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Evaluation of Seismic Performance of Simple Steel Frames with External Braces Axis with Viscous Damper

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Abstract

The present study was performed with the aim of evaluation of seismic performance of simple steel frames with external braces axis with viscous damper. Viscous dampers have the ability to absorb the earthquake's energy and supply the energy for resisting the movement of the structure. In the current study, we evaluate the seismic performance of frames with external braces axis under dynamic load in two states. In the early state a two-floor frame with the external braces axis (lack of viscous damper) in ABAQUS software was analyzed. The results were considered and compared to the outcomes of modeling in another frame with the same dimension and with the presence of viscous damper. The results indicate that by adding of the viscous damper to the structure the change of transferring rate during the time has reduced in the alignment of the first floor. In the hysteresis diagram of the structure, the function of the damper has been very effective in wasting of energy in seismic analyzing, so that if the internal area of the diagram increased then it absorbs more energy from the earthquake force. The rate of energy absorption causes 70% decreased in transferring of the structure in the direction of earthquake lateral force. The energy absorption rate by the damper is 70%.

Keywords: seismic function, simple steel frames, external braces axis, viscous damper

Introduction

From a long time ago, different systems were studied for resistance against lateral forces which enter to the structure, especially the earthquake forces; finally, some of these systems were recognized by the law. The related standards have expressed to design of them, among them, we can refer to bracing, shear wall, moment frame, dual or combinational system (Mohammadi and Ebrahimi, 2013). In fact, the energy dissipation systems can control the seismic vibrations in the structure by different forces. The correct control of vibrations leads to reduced respond of the structure transferring or acceleration against the earthquake lateral forces. The common method in seismic designing of the structure is an enhancement of resistance by absorbing the energy. Using the traditional methods and hardening of the structure cause absorption in a great level of acceleration. In an intensified earthquake, a building with non-structural components cannot tolerate the force and make damages even the foundation and main components are firm. This damage is not acceptable for the buildings which are made costly. Some important structures such as hospitals and fire stations require a reliable and secure designing method (Hwang, J. S., and Huang, Y., 2002). In general, the common methods in designing and analyzing of the buildings have this base that it has a bearing framework include steel or concrete frames, which carries the vertical loads. For horizontal forces like wind and earthquake we use the bracing and shear wall and similar systems. The braced frame is one of the common forms of implementing of the steel structures in Iran. The braced systems of structures against the earthquake may design in different methods. The function of each one of the braces depends on the especial circumstances (Farshchi et al, 2011). What we consider in this study is viscous damper which is one of the inactive means in wasting of energy. Viscous dampers are used for the first time in military and aerospace engineering for absorbing of the produced strike from the missiles or landing of an airplane. When these dampers for the first time were produced for developing usages, their technologies were completed, but at that time the dampers were used for protecting of missile silos from shockwaves (Behrosh et al, 2011). Therefore, our purpose in this study is an evaluation of seismic performance of steel frames with external braces axis with viscous damper.

Divergent or external braced frame (EBF)

This brace was proposed by professor Popov in Berkeley University for the first time in 1977. One of the most important profits of these braces is their high maneuverability in the architecture aspect. In this place, the brace components are not in the connection point of beam and column, and then it prevents from the complexity of connection point (Khan et al, 2015). In this system a part of the beam that is between the diameter and the column or between two braces is called link, it has the property that can transfer the braced forces by itself to a column or another diameter and finally enters the moderate forces to the brace. In fact, this link acts like a ductile fuse and it attracts most of the earthquake energy. Nowadays, using the eccentric braced frames for resistance against the earthquakes is noticed. The good ductile function of this system has a direct relation with a shear yield of link beam. So, in the designing procedure, determining of the optimized length of the link and providing of suitable hardening criteria for the beam is one of the essential points. As follows there are some important points in designing of eccentric braced frames:

1- The designing principle should be used as the basic designing of the frame. By this, we can be sure that dough or plastic hinges create in ductile link beam and not in a bracing, beams or columns which have less ductility.

2- For limiting of axial force in the beam avoid from bracing angles with a beam less than 30 degrees.

3- According to the junction of rigid connection of brace to the joiner beam, both the brace and beam should estimate based on firm criteria of beam-column (axial force in addition to the bending moment).

4- The function of the short link beams is better than the long links in the aspect of energy depreciation based on the maximum ductility. It seems by using this system between 15 to 50 percent of steel is reduced in comparison to ductile moment frames, the main cause of it is a reduction in changing the place (Bosco, 2014).

