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Seismic Performance Evaluation Of Momentresisting Steel Frames With Two Softwares

*Heba A. Fdiel[a] , Rabie A. Amnisi[b]
[a] Department Of Civil Engineering, High Institute For Eng. Professions Cyrene, Libya
[b] Department, Of Civil Engineering/University Of Omer AL-Mukhtar, Libya
*Corresponding author: hebaalzobair1981@gamil.com

Abstract Moment resisting steel frames (MRSF); which are widely used as lateral load Resisting systems for low- to medium-rise buildings; are one of the simplest ductile systems that can be built without bracing elements. The objective of this study is to evaluate the seismic behavior of a 6-story MRSF designed according to the Egyptian code using the DRAIN-2DX program and Siesmostruct program The 6-story office building is considered to have moment resisting steel frames (MRSF) in the perimeter of the short direction and braced steel frames in the perimeter of the long direction to carry the seismic loads. The focus of this study is to evaluate the seismic performances of the building MRSF using the two computer programs SeismoStruct and DRAIN-2DX. Seismic evaluation in this study has been carried out by static pushover analysis and time history earthquake analysis for nonlinear static analysis of building structures. The columns and beams are modeled using the inelastic force-based frame element type – FB. An inverted triangular lateral force distribution applied to the structural model in each step of the analysis. The evaluation is also performed by analyzing the building using nonlinear dynamic analysis. Ten earthquake records are used in the analysis to cover a wide range of ground motion duration and frequency content the element mass is assumed to be lumped at the joints and viscous damping is assumed 5%. The mean plus one standard deviation values of the roof-drift ratio, the maximum story drift ratio for the seismic performance evaluations. The results indicates that the performances under pushover static loading and nonlinear dynamic analysis indicated the same results in two programs.

Keywords: frame, lateral load, nonlinear dynamic, pushover analysis, seismic performance.

دراسة الاداء الزلزالي للإطارات الحديدية المقاومة للعزوم ومقارنة النتائج باستخدام برنامجين مختلفين

*ربيع أمبارك امنيسي[1] و هبه الزبير فضيل[2]
[1]قسم الهندسة المدنية–المعهد العالي للمهن الهندسية شحات، ليبيا
[2] قسم الهندسة المدنية–جامعة عمر المختار، ليبيا
*للمراسلة: hebaalzobair1981@gamil.com

الملخص الاطارات المقاومة للعزوم من الانظمة المهمة في مقاومة الحمل الجانبي في المباني المنخفضه أو متوسطه الارتفاع حيث تم في هذا البحث دراسة الاداء الزلزالي لمبنى هيكلي اداري مكون من 6 طوابق صمم بالكود المصري حيث تم تحليل واظهار النتائج باستخدام باستخدام برنامجين مختلفين حيث تم تعريض المبني لعدة احمال زلزاليه فى الاتجاه الطويل وعمل مقارنة بينهم في النتائج من خلال استخدام التحليل الاستاتيكي للحكم على الاطارات الحديدية عند تعرضها لأحمال جانبية المسلطه علي المبنى بشكل مثلثي والتحليل الديناميكي تحت تأثير عشرة زلازل مختلفة على المنشا مع توزيع كتل المبني بشكل مركز واستخدام معامل الاضمحلال 5% وحساب متوسط عشر زلازل عن طريق حساب الانحراف المعياري زائد 1 لكى نحصل علي نتائج أكثر دقه حيث ان عند حساب النسبة المئويه لازاحة المبني بالكامل واقصى ازاحة للدور الواحد تبين ان النتائج المعروضة اضهرت نفس الاداء فى الحالتين والنتائج كانت

الكلمات المفتاحية: الهيكل المعدني ،التحليل الاستاتيكي ، التحليل الديناميكي اللا خطي ،الحمل الجانبي ،الاداء الزلزالي.

1. Introduction

The main objective of seismic codes including the recent Egyptian code (ECP-201) [1] is to Achieve satisfactory performance of structural systems when subjected to earthquake loading. However, seismic design of building structures is usually conducted by Approximate procedures that rely on using elastic static analysis instead of the actual inelastic dynamic one. This highlights the importance of evaluating the actual dynamic inelastic performance of the code designed structures under the effect of real earthquake records .Such evaluation is essential To provide information on the level of protection afforded to the code designed structures against seismic loading. The Egyptian code provisions for the seismic design of MRSFs have been evaluated through parametric and comparative investigations using different analysis procedures and numerical models. The analysis has been conducted at either the structure-level or the beam-to-column connection level. Serror et al. [2] investigated how to define the boundary between special moment resisting frame and ordinary moment resisting frame in the ECP-201. The seismic provisions of ECP- 201 have been compared with those of the Euro-Code 8 and the Uniform Building Code with regard to ductility classes and their impact on the response modification factor. They suggested specifying a structure as special moment resisting frame means that its members should adhere to class 1 (compact width-to-thickness ratio) requirements; while specifying a structure as ordinary moment resisting frame means that using members of class 2 (non-compact/slender width-to thickness ratio) is permitted.

