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PERFORMING SEISMIC ANALYSIS AND DESIGNING A G+7 BUILDING ACCORDING TO THE IS CODE

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Abstract
Transformation in the earth's internal structure is indicated by earthquakes. Seismic activity is commonly experienced in most parts of the world, though the frequency of its occurrence is determined by the local tectonic setup. Huge loss of life and building stock has been demonstrated by past earthquake experiences, affecting the social and economic conditions of a country. Though it is not possible to prevent an earthquake, reducing the damage is the least that can be achieved by making the buildings earthquake resistant. With the advancement in understanding of earthquakes, the incorporation of seismic provisions in building design and architecture has been mandated by most countries. In the event of an earthquake, the seismic waves originating from the focus are transmitted in all possible directions. These shock waves are propagated in the form of body waves and surface waves through the earth's interior and are highly random in nature. Structures are caused to vibrate by these ground motions, inducing inertia forces in the structural elements. In the absence of seismic design, the building may fail, resulting in a catastrophe. The primary aim of seismic design philosophy is to ensure life safety and secure the functionality of the building. In conjunction with the design philosophy, earthquake-safe construction practices are essential for the efficient seismic performance of a building. This research found that STADD Pro result is more precise. For appropriate analysis of wind load ETABS is desire.

Keywords: AUTO CAD, Building Design, Earthquake, ETABS, Seismic analysis**,** STAAD Pro.

Introduction

India is prone to strong earthquake shaking, and hence earthquake resistant design is essential. The Engineers do not attempt to make earthquake proof buildings that will not get damaged even during the rare but strong earthquake. Such buildings will be too robust and too expensive. Design of buildings wherein there is no damage during the strong but rare earthquake is called earthquake proof design. The engineers do not attempt to make earthquake proof buildings that will not get damaged even during the rare but strong earthquake. Such buildings will be too robust and too expensive. The aim of the earthquake resistant design is to have structures that will behave elastically and survive without collapse under major earthquakes that might occur during the life of the structure. To avoid collapse during a major earthquake, structural members must be ductile enough to absorb and dissipate energy by post elastic deformation.

The seismic codes are prepared with consideration of seismology of country, accepted level of seismic risk, properties of construction materials, construction methods, and structure typologies etc. Furthermore, the provisions given in seismic codes are based on the observations, experiments & analytical case studies made during past earthquakes in particular region. In India, IS 1893 (Part1) Criteria for Earthquake Resistant Design of Structures is used as code of practice for analysis & designing of earthquake resistant buildings. In the last decade, the detailed & advanced research, damage survey was carried out by the Earthquake Engineering Sectional Committee of Bureau of Indian Standards. As a result, the huge data regarding behaviour of various types of structures during earthquake was collected which gained the knowledge. This continuous effort has resulted in revision of IS 1893 (Part 1): 2002 [1]. Hence the sixth revision of IS 1893 (Part 1) was published in 2016. To implement the latest code in practice, it is necessary to understand the revised codal provisions in IS

1893 (Part 1):2016 [2] with respect to IS 1893:2002. The paper aims to give brief idea about the revised clauses in latest seismic code. ETABS issue, for analysis and design for building systems. ETABS features are contain powerful graphical interface coupled with unmatched modelling, analytical, and design procedures, all integrated using a common database. It is quick and very easy for simple structures. This program is a very useful tool for the design check of concrete structures. The user must exactly understand the assumptions of the program and must independently verify the results. From the start of design conception through the production of schematic drawings, ETABS contain every aspect of the engineering design process. The Creation of models has never been easy. The AUTOCAD drawings can be converted directly into ETABS models & can easily analyze and design of building. This research is mainly based on software and it is essential to know the details of this software. STAAD Pro and AutoCAD. STAAD (structural analysis and design) STAAD is the powerful design software licensed by Bentley. to calculate SFD and BMD of complex loading beam it takes about an hour. So when it comes up to building with several members it will take a week. STAAD is very powerful to which it does this job in just an hours STAAD is a best alternative for high rise buildings which makes a compulsion for civil engineer to know about this software. AUTOCAD is a powerful software licensed by auto desk company and cad stand for computer aided design. It is used for drawing different layout, elevation, details, section, different section can be shown in AutoCAD. useful for drawing the plan of multi-storeyed building.

Building designed to prevent total collapse, preserve life, and minimize damage in case of an earthquake or tremor. Earthquakes exert lateral as well as vertical forces, and a structure's response to their random, often sudden motions is a complex task that is just beginning to be understood. Earthquake-resistant structures absorb and dissipate seismically induced motion through a combination of means: Earthquake-resistant or aseismic structures are designed to protect buildings to some or greater extent from earthquake. While no structure can be entirely immune to damage from earthquakes, the goal of Earthquake Resistant construction is to erect structures that fare better during seismic activity than their conventional counterparts. According to n building codes, earthquake-resistant structures are intended to withstand the largest earthquake of a certain probability that is likely to occur at their location. This means the loss of life should be minimized by preventing collapse of the buildings for rare earthquakes while the loss of the functionality should be limited for more frequent ones. Currently, there are several design philosophies in earthquake engineering, making use of experimental results, computer simulations and observations from past earthquakes to offer the required performance for the seismic threat at the site of interest. These range from appropriately sizing the structure to be strong and ductile enough to survive the shaking with an acceptable damage, to equipping it with base isolation or using structural vibration control technologies to minimize any forces and deformations. While the former is the method typically applied in most earthquake-resistant structures, important facilities, landmarks, and cultural heritage buildings use the more advanced (and expensive) techniques of isolation or control to survive strong shaking with minimal damage.

The manuscript provides valuable insights into the manual design and E-Tabs analysis of earthquake resistance for a G+7 building. It meticulously explores the details of the analysis, including comprehensive information on the results obtained from the E-Tabs software.