Though there are many advantages but each EBF system has weak points which the most important one is a lack of ability to change of link beam after an intensified earthquake. Because the link is a part of the main frame beam and its change is difficult. Furthermore, in order to activate the energy depreciation of shear links, the heavy diameter elements are required; these elements operate just in lateral intensified loads. The link elements are exposure to very complex states of tension-prostration because of their size and place; this matter causes more complexity of analyzing and designing procedure. Another subject is that the system in order to activate the shear links requires to rigid connections and we know these connections have some problems (Tafhim et al, 2013). Generally, in external bracing frames EBF, the diameter member connects to the bed beam. In the connection place of beam and column, a little eccentricity creates, and then the connector beam can tolerate the great ductility and acts like a ductile fuse (Hamrah, 2006).

The building and working method of viscous damper

The energy dampers are tools which are improvised on the structure and are kinds of passive systems that reduce the seismic respond of the structure by absorbing of earthquake energy. In the energy damper systems, the earthquake energy has been absorbed after entering the structure. These systems are divided into the related groups to transferring, related groups to speed and the other cases. The related tools to speed include viscoelastic and viscous dampers. The idea of using energy dampers in the structure in order to control of seismic vibrations was expressed in 1972 by Mr. Kelly's analyzing and laboratory studies (Takewaki et al, 2013). Nowadays, different materials are used for making waste of energy systems in the structures or dampers. These materials can be useful in increased hardening and resistance of the structures. The systems like dampers are used for achieving to some goals like reduction of possible destruction, diminution in collapsing of the structures and the related costs, reduction in the weight of the structures and also seismic rehabilitation of the buildings. The structure that has damper should be design optimizing in order to the justification of the damper using costs (Varzak et al, 2015).

One of the used dampers in the structure is a viscous damper. It has a steel piston with a bronze hole on the top. The cylinder fills with a glutinous fluid substance like silicone gel. The movement of the piston in this liquid encounters to the resistance. We can design the glutinous fluid damper that acts as pure energy damper or as a spring or as a combination of both of them. As you see in the figure (1) the glutinous fluid damper is similar to a shock absorber of a vehicle. The movement of the piston in the cylinder which has silicon liquid, causes absorption of kinetic energy and conveys it to thermal energy. Since in these kinds of dampers the damper force has been out of the entered tensions and the damper forces change very fast, then the damper reduces the created tensions and changes in the structure (Shamsi Zadegan and Ketabdari, 2008).

Figure 1 – Picture of a viscous damper (Malek and Hosseini, 2014)

The contrived holes in viscous dampers have the ability to design in a different range from damper functions. We can minimize the fluid viscosity changes in order to stabilize their function. In these kinds of dampers, the result is independent of temperature and the fluid type. In the place of coming out of piston from the cylinder in these dampers the dam is required for preventing of wasting of the fluid in the cylinder. This dam should have the ability to tolerate the high pressures and does not miss its efficiency during the time, and we should be careful in making it in order to guarantee its function (Pezeshki and ziaee far, 2010). If the viscous dampers design in a good manner they do not have permeation and they do not need to storage instrument of the external fluid for filling the damper by the fluid. As well as, in a viscous damper which is designed correctly, there is no thing for corrupting and no practical limitation in expiring time. It should be said that all of the materials in damper such as the fluid must be informal (Lee et al, 2001). This system has the prominent effect on the vibration control. This system has become a complete technology with inventing of dampers with a different structure, improving of modeling technics, progressing in new estimation methods, using dampers in designing of new buildings and resisting of the existing buildings. The study on the function of damper structure depends on the type of the damper and its formation. We can divide the damper sets into two classes: 1- The sets that are depend on speed 2- The sets that are depend on transferring. The viscous damper is one of the damper sets which depends on the speed (Saeedi and Vahdani, 2015).

Research method

Regarding the topic of the research, the purpose of this research is to analyze the function of the simple seismic steel frames with carrier output bracings with viscosity damper. On the basis of that, the method used in this research is stimulation and analysis using the limit component software ABAQUS.

In the present research, we analyze the seismic function of carrier output braced frame under dynamic load in two methods. In the first method, a two- floor frame with carrier output bracing (the absence of viscosity damper) in ABAQUS software will be modeled and analyzed. Then the results will be compared with the results of analyzing and modeling of another frame with the same measurements in which the viscosity damper is present. The height of each store will be determined 3 Meters and the length of the link beam will be determined 0.8 Meters.

The results of seismic analysis

The time- load chart has been defined as Fig 2.

