



# Evaluating the Effect of Column-Beam Joint Fixity in Eccentric Braced Frame (EBF)

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**Abstract:** Nowadays, the divergent braced system has become more common due to architectural problems, and using this type of system is growing. In this paper, it is tried to evaluate and compare one of the provisions of the tenth topic Regulations to be used for binding. Therefore, the effect of beam joint fixity rate was investigated in the amount of displacement, as well as design economy to reach a certain acceptable connector type. For this reason, a comparative method is used, and it has been tried to achieve a reasonable answer by modeling and analysis of buildings with similar design and type, but the fixity ratio of zero and one and comparing the results. PERFORM-3D software is used to perform modeling and analysis, and all of the above are done in accordance with 2800 Code and tenth topic Regulations.

**Keywords:** Divergent bracing, non-linear analysis, PERFORM -3D software

## Introduction

Bracing frames are one of the most common structural forms in designing frames. Generally, bracings are applied against lateral forces and axial forces in primary and secondary columns [1]. This case was first presented by Popov et al. [2] and the unique advantages of this system was recognized and the first building was built with this system in 1980. Bracings in this system are linked together by relatively short link beams to beam-column joints or other bracings. Link beams are yielded in the moment or shear and dissipates a lot of energy. If the length of the link beam is less than  $\frac{16 M_p}{V_p}$ , it is yielded in shear and if it is more than this value, it is yielded in the moment.  $M_p$  is the plastic moment capacity and  $V_p$  is the plastic shear capacity of the link beam. Bracings in EBF system should be designed for 5.1 times more than brace force to prevent buckling and yielding. "If the connection piece is not adjacent the column [4], beam-column connections can be designed in pinned mode in the web sheet. Such connection must be able to withstand 0.01F<sub>y</sub>b<sub>t</sub>f<sub>d</sub> torsional moment." In the above paragraph, the designer is free to design this connection in pinned mode or fixed and there is no obligation in this regard. These two designs can obtain in terms of displacement, consumption profiles, and design economy. Thus, it seems that the type of connection and their advantages and disadvantages can improve the design and design economy. In this paper, it is tried to examine the advantages and disadvantages of each of the above connections [5].

## Overview

To do this research by a comparative method, three types of 5-storey building, 9-storey building, and 16-storey building have been considered in joint and fixed mode. The buildings are put under loading and then, they were analyzed and designed to conclude from the obtained answers in a comparative mode. Loading in these buildings has been done according to national building regulations, sixth issue, loads on buildings, and their analyzing has been performed based on National Building Regulations, Section tenth, Design and Construction of Steel Construction and regulations for the seismic design of buildings (2800 code) edition 3. The applied software is PERFORM- 3D. These structures were analyzed and designed by this software. Finally, the results were obtained in the form of displacement for each of structures. In addition, the chart of these displacements was given as a linear graph for an easier comparison. These displacements represent the

ductility and energy absorption in each of semi-type structures. Therefore, the suitability of any of structures can be determined using these charts. It should be noted that these displacements are the maximum displacement derived from combinations of loads in both x, y directions, which is given for comparison.

**Profile of buildings**

Three types of 5-storey building, 9-storey building, and 16-storey building have been selected to evaluate and compare the fixed connections in two pinned and fixed connections under gravity. The connection of these structures is in the fixed mode in the span bracings in both directions with full percentage of fixity. The rest of the connections are in pinned mode (other than braced media). Column connections are pinned in all directions. The area of the five-storey building is 277.5m<sup>2</sup> in each floor with the total height of 15m and the parking height of 2.60m. The height of other floors is 3.10. The area of the nine-storey building is 423m<sup>2</sup> in each floor with the total height of 27.40m and the parking height of .60m. The height of other floors is 3.10. The area of the sixteen-storey building is 4235m<sup>2</sup> in each floor with the total height of 27.40m and the parking height of .60m. The height of other floors is 3.10.

