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ANALYSIS OF STEEL FRAMES WITH BRACINGS FOR SEISMIC LOADS

Shaik Mohammad
B. Tech Student, Department of Civil Engineering, Pace Institute of Technology and Sciences, Ongole. 523001, India.

N. Raja Nikhil Reddy
B. Tech Student, Department of Civil Engineering, Pace Institute of Technology and Sciences, Ongole. 523001, India

Ch. Saipraveen
Professor Department of Civil Engineering , Pace Institute of Technology and Sciences, Ongole. 523001, India.

Vankayalapati Raghu
Professor Department of Civil Engineering , Pace Institute of Technology and Sciences, Ongole. 523001, India

ABSTRACT

In recent decants steel structure had played an important role in construction industry. Providing strength, stability, ductility for buildings designed for seismic loads. It is necessary to design a structure that can withstand under seismic loads. Providing steel knee braces is one of the structural systems used to resist earthquake forces on structures. Steel bracing is economical, easy to erect and occupies less space which is flexible to design to meet the required strength and stiffness. There are various types of steel bracing (X, knee bracing). In knee brace frame system (KBFS) the non-buckling diagonal bracing provide most of the lateral stiffness, the flexural yielding of knee element. In our project a 6 storey steel frame building with knee bracing system with floor plan of 9 m x 9m is considered. We studied the performance of a 6 storied steel frame building with knee bracing system and compared with bare frame. Pushover analysis, equivalent static analysis, Response Spectrum analysis, Time history analysis is performed in ETABS based on IS 1893:2002 (part 1) guidelines. The manual calculation was done on the basis of Equivalent static analysis and Response spectrum analysis to find out base shear for foundation and lateral force for each storey deck slab and compared the values with bare frame. Depending on the complexity in the problem for bracing models, we had used Etabs software in order to analysis the Base shear and lateral shear. The results were plotted in the form of graphs and tables for their inter storey drift and inter storey displacement.

Key words: Equivalent static analysis, response spectrum analysis, storey drift, storey displacement, lateral force, base shear.

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1. INTRODUCTION

The planet greatest hazards are earthquake, which will vary along the magnitude on the Richter scale. The demolition of existing structures and reconstruction as per the code description is impractical, uneconomical and time consuming so that, the major disasters are avoided. For this, the deficient buildings should be identified first and detailed evaluation is to be carried out to check their strength and performances. The earthquake load which is acting on the base foundation called base shear. And the load which was acting on slab of each and every storey high is known as lateral load. Knee bracings are used to resist lateral load in steel structures. Which will be used for steel structure as retrofitting. In case of knee elements, since the damage is concentrated in a secondary member, it can be easily repaired or replaced at minimum cost. So, in this study, different knee elements are used in structures and analyzing their resistance against seismic forces. As far as Knee braced frames are concerned that can be utilized as nonlinear bulking diagonal member, that can provide the maximum lateral stiffness. The yielding shear or flexural member that can provide ductility under heavier seismic effects. However, the higher seismic impact can be greatly minimizing the length of various bracing configurations. As it is even less cost in case retrofitting the knee elements.

2. OBJECTIVES OF THE STUDY

- To study the seismic behavior in steel braced frames.
- The comparison of knee braced frame with normal storey like bare frame.
- To arrive at a configuration of knee braced frame by varying the length of knee element.
- Under different loads and load combinations based on those seismic loads.
- To investigate the displacement of a multi-story steel frame building for seismic loads.

3. LITERATURE REVIEW

Choudhari V.A, Dr. T. K. Nagaraj, et. al (2015).

From this journal want I had extract was the major concept of seismic resisting building frames of X braced, Chevron, inverted V, and Knee braced frames in steel structures. Here the SAP2000 software has been used which would help me to identify the ETABS for my project. The G+4 steel bare frame was considered and compared in different bases. As the plotted results were taken from the following computer software. The pushover analysis has done in order to identify the base shear and performance point.

Ratnesh Kumar, Prof. K. C. Biswal, et.al (2014).

