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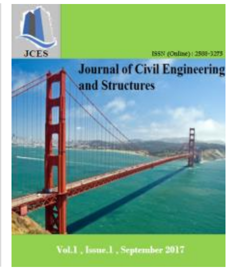

The seismic performance of frames with TKBF knee brace

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Abstract: Knee brace consists of a bending frame and a knee member which is connected to the beams and columns in the form of diagonal. The lateral intensity of the frame depends on the plasticity of joints and knee member. In this paper the effect of knee brace geometrical parameters in the lateral intensity of the structure were studied by ABAQUS software. As a result of roofs' lateral displacement were observed that lateral displacements of all studying models are studied in the regulations. The amount of lateral displacement of systems by TKBF cross and knee bracing has been in the amount of lateral displacements of EBF2, CBF1 ($2.6M_P/V_P$)models. In models by TKBF cross and knee bracing with increasing the ratio of b/B and h/H; the lateral displacement of system increases.

Keywords: Finite element; knee brace, bending frame, intensity, plasticity, geometric parameters.

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1. Introduction

To verify them we consider a frame like Figure 1. This is frames of the TKBF cross and knee braces. The frame which knee member is at the upper end of the diagonal member. In the KBF system; beam to column, beam to knee, and knee to column connections are bending type and brace-column's leg and knee member are assumed as articular connection (Figure 1).

A paper was focused on the laboratory examination of four cold-rolled steel frames by knee brace with dimensions 2.4m× 2.4m and variable profiles under periodic load, then the behavior of two knee braces on light steel buildings were studied by SAP 2000 software, and also numerical studies using ANSYS software on 12 samples of CFS frames with braces to evaluate and optimize the lateral performance of cold-rolled steel by different forms of knee braces were examined, Tahmooresi. et al. These studies have considered the maximum load capacity and deformation behavior of samples, and presented logic evaluation of earthquake response adjustment factor, R, from the walls by knee brace. The results showed that the use of the bracket (holder) on four corners of the wall panels with a knee brace, optimizes the lateral performance of the panel containing shear strength and panel plasticity. The braces were considered to improve the steel shear walls plasticity against relative movement and without any brittle fracture, like predicted breaking or buckling, Hasan Tahmoorsi and Iman Ghorbani, 2013.

In a study; the examination of bending frames system with knee connection was studied, using knee brace in the beam-column connection referred to increase strength and plasticity in bending frames. The system can be used to design both new structures and to improve the seismic behavior of existing bending frames. In this system, using the necessary proportion between knee member with members of beams and columns; can be utilized of the capabilities of link beam, bending plastic joints or tensile submission to the

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pressure of the knee member as a plasticity member. In other words, this system provides more appropriate using the hidden non-elastic capacity in the structure, Mirjalili .et al.

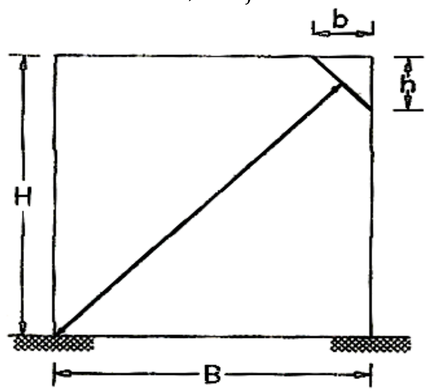

Figure 1. Fram with cross and knee bracing

Figure 1 frame contains 7 indefinite degrees in structural view. Three indefinite degrees related to closed-loop, three degrees related to fixed fulcrum, and one degree because of diagonal member which includes a total of 7 indefinite degrees. [1]

Structures' deformations are less in the structures by lateral bracing, and thus the second order effects of such structures are not very important. Since KBF are also braced systems, therefore evaluation of effects is not necessary in them. [2]

In this chapter, different lateral bracing frames systems (CBF, EBF, KBF) compared with each other and finally intensity curves is drawn for KBF systems.

To study the dynamic performance of above systems; dynamic analysis of time history is done under the accelerograms of Tabas and Naghan earthquakes. [3]

2. Profile of the building

The target building is a metal and regular building in plan and without twisting which for lateral bracing in both orthogonal directions; the lateral bracing systems of KBF, EBF and CBF will be used, respectively. The 2800 regulation is being used for loading. ABAQUS program will be used to analyze frames of the study. The AISC_LRFD regulation is being used to design frames' elements, and then sections are controlled using the second part of AISC regulation.

Figure 2 is driven axis plan of the building; the distance between the axis, loading side and bracing craters have been identified.

