STUDY ON SEISMIC BEHAVIOR OF KNEE BRACED STEEL FRAMES

Anitha M.[1], Divya K.K [2]

[1] *M.Tech Scholar, Dept of Civil Engg., SNGCE, Kerala, India*
[2] *Asst. Professor, Dept of Civil Engg., SNGCE, Kerala, India*

Abstract-*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.*

Key Words: *Steel bracing, Non linear static analysis, Non linear time history analysis.*

1. INTRODUCTION

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 replaced 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 behaviour of KBF structure[6]. The knee element will yield first without affecting the other main structural elements[7].

Fig -1: Knee bracing

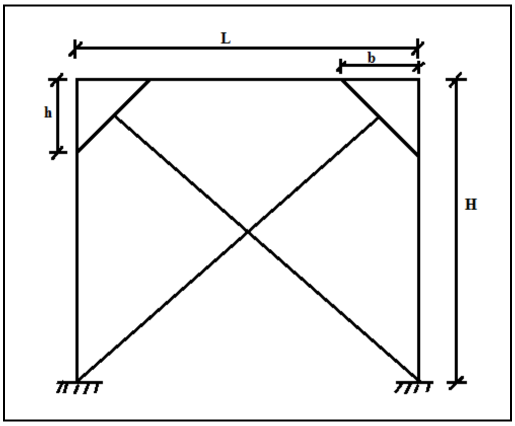

Fig -2: Basic parameters of double knee bracing

2. SCOPE

Steel plays an important role in construction industry due to its high strength to weight ratio. A study regarding the seismic response of steel structures is necessary. In the present study, modeling of the steel braced frame under non linear time history analysis and non linear static analysis was performed. Since in knee bracings, the replacement of knee element is very easy after severe earthquakes, it provides an effective way to seismic retrofitting.

3. OBJECTIVES

- To study the seismic effect in steel braced frames.
- To compare seismic performance of knee braced steel frame with concentric bracings, eccentric bracings and without bracings.

4. METHODOLOGY

- Literature review.
- Modelling ,assigning boundary conditions and inputting load data.
- Performing non linear static analysis and non linear time history analysis by finite element software.
- Result interpretation.

5. VALIDATION

A two storey frame of span 3 m and height 2 m is selected [7].

5.1 Section Details

The beams and columns were I-sections of sizes 200 x 150 x 30.6 kg/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 a 16 mm gap in between by 150 x 150 x12 mm thick batten at 500 mm spacings. The sections used were grade 43C ("BS 5950" 1990) hot rolled carbon steel. Wide flange I-section of size 125 x 125 x 23.8 kg/m was used for the first and second storey knee members.

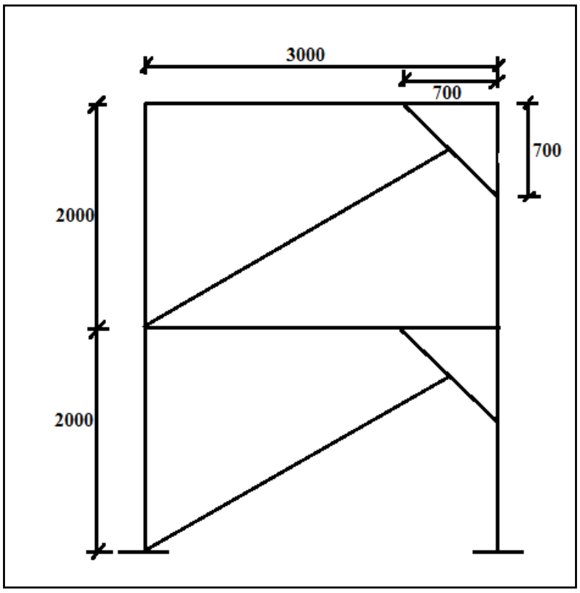

Fig -3: Geometry of two storey frame

5.2 Material Properties

Material properties were given as modulus of elasticity as 180 Gpa, poissons ratio as 0.285,density as 7830 kg/m^3,yield stress as 275 Mpa. The frame is modeled using finite element software.

Modal analysis is performed to obtain the frequencies. Then time period is calculated as per the equation T= 1/f.

