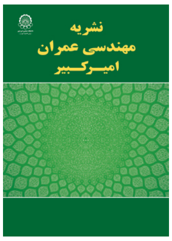

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Evaluation of Ductility Reduction Factor for X-braced Steel Frames Which are Braced in Two End spans

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ABSTRACT: In this study, the ductility reduction factor of Ordinary Concentrically Braced Frames (OCBFs) and special concentrically braced frames (SCBFs) which are braced concentrically in two end sides of frames, is evaluated. The results confirmed that, using SCBFs will reduce about 15 to 45 percent of total used material for one to 16 story frames respectively. In addition, for all of the 16 ordinary X-braced frames, which have 1 to 16 story height, calculated ductility reduction factor exceeds from ASCE7's proposed one, except for 16 stories frame. For studied frames, which are braced in two end sides, using the X-bracing system, the results confirmed that ductility demand is achievable without any significant problem. In addition, results indicated that although the response modification factor which is proposed by Iranian seismic design code (2800 standard), is more logical than ASCE7's one, for frames which are braced in the end sides, the response modification factor should be taken less than 5.5.

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1- Introduction

Ordinary concentrically braced frames (OCBFs) are one of the most ancient and famous structural systems which have been used widely by structural designers because of simple construction and economic considerations. OCBFs are paid special attentions in most of seismic design codes like ASCE7 [1] and AISC-341 [2]. Up to now there has been lots of studies about buckling of bracings during earthquake, and also over strength factor, ductility reduction factor and response modification factor of OCBFs. Because most of studies are based on previous versions of AISC-341 (before 2005), so these studies can't be referenced in this study.

In this study, first, the ductility reduction factor of OCBFs with X-bracing in two end spans are evaluated then the obtained ductility reduction factor is compared with demand ductility reduction factor. At the end of this study this main question is answered that whether or not the design of OCBFs with-bracing in two end spans can secure the expected ductility of seismic design codes, then according to the results of this study some recommendations are given for improving ductility of OCBFs with-bracing in two end spans.

2- Seismic design provisions

According to the mentioned designing codes, for seismic designing of beams, columns and X-bracings of OCBFs, there is no need for any complementary provisions. However for special concentrically braced frames, according to Iran's national building code (part 10, steel structures, 1392) designing strength of beams and columns should not be less than the following analysis: A) An analysis in which the force of bracings in tension is assumed to be $R_yF_yA_g$ and the force of bracings in compression is assumed to be $1.14\ F_{cre}A_g$.
B) An analysis in which the force of bracings in tension is assumed to be $R_yF_yA_g$ and the force of bracings in compression is assumed to be $0.3\times1.14\ F_{cre}A_g$, where: $R_yF_yA_g$ is expected force of bracing in tension, $1.14\ F_{cre}A_g$ is expected force of bracing in compression, A_g is the gross section of bracing member, R_y is the ratio of expected yield stress of steel to the minimum identified stress of steel, for considering required increase in strength, F_{cre} is the expected compression stress due to buckling which F_{ye} is used instead of F_y, F_{ye} is expected yield stress of steel and is equal to R_yF_y.

3- Studied frames in this research

In this study, for evaluating the ductility of X-braced frames which are braced in two end spans, 16 frames which are ordinary concentrically X-braced frames (OCBFs) and 16 special concentrically braced frames (SCBFs) are evaluated in this study.

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4- Results

4- 1- Ordinary concentrically X-braced frames which are braced in two end spans

According to the results of this study for 16 ordinary concentrically X-braced frames (OCBFs) which are braced in two end spans:

- The total amount of used materials for OCBFs with two end sides bracing is 15 to 45 percent more than SCBFs with two end side bracing for one to 16 story frames.
- For all of the 16 studied OCBFs, except 16 story frame, the ductility reduction factor is more than the ASCE7's ductility reduction factor (and no problem was found from ductility point of view.)
- The maximum height of OCBFs with bracing in two end sides, can be more than the ASCE7's proposed value, 35 foot (10.7 m).

