Seismic Analysis Of Knee Braced System In High Rise Steel Structure For Different Earthquake Zone

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Abstract- *Most effective and practical method of enhancing the seismic resistance is to increase the energy absorption capacity of structures by combining bracing elements in the frame. The braced frame can absorb a greater degree of energy exerted by earthquakes. Bracing system improves the seismic performance of the frame by increasing its lateral stiffness and capacity.*

This topic studies the use of bracing system for high-rise Steel building for different earthquake zone. As the height of the building increases the stiffness of the building reduces. Therefore to improve the performance of the building under seismic loading, bracing system is proposed in the present study of work. The present study is an effort towards analysis of the structure during the earthquake. G+20 stories residential building is considered. To study various parameters such as shear force, bending moment, storey drifts, storey shear, lateral displacement, response spectrum method (linear static) is carried out. The seismic performance of SMRF structures is evaluated in terms of its lateral load resistance, distribution of storey drift, and the sequence of yielding of the member in case of occurrence of sever earthquake. Seismic analysis of steel frame and different position of knee and eccentric bracings is carried out using "response spectrum method" as per IS 1893 (Part I): 2016 by using " E-TAB 2016". For this analysis different types of models as discussed and comparison of seismic performance is carried out.

Keywords- response spectrum method, E-TAB 2016, high-rise Steel building etc.

I. INTRODUCTION

General

The tallness of a building is relative and cannot be defined in absolute terms either in relation to height or the number of stories. But, from a structural engineer's point of view the tall building or multi-storied building can be defined as one that, by virtue of its height, is affected by lateral forces due to wind or earthquake or both to an extent that they play an important role in the structural design. Tall structures have fascinated mankind from the beginning of civilization. The Egyptian Pyramids, one among the seven wonders of world, constructed in 2600 B.C. are among such ancient tall structures. Such structures were constructed for defense and to show pride of the population in their civilization. The growth in modern multi-storied building construction, which began in late nineteenth century, is intended largely for commercial and residential purposes.

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, stability and human comfort.

Earthquake have become a frequent event all over the world. It is very difficult to predict the intensity, location, and time of occurrence of earthquake. Structures adequately designed for usual loads like dead, live, wind etc. may not be necessarily safe against earthquake loading. It is neither practical nor economically viable to design structures to remain within elastic limit during earthquake. The design approach adopted in the Indian Code IS 1893(Part I): 2002 'Criteria for Earthquake Resistant Design Of Structures' is to ensure that structures possess at least a minimum strength to withstand minor earthquake occurring frequently, without damage; resist moderate earthquakes without significant structural damage though some non-structural damage may occur; and aims that structures withstand major earthquake without collapse.

Structures need to have suitable earthquake resistant features to safely resist large lateral forces that are imposed on them during frequent earthquakes. Ordinary structures for houses are usually built to safely carry their own weights. Low lateral loads caused by wind and therefore, perform poorly under large lateral forces caused by even moderate size earthquake. These lateral forces can produce the critical stresses in a structure, set up undesirable vibrations and, in addition, cause lateral sway of structure, which could reach a stage of discomfort to the occupants.

The most effective and practical method of enhancing the seismic resistance is to increase the energy absorption capacity of structures by combining bracing elements in the frame. The braced frame can absorb a greater degree of energy exerted by earthquakes. Bracing members are widely used in steel structures to reduce lateral displacement and dissipate energy during strong ground motions. This concept extended to concrete frames. The various aspects such as size and shape of building, location of shear wall and bracing in building, distribution of mass, distribution of stiffness greatly affect the behaviors of structures. Diagonal bracing is efficient and economical method of resisting horizontal forces in a frame structure because the diagonals work in axial stress and therefore call for minimum member sizes in providing stiffness and strength against horizontal shear.

Fig. 1 Provision diagonal bracing

Bracing system improves the seismic performance of the frame by increasing its lateral stiffness and capacity. To the addition of bracing system load could be transferred out of the frame and into the braces, by passing the weak columns. Diagonal braced frames are efficient structural system for buildings subjected to seismic or wind lateral loading. Therefore, the use of diagonal bracing system for both retrofitting as well as newly constructed RC frame with adequate lateral resistance is attractive. The diagonal braces are usually placed in vertically aligned spans. This system allows obtaining a great increase of stiffness with minimum added weight, and so it is very effective for structure for which the poor lateral stiffness is the main problem. Diagonal bracing is well suited for strengthening operations. The stiffness added by the bracing system is maintained almost up to the peak strength. Stiffness is particularly important at serviceability state, where deformation are limited to prevent damage.