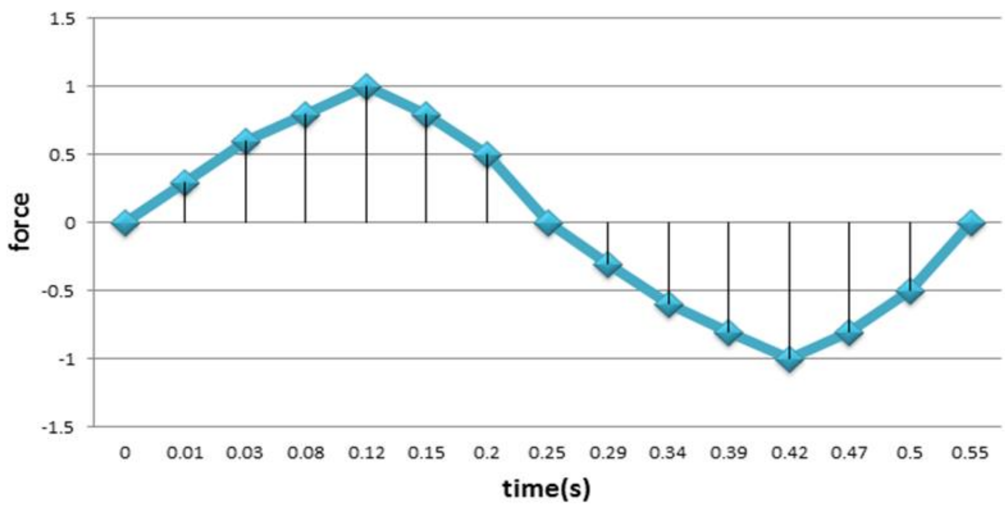


Fig 2 : the chart of load coefficients on the basis of time

In the graph of fig 2, the history of the load is stated on the basis of time. The increasing of the value of the side load to structure in a period of time and changing its direction and again increasing in the opposite direction is a causative factor of creating sinus graph. By imposing sinus load to the structure the movement of the defined point in justification of the first floor changes after analyzing the structure. The maximum values of the total movement in retrogression movement of the structure are +5E-4 and -5E-4, respectively. Also, the movement value of the structure is variable in small periods of time. The maximum values of movement in this method (structure without damper) are comparable with the structure equipped with damper.

After combining the movement chart, time chart, power chart, time of the power of chart, the change of place (hysteresis) is earned according to the graph 3.

