

Seismic Analysis of High-Rise Buildings (G+30) by Using ETABS

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Abstract— ETABS stand for Extended Three Dimensional Analysis of Building Systems. ETABS integrates every aspect of the engineering design process. In the present situations of construction industry, the buildings that are being constructed are gaining significance, in general, those with the best possible outcomes which are referred to members like beams and columns in multi storeys R.C structures. This software mainly used for structures like high-rise buildings, steel and concrete structures. The paper aims to analyze a high-rise building of 30 floors (G+30) by considering seismic, dead and live loads. The design criteria for high-rise buildings are strength, serviceability and stability. The version of the software used is ETABS 2016. In the present study, we are mainly determining the effects of lateral loads on moments, shear force, axial force, base shear, maximum displacement and tensile forces on structural system are subjected and also comparing the results of seismic zones 2, 3, 4 and 5.

Keywords: ETABS; Seismic Analysis; High-rise buildings.

a. INTRODUCTION

The increase in population by which land deficit occurs and to overcome that, high-rise buildings are opted. These type of high-rise buildings are effected by the natural calamities. Calamities like earthquakes are the most dangerous by means of the damage and chaos caused to the structural components and they cannot be controlled. These natural calamities caused property damage and interruptions in development of the normal lifecycle. Since it's a global concern, most of the analysis should be carried out and provided with the results to prep the structure in order to attain time period. With the technological advancement, man tried combating with these natural calamities through various ways like developing early warning systems for disasters, adopting new prevention measures, proper relief and rescue measures. But unfortunately it is not true for all natural disasters. Hazard maps indicating seismic zones in seismic codes (IS 1893:2002) are revised from time to time which leads to additional base shear demand on existing buildings. The collapse of a structure can be minimized if the following points are taken in to consideration.

- The pattern of failure can be made ductile instead if brittle. If ductility is assured, dissipation of energy produced will show small deteriorations.
- Shear failure comes after the failure of flexure.
- Columns should not fail before beams.
- The joints should be hard compared to members.

Due to these compatibilities, earthquake engineering is gaining more significance.

Statement of the Project:

Design data,

- | | |
|-----------------------------|-------------------------------|
| 1. Building type | : Residential building |
| 2. No. of storeys | : G+30 |
| 3. Building shape | : Rectangular |
| 4. Geometrical details | |
| a. Ground floor | : 2.5m |
| b. Floor – Floor height | : 3m |
| 5. Material details | |
| a. Concrete grade | : M30 |
| b. Steel grade | : HYSD reinforcement of Fe415 |
| c. Bearing capacity of soil | : 200 KN/m ² |
| 6. Type of construction | : R.C.C Framed structure |

Objectives of study:

- To study irregularities in structural analysis and design of G+30 storeys structure as per code (IS 1893:2002).
- To study the behavior of structure without masonry infill if seismic load is applied.
- Determination of displacements subjected to earthquake loading from zone to zone.
- To find out the bending moment and shear force selecting any one section for various seismic zones.
- Time history analysis subjected to intermediate frequency ground motion for the response of regular buildings and compared to the response spectrum analysis.

II. LITERATURE REVIEW

Ali Kadhim Sallal (2018): The main purpose of this software is to design and analysis multi-Storeyed building in a systematic process. This paper present a building where designed and analyzed under effect of earthquake and wind pressure by using ETABS software. In this case, (18m x 18m) and eight stories structure are modeled using ETABS software. Ten story is taken as (3m) height and making the total height of the structure (31m).

Pushkar Rathod and Rahul Chandrashekar (2017): With the help of seismic analysis, the structure can be designed and constructed to withstand the high lateral movement of earth's crust during an earthquake. Any type of basic or a highly advanced structure which maybe under static or dynamic conditions can be evaluated by using ETABS. ETABS is a coordinated and productive tool for analysis and designs, which range from a simple 2D frames to modern high-rises which makes it one of the best structural software for building systems.

Pardeshi Sameer and Prof. N. G. Gore (2016): This paper is concerned with the effects of various vertical irregularities on the seismic response of a structure. The objective of the project is to carry out Response spectrum analysis (RSA) of regular and irregular RC building frames and Time History Analysis (THA) of regular RC building frames and carry out the ductility based design using IS 13920 corresponding to response spectrum analysis. Comparison of the results of analysis of irregular structures with regular structure is done.