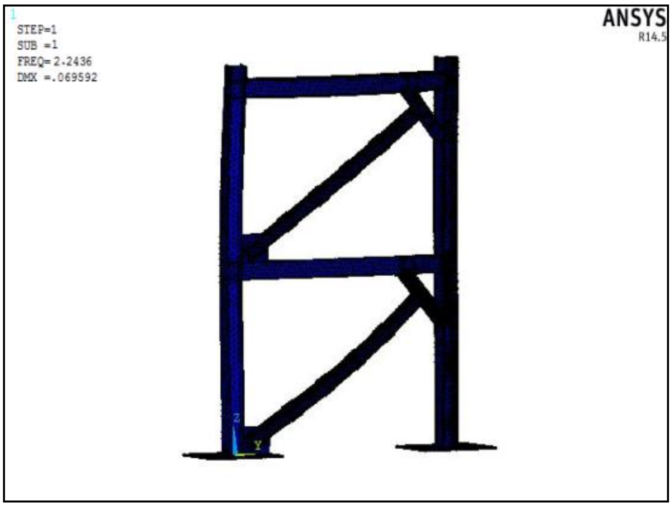

Fig -4: Fundamental mode shape

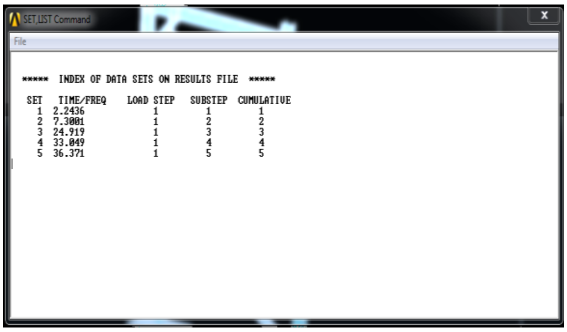

Fig -5: Frequencies obtained

Table -1: Validation details

Experiment			Using software ANSYS 14.5
Time period	1st mode shape	0.45 sec	0.445 sec
	2nd mode shape	0.15 sec	0.14 sec

6. PRESENT STUDY

A single storey frame of span 3 m and height 2 m is selected in this study. The beams and columns were I-sections of sizes 200 x 150 x 30.6 kg/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 a 16 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 knee members.

Material properties of frame

Young's modulus of elasticity = 200 Gpa

- Poisson's ratio of steel = 0.3
- Density = 7850 kg/m^3
- Yield stress = 250 Mpa
- The base of the frame is fixed

Numerical analysis

- ANSYS 14.5 is used.
- Frames are modelled with knee bracings, with eccentric bracings and without bracings.
- Material properties are assigned.
- Element 20 node solid 186 is used.
- Dynamic loading i.e., an incremental loading of 10 kN is given for non linear static analysis.
- El-centro earthquake data for time history analysis is assigned.
- Solution of problem and result interpretation.

