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The effects of the duration, intensity and magnitude of far-fault earthquakes on the seismic response of RC bridges retrofitted with seismic bearings

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Abstract

This paper investigates the effects of earthquakes' duration, intensity, and magnitude on the seismic response of reinforced concrete (RC) bridges retrofitted with seismic bearings, such as elastomeric bearings (EB), lead rubber bearings (LRB), and friction pendulum bearings (FPB). In order to investigate the effects of the seismic isolation, the condition of the deck with a rigid connection on the cap beams and abutments (i.e., without isolation) was investigated as the first model. The EB, LRB and FPB bearings are used between the superstructure and substructure of the studied bridge in the second, third and fourth models, respectively. First, the effects of using seismic bearings on the seismic retrofit of an RC bridge under the Tabas earthquake were investigated. The results of the nonlinear dynamic analysis showed that the use of seismic bearings leads to seismic retrofit of the studied bridge, and FPB and LRB had the best results among the studied isolation equipment, respectively. The same models were also studied subjected to the Landers and Loma Prieta earthquakes. The magnitude of the Landers and Tabas earthquakes is equal to 7.3 Richter, and the magnitude of the Loma Prieta earthquake is equal to 6.7 Richter. However, the duration and intensity of the Landers and Loma Prieta earthquakes are much larger than the Tabas earthquake. The Landers and Loma Prieta earthquakes caused instability in the isolated models due to their significant duration and intensity. This issue shows that using seismic bearings is very useful and practical for seismic retrofitting bridges subjected to far-fault earthquakes. According to most seismic codes, selecting earthquakes in far-region of faults is based on just magnitude criterion. However, this study indicates that there are two main factors in the features of far-fault earthquakes, including duration and intensity. Ignoring these factors in selecting earthquakes may lead to the instability of structures. Considering earthquakes' duration, intensity, and magnitude are vital for selecting earthquakes in the far region of the fault.

Keywords: Duration, Intensity, Magnitude, Far-fault earthquake, Seismic retrofitting, RC bridge, Seismic bearings

1 Introduction

The most widely used method for transportation and travel around the world is to use the road transportation network. Bridges are one of the most critical parts of the road and rail transport network. Because of this reason, their stability against various natural disasters such as earthquakes is always discussed and researched.

Most bridges were built after World War II. These structures need seismic retrofit for striking reasons like structural life and improving seismic codes. One of the most effective solutions to seismic retrofit of bridges is using energy dissipation equipment.

Extensive studies suggest that using seismic bearings and dampers leads to seismic retrofit of buildings and bridges (Xiang and Li 2016; Mansouri and Nazari 2017; Zhou and Tan 2018; Luo et al 2019; Kontoni and Farghaly 2019). Recently, studies on the effects of using seismic bearings and dampers indicated that these devices could reduce the seismic response of structures (Cho et al 2020; Hassan and Billah 2020; Cao et al 2020; Zheng et al 2020; Wei et al 2021; Xing et al 2021; Ristic et al 2021; Khedmatgozar Dolati et al 2021; Yuan et al 2021; Chen and Xiong 2022; Marnani et al 2022; Guo et al 2022).

In addition, Ma et al (2021) examined the dynamic response of the story-adding structure with an isolation technique subjected to near-fault ground motions. The results showed that using seismic isolation in both base-isolated and story-isolated structures led to reducing in the seismic response of structures.

In the paper of Mansouri (2021a), the strategies for seismic retrofit of a bridge were discussed. The results indicated that the displacement of the deck, cap beams, and abutment was equal in the integrated bridge, and its value was close to zero. This seismic behavior considerably increased base shear in integrated bridges compared to isolated ones. While using seismic bearings leads to the deck slides on seismic bearings exposed to the seismic loads. This seismic behavior increases the absorption and dissipation of energy in the isolated structure rather than the integrated structure.

Moreover, the study by An et al (2020) assessed the response of bridges with various aspect ratios subjected to near and far-fault earthquakes. This study showed that as the aspect ratio of the pier increased, the tendency to increase or decrease the maximum displacement of the bridge was similar to that of the displacement spectrum. On the other hand, the rate of increase or decrease in the displacement response was more significant than that of the response spectrum. Some differences between the maximum displacement and displacement spectrum could be attributed to the effects of the aspect ratio of the bridge.

Also, Fu et al (2022) investigated the temperature-dependent performance of isolated bridges using lead rubber bearings subjected to near-fault earthquakes. The results showed that the absorbed energy and shearing strain of LRBs increased. Because of these reasons, if the effect of lead core heating is not considered, the seismic demand of LRB would be underestimated, and lead core heating would have a negligible impact on the total input energy.

To mitigate the harmful effect of the vibration generated from each earthquake, four mitigation schemes were used and compared with the non-mitigation model to determine the effectiveness of each scheme, when applying on the SSI or fixed CSB models (Kontoni and Farghaly 2019).

According to the distance between the earthquake recording station and the fault, earthquakes are divided into two groups, including near and far fault earthquakes. Each group of earthquakes has specific characteristics (Mansouri 2017; Mansouri 2021b). Some earthquakes in the far region of the fault have significant duration and intensity effects.

Examining the effects of far-fault earthquakes, which have significant duration and intensity effects, is very important in the seismic retrofit of bridges. Ignoring these phenomena in evaluating and designing bridges may lead to significant damage.

