International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 09 | Sep-2016 www.irjet.net p-ISSN: 2395-0072

A COMPARATIVE STUDY OF KNEE BRACED STEEL FRAME

Sara Raphael[1], Soni Syed[2]

[1]M.Tech Scholar, Dept. of Civil Engineering, KMEA Engineering College, Kerala, India
[2]Asst. Professor, Dept. of Civil Engineering, KMEA Engineering College, Kerala, India

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Abstract - *Today steel is the most useful building material in the construction field. Its strength is approximately ten times that of concrete so it is used in the construction of buildings, bridges, towers and many other structures. Steel structures tend to be more economical than concrete structures for tall buildings and large span buildings and bridges due to its large strength to weight ratio. The steel structures in the areas of high seismic activity should be stiff enough to prevent structural damage and have sufficient ductility to prevent collapse. Bracing is the technique for resisting the lateral forces in a framed structure in an effective and economical way. Knee braced steel frame is that which have good ductility and lateral stiffness compared with other types of bracings. In knee braced steel frame, yielding occurs only to the knee element and no damage to major elements. In this study the seismic effect of knee braced steel frames was studied. A comparison of double knee braced steel frame with single knee braced frame had been done through pushover analysis. An angle study of knee member was conducted to study the effect of knee angle through a non-linear analysis. The parameters such as displacement and stiffness are investigated.*

Key Words: Knee braced steel frame, Pushover analysis, Nonlinear analysis, Displacement, Stiffness

1.INTRODUCTION

Today steel is the most useful building material in the construction field. Steel is used in the construction of buildings, bridges, towers and many other structures. Steel structures tend to be more economical than concrete structures for tall buildings and large span buildings and bridges due to its large strength to weight ratio. It is necessary to design a structure to perform well under seismic load in order to avoid damage. By introducing steel bracings in structure the shear capacity of the structure can be increased. Steel bracings can be used as retrofit as well. Bracings provide stability and resist lateral loads. The steel bracing are of different types, they are; concentric bracing, eccentric bracing and knee bracing. Concentric braced frames under large seismic force is dominated by buckling. The commonly used concentric bracings are X bracings which is very slender and has large tensile capacity and little compressive buckling capacity. But its concentration of inelastic deformations and energy dissipation during major earthquake is poor. In eccentric bracings, either one end or both ends of the brace are connected to the beams instead of the beam-column joints. The "shear link", which is the short beam segment between the brace-beam and beam-column joint, is designed to dissipate energy through shear yielding during severe earthquakes [7]. But its repair and replacement after severe earthquake is expensive and time consuming.

The knee bracing is a new bracing system where the diagonal brace is anchored to a short member instead of the beam-column joint. This short member is called the "knee element" which is designed to yield in flexure, whereby buckling of the brace is prevented [6]. The advantage of the knee braced frame is that damage is concentrated in the secondary element which can be easily replaced after earthquake. The knee braced frames are provided as single knee braced frame- knee element on one side and double knee braced frame- knee elements on both side.