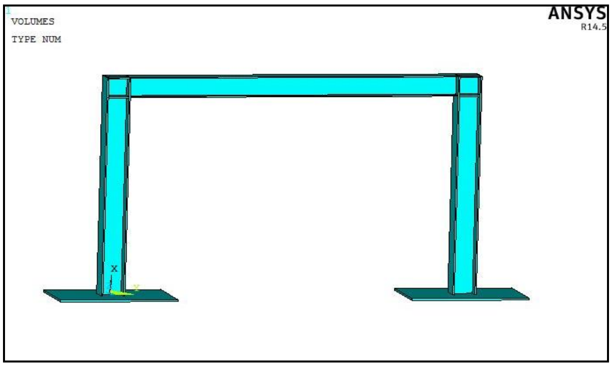

Fig -6: Model of frame wthout bracings

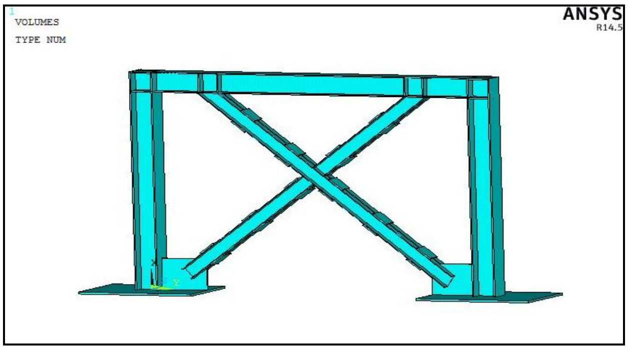

Fig -7: Model of frame wit eccentric bracings

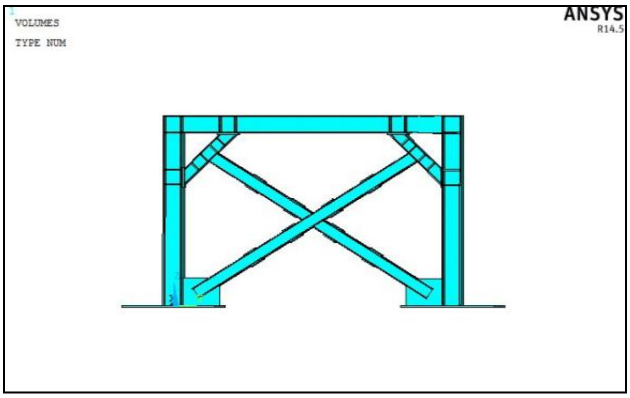

Fig -8: Model of frame with double knee bracings

6.1 Non linear static analysis

It is an analysis to evaluate the seismic performance of new and existing structures. In this dynamic loading is applied to the structure. An incremental loading of 10 kN is used in the present study. A non linear relationship is obtained between load and displacement. From that the stiffness can be calculated for each frame.

