



“INVESTIGATION OF LINEAR DYNAMIC ANALYSIS AND DUCTILE DESIGN OF HIGH RISE STRUCTURE AS PER REVISED INDIAN CODE”

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ABSTRACT

This thesis gives a comparative analysis of ductile column design using the New IS 13920-2016 and the Old IS 13920-1993 standards. The recent earthquakes in India revealed unequivocally that conventional structural design and construction techniques fail to meet fundamental seismic resistance standards. The use of ductile design and detailing methods in conventional construction is a critical topic that requires attention. The ductility of reinforced concrete structures as a whole is a difficult topic. However, specific design factors and reinforcing details may be used in particular critical spots of the building structure to reduce seismic damage and life-threatening collapse. The approaches are straightforward, affordable, and extensively detailed in the Indian Bureau of Standard Code of Practice's standard code of practise (IS13920). It is recommended to conduct a comparative assessment of multi-story framed buildings, including their column c/s aspect ratio and minimum column requirements, using the Equivalent Static technique in accordance with the provisions of both the new IS 13920-2016 and the older IS 13920-1993. Additionally, it is recommended to analyse and design multi-story buildings using computational software such as ETABS and compare characteristics such as time period, base shear, storey displacement.

Keywords — Linear analysis, ductile design, high rise building.

INTRODUCTION

1.1 INTRODUCTION

When earthquakes occur, a building undergoes dynamic motion. This is because the building is subjected to inertia forces that act in opposite direction to the acceleration of earthquake excitations. These inertia forces, called seismic loads, are usually dealt with by assuming forces external to the building. So, apart from gravity loads, the structure will experience dominant lateral forces of considerable magnitude during earthquake shaking. It is essential to estimate and specify these lateral forces on the structure in order to design the structure to resist an earthquake. The ductility

of a structure is the most important factor affecting its seismic

performance and it has been clearly observed that the well designed and detailed reinforced structures behave well during earthquakes and the gap between the actual and design lateral force is narrowed down by providing ductility in the structure.

The national building code of India (NBC) 2015 is likely to be released by bureau of Indian standards during December 2016/January 2017. Various sections of this NBC have undergone changes as per latest technologies and user requirements. The document CED 39 (and corresponding IS.1893) on “criteria for

earthquake resistant design of structures” (part-1–general provisions for all structures and specific provisions for buildings) has undergone tremendous changes for structural design requirements.

Indian seismic code IS: 1893 has also been revised in year 2016. This project presents the seismic load estimation and ductile design for multi-storied buildings as per new codal provisions. The process gives analysis and ductile design of multi-storied building by using new codal provisions and the results are used to compare old codal provisions viz. Lateral displacement, base shear, modal participation computed as per the two versions of seismic code and ductile detailing. The seismic forces and ductile provision, by new codes of IS: 1893 and IS: 13920 with structure properties. It is compared that such study to old codes provision needs to be carried out for structure to predict seismic vulnerability and ductile design of multi-storied buildings that were designed using earlier code. In view of the heavy construction programme launched all over the country after independence IS: 1893-1962 was published and subsequently revised six times. A number of important modifications have been made in the new 2016 (criteria for earthquake resistance of design of structures) of six revisions. The objective of this project is to compare the seismic design forces and ductile design obtained by the latest 2016 version with those obtained by the previous versions in different cases of buildings. The past earthquake experiences in India clearly demonstrated that the typical structural design and construction methods lacks the basic seismic resistance criteria. The implementation of ductile design and detailing practices in ordinary building is one of the major area need to be focused. The overall ductility in reinforced concrete structure is a tough issue. But in some strategic locations of the building structure certain design factor and reinforcement detailing can be adopted to minimise the seismic damage and life threatening collapse. The techniques are simple, inexpensive and elaborately discussed in the bureau of Indian standard code of practice (IS13920:1993). The structures need to be designed to have sufficient strength and ductility for overall safety against earthquake forces. Both the strength and the ductility are combined together to improve its seismic safety. This project study discussed the seismic and ductile behaviours of the reinforced concrete structures according to new Indian code. It also evaluates the earthquake resistance performance of structure based on design and detailing parameters. The behaviour of beam-column joints and the confinement in concrete columns are also addressed.

The process of designing high-rise buildings have changed over the past years. In the most recent years it is not unusual to model full three-dimensional finite element models of the buildings. This due to the increased computational power and more advanced software. However, these models produce huge amount of data and results where possible errors are easily overlooked, especially if the model is big and complex. If the engineer is not careful and have a lack of knowledge of structural behaviour and finite element modelling, it is easy to just accept the results without critical thoughts. Furthermore, different ways of modelling have a big influence on the force and stress distribution. This can lead to time consuming discussion and disagreements between engineers as they often have different results from calculations on the same building.

1.2. ANALYSIS PROCEDURES

1.2.1 LINEAR STATIC ANALYSIS

The response of a structure to redistributed loads following the sudden loss of a critical load carrying member is dynamic and nonlinear. However, as in seismic design, one simple approach is to use an equivalent static elastic analysis if buildings have relatively simple layouts and do not fall in the following categories:

- a) Buildings that utilize a combination of frames and walls in the structural systems,
- b) Buildings with vertical discontinuities in columns and walls, which utilize transfer girders,
- c) Buildings that have a large variance in structural bay size,
- d) Buildings that have plan irregularities, and
- e) Buildings that have closely spaced columns, which can lead to uncertainty in the application of a simplified analysis.

1.2.2 STRUCTURAL DUCTILITY

Structural ductility in a global sense depends on the displacement ductility of its members because response displacement of each member can be evaluated even with static analysis. Its quantification requires a relationship between the lateral load and displacement of the whole building. This may be obtained by pushover analysis by plotting total base shear versus the top displacement or preferably, versus the displacement at the level where the resultant forces are applied.

1.2.3 LINEAR DYNAMIC ANALYSIS

In linear dynamic analysis, the response of the structure to ground motion is calculated in the time domain, and all phase information is therefore maintained. Only linear properties are assumed. The analytical method can use modal decomposition as a means of reducing the degrees of freedom in the analysis.