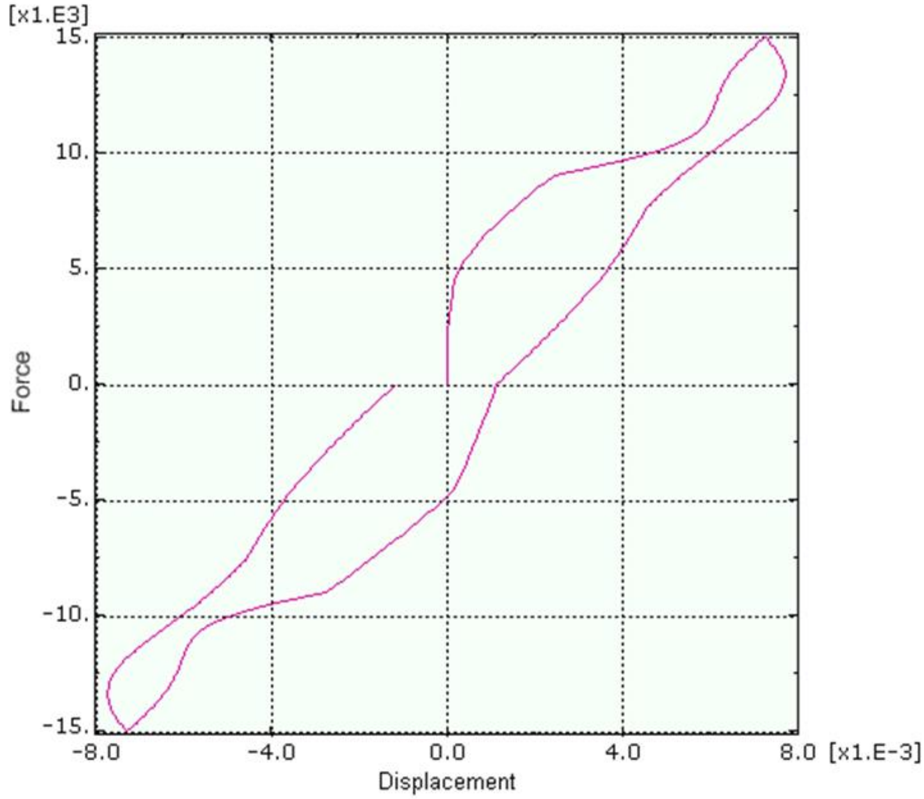


Fig 3: hysteresis chart of the structure without the presence of damper

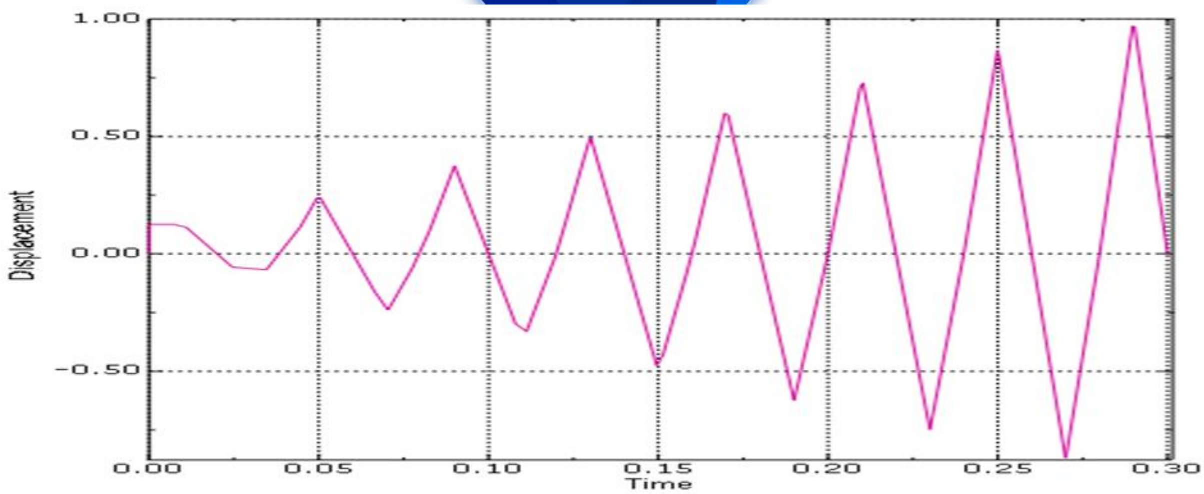
In the graph of fig 3, the value of the imposed power to the structure per movement has been drawn. As can be seen, the maximum value of movement is variable in the range orf +7E-3 to -7E-3 Meters and accordingly, the imposed power also varies in the range of +15W3N to -15E3N.

The results of the analysis of the second method with viscosity damper

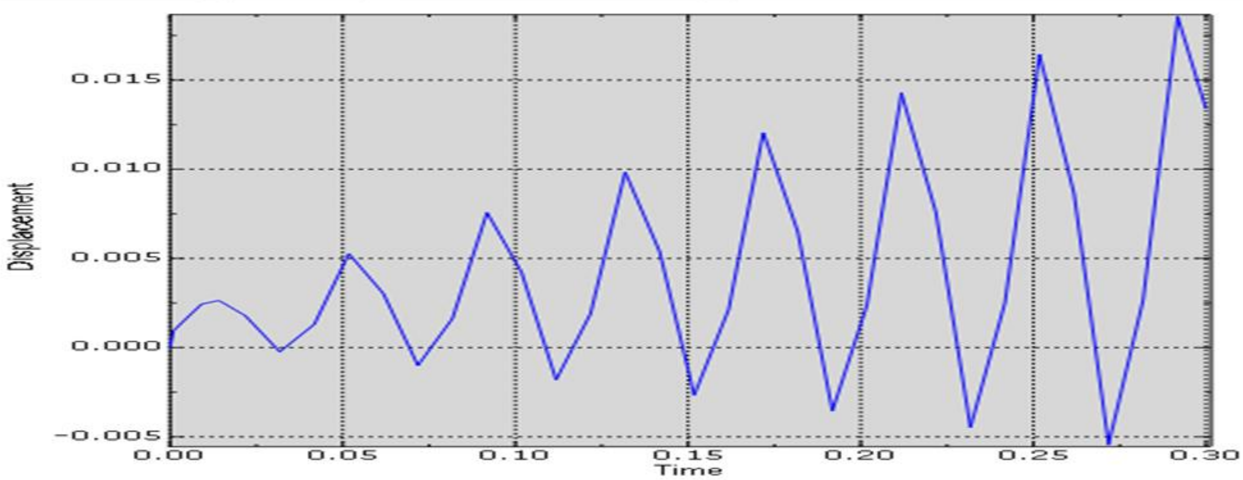
The maximum values of the total movement in retrogression movement of the structure are +7E-3 and -7E-3, respectively. In addition, the value of changes of the movements of the structure in small periods of time has also reduced compared with the method in which the structure was not equipped with damper. The values of the maximum movement in this method (structure equipped with damper) are comparable to the structure without a damper. Also, the effect of the damper in the simple metal frame has been effective in reducing the value of movement of the roof frame multiplied by 14. The maximum value of movement varies in the range of +0.55E-3 Meters to -0.55E-3 Meters, and accordingly, the value of the imposed power also varies in the range of +15E3N to -15E3N Meters. Regarding the fact that only one loading cycle of retrogression is imposed to the structure, the hysteresis chart also has one retrogression cycle. In fact, due to the utilizing damper, the value of extension of the chart has been reduced due to the increase of energy absorption by the damper and wasting the energy caused by the side power of the earthquake and the resistance of the structure against the side power of earthquake increases. Comparing this analysis, it could be said that the function of this damper in the waste of the energy of the structure has been quite effective. In other words, the portion of the structure equipped with the damper in absorbing the energy caused by the earthquake is more that the inside surface of the hysteresis chart is an indicator of the increase of energy absorption.