Fig.2 Retrofitting by diagonal bracing

1. Knee Bracing

Steel has become the predominate material for the construction of bridges, buildings, towers and other structures. Its great strength, uniformity, light weight and many other desirable properties makes it the material of choice for numerous structures such as steel bridges, high rise buildings, towers and other structures. Bracing element in structural system plays vital role in structural behavior during earthquake. Steel bracing is an effective and economical solution for resisting lateral forces in a framed structure. Bracings are of different types, namely concentric bracings, eccentric bracings and knee bracings. In concentric bracings, inelastic energy dissipation response is generally poor due to the possible buckling of the diagonal elements in compression. In eccentric bracings since it absorbs large seismic force, repair and replacement after a severe earthquake is expensive and time consuming. As a remedy for all these disadvantages knee braced frame developed. Frames with knee bracings (KBFs) provides an effective bracing solution. It can be obtained by providing a new element called "knee" in between the beam and column along with bracings. These bracings limits interstorey drifts, and knee element absorbs the earthquake energy, by providing cyclic deformations in shear or bending. The main advantage with respect to eccentric braced frames is that damage is concentrated in secondary element and it can easily replace after destructive earthquakes. The position and stiffness of knee was the most important factor affecting the lateral resisting ability of KBF.The beams and columns got great influence on the lateral behavior of KBF structure. The knee element will yield first without affecting the other main structural elements.

Fig.3 Knee bracing

Structures designed to resist moderate and frequently occurring earthquakes must have sufficient stiffness and strength to control deflection and to prevent damage. However, it is inappropriate to design a structure to remain elastic under severe earthquake because of economic constraints. The inherent damping of yielding structural elements can be advantageously utilized to lower the strength requirements, leading to a more economical design. This yielding provides ductility or toughness of structure against sudden brittle type structural failure. In steel structures, the moment resisting and concentrically braced frames have been widely used to resist earthquake loadings. The moment resisting frame possesses good ductility through flexural yielding of beam element but it has limited stiffness. It is necessary to design a structure to perform well under seismic loads. Shear capacity of the structure can be increased by introducing steel bracings in the structural systems. Bracing can be used as retrofit as well. There are n number of possibilities are there to arrange steel bracings. Such as X, K and V type Eccentric bracings. The present study develops a Pushover Analysis for Knee bracing steel frames designed according to IS 800 – 2007 and ductility behavior of each frame.

2. Objectives and Scope of the work:

Tall building developments have been rapidly increasing worldwide. The growth of multistory building in the last several decades is seen as the part of necessity for vertical expansion for business as well as residence in major cities. It is observed that there is a need to study the structural systems for steel framed structure, which resist the lateral loads due to seismic effect. Safety and minimum damage level of a structure could be the prime requirement of tall buildings. To meet these requirements, the structure should have adequate lateral strength, lateral stiffness and sufficient ductility. Among the various structural systems, shear wall frame or braced steel frame could be a point of choice for designer. Therefore, it attracts to review and observe the behavior of these structural systems under seismic effect. Hence, it is proposed to study the dynamic behavior of steel frame with and without knee and eccentric bracings. The purpose of this study is to compare the seismic response of above structural systems. Axial forces and moments in members and floor displacements will be compared.

The most effective and practical method of enhancing the seismic resistance is to increase the energy absorption capacity of structures by combining bracing elements in the frame. The braced frame can absorb a greater degree of energy exerted by earthquakes.

The present study is an effort towards analysis of the structure during the earthquake. G+20 stories residential building is considered. To study various parameters such as shear force, bending moment, storey drifts, storey shear, lateral displacement, response spectrum method (linear static) is carried out.