So far, no proper study on seismic retrofit of bridges using energy dissipation equipment under far-fault earthquakes with significant duration and intensity has been investigated. Therefore, this paper evaluates the effects of using seismic bearings in the seismic retrofit of bridges against far-fault earthquakes with significant duration and intensity effects.

2 The studied existing RC bridge

The studied bridge is located at the intersection of the Dogaz Highway with the Tehran-Karaj Freeway (Mansouri 2021a). This bridge has six spans. Figure 1 shows the plan view of the bridge and the deck, cap beam, and deck beam cross-sections. The width of the deck was 17 m. The lateral and middle spans' length was 12.6 m and 18.5 m, respectively.

3 The studied bridge models

This bridge uses conventional neoprene between the substructure and the superstructure. These bearings do not have a high capacity for energy consumption caused by earthquakes. Because of this reason, strategies for seismic retrofit of the studied bridge are investigated. In the first model, the deck is on the substructure with a rigid connection. In the second, third, and fourth models, EB (in the second model), LRB (in the third model) and FPB (in the fourth model) are used between the deck and the substructure, respectively.

Figure 2 shows a three-dimensional view and a view of the plan of the studied bridge. The CSI Bridge® 2022 software was used to model the bridge, and nonlinear time history analysis was used to study it. For this purpose, the nonlinear behavior model has been used to model the behavior of materials and seismic bearings.

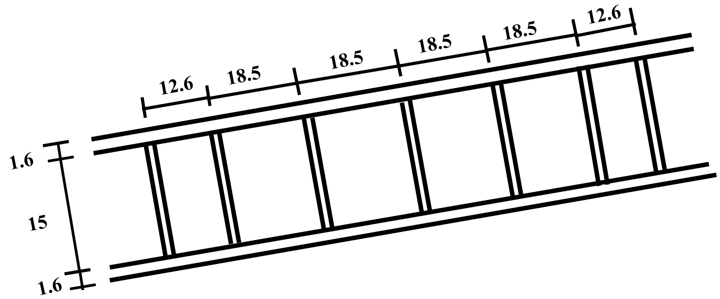
4 Energy dissipation equipment

In this study, the effects of using elastomeric bearing (EB), lead rubber bearing (LRB), and friction pendulum bearing (FPB) on the seismic response of bridges are investigated.

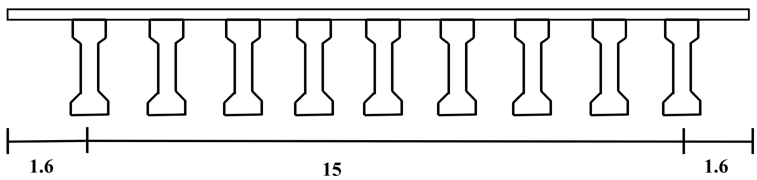
An elastomeric bearing (EB) is a type of seismic bearing that consists of a lot of steel and rubber layers; this device includes a rubber bearing that is reinforced with steel sheets (E.g., Jabbareh Asl et al 2014). Using the following information (Akogul and Celik 2008), EB can be modeled as:

$$K_H = k_{eff} = \frac{G_{eff}\,A}{H_r} = \frac{680 \times 0.1575}{0.061} = 1755\ kN/m$$

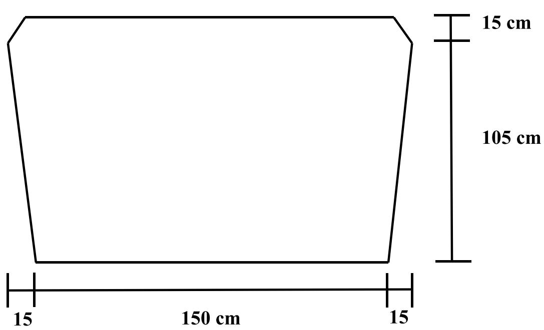
$$K_V = \frac{E_C\,A}{H} = \frac{617263 \times 0.1575}{0.085} = 1143752\ kN/m$$



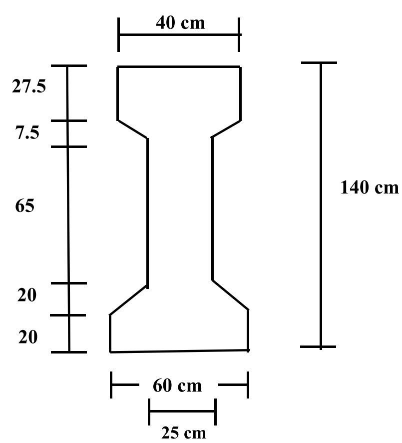
(a) Plan view (units in m).



(b) Cross-section of the deck (units in m).