Modeling and seismic analysis of a five- floor building in two methods of equipped with damper and without damper

After modeling and analyzing the simple steel frame equipped with damper in previous sections and analyzing the effect of presence of a damper on the value of energy absorption and reducing the structure movement at the time of imposing seismic load and analyzing results, now we model and analyze the five- floor building with carrier output shaft in addition to the effect of damper and comparing it with the method of absence of damper. The steel building with five floors and two 5- meters crater is in accordance with the X-axis and a 5- meter crater in accordance with the Y- axis and the floor height of 3Metrers. In the first geometric model, the structure is considered without a damper and is analyzed under the side load vibration. In the second geometric model the same structure with the same measurements and stores and so on, but equipped with damper under the same seismic load is put and analyzed. The results in these two methods will be compared and analyzed. After drawing the first geometric model, we prepare and determine steel materials. In this model, we define the kind of level as IPE14 and specify it to elements. Then we assemble the model and form a unified model. The second geometric model is drawn with the insertion of the damper in the frames of the X axis. The properties of the damper are of the Translator kind and are modeled in all the stores. After modeling the buildings in two different methods, we will put them on the side seismic load of 15000 N that varies according to time under an increasing coefficient. After analyzing the two geometric model in the software, the results of the seismic analysis with and without damper in floor justification will be stated as follows. The value of roof justification after seismic analysis has been drawn in the chart of fig 4, in which fig A is for the structure equipped with damper and the fig B is belonging to the structure without a damper.



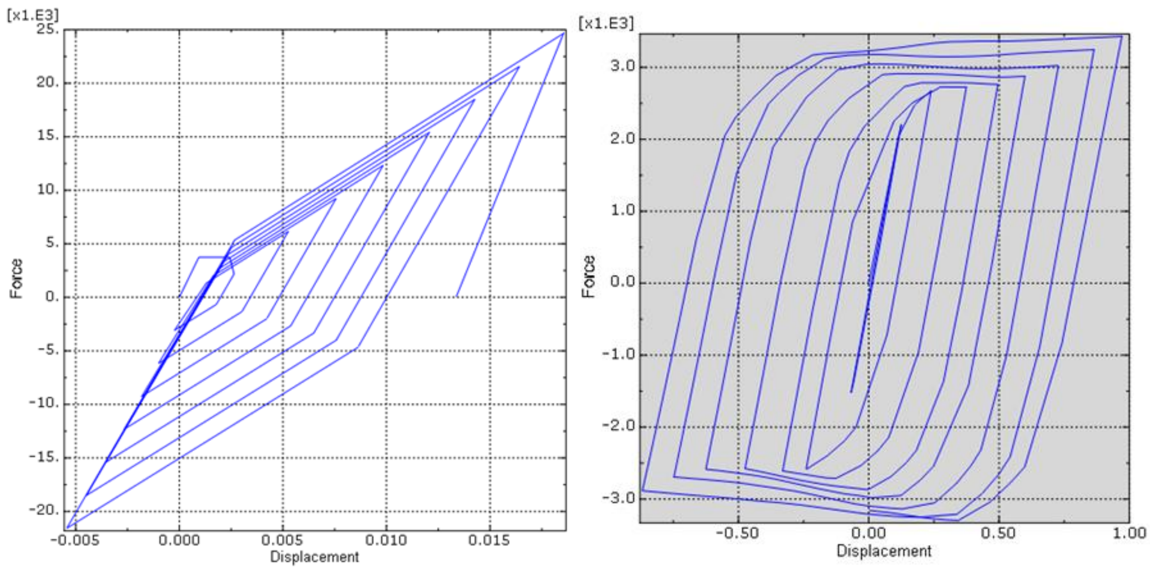
(B)



(A)

Fig 4: the chart of movement of roof justification based on time. A) building equipped with damper. B) building without a damper.