The study of braced steel frame response is widely studied in many branches of Structural engineering. Many researchers have been deeply studying these structures, over the years, mainly for their greater capacity of carrying external loads. Model 1 is a Steel Moment Resisting Frame (SMRFs) with concentric bracing as per IS 800-2007. Cross bracing, diagonal bracing and an unbraced frame is considered for study. Model 2 consist of two Steel

Moment Resisting Frame with similar V type bracing and Inverted V (Chevron bracing) configuration, but with varying height. Performance of each frame is studied through Equivalent static analysis, Response Spectrum analysis, and linear Time History analysis.

Anitha M, Divya K.K. et. al (2015)

The knee bracing frames could be in farther classified by Finite element method. In order to determine the exact determination in approximate methodology. In this journal the 2D frame has been taken into consideration and as we generally consider it in a piece of paper to write down it considers as single frame structure to calculation external force. A single diagonal frame is considered and the double knee bracing has taken. Due to strength to weight ratio the properties of material, ductility, quality of structure is adopted. The main aim is to compare Knee braced frame with eccentricity. Which Nonlinear static analysis and nonlinear time history analysis is determined by using computer software Ansys in order to identify the means of EI centro earthquake data from recorded data. By this the ultimate load and stiffness were calculated.

Arathi Thamarakshan, Prof. Arunima .S et. al (2017)

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 are available. In the present study, steel frame with various configurations are analyzed by ETABS software. The results of time history analysis were then compared with the results of the pushover analysis. The study also involving the analysis for suggesting the best configurations.

Sara Raphael, Prof. Soni Syed, et. al (2016)

In this paper a comparative study of different knee bracing system is presented. Pushover analysis performed, steel frames with double knee bracings showed very good behavior during a seismic activity with less directional deformation and stress. 4 knee braced steel frames with varying angles are modeled and analyzed for an angle study of knee member. From the nonlinear analysis the total deformation for corresponding ultimate load are obtained and compared. From the results obtained it can be concluded that, steel frames with double knee bracings showed very good behavior during a seismic activity and the degree of inclination of the knee member with 35^0 shows maximum stiffness.

J. Sankar, E.V. Raghava Rao, N. Chennakesavulu. Et. al (2016)

A major purpose of the project being commented upon is to determine forces on components of a building or a structure as required for design purposes. For buildings, Earthquake force is required in order to design with supporting elements, from which the forces get transferred to the framework. This project provides values of bending moments, shear forces, storey drifts for a variety of cases covered. Storey drift was considered, storey drift increase from bottom to top. We have observed that storey drift will be increased from zone II to zone V in both the directions X and Z. Amount of storey drift depends up on the amount of earthquake effect and also on the displacement of the storey. Bending moment and shear force values vary from one zone to another zone; these will be increased from zone II to zone V. Maximum bending moment occurred in 336th beam in the first storey and 167^{h} column in ground floor in zone – V.

Viswanath K.G, Prof. Prakash K.B, Anant Desai. et. al (2016).

The concept of using steel bracing is one of the advantageous concepts which can be used to strengthen or retrofit the existing structures. Steel bracings can be used as an alternative to the other strengthening or retrofitting techniques available as the total weight on the existing building will not change significantly. Steel bracings reduce flexure and shear demands on beams and columns and transfer the lateral loads through axial load mechanism. The lateral displacements of the building studied are reduced by the use of X. Comparing the results obtained for maximum lateral displacement in X and Z direction for G+4, G+8, G+12 and G+16 storied buildings, it can be found that the X type bracing reduce the lateral displacement considerably.

Luigi DI Sarno, Amr S. Elnashai. et. al (2004)

The present study assesses the seismic performance of steel moment resisting frames (MRFs) retrofitted with different bracing systems. Three brace configurations were utilized: special concentrically braces (SCBFs), buckling-restrained braces (BRBFs) and mega-braces (MBFs). A 9-storey steel perimeter MRF was designed with lateral stiffness insufficient to satisfy code drift limitations in zones with high seismic hazards. It is shown that MBFs are the most cost-effective bracing systems. Maximum storey drifts of MBFs are 70% lower than MRFs and about 50% lower than SCBFs. Configurations with buckling-restrained mega-braces possess seismic performance marginally superior to MBFs despite their greater weight. The amount of steel for structural elements and their connections in configurations with mega-braces is 20% lower than in SCBFs. This reduces the cost of construction and renders MBFs attractive for seismic retrofitting applications.

Mahnoud Miri, Abdolreza Zare, Hossein Abbas Zadeh. et. al (2009).