3. Theme of Investigation:

The linear response spectrum analysis is carried out for special moment resisting frame under different earthquake and wind loading using computer software E-TAB 2016. The seismic performance of SMRF structures is evaluated in terms of its lateral load resistance, distribution of storey drift, and the sequence of yielding of the member in case of occurrence of sever earthquake.

Seismic analysis of steel frame and different position of knee and eccentric bracings is carried out using response spectrum method as per IS 1893 (Part I): 2016 by using E-TAB 2016. For this analysis different types of models as discussed in chapter 4 are considered and comparison of seismic performance is carried out.

II. LITERATURE REVIEW

The great strength, uniformity, light weight and many other desirable properties makes steel the material of choice for numerous structures such as steel bridges, high rise buildings, towers and other structures. Steel structures situated in high seismic activity should be stiff enough to limit the drift and should have enough ductility to prevent collapse. Bracing technique is one of the economic method for resisting seismic activity. In this steel bracing provides an effective and economical solution for resisting lateral forces in a framed structure. Knee braced steel frame is that which has got excellent ductility and lateral stiffness. Since the knee element is properly fused, yielding occurs only to the knee element and no damage to major elements. Compared to other type of bracings it performs better during a seismic activity. In this study the configuration of knee braced had been arrived. And after that a comparison of knee braced steel frame with eccentric bracings had been done. Performance of both the frames had been studied using non-linear static analysis and non-linear time history analysis. Various parameters such as displacement and stiffness were studied in paper[1].

In[2] General, the structure in high seismic areas may be susceptible to the severe damage. Along with gravity load structure has to withstand to lateral load which can develop high stresses. Now a day, shear wall in R.C. structure and steel bracings in steel structure are most popular system to resist lateral load due to earthquake, wind, blast etc. The shear wall is one of the best lateral load resisting systems which is widely used in construction world but use of bracing will be the viable solution for enhancing earthquake resistance. So there is a need of precise and exact modeling and analysis using software to interpretrelation between brace frame parameters and structural behavior with respect to conventional lateral load resisting frame. There are various softwares used for analysis of different type of lateral load resisting system such as, E-TABS, SAP2000, STADPRO, etc. In this paper, a few of the past research work has been discussed for modeling and analysis of brace frame RC structure and conventional lateral load resisting frame structures, co-relation of efficiency and various parameters are compared. It is found from the analysis in software, The type of bracing, location of bracing, bracing stiffness and bracing material, etc. have significant effects to the lateral capacity of the structure. In this paper comparative study of RC brace frame structure with conventional lateral load resisting frame has been carried out with different type of bracing, various parameters of bracing and property of bracing by different researchers discussed.

In[3] last decades steel structures has played an important role in construction industry. Providing strength, stability and ductility are major purposes of seismic design. It is necessary to design a structure to perform well under seismic loads. Steel braced frame is one of the structural systems used to resist earthquake loads in structures. Steel bracing is economical, easy to erect, occupies less space and has flexibility to design for meeting the required strength and stiffness. Bracing can be used as retrofit as well. There are various types of steel bracings such as Diagonal, X, K, V, inverted V type or chevron and global type concentric bracings. In the present study, it was shown that modelling of the G+4 steel bare frame with various bracings (X, V, inverted V, and Knee bracing) by computer software SAP2000 and pushover analysis results are obtained. Comparison between the seismic parameters such as base shear, roof displacement, time period, storey drift, performance point for steel bare frame with different bracing patterns are studied. It is found that the X type of steel bracings significantly contributes to the structural stiffness and reduces the maximum interstate drift of steel building than other bracing systems.

In paper [4] Steel has become the predominate material for the construction of bridges, buildings, towers and other structures. Its great strength, uniformity, light weight and many other desirable properties makes it the material of choice for numerous structures such as steel bridges, high rise buildings, towers and other structures. The advantages in general credited to steel as a structural design material are high strength/weight ratio ductility, predictable material properties, speed of erection structures, quality of construction, ease of repair, adaptation of prefabrication, repetitive use, expanding existing structures and fatigue strength. Steel structures in areas prone to high seismic activity should satisfy two main conditions. It should be stiff enough to control the drift to prevent structural damage, and also must have sufficient ductility to prevent collapse caused by dramatic deformation. Bracing element in structural system plays vital role in structural behavior during earthquake. Steel bracing is an effective and economical solution for resisting lateral forces in a framed structure. Knee braced steel frame is that which has got excellent ductility and lateral stiffness. Since the knee element is properly fused, yielding occurs only to the knee element and no damage to major elements. Compared to other type of bracings it performs better during a seismic activity. In this study the seismic effect of different types of steel bracings was studied. A comparison of knee braced steel frame with other types of bracings had been done. Performance of each frame had been studied using non-linear static analysis and non -linear time history analysis. Various parameters such as displacement and stiffness were studied[5].

