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Evaluation of the Effect of Connection Stiffness on the Failure Probability of Zipper Bracing Frames under the Near- and Far-Fault Earthquakes, Performance Levels Approach

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ABSTRACT: Vertical elements between the beams can be used to control the failure of the chevron braces due to the post-buckling behavior. Zipper bracing is a new bracing system which expected to recover chevron bracing defects. By applying the vertical element to the chevron bracing and converting it to a zipper frame, it improves frame resistance, ductility and energy absorption. In this thesis, the seismic behavior of zipper brace frames is investigated for different percentages of beam-to-column connection stiffness under near- and far-field earthquakes. For this purpose, two types of pre-designed 4 and 8-story steel frame with 0, 25, 75 and 100 stiffness percentages are analyzed using the IDA method in OpenSEES. Finally, the fragility curves are compared at 4 performance levels. According to the results obtained from IDA analysis and the fragility curves, the effect of different stiffness percentages under near-fault earthquakes is more noticeable than far-fault earthquakes, which decreases the percentage of structural collapse by articulation the retention and articulation of joints. This probability also depends on the height of the frame. On the other hand, it can be obtained that the rigidity of the connections does not significantly change the structural capacity and performance levels.

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1- Introduction

In this paper, 4 and 8-story frames are examined. The number and length of bays for all frames are assumed to be 3 bays of 5 meters. These frames are designed based on the 4th edition of Standard 2800 [1], using ETABS2019 software [2]. After obtaining the optimal design sections for structural members, the frames were transferred to OpenSEES software [3] to produce nonlinear models. Assuming 3 different types, changes in the difficulty of connecting new models are developed.

In one case, the stiffness of the connection is completely rigid, and in the other two cases, the value is examined by changing this value. Finally, using IDA analysis and analysis results, 14 different records of previous earthquakes were recorded, including 7 far earthquakes and 7 near-fault earthquakes. The output data of the analyzes, including relative displacement, drift between stories, acceleration and velocity in were compared to examine and plot the output profiles and fragility curves.

2- Material and Method

The Hasuz_MH MR5 instruction [4] has been used to determine the performance levels. According to the Hasuz instruction, for a braced steel bending frame with 4 and 8 layers, the type of frame in the table is called S1M (long frame) and S1H, respectively. Given that the performance level proposed in the Hezuz instruction [4] is independent of the degree of flexure of the flexural frame, the beam-to-column connections are intended to be clamped.

For IDA analysis, 7 distant earthquake records and 7 near-fault earthquake records were used. In order to obtain the values of spectral acceleration corresponding to the period of rotation of the first mode of the structure, first the elastic spectrum of the selected records is plotted. To do this, the analytical frequency calculated by ETABS software [2] has been used.

3- Results and Discussion

One of the goals set in the research is to answer the question for a group of earthquakes with similar content (far or near the fault), what effect will the change in stiffness have on the probability of exceeding a certain performance level? This is possible by drawing fragility curves corresponding to different functional levels and different degrees of rigidity.

Figure 1 shows the fragility curves of 4 and 8-story structures for different performance levels and different percentages of stiffness due to earthquakes far from the fault, and Figure 2 shows the same category of curves due to near-

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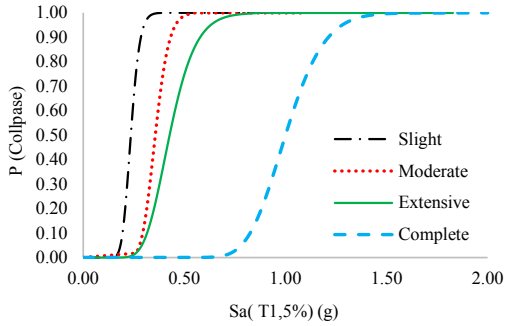

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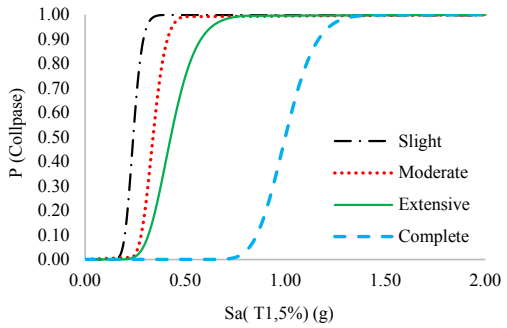

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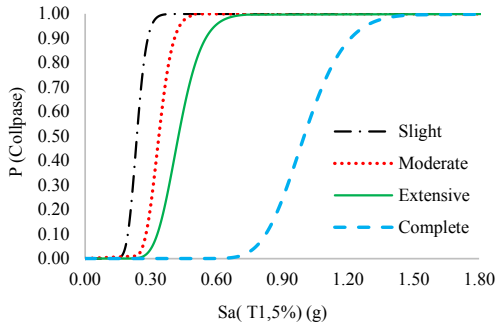