Vijaya Bhaskar reddy. S et. al. (2015): This paper presents illustration of a comparative study of static loads for 5 and 10 storey multi storeyed structures. The significance of this work is to estimate the design loads of a structure. They conclude that deflection of the members is high with an increase in no. of floors. It can be observed that axial force is high in 10-storey compared to 5-storey building.

Abhay Guleria (2014): The case study in this paper mainly emphasizes on structural behavior of multi-storey building for different plan configurations like rectangular, C, L and I-shape. Modelling of 15- storeys R.C.C. framed building is done on the ETABS software for analysis. Post analysis of the structure, maximum shear forces, bending moments, and maximum storey displacement are computed and then compared for all the analyzed cases. The analysis of the multistoried building reflected that the storey overturning moment varies inversely with storey height. From dynamic analysis, mode shapes are generated and it can be concluded that asymmetrical plans undergo more deformation than symmetrical plans.

Methodology:

In the present study, analysis of G+30 multi-story building in all seismic zones for wind and earthquake forces is carried out. 3D model is prepared for G+30 multi-story building using ETABS.

Methods of analysis of structure:

The seismic analysis should be carried out for the buildings that have lack of resistance to earthquake forces. Seismic analysis will consider seismic effects hence the exact analysis sometimes become complex.

However for simple regular structures equivalent linear static analysis is sufficient one. This type of analysis will be carried out for regular and low rise buildings and this method will give good results for this type of buildings. Dynamic analysis will be carried out for the building as specified by code IS 1893-2002 (part1). Dynamic analysis will be carried out either by Response spectrum method or site specific Time history method. Following methods are adopted to carry out the analysis procedure.

- Equivalent Static Analysis
- Linear Dynamic Analysis
- Response Spectrum Method
- Time History Analysis
- Pushover Analysis
- Non Linear Static Analysis
- Non Linear Dynamic Analysis

Loads Acting on Multi-Storey G+30 Building:

Loading on tall buildings is different from low-rise buildings in many ways such as large accumulation of gravity loads on the floors from top to bottom, increased significance of wind loading and greater importance of seismic effects. Thus, multi-storied structures need correct assessment of loads for safe and economical design. Except dead loads, the assessment of loads cannot be done accurately. Live loads can be anticipated approximately from a combination of experience and the previous field observations. Wind and earthquake loads are random in nature and it is difficult to predict them. They are estimated based on a probabilistic approach.

The following discussion describes some of the most common kinds of loads on multi-storied structures.

