Seismic Response of a Steel Building with Viscoelastic Damper with Different Configurations: A Case Study

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ABSTRACT

The viscoelastic damper represents a significant technological advancement in the field of energy dissipation, with the objective of mitigating vibrations in engineering structures that may be caused by seismic activity or wind. The damper is composed of steel plates and a viscoelastic material. In this study, the finite element program Extended Three-Dimensional Analysis of Building System (ETABS) was employed to create a three-dimensional numerical model of a steel building equipped with a viscoelastic damper. The study identifies the optimal location for the damper, assesses its performance under different configurations, and illustrates its efficacy. The findings indicated that the installation of the viscoelastic damper in a ten-story building resulted in a reduction in maximum displacement during seismic events. Furthermore, the study compared the performance of various damper types, including diagonal, chevron, and upper toggle friction dampers, at different levels of the building. The findings indicated that when positioned in the mid-story of the model, the upper toggle friction damper resulted in a 37% reduction in maximum displacement, thereby demonstrating its superior effectiveness in enhancing structural resilience.

Keywords-steel building; viscoelastic damper; configuration; ETABS

I. INTRODUCTION

In recent decades, the development of more adaptable mechanisms for the dissipation of seismic energy has become a pivotal area of research within the field of seismic engineering. In the event of seismic activity or an explosion, it is of great importance to implement measures that facilitate the effective dissipation of energy within structures. This is of critical importance in the mitigation of damage caused by erratic and powerful forces that exceed the structural elements' capacity to withstand stress. The recent seismic events have demonstrated that the inefficient absorption of energy by structures contributes to their poor performance. At present, a diverse range of manufactured dampers is available on the market. A diverse range of materials is employed to achieve varying degrees of rigidity and vibration reduction. Passive dampers are characterized by a straightforward design and do not rely on external energy sources. The former constitute a cost-effective solution that requires minimal maintenance. Consequently, passive dampers are an efficient and cost-effective solution for mitigating vibrations in structures [1, 2]. Dampers, which can serve as the primary means of dissipating energy, have recently gained popularity as a means of controlling the lateral movement of buildings. Control mechanisms frequently serve to enhance structural safety and functionality, while simultaneously preventing the collapse of a building during vibration [3-6]. The viscoelastic damper is a common passive damper that offers both stiffness and energy dissipation, even when subjected to minimal deformations. This renders it an optimal selection for structures that must withstand high winds or frequent seismic activity [7-10].

Authors in [11], examine the design and production of a viscoelastic damper manufactured from locally sourced natural rubber. The study involved the use of identical structures, comprising natural rubber dampers, to link two adjacent fifteen-story buildings. The research compares the efficacy of these natural rubber dampers in enhancing earthquake resilience to that of conventional viscoelastic dampers. A time-history analysis was conducted on the buildings, both with and without dampers, to assess their response to intense ground motions. Authors in [12] investigate the enhancement of performance in damaged Reinforced Concrete (RC) structures embedded with viscoelastic dampers. The study concentrates on evaluating the extent of damage and identifying the optimal location for the installation of the dampers. It employs a combination of experimental and numerical methods to evaluate the potential of viscoelastic dampers to enhance the seismic resilience of RC structures. The findings illustrate that the strategic installation of viscoelastic dampers markedly diminishes structural deterioration and augments the overall stability of structures during seismic events. Authors in [13] present a probabilistic analysis of the seismic impact on single-layer reticulated shell structures equipped with viscoelastic dampers. The authors concentrate on the identification of optimal damper locations for the management of seismic responses in these structures. The study employs probabilistic methods to evaluate the functionality and reliability of the shell structures under seismic loads. The findings indicate that the optimal placement of viscoelastic dampers markedly enhances seismic performance and mitigates the risk of structural failure. In contrast, authors in [14] put forth a design methodology for ascertaining the characteristics of viscoelastic dampers founded upon the elastic-plastic response reduction curve. The objective is to optimize the damping performance of viscoelastic dampers with a view to enhancing the seismic resilience of structures. By analyzing the elastic-plastic response reduction curve, the study presents a systematic approach for the selection of damper parameters that effectively reduce structural responses under seismic loads. The findings reveal that this approach can subsstantially enhance the efficacy and efficiency of viscoelastic dampers in mitigating earthquake-induced vibrations.

Authors in [15] present the development of a hybrid test system for 3D viscoelastic damping frame buildings, which employs combined programming in Matlab and OpenSees. The objective is to enhance the simulation and testing capabilities for the analysis of the seismic behavior of frame structures with viscoelastic dampers. The integration of Matlab's computational efficiency with OpenSees' robust simulation environment provides a comprehensive tool for evaluating the dynamic behavior of these structures. The results indicate that the hybrid system is an effective means of accurately modeling and assessing the seismic response, thereby offering valuable insights for the design and optimization of viscoelastic damping systems. In another study, [16], authors carried out an experimental investigation into the mechanical properties of a hybrid lead viscoelastic damper. A series of tests was conducted to evaluate the performance and effectiveness of the damper in damping structural vibrations. The study examines a range of mechanical properties, including stiffness, damping capacity, and energy dissipation characteristics under diverse loading conditions. The findings illustrate that the hybrid lead viscoelastic damper displays exemplary damping capabilities and fortifies the seismic resilience of structures, establishing it as a promising solution for vibration control in engineering applications.