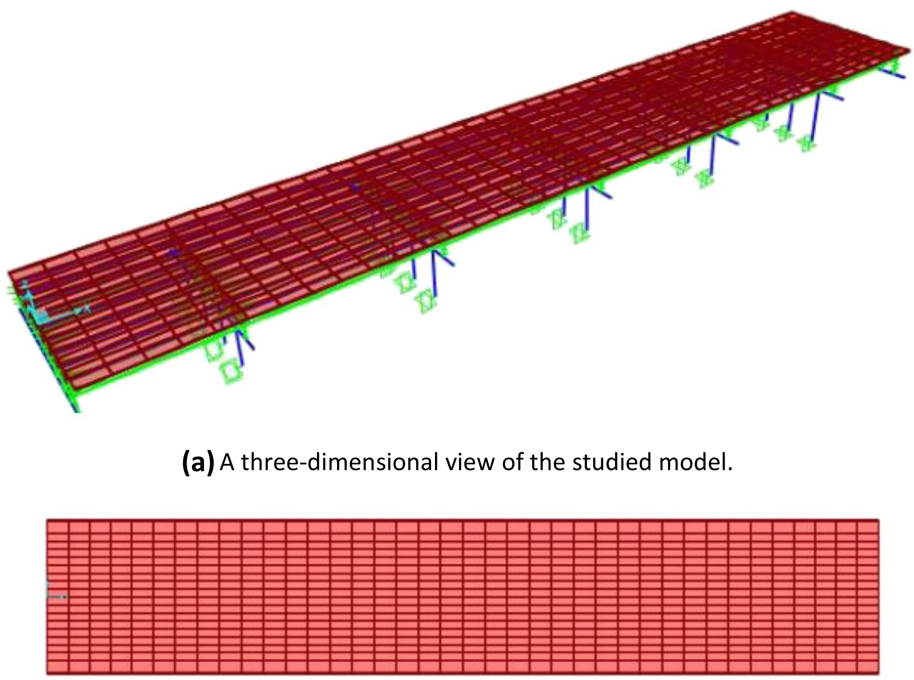


(c) Cross-section of the bent cap beam (units in cm).



(d) Cross-section of the deck beam (units in cm).

Fig. 1 The plan view and cross-sections of the existing RC bridge. **a** Plan view (units in m). **b** Cross-section of the deck (units in m). **c** Cross-section of the bent cap beam (units in cm). **d** Cross-section of the deck beam (units in cm)



(a) A three-dimensional view of the studied model.

(b) A view of the plan of the studied model.

Fig. 2 The studied model of the RC bridge. **a** A three-dimensional view of the studied model. **b** A view of the plan of the studied model

$$K_\theta = \frac{EI}{H_r} = \frac{617263 \times 0.0016}{0.061} = 16270\ kN/m$$

In order to eliminate the weakness of EB in reducing seismic forces in the structure, a lead core was used in the center (see, e.g., Mansouri et al 2017). A lead rubber bearing (LRB) can be modeled with the following specifications (Torunbalci and Ozpalanlar 2008):

Link element = Rubber Isolator.

U1 → linear Effective Stiffness = 1,500,000 kN/m.

U2 = U3 → linear Effective Stiffness = 800 kN/m.

U2 = U3 → Nonlinear Stiffness = 2500 kN/m.

U2 = U3 → Yield Strength = 80.

U2 = U3 → Post Yield Stiffness Ratio = 0.1.

A friction pendulum bearing (FPB) is one of the seismic bearings used to reduce the seismic response of bridges (Hong et al 2020). Using FPB increases the period of isolated bridges and their protection against the strongest earthquakes. FPB can be modeled with the following specifications (Torunbalci and Ozpalanlar 2008):

Link element = Friction isolator.

U1 → linear Effective Stiffness = 15,000,000 kN/m.

U1 → Nonlinear Effective Stiffness = 15,000,000 kN/m.

U2 = U3 → Linear Effective Stiffness = 750 kN/m.

U2 = U3 → Nonlinear Stiffness = 15,000 kN/m.

U2 = U3 → Friction Coefficient Slow = 0.03.

U2 = U3 → Friction Coefficient Slow = 0.05.

U2 = U3 → Rate Parameter = 40.

U2 = U3 → Radius of Sliding Surface = 2.23.

The features of these seismic bearings (EB, LRB, and FPB), according to the Iranian code no. 523 (2010) are designed and verified.

5 Eigenvalue analysis

The stiffness of the isolated bridge is less than the integrated bridge. Because of this, the isolated bridges' period is higher than the integrated bridge. According to Fig. 3, the period of the first model is equal to 0.14 seconds (integrated bridge), and the periods of the second to fourth models (isolated bridge) are equal to 0.96, 1.39, and 1.43 seconds, respectively. Using seismic bearings in bridges leads to a considerable increase in the period of bridges compared to integrated bridges.

6 Selected earthquakes

According to an interpretation study of the Iranian seismic code (Mansouri 2017), seven earthquakes have been selected with a magnitude between 6.5 and 7.5, including the Chi-Chi, Landers, Loma Prieta, Northridge, Parkfield, San Fernando, and Tabas earthquakes. These earthquakes are located between 20 and 60 km from the fault. The characteristics of these earthquakes were taken from the Pacific Earthquake Engineering Research Center (PEER) 2022 website (https://peer.berkeley.edu/peer-strong-ground-motion-databases), and the SeismoSignal 2022 software was used to edit and extract information. The records of the horizontal components of each earthquake are combined using the SRSS (Square Root of the Sum of the Squares) method to obtain only one spectrum for each earthquake. The seven spectra calculated for the discussed seven earthquakes are added together, and their average is calculated to obtain the average spectrum of earthquakes. According to the Iranian seismic code, the scale factor is calculated for each earthquake. The response spectrums for all seven earthquakes are

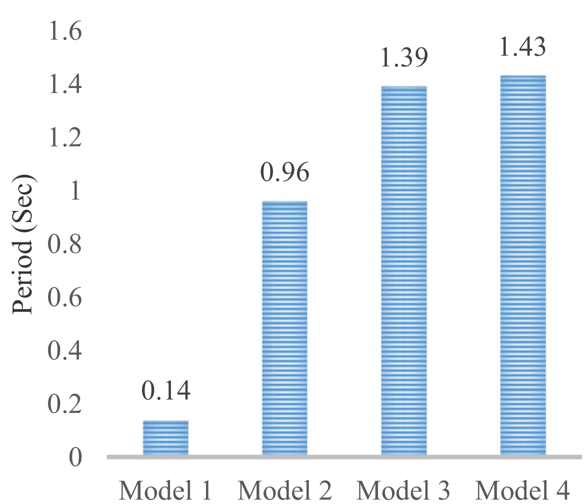


Fig. 3 The period of the studied models

shown in Figs. 4 and 5 compares the response spectrum obtained from the Iranian seismic code with the response spectrum obtained from the average response spectrum of the seven earthquakes.