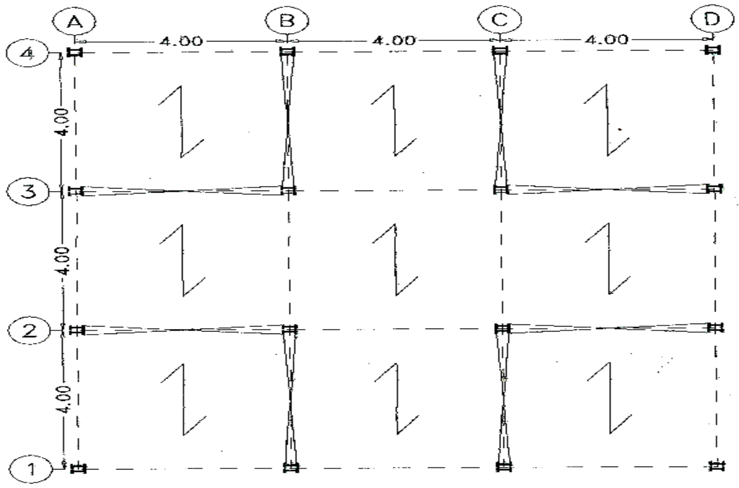

Figure 2. Axis plan

General specifications intended for the above-mentioned structure is as follows:

• Connection of beams to columns is assumed bending.

• Connection of knee to beam and knee to column is assumed fixed.

• Connection of diagonal member to knee and to foot of the column is assumed articular.

• Connection of columns to foundation is assumed fixed.

• Type of building's ground according to Table (2) and 2800 regulations type III; contains soils with average density.

• Construction site in Mashhad is considered a relatively high risk.

• Roof system is beams and blocks.

• Studying frame is frame-based 2.

Different structural systems for lateral bracing are as follows:

A) system with TKBF + MRF cross and knee bracing:

Geometric parameters of the system are shown in Figure 3.

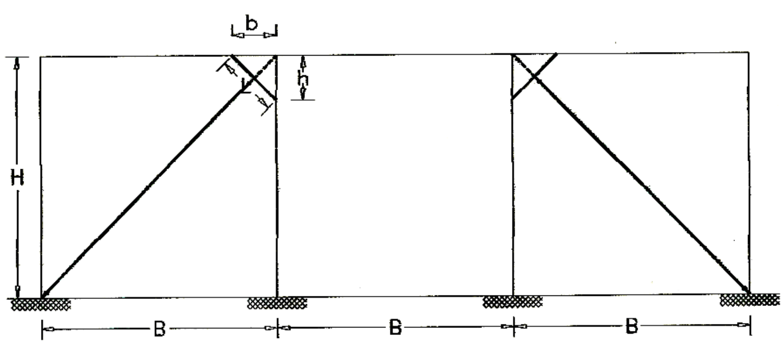

Figure 3. System with TKBF + MRF cross and knee bracing

B) EBF + MRF System:

The mentioned system is considered in two models namely EBF1; the system with thrust out $1.6M_P/V_P$ and EBF2; with thrust out $2.6M_P/V_P$ As the first system deals in shear mode and with the second system deals in bending mode[4,5] (Fig. 2).

The length of connector beam will be calculated as follows.

IPE270:

$$M_P = ZF_y = 484 \times 2400 = 1161600 Kg.cm$$

$$V_P = 0.55 F_y dt = 0.55 \times 2400 \times 27 \times 0.66 = 23522.4 Kg$$

$$e_1 = 1.6 \frac{M_p}{V_P} = 78 cm$$

$$e_2 = 2.6 \frac{M_p}{V_P} = 128 cm$$

loading :

$$W_D = 144 \times 850 + 1.5 \times 600 \times 2 = 124200 Kg$$

$$W_L = 144 \times 150 \times 0.2 = 4320 Kg$$

$$W = W_D + W_L = 124200 + 4320 = 128520 Kg \cong 129 ton$$

W_D :Weight of the building due to dead load

W_L :Weight of the building due to live load

W :Total weight of the building for lateral load calculations

2.1 Lateral loading

Fourth Edition 2800 regulation is used to load. The analytical method used for this purpose, is equivalent static analysis. In this method, seismic lateral force is determined based on the fundamental period of the building sway by using plan reflection spectrum.

3. Dynamic analysis of time history

In this section, dynamic analysis of time-history in introduced frames at the beginning of the chapter is being considered, and the response of the system is being compared.