Table 1. Profile of materials

E (kg/cm <sup>2</sup> )	F <sub>y</sub> (kg/cm <sup>2</sup> )	F <sub>u</sub> (kg/cm <sup>2</sup> )
2.1*10 <sup>6</sup>	2400	3600

Table 2. Summary of the gravity loading on the building

Location	Dead load (kg/cm <sup>2</sup> ), (kg/m)	Live load (kg/cm <sup>2</sup> )
Floor Floors	600	200
Roof Floors	150	200
Staircase Floors	600	350
Side walls without openings	800	---
Side walls with openings	650	----

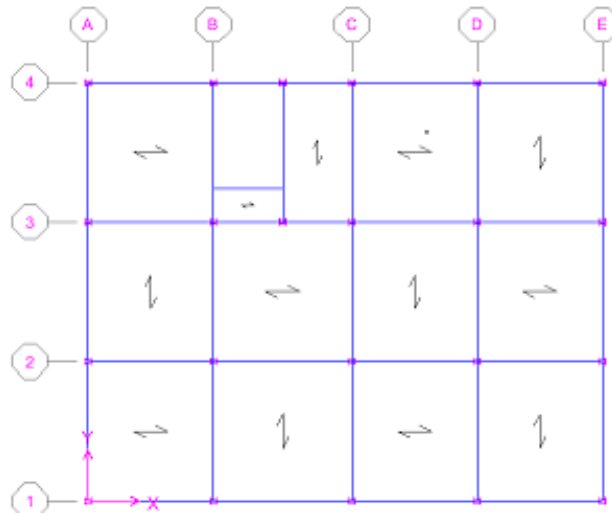


Figure 1. 5-storey building plan

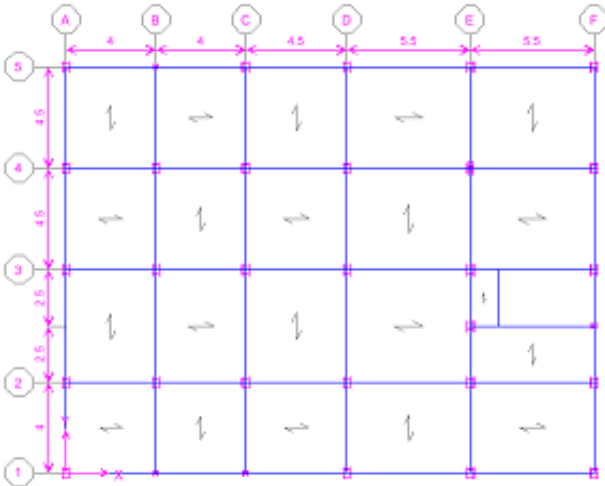


Figure 2. 9-storey building plan

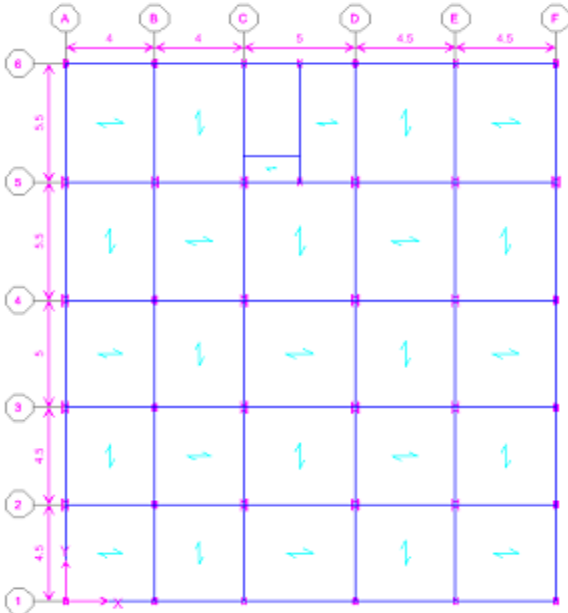


Figure 3. 16-storey building plan

**Results**

The applied software for analyzing and designing is PERFORM- 3D. The results are given in the form of displacements for each of the structures. In addition, the related graph for these displacements is presented as a linear graph for an easier comparison. According to Figure 4 and 5, it is clear that in the five-story structure, the displacements in fixed mode is more than the pinned mode, but whatever the building is taller, but whatever the building is taller the amount of fixed displacements becomes less than pinned displacements.