1.2.4 DUCTILITY

It describes the extent to which a material (or structure) can undergo large deformations without failing. The term is used in earthquake engineering to designate how well a building will endure large lateral displacements imposed by ground shaking. Stiffness is a measure of how much force is required to displace a building by a certain amount. If it requires more force to shift Building A than Building B, we would say that Building A is stiffer. Stiffness can be advantageous with respect to earthquake damage because it can limit the deformation demands on a building.

1.2.5 DUCTILITY DESIGN

Instead of designing structures elastically to withstand lateral forces from severe and infrequent earthquakes, designing structures for lower force levels and higher ductility is a widely accepted practice in performance-based design.

LITERATURE REVIEW

2.1 LITERATURE PAPERS

Mahesh Patil, Yogesh Sonawane (2015) “*Seismic Analysis of Multi-storeyed Building*” The effective design and the construction of earthquake resistant structures have much greater importance in all over the world. In this paper, the earthquake response of symmetric multi-storeyed building is studied by manual calculation and with the help of ETABS 9.7.1 software. The method includes seismic coefficient method as recommended by IS 1893:2002. The responses obtained by manual analysis as well as by soft computing are compared. This paper provides complete guide line for manual as well software analysis of seismic coefficient method.

Balaji.U. A, Mr. Selvarasan M.E. B (2016) “*Design and Analysis of Multi-storeyed building under static and dynamic loading conditions using Etabs*” In this project a residential of G+13 multi-story building is studied for earth quake loads using ETABS. Assuming that material property is linear static and dynamic analysis is performed. These non-linear analyses are carried out by

considering severe seismic zones and the behavior is assessed by taking types II soil condition. Different response like, displacements, base shear are plotted.

Pardeshisameer, Prof. N. G. Gore (2016) “*Study of seismic analysis and design of multi storey symmetrical and asymmetrical building*” The current version of the IS: 1893-2002 requires that practically all multi storied buildings be analysed as three-dimensional systems. Buildings may be considered as asymmetric in plan, in mass and stiffness along storey, of the buildings. Most of the hilly regions of India are highly seismic. In this study, 3D analytical model of G+15storied buildings have been generated for symmetric and asymmetric building models and analysed using structural analysis tool ETABS software. Mass and stiffness are two basic parameters to evaluate the dynamic response of a structural system. Multi-storied buildings are behaved differently depending upon the various parameters like mass-stiffness distribution, foundation types and soil conditions. 2001 Bhuj earthquake in Gujrat, India demonstrated the damage and collapse of the buildings due to the irregularities in structural stiffness and floor mass. This paper is concerned with the effects of various vertical irregularities on the seismic response of a structure. They studied Response spectrum analysis (RSA) of regular and irregular RC building frames and Time history Analysis (THA) of regular RC building frames and carried 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.

Kollimarla et.al (2016) “*Seismic Analysis of a Multi Storey Plane Frame using Static & Dynamic Methods*” In the context of seismic analysis and design of structures, in earthquake engineering, a verity of methods are available. Standard codes provide provision for certain methods for the analysis of wide range of structures of engineering interest. In this paper an attempt is made to present the provisions of IS 1893:2002, part-1 for the analysis of structures and its suitability.

SagarBelgaonkar, RajashekharBilagi (2016) “*Seismic Comparison of Building with or without Deep Beam*” The structure analysis of proposed building is carried out by E-tabs2013 software. The proposed building model has been done. Models are analysed by equivalent static method and dynamic method to resist the lateral load. From the study on the behaviour of the models with and without deep beams it is seen that deep beam has a significant impact on the entire structure and

hence deep beams can be one of the solutions for resisting effect of earthquake on the structure.

C.V.S. Lavanya, Emily.P.Pailey, Md. ManshaSabreen (2017) “*Analysis and design of g+4 residential building using Etabs*” ETABS stands for Extended Three Dimensional Analysis of Building Systems. The main purpose of this software is to design multi-storied building in a systematic process. The effective design and construction of an earthquake resistant structures have great importance all over the world. This project presents multi-storied residential building analysed and designed with lateral loading effect of earthquake using ETABS. This project is designed as per INDIAN CODES- IS 1893-part2:2002, IS 456:2000 and analysis is carried out by considering severe seismic zones and behaviour is assessed by taking type-II Soil condition.

Rama Raju, K., Shereef, M. I., Iyer, N. R., & Gopalakrishnan, S. (2013) This paper states that, consideration of site specific lateral loading due to wind or earthquake loads along with vertical gravity loads is important for finding the behavior of the tall buildings. As the height of a building becomes taller, the amount of structural material required to resist lateral loads increases drastically. The design of tall buildings essentially involves a conceptual design, approximate analysis, preliminary design and optimization, to safely carry gravity and lateral loads. The design criteria are strength, serviceability and human comfort. The aim of the structural engineer is to arrive at suitable structural schemes, to satisfy these criteria. In the present study, the limit state method of analysis and design of a 3B+G+40-storey reinforced concrete high rise building under wind and seismic loads as per IS codes of practice is described. Safety of the structure is checked against allowable limits prescribed for base shear, roof displacements, inter-storey drifts, accelerations prescribed in codes of practice and other relevant references in literature on effects of earthquake and wind loads on buildings.

Svetlana Brzev (2016) This paper states that , the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to

promote the timely dissemination of this information in an accurate manner to the public.

Hosseini, M., & Rao, N. V. R. (2017) This paper states that, the shear walls are located on each level of the structure, to form an effective box structure, equal length shear walls are placed symmetrically on opposite sides of exterior walls of the building. Shear walls are added to the building interior to provide extra strength and stiffness to the building when the exterior walls cannot provide sufficient strength and stiffness or when the allowable span-width ratio for the floor or roof diaphragm is exceeded. Shear walls are analyzed to resist two types of forces: shear forces and uplift forces. Shear forces are created throughout the height of the wall between the top and bottom shear wall connections. Uplift forces exist on shear walls because the horizontal forces are applied to the top of the wall. These uplift forces try to lift up one end of the wall and push the other end down. In some cases, the uplift force is large enough to tip the wall over. Shear walls are analyzed to the provide necessary lateral strength to resist horizontal forces. Shear walls are strong enough, to transfer these horizontal forces to the next element in the load path below them. The seismic motion that reaches a structure on the surface of the earth is influenced by local soil conditions.