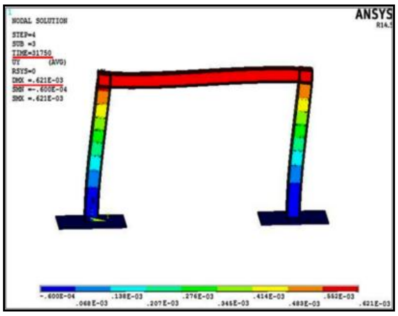

Fig -9: Ultimate load of frame without bracings

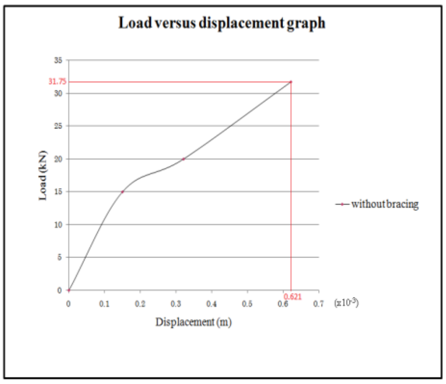

Fig -10: Load v/s displacement graph of frame without bracings

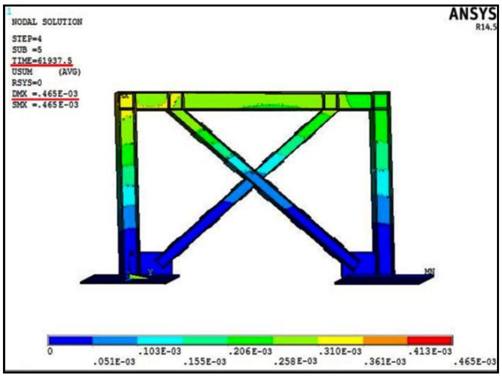

Fig -11: Ultimate load of frame with eccentric bracings

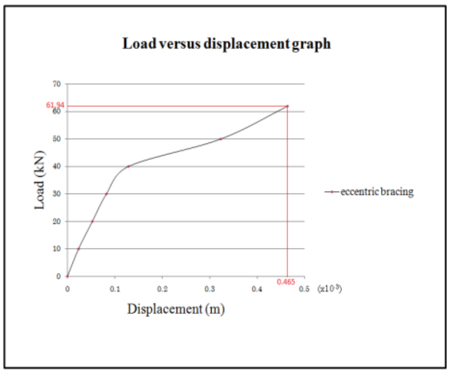

Fig -12: Load v/s displacement graph of frame without eccentric bracings

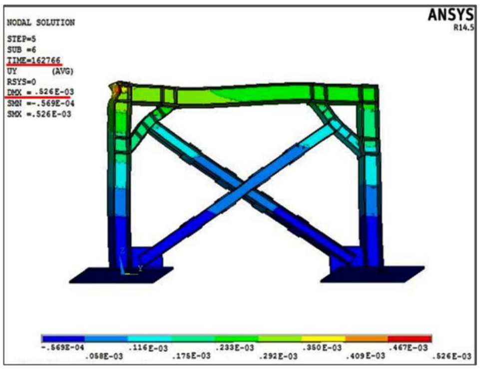

Fig -13: Ultimate load of frame with double knee bracings

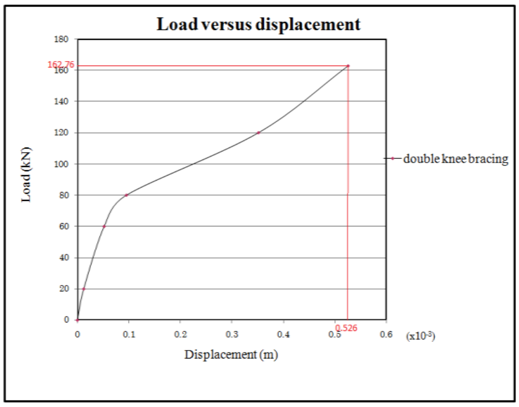

Fig -14: Load v/s displacement graph of frame with double knee bracings

Table -2: Comparison of stiffness of frames

Sl.no	Frame	Ultimate load (kN)	Stiffness (kN/mm)
1	Without bracings	31.75	51.08
2	With eccentric bracings	61.937	135.21
3	With double knee bracings	162.766	309.44

6.2 Non linear time history analysis

Non linear static analysis cannot represent seismic phenomena in a high accuracy mode, time history analysis has been performed to get the displacement due to transient loading. Here an earthquake data is used as input loading. El centro earthquake data is used in the present study. It is a very tedious and complex analysis which requires enough time for solving.

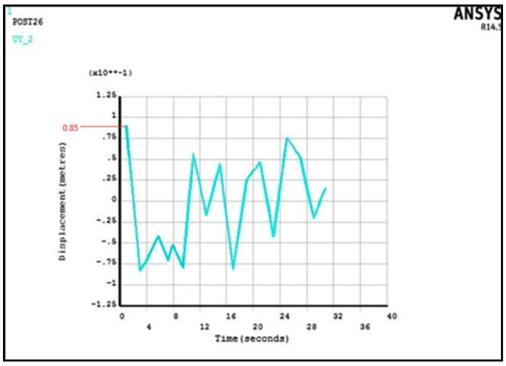

Fig -15: Displacement graph without bracings

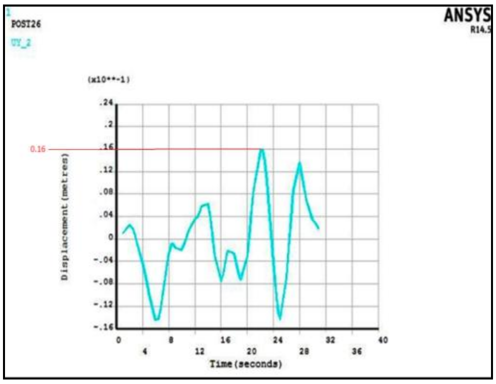

Fig -16: Displacement graph with eccentric bracings

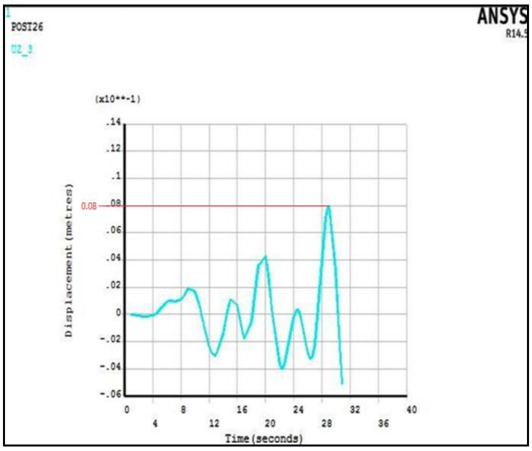

Fig -17: Displacement graph with double knee bracings

Table -3: Comparison of displacement of frames

Sl.no	**Frame**	**Displacement (mm)**
1	Without bracings	85
2	With eccentric bracings	16
3	With double knee bracings	8

7. CONCLUSIONS

The development of a lateral bracing system known as knee bracing system presented in this paper can be used as a suitable seismic retrofitting method. In this study a comparative analysis of double knee braced frames with eccentric bracings and without bracings had been studied. In non linear static analysis performed, steel frames with double knee bracings showed very good behaviour during a seismic activity. The ultimate load for double knee bracings is very much higher compared to without bracings and with eccentric bracings.Double knee bracings showed more lateral stiffness compared to other type of bracings.In time history analysis the maximum displacement observed for double knee bracings was 90.5% more than without braced frame and 50% more than eccentric braced frame.

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