In [6] Indian standard codal provisions for finding out the approximate time period of steel structure is not considering the type of the bracing system. Bracing element in structural system plays vital role in structural behavior during earthquake. The pattern of the bracing can extensively modify the global seismic behavior of the framed steel building. In this paper the linear time history analysis is carried out on high rise steel building with different pattern of bracing system for Northridge earthquake. Natural frequencies, fundamental time period, mode shapes, inter story drift and base shear are calculated with different pattern of bracing system. Further optimization study was carried out to decide the suitable type of the bracing pattern by keeping the inter-story drift, total lateral displacement and stress level within permissible limit. Aim of study was to compare the results of seismic analysis of high rise steel building with different pattern of bracing system and without bracing system.

Paper[7] studied the seismic analysis of reinforced concrete (RC) buildings with different types of bracing (Diagonal, V type, Inverted V type, X type). The bracing is provided for peripheral columns. A seven-storey (G+6) building is situated at seismic zone III. The building models are analyze by equivalent static analysis as per IS 1893:2002 using Staad- Pro V8i software. The main parameters consider in this paper to compare the seismic analysis of buildings are lateral displacement, storey drift, axial force, base shear. It is found that the X type of steel bracing significantly contributes to the structural stiffness and reduces the maximum inter storey drift of R.C.C building than other bracing system. The lateral displacement of the building is reduced by 50% to 56 % by the use of X Type steel bracing system, and X bracing type reduced maximum displacement. The steel braced building of base shear increase compared to without steel bracing which indicates that stiffness of building is increases.

Paper[8] focused on the effect of a provision of concentric bracings on the seismic performance of the steel frames. In this paper study of two different types of concentric

bracings (X and inverted V- type bracing) have been considered for the different storey levels. ETABS, Finite Element software has been used and the comparison between the performances of 1- bay Xand inverted–V type and un-braced frames is made using pushover curves. Seismic performances of the frames are carried out the parameters such as Base shear, roof displacement and the number of hinges formed. Steel bracings can be used to strengthen or to retrofit the existing structure. The provision of bracing enhances the bases hear carrying capacity of frames and reduces roof displacement undergone by the structures. The lateral storey displacements of the building are reduced by the use of inverted-V bracing in comparison to the X bracing system.
Paper[9] nonlinear push over analysis is carried out for high rise steel frame building with different pattern of bracing system. The shear capacity of the structure can be increased by introducing Steel bracings in the structural system. A typical 15th- story regular steel frame building is designed for various types of concentric bracings like Diagonal, V, X, and Exterior X and Performance of each frame is carried out through nonlinear static analysis. Three types of sections i.e. ISMB, ISMC and ISA sections are used to compare for same patterns of bracing. ISMC Sections reduces more displacement compare to angel and beam section for similar type of brace. It is shown that bracings have increased level of performance both in terms of base shear carrying capacity and roof displacement. ISMB Sections gives more stiffness compare to angel and channel sections for similar type of brace.

In this paper[10] provides an introduction and overview of the design and behaviour of seismic-resistant eccentrically braced frames (EBFs). EBF_s have become a widely recognized lateral load resisting system for steel building in areas of high seismicity. In general, braces are the members that resist against lateral forces in a steel structure while the structures are under seismic excitation. In this paper six frames were exerted which were braced with three different eccentric braces (V, Inverted-V and Diagonal) in two different heights (4 and 8 storey). Then the frames were assessed by nonlinear static (pushover) analysis mainly based on FEMA 440. As a result of these frame analysis, it can be observed that the plastic hinges firstly occur at the fuse section of braces and then at the compressive members of the eccentric braces. The primary purpose of this paper is to present the best suitable bracing system up to 8 storey level in performance point of view and also economy point of view.
Paper[11] concluded that the displacement of the frame has been drastically reduced by a concentric application of shape memory alloy wires in reinforced concrete frame seismic prone areas. Under time history analysis method, the maximum top story displacement exhibited by the reinforced concrete frame with the straw bale infill has significant effect.