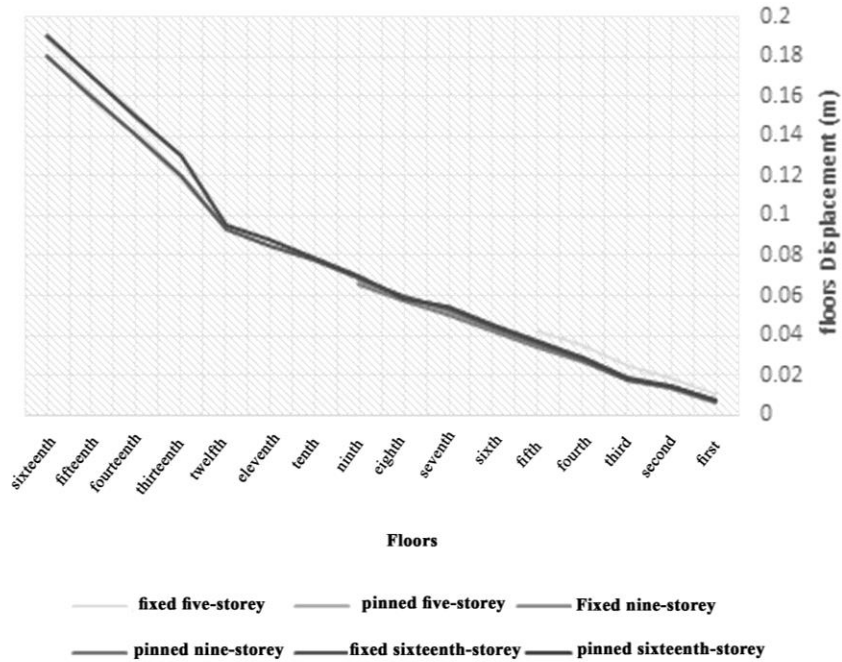


Figure 4. Displacement graph for X direction

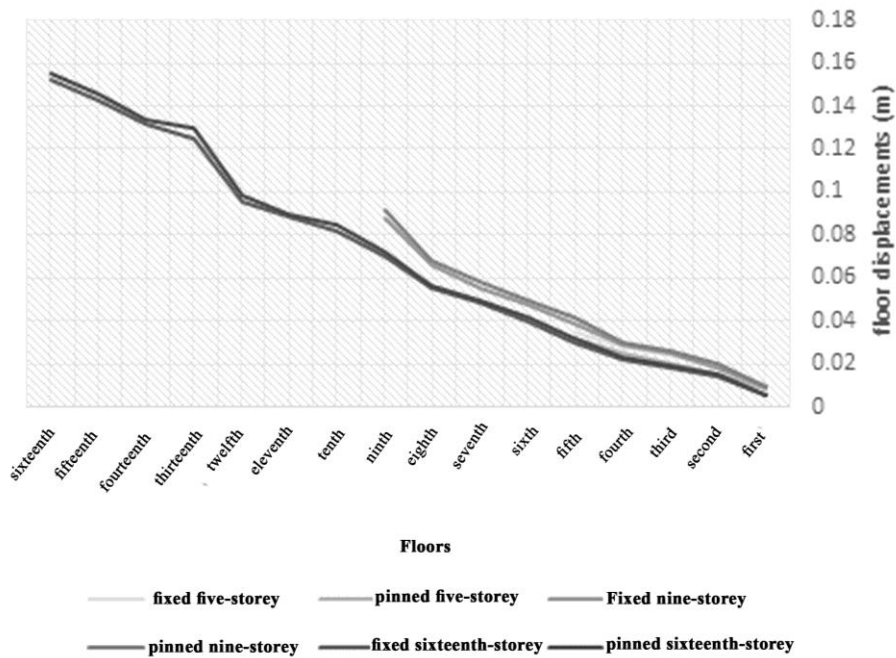


Figure 5. Displacement graph for Y direction

According to Figure 6 it is clear that in all three buildings, the steel weight in pinned connection is 3 to 7% more than fixed connections, which naturally increases the current cost.