Authors in [17] present a systematic approach to determine the optimal design for both dampers and their supporting components, with the objective of minimizing the target function of a linear multi-story structure. The structure was modeled using a shear building system and was subjected to resonance ground stimulation. The objective function is defined as the mean of the squares of the inter-story drifts. An analysis was conducted on a viscoelastic damper with frequency-dependent properties. Meanwhile, the authors in [18–19] oerformed analytical and experimental studies on the performance of the viscoelastic damper with different types of model steel and concrete. Previous numerical studies have predominantly employed a two-dimensional methodology to investigate the correlation between seismic response and damper configurations in buildings. Nevertheless, further research is required to gain a comprehensive understanding of this interaction. In this study, ETABS v21 was employed to develop a three-dimensional finite element model for the case study. The building and dampers were modeled, and a nonlinear time-history analysis was conducted. The analysis included the determination of the optimal damper location for three different configurations. The performance of each damper configuration was evaluated based on the mean of the maximum displacement and maximum acceleration of the model during the earthquake excitation. The objective of this research is to analyze the behavior of viscoelastic dampers under seismic loads and to gain insight into the seismic performance of different damper configurations. Additionally, it tries to enhance the understanding of viscoelastic damper behavior and configuration in seismic design. The findings of this study can inform the development of enhanced design principles.

II. MODEL GEOMETRY AND APPLIED LOADS

The model under investigation in this study is a steel-constructed building located in Basra, Iraq. It comprises a ten-story structure with six bays in the x-direction and four bays in the y-direction, as shown in Figure 1. The structure has an overall height of 36 meters. It was designed to withstand wind forces exclusively. The material used, is steel for the columns, primary beams, and secondary beams, as presented in Table I. Concrete was utilized for the slabs. The concrete exhibited a modulus of 21.718 MPa, a Poisson ratio of 0.17, and a density of 2400 kg/m³. The steel structure members have a Young's modulus of 205,000 MPa, a Poisson ratio of 0.3, and a density of 7,830 kg/m³. The dead load applied was 5.3 kN/m², inclusive of self-weight, floor finish material, concrete slab, movable partition, and roof construction, in accordance with the International Building Code 2021. The applied live load was 4 kN/m², as indicated in Table 1607.1 of the International Building Code (IBC) [20].

In order to ascertain the optimal placement of the damper, genetic algorithms were employed. The optimal placement of the damper was evaluated through a process of positioning it in sixteen distinct locations within the building. The initial set of dampers was installed on a single floor and designated as F1, F2, F3, F4, F5, F6, F7, F8, and F9. The second set involved the installation of the damper in two levels, specifically referred to as F12, F34, F56, and F78. The final installation involved the positioning of the damper in three distinct levels, specifically identified as F123, F456, and F789. Two dampers are installed on either side of the building. Figure 2 depicts the distribution of the dampers throughout the building.

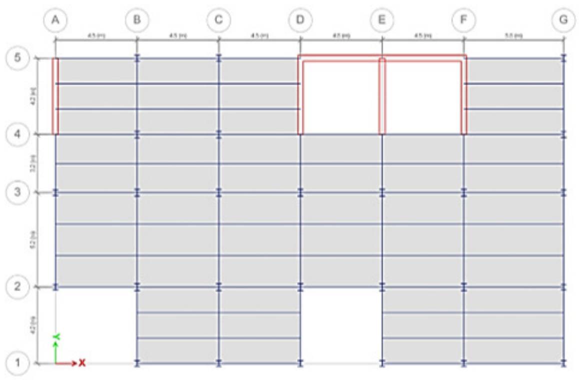

Fig. 1. Building plan.

TABLE I. BUILDING SECTIONS

	Exterior Column	Interior Column	*X*-direction Beams	*Y*-direction Beam
Story 1- 5.25 m	HEB 340	HEB400	IPE 220-IPE 270	H300×150×6.5-H396×199×7
Story 2- 4.45 m	HEB 340	HEB400	IPE 220-IPE 270	H300×150×6.5-H396×199×7
Story 3-9 3.4 m	HEA 340	HEA400	IPE 220-IPE 270	H300×150×6.5-H396×199×7
Story 10- 2.5 m	HEA 400	HEA 400	IPE 240	H300×150×6.5-H396×199×7

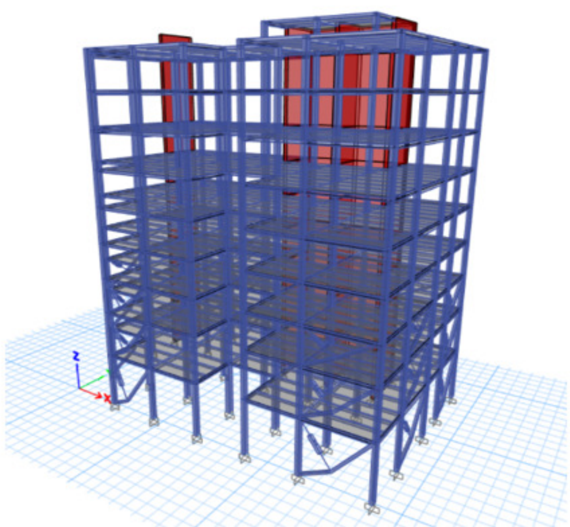

Fig. 2. Damper distribution through the building F123.