Material and methodology

Architectural plan of G+7 regular building is considered for seismic design and analysis.

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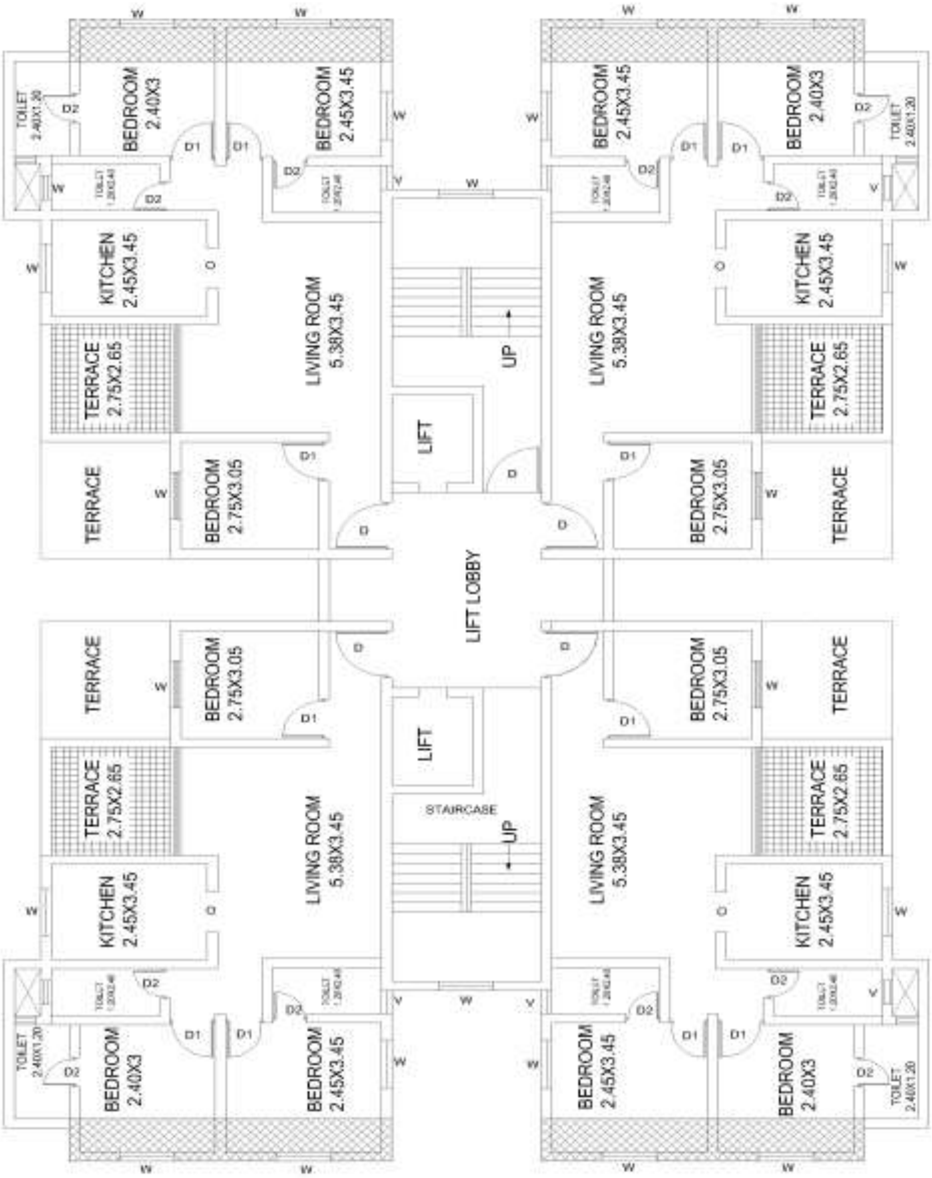

Fig. 1. G+ 7 Regular Building Plan

Manual design of regular building by IS1893-2002, and IS1893-2016.
G+7 residential building as per IS 1893:2002 of plan regularity
Preliminary Data-
1. Type of Structure-Multistorey SMRF Building
2. Seismic Zone-III (Table 2 Is1893;2002)
3. Number of Stories-8 (G+7)
4. Floor Height-3m
5. Infill Wall-230 mm Thick Including Plaster in Longitudinal & 100 mm In Traverse Direction
6. Imposed Load-3kN/m^2
7. Materials-M_{20} for (Beam, Slab) M_{25} (Column, Footing)
8. Size of columns-There are 6 Types of Columns in this Building.
9. 380x380=8 Column
10. 230x600=4 Column
11. 230x900=30 Column

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12. 230x1000=14 Column
13. 230x1350=4 Column
14. 230x1600=4 Column
15. Size of Beams-230x300mm
16. Depth of Slab-130mm Thick
17. Specific Weight of Rcc-25kN/m^2
18. Specific Weight of Infill-20kN/m^2
19. Type of Soil-Medium

Equivalent static lateral force method

A step-by-step procedure for analysis of the frame by equivalent static lateral force method is as follows:

Step 1-calculation of lumped masses to various floor levels

The earthquake forces shall be calculated for the full dead load plus percentage of imposed load as given in table 8 of IS1893: 2002.the imposed load on roof is assumed to be zero. The lumped masses of each floor are worked out as follows.

