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Seismic Evaluation and Retrofitting of R.C. Building by using Pushover Analysis

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Abstract: In India mainly the need of seismic evaluation and retrofitting of the reinforced concrete building, because the past earthquakes in which many reinforced concrete structure where severely damaged. Seismic evaluation of existing building has become very important. Seismic evaluation eventually leads to retrofitting of the damage building. Pushover analysis and evaluation of performance of building using maximum base shear and maximum story displacement.
A nonlinear static pushover analysis as described in ETAB2015 is carried out an existing Biyani Science college, Amravati built in 2000. The subject college building is a G+2 story, irregularity structure. The building analysed for zone lll.
Keywords: Seismic evaluation, Retrofitting, Non-linear static analysis.

I. INTRODUCTION

The strengthening and embellishment is adapted of damage reinforced concrete building or the reinforced concrete building as a whole is referred to as retrofitting. The main aims of a retrofitting is the structural strengthening of the reinforced concrete building before or after an earthquake predefined performance. The proposed work consist of seismic evaluation and retrofitting of the reinforced concrete building.

II. LITERATURE SURVEY & REVIEW

Damages caused by recent earthquakes have exposed the vulnerability of buildings in India. Many of existing buildings these will be found to lack compliance with the current codes of practice, especially in terms of earthquake resistance. This is partly attributable to the increased seismic demand and up-gradation of some seismic zones in the country. The degree of seismic vulnerability (risk of failure) can be ascertained only after a proper structural evaluation. Based on this assessment, proposals can be worked out to retrofit the vulnerable buildings.

The retrofit is required analyses in order to avert potential disaster in the event of an earthquake and can be done in various ways, to various levels.Tanaya Sarmaha, Sutapa Das. (2017) This paper attempts to develop a ward-level hazard map of the city through systematic vulnerability.

Piyoosh Rautela, Girish Chandra Joshi, Suman Ghildiyal (2015) The evaluation is done using rapid visual screening (RVS) technique of FEMA and the likely seismogenic damage is depicted as a function of the damage grades of EMS-98.G Navya, Pankaj Agarwal. (2015) The paper focuses on complete procedure of seismic vulnerability assessment and retrofitting of G+6 RC frame building located in Zone IV.

III. METHODOLOGY

India's national vulnerability assessment methodology, as a component of earthquake disaster risk management framework includes the following procedures:

A. Rapid visual screening (RVS) method requiring only visual evaluation and limited information (Level 1 procedure). This method is recommended for all reinforced concrete buildings.
B. Simplified vulnerability assessment (SVA) method requiring engineering analysis based on information data from visual observations and structural drawings or on-site measurements (Level 2 procedure). This method is recommended for all reinforced concrete buildings with high concentration of people.
C. Detailed vulnerability assessment (DVA) method requiring detailed computer analysis, similar to or more complex than that required for design of a new building (Level 3 procedure). This method is recommended for all important and lifeline for reinforced concrete buildings.

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IV. DETALS AND MODELING OF EXISTING R.C. BUILDING

The structure is G+2 storey reinforced concrete educational institute. The structural drawings for the building are not available and all the features were collected by walk around the building by RVS procedure. The architectural plan of the college is obtained from the administrative office of college. The reinforcement for the structure is assumed as per Indian Standard IS 456 2000 for gravity load only. The ETABS model of the building is as shown in the Fig. 1 Typical height for ordinary storey is 4.0 m. The grade of concrete for complex is assumed to be M20 and grade of steel is Fe415 for longitudinal steel as well as transverse steel.

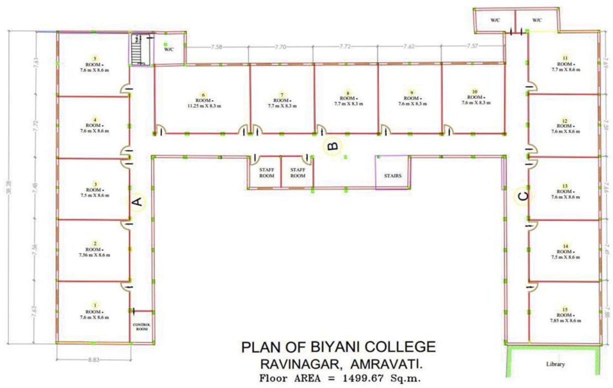

Figure .1 Typical Floor Plan of Biyani College and ETABS Model for Biyani College

The thickness of infill walls as observed at site is 0.23 m. The load of the infill wall is uniformly distributed on the beams and the stiffness of the same is not considered. The slab thickness is assumed to 0.15 m at all storey levels. The dead loads confirming to IS 875 Part-I and Live Load confirming to IS 875 Part-II have been taken in the analysis of building. The sizes of beams and columns have been obtained from site. Knowledge factor is taken as 0.5 as per IS 15988: 2013 . Further Useable Life factor is taken for reducing lateral load as per available life as 0.67 . The importance factor for the building is taken as 1.5. The building configuration check for Biyani College is as shown in the table 1

Sr. No.	Configuration Check	Remark
1	Load Path	No discontinuities observed in load path. Complete load path exists which transfers the inertial forces from the mass to the foundation.
2	Geometry	Plan Irregularity Re-entrant Corners
3	Weak Storey	No weak story
4	Soft Storey	No soft story
5	Vertical Discontinuity	Vertical elements in the lateral force resisting system are continuous to the foundation.
6	Mass	No mass irregularities
7	Torsion	Irregular structure without expansion joints results in torsional mode of vibration.
8	Adjacent Buildings	Not applicable.
9	Short Columns	Short columns does not exist in building.

