Base Isolation System for Multi Storied Building

P. V. Auti[1] U. R. Kawade[2]
[1]ME Structure Student [2]Professor & Head
[1,2]Department of Civil Engineering
[1,2]Padamshri Dr. Vitthalrao Vikhe Patil Collage Of Engineering, Ahmednagar

Abstract— Earthquakes are the one of the natural greatest hazards, throughout historic time they have caused significant loss of life and several damage to property, especially manmade structures. To avoid this hazard research on the structural dynamics are study on the isolators . This base isolation techniques to protects structures against damage from earthquake attacks. Over the period of the time the research on structural dynamics, study and analysis are carried on using series of earthquake movement by means of varying the seismic intensity. As per the analysis with effective of isolated structure. It was discovered that the isolators minimizes the lateral load imposed on the structure and in accordance to that it also tends to reduce the sizes of the building components. Some basic benefits pertaining to use of base isolation are increase in durability of structures by improving its flexibility and reducing the lethal consequences that may tends to abide by the structure. Base isolation limits the effects of the earthquake attack, a flexible base largely decoupling the structure from the ground motion, and the structure response accelerations are usually less than ground acceleration. Here we take a detailed glance at the designing, working, testing as well as the suitability of the base isolation design .The mathematical model of base isolation system and fixed base system its conclude that for isolation building reduces the sizes of structural member , analyze the building upto 9th stored with isolators are provided to base of the structure.

Key words: Base isolation, Non linear analysis, Ductility, Zone factor, Response spectra, Soil factor, ATC-58, Importance factor, ICBO

I. INTRODUCTION

IN order to design a structure to resist wind and earthquake loads, the forces on the structure must be specified. The seismic performance objectives implicit in United States building codes currently differ for fixed-base and base-isolated buildings. As an example, fixed-base buildings are permitted a force reduction factor R of up to eight, which may allow signifi- cant inelastic action in the design basis earthquake and can be interpreted as a “life safety” performance objective. Likewise, isolated buildings are limited to R factors no larger than two, and remain essentially elastic due to overstrength. The reduced R fac- tor, together with other requirements, may be interpreted as seek- ing a performance objective more comparable to “immediate occupancy” or “operational” (SEAOC 1995). Consequently, the superstructure design forces in an isolated building are sometimes larger than in a comparable fixed-base building. This paper describesthe camparison between fixed base and base isolation building, for the analysis purpose a three story reinforced concrete framed structure is selected for this mathematical model can be used to analyze the reinforced concrete buildings under wind and earthquake loads.

The objective of this paper is to study the comparison of fixed base and base isolation building. . A comparative performance measure (CPM) was developed to assess relative response quantified by structural drift and acceleration of the comparable isolated and fixed-base buildings. the design yield acceleration *Ay* and the relative response of fixed-base and isolated buildings responding with the same ductility are compared.

II. MATERIAL PROPERTIES

In India the design of Inelastic Reinforced concrete buildings are based on IS 456, IS 1893 & IS 875 and ATC-58. A typical value of concrete compressive strength(fck) and reinforcing yeild stress(fy) is 25 N/mm² & 415 N/mm². The concrete modulus elasticity(E) 25000 N/mm² and shear modulus(G) 9615.38 N/mm² were taken in the design consideration.

III. LOADINGS

There are two types of loads that are considered in this study; i) Gravity load ii) Lateral load. Gravity loads carried the dead load and live load while lateral loads considered wind and earthquake loads.

A. Gravity load

This loading represents all tributary dead loads and live loads. The dead load included cladding and concrete self weight with concrete density equal to 25kN/m³. Based on IS 875:1987 (part3) the live load was taken as 3.0kN/m² for building which is categorized under institutional occupancy class. The loads were distributed uniformly on all beams between of column lines.

B. Lateral load

In order to performance of wind and earthquake loads on the reinforced concrete buildings, the static lateral loads of wind and earthquake forces were analysed.

IV. ANALYSIS PROCEDURE

A. Calculation of Earthquake loads

In equivalent lateral force procedures the magnitude of force is base on an estimate of the fundamental period and on the distribution of force, as given by the simple formulas appropriate for regular buildings using IS: 1893 (Part 1)-2002. The total design lateral force or design seismic base shear (VB) along any principal direction shall be determine by the following expression.

$$VB = Ah\ W$$

Where, Ah = Design horizontal seismic coefficient, W = Seismic weight of the building.