Roof

Mass of infill Mass of column Mass of beams in longitudinal and transverse direction of that floor +Mass of slab Imposed load of that floor if permissible

Mass of infill=

$\rho = \frac{m}{V}$

m= ρ x V

=20xLxBxH

=20x166.30x0.23x1m

=764.980KN

Mass of Column=

A	B	C	D	E	F
380X380	**230X600**	**230X900**	**230X1000**	**230X1350**	**230X1600**
m= ρxV	m= ρxV	m= ρxV	m= ρxV	m= ρxV	m= ρxV
25x038x038x1	25x0.23x0.6x1	25x0.23x0.9x1	25x0.23x1x1	25x0.23x1.350 x1	25x0.23-1.600x1
3.61	3.45	5.175	5.75	7.7625	9.2
3.61x8=28.88kN	3.45x6=20.7 kN	5.175x0=144.9 kN	5.75x14=80.5 kN	7.7625x4=31.05kN	9.2x4=36.8KN

Total load on column on roof-A+B+C+D+E+F=28.88+20.7+144.9+80.50+31.05+36.80**=342.91kN**

Mass of beam=

Size of beam=230x300

=(2.15x4)+(2.768 x 2)+(8.625 x 4)+ (5.692 x 4)+(2.583 x 4)+(2.07 x 2)

=348.94kN

Mass of Slab=

=Area x Thickness

=25 x 448 x 0.13

=**1456kN**

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Total Load on Roof
=764.98+342.91+348.94+1456**+0**
=2912.830kN
as per IS imposed load on roof is not considered so, here we consider 0 & 50% of imposed load if imposed load is greater than 5kN/m^2

7^{th} ,6^{th},5^{th},4^{th},3^{rd},2^{nd},1^{st} floor load

A	B	C	D	E	F
380X380	**230X600**	**230X900**	**230X1000**	**230X1350**	**230X1600**
m= ρxV	m= ρxV	m= ρxV	m= ρxV	m= ρxV	m= ρxV
25 x 038 x 038 x 3	25x0.23 x 0.6 x 3	25 x 0.23 x 0.9 x 3	25 x 0.23 x 1 x 3	25 x 0.23 x 1.350 x 3	25 x 0.23 x 1.600 x 3
10.83 x 8=86.64 kN	10.35 x 6=62.1 kN	15.525 x 28=434.7 kN	17.25 x 14=241.5 kN	23.287 x 4=93.15 kN	27.6 x 4=110.4 kN
693.12kN	**496.8 kN**	**3477.6 kN**	**1932 kN**	**745.2 kN**	**883.2 kN**

Total mass of column
=693.12+496.8+3477.6+1932+745.2+883.2
=8227.92KN

Total infill wall load
For 1 flat=669.33kN
So,here we have 4 no. flat on one floor-669.33*4=2677.32kN
TOTAL LOAD OF INFILL WALL
=2677.32x7
=18741.24 x **kN**
Mass of staircase
=25xAreaxVolume
=25x24.87x1
=621.75kN
Here we have 2 no. of staircase in each floor
621.75x2=1243.5kN
Calculate it by upto7^{th} floor
=1243.5x8
=9948kN

Total Load of 7^{th},6^{th},5^{th},4^{th},3^{rd},2^{nd},1^{st} Floor
=2677.32+1028.49+348.94+1456+1243.5
=6754.25kN
=54034KN

Live Load Calculation
Area=length x breadth
=448m^2
As per IS 1893:2002
Live load on roof=0 (cl.7.3.2 p.g.17)
Live load on floor=>3kN/m^2 (p.g.24)

50% of L.L in Calculation
Here, L. L=3kN/m^2
3x0.5=1.5kN/m^2 consider
L.L=Areax1.5
=448x1.5
=672kN
Seismic Weight of Building
1)For Floor-D. L of Floor+L.L of Floor
=6754.25+672
=7650.25kN
2)For Roof=2912.8.kN
Total seismic weight of building
=7x7650.25+1x2912.83
=56464.58kN

Step 3-Determination of fundamental natural period
Ta=0.075x$h^{0.75}$
=0.075x$24^{0.75}$
=0.8132 sec.

Step 4-Determination of Design Base Shear
Design seismic base shear
VB=AhxW
Ah=Z/2 xI/RxSa/g
=0.16/2 x 1/5 x 2.5
∴Ah=0.04
Design seismic base shear
VB=0.04X56464.58
=2258.58kN

Step 5-Vertical Distribution of Base Shear
The design base shear (VB)computed shall be distributed along the height of the building as per expression.