Fig -1: Knee bracing

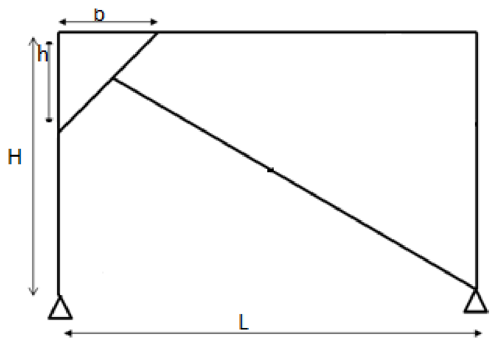

Fig -2: Single knee braced frame

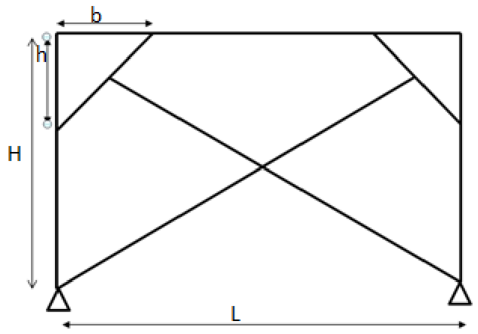

Fig -3: Double knee braced frame

2. PUSHOVER ANALYSIS OF KNEE BRACED FRAMES

Pushover analysis is a static, nonlinear procedure in which the magnitude of the structural loading is incrementally increased in accordance with a certain predefined pattern. Pushover analysis is conducted to study the seismic response of the steel frame. In this study a five storey single knee braced frame and double knee braced frame is selected. Each storey having 2 m height and 3 m span.

2.1 Description Of Sample Frame

The beams and columns are made up of I sections of sizes 200 x 150 x 30.6kg/m and 200 x 200 x 56.2 kg/m, respectively. The braces were made of two C-channels (125 x 65 x 6 x13.4 kg/m) connected back to back with a16 mm gap in between by 150 x 150 x12 mm thick batten at 500 mm spacings. Wide flange I-section of size 125 x 125 x 23.8 kg/m was used for the knee members.

Table - 1: Material properties of knee braced frame

Material	Young's modulus	Poisson's ratio	Density	Yield stress
Steel	200 Gpa	0.3	7830Kg/m^3	250 Mpa

<u>Numerical Analysis</u>

- ANSYS 15 is used.
- Single knee braced frame and double knee braced frames are modelled.
- Material properties are assigned.
- Modal analysis performed.
- Ahmedadad earthquake data is assigned for pushover analysis.
- Solution of problem and interpretation of results.

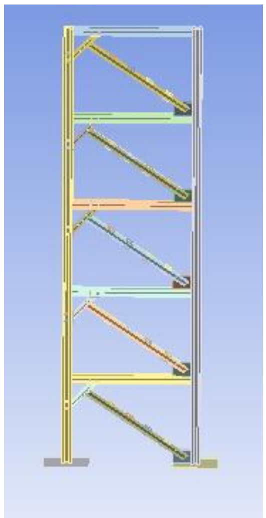

Fig -4: Modal of single knee braced frame

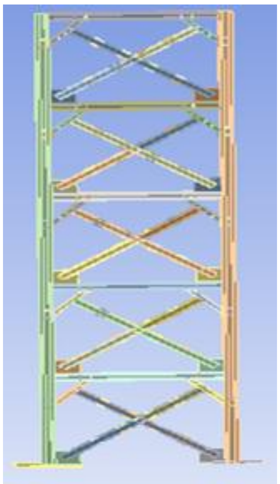

Fig -5: Modal of double knee braced frame

Pushover analysis is conducted to evaluate the seismic response of the new and existing structures. For this Ahmedadad earthquake data is assigned.

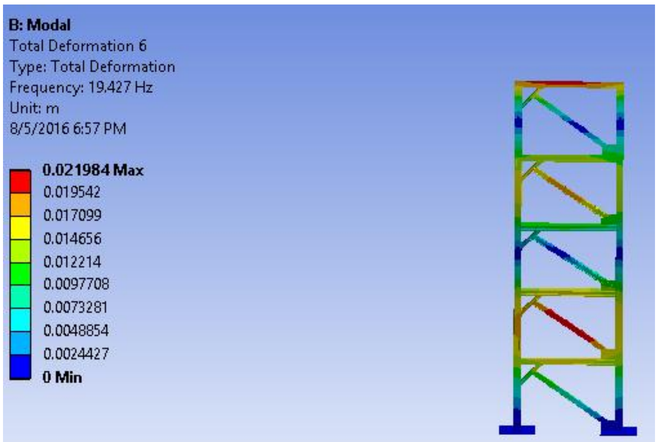

Fig -6: Maximum displacement of single knee braced frame with corresponding frequency