Frames with similar dimensions but various heights in both systems are designed according to Iranian code of practice for seismic resistant design of building, and then based on a non-linear push over static analysis; the seismic parameters such as behavior factor and performance levels are compared. By studying tables related to seismic parameters it is proved that whatever the stages increased the overstrength factor reduced and also the ductility factor are increased. The amount of dissipating and energy absorption in chevron knee braces system is more than ordinary knee braces system which indicates high ductility of chevron knee braces system against stiffness of ordinary knee braces system.

Jinkoo Kim, Junhee Park, Prof. Sang-Dae Kim. et. al (2009).

The seismic behavior of a framed structure with chevron-type buckling restrained braces was investigated and their behavior factors, such as overstrength, ductility, and response modification factors, were evaluated. Two types of structures, building frame systems and dual systems, with 4, 8, 12, and 16 stories were designed per the IBC 2003, the AISC LRFD and the AISC Seismic Provisions. Nonlinear static pushover analyses using two different loading patterns and incremental dynamic analysis using 20 earthquake records were carried out to compute behavior factors. Time history analyses were also conducted with another 20 earthquakes to obtain dynamic responses. The dual systems, even though designed with smaller seismic load, showed superior static and dynamic performances.

Leelataviwat.S, Doung.P, Prof. Junda. E, Chan-anan.W. et. al (2017).

This paper presents the behavior and design concept of efficient structural steel systems based on innovative applications of knee braces. Advantages of knee-braced frames (KBF) include relatively simple connections for ease of construction and reparability after an earthquake and less obstruction as compared to conventional bracing systems. Various configurations of KBFs can be designed and detailed for different levels of strength, stiffness, and ductility. KBFs are designed so that all inelastic activities are confined to the knee braces and designated yielding elements only. Key design concepts to ensure ductile behavior of KBFs are first summarized. Finally, results from experimental and analytical studies into the behavior of KBFs are briefly presented. The results show that KBFs can provide viable alternatives to conventional structural systems.

3. EQUIVALENT STATIC ANALYSIS

In the solving of seismic loads on the structure can be associated with number of methods. In that following methods we had two simple methods in which one is going to do manually and another use to do by computer calculations. The Equivalent static analysis (ESA) is the simplest method to solve and identify the load carry capacity for the structure. As it is a fundamental concept involve in it by using IS 1893:2002 (PART 1). Initially, the base shear is calculated, and then the load has been uniformly distributed over the entire height of building it was calculated, it is taken from the code. The base shear and lateral shear were plotted by code provided in distribution of mass means seismic weight of body. Zones of the country was provided in each and every individual by explaining the terms and logistics of importance factor, zone factor, response reduction factor.

Base shear or total lateral shear were determined by the Criteria for the Earthquake Resistant Design of structures.

From IS 1893:2002 (PART 1), Clause 7.5.3.

$V_B = A_h * W$

Where,

A = Seismic coefficient for a structural building.

W = Seismic weight of structural building.

The design horizontal seismic coefficient for a structure A is given by from 1893:2002, Clause 6.4.2

$A = \frac{Z*I*S_a}{2*R*g}$

Z = The zone factor from the Table 2 of IS 1893:2002 (part 1).

I = The importance factor.

R = The response reduction factor.

S_a / g = The coefficient of response acceleration for rock and soil sites as given in fig 2 of IS 1893:2002 (part 1). The values show 5% damping of the structure are given.

T = the fundamental natural period for buildings calculated as per clause 7.6 of IS 1893:2002 (part1).

$T_a = 0.075h^{0.75}$ for resisting structures RC frame building.

$Ta = 0.085h^{0.75}$ for resisting steel frame building.

$Ta = 0.09 \frac{h}{\sqrt{d}}$ for the other building of moment resisting frames and structures.

h = The height of the building from the base foundation to top roof in m.

3.1. Lateral distribution of base shear

The base shear has distributed along the height of steel structure. The base shear at any storey is dependent on the height of the storey and the mass at which it is concentrated, and the shape of building. Seismic loads are tend to move and displace the foundation could done with extreme levels. The degree of freedom which was denoted by nodal points on which the load due to deflection is zero. As a result, the number of stories is equal to number floors.

