Seismic Vulnerability Assessment of Existing Buildings in Imphal City

Th. Kiranbala Devi, Soibam Sandhyarani Devi, Christina Usham

Abstract*: Frequent seismic activity in various parts of India has jeopardized the existing building stock and hence necessitated their vulnerability assessment. Such assessments are helpful for the administrators to adopt appropriate measures that can reduce the loss of human lives and properties. Imphal is a growing city in the northeast part of India, which falls under zone V. Most recent construction in the city consists of poorly designed and constructed buildings. The older buildings, even constructed in compliance with relevant standards at that time, may not comply with the more stringent specifications of the latest standards. Further, with high degree of population density in the urban, 998/Km^2 in Imphal West and 643/Km^2 in Imphal East, while the average density of population of the state of Manipur recorded at 115/Km^2 and concentration of houses and buildings in the area consisting of significant numbers of liveable and dilapidated houses (Census of India- 2011), assessment of seismic vulnerability of existing buildings is a matter of great importance. The present study deals with the seismic vulnerability assessment of the existing buildings in Imphal. A field survey of some of the existing buildings in Imphal was carried out and a preliminary assessment of seismic vulnerability was made. The Rapid Visual Screening (RVS) was done by using RVS form by Prof. Arya. One of the buildings which were found to be vulnerable from RVS was evaluated using numerical analysis, using SAP 2000 in order to assess their vulnerability for Simplified Vulnerability Assessment (SVA). The deficient members observed from the output are suggested for strengthening and retrofitting.

Keywords - Vulnerability Assessment, RVS, SVA, Modelling, SAP, Retrofitting

I. INTRODUCTION

It has been observed that seismic activity in various part of India has increased in recent years. Imphal is a growing city in the North-East part of India, which falls under Zone –V of the earthquake zonation map of India (IS:1893-2002), located at longitude 93^{0}58′ and latitude 24^{0}44′, which is extremely prone to earthquake. The city has experienced very rapid population growth during the last few decades due to economic factors such as decrease in economic opportunities in rural areas and consequent migration in the city areas. Most recent construction consists of poorly designed and constructed buildings. The older buildings even if constructed in compliance with relevant standards at that time, may not comply with the more stringent specifications of the latest standards.

There are three sources of deficiencies in structures:

1) Defects arising from original design,
2) Defect arising from original construction,
3) Deterioration since the completion of the construction

Revised Version Manuscript Received on December 15, 2015.

Dr. Th. Kiranbala Devi, Department of Civil Engineering, Manipur Institute of Technology, Manipur University, Imphal, Manipur, India.

Soibam Sandhyarani Devi, Department of Civil Engineering, Manipur Institute of Technology, Manipur University, Imphal, Manipur, India. **Christina Usham,** Department of Civil Engineering, Manipur Institute of Technology, Manipur University, Imphal, Manipur, India.

In Imphal, it is generally a combination of all the three deficiencies and the retrofitting of the structure has to take care of all the three. There is an urgent need to assess the seismic vulnerability of existing buildings in Imphal as an essential component of a comprehensive earthquake disaster risk management policy.

II. VULNERABILITY ASSESSMENT OF EXISTING BUILDINGS

For large number of seismically deficient buildings, a quick assessment method and guidelines have to be developed together with training and capacity building. To handle the task of seismic evaluation of existing buildings, three levels or Tiers have been suggested.

1. Rapid Visual Screening (RVS)
2. Simplified Vulnerability Assessment (SVA)
3.Detailed Vulnerability Assessment (DVA)

I. Rapid Visual Screening (RVS):

Rapid Visual Screening is a method that can be adopted for preliminary investigation without performing any structural calculations. It is a very quick way of assessing the building vulnerability based on visual screening. A building is examined visually to identify features that affect the seismic performance of the building such as primary structural lateral load-resisting system and building attributes that modify the seismic performance expected for this lateral load-resisting system.