3.1 Dynamic balance equations

If a single free degree system under the effect of a time function F(t) power is located, its balanced irrational equation will be in the form of Equation 1 [6].

$$F_I + F_D + F_S = F(t) \tag{1}$$

There fore:

F_I : Inertial force of acceleration

F_S :The force of frame intensity against the horizontal movement

F_D : depreciation force

$F(t)$: External force acting on the structure

So:

$$m\ddot{u} + c\dot{u} + ku = F(t) \tag{2}$$

When the structure is under the rapid flow of ground $\ddot{U}_g$, F_I can be wrote:

So we have:

$$m\ddot{u} + c\dot{u} + ku = -m\ddot{U}_g \tag{3}$$

About a few free degrees system; dynamic balance equation will be (4).

$$[m][\ddot{u}(t)] + [c][\dot{u}(t)] + [k][u(t)] = [F(t)] \tag{4}$$

[M], [c] and [k], are matrices of mass, damping, and intensity, respectively, and $[\ddot{u}(t)]$, $[\dot{u}(t)]$, $[u(t)]$ are acceleration vectors, velocity, displacement and $[F(t)]$ dynamic forces vectors, respectively, that acting on structure.

In the case of dynamic forces caused by movement of the Earth, we will have:

$$[M][\ddot{u}(t)] + [c][\dot{u}(t)] + [k][u(t)] = [M]\ddot{u}_g(t) \tag{5}$$

In equation (5) $\ddot{u}_g(t)$ is ground movement acceleration. While the response of the structure is desired at proper range, due to the intensity and damping of system in the total time effect of dynamic load is assumed fixed, with the integration of the above equation structural response is achieved. In this case, in short time intervals, above equation will be summed by using two Hamel integration and structure linear response obtained at the end of the period. This response is considered as initial conditions for the next interval and integration is done in the next interval. Integration constants from the initial response of the structure are obtained at the end of the last time interval. Integration continues to the end of time in this way [7].

4. Dynamic properties of the studying frames

General profiles of the studying frames include:

• The analysis considered two-dimensional.
• Studying frames are the frames introduced early in the chapter.
• The steel consumption strength is considered 2400 kg per square centimeter and its modulus of elasticity 2100000 kg per square centimeter.
• Category mass is considered to be concentrated in one node.
• To reduce the size of computer calculations, the pans of frame were considered rigid.
• Tabas and Naghan earthquakes accelerograms are used for dynamic loading of the frames.
• Damping for frames intended to 0.05.

4.1 Acceleration mappings Acts

Studying the dynamic behavior of structures, using the accelerograms and response spectrum is done. Because of the difference in the intensity, duration and frequency content of various earthquakes, their impact is different in dynamic response of structures in the earthquake frequency content is one of the most important. So, if the dominant frequency of earthquakes on structures being adapted to the natural frequency, will have severe effects. The end of three earthquakes on seismic frames were chosen for evaluation are as follows:
• Earthquake in 1357 AD. Tabas, Iran with maximum acceleration 915.39 cm squared second
• The 1356 earthquake. Naghan, Iran with maximum of 709.46 cm squared second Naghan

C) CBF + MRF System:

It also considered in two models; CBF1 and CBF2. In the first type system; braces designed to prevent buckling, but the second type system braces designed to stretch(Figure 4).