III. EARTHQUAKE RECORDS

Seven earthquakes were analyzed in this study. Five earthquakes were selected for the purpose of this investigation based on their historical significance and known effects on buildings similar to the one under investigation. The earthquakes considered were Ali Algarbi, Bam, El Centro, Izmit, Iraqi-Iranian border (Baquba), Kobe, and Northridge, as illustrated in Table II. The earthquake data were obtained from the U.S. Geological Survey (U.S.G.S.) and the International Monitoring System (I.M.O.S.) [21]. The precise location of a structure at the epicenter of an earthquake has a significant effect on the amount of earthquake damage it will encounter. Buildings located close to the epicenter suffer greater levels of shaking and ground acceleration than those located farther away. This results in greater and more widespread damage to the structure due to the powerful and rapid application of seismic forces. The selected earthquakes are known for their devastating effects on buildings

TABLE II. EARTHQUAKE DISCRIBTION

Earthquake	Year	Place	Magnitude (Richter)	PGA	Intensity (Mercalli)
Ali Algarbi	2012	Iraq	4.9	0.102g	V (Moderate)
Bam	2003	Iran	6.6	0.727g	IX (Violent)
Iraqi-Iranian border	2017	Iraq	7.3	0.098g	IX (Violent)
Northridge	1994	USA	6.69	0.635g	VII (Very strong)
Kobe	1995	Japan	6.9	0.483g	VIII (Severe)
El Centro	1940	USA	6.95	0.28g	VIII (Severe)
İzmit	1999	Turkey	7.6	0.282g	X (Extreme)

IV. CONFIGURATION OF VISCOELASTIC DAMPER

The passive control system deploys dampers within the structural framework. Passive control systems are a commonly employed technique in civil engineering, used to mitigate the effects of dynamic loads. In this investigation, the viscoelastic damper constitutes the passive control system employed. Viscoelastic dampers are a popular choice among structural engineers owing to their efficacy in dissipating energy and reducing vibrations, as observed in Figure 3. They function effectively across a broad spectrum of frequencies and temperatures, thereby conferring versatility for deployment in diverse environmental contexts. The installation and maintenance of these dampers is straightforward, regardless of whether they are being incorporated into new construction projects or retrofitting existing structures. Viscoelastic dampers are utilized in a variety of structural applications, including buildings and bridges to enhance earthquake resistance, tall buildings to mitigate wind-induced vibrations, and industrial facilities to isolate machinery vibrations. Furthermore, they are a crucial component in offshore structures, such as wind turbines and platforms, to accommodate the dynamic loads induced by waves and wind. The efficacy of these devices is corroborated by a substantial body of research, which demonstrates that they markedly enhance the functionality and longevity of structural systems.

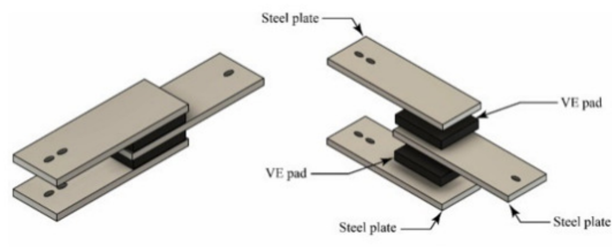

Fig. 3. Viscoelastic damper.

The use of viscoelastic dampers in buildings has been demonstrated to enhance seismic safety, mitigate sway in skyscrapers, and prolong the lifespan of bridges. These dampers have been proven to be a reliable solution in numerous studies. Viscoelastic materials demonstrate both viscous behavior, which entails the dissipation of energy through internal friction, and elastic behavior, which involves the storage and release of energy when the viscoelastic material is deformed. The damper was fixed in three configurations (diagonal, chevron, and upper toggle), as evidenced in Figure 4 [22].

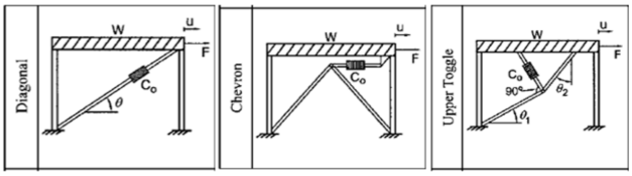

Fig. 4. Viscoelastic damper configuration.