The evaluation is based on parameters as recorded during RVS of the building surveyed. For this screening a team of at least two surveyors visits the building and try to collect the information in a specially designed format RVS Form. The RVS form are given by FEMA 154 and Professor Arya. In India, the procedure given by Prof. Arya is generally used. Once the class or the grade of the building is decided, the expected behaviour of the building or the expected damage during a future earthquake can be assessed. The results of the evaluation depend to a large extent of the training and the skill of the surveyors. The purpose of the screening is to identify the buildings which require further investigation using Level-2 or Level-3 procedure. The RVS methodology is also not intended for structures other than buildings. For important structures such as bridges and lifeline facilities, the use of detailed evaluation methods is recommended. Even in urban areas, some very weak forms of non-engineered buildings are well-known for their low seismic vulnerability and do not require RVS to estimate their vulnerability. These building types are also not included in the RVS procedure.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

II. Simplified Vulnerability Assessment:

The Simplified Vulnerability Assessment (SVA) procedure is more complex than the RVS procedure. This preliminary evaluation methodology is applied when in-depth evaluation of buildings stock is required. It utilises engineering information such as size and strength of lateral load resisting members and more explicit information on the design ground motion. This data is used to carry out a highly simplified analysis of the structure to estimate the building drift. Since good correlation exists between building drift and damage, the analysis results can be used to estimate the potential seismic hazard of the building. Unlike the RVS procedure, the Simplified Vulnerability Assessment requires the use of a computer; however, the required inputs can be collected in paper form for later entry into the software system. Such procedure has been developed for RCC buildings by IIT Bombay and the SVA procedure can be adopted on a large scale. The results of the SVA procedure can be used to determine the potential status of the selected buildings, and to further short-list the buildings requiring Detailed Vulnerability Assessment.

The SVA is based on Limited Engineering Analysis. In this stage, simplified analysis of the building under investigation is performed based on a variety of methods. This phase involves collection of drawings and redraws (if possible) in AutoCAD, identification of the sizes of all columns and beams, load calculations, configuration related checks and strength related checks.

III. Detailed Vulnerability Assessment :

The Detailed Vulnerability Assessment (DVA) is used for those buildings, which are found vulnerable from Level-2 procedure, for buildings with abnormal or irregular structural configurations and for monumental or important buildings. DVA of a building requires carrying out comprehensive engineering analysis considering the nature of potential ground motions and behaviour of the structural members. The DVA procedure is highly specialised and very few engineers in our country are currently capable of performing this task. The procedure also requires extensive as-build information regarding a building, which may not be readily available in the Indian context.

III. SURVEY WORKS OF RVS ON EXISTING BUILDINGS

1. Procedure:

Rapid visual screening has been conducted on some of the RCC buildings in Imphal including office building, residential building, hospital, clinic and school. Here, the RVS procedures of Professor Arya have been used to evaluate the buildings. Almost all the buildings are found to be vulnerable to earthquake. During the field survey many residential building are found to be Residential cum Commercial of 3-4 storeys. The infill walls are made of brick masonry. RC columns are tied together with RC beams at the slab levels. Foundations are usually in the form of isolated footings. In many cases architectural and structural drawings were not available. And so it was assumed that the buildings do not meet the earthquake resistant requirements of latest Indian codes.

In this paper, a residential building located at Thangmeiband in Imphal city area is presented. The building was checked by the method of rapid visual screening given by Professor Arya.

Figure 1. Residential Building located in Imphal City

II. Observation of the level 1 procedure:

RVS has been done on this RCC Building, which is a non-engineered structure and is found to be vulnerable. Such building is recommended for the level-2 procedure.

IV. SVA USING NUMERICAL ANALYSIS

Here, the re-evaluation of the building is done by numerical analysis using SAP2000. The building is evaluated by linear analysis considering the thirteen loads combinations for RCC as per IS:1893-2002. If the building members are found to be deficient, member sizes are increased and analysis will be done. Typical floor plan of the building taken for analysis is shown below in figure 2.