$$Qi = VB\frac{wihi^2}{\sum_{i=0}^{n} wihi^2}$$

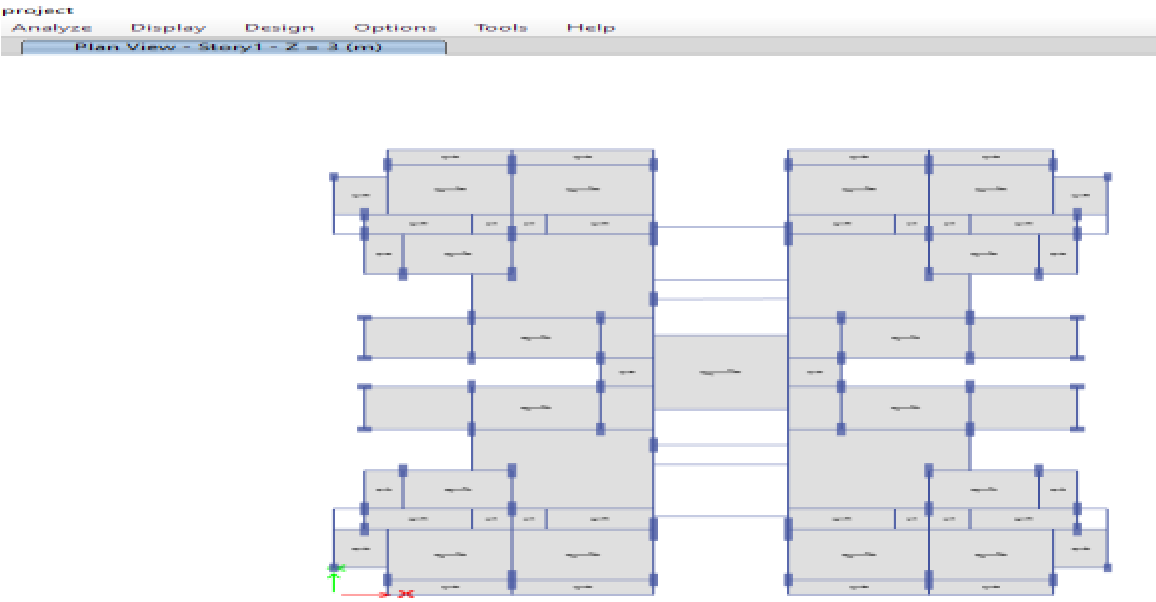
∴VB=2258.58kN

Step 6-Calculation Lateral Force and Shear Force

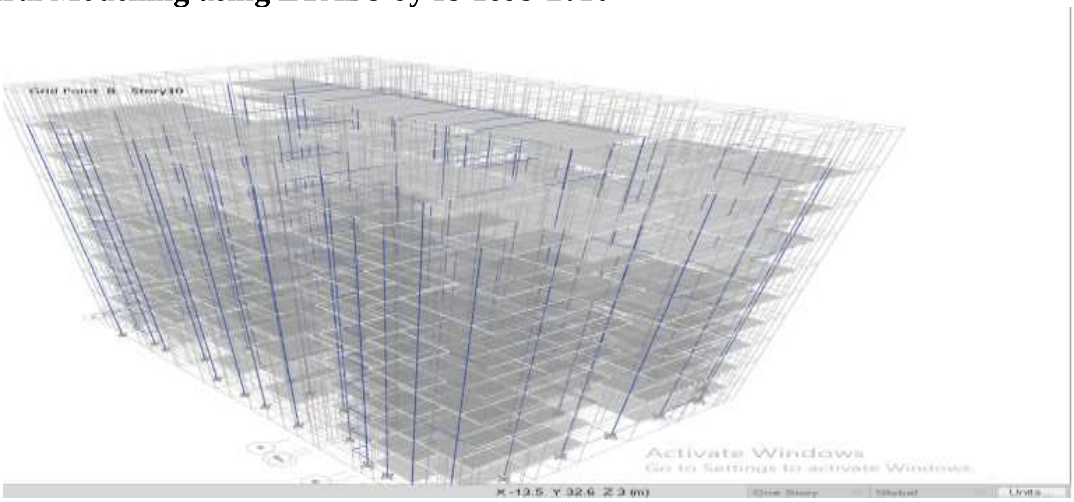
Floor level	**wi(kN)**	**hi(m)**	**Wihi^2**	Shear force $Qi= VB\frac{wihi^2}{\sum_{i=0}^{n} wihi^2}$	Story Shear force (kN)
1	2912.83	24	1677790.08	334.840	334.840
2	7650.25	21	3373760.25	673.308	1008.148
3	7650.25	18	2478681	494.67	1502.818
4	7650.25	15	1721306.25	343.524	1846.342
5	7650.25	12	1101636	219.855	2066.167
6	7650.25	9	619670.25	123.668	2189.835

7	7650.25	6	275409	54.963	2244.798
8	7650.25	3	68852.25	13.740	2258.53

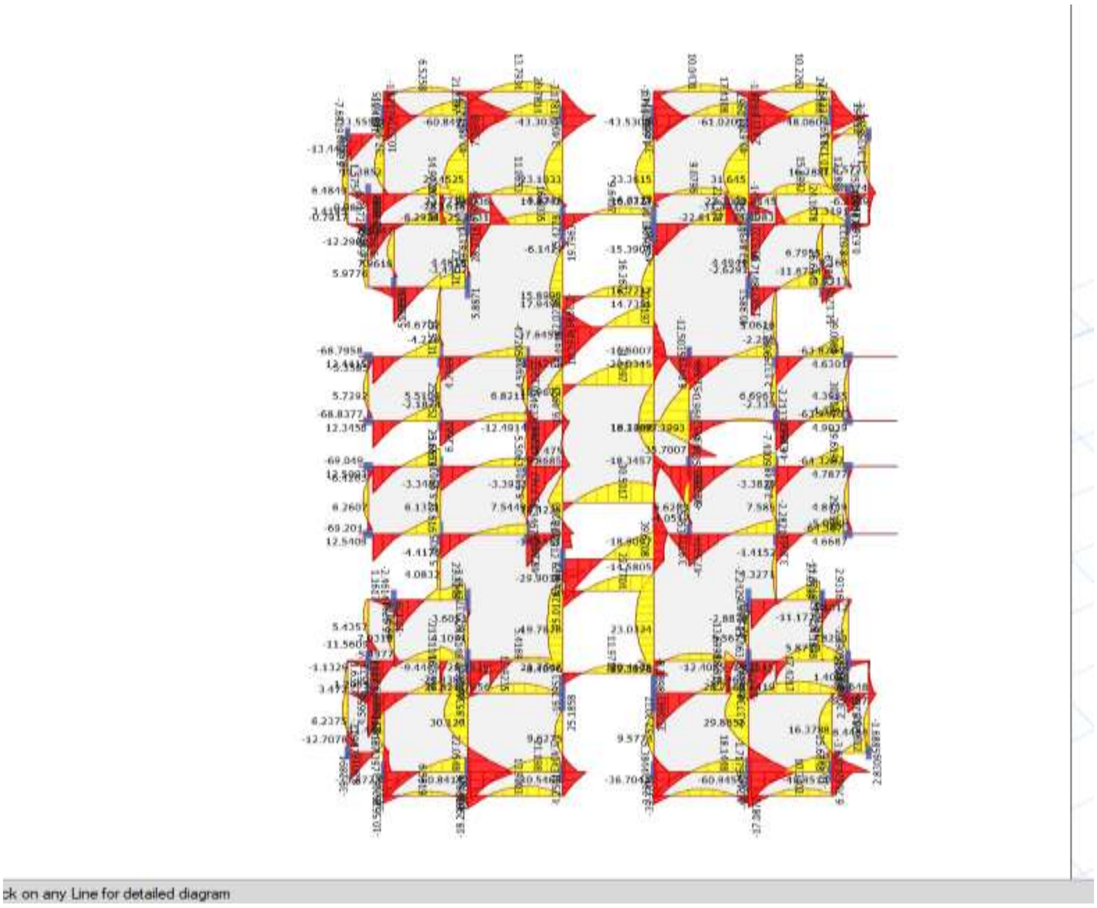
STEP 7- Lateral Force and Shear Force Distribution