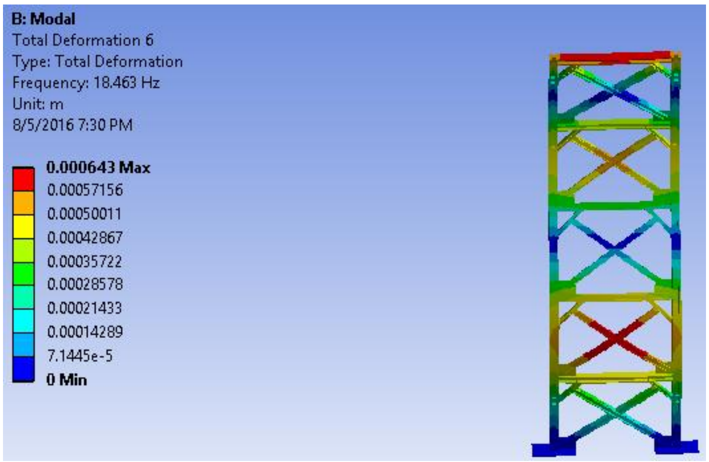

Fig -7: Maximum displacement of double knee braced frame with corresponding frequency

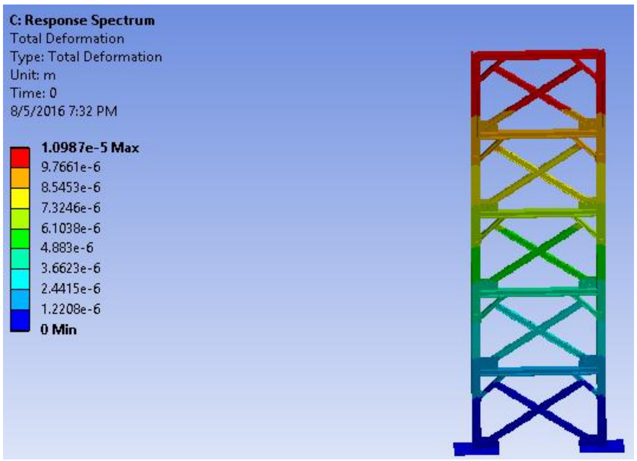

Fig -9: Total deformation of double knee braced frame in PA analysis

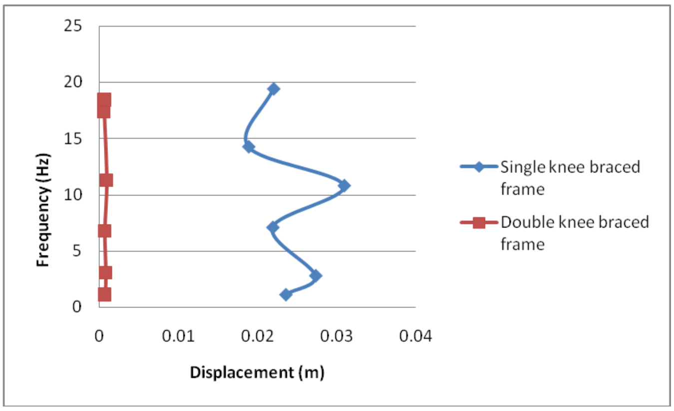

Chart -1: Frequency- displacement graph from modal analysis

In modal analysis, it is clear that the double knee braced frame has less displacement compared with single knee braced frame.