RVS FORM FOR REINFORCED CONCRETE FRAME (RCF) / STEEL FRAME (SF) BUILDINGS FOR SEISMIC HAZARD (by Padmshree, Prof. Anand S. Arya)

Seismic Zone V, All Buildings (Also for Seismic zone IV Important Buildings)

1.0 General Information

1.1 Seismic Zone V
1.2 Building name
1.3 Use Residential □ Office □ School □ Hospital □ Others □
1.4 Address: Thangmeiband Pin
1.5 Other Identifiers
1.6 No. of Stories G + 2
1.7 Year Built 2002
1.8 Total Covered Area; all floors (sq.m) 371·28
1.9 Ground Coverage Sq.m) 123·76
1.10 Soil Type: Medium

2.0 RC / Steel Frame Building Typology

2.1 Foundation Type

2.1.1 Individual footing Yes □ No □
2.1.2 Individual footing with connecting beam Yes □ No □
2.1.3 Beam Raft foundation Yes □ No □
2.1.4 Full solid raft Yes □ No □
2.1.5 Pile foundation Yes □ No □
2.1.6 Any other (describe)

2.2 Flat Roof or Floor

2.2.1 RC slab or T beam Yes □ No □
2.2.2 Steel beam and plate deck Yes □ No □
2.2.3 Flat slab or flat plate Yes □ No □
2.2.4 Overall depth of floor / roof Yes □ No □
2.2.5 Any other (describe)

2.3 Pitched roof Understructure

2.3.1 RCC Elements Yes □ No □
2.3.2 Steel Truss / rafter / purlin Yes □ No □
2.3.3 Any other (describe)

2.4 Pitched Roof Covering

2.4.1 CGI Sheets Yes □ No □
2.4.2 A.C. Sheets Yes □ No □
2.4.3 Fiber sheets Yes □ No □
2.4.4 Any other (describe)

3.0 Structural Frame Types *

3.1 RC beam-post buildings without Earthquake Resistant Design, (built in Non-engineered way). Yes □ No □

3.2 C Steel Frame (RCF/SF) of ordinary design for gravity loads, without Earthquake Resistant Design Yes □ No □

3.3 Moment Resistant Frame –(RCF/SF) of ordinary design, without Earthquake Resistant Design Yes □ No □

3.4 Moment Resistant Frame – (RCF/SF) with ordinary Earthquake Resistant Design and with ordinary in-fill walls. Yes □ No □

3.5 Moment Resistant – (RCF/SF) with high level of Earthquake Resistant Design and special ductile details. Yes □ No □

3.6 Moment Resistant Frame – (RCF/SF) with high level of Earthquake Resistant Design and special ductile details and with well designed in-fill walls/braces.* Yes □ No □

3.7 Moment Resistant Frame– (RCF/SF) with high level of Earthquake Resistant Design, special ductile details and with detailed RC shear walls or, detailed steel braces & cladding. Yes □ No □

** Indian Standards IS:13920-1993, IS:1893-2002, and SP6(6)-1972*

4.0 Special Hazard

4.1 High Water Table (within 3m below ground level) & if sandy soil, then liquefiable site indicated. Yes □ No □
(If yes, Increase damageability grade by 2 units upto G5)

4.2 Severe Vertical Irregularity in building Yes □ No □
(If yes, Increase damageability grade by 2 units upto G5)

4.3 Severe Plan Irregularity in the building Yes □ No □
(If yes, increase damageability grade by 1 unit upto G4)

4.4 Land Slide Prone Site Yes □ No □
(If yes, it may lead to damageability grade G5)

5.0 Non-structural Building Components

Whether the following non-structural building elements are present and stabilized against the earthquake?

5.1 Divisions/partition (brick wall/wooden partitions)
Provided Yes □ No □
Stabilized against Earthquake Yes □ No □

5.2 Façade elements (cladding/decorative elements)
Provided Yes □ No □
Stabilized against Earthquake Yes □ No □

5.3 False Ceilings
Provided Yes □ No □
Stabilized against Earthquake Yes □ No □

5.4 Brick parapets / pillars / planters etc.
Provided Yes □ No □
Stabilized against Earthquake Yes □ No □

5.5 Roof Chimneys
Provided Yes □ No □
Stabilized against Earthquake Yes □ No □

5.6 RC / Masonry Water Tank on Roof
Provided Yes □ No □
Stabilized against Earthquake Yes □ No □

5.7 Signs/display boards etc.
Provided Yes □ No □
Stabilized against Earthquake Yes □ No □

Note: Assessment of 5.0 does not modify the damageability grade of the building, but non-structural damage could be harmful to occupants