The computed force-deformation response can be used to assess the overall structural damage of a structure with the composition shape memory alloy braces[12].
aper concluded that infill wall effect should be included to have a better estimation of seismic behavior. So, for design purposes neglecting infill walls would not always lead safe design or assessment results. Braced frame results showed that buckling of braces has significant importance on performance of this retrofitting method. After buckling occurs, lateral load capacity of the system may drop dramatically. [13] Performance limit states determined by deficient RC members and they found to be nearly independent from brace slenderness whereas dependent from axial load on columns. Time history analysis showed that including correct boundary conditions can dramatically affect the response of these systems. According to the analysis results, keeping system under low deformations can lead RC members to take any significant damage. However, high axial forces can be transferred from upper story braces to first story columns due to overturning effects. That may increase damages on the first story columns. ISF (internal steel frame) could be improved by using alternative boundary conditions and results could be matched better in terms of loading stiffness and cyclic behavior[14].

In paper[15] concluded that (1) The concept of using steel bracing is one of the advantageous concepts which can be used to strengthen structure 2) Steel bracings reduce flexure and shear demands on beams and columns and transfer the lateral load through axial load mechanism. 3) The lateral displacement of the building is reduced by use of shear wall and steel bracing system. (4) Storey drift is controlled by use of the Shear wall and steel brace. 5) Steel bracings can be used as an alternative to the other strengthening techniques available as the total weight of structure changes significantly. 6) Shear wall has more storey shear as compare to steel bracing but there is a difference in lateral displacement between shear wall and steel bracing. 7) Shear wall and steel bracing increases the level of safety since the demand curve intersect near the elastic domain. 8) Capacity of the steel braced structure is more as compare to the shear wall structure. 9) Steel bracing has more margin of safety against collapse as compare with shear wall.

In paper [16] concluded that the bracing in bare frame increases the overall stiffness of the structure. The lateral displacement in bare frame is more in comparison to the frame with bracings .The bracings prevent the excessive damage in nonstructural elements. Significant reduction in moment in case of frame with bracings in comparison to bare frame. Significant reduction in reinforcement demand by the frame members other than the one associated with bracings.

The performance of frame[17] with bracings is better and within the limit. Maximum inter story drift for frame without bracings is in storey just above the GF. For frame with bracings maximum ISD is found at height nearly to one third height of the building .Deflection pattern is of flexure shape at lower heights in which rate of deflection increase and follows the shear configuration in upper heights.

In paper [18] concluded that the seismic performances of without braced frames are weak. The strength capacity of reinforced concrete frames can be enhanced to a desired level using either concentric bracing or knee bracing. The ductility is highest for a frame without brace. While in the Concentric Braced Frame and Knee Braced Frame, stiffness is highest among other properties. Stiffness is higher in Concentric Braced Frame compare to the Knee Braced Frame. Ductility is higher in the Knee Braced Frame compared to the Concentric Braced Frame. Paper [19] Energy absorption is highest in the Knee Braced Frame. Both concentric bracing and knee bracing systems can be employed to increase the yield capacity of a reinforced concrete frame. Substantial increases may be obtained using concentric bracing. The global displacements of a reinforced concrete frame can be reduced to a desired level by providing either a concentric or a knee steel bracing system. Both concentric bracing and knee bracing systems may be utilized to design or retrofit for a damage level earthquake. Concentric bracing is more suitable for a strength-based design. Knee bracing, on the other hand, is suitable for both the strength-based and ductility-based designs[20]

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III. MODELING

3.1 Problem statement

The building is analyzed is G+20 steel framed building of unsymmetrical plan configuration. Complete analysis is carried out for dead load, live load, wind load& seismic load using ETAB 2016. Response Spectrum Method of seismic analysis is used. All combinations are considered as per IS 1893:2016.