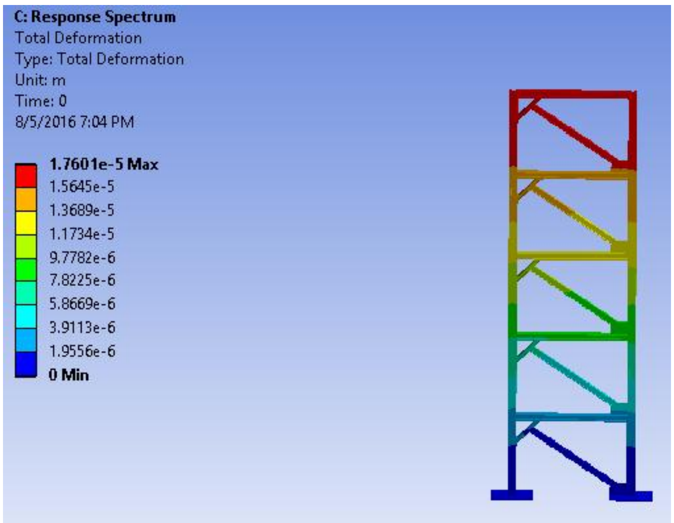

Fig -8: Total deformation of single knee braced frame in PA analysis

In pushover analysis the double knee braced frame have less deformation than single knee braced frame, which shows that double knee braced frame have good seismic response during an earthqake.

3. ANGLE STUDY OF KNEE BEACED FRAME

To study the effect of knee angle, a nonlinear static analysis is conducted. For the study the angle of the knee member is varied from 35^0 to 65^0 and four sample frames are modeled for the analysis. Load was applied at the top end of the frame in x direction with an incremental loading of 10kN. The material properties are same that is used for the pushover analysis.

3.1 Description Of Sample Frame

Different samples of knee braced frames are modeled with varying knee angles of 35^0, 45^0, 55^0 and 65^0. A single storey frame of 3.2 m span and 2.8 m height. The beams, columns, diagonal bracing and knee bracings were I sections of sizes 100x100x7x7,125x125x8x8,100x100x10x10 and 60x60x5x5 respectively.

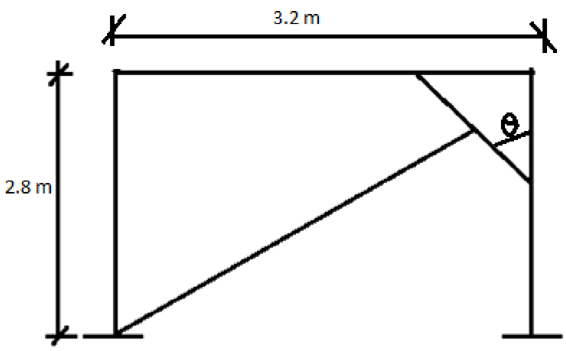

Fig -10: Geometry of the frame

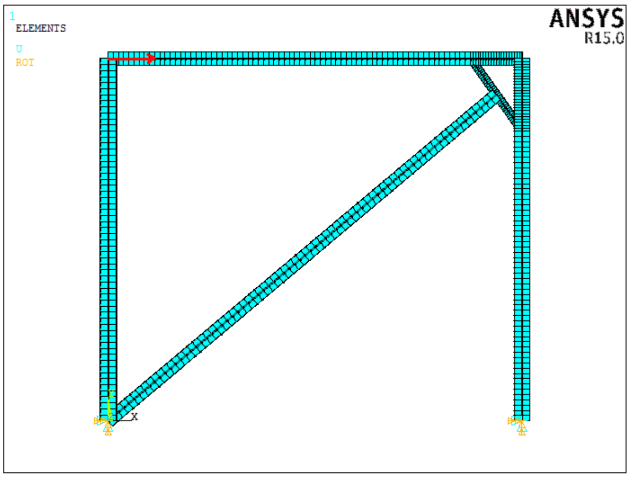

Fig -11 Model of 35⁰ inclined knee member

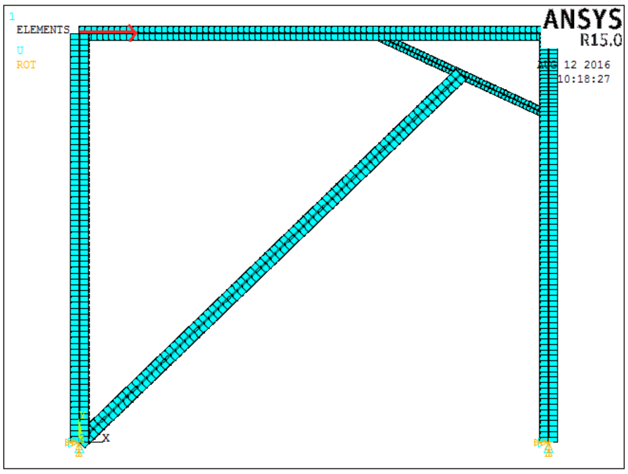

Fig -12: Model of 65⁰ inclined knee member

It is a nonlinear analysis. In this dynamic loading is applied to the structure. An incremental loading of 10kN is used in the present study.