The viscoelastic damper used in this study exhibits the following properties: a stiffness coefficient (K_d) of 1.29 × 10^6 N/m and a damping coefficient (C_d) of 7.8 × 10^6 Ns/m, which correspond to a model natural frequency of 0.827 cycles per second. These properties were calculated based on a double-layer viscoelastic material with dimensions of 1,850 mm by 400 mm. The material has a thickness of 10 mm. The shear storage modulus has a value of 872,000 Pa, while the shear loss modulus has a value of 1,240,000 Pa. All data were calculated using (1)-(4):

$$K_d = \frac{G'A}{t} \tag{1}$$

$$C_d = \frac{G''A}{\omega t} \tag{2}$$

$$G' = 16\,\omega^{0.51}\,\gamma^{-0.23}\,e^{\frac{72.46}{Temp}} \tag{3}$$

$$G'' = 18.5\,\omega^{0.51}\,\gamma^{-0.2}\,e^{\frac{73.89}{Temp}} \tag{4}$$

where K_d is the stiffness coefficient, C_d is the damping coefficient, G' is the shear storage modulus. G'' is the shear loss modulus, A is the shearing area of the viscoelastic material, t is the viscoelastic material thickness, ω is the loading frequency of the damper, and γ is the shear strain.

V. RESULTS AND DISCUSSION

A. Diagonal Viscoelastic Damper (DVED)

The baseline for all displacement reduction calculations was established by measuring the displacement of the building without any dampers. Figure 5 presents the percentage of reduction in the maximum joint displacement experienced by the model of the building embedded with a diagonal viscoelastic damper in nine different locations under seven excitations. The diagonal viscoelastic damper demonstrated remarkable performance in response to the Bam, Iraqi-Iranian border, and El Centro earthquakes. The efficiency of the damper when subjected to the Kobe and Izmit earthquakes was clearly inadequate. The optimal performance of the damper was observed in response to the Iraqi-Iranian border earthquake, with an average maximum joint displacement reduction of 15%. The maximum joint displacement reduction for the Bam and El Centro earthquakes was slightly lower, while the performance of the damper when subjected to the Ali Algarbi and Northridge earthquakes was also slightly lower. The maximum joint displacement reduction noted in response to the Kobe earthquake exhibited an unfavorable increase in the maximum joint displacement.

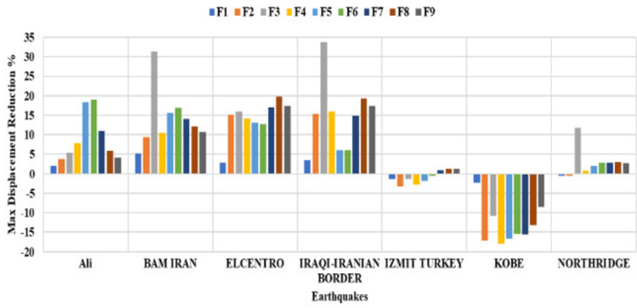

Fig. 5. DVED located in one story for different earthquakes.

Figure 6 shows the maximum joint displacement reduction results for the same structure in terms of damper location. The optimal placement for the damper was identified as being within the third story. The maximum displacement reduction when the damper is located in the third story is 32%, with 34% observed for Bam and Iraqi-Iranian. Figure 7 displays the maximum joint displacement reduction for a structure equipped with a viscoelastic damper, situated in two stories with disparate locations. As anticipated, the results demonstrated an enhancement in the maximum joint displacement reduction of the structure. The highest average maximum joint displacement reduction of 21% was obtained when the structure was subjected to the Bam earthquake, while the lowest maximum joint displacement of 2% was observed when the Izmit earthquake was used as a stimulus. These findings align with those of the previous case study, which involved placing the damper in a single story. The maximum joint displacement for Kobe exhibited an inverse relationship with the maximum joint displacement, resulting in an unfavorable increase.

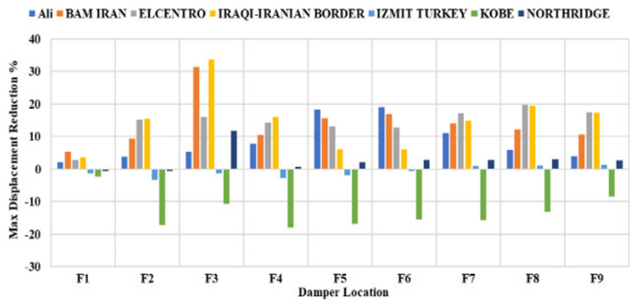

Fig. 6. DVED located in one story for different damper location.

Figure 8 portrays the maximum reduction in joint displacement as a function of damper placement. The optimal performance of the viscoelastic damper was observed when it was situated in the mid-stories. The highest maximum joint displacement reduction of 27% was observed in the fifth and sixth stories, where the maximum story drift occurs. The results demonstrated a general alignment with expectations, exhibiting a notable reduction in maximum joint displacement of the structure. Nevertheless, a comparable response was observed in Figure 9 for the damper situated in a single story. The highest average maximum joint displacement reduction was evidenced in the Bam, Ali Algarbi, and Iraqi-Iranian border regions. The highest average reduction in maximum joint displacement was 29% and was noted when the structure was subjected to the effects of the Bam earthquake. In contrast, there is an increase in the maximum joint displacement for Kobe, which is an unfavorable outcome.