The lateral force magnitude at floor node is determined by:

1) Mass of that floor.
2) Distribution of stiffness over the height of the structure.
3) Nodal displacement in given mode.

IS 1893:2002 (part 1) uses a lateral force along the parabolic distribution of the height of the building. The base shear was distributed with the vertical direction of the building.

As per IS 1893:2002 (part 1), Clause 7.7.1.

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_i h_i^2}$$

Where,

Q_i = design lateral force at floor i.

W_i = seismic weight at floor i

h_i = height of storey from foundation and to the top roof.

n = number of stories in a structure.

4. STRUCTURE MODELLING

Three bay frame 3D four storied moment resisting frame is selected for analysis. The length and width of building is 9m. Height of typical storey is 3m. Building is symmetrical to X and Y axis. The non-structural element and components that do not significantly influence the building behavior were not modelled. The joints between Beams and Columns are rigid. At the foundation the moment rotation and displacement of columns are assumed to be fixed at the ground level. Following are the Description of a building.

4.1. Structural Configuration

Following two types of structural configurations is studied.

1) G+5 steel moment resisting bare framed structure.

2) G+5 moment resisting steel bare frame with different bracing patterns such as Knee bracing frame.

Following were the rolled steel sections. Which are used for beams, columns and bracings.

Beam:	ISLB 200
Column:	ISWB 250-2
Bracing:	ISMB 175.

5. BASE SHEAR CALCULATION

5.1. Equivalent Static Analysis for Calculating the Base Shear and Lateral Shear

Plan and elevation of a six-storey steel residential building as shown in figure, the building are as follows.

Given data,

Number of stories = 6

Zone = III

Live load = 3kN/m^2

Columns = ISHB250-2

Beams = ISLB200

Bracing = ISMB175

Thickness of Deck = 110mm

Thickness of wall = 120mm

Importance factor = 1.0

Structure type = Steel structure without bracings.

5.2. Compution of Seismic Weights

(Assuming unit weight of concrete as 25kN/m^3 and 20 kN/m^3 for masonry)

1) SLAB: Dead load to self-weight of Deck = Volume of Deck * unit weight of concrete.

= (9*9*0.11) * 25

= 222.75kN.

2) COLUMNS: from steel tables TABLE-1

ISHB250-2 = 54.7kg/m = 547N/m

Dead load due to self-weight (16 no's) = No. of columns * self-weight * length of column.

= 16 * 0.547 * 3 = 26.26kN.

3) BEAMS

ISLB200 = 19.8kg/m = 198N/m

Dead load to self-weight (18 no's) = 0.198 * 18 * 3 = 10.7kN

4) WALL

Self-weight of wall per unit length = 0.12 * 3 * 20

Dead load due to weight = (9+9+9+9) * 7.2

= 259.2kN.

5) Live Load (Imposed Load) (25%)

= unit weight * area of deck

= (0.25*3) * (9*9)

= 60.75kN.

Load on all Floors

$W_1 = W_2 = W_3 = W_4 = W_5$ = DECK + COLUMNS + BEAMS + WALLS + LIVE LOAD

= 222.75 + 26.26 + 10.7 + 259.2 + 60.75

= 579.66kN ≈ 580kN

Load on Roof Slab (L.L on Slab is Zero)

$W_6 = \text{DECK} + \frac{COLUMN}{2} + \text{BEAMS} + \frac{WALLS}{2}$

= 222.75 + (26.26/2) + 10.7 + (259.2/2)

= 376.18kN ≈ 380kN

Total Seismic Weight

$WS = WS_1 + WS_2 + WS_3 + WS_4 + WS_5 + WS_6$

= (6 * 580) + 380

= 3860kN

Fundamental Period

Natural period, $T_a = 0.09 * \frac{H}{\sqrt{d}}$

$= 0.09 * \frac{18}{\sqrt{9}}$

= 0.54 s

Moment Resisting Frame with in-Fill Walls

Type of soil = Medium soil

For T_a = 0.54 s

S_a/g = 2.5

Zone factor: for Zone III, Z = 0.16

Importance factor, I = 1.0

Response Reduction factor,R = 3.0

Horizontal acceleration coefficient (A_h)

$$A_h = \frac{Z}{2} * \frac{Sa}{g} * \frac{I}{R}$$

$$= \frac{0.16}{2} * 2.5 * \frac{1.0}{3.0}$$

A_h = 0.0667

Base Shear (V_B)