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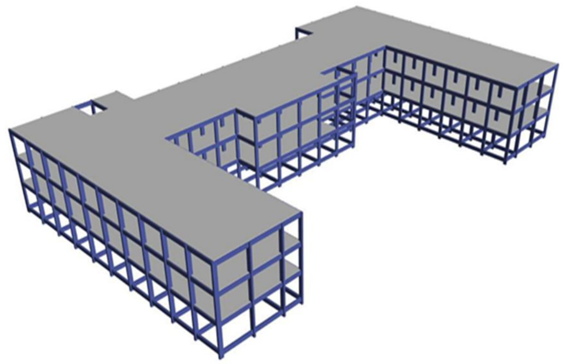

V. DESIGN & IMPLEMENTATION

Pushover Analysis has been done for the G+2 Storey R.C building. The analysis was done in ETABS 2015 and the results are shown below. The maximum base shear for Zone 3 DBE is 3543 kN about Y axis and max. roof displacement is 20 mm in X-direction

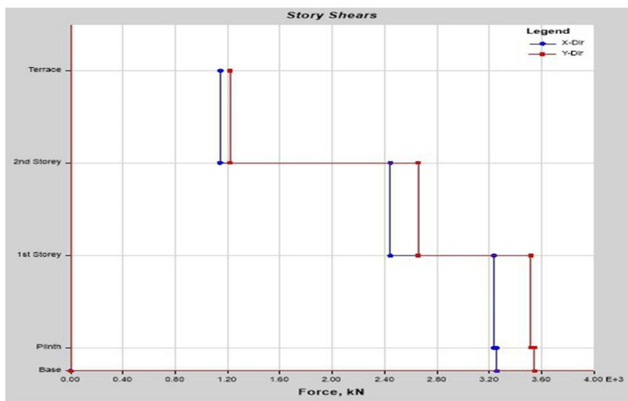

Figure 2. Maximum Storey Displacement

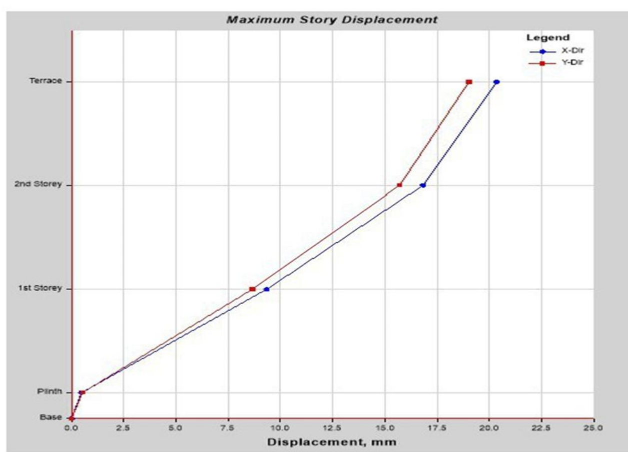

Figure 3. Max Base Shear for Biyani College

Average shear stress in the column at plinth leve= l 1.10 MPa
No. of Columns = 82, No. of Frames = 64
Base shear at Plinth Level = 3520 X 0.67 = 2360 kN and Area of Concrete = 9591000 mm^2.
Since the maximum shear stress allowed = 0.4 MPa. Hence DCR = 2.75,
The check is not satisfied. Check for axial stress in columns due to overturning moment is done as per following equation 4.2. Axial stress limit is 0.25 Fck and DCR = 0.7 is within limits. Hence OK. The is no torsional irregularity in the structure.

Maximum storey displacement at one end 1.01 of the average displacement. Also the maximum drift is within limits laid by IS 1893: 2002.

Now checking for forces in the frame elements at the location of reentrant corners. Max positive moment in beam due to earthquake loading at center = 112 kNm and max negative moment due to earthquake loading near support = 84 kNm. Also capacity of the beam assumed from the gravity load design at center = 150 kNm and capacity near support = 87 kNm. DCR for flexural strength of the beam = 0.96, hence the check is satisfied for beams

Max axial load in column due to earthquake loading = 800 kN and max biaxial moment due to earthquake loading M3 = 170 kNm and M2 = 60 kNm. Capacity of the column assumed from gravity load design is P = 900 kN, M3 = 25 kNm and M2 = 24 kNm. DCR for capacity of column = 2.05, hence, the check is not satisfied. A more detailed evaluation of the structure is performed as nonlinear static analysis to study the effect of re-entrant corners in building.