Figures 6, 7, 8, 9, 10 and 11 show the horizontal components of acceleration-time of the Tabas, Landers, and Loma Prieta earthquakes. The magnitude of both the Tabas and Landers earthquakes is equal to 7.3 Richter. Due to this reason, the effect of these far-fault earthquakes on the seismic response of the bridge is investigated.

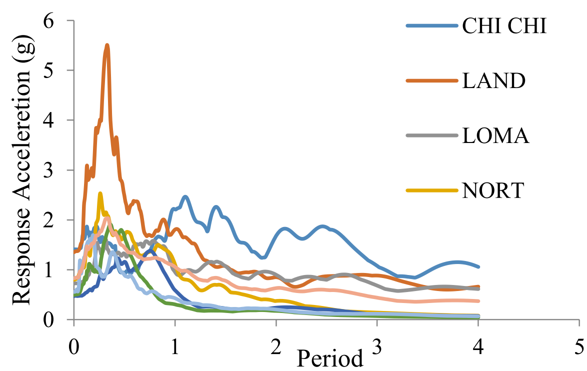


Fig. 4 The response spectrums of selected seven earthquakes

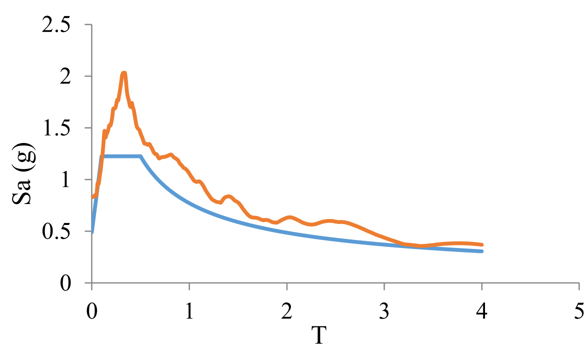


Fig. 5 The comparison of the response spectrum of Iranian Standard No. 2800 with the response spectrum obtained from the average response spectrum of the selected seven earthquakes

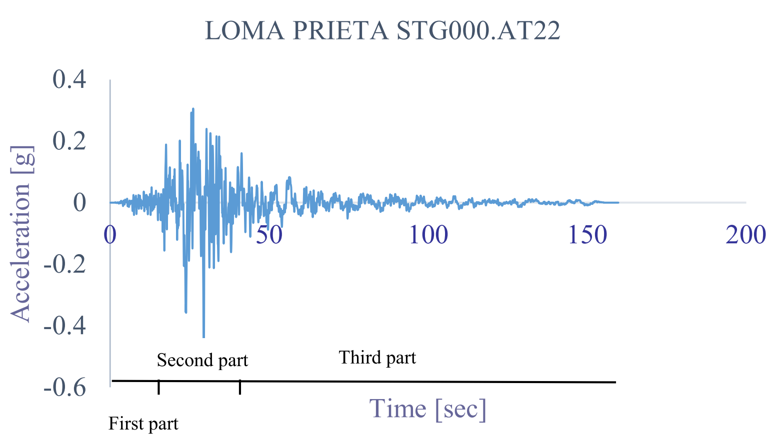


Fig. 6 The record of the horizontal component (STG000) of the Loma Prieta earthquake

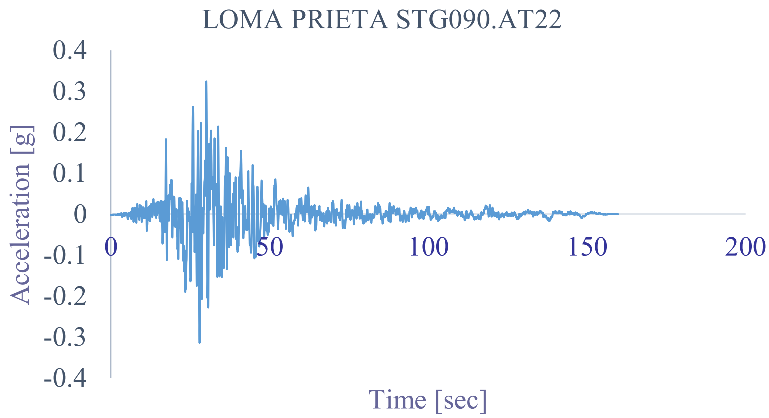


Fig. 7 The other record of the horizontal component (STG090) of the Loma Prieta earthquake