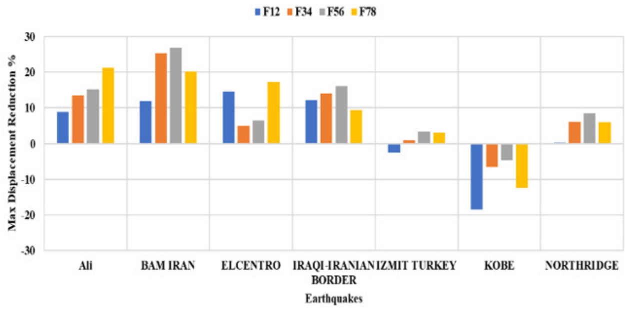

Fig. 7. DVED located in two stories for different earthquakes.

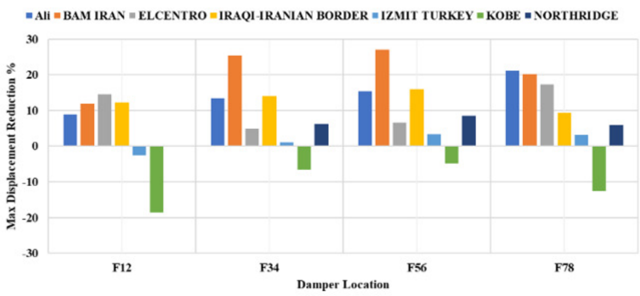

Fig. 8. DVED located in two stories for different damper location.

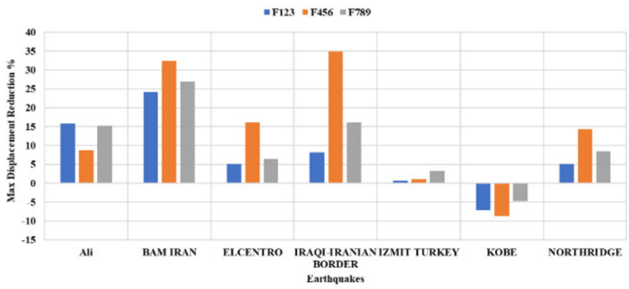

Fig. 9. DVED located in three stories for different earthquakes.

Figure 10 shows the maximum reduction in joint displacement of the structure as a function of damper placement. The optimal efficiency of the damper was achieved when it was installed in the mid-stories of the building. In this position, the maximum joint displacement reduction was observed to be 35%.

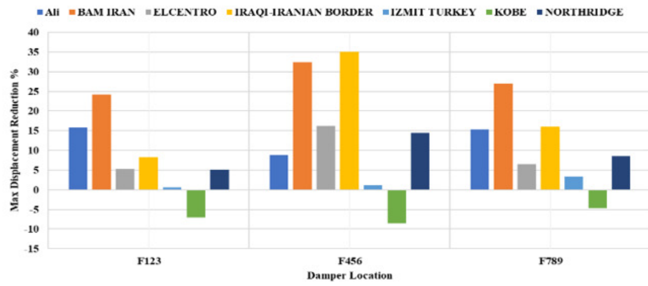

Fig. 10. DVED located in three stories for different damper location.

B. *Chevron Viscoelastic Damper*

Figure 11 illustrates the maximum displacement reduction of a structure embedded with a chevron viscoelastic damper situated on one level. The figure depicts the damper's embedment in nine distinct locations under seven seismic events. The damper demonstrated remarkable performance in the El Centro and Iraqi-Iranian border earthquakes. The mean maximum displacement reduction was observed to be up to 13%. The reduction noted in the Ali Algarbi and Northridge cases was relatively low and exhibited inconsistency. It was evidenced that the maximum displacement increased in the case of the Kobe and Izmit earthquakes. This can be attributed to the fact that the addition of the damper resulted in a change in the natural frequency of the structure.

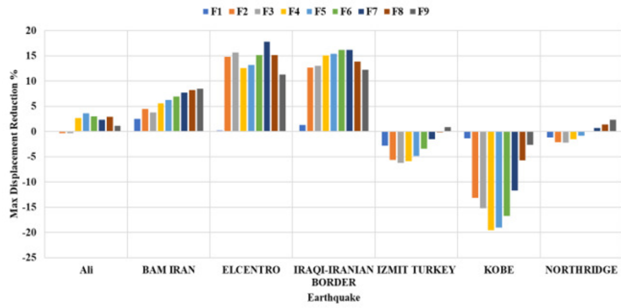

Fig. 11. CVED located in one story for different earthquakes.