The design horizontal seismic coefficient (Ah) is given by

$$Ah = (Z/2).(I/R).(Sa/g)$$

Where, Z = Zone factor (Table No.2), for zone-III Z = 0.24, I = Importance factor, R = response reduction factor and Sa/g = Average response acceleration coefficient. The fundamental natural period (Ta) is taken for moment resisting frame building without brick infill panels as

$$\omega_s = \sqrt{\frac{k}{m}} \quad T_s = \frac{2\pi}{\omega_s}$$

$$\omega_b = \sqrt{\frac{k_b}{m+m_b}} \quad T_b = \frac{2\pi}{\omega_b}$$

where The characteristic natural vibration frequencies and periods of the fixed-base building (ws, Ts) and the isolated building (wb, Tb) are given by

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{j-1}^{n} W_j h_j^2}$$

where, Qi = Design lateral force at floor i, Wi = Seismic weight of floor i, hi = height of floor i measure from base, and n = Number of stories.

B. *Calculation of Wind loads*

1) *Static method*

The basic wind speed (Vb) for any site shall be obtained IS 875 (part 3) and shall be modified to get the design wind velocity at any height (Vz) for a chosen structure.

$$Vz = Vb\, k_1\, k_2\, k_3$$

Where, Vz = design wind speed at any height z in m/s, Vb = Basic wind speed in m/s, k_1 = probability factor (risk coefficient), k_2 = terrain roughness and height factor and k_3 = topography factor.

The basic wind speed map of India, as applicable at 10 m height above mean ground level for different zones of the country selected from the code. The design wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind velocity.

$$Pz = 0.6\, Vz^2$$

Where, Pz = wind pressure in N/m2 at height z and Vz = design wind speed in m/s at height z.

2. In this study, analysis is restricted to single story _i.e., single degree-of-freedom SDOF structures with and without an isolation system subjected to a suite of 20 ground motions.

Number	Site	Magnitude	H	Scale	PGA	PGA
1,2	EI Centro	6.9	10	2.01	0.460	0.675
3,4	EI Centro Array #5	6.5	4.1	1.01	0.393	0.487
5,6	EI Centro Array#6	6.5	1.2	0.84	0.301	0.234
7,8	Barstrow Vineyard	7.3	36	3.20	0.421	0.425
9,10	Yermo fire sta	7.3	25	2.17	0.519	0.360
11,12	Gil roy Array#3	7.0	12	1.79	0.665	0.968
13,14	Newhall fire sta	6.7	6.7	1.03	0.677	0.565
15,16	Rine=alai rec sta	6.7	7.5	0.79	0.533	0.579
17,18	Salmar –olive view	6.7	6.4	0.99	0.569	0.816
19,20		6.0	6.7	2.97	1.018	0.985

The parameter t shift gives the separation between the isolation period and the superstructure period

T (shift)=T(isobase)-T(fixed)

Period for fixed base is meaning full for short period (0.01s)to long period of superstructure(2s). for a given superstructure period, the isolation period increases then period shift increases. Thus, a larger period shift is synonymous with a more effective isolation system. In the present study, values of Tshift from 1.5 to 4 are considered. The equations governing the motion of the isolated building eq. 1 in matrix form

$$\begin{bmatrix} m_b+m & m \\ m & m \end{bmatrix} \begin{Bmatrix} \ddot{u}_b \\ \ddot{u}_s-\ddot{u}_b \end{Bmatrix} + \begin{Bmatrix} 0 \\ c_s\cdot(\dot{u}_s-\dot{u}_b) \end{Bmatrix} + \begin{Bmatrix} f_b(u_b) \\ f_s(u_s-u_b) \end{Bmatrix} = -\begin{Bmatrix} m_b+m \\ m \end{Bmatrix} \ddot{u}_g$$

……..1

u g=ground acceleration

ub= deformation of the isolation system.