- Dead loads
- Live loads
- Earthquake loads

Plan and Elevation of G+30 Building

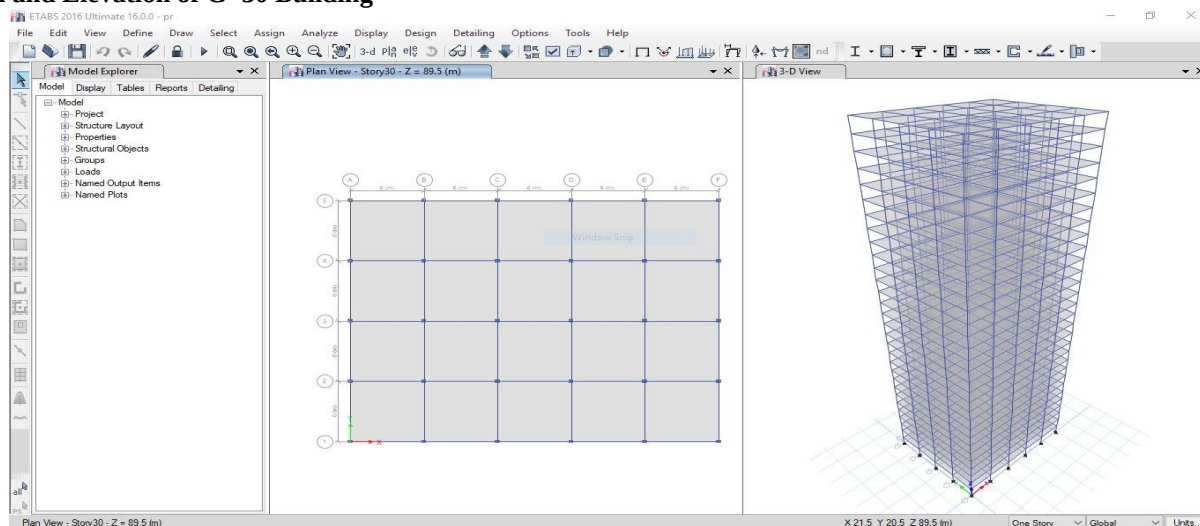


Fig. 1 G+30 Building Design using ETABS 2016

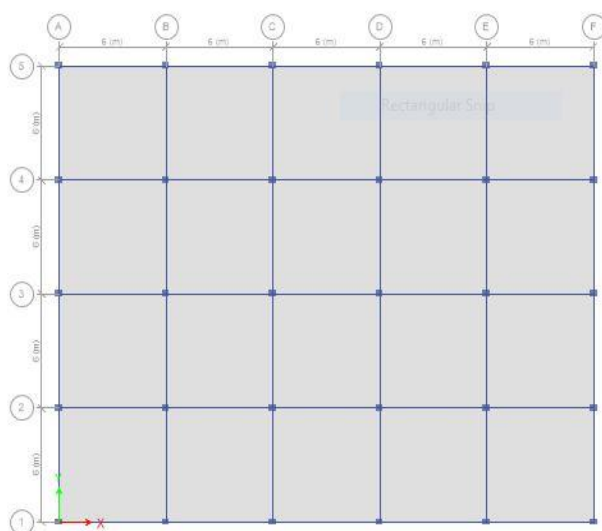


Fig. 2 Plan of G+30 Building



Fig. 3 Elevation of G+30 Building

III. ANALYSIS AND RESULTS

For every seismic zone the software gives six possible seismic load cases and two combination load cases i.e., maximum and minimum. The six possible load cases depends upon the loads acting on the structure.

Zone 5 results

TABLE 1
STORY DRIFT IN X DIRECTION FOR TOP 10 FLOORS

STORY	LOAD CASE/COMBO	DIRECTION	DRIFT
Story 30	Seismic	X	0.000515
Story 29	Seismic	X	0.000681
Story 28	Seismic	X	0.000850
Story 27	Seismic	X	0.001008
Story 26	Seismic	X	0.001155
Story 25	Seismic	X	0.001290
Story 24	Seismic	X	0.001414
Story 23	Seismic	X	0.001528
Story 22	Seismic	X	0.001630
Story 21	Seismic	X	0.001723

TABLE 2
STORY DRIFT IN Y DIRECTION FOR TOP 10 FLOORS

STORY	LOAD CASE/COMBO	DIRECTION	DRIFT
Story30	seismic	y	0.000647
Story29	seismic	y	0.000835
Story28	seismic	y	0.001025
Story27	seismic	y	0.001008
Story26	seismic	y	0.001366
Story25	seismic	y	0.001516
Story24	seismic	y	0.001655
Story23	seismic	y	0.001780
Story22	seismic	y	0.001894
Story21	seismic	y	0.001997

Base Reactions

TABLE 3
BASE REACTIONS OF ZONE 5

Load Case/Combo	Force in x direction Fx kN	Force in y direction Fy kN	Force in z direction Fz kN	Moment in x direction Mx kN m	Moment in y direction My kN m	Moment in z direction Mz kN m
Dead	0	0	113873.4502	1366481	-1708102	0
Live	0	0	44100	529200	-661500	0
Seismic 1	-1326.4762	0	0	6.118E-06	-90389.3333	15917.7145
Seismic 2	0	-1326.4762	0	90389.3332	-6.986E-06	-19897.1431
Seismic 3	-1326.4762	0	0	6.118E-06	-90389.3333	15917.7145
Seismic 4	0	-1326.4762	0	90389.3332	-6.986E-06	-19897.1431
Seismic 5	-1326.4762	0	0	6.118E-06	-90389.3333	15917.7145
Seismic 6	0	-1326.4762	0	90389.3332	-6.986E-06	-19897.1431
Comb1 Max	0	0	157973.4502	1895681	-2369602	0
Comb1 Min	0	0	157973.4502	1895681	-2369602	0