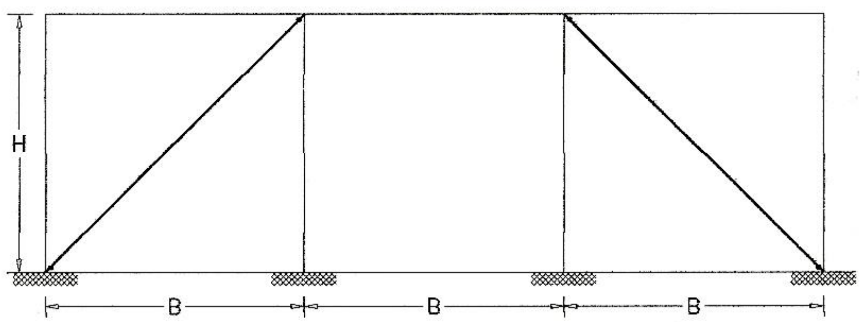

Figure 4. CBF + MRF System

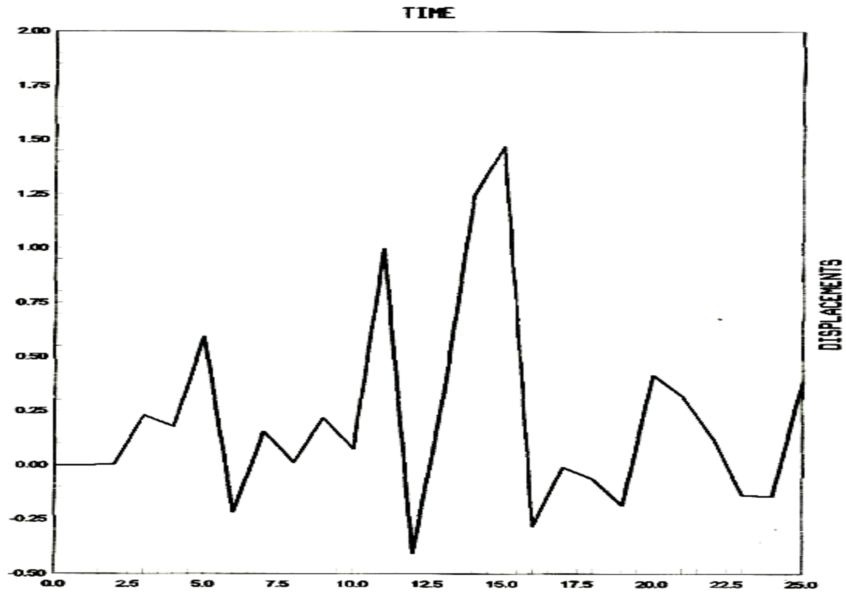

Figure 5. Graph of frame time-location with TKBF1 cross and knee brace by Tabas earthquake (s-m)

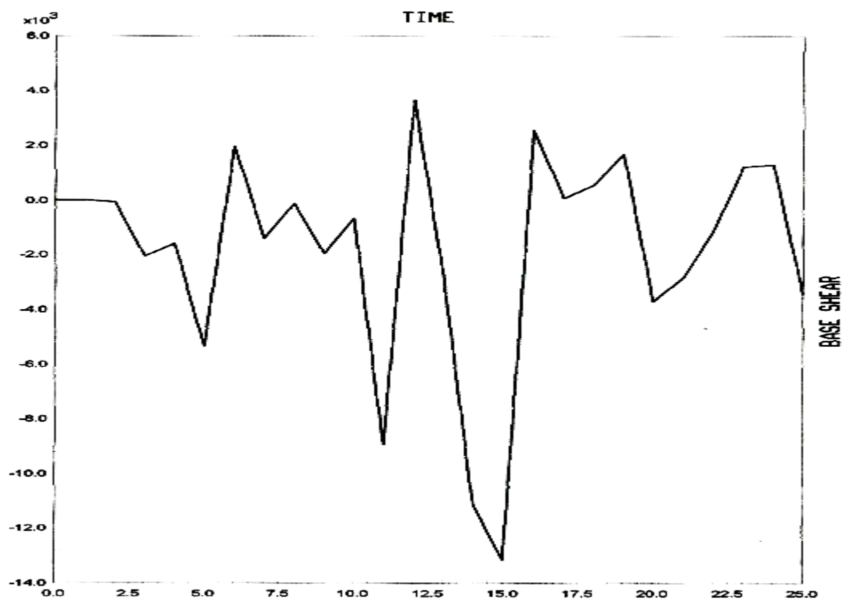

Figure 6.Graph of frame time-base shear with TKBF1 cross and knee brace by Tabas earthquake (S-T)