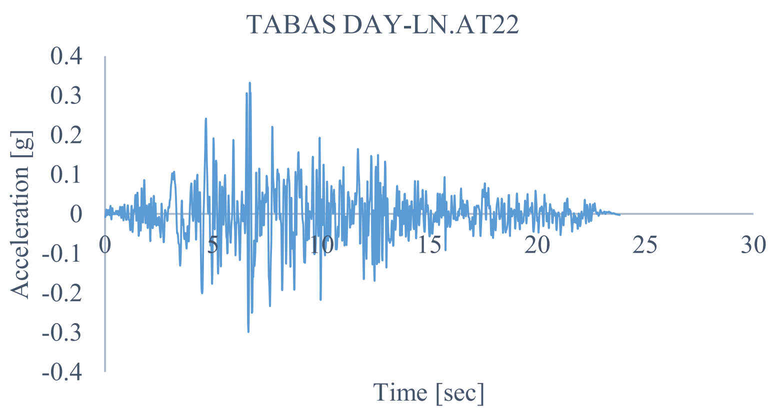


Fig. 8 The record of the horizontal component (DAY-LN) of the Tabas earthquake

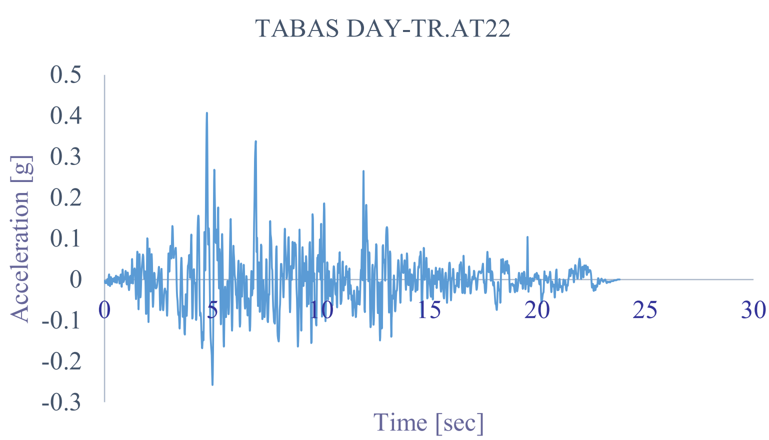


Fig. 9 The other record of the horizontal component (DAY-TR) of the Tabas earthquake

The magnitude of the Loma Prieta earthquake is equal to 6.7 Richter, but the duration and intensity of the Landers and Loma Prieta earthquakes are much greater than the Tabas earthquake. Because of this reason, to investigate the effect of the magnitude of

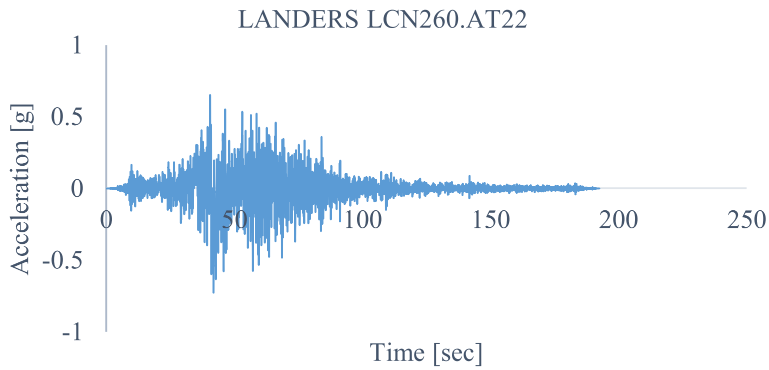


Fig. 10 The record of the horizontal component (LCN260) of the Landers earthquake

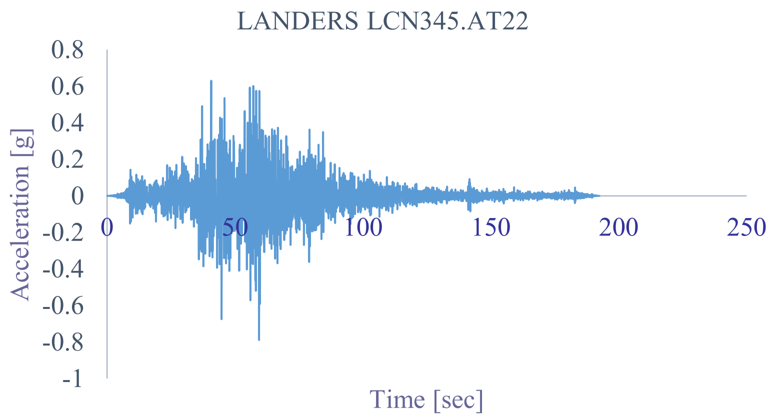


Fig. 11 The other record of the horizontal component (LCN345) of the Landers earthquake

far-fault earthquakes, the effect of the Loma Prieta earthquake on the bridge is investigated and compared to the seismic response of this bridge under the Tabas earthquake and the Landers earthquake. In the following, the models' response to these earthquakes is examined. Usually, according to Fig. 6, records of far-fault earthquakes are divided into three parts. The ground motions of the first and third parts are negligible and do not have strong effects on the seismic response of the structure. However, strong ground motions in the second part strongly affect the seismic response of structures. Especially there are two vital factors in the second part, including duration (related to the horizontal axis of the record) and intensity (related to the vertical axis of the record).

Most seismic codes consider features of magnitude and or PGA (Peak Ground Acceleration) of earthquakes for selecting earthquake to seismic design of structures. The PGA is related to a moment, and AGA (Average Ground Acceleration) in the second part of the record is very effective on the seismic response of a structure (Mansouri 2021b).

Usually, there are some stations to record an earthquake. Features of earthquakes like the acceleration-time record, velocity-time record, and displacement-time record are different in every station compared to others. Due to this reason, the intensity and duration of an earthquake in different stations are not equal to each other. However, magnitude measures the size of the earthquake at its source. Every earthquake has one magnitude and does not depend on stations. The effect of the magnitude as a vital criterion for selecting earthquakes (according to seismic codes) on the seismic response of the structure will be investigated in this paper.