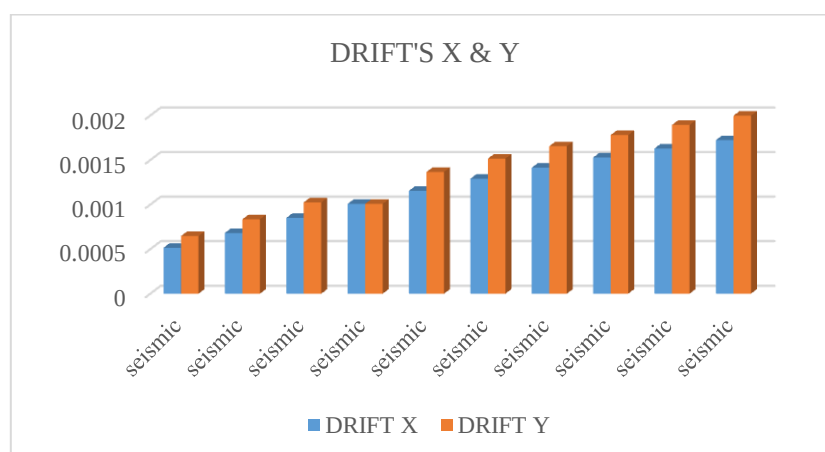


Fig. 4 Comparison of drifts x and y of the structure in zone 5

Zone 4 Results

TABLE 4
STORY DRIFT IN X DIRECTION FOR TOP 10 FLOORS

STORY	LOAD CASE/COMBO	DIRECTION	DRIFT
Story30	seismic	x	0.000343
Story29	seismic	x	0.000454
Story28	seismic	x	0.000566
Story27	seismic	x	0.000672

Story26	seismic	x	0.000770
Story25	seismic	x	0.000860
Story24	seismic	x	0.000943
Story23	seismic	x	0.001018
Story22	seismic	x	0.001087
Story21	seismic	x	0.001149

TABLE 5
STORY DRIFT IN Y DIRECTION FOR TOP 10 FLOORS

STORY	LOAD CASE/COMBO	DIRECTION	DRIFT
Story30	seismic	y	0.000432
Story29	seismic	y	0.000557
Story28	seismic	y	0.000683
Story27	seismic	y	0.000801
Story26	seismic	y	0.000910
Story25	seismic	y	0.001011
Story24	seismic	y	0.001103
Story23	seismic	y	0.001187
Story22	seismic	y	0.001263
Story21	seismic	y	0.001331

Base Reactions

TABLE 6
BASE REACTIONS OF ZONE 4

Load Case/Combo	Force in x direction Fx kN	Force in y direction Fy kN	Force in z direction Fz kN	Moment in x direction Mx kN m	Moment in y direction My kN m	Moment in z direction Mz kN m
Dead	0	0	113873.4502	1366481	-1708102	0
Live	0	0	44100	529200	-661500	0
Seismic 1	-884.3175	0	0	4.078E-06	-60259.5555	10611.8097
Seismic 2	0	-884.3175	0	60259.5555	-4.657E-06	-13264.7621
Seismic 3	-884.3175	0	0	4.078E-06	-60259.5555	10611.8097
Seismic 4	0	-884.3175	0	60259.5555	-4.657E-06	-13264.7621
Seismic 5	-884.3175	0	0	4.078E-06	-60259.5555	10611.8097
Seismic 6	0	-884.3175	0	60259.5555	-4.657E-06	-13264.7621
Comb1 Max	0	0	157973.4502	1895681	-2369602	0
Comb1 Min	0	0	157973.4502	1895681	-2369602	0

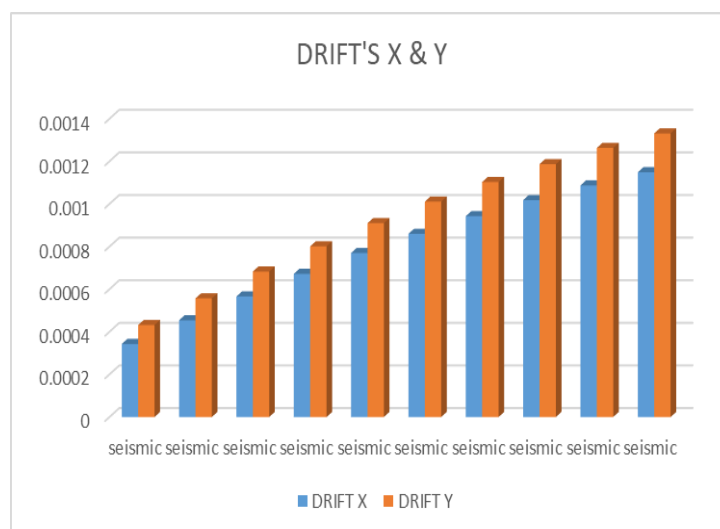


Fig. 6 comparison of drifts x and y in zone 4

Zone 3 Results

TABLE 7
STORY DRIFT IN X DIRECTION FOR TOP 10 FLOORS

STORY	LOAD CASE/COMBO	DIRECTION	DRIFT
Story30	seismic	x	0.000229
Story29	seismic	x	0.000303
Story28	seismic	x	0.000378
Story27	seismic	x	0.000448
Story26	seismic	x	0.000513
Story25	seismic	x	0.000573
Story24	seismic	x	0.000629
Story23	seismic	x	0.000679
Story22	seismic	x	0.000725
Story21	seismic	x	0.000766

