STUDY ON SEISMIC BEHAVIOUR OF RC FRAME VERTICALLY ASYMMETRICAL BUILDINGS

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Abstract : *Reinforced concrete framed building may be balanced and may be irregular. In every type of building earthquake gives vary bad impact. The balanced building is more stronger then irregular buildings. RC framed building consists of frame with flexible joint and bracing member.*

As structural design RC multi-storied buildings are very difficult to model. The latest version of code IS: 1893-2002 say that three – dimensional systems is used to analyzed all type of building and multi-storied buildings. This is fact that most of the buildings have asymmetry in plan and elevation, due to this in seismic performance it gives bad influence and effect. Vertical irregularity of RC Buildings is discuses in this paper. ,we study to evaluate the response of all type of vertical irregular RC Buildings dynamically an and analysed the persuasion parameters which can control the reaction on Base shear irregular distribution of mass ,stiffness and strength or due to irregular geometrical configuration a structure is called irregular structure. A story in a building having mass irregularity more than 200% of adjacent story, we call it irregular building. If stiffness of a storey is 60% of the adjacent storey; that case we say the storey is 'weak storey ', and if it is less than 70% of the storey it is 'soft storey'. Due to functional and aesthetic requirements there are many building (church, temple, hospital) which contain different irregularly. There is major function of open space, if no more open place is there, then we make multi-storey building. to short out the problem of open space. However, past earthquake records shows vary bad seismic effect on these structures. The seismic codes (,IS 4326:1993, IS 1893: 2002,EC8:2004,UBC 1997,NBCC 1989, etc Unawareness of the asymmetry condition). In reinforced concrete (RC) frame structures beam and column elements built in such a way they resist the two seismic and gravity loads. The failure of this member to take the weight starts to break of the structure. Collapse capacity of structure under seismic excitation has always been a essential condition determining performance of structure. The field of vertically uneven type of building is now accept a lot of concern in seismic analysis. Several structures are constructed with vertical irregularity for architectural appearance. Important change in firmness and toughness vertical irregularity appear in the buildings. Open ground storey (OGS) is a case of vertically irregularity. The common OGS and stepped types of buildings along with different shape of structure, for designing these structure different magnification factors are well chosen in process study adopting Equivalent static Analysis and response spectrum analysis. For analyzing of the OGS magnification factors (MF) are advised by the design codes.

Keyword: Seismic performance, RC Building, Vertical irregularity, soft story, response spectrum analysis.

1. INTRODUCTION:

Structure failure occurs at points of weakness during an earthquake. This weakness arises due to discontinuity in mass, stiffness and geometry of structure. All Irregular structures having this discontinuity. A large portion of urban infrastructure contributes irregular structures. One of the major reasons of failures of structures during earthquakes are vertical irregularities. Soft storey structures are the example of structures which collapsed. So, the effect of vertically irregularities in the seismic performance of structures becomes really important. Height-wise changes in stiffness and mass render the dynamic characteristics of these buildings different from the regular building. IS 1893 definition of Vertically Irregular structures. The irregularity in the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of building. When such buildings are constructed in high seismic zones the analysis and design becomes more complicated.
There are two types of irregularities-

1.1 Horizontal Irregularities.

a) Asymmetrical plan shape
b) Re-entrant corners
c) Diaphragm Discontinuity
d) Irregular distribution

1.2. Vertical Irregularities.

a) Stiffness Irregularity
b) Stiffness Irregularity
c) Mass Irregularity
d) Vertical Geometric Irregularity
e) In-Plane Discontinuity in Vertical Elements Resisting Lateral Force.
f) Discontinuity in Capacity

II PRESENT RESEARCH STATUS

Open ground storey building frames designed with various MFs (Magnification factor) and stepped irregular frames with different infill configurations, and having heights (3 stories) are considered for the present study. We take for observation non-ductile RC frame having a 3 storey 2 bay open ground- storey building. We observed that in the presence of masonry infill at the upper floor of the building the stiffness of the building increases as the total storey shear force increases. Because formation of hinges the failure is formed due to soft storey mechanism occur in ground storey columns and the bending moments in the ground floor columns increase. Base shear for OGS building a multiplication factor was proposed. The modelling the stiffness of the infill walls in the analysis was focused. The effect of in Multiplication factor with the increase in storey height was studied. We observed as the number of storey increases from three to six the multiplication factor ranging from 1.5to1.86. We observed for load transferring assemblies the steel cage-to-RC footing connection and brace-to-steel cage connection exhibited excellent performance under lateral cyclic loading without any sign of failures. Whereas compared to the non-ductile frame only steel caging RC frame strengthened and improved lateral strength, movement capacity and energy dissipation potential but it could not avoid collapse completely. For OGS buildings the effect of the infill wall is studied considering the Indian standard code IS 1893 2002 criteria Equivalent Static Analysis and Response Spectrum Analysis is used to study. We observed that both method gives same result and if time history is not present response spectrum gives fairly results.

III EXPERIMENTAL PROCEDURE SEISMIC ANALYSIS:

Seismic analysis:

Is a major tool in earthquake engineering which is used to understand the response of buildings due to seismic excitations in a simpler manner. In the past the buildings were designed just for gravity loads and seismic analysis is a recent development. It is a part of structural analysis and a part of structural design where earthquake is prevalent.