V_B = A_h * W

= 0.0667 * 3860

V_B = 257.47kN

Storey shear forces are calculated as follows (last column of the table),

$V_6 = Q_6$ = 77.27kN

$V_5 = V_6 + Q_5$ = 77.27 + 81.90 = 159.17kN

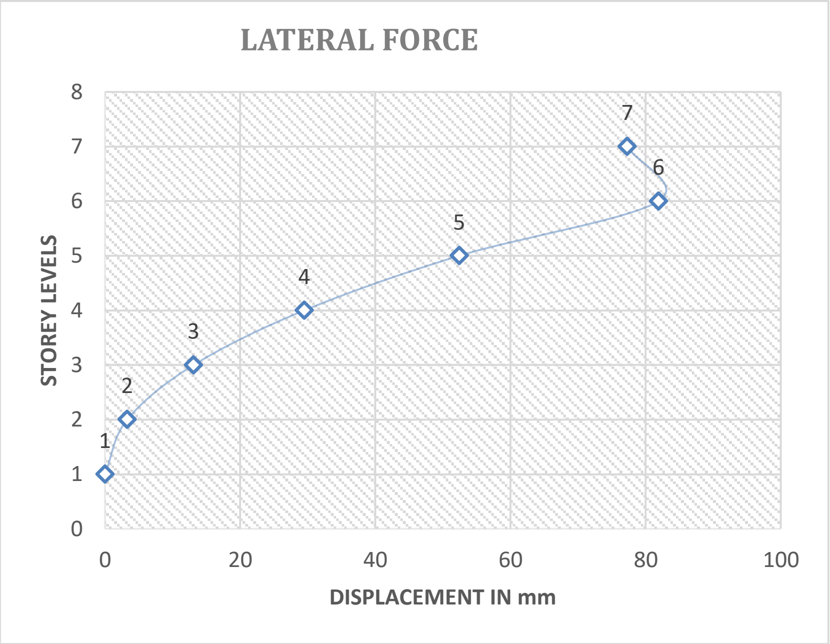
$V_4 = V_5 + Q_4$ = 159.17 + 52.42 = 211.59kN

$V_3 = V_4 + Q_3$ = 211.59 + 29.49 = 241.08kN

$V_2 = V_3 + Q_2$ = 241.08 + 13.11 = 254.19kN

$V_1 = V_2 + Q_1$ = 254.19 + 3.28 = 257.47kN

Ateral Force and Shear Force Distribution is Shown in Fig



Lateral Force and Shear Force Distribution

FLOOR LEVEL	W_i (kN)	hi (m)	$W_i h_i^2$ ($kN\text{-}m^2$)	Storey forces $Q_i = V_B \frac{w_i h_i^2}{\sum_{i=1}^{n} w_i h_i^2}$	Storey shear force (v_i) (kN)
6	380	18	123,120	77.27	77.27
5	580	15	130,500	81.90	159.17
4	580	12	83,520	52.42	211.59
3	580	9	46,980	29.49	241.08
2	580	6	20,880	13.11	254.19
1	580	3	5,220	3.28	257.47
			$\sum_{i=1}^{n} W_i h_i^2$= 410,220		

6. PRELIMINARY DIMENSIONS

Base Shear in X Direction by ESA and RSA for Different Buildings

Type of Models	Equivalent Lateral Force Analysis in X-direction	Response Spectrum Analysis in X-direction
	Base Shear (KN)	Base Shear (KN)
Bare Frame	193.635	86.5
Frame with Knee Bracing	219.813	216.265

Base Shear in Y Direction by ESA and RSA for Different Buildings

Type of Models	Equivalent Lateral Force Analysis in Y-direction	Response Spectrum Analysis in Y-direction
	Base Shear (KN)	Base Shear (KN)
Bare Frame	193.635	71.91
Frame with Knee Bracing	219.813	238.055

Time in X Direction by ESA and RSA for Different Models

Type of Models	Equivalent Lateral Force Analysis in X-direction	Response Spectrum Analysis in X-direction
	Time Period(s)	Time Period (s)
Bare Frame	0.647	1.19
Frame with Knee Bracing	0.647	0.321

Time Period in Y Direction by ESA and RSA for Different Models

Type of Models	Equivalent Lateral Force Analysis in Y-direction	Response Spectrum Analysis in Y-direction
	Time Period (s)	Time Period (s)
Bare Frame	0.647	1.4
Frame with Knee Bracing	0.647	0.38

7. RESULTS AND DISCUSIONS

Inter Storey Drifts in X-Direction

Following table shows the storey level, storey displacement and inter storey drift for steel bare frame and different types of bracing patterns such as bare frame, knee bracing in X- direction by RSA as shown in Table.