TABLE 8
STORY DRIFT IN Y DIRECTION FOR TOP 10 FLOORS

STORY	LOAD CASE/COMBO	DIRECTION	DRIFT
Story30	seismic	y	0.000288
Story29	seismic	y	0.000371
Story28	seismic	y	0.000455
Story27	seismic	y	0.000534
Story26	seismic	y	0.000607
Story25	seismic	y	0.000674
Story24	seismic	y	0.000735
Story23	seismic	y	0.000791
Story22	seismic	y	0.000842
Story21	seismic	y	0.000888

Base Reactions

TABLE 9
BASE REACTIONS OF ZONE 3

Load Case/Combo	Force in x direction Fx kN	Force in y direction Fy kN	Force in z direction Fz kN	Moment in x direction Mx kN m	Moment in y direction My kN m	Moment in z direction Mz kN m
Dead	0	0	113873.4502	1366481	-1708102	0
Live	0	0	44100	529200	-661500	0
Seismic 1	-589.545	0	0	2.72E-06	-40173.037	7074.5398
Seismic 2	0	-589.545	0	40173.037	-3.11E-06	-8843.1747
Seismic 3	-589.545	0	0	2.72E-06	-40173.037	7074.5398
Seismic 4	0	-589.545	0	40173.037	-3.11E-06	-8843.1747
Seismic 5	-589.545	0	0	2.72E-06	-40173.037	7074.5398
Seismic 6	0	-589.545	0	40173.037	-3.11E-06	-8843.1747
Comb1 Max	0	0	157973.4502	1895681	-2369602	0
Comb1 Min	0	0	157973.4502	1895681	-2369602	0

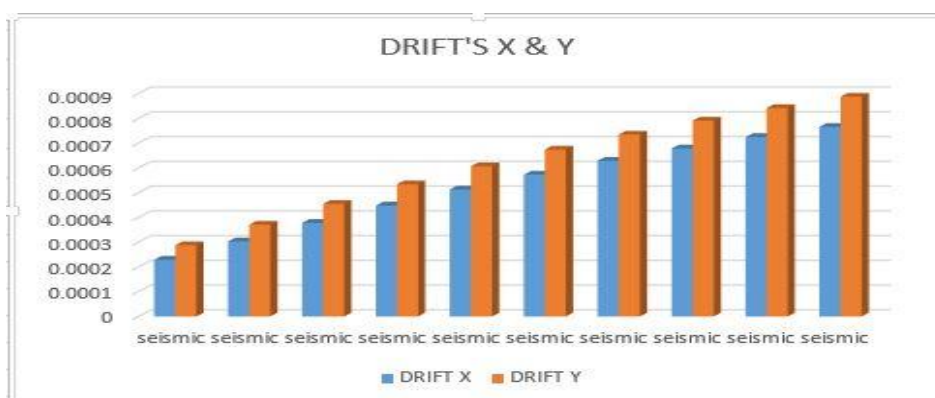


Fig. 7 comparison of drifts x and y in zone 3

Zone 2 results

TABLE 10
STORY DRIFT IN X DIRECTION FOR TOP 10 FLOORS

STORY	LOAD CASE/COMBO	DIRECTION	DRIFT
Story30	seismic	X	0.000143
Story29	seismic	X	0.000189
Story28	seismic	X	0.000236
Story27	seismic	X	0.000280
Story26	seismic	X	0.000321
Story25	seismic	X	0.000358
Story24	seismic	X	0.000393
Story23	seismic	X	0.000424
Story22	seismic	X	0.000453
Story21	seismic	X	0.000479

TABLE 11
STORY DRIFT IN Y DIRECTION FOR TOP 10 FLOORS

STORY	LOAD CASE/COMBO	DIRECTION	DRIFT
Story30	seismic	Y	0.000180
Story29	seismic	Y	0.000232
Story28	seismic	Y	0.000285
Story27	seismic	Y	0.000334
Story26	seismic	Y	0.000379
Story25	seismic	Y	0.000421
Story24	seismic	Y	0.000460
Story23	seismic	Y	0.000495
Story22	seismic	Y	0.000526
Story21	seismic	Y	0.000555