There are different types of earthquake analysis methods. Some of them used in the project are-

1. OGS Building

2 Equivalent Static Analyses

1.1 Calculation of design horizontal seismic coefficient

The total design seismic base shear (*VB* along any principal direction shall be determined by following expression.

V A W B h = * (1)

Where, W is the total weight of the building calculated using the structural

Details and *Ah* is calculated as shown below:

$$A_h = \left(\frac{Z}{2}\right) * \left(\frac{I}{R}\right) * \left(\frac{S_a}{g}\right)$$

Where, *Z* is zone factor, *I* is Importance factor, *R* is response reduction factor and Sa/*g* is spectral acceleration coefficient.

1.2 Design lateral force at each floor i

The design lateral force, *Vb* shall be distributed along the height of the building

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

Where, *Q i* = Design lateral force at floor i
W i = Seismic weight of floor i
h i = Height of floor I measured from base and
n = Number of storeys in the building

3. Response Spectrum Analysis Outline:

- Building Detail
- Mass, Stiffness and Damping Matrix
- Dynamic Equilibrium Equation
- Decoupling of Equation of Motion
- Modal Response From Spectrum
- Total Response at Floor

Generation of Mass Matrix, Stiffness Matrix, Damping Matrix

Mass Matrix:

$$\begin{bmatrix} m_1 & 0 & 0 \\ 0 & m_2 & 0 \\ 0 & 0 & m_3 \end{bmatrix}$$

Stiffness Matrix:

$$\begin{bmatrix} k_1+k_2 & -k_2 & 0 \\ -k_2 & k_2+k_3 & -k_3 \\ 0 & -k_3 & k_3 \end{bmatrix}$$

Damping Matrix:

$$\begin{bmatrix} c_1+c_2 & -c_2 & 0 \\ -c_2 & c_2+c_3 & -c_3 \\ 0 & -c_3 & c_3 \end{bmatrix}$$

Dynamic Equilibrium Equation

$$M\ddot{U} + C\dot{U} + KU = F(t)$$
$$M\ddot{U} + C\dot{U} + KU = -M[\ddot{U}g\{1\}] \qquad U=U(x,t)$$

For decoupling the equation

$$U(x,t) = \emptyset(x)q(t)$$
$$M\emptyset\ddot{q} + C\emptyset\dot{q} + K\emptyset q = -M\ddot{U}g\{1\}$$

Pre multiply with $\emptyset^T$

$$\emptyset^T M\emptyset\ddot{q} + \emptyset^T C\emptyset\dot{q} + \emptyset^T K\emptyset q = -\emptyset^T M\ddot{U}g\{1\}$$

Due to modal orthogonality, M, C, K matrices will become diagonal matrices

$$\begin{bmatrix} m_{11} & 0 & 0 \\ 0 & m_{22} & 0 \\ 0 & 0 & m_{33} \end{bmatrix}\begin{Bmatrix} \ddot{q}_1 \\ \ddot{q}_2 \\ \ddot{q}_3 \end{Bmatrix} + \begin{bmatrix} C_{11} & 0 & 0 \\ 0 & C_{22} & 0 \\ 0 & 0 & C_{33} \end{bmatrix}\begin{Bmatrix} \dot{q}_1 \\ \dot{q}_2 \\ \dot{q}_3 \end{Bmatrix} + \begin{bmatrix} K_{11} & 0 & 0 \\ 0 & K_{22} & 0 \\ 0 & 0 & K_{33} \end{bmatrix}\begin{Bmatrix} q_1 \\ q_2 \\ q_3 \end{Bmatrix} = \begin{Bmatrix} m_1^1 \\ m_2^2 \\ m_3^3 \end{Bmatrix}\ddot{U}g$$

The decoupled equations are

$$m_{11}\ddot{q}_1 + c_{11}\dot{q}_1 + k_{11}q_1 = -m_1^1\ddot{U}g = P_1$$
$$m_{22}\ddot{q}_2 + c_{22}\dot{q}_2 + k_{22}q_{22} = -m_2^1\ddot{U}g = P_2$$
$$m_{33}\ddot{q}_3 + c_{33}\dot{q}_3 + k_{33}q_{33} = -m_3^1\ddot{U}g = P_3$$

Divide the equation by mass,

$$\ddot{q}_1 + \frac{c_{11}}{m_{11}}\dot{q}_1 + \frac{k_{11}}{k_{11}}q_{1=} -\frac{m_1^1}{m_{11}}\ddot{U}g$$
$$\ddot{q}_1 + 2\xi_1\omega_1\dot{q}_1 + \omega_1^2 q_{1=} -P_1\ddot{U}g$$

Generalizing,

$$\left.\begin{aligned} m_{ii}\ddot{q}_i + c_{ii}\dot{q}_1 + k_{ii}q_i &= -m_i^1\ddot{U}g \\ \ddot{q}_i + 2\xi_i\omega_i\dot{q}_i + \omega_i^2 q_{1=} &-P_i\ddot{U}g \end{aligned}\right\} \quad i=1,2,3........n$$

