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# Comparative Study On Seismic Behaviour Of Steel Knee Braced Frame With Eccentric Braced Frame

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***Abstract:*** *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.*
***Keywords -*** *Displacement,Non linear static analysis , Non linear time history analysis, Steel bracing, Stiffness.*

## I. Introduction

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. Compared to all other bracings, knee bracings have got excellent ductility and stiffness. Frames with knee bracings (KBFs) provide 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 limit 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 be replaced after destructive earthquakes.

The first step in designing a knee braced moment frame is to design the base moment frame using any valid design method. After the determination of beams and columns dimensions, the knee braces dimensions are to be fixed so that the yielding of knee braces and formation of plastic hinges in the intermediate beams and column bases during a seismic activity. 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

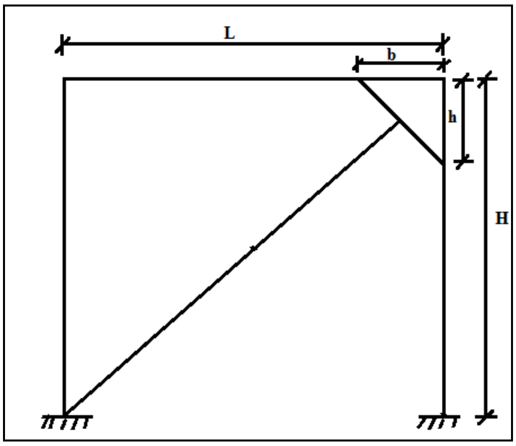


**Fig.2.** Typical parameters of knee braced frame

## II. 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.

## III. Objectives

- To study the seismic effect in steel braced frames.
- To arrive at a configuration of knee braced frame by varying the length of knee element.
- To compare the knee braced frame with eccentric braced frame.

## IV. 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.

## V. 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 varying length of knee element.
- To vary the length of knee, the dimension 'b' is varied at 500 mm, 600 mm, 700 mm, 800 mm, 900 mm.
- 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.
- Configuration of knee braced frame is arrived.
- Comparison of knee braced frame with eccentric bracings is done.
- Solution of problem and result interpretation.

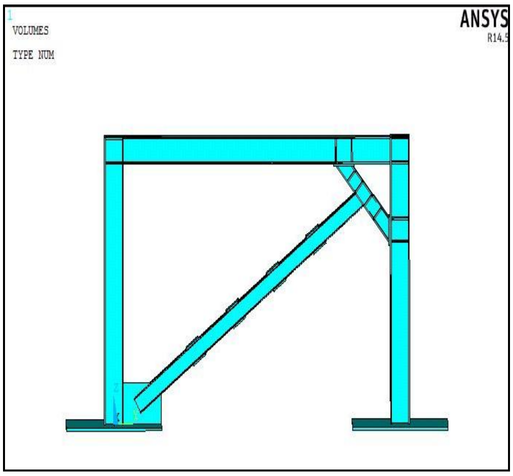


**Fig.3.** Model of frame wth knee at 700 mm

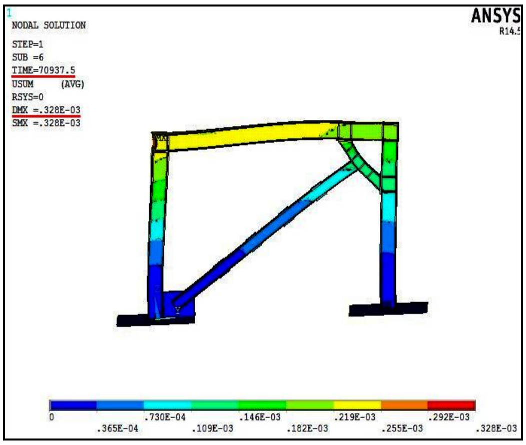


**Fig .4.** Ultimate load of frame with knee at 700 mm

**Table 1.** Comparison of variation in stiffness

| b (mm) | h (mm) | b/L | $l_k$ (mm) | Ultimate load (kN) | Stiffness (kN/mm) |
|---|---|---|---|---|---|
| 500 | 700 | 0.16 | 860.23 | 60.83 | 198.45 |
| 600 | 700 | 0.2 | 921.95 | 64.19 | 209.08 |
| 700 | 700 | 0.23 | 989.94 | 70.94 | 216.27 |
| 800 | 700 | 0.26 | 1063.01 | 73.5 | 226.85 |
| 900 | 700 | 0.3 | 1140.18 | 75.75 | 238.2 |

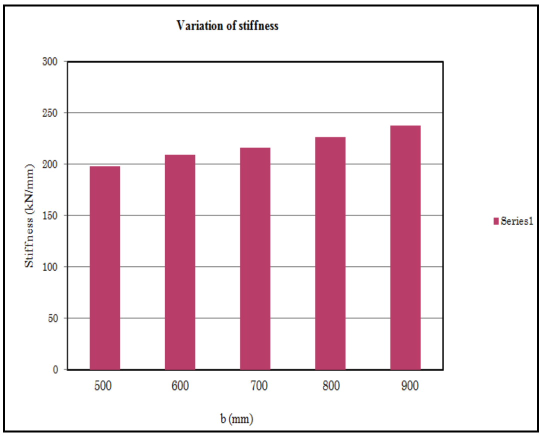


**Fig.5.** Graph representing variation of stiffness

From the tabulated results it was observed that the lateral stiffness will increase as the length of knee element increases. Since ductility value reduces with further increase in length of knee element, the length of knee element is restricted to 0.15-0.3[6].Therefore knee element at 700 mm is selected.