Figure 12 shows the maximum displacement reduction of the structure in relation to the positioning of the damper. The findings indicated that the greatest maximum displacement reduction was observed when the damper was situated in the seventh floor. The lowest maximum displacement reduction was observed when the damper was situated on the first floor. The maximum displacement reduction was 18%, occurring when the damper was located on the seventh floor. Figure 13 presents the maximum displacement reduction of a structure embedded with a chevron viscoelastic damper in two stories. The results demonstrated an increase in maximum displacement reduction in comparison to the findings obtained from the analysis of a structure equipped with a damper in a single story. The highest average maximum displacement reduction evidenced in the context of the Bam earthquake was 17%. The average maximum displacement reduction for the Northridge and Izmit earthquakes was found to be slightly low and insufficient. It was noted that an increase in the maximum displacement was obtained under the Kobe earthquake.

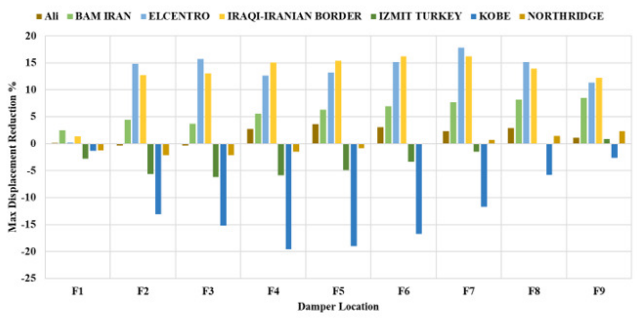

Fig. 12. CVED located in one story for different damper location.

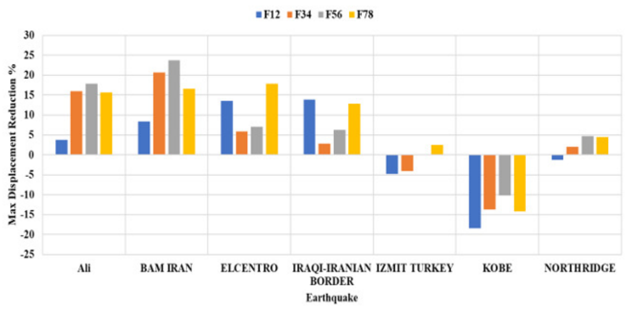

Fig. 13. CVED located in two stories for different earthquakes.

Figure 14 exhibits the maximum displacement reduction in relation to the positioning of the damper. The optimal positioning of the damper is in the mid-stories, as this configuration yields the greatest performance. Conversely, relocating the damper to the top story of the structure results in a notable decline in performance. The maximum displacement reduction was 24%, as it was obtained when the damper was located in the fifth and sixth stories. This phenomenon was detected in all earthquakes except for the Kobe earthquake. It was found that the maximum displacement was significantly increased in the following instances.

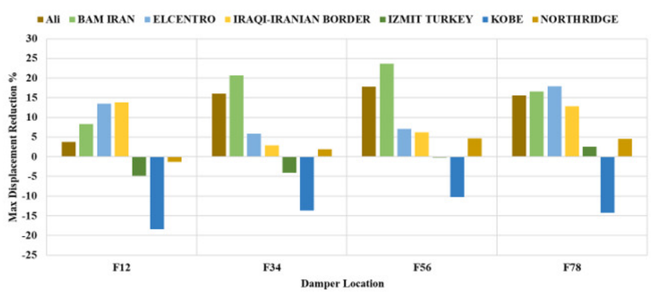

Fig. 14. CVED located in two stories for different damper location.

The highest average maximum displacement reduction evidenced in the aftermath of the Bam earthquake was 24%, as shown in Figure 15. The average maximum displacement for Ali Algarbi, Iraqi-Iranian, and El Centro earthquakes was sufficiently high. It is evident that the lowest and insufficient maximum displacement reduction was observed in the Northridge and Izmit earthquakes, with values of 1% and 5%, respectively. The outcome of the Kobe earthquake exhibited a similar pattern to that noted in the previous placement of the damper in two stories. With regard to the Bam and Iraqi-Iranian earthquakes, the greatest reduction in maximum displacement was spotted when the damper was situated in the mid-story, as manifested in Figure 16. The highest average maximum displacement of 29% was observed when the damper was installed in the mid-story. The damper exhibited the least optimal performance in the Izmit and Northridge scenarios. In the case of the Kobe earthquake, the maximum displacement increased when the damper was located in the building.

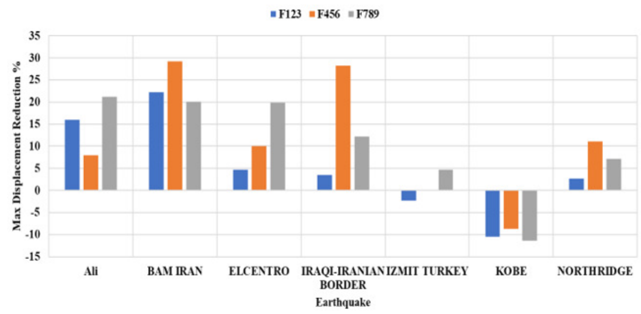

Fig. 15. CVED located in three stories for different earthquakes.