Where P_i is participation factor

$$P = \frac{\emptyset^T M\{1\}}{\emptyset^T M\emptyset}$$

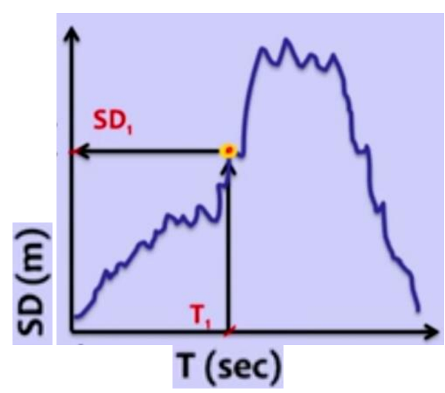
Modal Response from Spectrum

Maximum displacement is more important for calculating the Design forces.

Hence from Response Spectrum.

$$\ddot{q}_i + 2\boldsymbol{\xi_i\omega_i}\dot{q}_i + \omega_i^2 q_{1=} -P_i\ddot{U}g$$

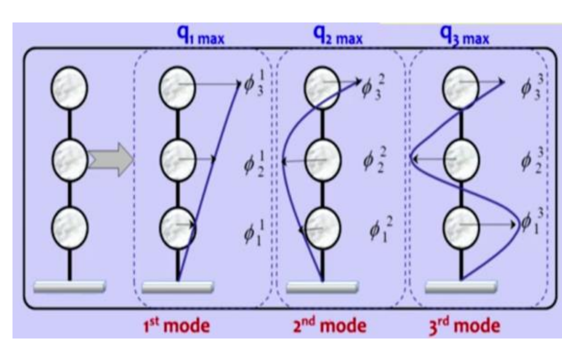
$$=> |q_{i\,(t)}|_{max} = P_i SD(\omega_{i,}\xi)$$



Spectral Displacement (SD) is for complete earthquake but the particular participation in the total response of the building. Therefore, the amount of displacement in one mode is given by:

$$`|U_{ij\,(t)}|_{max} = P_i\emptyset_j^i SD(\omega_{i,}\xi)$$

Where j represent the floor and i represent the mode.



Total Response at Floor:

As the maximum values do not occur at a same time instant, the cannot be added. There are two methods for obtaining total response.

- CQC method (Complete Quadratic combination)
- SRSS Method (Square root of sum of square)

We use SRSS Method

SRSS Method:

This method is used when first Eigen value is 30 and second value may be 40, 50, 60.

$$U_j = \sqrt{(U_{1j})^2 + (U_{2j})^2 + (U_{3j})^2}$$

$$U_j = \sqrt{(P_1 Ø_j^1 SD_1)^2 + (P_2 Ø_j^2 SD_2)^2 + (P_3 Ø_j^3 SD_3)^2}$$

$$U_1 = \sqrt{(P_1 Ø_1^1 SD_1)^2 + (P_2 Ø_1^2 SD_2)^2 + (P_3 Ø_1^3 SD_3)^2}$$

$$U_2 = \sqrt{(P_1 Ø_2^1 SD_1)^2 + (P_2 Ø_2^2 SD_2)^2 + (P_3 Ø_2^3 SD_3)^2}$$

$$U_2 = \sqrt{(P_1 Ø_3^1 SD_1)^2 + (P_2 Ø_3^2 SD_2)^2 + (P_3 Ø_3^3 SD_3)^2}$$

Data we assume:

- 3Storeyed building
- Location- Himachal Pradesh (Zone IV)
- Soil Type- Medium Soil
- Purpose: Residential
- Structure type- Ordinary Moment Resisting Frame Without Infill.
- Storey Height- 3m
- Column Dimensions : 230mm X230mm
- Beam Dimensions : 230mmX230mm
- Slab Dimensions : 6mX6m
- Number of column : 9
- Number of Beam: 6
- Unit Weight of Concrete: 25KN/m^3
- Live Load is 2KN/ m^3\
- Thickness of slab 100mm

That data is used for Equivalent Static Analysis and Response Spectrum Analysis.

IV RESULTS

Equivalent Static Analysis

U_1	U_2	U_3
0.481	−1.025	0.804
0.845	−0.161	−1.204
1.000	1.000	1.000

Since natural frequencies are distinct, SRSS method of modal combination can be used. In such case, maximum displacement response of the structure is 0.357m

Response spectrum analysis

$U_1 = 1.489m$
$U_2 = 2.462m$
$U_3 = 3.100m$

In such case, maximum displacement response of the structure is 3.100m

CONCLUSION

- The Response spectrum may give fairly good results, when maximum displacement and maximum forces might occur on the structure.
- If time history is available Time history Response is done for critical structure,.
- In multi-storey buildings maximum displacement occur in topmost storey.
- In multi-storey buildings torsion moment also exist.
- Vertical stiffness irregularity at a storey in a building causes increase in storey movement, while buildings without stiffness irregularity perform well for lateral loads.
- Base shear will increase when the zones changes from II to V and soil stratum III to I in Equivalent Static method as well as Response Spectrum method.

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