(us−ub)=relative deformation or drift

For the normalised strenth design parameter define

After putting the value of $U_{b=\dot{u}b=\ddot{u}}b=0$ we gettimg the eq no,2

$M\ddot{u}_s + C_s\dot{u}_s + F_s(U_s) = -M\ddot{u}_g$……………………..2

The acceleration histories for the 10% in 50 year event in Los Angeles are selected for this study, referred to hereafter as the SAC-LA 10 in 50 suite. The suite consists of ten pairs of orthogonal motions, of which all 20 components are singly applied in that project. Although the SAC-LA suite is not meant to be explicitly characteristic of near-fault motions, several of the motions were recorded within 10 km of the fault. Essential characteristics of the recorded motions are listed in Table 1, including the site, the earthquake, and magnitude, the closest distance to fault rupture *H*, the amplitude scale factor, and the peak ground acceleration PGA for each component after scaling.

C. *Effective Characterization of Isolation System*

If suppose the structure is rigid the total deformation will be zero

Put that condition in eq.1 we get

$(m+m_b)\,\ddot{u}_b + f_b(k_i, u_b, \dot{u}_b) = -(m+m_b)\ddot{u}_g$……..3

Bilinear force deformation f_b for SDFS is

$Fb = Kb.Ub + Qz(ai, ub, \dot{u}b)$………..4

Introducing Eq.4 for *fb* into Eq. 3 and dividing by the total mass *m+mb* leads to

$$\ddot{u}_b + \omega_b^2 u_b + \frac{Q}{W} gz(k_i, u_b, \dot{u}_b) = -\ddot{u}_g$$

……………5

Q□*W*=characteristic strength ratio(isolation system strength)

Characterization leads to appropriate selection of the nonlinear parameters of the isolation system considering the intensity of the ground motion. Sayani and Ryan _2009_ have proposed that the isolation system be characterized by the isolation period *Tb* and normalized strength , defined as

$$\eta = \frac{Q}{m\omega_b \dot{u}_{go}}$$ …………………………6

Q□*W* varies with the isolation period *Tb*.

At representative ground motion intensities, _ is recommended to range from 0.2 to 0.8 Using the median value of *u go*=77.1cm□□s for the SAC-LA 10 in 50 suite

Q□*W* ranges from 0.05 to 0.2 for *Tb*=2 s and From 0.025 to 0.1 for *Tb*=4 s.

The range of *Q*□*W* could vary with differing peak ground velocity for other ground motion suites.

D. *Superstructure Strength and Ductility*

Deformation ductility _ and force reduction factor R are mathematically defined and interpreted for meaningful comparative response analysis of fixed-base structures and isolated superstructures.

Deformation ductility is defined as the ratio of the deformation to the yield deformation of the system

$$\mu = \frac{(u_s - u_b)}{u_y}$$ ………………………..7

alternative and more commonly used intensity to strength measure is the previously mentioned force reduction factor *R*, relevant only for inelastic systems

R= f_o / f_y………………………………8

where *fo*=peak force if the superstructure were to remain elastic

The value of *R* is considered to be 1 for linearly elastic systems and greater than 1 for inelastic systems. Prescribed *R* values are lower for isolated buildings compared to fixed-base buildings, which limits superstructure ductility but leads to larger base shear demands.

E. *Analysis Results*

1) *Constant Ductility Spectra*

Median constant ductility spectra—responses at specified values of ductility—are generated for both fixed-base and isolated systems.

In present study, analysis of muiltistorey building in moderate zones for wind and earthquake forces is carried out. Here the buildings situated and earthquake zone III are taken for analysis .3-D models are prepared for G+3, multistorey building. Building has typical plan size 24m×09m.Fig.1 shows position of beams and columns in plan of building for all the floors.

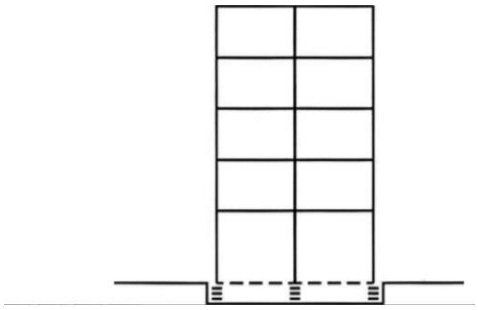
The basic parameters considered for the analysis.
Typical storey height: 3m
Foundation: column is fixed at support
Slab depth: 150 mm thick
Live load : 3 kN/sq m
Floor finish load: 1 kN/ sq m

Earthquake parameters considered
Zone: III
Soil type: Medium soil
Importance factor: 1.5
Seismic zone factor: 0.16 for zone III

Wind parameters considered
Zone: II
Basic wind speed: 39 m/s
Terrain category: 2
Risk coefficient: 1
Topography factor: 1