Inter Storey Drifts in Y-Direction

Following table shows the storey level, storey displacement and inter storey drift for steel bare frame and different types of bracing patterns such as bare frame, knee bracing in Y- direction by RSA as shown in Table.

Inter Storey Drifts in X-Direction

Storey level	Bare Frame	Frame with Knee bracing	IS 1893:2002
6	0.014	0.0010	0.024
5	0.022	0.0010	0.020
4	0.029	0.0016	0.016
3	0.034	0.0016	0.012
2	0.029	0.0012	0.008
1	0.050	0.0020	0.004
0	0	0	0

Inter Storey Drifts in Y-Direction

Storey level	Bare Frame	Frame with Knee bracing	IS 1893:2002
6	0.0163	0.0001	0.024
5	0.0296	0.0013	0.020
4	0.0416	0.0016	0.016
3	0.0506	0.0016	0.012
2	0.0051	0.0002	0.008
1	0.0086	0.0005	0.004
0	0	0	0

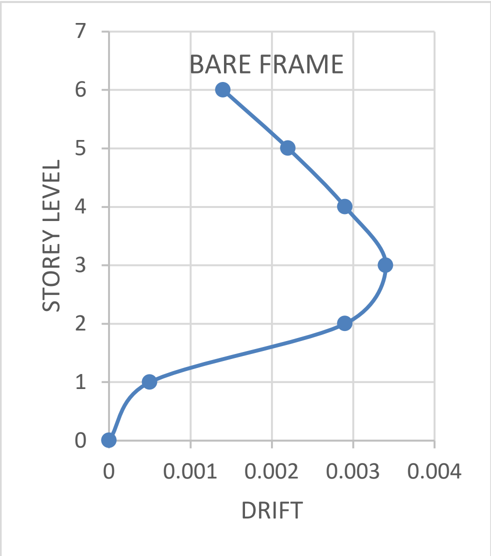
Inter Storey Displacement in X-Direction

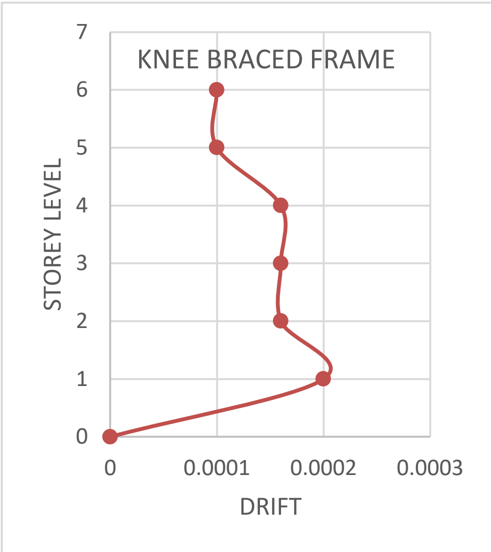
Storey level	Bare Frame	Knee with Knee bracing	IS 1893:2002
6	0.127	0.0090	0.084
5	0.113	0.0080	0.060
4	0.093	0.0070	0.040
3	0.064	0.0054	0.024
2	0.034	0.0036	0.012
1	0.005	0.0020	0.004
0	0	0	0