Abbreviations:

RC: reinforced concrete, RCF: reinforced concrete frame, SF: steel frame, CGI: Corrugated Galvanized Iron Sheets, AC: Asbestos Cement Sheets, URM: unreinforced masonry, R/F reinforcement

6.0 Probable Damageability in few / many RCG/SF Buildings

RC or Steel Frame Building type*(See Table-1)*	C / C+	D	E / E+	F	URM Infill
Damageability in Zone V, Very High Intensity MSK IX or more *See Table-2)*	G4 / G3	G3	G2 / G1	G2 / G1	G4

Note: + sign indicates higher strength hence somewhat lower damage expected as stated. Also average damage in one building type in the area may be lower by one grade point than the probable damageability indicated. Surveyor will identify the building type, encircle it, also the corresponding damage grade.

7.0 Recommended Actions during evaluation

If the **damageability grades** are:

- G1/G2 : building may be considered seismically safe.
- G3 : the building will not be likely to collapse, but subject to moderate to heavy damage. In such case, the building may be recommended for retrofitting.
- G4/G5 : the building is unsafe and will need re-evaluation and retrofitting.

If any **Special hazard** -

- Special hazard (4.0) is found, hazard should be removed or prevented.
- Special hazard (5.0) is present, either remove it, or stabilize against earthquake.

8.0 Attach Sketch Plan with section

9.0 Attach Photographs of the building

Surveyor's sign:____________ **Date:**________

Name:________________________

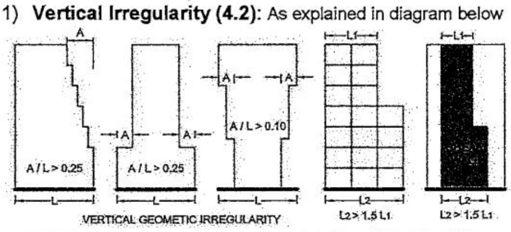
QUICK GUIDE FOR READY REFERENCE

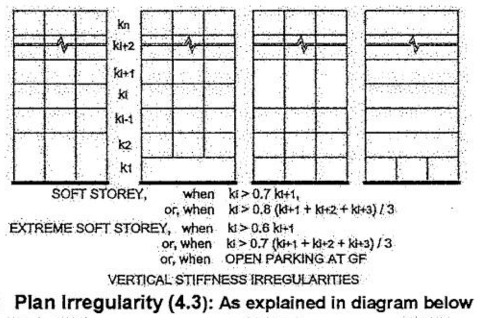
Equipments to be carried by the Surveyor:-

1) Digital Camera, Measuring tape
2) Hard board with clip, Pen (black), pencil, eraser
3) Adequate no. of survey sheets, RVS guidelines.

EXPALANTORY NOTE:-

1) **Vertical Irregularity (4.2):** As explained in diagram below





2) **Plan Irregularity (4.3): As explained in diagram below**

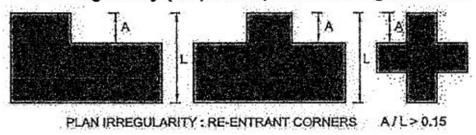


Table 1: Reinforced Concrete Frame Buildings (RCF) and Steel Frames (SF)

Type	Description
C	a) RC Beam Post buildings without ERD or WRD, built in non-engineered way. b) SF without bracings having hinge joints;. c) RCF of ordinary design for gravity loads without ERD or WRD. d) SF of ordinary design without ERD or WRD
C+	a) MR-RCF/MR-SF of ordinary design without ERD or WRD. b) Do, with unreinforced masonry infill. c) Flat slab framed structure. d) Prefabricated framed structure.
D	a) MR-RCF with ordinary ERD without special details as per IS: 13920*, with ordinary infill walls (such walls may fail earlier similar to C in masonry buildings.) b) MR-SF with ordinary ERD without special details as per Plastic Design Hand Book SP:6(6)-1972*.
E	a) MR-RCF with high level of ERD as per IS: 1893-2002* & special details as per IS: 13920*. b) MR-SF with high level of ERD as per IS: 1893-2002* & special details as per Plastic Design Hand Book, SP:6(6)-1972*
E+	a) MR-RCF as at E with well designed infills walls. b) MR-SF as at E with well designed braces.
F	a) MR-RCF as at E with well designed & detailed RC shear walls. b) MR-SF as at E with well designed & detailed steel braces & cladding. c) MR-RCF/MR-SF with well designed base isolation.