El-Shaer [3] evaluated the effect of earthquake on steel frames with partial rigid connection. The analysis was based on the nonlinear dynamic analysis considering both geometrical and material nonlinearities. The analysis demonstrated that the calculated displacement responses are close to those proposed by different seismic codes. Abdel Raheem [4] evaluated the Egyptian code.

Provisions for the seismic design of moment-resistant frame multi-story building through using nonlinear time history analysis, equivalent static load and response spectrum analysis methods. He found that diaphragm flexibility caused an increase in the fundamental period and in floor displacements compared with the case of rigid diaphragms of equivalent buildings. He concluded that the code empirical methods under-predict the fundamental period of structures with flexible diaphragms. He also concluded that the equivalent static force approach of the ECP-201 is not accurate as it overestimates the base she

2. BUILDING CONFIGURATION:

The prototype steel building considered in this study is a 6- story office building located in Cairo, Egypt with a design PGA(peak ground acceleration) of 0.15 g. The plan of the building, shown in Fig. 1, has a rectangular configuration with 5-bays in the short direction and 7-bays in the long direction. The bay width in both directions is constant and equals to 7.5 m. The story height is 4.5 m for the ground floor and 3.5 m for other floors with the total building height of 22.0 m. The floors consist of 10 cm light weight concrete slab over a composite metal deck. Structural members are selected from the American wide flange sections (W-sections). The usual structural steel specification for W-sections is ASTM A992.

3. STRUCTURAL MATERIALS:

The yield strength is 345 MPa, modulus of elasticity is 200 GPa, strain hardening ratio is 0.01, and the shear modulus is 81 GPa. The building is considered to have MRSFs in the perimeter of the short direction and braced steel frames in the perimeter of the long direction to carry the seismic loads. A typical perimeter MRSF in the short direction is shown in Fig. 2. The dead load is assumed equal to 5 kPa and it includes weights of deck, beams, girders, ceiling, partitions and mechanical and electrical systems. Surface weight of the exterior walls is considered equal to 1.25 kPa. The applied live load considered is taken 3 kPa for office buildings. The MRSF design has been performed in accordance with the Egyptian codes ECP-201 and ECP-205 [5]. The design internal forces are calculated by considering the critical combination of gravity and seismic or wind loading. The factor R is the response reduction factor and is equal to 7.0 for steel frames with adequate ductility. Beams and columns have been designed using the compact rolled sections. This has been accomplished by applying the code requirements for local buckling requirements of webs and flanges of cross sections. The code requirements for preventing the panel zone yielding and for the strong-column weak-beam design have also been applied.

The sizes of the columns and beams cross sections are summarized in Table 1.

4. COMPUTER PROGRAMS:

The frame was modeled using the SeismoStruct computer program [6] and DRAIN-2DX computer program [7]. Beams and columns are modeled

Using the force-based beam-column element that utilizes the fiber modeling approach to capture the spread of inelasticity along the member length. The member is subdivided into segments distributed along the member length, and the cross section of Seismic performance of steel frame. Is a general-purpose computer program for static and dynamic analysis of inelastic plane structures. In two programs, the structural masses are assumed to be lumped at the frame nodes and the damping effects are specified to be proportional to the mass and the initial elastic stiffness of the structure.

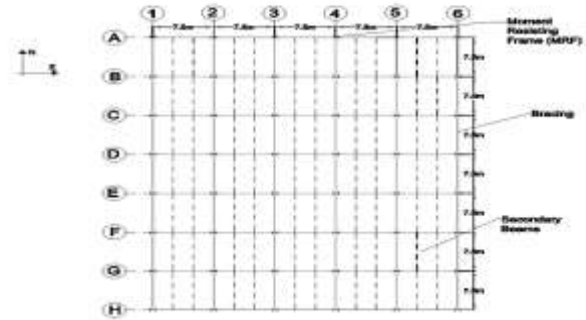

Fig. 1: Floor plan view of the steel office building

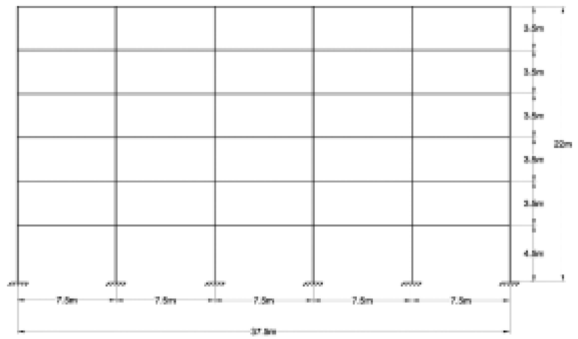

Fig.2 : Elevation view of the MRSF

Table.1 Cross section details of the MRSF design

Member sizes			
Story	Beams	Exterior column	Interior column
1	W30x116	W14x193	W14x311
2	W30x108	W14x159	W14x257
3	W30x 99	W14x132	W14x257
4	W27x 84	W14x120	W14x211
5	W21x 68	W14x109	W14x159