Inter Storey Displacement in Y-Direction

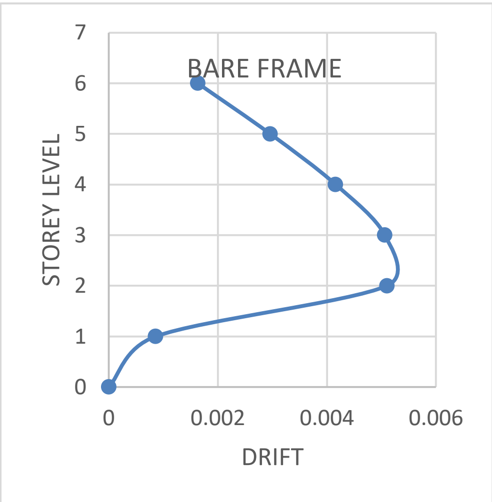
Storey Level	Bare Frame	Knee with knee bracings	Is 1893:2002
6	0.0273	0.0125	0.084
5	0.0260	0.0115	0.060
4	0.0230	0.0102	0.040
3	0.0188	0.0086	0.024
2	0.0137	0.0070	0.012
1	0.0086	0.0030	0.004
0	0	0	0

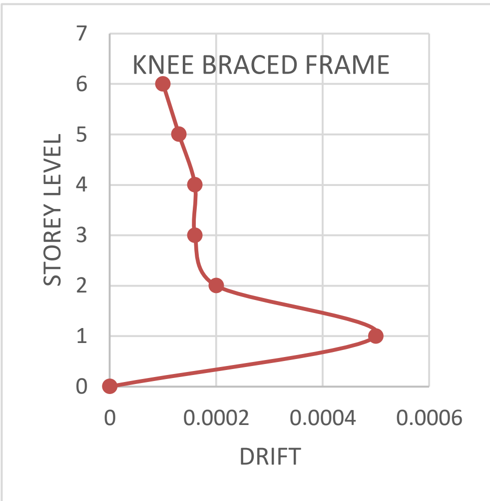
Inter Storey Drifts in X-Direction



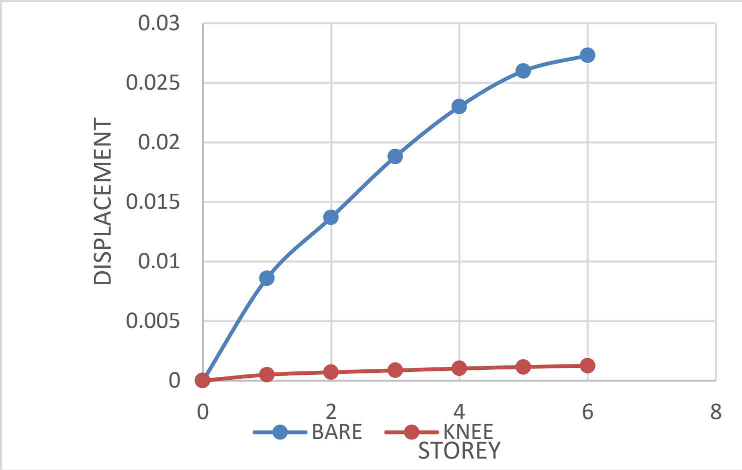


Inter Storey Drifts in Y-Direction

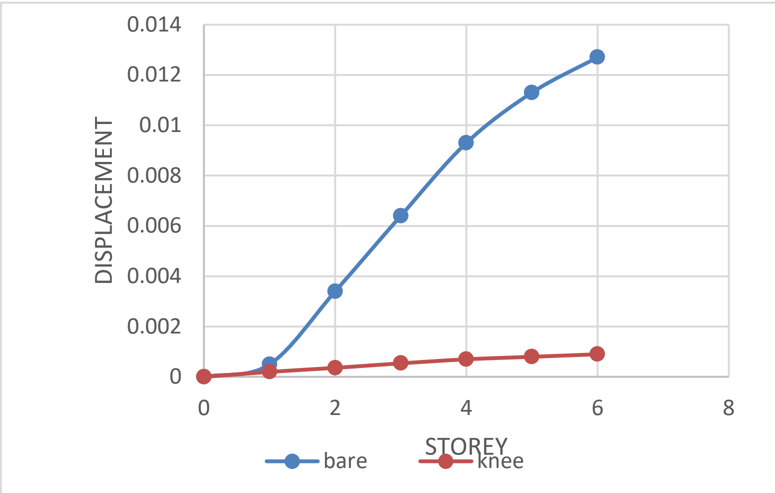




Inter Storey Displacement in X-Direction



Inter Storey Displacement in Y-Direction



8. SUMMARY

The model of G+5 storey building was analyzed by equivalent static and Response Spectrum analysis. The bare frame and knee braced frame are analyzed in order to check out the permissible storey drift as per IS 1893:2002 (part 1). The model of base length 9m and width 9m for typical storey height of 3m of each storey in building. The joints between beams and columns are assumed as fixed. The column at ground level is fixed support with zero orientation and displacement. The Beam ISLB200, Column ISHB 250-2 and Bracings ISMB175. As the equivalent static analysis is done by manually for base shear and lateral displacement. The software used in this project was ETABS, the first modelled and then pushover analysis and response spectrum analysis has done. Therefore, the output of their storey drift, and storey displacement are plotted either of bare frame and knee braced frame.