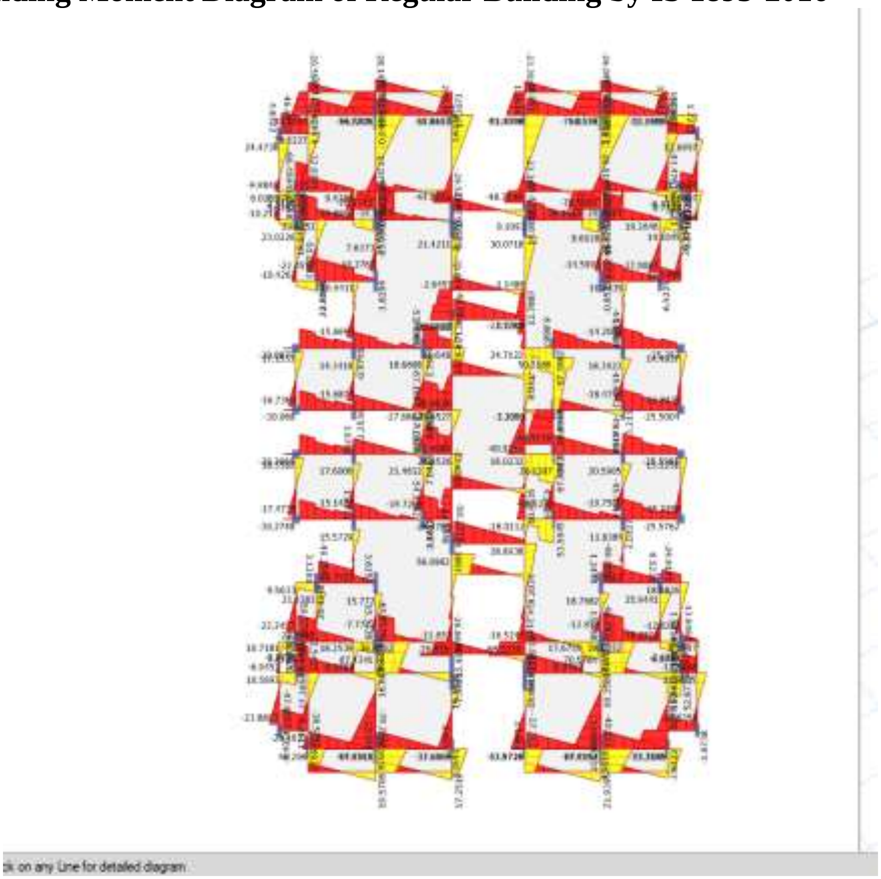
Structural Modelling using ETABS by IS 1893-2016