6	W21x 44	W14x 43	W14x109

5. NONLINEAR PUSHOVER STATIC ANALYSIS:

The results of the pushover analysis obtained using the SEISMOSTRUCT and DRAIN 2DX computer program provide information on the load-displacement relationships of the roof level and the various stories of the structure. The distributions of the story displacements obtained from the pushover analysis are very important in evaluating the overall ductility of the structure. Also, local deformations of the structure elements obtained from the pushover analysis are important in determining the critical elements in the structure. Pushover analysis is conducted up to 2% roof drift ratio using the lateral load distribution pattern specified in the Egyptian code. Gravity loads are applied on the frame during the pushover analysis and is considered equal to the dead loads plus half of the live loads. Fig. 3 shows the relationships between the base-shear coefficient and the roof drift ratios of the frame. The base-shear coefficient is defined as the base shear divided by the building weight. The results shown in Fig. 3 indicates that the base shear coefficient increases as the roof drift ratio of the building increases, and same the performances under pushover static loading in two cases.

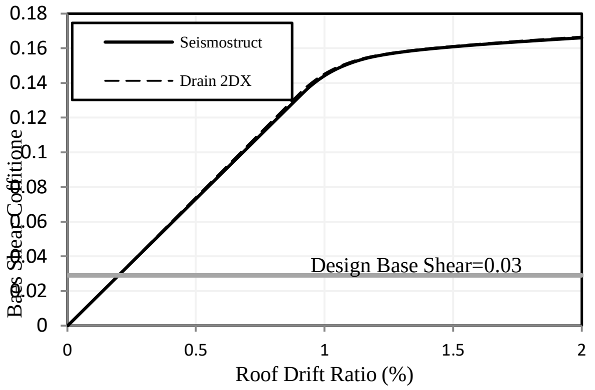

Fig. 3: Relationships between the base shear coefficient and the roof drift ratio

6. EARTHQUAKE RESPONSE OF THE MRSF

The earthquake analysis of the MRSFs is performed using a time step increment of 0.005 s and Rayleigh damping which is defined to achieve 5.0% viscous damping in the first The earthquake analysis of the MRSFs is performed using a time step increment of 0.005 s and Rayleigh damping which is defined to achieve 5.0% viscous damping in the first two natural modes of the building. Ten ground motions with different PGA (peak ground acceleration) levels are used in the analysis. The Earthquake data and site information for the selected ground motions records are presented in Table 2. The seismic performances of the investigated parameters which include the roof drift ratio, the maximum story drift ratio. The mean plus one standard deviation (M+ SD) values of the performance parameters are used as the basis for the seismic performance evaluations. Fig. 4 shows the relationships between the (M +SD) Roof drifts ratios and the PGA of the earthquakes. The roof drift ratio is the roof displacement divided by the building height. It represents an important parameter in determining the level of deformation of the frame due to lateral loading Fig. 5 shows the Represents an important parameter in determining the level of deformation of the frame due to lateral loading Fig. 5 shows the Relationships between the (M+SD) story drift ratios and the PGA of the earthquakes. The results in fig. 4, 5 indicate that the PGA of the Earthquakes increases as the roof drift ratio and story drift ratios of the building increases and the performances under inelastic earthquake analysis in two figures indicate the same result in two programs use.

Table.2 Earthquake data and site information for the selected ground motions

Record No	Event	Year	Record Station	Φ^1	M^{*2}	R^{*3} (km)	PGA (g)
1	Imperial Valley	1979	Cucapah	85	6.9	23.6	0.309
2	Loma Prieta	1989	Anderson Dam	270	6.9	21.4	0.244
3	Imperial Valley	1979	Chihuahua	282	6.5	28.7	0.254
4	Imperial Valley	1979	El Centro Array # 13	230	6.5	21.9	0.139
5	Imperial Valley	1979	El Centro Array # 13	140	6.5	21.9	0.117
6	Superstition Hill	1987	Wildlife Liquefaction Array	360	6.7	24.4	0.2
7	Loma Prieta	1989	Holister South & Pine	0	6.9	28.8	0.371
8	Superstition Hill	1987	Wildlife Liquefaction Array	90	6.5	24.4	0.18
9	Loma Prieta	1989	Sunnyvale Colton Ave	360	6.9	28.8	0.209
10	Loma Prieta	1989	Waho	90	6.9	16.9	0.638

The steps and process adopted to retrieve the results from the model have been presented in prototype frames and computer programs. These results have been prepared in Microsoft excel. Tables and graphs have been obtained from these data. The results will be discussed and compared to the Egyptian code with three peak ground accelerations.