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Gautam, K., & Gupta, M. (2020) This study reviewed the recent developments in finding the response reduction factor for RC framed building and the

influence of soil-structure interaction (SSI) effects in the various responses of the building. For Response Reduction Factor, the nonlinear analysis was done in order to capture all the hysteretic Energy beyond the elastic limit. Various approaches to pushover analysis and time history analysis have been mentioned in this review paper.

Çavdar, Ö. (2021) In this paper, the seismic behavior of existing reinforced concrete tall building is investigated by the linear and nonlinear dynamic analysis. The selected reinforced concrete structure was designed according to “Turkey Seismic Code-2007” (TEC-2007). A typical 41 story reinforced concrete building is designed. Turkey Building Earthquake Code-2018 (TBEC-2018) is utilized for evaluating the seismic performance of the selected building. Natural earthquake acceleration record selected and adjusted for compatibility with the adopted design spectrum, is used.

Ferraioli, M. (2021) This paper states that, the current generation of seismic design codes is based on a linear elastic force-based approach that includes the nonlinear response of the structure implicitly through a response modification factor (named reduction factor R in American codes or behaviour factor q in European codes). However, the use of a prescribed behaviour factor that is constant for a given structural system may fail in providing structures with the same risk level. In this paper, the behaviour factor of reinforced concrete frame structures is estimated by means of nonlinear static (pushover) and nonlinear incremental dynamic analyses.

The objectives of this study are twofold. Firstly, it aims to analyze the dynamic behavior of high-rise structures using the response spectrum method outlined in IS 1893 Part1-2016, employing FEM-based software such as ETABS, SAP, or STAD PRO. The focus is on interpreting dynamic responses, including parameters like displacement, time period, base shear, mode shape, and modal mass participation ratios. Secondly, the study seeks to evaluate and compare the impact of the newly revised codal provisions on seismic behavior in high-rise structures against the old code provisions. Additionally, the research entails the implementation of ductile design for high-rise structures following the updated codal provisions specified in IS 13920-2016.

METHODOLOGY

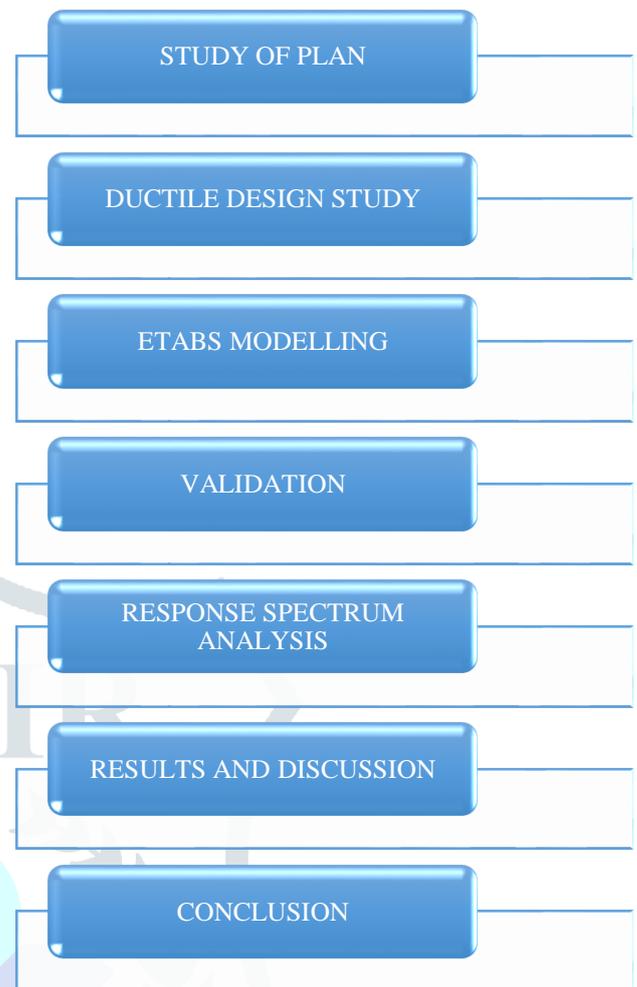


Fig 1 Flowchart

The finite part analysis may be a numerical technique. during this technique all the complexities of the issues, like variable form, boundary conditions and masses are maintained as they are they're however the solutions obtained are approximate. attributable to its diversity and adaptability as Associate in Nursing analysis tool, it's receiving abundant attention in engineering.

The quick enhancements in component technology and dynamic of price of computers have boosted this technique, since the pc is that the basic want for the applying of this technique. variety of in style whole of finite part analysis packages are currently accessible commercially. a number of the popular packages are STAAD-PRO, GT-STRUDEL, NASTRAN, NISA and ANSYS. victimization these packages one will analyze many complicated structures. The finite element analysis originated as a method of stress analysis in the design of aircrafts. It started as an extension of matrix method of structural analysis.

Civil engineers use this method extensively for the analysis of beams, space frames, plates, shells,

folded plates, foundations, rock mechanics problems and seepage analysis of fluid through porous media. Both static and dynamic problems can be handled by finite element analysis.

3.1 DESCRIPTION OF METHOD

In engineering issues their square measure some basic unknowns. If they're found, the behaviour of the complete structure may be expected during a time, these unknowns square measure infinite. The finite component procedure reduces such unknowns to a finite range by dividing the answer region into little components known as parts and by expressing the unknown field variables in terms of assumed approximating functions (Interpolating functions/Shape functions) inside every component. The approximating functions square measure outlined in terms of field variables of specified points known as nodes or nodal points. so, within the finite component analysis the unknowns square measure the sphere variables of the nodal points. once choosing parts and nodal unknowns next step in finite component analysis is to assemble component properties for every component. maybe, in solid mechanics, we've got to seek out the force-displacement i.e. stiffness characteristics of every individual component. Mathematically this relationship is of the shape.