Base Reactions

TABLE 12
BASE REACTIONS OF ZONE 2

Load Case/Combo	Force in x direction Fx kN	Force in y direction Fy kN	Force in z direction Fz kN	Moment in x direction Mx kN m	Moment in y direction My kN m	Moment in z direction Mz kN m
Dead	0	0	113873.4502	1366481	-1708102	0
Live	0	0	44100	529200	-661500	0
Seismic 1	-368.4656	0	0	1.699E-06	-25108.1481	4421.5874
Seismic 2	0	-368.4656	0	25108.1481	-1.941E-06	-5526.9842
Seismic 3	-368.4656	0	0	1.699E-06	-25108.1481	4421.5874
Seismic 4	0	-368.4656	0	25108.1481	-1.941E-06	-5526.9842
Seismic 5	-368.4656	0	0	1.699E-06	-25108.1481	4421.5874
Seismic 6	0	-368.4656	0	25108.1481	-1.941E-06	-5526.9842
Comb1 Max	0	0	157973.4502	1895681	-2369602	0
Comb1 Min	0	0	157973.4502	1895681	-2369602	0

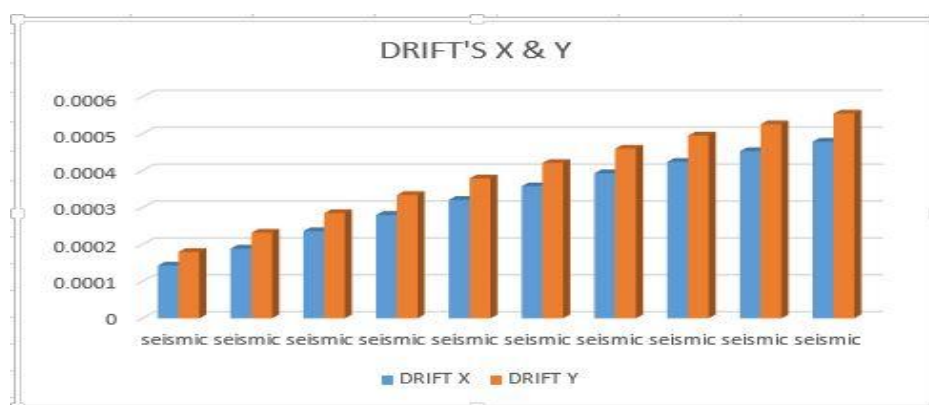


Fig. 8 comparison of drifts x and y in zone 2

IV. CONCLUSIONS

- A high-rise building of 30 floors subjected to seismic, wind and live loads were analyzed using ETABS 2016 software.
- Behavior of the high rise building was shown clearly using the graphs and lateral displacements.
- It is found that the lateral displacements or drifts are more in zone 5 when compared to the zones 4, 3&2.
- It is also found that from the base reactions of structure obtained in zone 5, the story shear is higher in zone 5 than in zone 2.
- All members were designed using ETABS.
- The members which are not appropriate will be obtained and suitable sections are recommended by the software.
- Better accuracy of the analysis can be obtained by using this software.

REFERENCES

- [1] IS 1893 (part 1): (2002), "Criteria for Earthquake Resistant Design of Structures Part General Provisions and Buildings", Bureau of Indian Standards.
- [2] CSI Computers and Structures INC. "Introductory Tutorial for ETABS: Linear and Nonlinear Static and Dynamic Analysis and Design of Three-Dimensional Structures" 2011.
- [3] B.C. Punmia, A.K. Jain, 2006, R.C.C Designs", Laxmi Publications New Delhi.
- [4] IS-456 2000 plain and reinforced concrete code of practice.
- [5] P.Agarwal, M.Shrinkhande, earthquake resistance design of structures, PHI learning Pvt. 2012.
- [6] Pardeshi Sameer, Prof. N. G. Gore (2016), "Study of seismic analysis and design of multi storey symmetrical and asymmetrical building "Volume: 03 Issue: 01.
- [7] Ali Kadhim Sallal (2018) "Design and analysis ten storied building using ETABS software-2016" Volume 4; Issue 2; May 2018; Page No. 21-27
- [8] Pushkar Rathod, Rahul Chandrashekar "seismic analysis of multistoried building for different plans using ETABS 2015" Volume: 04 Issue: 10 | Oct -2017
- [9] S. Vijaya Bhaskar Reddy, Jagath Chandra. P, Srinivas Vasam, P Srinivasa Rao "Analysis Of Multistoried Structures Using ETABS" Vol. 3, Issue 1, pp: (151-158), Month: April 2015 - September 2015,