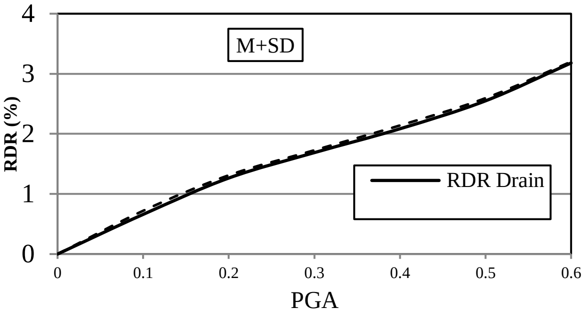

Fig. 4 : Relationship between the (M+SD) roof drift ratios and the PGA of the earthquakes

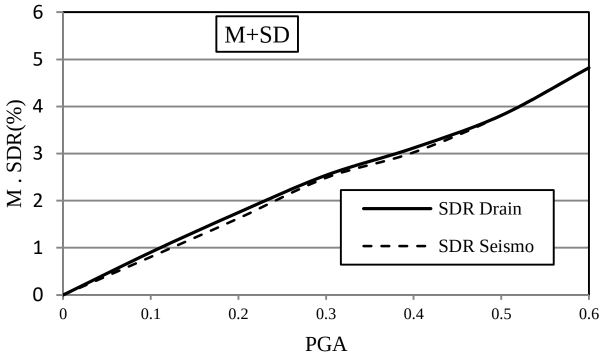

Fig. 5: Relationship between the (M+SD) story drift ratios and the PGA of the earthquakes

7. Conclusion

The feasibility of using two software programs to performance seismic steel building under different PGA was investigated, the following conclusions were made.

For structural system with more than 2 degrees of freedom, it is best to carry out the modal analysis using computer methods rather than the classical methods previously described. A commonly used computer method is the finite Element Method. The theory behind the finite element approach is method. All the major finite element code, such as DRAIN-2DX and Siesmostruct have the capacity to carry out modal analysis.

The allowed story drift limit of the frame increase as the strength and the initial stiffness of the moment resisting steel frame decrease.

Figure 4 present the equivalent (M+SD) roof drift ratios and the PGA of the earthquakes. the height-wise distribution of the (M+SD) story drift ratios along the heights of the six story frames at different PGA levels. There is a gradual increase in maximum applied the PGA of the earthquakes with increasing the (M+SD) story drift ratios. The curves in all the DRAIN-2DX program and Siesmostruct program a similar pattern with the behaviour of roof drift ratios.

The results presented in figures (5.) indicate that the story drift response increases with the increase in the allowable story drift limit of the frames. The curves in all the DRAIN-2DX program and Siesmostruct program a similar pattern with the behaviour of story drift ratios.

It is observed that the (M+SD) roof drift ratios in the Siesmostruct occur at almost the same time in DRAIN-2DX program and the graphs are seen to diverse on from that point. All the major finite element code, DRAIN-2DX and Siesmostruct have the capability to carry out model analyses.

References

[1]- ECP-201, Egyptian Code for Calculating Loads and Forces in Structural Work and Masonry, Housing and Building National Research Center, Ministry of Housing, Utilities and Urban Planning, Cairo, 2012.

[2]- M.H. Serror, M.M. Hassan, S.A. Mourad, Towards a boundary between special and ordinary steel moment resisting frames in the Egyptian code, in: Proc. of 14th European Conference on Earthquake Engineering, Paper 197, Ohrid, 2010.

[3]- M.A.A. El-Shaer, Effect of earthquake on steel frames with partial rigid connection, J. Eng. Sci., Assiut Univ. 40 (2) (2012) 343–352.

[4]- S. Abdel Raheem, Evaluation of Egyptian code provisions for seismic design of moment-resisting-frame multi-story buildings, Int. J. Adv. Struct. Eng. 5 (2013) 1–20.

[5]- ECP-205: Egyptian Code of Practice for Steel Construction, Load and Resistance Factor Design (LRFD), Housing and Building National Research Center, Ministry of Housing, Utilities and Urban Planning, Cairo, 2008.

[6]- SeismoStruct v7.0 – A Computer Program for Static and Dynamic Nonlinear Analysis of Framed Structures, 2014. <http://www.seismosoft.com>.

[7]- Prakash, V., and Powell, G.H., 1992. "DRAIN-2DX user guide" Department of Civil Engineering, University of California, Berkeley, California