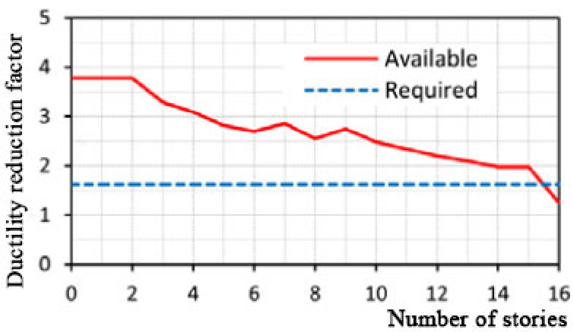

Figure 1: Comparing available ductility reduction factor with required ductility reduction factor (OCBFs)

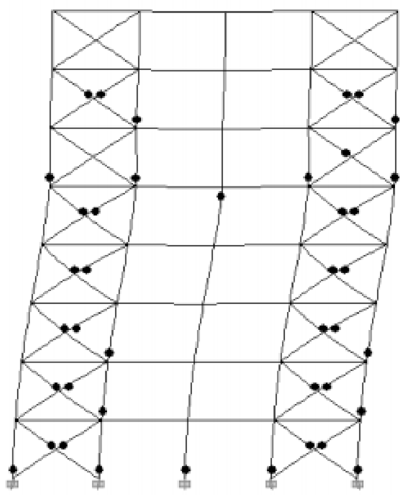

Figure 2: Collapse mechanism of X-braced OCBF, 8 stories

4- 2- Special concentrically X-braced frames which are braced in two end spans

According to the results of analysis, design and push over analysis of SCBFs:

- From used material point of view, one to 16 story SCBFs which are braced in two end spans are 15 to 45 percent more cost efficient than OCBFs.
- The response modification factor which is proposed in 4th edition of Iranian code of practice for seismic resistant design of buildings 2800 standard, is more logical the ASCE7's one.
- For SCBFs which are braced in two end spans the expected response modification factor can't be obtained and should be less than 5.5.
- According to the obtained capacity curves for SCBFs which are braced in two end spans, and also are more than 8 story height, the frames cannot experience the target displacement and reach to their mechanism before getting to target displacement. For this reason, the seismic design codes should be revised for SCBFs (Figures 3 and 4).

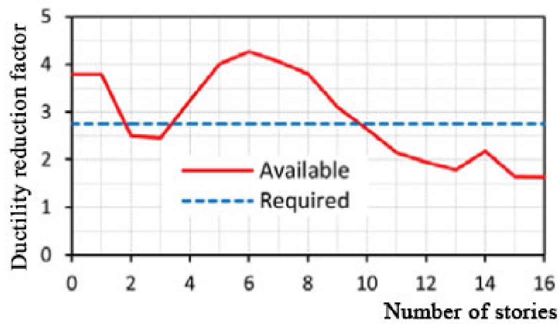

Figure 3: Comparing available ductility reduction factor with required ductility reduction factor (SCBFs)

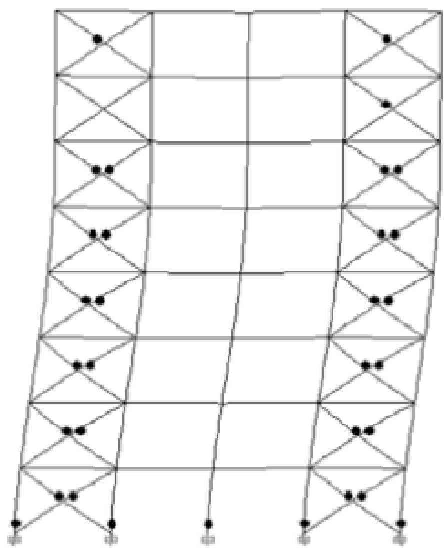

Figure 4: Collapse mechanism of X-braced SCBF, 8 stories

References

[1] American Society of Civil Engineers (ASCE7), Minimum Design Loads for Buildings and Other Structures, (2010).

[2] American Institute of steel construction (AISC-341), Seismic Provisions for Structural Steel Buildings, (2010).

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