3.2 STRUCTURAL DESIGN CONSIDERATION METHODS OF SEISMIC ANALYSIS OF BUILDING

3.2.1 GENERAL

Earthquakes area unit nature's greatest hazards to life on this planet. The hazards obligatory by earthquakes area unit distinctive in several respects, and consequently going to mitigate earthquake hazards needs a novel engineering approach. a crucial distinction of the earthquake drawback is that the hazard to life is associated virtually entirely with manmade structure expect for earthquake triggered landslides, the sole earthquake impact that causes in depth loss of life area unit collapse of bridges, buildings, dams, and alternative works of man. This facet of earthquake hazard may be countered solely by styles and construction of earthquake resistant structure. The optimum engineering approach is to style the structure therefore on avoid collapse in most doable earthquake, so guaranteeing against loss of life however acceptive the chance of harm.

Various methods for determining seismic forces in structures fall into two distinct categories:

- (i) Equivalent static force analysis

- (ii) Dynamic Analysis

3.3 EQUIVALENT STATIC FORCE ANALYSIS:

Earthquakes area unit nature's greatest hazards to life on this planet. The hazards obligatory by earthquakes area unit distinctive in several respects, and consequently going to mitigate earthquake hazards needs a novel engineering approach. a crucial distinction of the earthquake drawback is that the hazard to life is associated virtually entirely with manmade structure expect for earthquake triggered landslides, the sole earthquake impact that causes in depth loss of life area unit collapse of bridges, buildings, dams, and alternative works of man. This facet of earthquake hazard may be countered solely by styles and construction of earthquake resistant structure. The optimum engineering approach is to style the structure therefore on avoid collapse in most doable earthquake, so guaranteeing against loss of life however acceptive the chance of harm. Basically, they give total horizontal force (Base Shear) V , on a structure:

$$V = ma$$

Where, m is mass of structure

V is applied to the structure by a simple rule describing its vertical distribution. In a building this generally consist of horizontal point loads at each concentration of mass, most typically at floor level. The seismic forces and moments in the structure are then determined by any suitable analysis and the results added to those for the normal gravity load cases. An important feature of equivalent static load requirement in most codes of practice is that calculated seismic forces are considerably less than those which would actually occur in the larger earthquakes likely in the area concerned.

$$V = F_1 + F_2 + F_3$$

3.10 CURRENT PRACTICE AND COMMENTS

The preface of the present Bureau of Indian commonplace code IS 1893-2002 (Part1) will mentioned inadequacy of the 'seismic coefficient' technique and recommend that an in depth dynamic analysis is meted out just in case of necessary structure in earthquake prone areas. The mentioned inadequacy in technique has higher underlining significance in geotechnical engineering and structures subjecting giant earthquake forces. there's no any provision of base isolation style and mix result of soil-base isolation. there's have to be compelled to embody pointers aboard isolation style and result of SSI with base isolation subjected to ground motion.

3.11 DUCTILE DESIGN

Ductility refers to a material's (or structure's) ability to withstand substantial deformations without failing. The word is used in earthquake engineering to describe a structure's ability to withstand significant lateral displacements caused by ground shaking.

The stiffness of a structure indicates the amount of force necessary to move it by a certain quantity. If shifting Building A required greater force than shifting Building B, we would argue that Building A is stiffer. Stiffness may be favorable in terms of earthquake damage since it reduces the amount of deformation required of a structure.

However, there is such a thing as too much of a good thing. A structure that is excessively stiff (sometimes referred to as brittle) is prone to failure when subjected to relatively minor deformation demands. A brittle structure is an unreinforced masonry construction that will withstand only a small amount of movement before sustaining damage and collapse.

The capacity of a ductile structure to contort and release energy during an earthquake is also beneficial, since it will continue to distort without eventually failing or collapsing. A ductile structure is a correctly specified steel frame with sufficient elasticity to withstand substantial deformations before failing.

3.13 BUILDING STRUCTURAL DUCTILITY FOR EARTHQUAKE RESISTANT DESIGN

Ductility is essential for earthquake-resistant design of buildings, structures, and construction materials. The relevance of ductility in design is explored. To comprehend the significance of ductility in determining building performance, it is necessary to first define ductility. In material engineering science, ductility is defined as the ratio of ultimate strain to yield strain of a material. In a wider sense, ductility is defined as a structure's capacity to withstand bigger deformations without collapsing. The detailing of the structure that allows the structure to achieve a greater ductility other than the contributions of material ductility is referred to as ductility detailing or ductile detailing, according to particular requirements indicated in codes. When a structure is subjected to dynamic forces (also known as seismic demand), the structure can no longer stay elastic, and the next step is damage. It may go through a plastic stage, fracture, or damage, when stiffness decreases noticeably and deformations increase dramatically even with a tiny force. These conditions must be anticipated by an engineer, and we must

guarantee that our design can withstand these stresses without experiencing bigger deformations or collapsing. To attain this goal, we must include or improve the ductility of the construction.

3.14 COLUMNS AND FRAME MEMBERS SUBJECTED TO BENDING AND AXIAL LOAD

3.14.1 GENERAL

- These requirements apply to frame members which have a factored axial stress in excess of 0.1 let under the effect of earthquake forces.
- The minimum dimension of the member shall not be less than 200 mm. However, in frames which have beams with center to center span exceeding 5 m or columns of unsupported length exceeding 4 m, the shortest dimension of the column shall not be less than 300 mm.
- The ratio of the shortest cross sectional dimension to the perpendicular dimension shall preferably not be less than 0.4.