As can be seen in fig 4, the value of structure movement based on time has been drawn for both models. In this graph which has been gained after seismic analysis of the structure, the response of the structure regarding the increase of the value of imposing load to the model will be different. it is seen that in the structure without damper the maximum values of retrogression movement of the structure in times of 0.26 and 0.28 seconds are 0.86 and 0.97 Meters, respectively. On the other side, in the structure equipped with damper, part of the energy caused by the side power of earthquake is absorbed by damper and consequently, the value of the movement of the structure has been reduced, in such a way that the maximum of the value of the retrogression movement of the structure equipped with damper at the times of 0.27 and 0.29 seconds are 0.05 and 0.18 Metres, respectively. By combining the two charts of the power per time and movement per time, the power per movement chart (the hysteresis chart) has been earned (Figure5).



(A) (B)

Figure5: the hysteresis chart. A) structure equipped with damper. B) structure without a damper.

Regarding the chart, the effect of the presence of a damper on the value of the energy absorption by the structure is seen. By equipping the structure in floor justification with viscosity damper, the value of the movement has been reduced and the level of the hysteresis chart has been reduced. The reduction of the level of the hysteresis chart is an indicator of the increasing of the absorption of the side energy caused by the earthquake by the damper and therefore, the imposed power to the structure reduces. But in ordinary structure (without damper), the absorption of the total energy is through the main structure and therefore the hysteresis chart includes more surface and the value of the movement of the structure also increases. Also, the value of tension in both structures regardless of the positive or negative values of them has been drawn in Fig 6, that, by comparing the colorful contour and the stated values, the effect of the damper can be analytical. The maximum values of tensions in the structure equipped with damper are 1.79E7, while in the structure without a damper, this maximum amount reaches 6.01E7. The values of the maximum of tensions occur in the place of the connection of the beam with the column and the effect of the damper in reducing the number of tensions is significant.

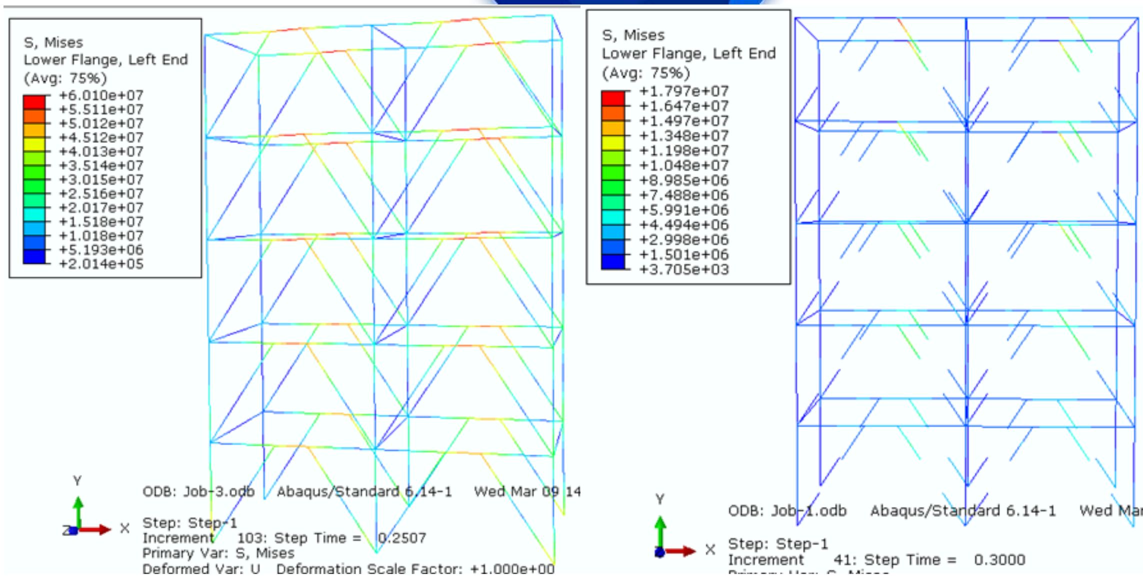


Fig 6: tensions A) structure equipped with damper. B) structure without damper

The obvious change in the value of tensions in both structures that have been the same in the fields of measurements and floors and one of them is equipped with the damper and the other one is not, has been analytical in fig 6.