Base Isolation

Isolator at the base of the structure



Isolator at the base of the structure

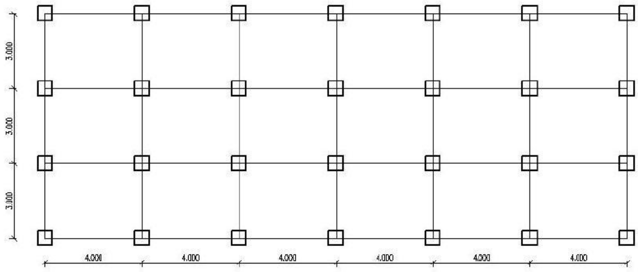


Fig. 1: Plan of Building

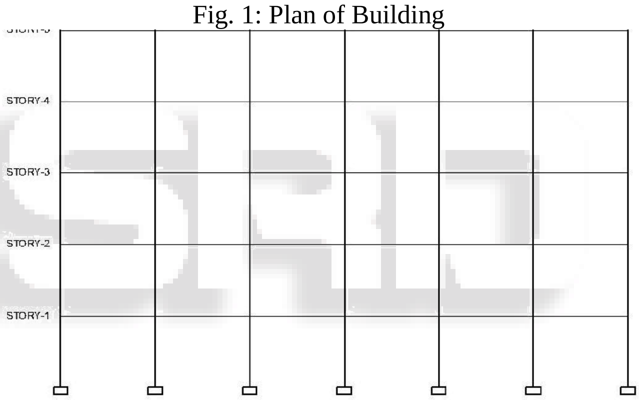
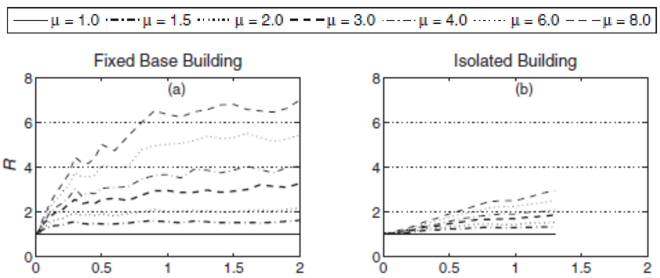


Fig. 2: Elevation in 2D

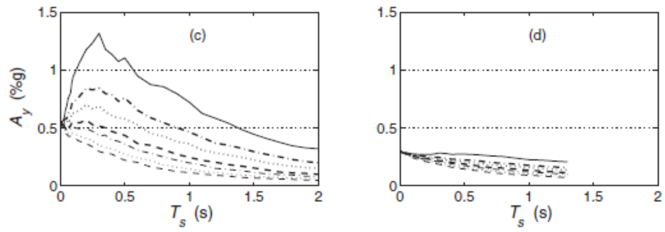
V. ANALYSIS RESULTS

The parameter ranges considered in this study are as follows
Ts=0–2 s,
Ductility _=(1,1.5,2,3,4,6, and 8),
*T*shift =1.5,2,3, and 4, and
Normalized strength _= 0.2, 0.4, 0.6,and 0.8.

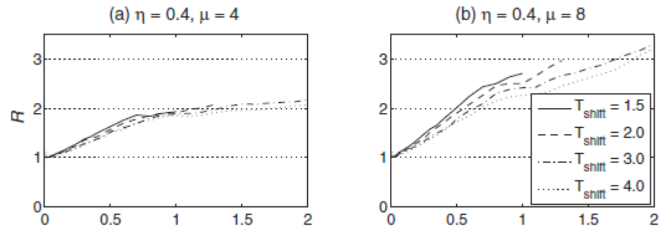
To ensure that the period shift is sufficient to lead to an effective isolation system, the range of *Ts* for isolated buildings is constrained by the requirement



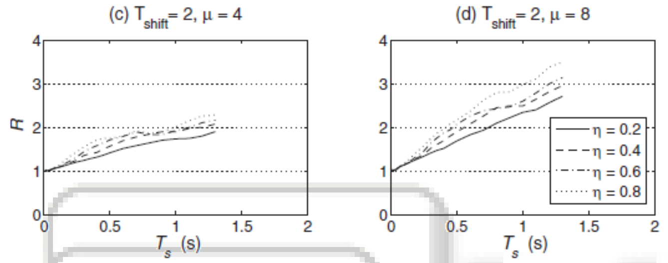
Constant ductility spectra for a and b force reduction factor *R*