### 5.1. Comparative Analysis Of Double Knee Braced Frame With Eccentric Braced Frame

#### 5.1.1 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.

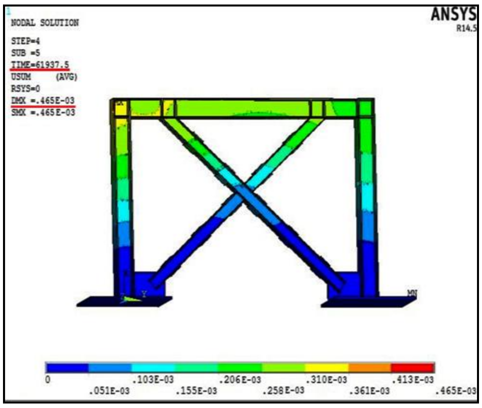


**Fig.6.** Ultimate load of frame with eccentric bracings

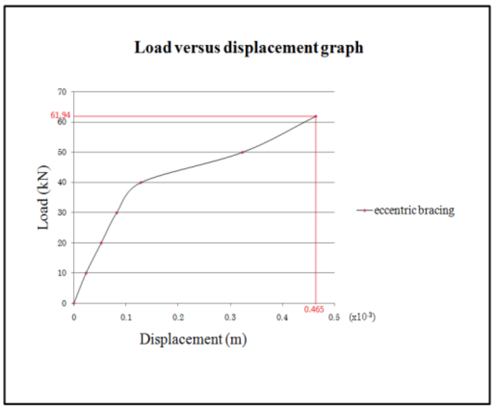


**Fig.7.** Load v/s displacement graph of frame without eccentric bracings

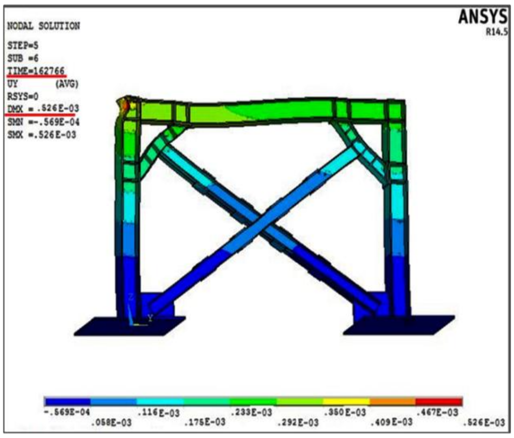


**Fig.8.**Ultimate load of frame with double knee bracings

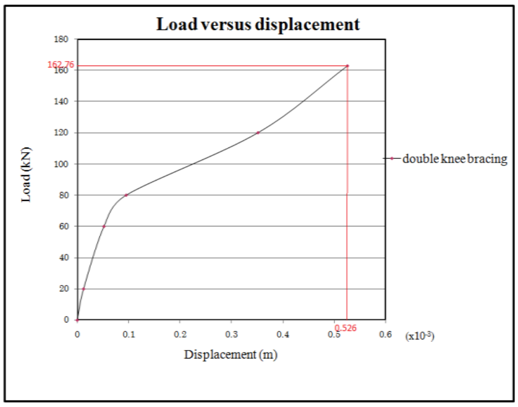


**Fig.9.**Load v/s displacement graph of frame with double knee bracings

**Table 2.** Comparison of stiffness of frames

| Sl.no | Frame | Ultimate load (kN) | Stiffness (kN/mm) |
|---|---|---|---|
| 1 | With eccentric bracings | 61.937 | 135.21 |
| 2 | With double knee bracings | 162.766 | 309.44 |

### 5.1.2 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.

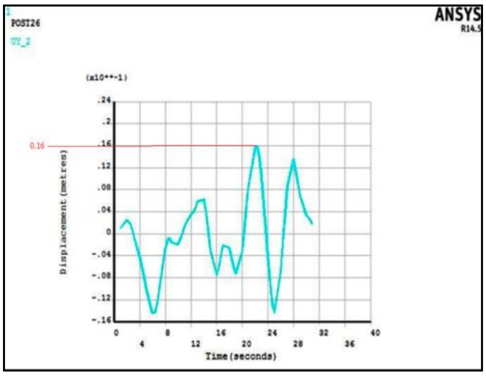


**Fig.10.** Displacement graph with eccentric bracings

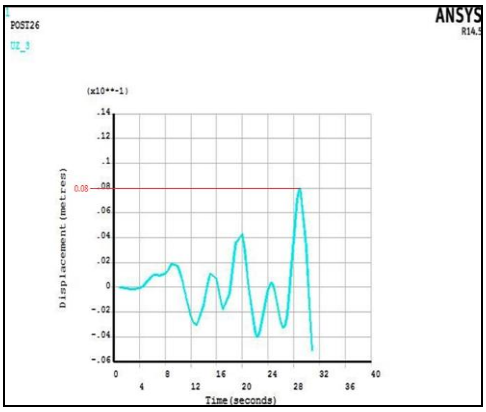


**Fig.11:** Displacement graph with double knee bracings

**Table 3.** Comparison of displacement of frames

| Sl.no | Frame | Displacement (mm) |
|---|---|---|
| 1 | With eccentric bracings | 16 |
| 2 | With double knee bracings | 8 |

## VI. 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 an effective configuration of knee braced frame had been arrived.(b=h=700 mm). And a comparison of double knee braced frame with eccentric braced frame had been done. 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 eccentric bracings.Double knee bracings showed more lateral stiffness compared to eccentric bracings.In time history analysis the maximum displacement observed for double knee bracings was 50% more than eccentric braced frame.

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