9. CONCLUSIONS

From the above experimental study, the following conclusions were made

- The seismic behavior on G+5 structural model with different bracing arrangements for investigation.
- The internal storey drift in X-direction is far compared to permissible drift ratio as per IS 1893:2002 (part 1).
- Hence the knee braced frame system is significant to reduce the effect on lateral displacement by spectral acceleration (S_a).
- The internal storey drift in Y-direction is far compared to permissible drift ratio as per IS 1893:2002 (part-1).
- Therefore, the knee bracing frame structural internal storey drift is acceptable by IS 1893:2002 (part 1).

FUTURE SCOPE OF WORK

- The present study was conducted to find out comparison between seismic parameters such as base shear, roof displacement, time period, storey drift, storey displacement for steel bare frame with knee braced patterns are studied.
- In this study moment resisting steel bare frame with knee bracing patterns are analyzed using pushover analysis, equivalent static analysis, response spectrum analysis.

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REFERENCES

[1] Mr. Choudhari V.A. CE Department of S.B.Patil College of Engineering, Indupur, Maharashtra, India. International journal of innovations in engineering research and technology [ijiert] issues no.: 2394-3696 volume 2, issue 6, june-2015.

[2] Arathi Thamarakshan, Arunima, Scholar, Dept. of Civil Engineering, SVNCE. "Analysis of knee braced frame with different bracing configurations using ansys". International

Research Journal of Engineering and Technology (IRJET). e-ISSN: 2395 -0056. Volume: 04 Issue: 04. Apr -2017 www.irjet.net.

[3] Ratnesh Kumar, Prof. K. C. Biswal. "Seismic analysis of braced steel frames". National Institute Of Technology Rourkela Orissa, India. May 2014.

[4] Anitha M, Divya K.K, "Comparative Study On Seismic Behavior Of Steel Knee Braced Frame With Eccentric Braced Frame". IOSR Journal of Mechanical and Civil Engineering e-ISSN: 2278-1684,p-ISSN: 2320-334X, PP 01-07.

[5] D. Kawai, Osaka Institute of Technology, Osaka, Japan, K. Suita Kyoto University , Y. Koetaka &, Tokyo, Japan, K. Inoue General Building Research Corporation of Japan (RCJ), Osaka, Japan, N. Uno & Y. Fukuchi Nippon Steel & Sumaiken Metal Products Corporation, Ltd., Tokyo, Japan. "Mechanical behavior and design method of weld-free steel structure with knee brace damper using square tube column". 2012.

[6] Leelataviwat, S. & Doung, P. CE Department, King Mongkut's University of Technology Thonburi, Thailand. "Ductile Knee-Braced Frames for Seismic Applications". International Conference on Earthquake engineering and Structural Dynamics. June-2017.

[7] Viswanath.K.G, Prakash K.B, Anant Desai, Director/Principal, Ashokrao Mane Group of Institutions, Vathar Tarf Vadgaon, Kolhapur.Seismic Analysis of Steel Braced Reinforced Concrete Frames".

[8] HUANG Zhen, LI Qing-song, CHEN Long-zhu, (2005), "Elastoplastic analysis of knee bracing frame," Journal of Zhejiang University Science.

[9] MehrdadLotfollahi, MassoodMofid (2006), "On the design of new ductile knee bracing, Journal of Constructional Steel Research 62, pp 282–294

[10] Mahmoud Miri, Abdolreza Zare, Hossein Abbas zadeh,(2009),"Seismic behavior of steel frames investigation with knee brace based on pushover analysis," World Academy of Science, Engineering and Technology 50

[11] Mina Naeemi, Majid Bozorg,(2009),"Seismic performance of knee braced frame," World Academy of Science, Engineering and Technology 50.