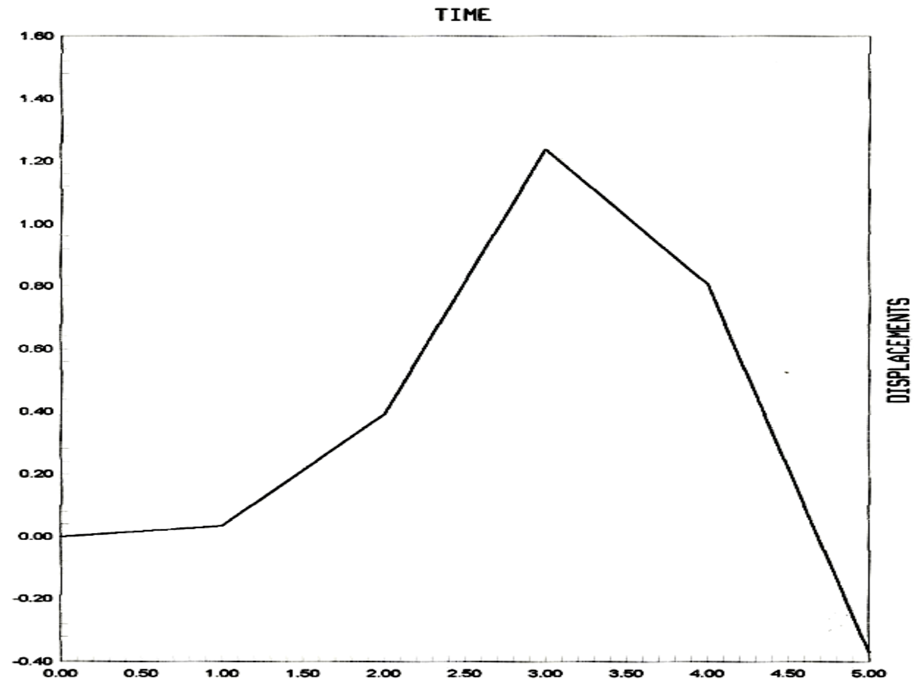

Figure 7.Graph of frame displacement-time with TKBF1 cross and knee bracing under Naghan earthquake (s-m)

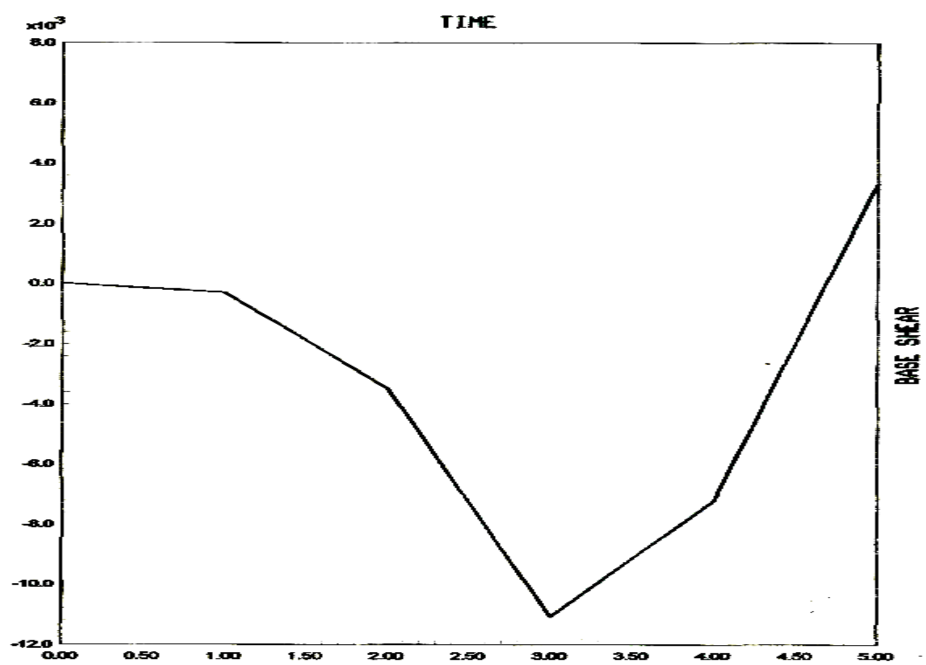

Figure 8. Frame time-base shear with TKBF1 cross and knee bracing under Naghan earthquake (S-T)

5. Conclusion

Following results were obtained by performing static analysis on the studying models:

A) The comparison of roofs' lateral displacement have shown that lateral displacement of all models are in the regulations. The amount of lateral displacement of systems with TKBF cross and knee bracing are in the amount of models EBF2, CBF1 **(**2.6M_p/V_p**)** lateral displacement, respectively. In models with TKBF cross and knee bracing; by increasing the ratio of b/B and h/H; the system lateral displacement increases.

B) Comparing the forces produced by the knee member, knee member graph force and bending moment increases by the increasing of ratio whereas shear force is reduced on the knee member.

C) To compare the internal forces generated in floor beam; bending moment increased in floor beam by the increasing of b/B and h/H ratio, but shear force decreases about 0.3 and then increases. Also the comparison of EBF model TKBF cross and knee braces together; floor beams in TKBF cross and knee braces, has smaller share of the shear and moment.

D) By comparing the compressive forces of diagonal members in different bracing systems; diagonal members of the EBF models attract the highest compressive force. The pressure forces in models with TKBF cross and knee bracing has the lowest amount among the other models. This implies that in models with TKBF cross and knee braces weaker braces can be used than EBF frames.

E) By comparing the sample columns internal forces, it has been observed that with increasing the ratio of b/B and h/H pressure force reduces, but the bending moment and shear force are increasing.

F) In general, of the static analysis can be concluded that internal forces in beams and columns of TKBF cross and knee braces are between models of EBF, CBF. However, the compressive force of brace is less than models EBF, CBF.

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