7 Nonlinear time history analysis

The seismic response of the studied models exposed to the Tabas earthquake, the Loma Prieta earthquake, and the Landers earthquake is studied using time-history analysis. According to Fig. 12, the point "Deck" is in the middle of the deck, and the point "Cap beam" is in the middle of the cap beam 3. The unit system of all graphs is in Ton-cm.

7.1 Results of lateral displacement

Figures 13, 14, 15, 16, 17, 18, 19 and 20 show the results of the horizontal displacements of the studied points subjected to the Tabas earthquake.

According to Figs. 13, 14, 15, 16, 17, 18, 19 and 20, in the integrated bridge, the horizontal displacement of the studied points on the deck and cap beams is equal to each other, and its value is negligible. However, in the isolated bridge, the deck slips on seismic bearings so that the displacement of the substructure is minimal, and the deck dissipates the energy caused by the earthquake with horizontal movements.

Table 1 shows the results of the maximum lateral displacement of the deck for isolated bridges exposed to the Tabas earthquake, the Loma Prieta earthquake, and the Landers earthquake. In the second to fourth models, the maximum horizontal displacement of the cap beams was subjected to mentioned earthquakes. The maximum displacement of the deck in the lateral direction for the second model is 36 cm; for the third model is equal to 25 cm, and for the fourth model is equal to 295 cm, respectively. Comparing the results of the maximum lateral displacements with the allowed displacement rates for these seismic bearings, it is clear that the isolated models are unstable under the Landers earthquake and the Loma Prieta earthquake. The deck of isolated bridges may fall from substructures subjected to the Landers earthquake and the Loma Prieta earthquake because the maximum lateral displacements of the deck for isolated bridges under the Landers earthquake and Loma Prieta earthquake are higher than the allowed displacements of seismic bearings. Time history analysis does not show structural collapse levels.

7.2 Results of input and kinetic energies

Due to an earthquake, energies are applied to structures. Some parts of the input energy are transformed into kinetic energy. Due to this reason, the input and kinetic energies of the second model are investigated in this study.

The energy should be either absorbed or dissipated. This issue is made clear by considering the conservation of energy relationship (1), where E is the absolute energy input from the earthquake motion, Ek is the absolute kinetic energy, Es is the recoverable elastic strain energy, and Eh is the irrecoverable energy dissipated by the structural system through inelastic or other forms of action. Ed is the energy dissipated by supplemental damping devices (Constantinou and Symans 1993).

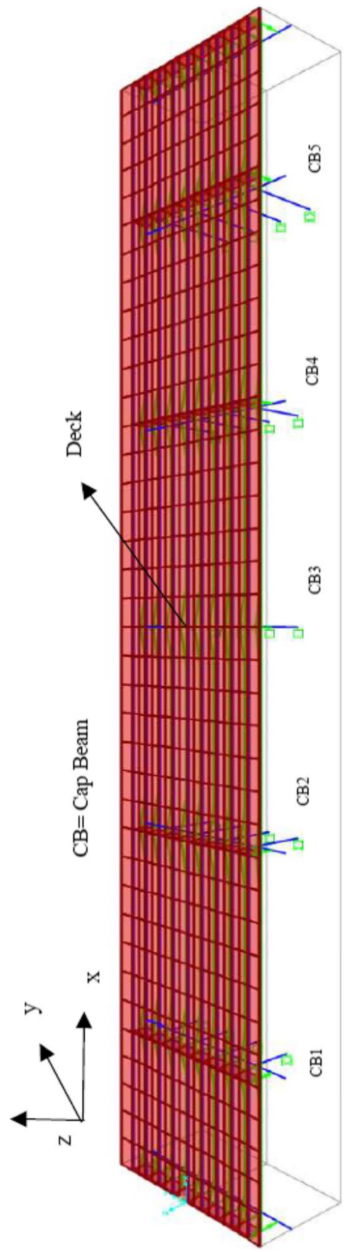


Fig. 12 A view of studied point

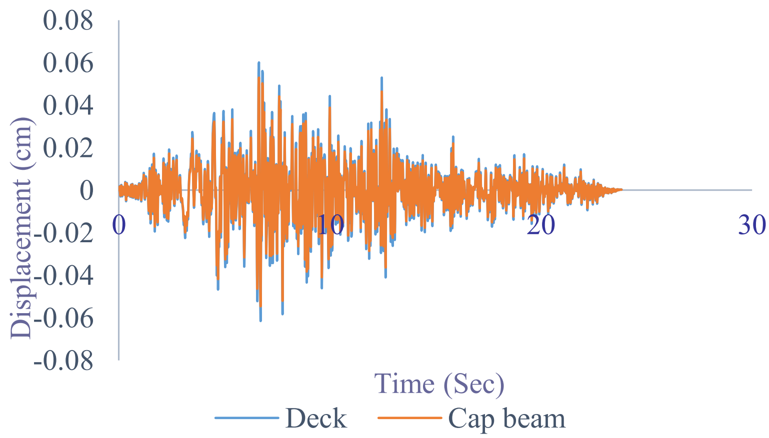


Fig. 13 The lateral displacement of points Deck and Cap beam in longitudinal direction (X) in model 1 under the Tabas earthquake