Performance point parameters for Zone III DBE			
Sr. No	Parameters	PUSH X	PUSH Y
1	Base Shear	7042 kN	6112 kN
2	Roof Displacement	9.8 mm	6.1 mm
3	Spectral Acceleration	0.1g	0.09g
4	Spectral Displacement	7.8 mm	5.3 mm
5	Ductility Ratio	7.6	2.6

Table 2. Performance Point for Biyani College

Since the performance objective achieved here is collapse prevention at a drift of 0.5 %, which shows moderate performance of building in Zone III DBE. The only way to reduce demand on re-entrant corners of such structure is by providing seismic gap or expansion joint of min. 50 mm. Hence the structure cannot be retrofitted.

VI. CONCLUSION

The building considered for study is Biyani Science College which has plan irregularity and re-entrant corners. The demand to capacity ratio for shear stress and forces in frame elements are not satisfied. The performance objective achieved by the structure is collapse prevention. Individual column strengthening is not proposed as approximately 22 no. of columns near re-entrant corners have DCR above 1.0. Seismic gap should be provided to reduce demand on frame elements near re-entrant corners.

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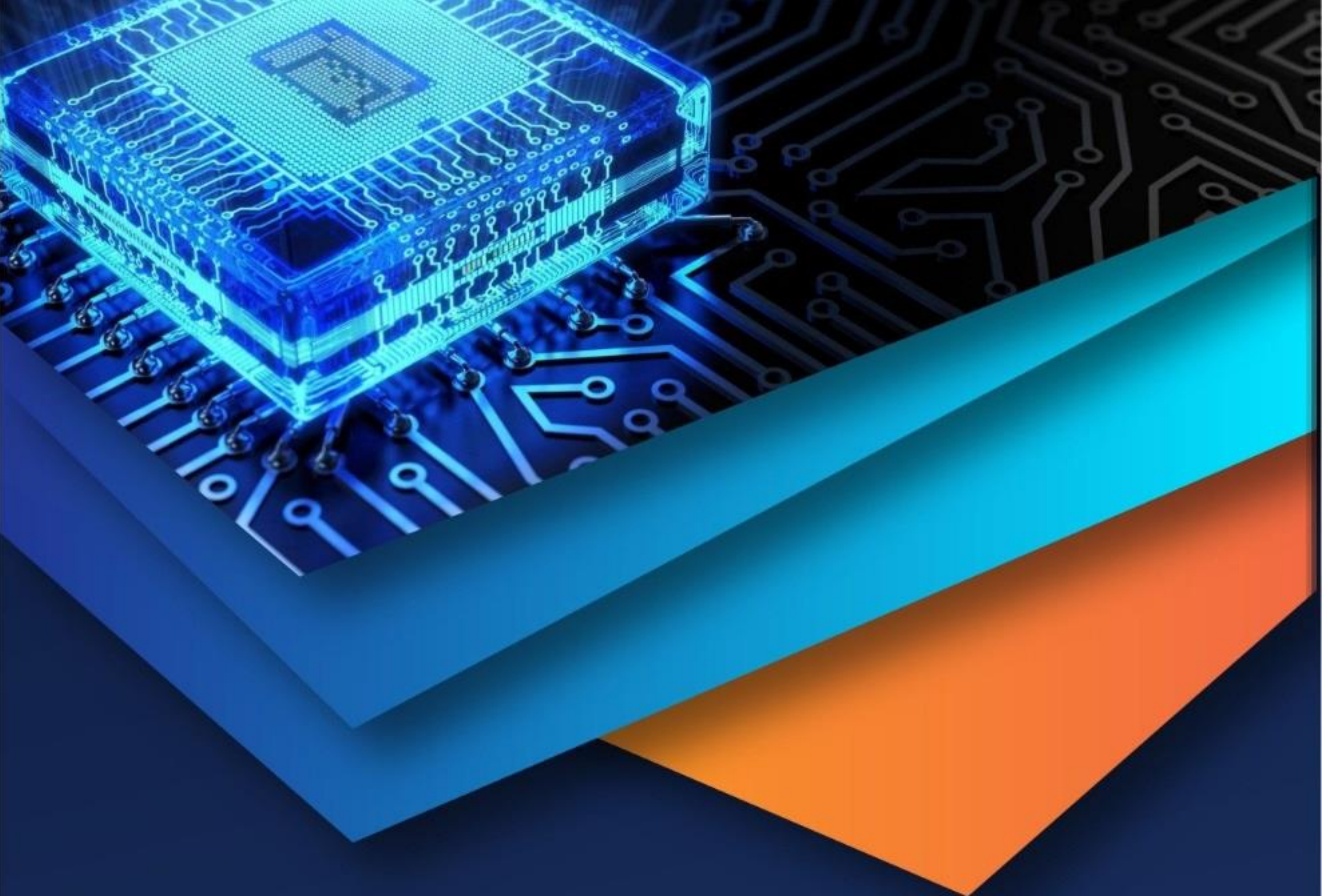

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