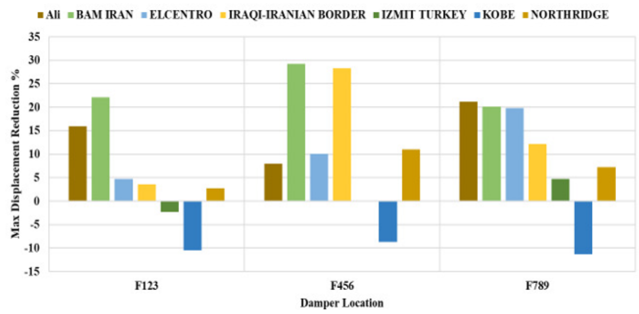

Fig. 16. CVED located in three stories for different damper location.

C. Upper Toggle Viscoelastic Damper

As shown in Figure 17, the highest average maximum displacement was observed in the El Centro earthquake, reaching 13%. Notably, the maximum displacement exhibited a considerable reduction in the Bam and Iraqi-Iranian border earthquakes. Conversely, the maximum displacement reduction detected in the Izmit and Northridge earthquakes was notably low and inconsistent. Figure 18 portrays the maximum displacement of the structure with an upper toggle viscoelastic damper situated in nine distinct stories. The greatest average reduction in maximum displacement, amounting to 20%, was observed in the case of the damper situated in the eighth story. The efficacy of the damper in the alternative location was somewhat diminished. The greatest reduction in maximum displacement was evidenced in the case of the El Centro and Iraqi-Iranian border earthquakes, with the greatest reduction occurring when the damper was situated at the top of the structure. In the case of Ali Algarbi, the Bam earthquake, the maximum displacement exhibited an increase when the damper was situated in the mid-story. In both the Izmit and Northridge earthquakes, the maximum displacement reduction demonstrated a similar trend, shifting from a negative value to a positive one. In contrast, the maximum displacement displayed an increase in the Kobe earthquake.

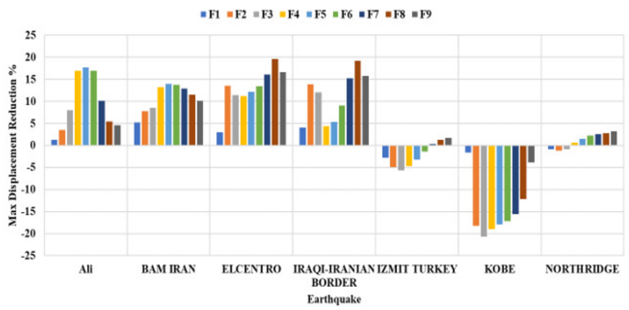

Fig. 17. UTVED located in one story for different earthquakes.

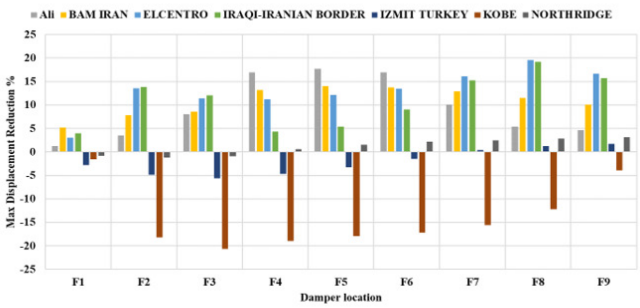

Fig. 18. UTVED located in one story for different damper location.

The performance of the damper was highly satisfactory. The highest average maximum displacement reduction of 23% was observed in the Bam earthquake, as shown in Figure 19. The average maximum displacement of the Ali Algarbi, El Centro, and Iraqi-Iranian border earthquakes also exhibited a notable reduction. In contrast, the Izmit and Northridge earthquakes resulted in the lowest average maximum displacement. Notably, the maximum displacement of the Kobe earthquake was observed to have increased. Figure 20 presents the maximum displacement reduction of the structure in relation to the damper location. The highest maximum displacement reduction of 29% was noticed when the damper was situated in the mid-story. The reduction evidenced in the Bam and Iraq-Iranian border scenarios was sufficiently pronounced when the damper was situated in the mid-story. In the case of the Kobe earthquake, the observed behavior was consistent with that of the one-story placement. As depicted in Figure 21, the damper exhibited an exemplary capacity to diminish the maximum displacement, comparable to that noted in structures equipped with an upper toggle viscoelastic damper across three stories. The mean maximum displacement reduction of 29% was observed in the Bam earthquake. In the case of the El Centro and Iraqi-Iranian border earthquake, the maximum displacement reduction was found to be sufficiently high. The lowest reduction was detected in the Izmit earthquake. The upper toggle damper demonstrated an unfavorable performance in reducing the maximum displacement under the Kobe earthquake.

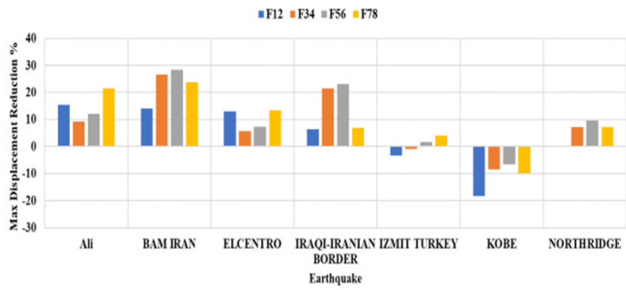

Fig. 19. UTVED located in two stories for different earthquakes.