Typical plan of building is shown in Fig.4.1

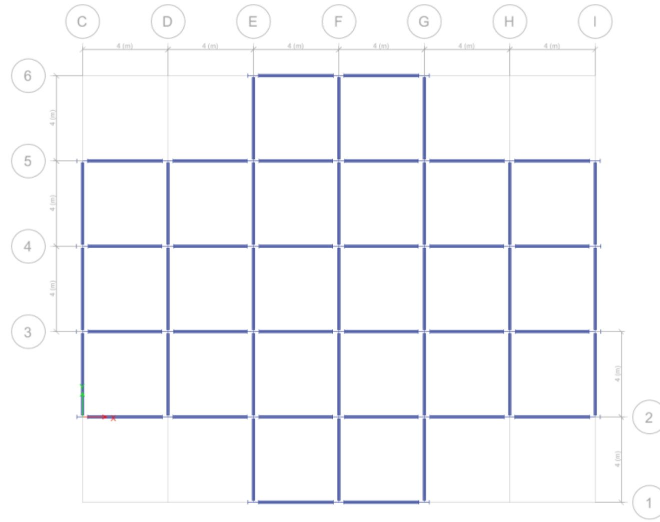

Fig.4. Plan of G+20 steel framed structure

3.2 Building properties

Site Properties:

Details of building:: G+20
Plan Dimension::24m x 20m , 4m span in each direction.
Outer wall thickness:: 230mm
Inner wall thickness:: 230mm
Floor height ::3 m
Parking floor height :: 3m
Seismic Properties
Seismic zone:: IV
Zone factor:: 0.24
Importance factor:: 1.2
Response Reduction factor R:: 5
Soil Type:: medium
Material Properties
Material Name:: Fe345
Weight per unit volume:: 76.9729 kN/m3
Young modulus :: 210000MPa
Poisson’s ratio: 0.3
Shear_modulus:80769.23Mpa

Loading on structure

Dead load : self-weight of structure
Weight of 230mm wall : 13.8 kN/m²
Live load: For G+25: 3.0kN/m²
Roof : 1.5 kN/m²
Wind load : Consider as per IS 875:2015-part 3
Seismic load: Seismic Zone IV

Preliminary Sizes of members

Column:: ISMB 600 with two plates of 600mm X 25mm
Beam::ISMB 450 with two plates of 400mm X 12mm
Slab thickness:: 125mm
Bracing:: ISMC 350
Knee leg:: ISMB 250