It is inferred from fig 6 that in structure without damper the maximum tension has occurred in the link beam that with the presence of the damper the effect of the vibrating load on the structure significant reduction in the value of these tensions in the whole of the structure especially the place of the link beam can be seen. The value of the movement of the elements in both structures is in a way that by increasing the height in structure the value of the effect of the side powers on the value of the horizontal movement of the structure is efficient. In these structures, regarding the effect of the equal side powers, it can be seen that a number of movements affected by the presence of the damper have been differently reported. In fact, the effect of the damper in energy absorption and reducing the value of the imposed power to the structure and consequently, reducing the value of structure drifting in roof justification is analytical. The maximum of the value of the movement in the structure equipped with the damper in roof justification is 905E-2, and in the structure without a damper, this values reaches 1.7E-3. In the first geometric model, the structure is considered without a damper and is analyzed under the side vibrating load. In the second geometric model, the same structure with the same measurements and the same number of floors and so on, but equipped with damper is put under the same vibrating load and will be analyzed. the results in both methods will be compared and analyzed. Then, the solution method and load function per time in the form of a retrogression cycle with an increase in the domain within the time period of 0.3 seconds for each of the structures in upper roof justification will be defined and applied.

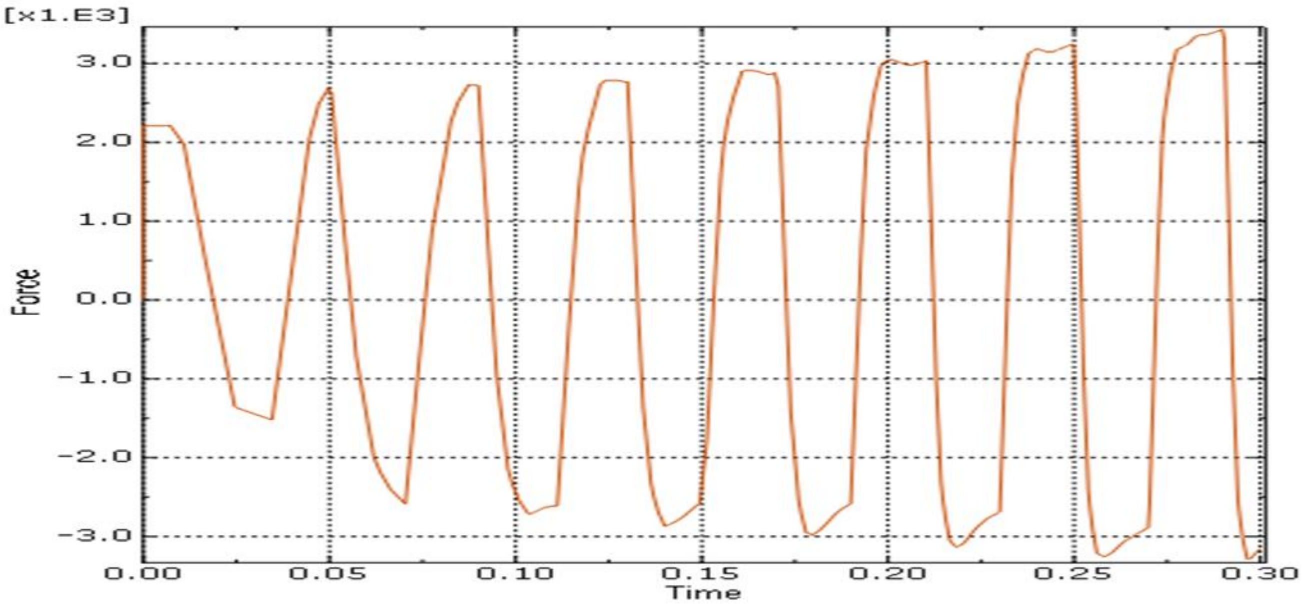


Figure 7: the load function per time during 0.3 seconds of time

Discussion

By inserting the viscosity damper to the structure, the number of its movement variables in a time period in justification of the first floor have been reduced.

In hysteresis chart of the structure, the function of this damper in the wasting of the energy of the structure has been so effective in seismic analysis in such a way that by increasing the inside geometry of the chart, it has absorbed more energy of the earthquake power.

Reducing the changes of movement of the floor justification under dynamic loading in the empowered frame with damper.

Reducing the changes of the basic cutting power under dynamic loading in the presence of the damper.

The reduction of the level of the hysteresis chart is an indicator of the increase of the energy absorption caused by the earthquake by the damper and therefore the imposed power to the structure reduces. While in the ordinary structure (without damper) the absorption of the total energy is through the main structure and hence, the hysteresis chart includes more surface and the amount of the movement of the structure will also increase.

Increasing the value of energy absorption cause a reduction of 70% in the movement of the structure in order to impose the side power of the earthquake. Also, the value of energy absorption by damper was earned 79%.