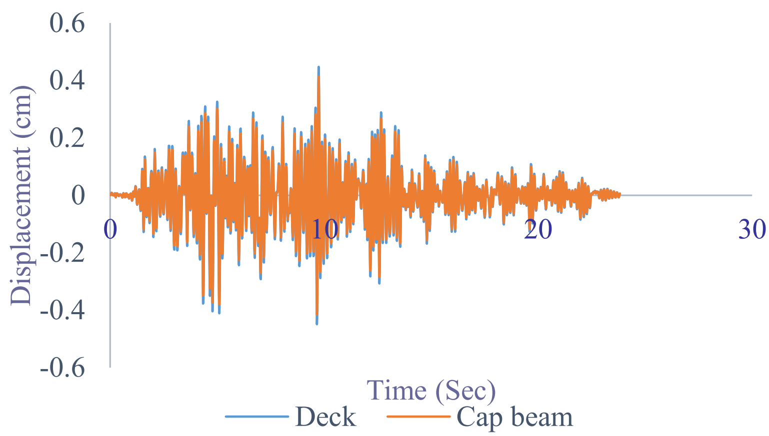


Fig. 14 The lateral displacement of points Deck and Cap beam in the transverse direction (Y) in model 1 under the Tabas earthquake

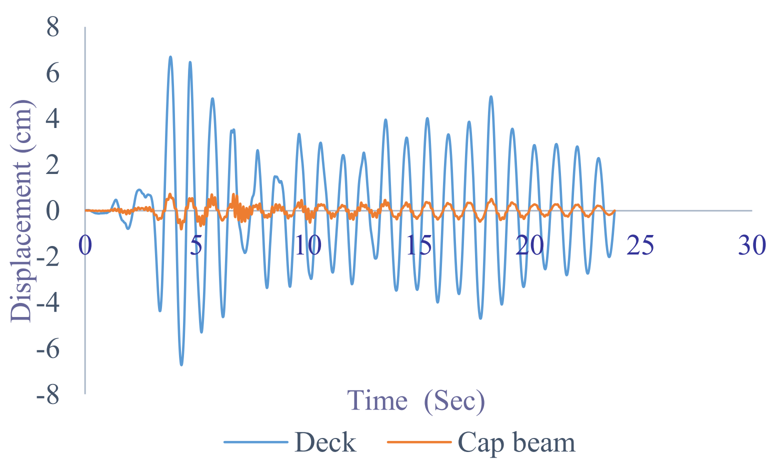


Fig. 15 The lateral displacement of points Deck and Cap beam in the longitudinal direction (X) in model 2 under the Tabas earthquake

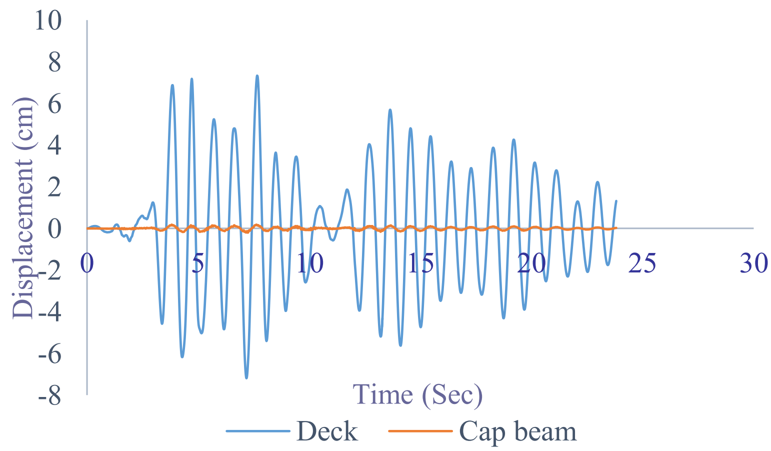


Fig. 16 The lateral displacement of points Deck and Cap beam in the transverse direction (Y) in model 2 under Tabas earthquake

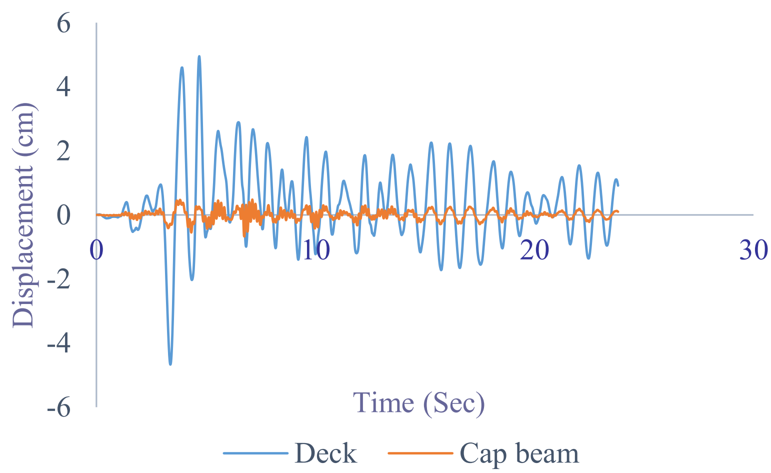


Fig. 17 The lateral displacement of points Deck and Cap beam in the longitudinal direction (X) in model 3 under the Tabas earthquake