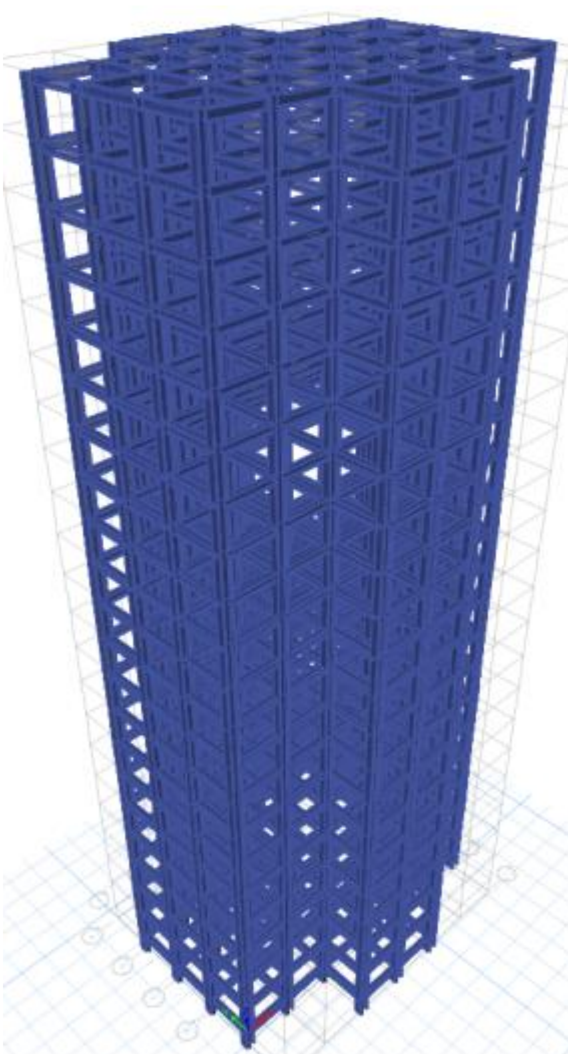

Fig4. 3D view of G+20 steel framed structure

IV. RESULTS AND DISCUSSION

A 20 storied steel building in all seismic zone is modeled using ETAB 2016 software and the results are computed. The configurations of all the models are discussed in previous chapter. Fifty two models were prepared based on different configuration, Model 1 is Steel frame structure, Model 2 Steel frame with diagonal bracing-1, Model 3 is Steel frame with diagonal bracing-2, Model 4 is Steel frame with X type bracing-1, Model 5 is Steel frame with X type bracing-2, Model 6 is Steel frame with V type bracing-1, Model 7 is Steel frame with V type bracing-2, Model 8 is Steel frame with knee diagonal bracing-1, Model 9 is Steel frame with knee diagonal bracing-2, Model 10 is Steel frame with knee X type bracing-1, Model 11 is Steel frame with knee X type bracing-2, Model 12 is Steel frame with knee V type bracing-1, Model 13 is Steel frame with knee V type bracing-2.These models are analyzed and designed as per the specifications of Indian Standard codes IS 1893:2016 IS and IS 456: 2000. The response spectrum method had been used to find the design lateral forces along the storey in X and Z direction of the building.

1. Base shear

The response spectrum method had been adopted for seismic analysis in ETAB 2016. The Table I shows maximum base shear in X direction for all models in Seismic zone II,III,IV and V.

Table I. Base shear (kN) in X-direction

Type of Model	Zone II	Zone III	Zone IV	Zone V
Steel frame structure	17301331	27614314	4629.386	62132207
Steel frame with diagonal bracing-1	19289108	30862573	46262212	6944.079
Steel frame with diagonal bracing-2	19275922	30841475	46548542	69393318
Steel frame with X type bracing-1	19395226	31032361	46502466	69822813
Steel frame with X type bracing-2	19376027	31001644	46402586	69753699
Steel frame with V type bracing-1	19334411	27814906	46355163	69603878
Steel frame with V type bracing-2	19314651	2785.166	46155423	69532745
Steel frame with knee diagonal bracing-1	17365386	27784618	41676928	62515391
Steel frame with knee diagonal bracing-2	17356762	27770819	41656229	62484344
Steel frame with knee X type bracing-1	17476301	27962082	41943124	62914685
Steel frame with knee X type bracing-2	17459658	27935453	4190.318	62854769
Steel frame with knee V type bracing-1	17384316	27814906	4172.236	62583539
Steel frame with knee V type bracing-2	17407287	2785.166	4177.749	62666235

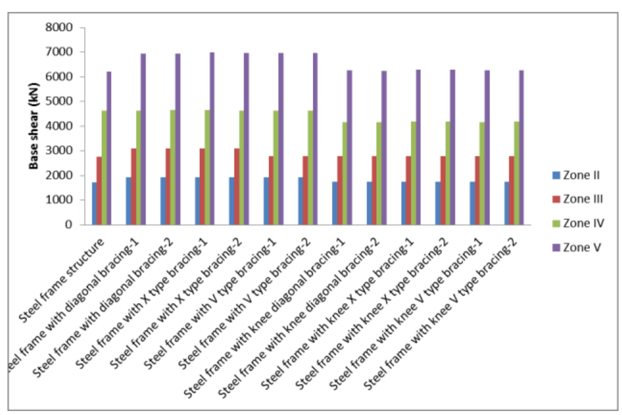

Fig 4.4 Base shear (kN) in X-direction

Fig 44 shows graph of maximum base shear in X direction for all models in Seismic zone II,III,IV and V. It shows that base shear values is maximum for frame with X type bracing-1 and minimum for steel frame structure.

The Table II shows maximum base shear in Y direction for all models in Seismic zone II,III,IV and V.