Conclusion

In this study, regarding the fact that the structures have undergone the retrogression load, so after the performance of the analysis by the ABAQUS software, different results including the power-movement chart (hysteresis) for the selective sample of the structure are accessible. As stated, in order to analyze the function of the structure ,the mode of number analysis has been totally modeled. After performing the number analysis by the ABAQUS software, it was seen that by imposing the retrogression loading to the structure, the tension will increase in link place by increasing the lateral displacement, and in some places, it has reached the surrounded condition. As another result, in the figure the movement power curve (hysteresis) on the basis of the number analytical studies with the aid of the limited element by the ABAQUS software, the chart first illustrated that by increasing the cyclic lateral displacement power, the tolerable cutting force increases by the structure. According to the results of modeling using the viscosity damper, the hysteresis curve earns more broadening indicating the more energy absorption compared to the structures without dampers. Also, the value of shaping, lateral resistance, and the change of final place is more.

Suggestions

Performing new ideas and plans in areas with an earthquake to reduce the imposed damages.

It is suggested that other researchers and experts in other fields of research and in their future plans, for increasing the effects of these dampers develop this method by modifying and changing its structure.

The analyzing of the results of this method compared to other proposed methods like a fluid damper and tuned mass damper also be dedicated to future studies so that students and researchers can include that in their own research programs.

It is also possible to analyze the use of other methods like the effect of arrangement and the manner of placing dampers in different areas of the structure on this issue and compare the results to the results of this research.

References

1- Khan, Z., Narayana, B. R., & Raza, S. A. (2015). EFFECT OF CONCENTRIC AND ECCENTRIC TYPE OF BRACINGS ON PERFORMANCE-BASED SEISMIC ANALYSIS OF RC BUILDING.

2- Bosco, M., Marino, E. M., & Rossi, P. P. (2014). Proposal of modifications to the design provisions of Eurocode 8 for buildings with split K eccentric braces. *Engineering Structures*, *61*, 209-223.

3- Tafheem, Z., & Khusru, S. (2013). Structural behavior of steel building with concentric and eccentric bracing: A comparative study. *international journal of civil and structural engineering*, *4*(1), 12.
4- Takewaki, I., Moustafa, A., & Fujita, K. (2013). Optimal Placement of Visco-Elastic Dampers and Supporting Members under Variable Critical Excitations. In *Improving the Earthquake Resilience of Buildings* (pp. 249-275). Springer London.
5- Walczak, J., Młyńczak, J., Burdzik, R., & Konieczny, Ł. (2015). 1655. Simulation of a visco-elastic damper based on the model of the vehicle shock absorber. *Journal of Vibroengineering*, *17*(4).
6- LEE, D. and TAYLOR, D.P. (2001),"Viscous Damper Development and Future Trends", International Journal of the Structural Design of Tall Buildings, 10,311-320 (WileyInterscience)

7- Hwang, J. S., & Huang, Y. (2002). Seismic design of structures with viscous dampers. International Training Programs for Seismic Design of Building Structures, 124-138.

8- Saidi, Asif, Vahdani, Reza, 2015. The vibrating efficiency of the steel bending frames with fluid viscosity damper system, the 10th international conference on civil engineering.

9- Malik, Amir Masoud, Hosseini, Mahmoud. 2014. The effect of flat viscosity dampers in the columnar power of columns, international monthly on building and roads.

10- Pezeshki, Hoseyn, Ziaeifar, Mansour. 2010. Developing a non- linear viscosity damper. Laboratory studies and determining the mechanical behavior characteristics. Iranian society of steel structures.

11- Shamsi Zadegan, Mehrdad, Ketabdari, Muhammad Javad. 2008. Inactive dampers and their usages in the improvement of dynamic behavior of Marine structures.

12- Behravesh, Aladdin, Armaghani, Arastou, Akbar Lou, Ahmad. Sadeqi Balkan, Vahid. 2011. Evaluating the effect of viscosity dampers in seismic function of structures. The 6th national conference on civil engineering.

13- Farshchi, Hamid Reza, Sarveqad Moqaddam, Abd al-Reza, Ahmadi Jazani, Ruhollah. 2011. Laboratory- analytical analysis of the effect of connection resistance in cross external braces. The scientific- research magazine of Omran Pajouhesh.

14- Muhammadi, Majid, Ebrahimi, Hamid, 2013. Comparing the weight of the consuming steel in different kinds of bending frames and two- sided system for short to medium buildings designed on the basis of Iranian regulations, research letter of earthquake engineering, 16th year, 2nd No.

15- Hamrah, Hamid, 2013. Analyzing the effective factors on behavior factor in simple steel frames with carrier output shaft, Master of Art thesis, University of Mazandaran.