IS:13920-1993, "Ductile Detailing of Reinforced concrete structures subjected to seismic forces-Code of Practice" IS:1893(Part-I) 2002, "Criteria for Earthquake Resistant Design of Structures". SP:6(6)-1972, "Plastic Design of Steel Structures—Handbook"

***Abbreviations:** ERD : Earthquake Resistant Design, WRD: Wind Resistant Design, MR : Moment Resistant jointed frame*

Table 2: Grades of Damageability of RCF/SF Buildings

Grade	Description
G1	*Negligible to slight damage (no structural damage, slight non-structural damage)* Fine cracks in plaster over frame members or in walls at the base. And Fine cracks in partitions & infills.
G2	*Moderate damage (Slight structural damage, moderate non-structural damage)* Cracks in columns & beams of frames & in structural walls. Cracks in partition & infill walls; fall of brittle cladding & plaster. Falling mortar from the joints of wall panels.
G3	*Substantial to heavy damage (moderate structural damage, heavy non-structural damage)* Cracks in columns & beam column joints of frames at the base & at joints of coupled walls. Spalling of concrete cover, buckling of reinforced rods. Large cracks in partition & infill walls, failure of individual infill panels.
G4	*Very heavy damage (heavy structural damage, very heavy non-structural damage)* Large cracks in structural elements with compression failure of concrete & fracture of rebar's; bond failure of beam reinforcing bars; tilting of columns. Collapse of a few columns or of a single upper floor.
G5	*Destruction (very heavy structural damage)* Collapse of ground floor parts (e.g. Wings) of the building.

NOTES: The grades of damage in steel and wood buildings will also be based on non-structural and structural damage classification (shown in bold print in above Table2. Non-structural damage to infills would be the same as masonry building.

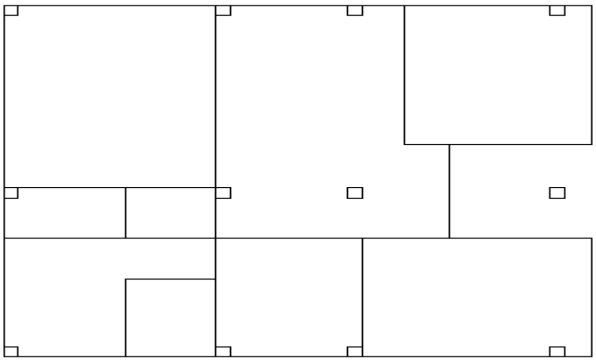


Figure 2. Typical floor plan of the Building

I. Structural details

The Base of the Building has horizontal dimension of 10.4 m x 11.9 m. It has three bays along X-axis and two bays along Y-axis. Height of the building is 9.7 m with first storey height of 3.3 m, second storey height of 3.15 m and third storey height of 3.15 m. As the building is situated in zone V, the value of Z=0.36. The material Properties are M20Grade concrete, Fe 415 steel for the yield strength of the longitudinal and shear reinforcement. The plan layout is shown in fig and the sectional properties of various elements obtained based on gravity analysis and used as initial sizes for further analysis are presented in Table 1.