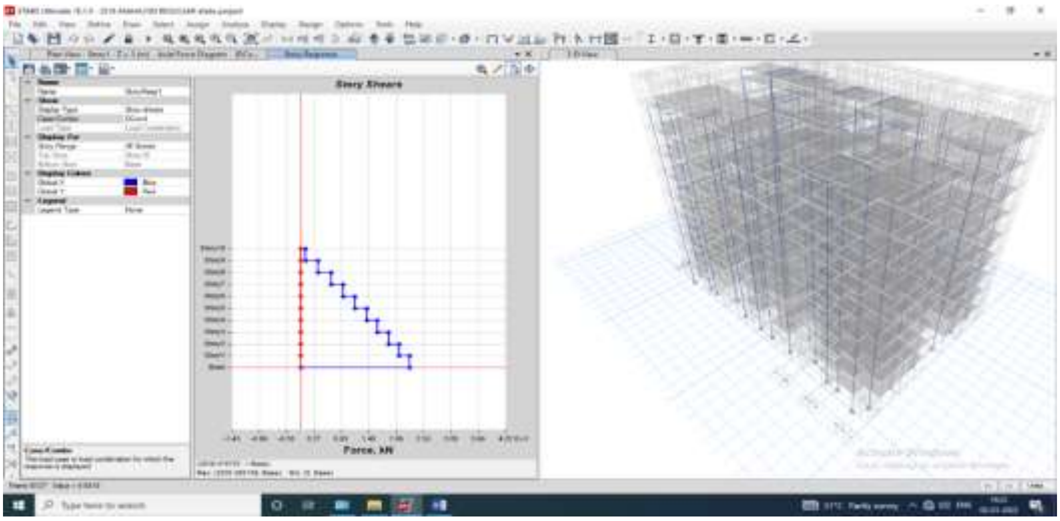
3D Modelling in ETABS by IS 1893-2016



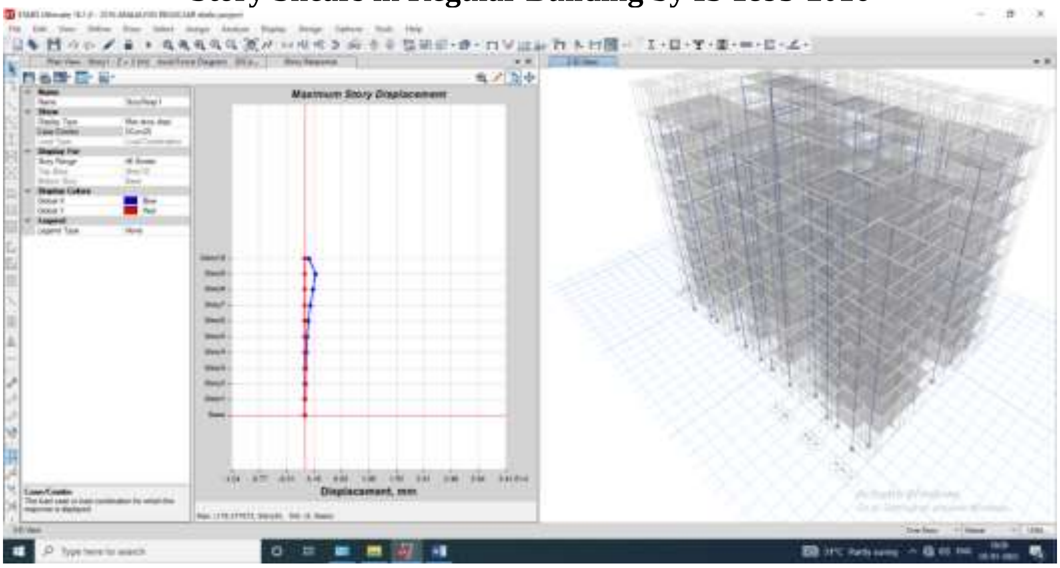
Bending Moment Diagram of Regular Building by IS 1893-2016