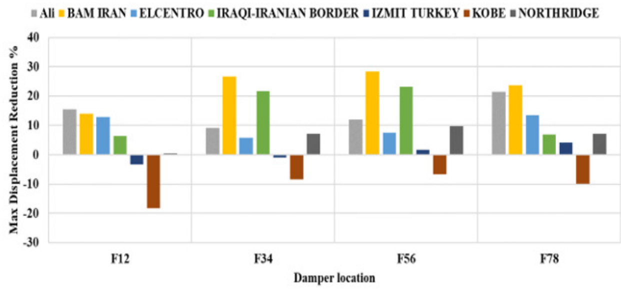

Fig. 20. UTVED located in two stories for different damper location.

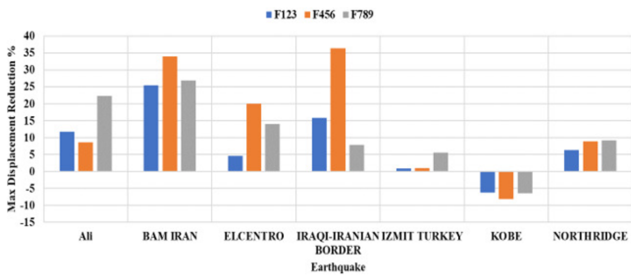

Fig. 21. UTVED located in three stories for different earthquakes.

The highest average maximum displacement of 15% was obtained when the damper was situated in the fourth, fifth, and sixth story, as illustrated in Figure 22. The greatest reduction in displacement, amounting to 37%, was spotted when the damper was situated in the fourth, fifth, and sixth floor in the vicinity of the Iraqi-Iranian border during the earthquake. In general, the viscoelastic damper resulted in a significant reduction in the maximum displacement in the majority of cases. However, the range of results was considerable. In order to reduce the maximum displacement in accordance with the Kobe earthquake, a different arrangement is required, namely an increase in the number of dampers on each floor. Additionally, the structure was constructed in accordance with the relevant seismic safety regulations. Furthermore, the investigation did not examine the influence of seismic excitation on the foundation. The investigation was limited to a single building and a specific type of damper.

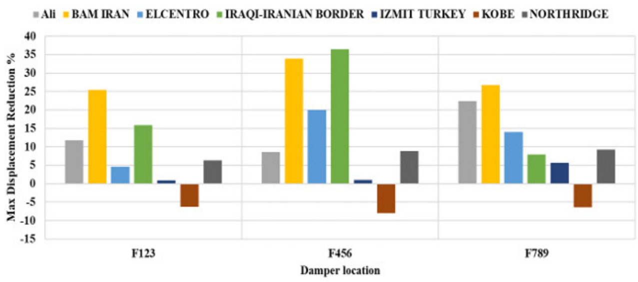

Fig. 22. UTVED located in three stories for different damper location.

VI. CONCLUSIONS

In this study, the Extended Three-Dimensional Analysis of Building System (ETABS) v21 software was employed to create a three-dimensional model of a multistory building, which was then subjected to a series of seven seismic events for evaluation of its performance. The configurations included diagonal, chevron, and upper toggle dampers, each of which exhibited distinct performance characteristics. The displacement of the building in the absence of any dampers was deployed as the baseline for all displacement reduction calculations. The study had the following results:

- Upper toggle friction damper: this damper resulted in the most significant reduction in maximum displacement and demonstrated exceptional performance when positioned on any floor of the building.
- Diagonal friction damper: significant displacement reductions were observed when this damper was installed on the upper floors. However, its efficiency decreased when placed on the lower floors.
- Diagonal friction damper mid-story placement: the greatest reduction in maximum displacement occurred when the diagonal friction damper was placed in the middle of the floors where story drift is the greatest. A significant reduction in maximum displacement was achieved with this placement.
- Chevron friction damper: the damper demonstrated comparable performance to the diagonal friction damper, exhibiting optimal efficacy in the mid-stories and diminished performance in the lower stories.

The study provides evidence that viscoelastic dampers have a substantial influence on the reduction of seismic responses in structures. The significant reduction in displacement and acceleration during various seismic events substantiates the efficacy of the dampers. The effectiveness of viscoelastic dampers is contingent upon their strategic positioning and alignment within the structure, as different arrangements offer varying levels of performance enhancement. Viscoelastic dampers have been proven to be highly effective in reducing responses during seismic events from medium to high intensities. This suggests their potential usefulness in areas that are susceptible to frequent seismic activity. Engineers are able to use configuration-specific performance knowledge to create personalized damper solutions that are perfectly suited to the unique designs of each building. This method ensures that each structure receives the optimal amount of damping, considering its unique properties.

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