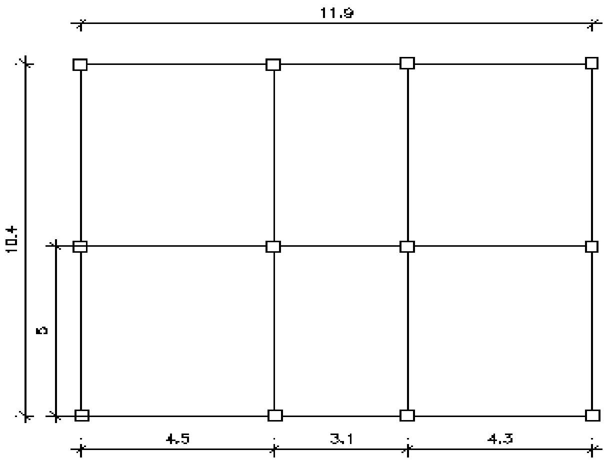


Figure 3. Plan of Frames (Placing of beams and column)

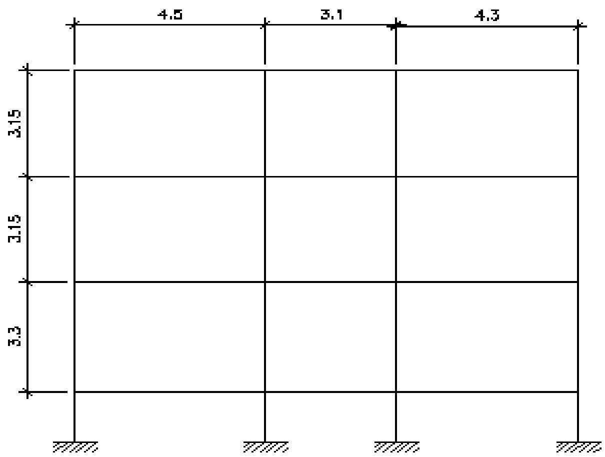


Figure 4. Elevation of frames

Table . 1. Member sizes

Members	Sizes in mm
All column at all floor	300 ×300
Beam at all floor	250 ×250
Thickness of slab	175

The loads on the structure are as per IS 875 Part 2 1987. Live load for the roof is taken as 1.5kN/m^2 and for the floor 3kN/m^2. The thickness of the floor is assumed as 175mm. The walls are half brick. Dead load is self weight of structures. Self weight of member is automatically involved by SAP2000 on the calculations. The weight of the slab was distributed to the surrounding beams. The foundation system for Building is an isolated foundation

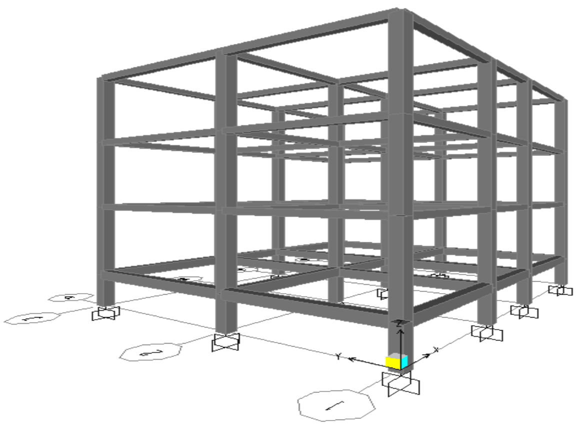


Figure 5. 3D Model in SAAP

II. Analysis considering the thirteen load combination:

The thirteen load combination as per IS:1893-2002 is considered in the analysis of the existing sizes of the member and the results are given in the form of 3-D model as an output of analysis by finite element package SAP2000.

Analyses expose some weaknesses in the building. It shows that the middle column sections at the ground floor fails indicating excessive ductility demand in the ground storey columns, which may lead to collapse indicating unacceptable performance and need to be retrofitted.