Shear Force Diagram of Regular Building by IS 1893-2016

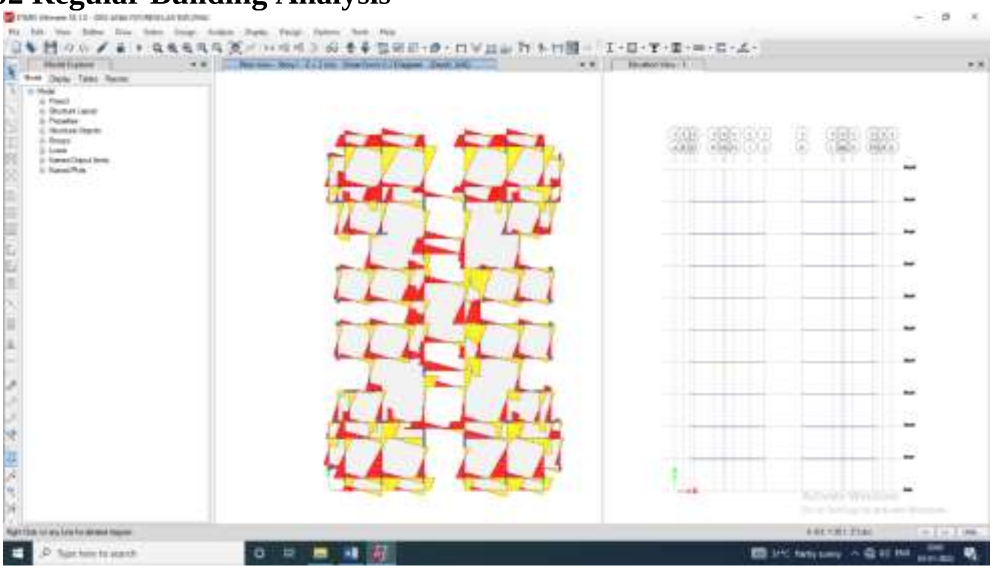


Story Shears in Regular Building by IS 1893-2016

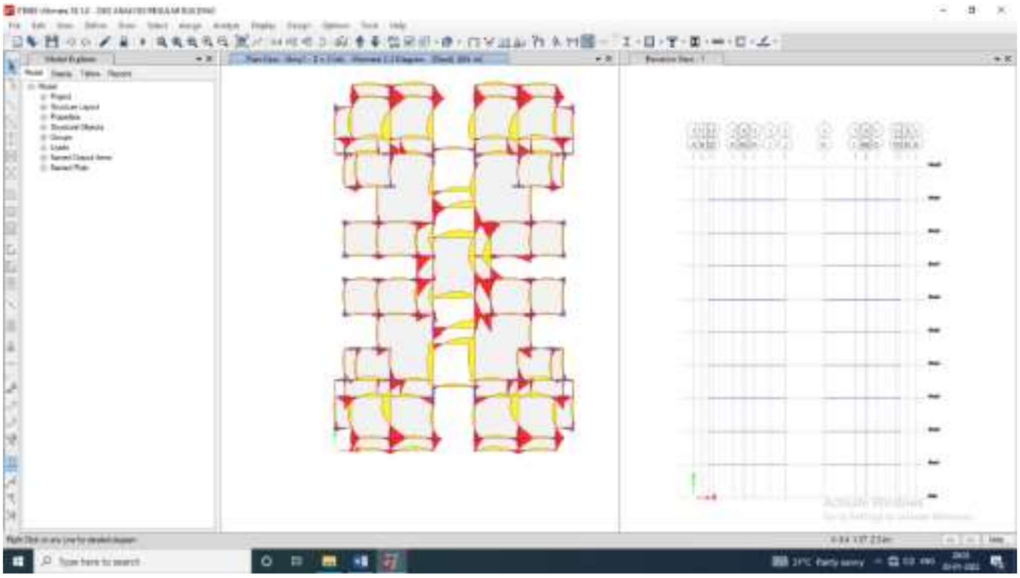


Maximum Story Displacement in Regular Building by IS 1893-2016

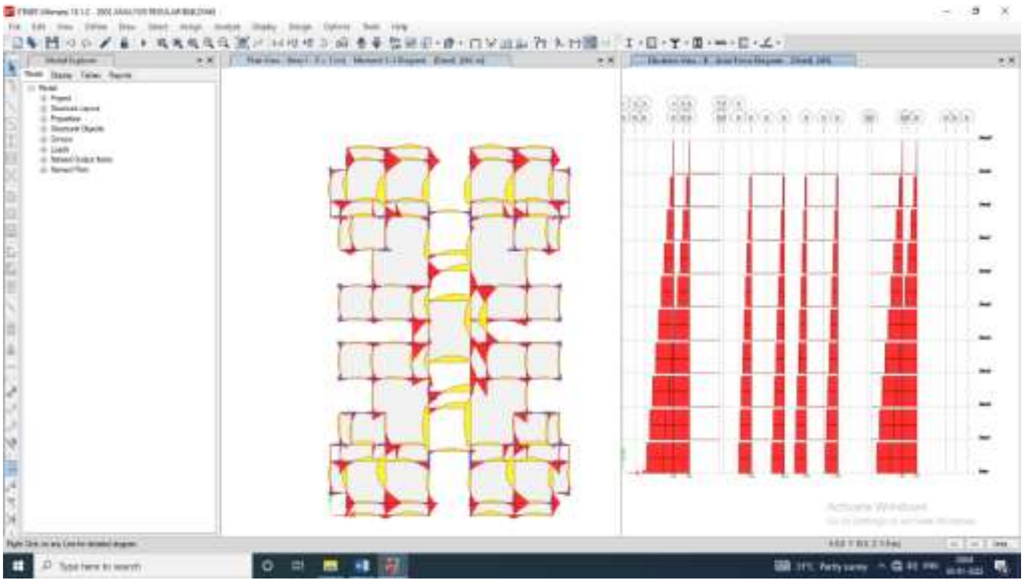
IS 1893-2002 Regular Building Analysis



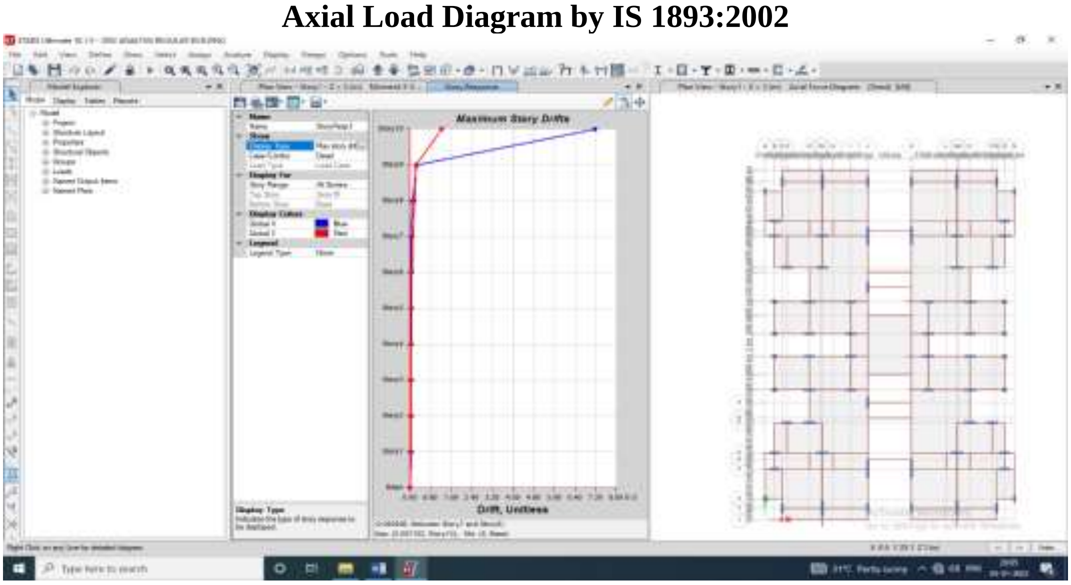
Shear Force Diagram of Regular Building by IS 1893: 2002