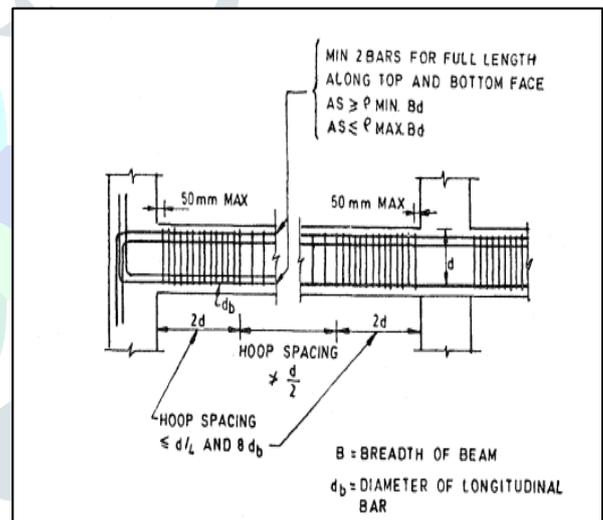


Fig 2 Beam Reinforcement

PROBLEM STATEMENT

In this project, a G+20-storey structure of a rectangular building with 3 m floor to floor height has been analysed Non-Linear Dynamic Analysis of Multi-storey R.C.C Buildings using ETAB software in zones III. The plan selected is Rectangular in shape. Medium soil condition has been selected for the structure.

Proposed work design the high story building to find the location of maximum shear force in the beam to column joints. Complete analysis is carried out for dead load, live load and seismic load. Analysis Modeling of G+20 storey R.C.C frame structure using commercial software ETABS Connect for various seismic zones i.e. III. Compare Shear Strength capacity of beam column

joints for different zone. Beam column joints in a reinforced concrete moment resisting frame are crucial zones for transfer of load effectively between the connecting element (i.e, beam and columns) in structure and hence shear strength checked and Design by draft provision in IS 13920-1993 and IS 13920-2016.

4.1 PRELIMINARY DATA REQUIRED FOR ANALYSIS: -

Table 1 Parameters to Be Consider for Rectangular Geometry Analysis

Sr. No.	Parameter	Values
1.	Number of stories	G+20
2.	Base to plinth	3m
3.	Grade of concrete	M30
4.	Grade of steel	Fe 500
5.	Floor to Floor height	3 m
6.	Total height of Building	66m
7.	Soil Type	Medium
8.	Dead Load	Calculated By Software
9.	Live load on roof	2 kN/m ²
10.	Live load on floors	3 kN/m ²
11.	Frame size	32m X 40m building size
12.	Grid spacing	8 m grids in X-direction and Y-direction.
13.	Size of column for IS 13920- 1993	300mm x 750 mm
14.	Size of column for IS 13920- 2016	350mm x 750 mm
15.	Size of beam	230mm x 600 mm
16.	Depth of slab	200 mm

17.	Importance factor for office building	1
18.	Damping percent	5%

4.2 IS CODE USE:

- 1) IS Code for Dead Load: - IS 875 Part 1
- 2) IS Code for Dead Load: - IS 875 Part 2
- 3) IS Code for Seismic Load: - IS 1893-2016 Part 1
- 4) IS Code for Ductile Detailing: IS 13920:1993 and IS 13920:2016

RESULT AND DISCUSSION

In this project, a G+20-storey structure of a rectangular building with 3 m floor to floor height has been analysed Non-Linear Dynamic Analysis of Multi-storey R.C.C Buildings using ETABS software in zones III, IV. The plan selected is Rectangular in shape. The structure has been analysed for both static and dynamic wind and earthquake forces. Hard, Medium and soft soil condition has been selected for the structure. The finite element method (FEM) is a widely used method for numerically solving differential equations arising in engineering and mathematical modelling.

Results are given below: -

Table 2 Models

MODEL 1	G+20 IN ZONE III (IS code- 13920-1993)
MODEL 2	G+20 IN ZONE III (IS code- 13920-2016)

Models:

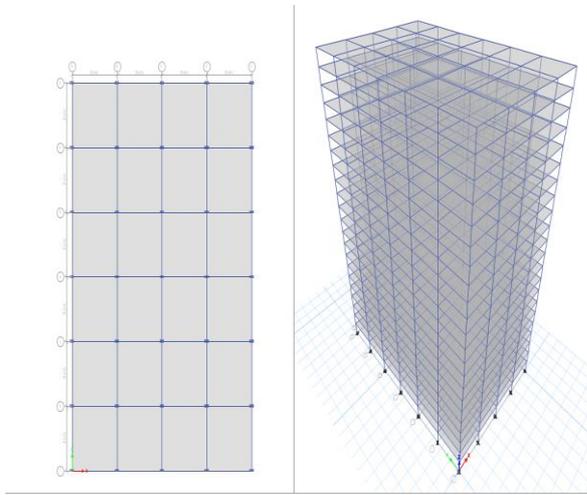
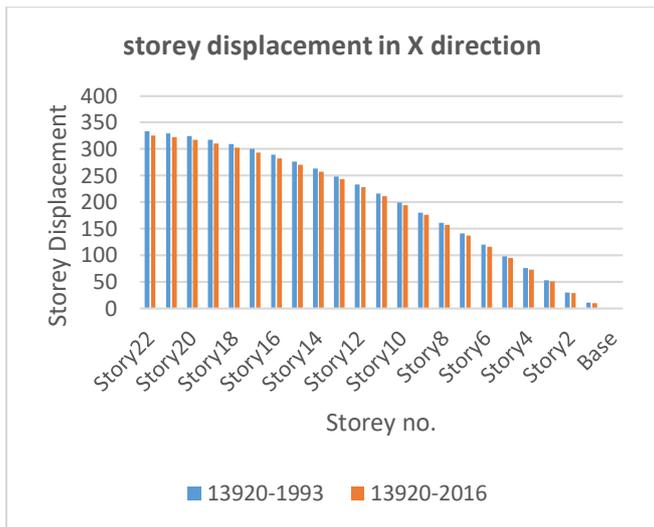


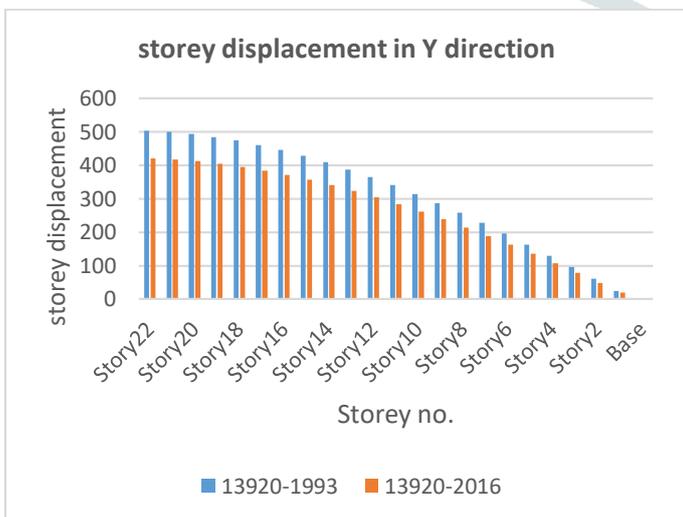
Fig 1 Building structure

displacement which is 503.456 mm and IS 13920-2016 has the lower displacement which is 420.773mm.