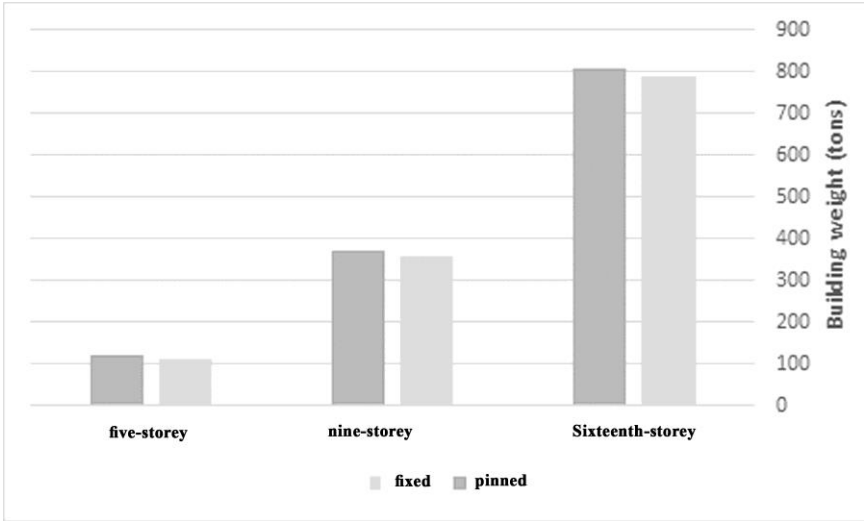


Figure 6. Comparing the weight of buildings in two pinned and fixed modes

One of the most important factors in comparing the performance of two types of building is comparing the base shearing in two modes. According to Figure 7, it is clear that the shearing force to the pinned connection structures is more than fixed connection ones. Since, the fixed connection amortizes the input energy rotation, thus it can be claimed that the buildings' stability with fixed connection is more than pinned ones.

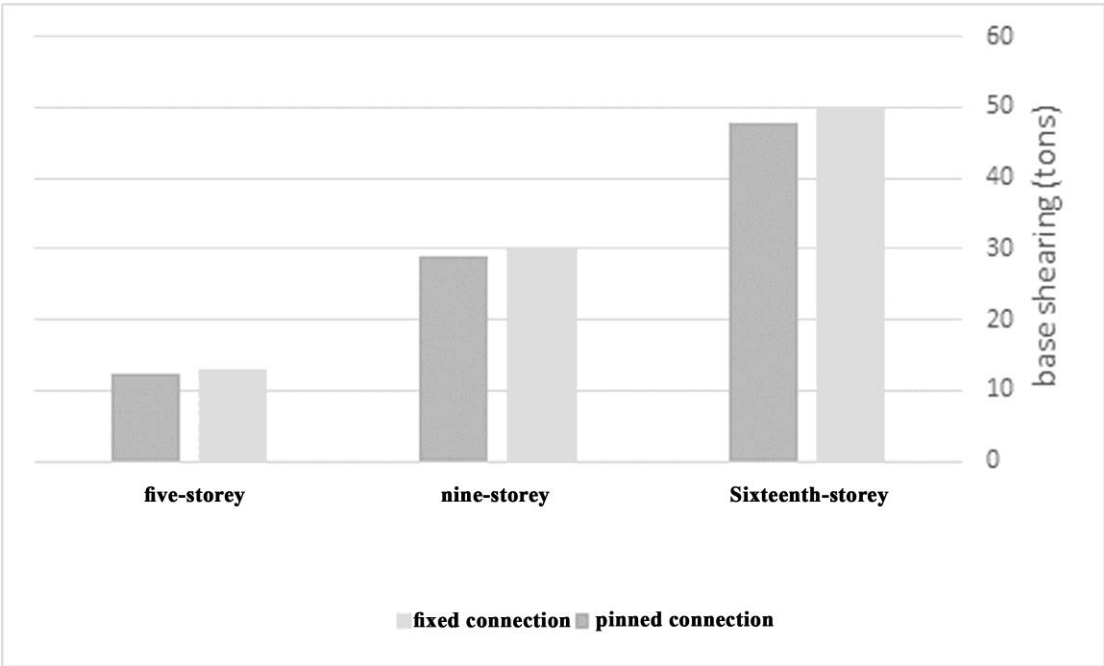


Figure 7. Comparing the basic shearing of buildings in two pinned and fixed modes

**Conclusion**

According to results and charts, the following results can be examined for the displacement and rotation of connections in different directions.

- The obtained displacements for pinned connections are more than the simple connection.
- The fixed connection displacements in short structures are more than pinned connection.
- The basic shearing of the pinned connection in all structures is more than fixed ones.
- The buildings' weight with fixed connections is 3 to 7% more than pinned ones.

#### **References**

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