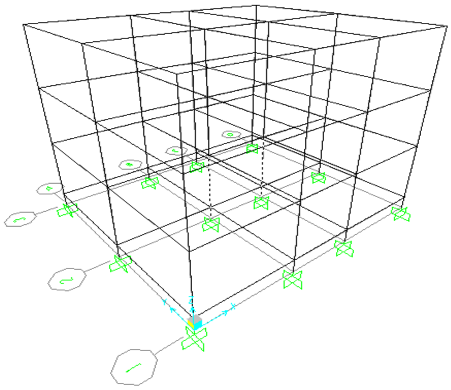


Figure 6. Dotted line showing failed Column of the structure

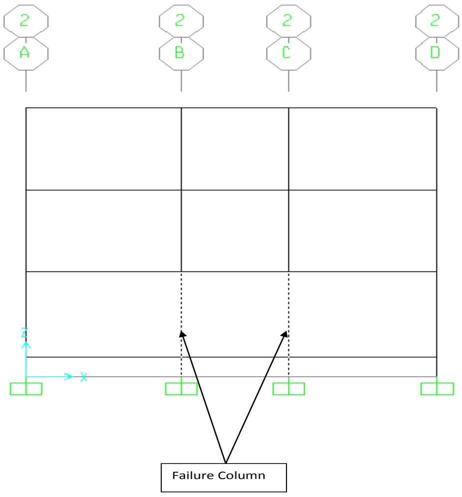


Figure 7. Failure Column at Frame 2

III. Analysis of the structure after increasing the member sizes:

Increasing the cross sectional area of the failure column to 350 x 350 mm and analysing with the thirteen load combination, it was found that the column does not undergo any failure.

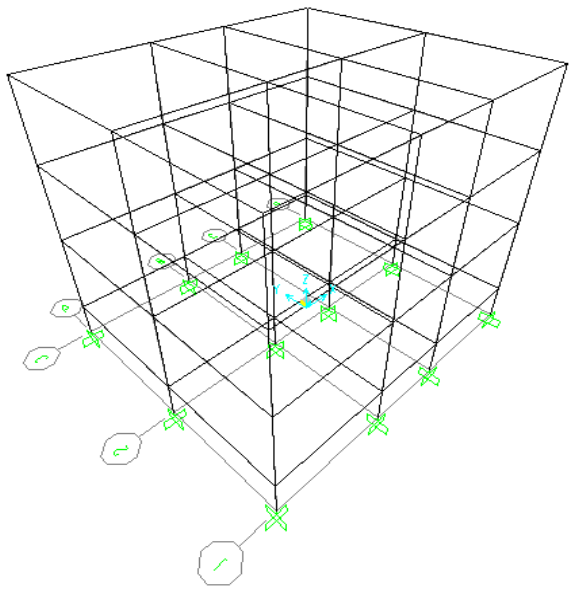


Figure 8: 3D Structure of building after increased size

V. RESULT OF SVA

The level-2 procedure, SVA have been completed on a building and the performance objectives have been imposed to satisfy the code compliance and to insists favourable failure pattern preferably a strong column-weak beam mechanism. 2 (two) numbers of column member were found deficient. Thus, the cross sectional area has been increased and reanalysed and found safe. Therefore, the deficient columns are recommended for retrofitting.

VI. CONCLUSION

Problem of assessment of safety of existing structures against various loads, including earthquake load, has been recognized world over. In developing countries, about 50% of the construction industries resources are being utilized for problems associated with existing structure. Many countries have developed standards for assessment of existing structure. In India also the problem is slowly showing it’s extend.

In Imphal, the need of assessing building as an earthquake safety measure is a must. Most of the buildings were found to be non-engineered structure, thus, making the structure vulnerable to earthquake. This is mainly due to lack of awareness on the concept of seismic design code and ignorance of the people.

In our present study, 70% of the buildings, which have been surveyed in the level-1 procedure, were found to be vulnerable to earthquake. In the level-2 procedure, a building was evaluated by Numerical Analysis using SAP2000. Considering the thirteen-load combinations as per IS: 1893-2002, the building was found to be deficient in 15 columns out of the total members. In older reinforced concrete frames, column failures were more frequent since the strength of beams in such constructions was kept higher than that of the columns. These shear failures bring forth loss of axial load carrying capacity of the column. As the axial capacity diminishes, the gravity loads carried by the column are transferred to neighbouring element resulting in massive internal redistribution of forces, which is also amplified by dynamic effect causing spectacular collapse of building. Thus, with the concept of strong column-weak beam, the cross sectional area of the deficient members were enlarged and analysed linearly, and the building was found to be safe. The building was recommended for retrofitting through Column Jacketing.

