	414.2	601.3
4	PUSH-X	388.1	599.7
3	PUSH-X	332.1	597.7
2	PUSH-X	253.6	595.4
1	PUSH-X	166.5	592.8
BASE	PUSH-X	78	589.6

Table 2: Showing Displacement In X-Direction For 9 Storey Building

PUSHOVER FOR 9 STOREY			
STOREY LEVEL	**LOAD CASE**	**STOREY DISPLACEMENT WITHOUT ISOLATOR IN MM**	**STOREY DISPLACEMENT WITH ISOLATOR IN mm**
9	PUSH-Y	392.3	606.2
8	PUSH-Y	390	605.6
7	PUSH-Y	386.8	604.7
6	PUSH-Y	382.5	603.5
5	PUSH-Y	374.4	602
4	PUSH-Y	349.7	600.1
3	PUSH-Y	296.7	598
2	PUSH-Y	223.9	595.6
1	PUSH-Y	143.9	593
BASE	PUSH-Y	64.8	589.8

Table 3: Showing Displacement In Y-Direction For 9 Storey Building

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Step	StepNum	time Period without isolator	Time period with isolator
		Sec	sec
Mode	1	0.955058	2.181772
Mode	2	0.951113	2.18072
Mode	3	0.861339	2.015096
Mode	4	0.316245	0.452162
Mode	5	0.314956	0.450839
Mode	6	0.286143	0.404495
Mode	7	0.185252	0.224906
Mode	8	0.184371	0.223754
Mode	9	0.169922	0.205859
Mode	10	0.131856	0.149702
Mode	11	0.131316	0.14898
Mode	12	0.121162	0.137592

Table 4: Showing Time Periods For 9 Storey Building

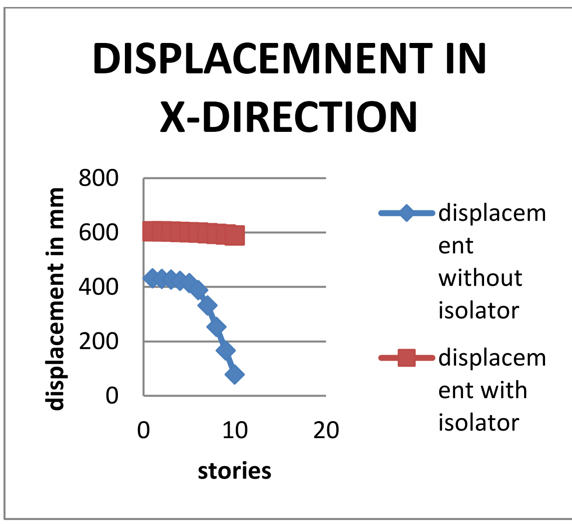

Fig 4: Displacement in x –direction

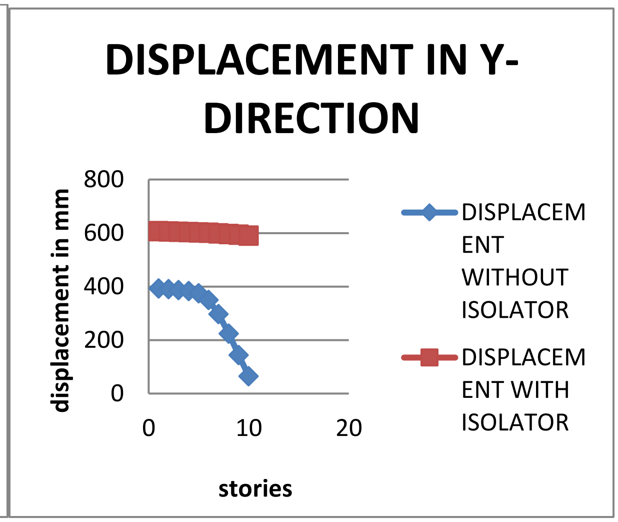

Fig 5: Displacement in y –direction

TABLE 5: SHOWING TIME PERIOD FOR 9 STORIES BUILDING

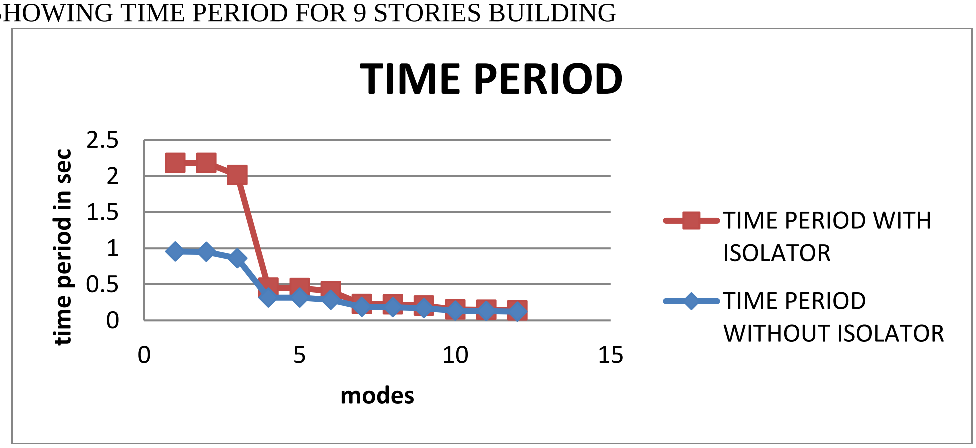

Fig 6: Time Period Of 9 Stories Building

CONCLUSIONS

The nonlinear static (Pushover) analysis as introduced byATC-40 has been utilized for the evaluation of an existing reinforced concrete building frame, in order to examine its applicability. Potential structural deficiency in RC frame, when subjected to a moderate seismic loading.

- The pushover analysis is a useful tool for accessing in elastic strength and deformation demands and for exposing design weakness. The pushover analysis is a relatively simple way to explore the nonlinear behavior of buildings.
- Sequence of formation of plastic hinges (yielding) in the frame members can be clearly seen in the beams only. The building clearly behaves like the strong column- weak beam mechanism.
- Looking at the deflected shape the highest inelastic roof displacement of 234 mm was observed as the structure is about to reach its ductile limit (Collapse Prevention), where significant strength loss begins.
- The storey drifts were decreased by 97% for nine storey symmetric building suggesting the effectiveness of Base Isolators for Buildings.
- Most of the present structural systems are highly advanced in terms of structural efficiency and aesthetic quality, but lacks the much needed geometric versatility. As we have seen, that base isolation has in addition to strength and aesthetics, that extra quality of geometric versatility, making it the most suited structural system to this respect. Thus the base isolation, with an optimal combination of qualities of aesthetic expression, structural efficiency and geometric versatility is indeed the language of the modern day builder.

SCOPE FOR FURTHER STUDY

- Further studies can be done to compare the accuracy of non-linear pushover analysis and non-linear time history analysis taking the displacement as a common parameter.
- Further studies on the effect of various lateral load patterns (such as uniform building code, Indian code, SRSS and FEMA-273) utilized in pushover analysis can be done.
- Soil structure interaction has always attracted many researchers as an interesting topic for static procedures. The same can also be done for non-linear time history analysis using soil structure interaction.

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