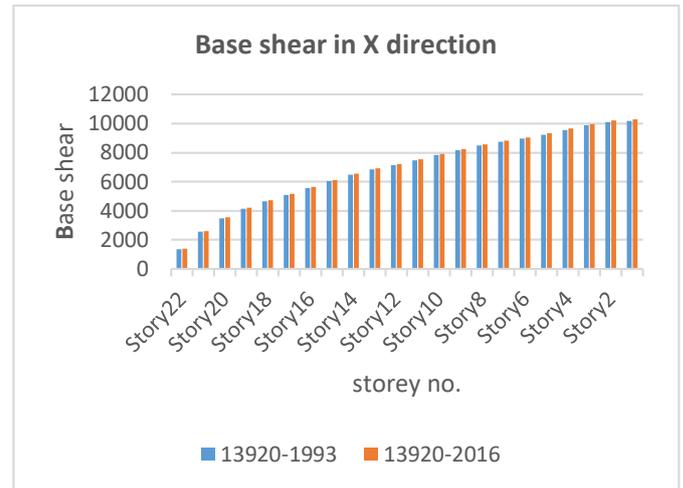
Graph 1 storey displacement in mm in X direction

The graph shows storey displacement in x direction in mm for zone III. IS-13920-1993 has the higher displacement which is 333.637 mm and IS 13920-2016 has the lower displacement which is 325.844mm.



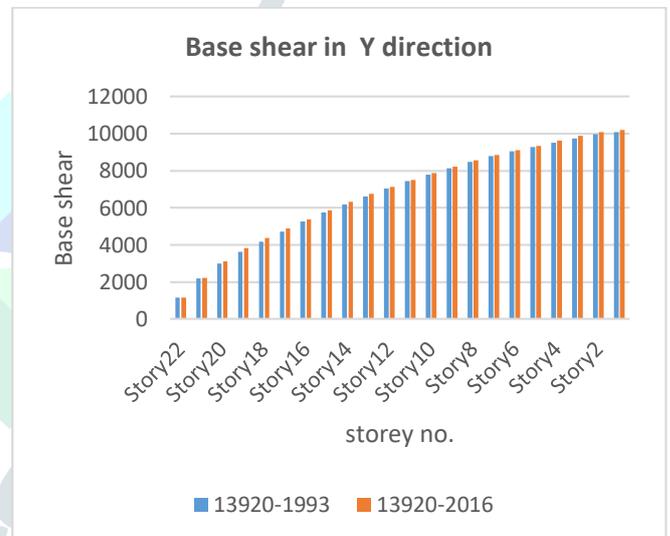
Graph 2 storey displacement in mm in Y direction

The graph shows storey displacement in Y direction in mm for zone III. 13920-1993 has the higher



Graph 3 base shear in X direction

The graph shows base shear in X direction in KN for zone III. IS-13920-2016 has the higher shear which is 1387.1415 KN and IS 13920-1993 has the lower shear which is 1357.018 KN.



Graph 4 base shear in KN in Y direction

The graph shows base shear in Y direction in KN for zone III. IS-13920-2016 has the higher shear which is 1160.522 KN and IS 13920-1993 has the lower shear which is 1154.3325KN.