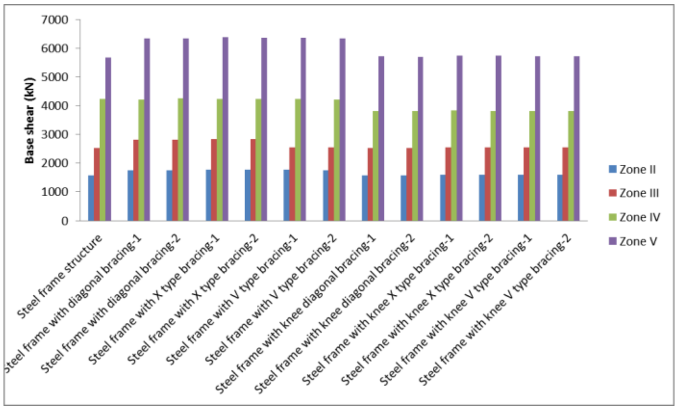

Fig 4.5 Base shear (kN) in Y-direction

Table I. Base shear (kN) in Y-direction

Type of Model	Zone II	Zone III	Zone IV	Zone V
Steel frame structure	1579.4082	2520.701	42241012	5671.5764
Steel frame with diagonal bracing-1	1760.9809	2817.569	42216645	6336.1519
Steel frame with diagonal bracing-2	1759.0269	2814.443	42489778	6332.4968
Steel frame with X type bracing-1	1770.4074	2832.652	42415197	6373.4667
Steel frame with X type bracing-2	1767.2999	2827.68	42339146	6362.2795
Steel frame with V type bracing-1	1764.1311	2538.981	42290992	6350.8719
Steel frame with V type bracing-2	1762.1247	2540.438	42051192	6343.6488
Steel frame with knee diagonal bracing-1	1585.342	2536.547	38048208	5707.2311
Steel frame with knee diagonal bracing-2	1584.1043	2534.567	38018503	5702.7754
Steel frame with knee X type bracing-1	1593.8478	2550.156	38252346	5737.852
Steel frame with knee X type bracing-2	1592.4193	2547.871	38218064	5732.7096
Steel frame with knee V type bracing-1	1586.863	2538.981	38084711	5712.7066
Steel frame with knee V type bracing-2	1587.7739	2540.438	38106573	5715.9859

Fig 4.5 shows graph of maximum base shear in X direction for all models in Seismic zone II,III,IV and V. It shows that base shear values is maximum for frame with X type bracing-1 and minimum for steel frame structure.

V. CONCLUSION

Modeling and analysis is carried out for Steel frame structure, Steel frame with diagonal bracing-1, Steel frame with diagonal bracing-2,Steel frame with X type bracing-1,Steel frame with X type bracing-2, Steel frame with V type bracing-1, Steel frame with V type bracing-2, Steel frame with knee diagonal bracing-1,Steel frame with knee diagonal bracing-2,Steel frame with knee X type bracing-1,Steel frame with knee X type bracing-2, Steel frame with knee V type bracing-1,Steel frame with knee V type bracing-2in ETAB 2016. Some discussions are put here from results are as follows:

1. Modal period is maximum for normal steel frame structure.
2. Modal frequency is maximum for steel frame with X type bracing -1.
3. Bar diagram shows base shear is high for steel frame with X type bracing and least for normal steel frame structure.
4. Maximum lateral displacement is maximum for normal steel frame structure. Frame with X type bracings reduces lateral displacement upto 40% whereas frame with X type knee bracings reduces lateral displacement more than 20%. Hence response of structure is increased by combination of X type bracings.
5. Axial force in columns is maximum for steel frame with X type bracing 2 and minimum for steel frame structure.
6. Shear force in columns is maximum for steel frame with knee V type bracing 2 and minimum for steel frame with X type knee bracing 2.
7. Moment in columns is maximum for steel frame structure and minimum for steel frame with X type bracing 2.

VI. FUTURE SCOPE

1. The study can be further extended to analysis of irregular building.
2. Analysis can be done by using software SAP 2000, STAAD- pro etc.
3. Analysis can be carried out using Time history method.
4. Comparison of Time history method and response spectrum method can be done.

5. Analysis can be doing with different soil conditions.
6. Analysis can be done with different ground slope.

VII. ACKNOWLEDGMENT

The authors would like to thank the Department of Civil Engineering of BIT Bamni, MH, India for their generous support.

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