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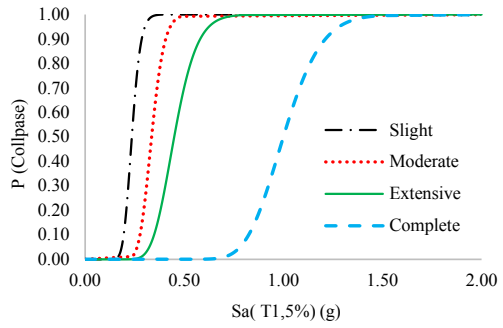

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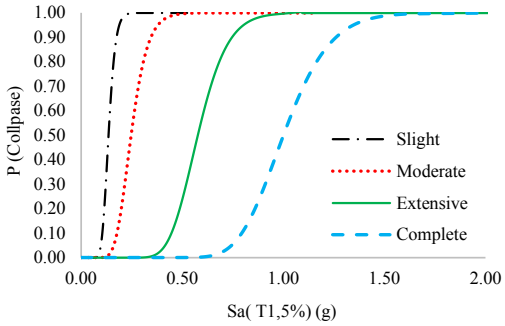
Fig. 1. Category of fragility curves of 4 and 8-story structures for different performance levels and different percentages of rigidity – far field



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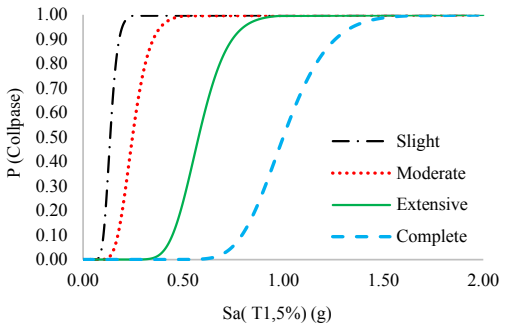

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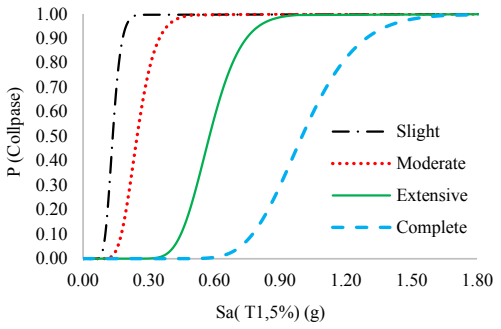

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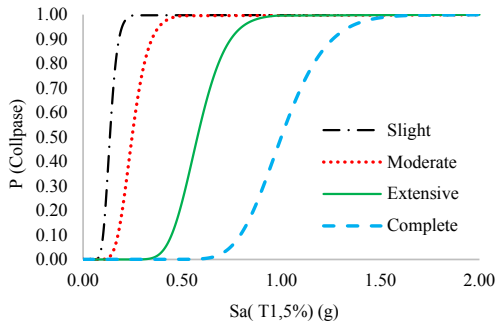

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Fig. 2. Category of fragility curves of 4 and 8-story structures for different performance levels and different percentages of rigidity – near field

fault earthquakes.

According to the results of the diagrams obtained in Figures 1 and 2, the effect of the capture percentage is zero percent less. Also, in the 8-story structure, the percentage of entanglement is 50% and 75% of the probability of failure is reduced, while in the 4-story model, it was not like this. In addition, it seems that the height of the structure has a significant effect on the results due to earthquakes near the fault. In this way, the probability of complete failure of the structure with trapped joints due to near-fault earthquakes is much lower compared to the articulated condition with increasing height compared to the articulated state.

4- Conclusion

The results showed that the effect of joint stiffness is more noticeable due to earthquakes far from the fault and compared to earthquakes near the fault, the percentage of probability of frames reaching functional levels is formed at lower spectral acceleration. Also, with increasing frame height, the effect of the percentage of joint stiffness on seismic responses increases. In short-range frames under earthquakes far from faults, the percentage of joint stiffness at low-performance levels has no effect on the results. However, due to earthquakes near the fault, the joint connection at the functional level of complete failure causes the possibility of the collapse of the structure with a lower percentage than the percentage of rigidity 25, 75 and 100.

References

[1] S. No, 2800 “Iranian Code of Practice for Seismic Resistant Design of Buildings”, Third Revision, Building and Housing Research Center, Tehran, (2005).

[2] V. Etabs, Ultimate, Integrated Software for Structural Analysis &Design, Computers and Structures Inc, (2016).

[3] F. McKenna, OpenSees: a framework for earthquake engineering simulation, Computing in Science & Engineering, 13(4) (2011) 58-66.

[4] F. HAZUS, Multi-Hazard Loss Estimation Methodology Earthquake Model: Technical Manual, Washington DC: NIST, (2003).

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