IS 13920- 1993

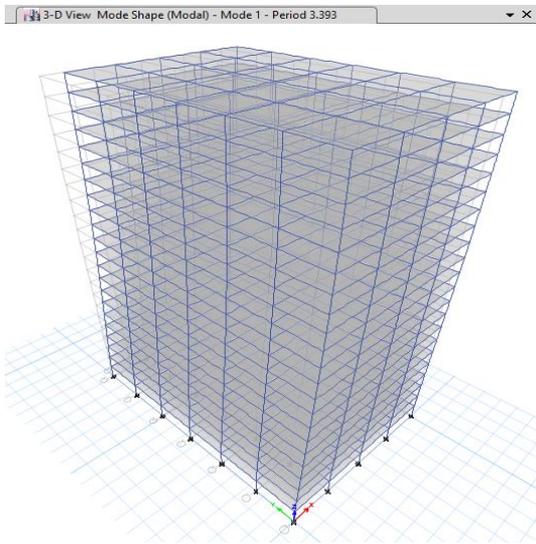


Fig 4 Mode shape 1 IS 13920- 1993

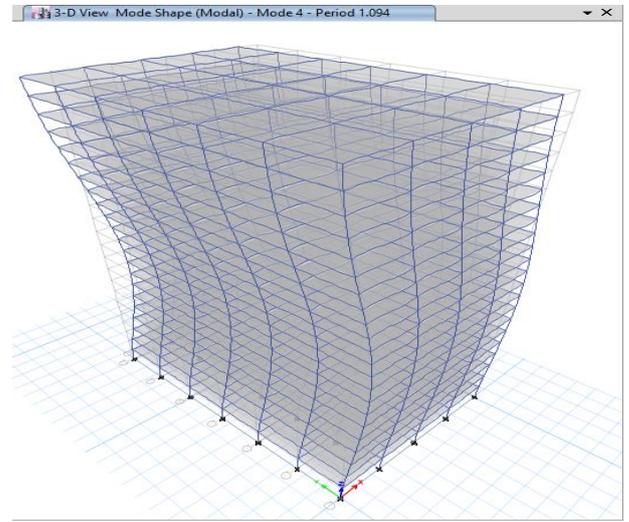


Fig 7 Mode shape 4 IS 13920- 1993

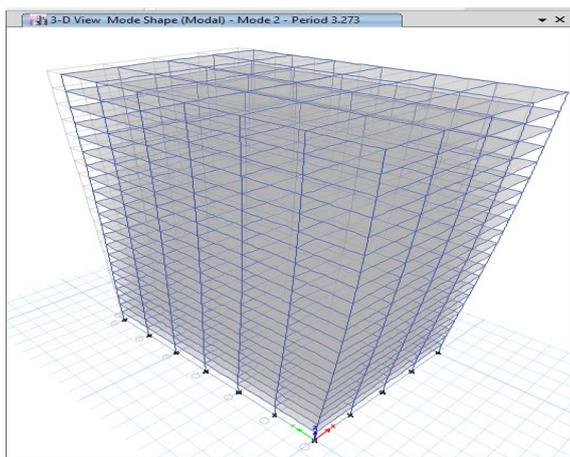


Fig 5 Mode shape 2 IS 13920- 1993

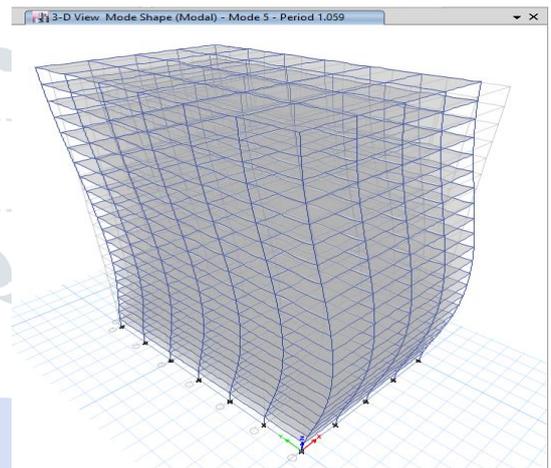


Fig 8 Mode shape 5 IS 13920- 1993

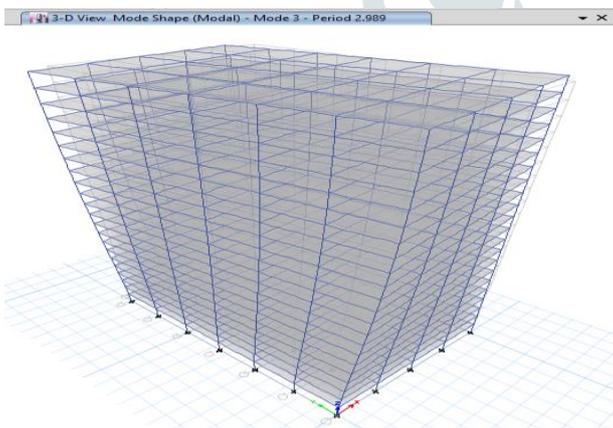


Fig 6 Mode shape 3 IS 13920- 1993

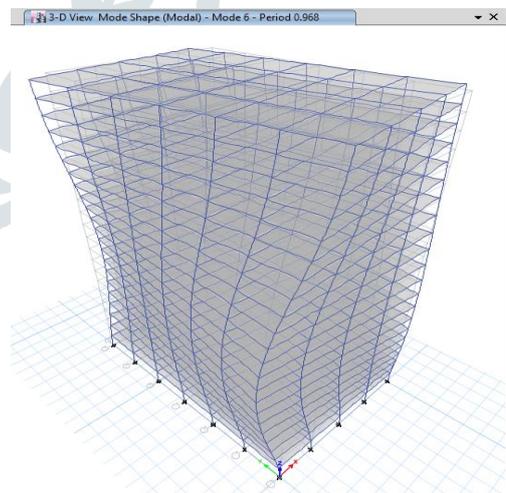


Fig 9 Mode shape 6 IS 13920- 1993

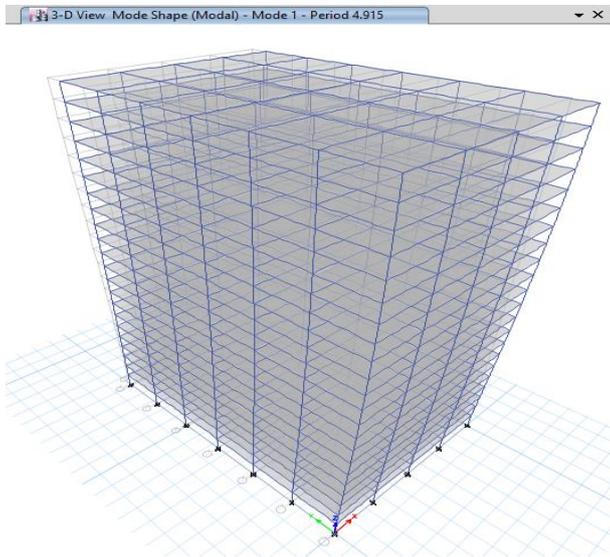


Fig 10 Mode shape 1 IS 13920- 2016

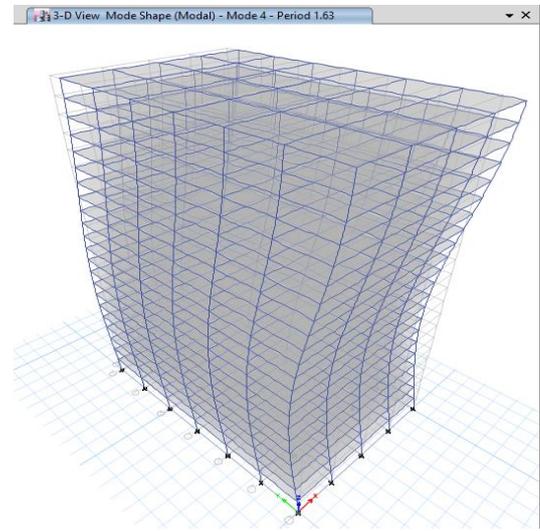


Fig 13 Mode shape 4 IS 13920- 2016

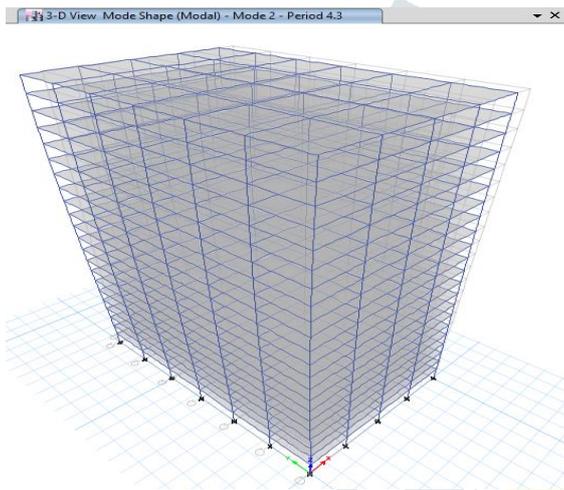


Fig 11 Mode shape 2 IS 13920- 2016

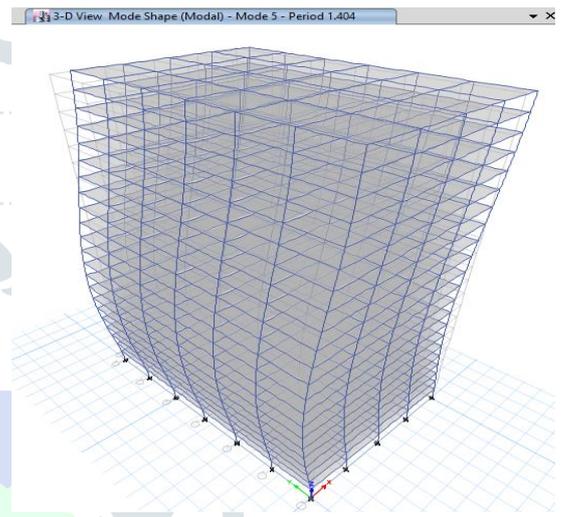


Fig 14 Mode shape 5 IS 13920- 2016

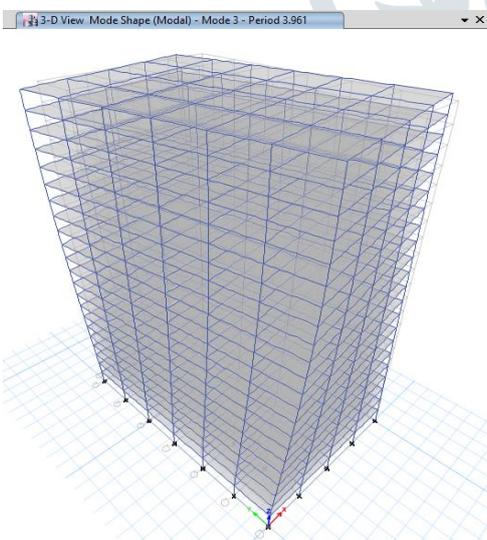


Fig 12 Mode shape 3 IS 13920- 2016

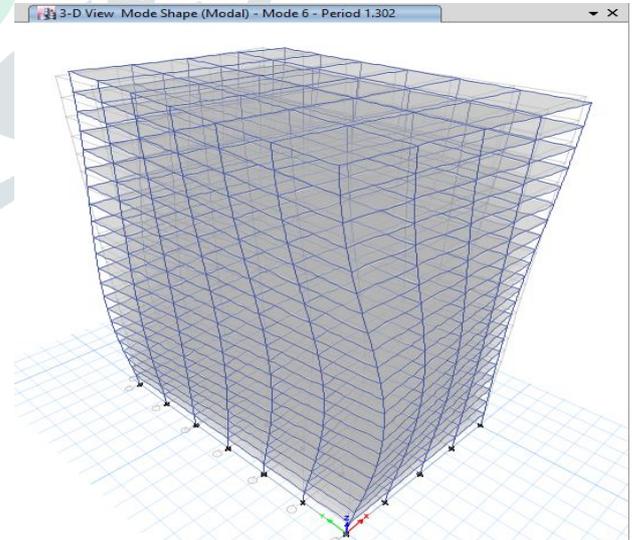
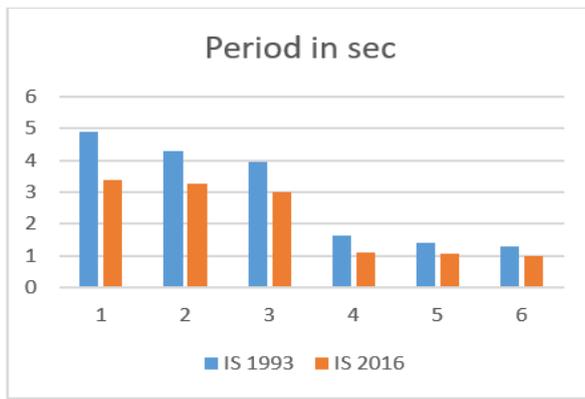


Fig 15 Mode shape 6 IS 13920- 2016



Graph 5 Time period

CONCLUSION

The 1993 version of IS 13920-1993 incorporated some provisions on the design beam column joints.

1. the storey displacement in X and Y direction for zone III structure with IS-13920-1993 has the higher displacement and IS 13920-2016 has the lower displacement
2. The base shear in X and Y direction for zone III structure with old IS code has the lower base shear than new IS code.
3. Base shear is increase with using new IS 13920-2016 code column C/S aspect ratio & minimum dimension of column & shear design of beam Column joint.
4. Time period is decrease with using new code requirements compare to old code data.
5. The displacement is also decrease with new IS requirements.
6. Using the new code requirements of shear design of beam column joint, they are effective for high rise building.
7. The revision of codes is a periodic process which results from continuous and systemic research in the related field. IS: 13920-2016 is the first revision of the code on ductile detailing of RC structures subject to seismic forces. The first revision has added some design aspects also along with detailing. The provisions of earlier code have been suitably modified keeping in view more strength and stiffness and enhanced energy dissipation in the event of an earthquake along with ductility for seismic resistance of structures. The revised code will lead to major modifications in beam-column design owing to the inclusion of strong column-weak beam theory. Hence it can be concluding that IS 13920:1993 should be restricted for Practitioner

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