Bending Moment Diagram by IS 1893:2002



Axial Load Diagram by IS 1893:2002



Maximum Storey Drift by IS 1893:2002

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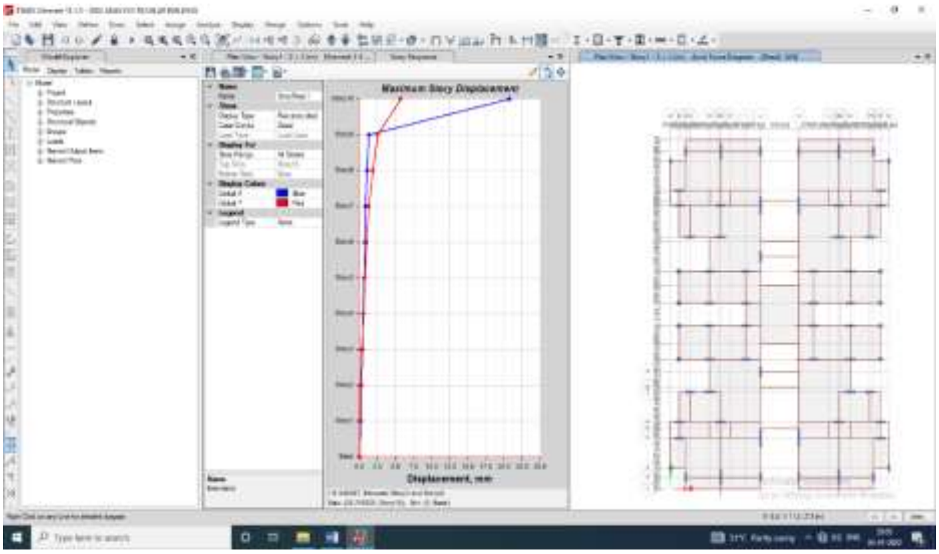
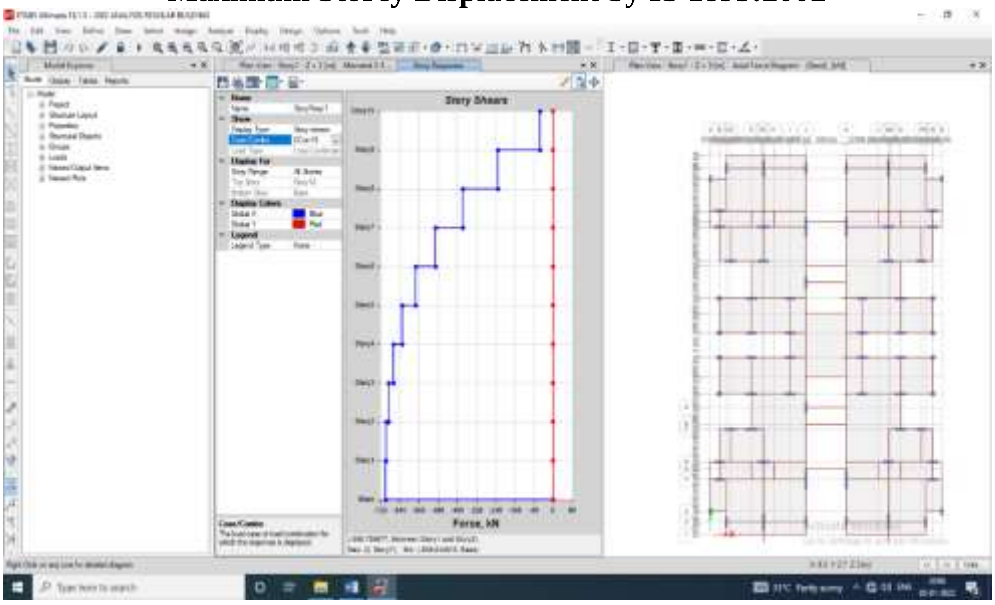


Maximum Storey Displacement by IS 1893:2002



Story Shear by IS 1893:2002

Conclusion

1. It is cleared that Required or Minimum area of reinforcement is less in ETABS than STAAD Pro. Although Area of Reinforcement provided in ETABS is more than STAAD. Pro.
2. B/C strong column weak beam theory design tool available in ETABS and same is absent in STADD Pro.
3. It is found that ETABS is more reliable or suitable to high rise structure.
4. It shows that the result of base shear is vary between 0-6% for irregular building and 0-2% for regular building i.e manual and software design analysis for both IS 1893-2002 and IS 1893-2016,
5. Both versions of seismic design focus on making strong and flexible buildings. But the 2016 version aims for structures to handle intense shaking better than the 2002 version.

References

1. Is 1893 (part 1): 2002 code of practice for earthquake resistant design of structure fifth revision (bureau of indian standards, new delhi)
2. Is 1893 (part 1): 2016 code of practice for earthquake resistant design of structures sixth revision (bureau of indian standards, new delhi)

3. M.R.Wakchaure-Earthquake Analysis Of High Rise Building With And Without Infill Wall.International Journal Of Engineering And Annovative Technology (IJEIT) Vol.2.
4. Mayur R. Rethaliya A Comparative Study of Various Clauses of New IS 1893 (Part 1):2016 and Old IS 1893 (Part 1):2002.
5. M. S. Kakamare Static analysis of multi-storeyed building as per IS 1893-2002 and IS 1893-2016.
6. Balaji. U, “Design and Analysis of Multi-Storied Building under static and dynamic loading conditions using ETABS”, International Journal of Technical Research and Applications, ISSN: 2320-8163, Volume 4, Issue 4 (July-Aug,2016), PP. 1-5.
7. 8. B. Srikanth and V. Ramesh "Comparative Study of Seismic Response for Seismic Coefficient and Response Spectrum Methods”, International Journal of Engineering Research and Applications, ISSN: 2248-9622, Vol. 3, Issue 5, Sep-Oct 2013.
8. Girum Mindaye, Dr. Shaik Yajdani “Seismic Analysis of a Multistorey RC Frame Building in Different Seismic Zones”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 9, September 2016.
9. Ravikant Singh and Vinay Kumar Singh Analysis of Seismic Loads acting on multistory Building as per IS:1893-2002 and IS: 1893-2016: - A comparative Study
10. Nagaratna. S.A, Ranjita. N.H, Asif. R.S, Vijaykumar. K.J, Sudha. P.H, Prof. D.S. Maganur6 Analysis and design of multistory building (G+3) by using ETABS softwear.
11. Rakeshkumar Gupta, Prof. D.L. Budhlani Review of IS 1893:2016 with IS1893:2002 for high rise structure with irregularities.
12. K. Kiran Mai Analysis and Design of Residential Building G+7 using E-Tabs.
13. Ajay Kumar A comparative study of static analysis (as per code IS: 1893-2002) & dynamic analysis as per IS:1893-2016) of a building for zone V.
14. S.K. Ahirwar, S.K. Jain & M.M. Pande, Earthquake loads on multi-storey buildings as per IS 1893-1984 & IS 1893 – 2002: A comparative study, the 14th World Conference on EarthquakeEngineering, Beijing, China.
15. K Rama Raju, A. Cinitha, Nagesh R. Iyer, Seismic performance evaluation of existing RC buildings designed as per past codes of practice, Indian Academy of Science, Sadhana, vol. 37, part 2, 281–297.
16. Dr. H. Sudarsana Rao, Comparative study of seismic lateral forces as per IS 1893- 1984 & IS1893-2002, International Journal of Emerging Trends Engineering & Development, issue 4, vol.4,282-299.
17. Azhar Bagadia, Comparison of response of industrial structure as per IS 2893-1984 with IS1983 part 4 2005, International Journal of Advanced Engineering Research & Studies, Vol. I,issue III, 95-97.