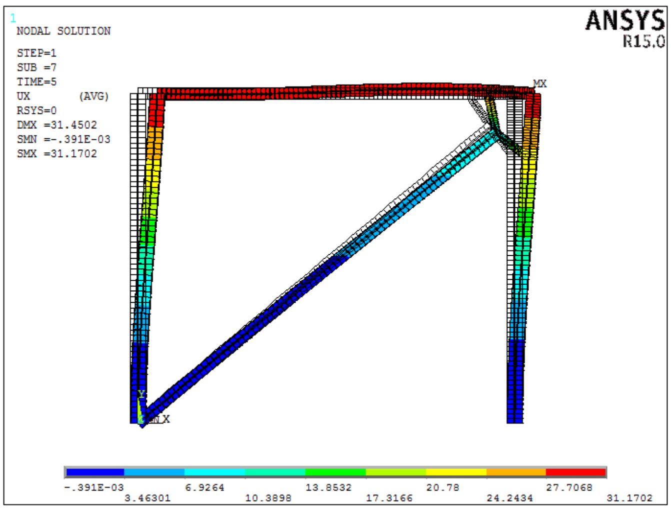

Fig -13: Maximum displacement of 35⁰ inclined knee member

A nonlinear relationship is obtained between load and displacement. From that the stiffness can be calculated.

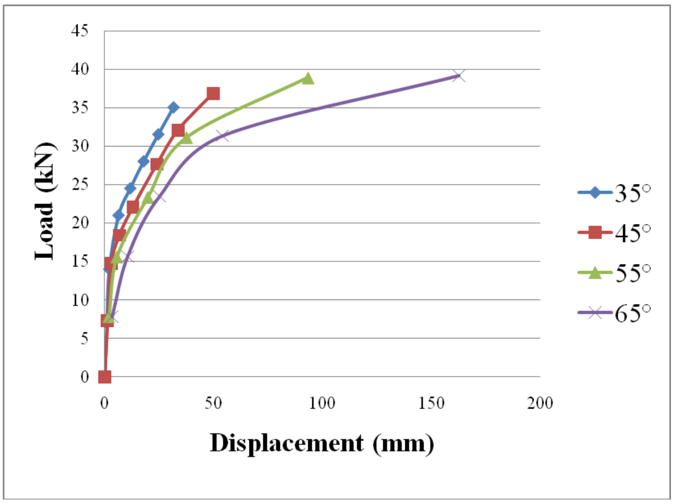

Chart -2: Load- displacement graph of knee braced frame with varying knee angles

Table - 2: Comparison of stiffness of frame

Sl.No	Degree of inclination of knee member	Ultimate Load(kN)	Stiffness(kN/m^2)
1	35	35	1112.8
2	45	36.9	740.07
3	55	38.9	416.22
4	65	39.2	240.88

4. CONCLUSIONS

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.

ACKNOWLEDGEMENT

I thank Almighty God for having showered upon me his kindest blessings enabling me to fulfill this task successfully.

I express my heartfelt thanks to my thesis guide Mrs.Soni Syed, Assistant Professor, Department of Civil Engineering, KMEA Engineering College, for her intellectual guidance, valuable suggestions and for spending her precious time for the successful completion of my work.

I also express my sincere thanks to Mrs. Bindu Sebastian, Associate Professor & Head, Department of Civil Engineering, KMEA Engineering College, for her valuable suggestion and also to all the faculty members and staff of the Civil Engineering Department for their co-operation.

Last and most of all, I offer a special word of thanks to my beloved parents and friends who have encouraged me with good spirit by their incessant prayers and suggestions, which helped me to complete my work successfully.

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