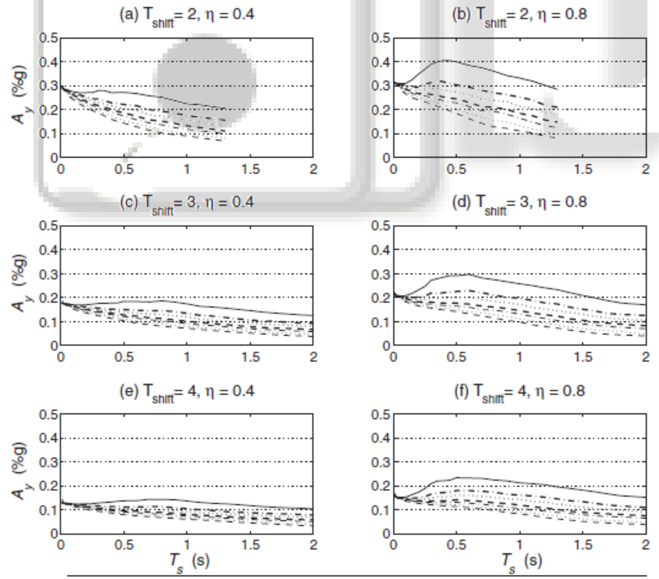
Constant ductility spectra for c-d yield acceleration spectra *Ay*. Spectra are shown for fixedbase buildings and base-isolated buildings with *T*shift=2 and _=0.4.



Influence of T_{shift} on R for: (a) μ=4; and (b) μ=8;



influence of η on R for (c) μ=4; and (d) μ=8



Yield acceleration spectra *Ay* for isolated buildings with _=0.4 and: _a_ *T*shift=2.0; _c_ *T*shift=3.0, _e_ *T*shift=4.0; and with
_=0.8; _b_ *T*shift=2.0; _d_ *T*shift=3.0, and _f_ *T*shift=4.0

VI. Conclusion

Response history analysis results have demonstrated that given comparable ductility, force reduction factors *R* in base-isolated buildings are smaller than in fixed base buildings, but superstructure design forces in isolated buildings can still be reduced considerably. Also, at the same superstructure ductility, isolated buildings showed greatly enhanced performance with respect to superstructure deformation and total acceleration demands. Thus, isolated buildings designed to reduced strength, which is expected to correlate to reduced design costs, still outperform fixed-base buildings.

Reference

[1] Applied Technology Council _ATC_. _2007_. "Guidelines for seismic performance assessment of buildings 35% complete"
[2] Chopra, A. K. _2007_. Dynamics of structures: Theory and applications to earthquake engineering, 3rd Ed., Prentice-Hall, Upper Saddle River, N.J.
[3] International Conference of Building Officials _ICBO_. _1991_. Uniform building code, Whittier, Calif.
[4] Lin, A. N., and Shenton, H. W., III. _1992_. "Seismic performance of fixed-base and base-isolated steel frames." J. Eng. Mech., 118_5 921–941
[5] Ryan, K. L., Morgan, T. A., and Sayani, P. _2006_. "Consistent performance comparison of seismic-isolated and fixed-base buildings." Proc., 8th U.S. National Conf. of Earthquake Engineering, San Francisco, Earthquake Engineering Research Institute, Oakland, Calif.Paper No. 1617.
[6] P. Agarwal, M. Shrikhande, Earthquake resistance design of structures, PHI learning Pvt. 2012
[7] IS 456:2000, "Indian Standard plain and reinforced concrete-Code of Practice", Bureau of Indian Standards, New Delhi, 2000.
[8] IS: 1893, Criteria for earthquake resistant design of structures - general provisions for buildings: Part 1, Bureau of Indian Standards, New Delhi, India, 2002.
[9] IS: 875 (Part 1), "Indian Standard Code of Practice for design loads for building and structures, Dead Loads" Bureau of Indian Standards, New Delhi.
[10] IS: 875 (Part 2), "Indian Standard Code of Practice for design loads for building and structures, Live Loads" Bureau of Indian Standards, New Delhi.
[11] IS: 875 (Part 3), "Indian Standard Code of Practice for design loads (Other than earthquake) for building and structures, Wind Loads" Bureau of Indian Standards, New Delhi.