REFERENCES

1. ATC-40 (1996): Seismic Evaluation and Retrofit of Concrete No. SSC 96-01, Applied Technology Council, California.
2. AlpaSheth (2002): Seismic Retrofitting by Conventional Methods The Indian Concrete Journal, Vol.76, Number 8, August 2002. Pp.489-495.
3. Dr. Anand S. Arya, FNA, FNAE, FIE (Professor Emeritus, Dept. of Eq. Engineering, IIT Roorkee) National Seismic Advisor (EVR) Ministry of Home Affairs, SEISMIC EVALUATION AND STRENGTHENING OF EXISTING REINFORCED CONCRET BUILDINGS – Guidelines, Prepared Under GOI – UNDP Disaster Risk Management Programme.
4. Dr. Th. Kiranbala Devi (2011): Earthquake Disaster Mitigation, Proceedings of International Conference on Advances in Materials and Techniques for Infrastructure Development (AMTD 2001), NIT Calicut, India 28-30 September 2011, pp. 1-8.
5. Dr. Th. Kiranbala Devi, N. Monika Chanu, S. Satyakumar Singh and T. Bishworjit Singh(2013):SEISMIC RETROFITTING OF STRUCTURE BY CONVENTIONAL METHOD, proceedings of National Conference on Geotechnical and Geo-environmental Aspects of Waste and their utilization in infrastructure projects’, Guru Nanak Dev, Ludhiana, Punjab,15-16 Feb,2013.
6. Dr. D.K.Paul(2006): Earthquake Resistant Design,IS:1893-2002 CODE. Department of Earthquake Engineering, IIT Roorkee, Roorkee,247667.
7. FEMA (1997): “FEMA-273- NEHRP Guidelines for the Seismic Rehabilitation of Buildings”, Federal Emergency Management Agency, Washington DC, USA.
8. Guidelines for Retrofitting of Concrete Structure (1999), Concrete library, No. 95, published by JSCE, September 1999, pp. 203-210.
9. IS: 875-1987(Part-2)”code of practice for design loads for buildings and structures-Part-2 Imposed loads”, BIS, New Delhi,1987.

10. IS 1893 (Part 1): 2002," Criteria for Earthquake Resistant Design of Structures", Bureau of Indian Standards, New Delhi.
11. IS 13920: 1993, "Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces-Code of Practice", Bureau of Indian Standards, New Delhi.
12. IS 13935: 1993: Repair and Seismic strengthening of buildings Guidelines, BIS 2002-2004, New Delhi.
13. IS 1893 (Part 1): 2002: Indian Standard Criteria for earthquake resistant design of Structures, BIS 2002, New Delhi.
14. IS 456: 2000, "Plain and Reinforced Concrete-Code of Practice", Bureau of Indian Standards, New Delhi.
15. IS 1786:2008, "high strength deformed steel bars and wires for concrete reinforcement-specification(Forth Revision), Bureau of Indian Standards, New Delhi.
16. Jain A.K.," Advanced Structural Analysis with Computer Applications".
17. Jan T.S., Liu M.W., Kao Y.C.,"An upper-bound pusho analysis procedure for estimating the seismic demands of high-rise buildings". Engineering Structures (2004), pp 117-128.
18. Sudhir K. Jain and T. Srikant (2002): Analysis for Seismic Retrofitting of Buildings. The Indian Concrete Journal, Vol.76, Number 8, August 2002 pp 479-484.
19. Selection of Retrofitting Method- Building Research Institute (P) Ltd. Nepal, www.BREINS.com pp 1-5
20. Yogendra Singh and D.K. Paul (2006): Seismic Vulnerability Assessment of Existing Buildings. Lecture Notes for NPCBEERM, Department of Earthquake Engineering, IIT Roorkee, pp 181-192.

AUTHORS PROFILE

Dr. Th. Kiranbala Devi, M.E. (Civil), PhD.(Technical University of Brno, Czechoslovakia),currently working as Head of Civil Engg. Dept. in Manipur Institute of Technology, Manipur University, doing research works on earthquake engineering.

Soibam Sandhyarani Devi, is a Final Year Student of B.E. Civil Engineering, MIT, Manipur University, India.

Christina Usham is a Final Year Student of B.E. Civil Engineering, MIT, Manipur University, India.