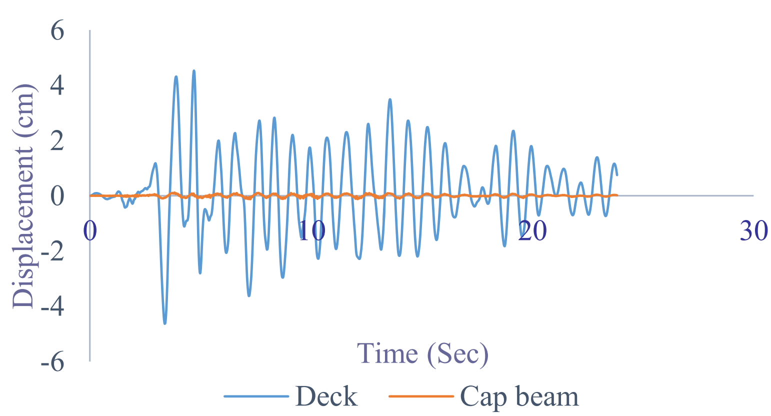


Fig. 18 The lateral displacement of points Deck and Cap beam in the transverse direction (Y) in model 3 under the Tabas earthquake

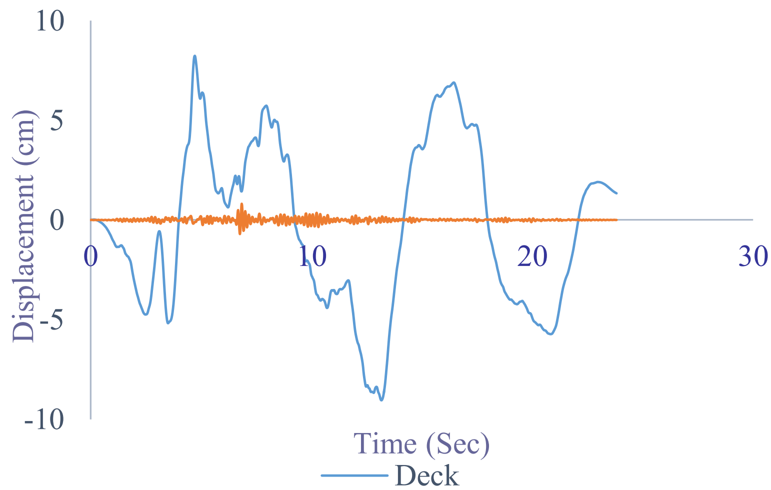


Fig. 19 The lateral displacement of points Deck and Cap beam in the longitudinal direction (X) in model 4 under the Tabas earthquake

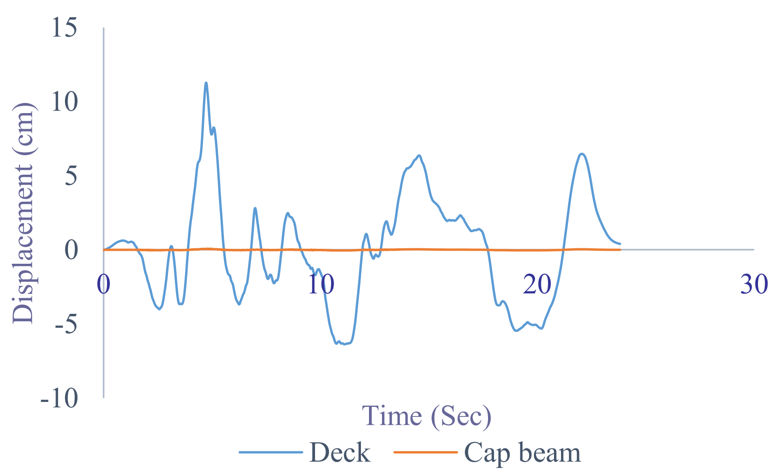


Fig. 20 The lateral displacement of points Deck and Cap beam in the transverse direction (Y) in model 4 under the Tabas earthquake

Table 1 The maximum lateral displacement of the deck in isolated bridges

Models	Allowed Displacement (cm)	Subjected to Tabas earthquake		Subjected to Landers earthquake		Subjected to Loma Prieta earthquake	
		Displacement (cm)	Stable/ Unstable	Displacement (cm)	Stable/ Unstable	Displacement (cm)	Stable/ Unstable
Model 2 (EB)	10	7.34	Stable	36	Unstable	29	Unstable
Model 3 (LRB)	15	4.9	Stable	25	Unstable	21	Unstable
Model 4 (FPB)	15	11.3	Stable	295	Unstable	190	Unstable

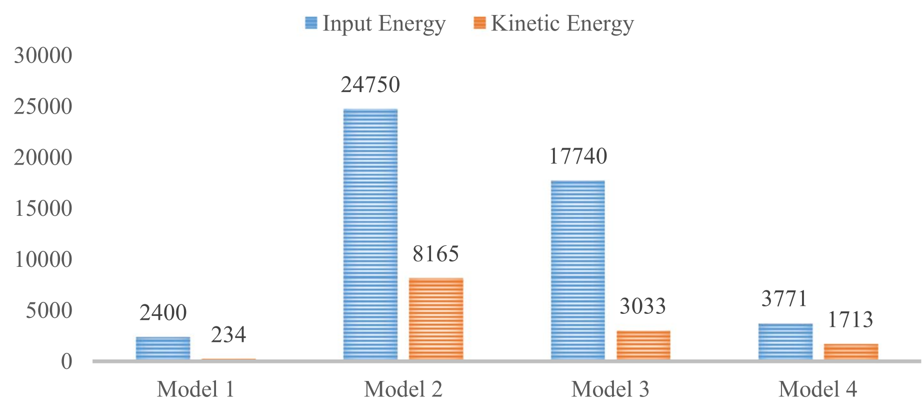


Fig. 21 Input energy and kinetic energy results for the studied models under the Tabas earthquake

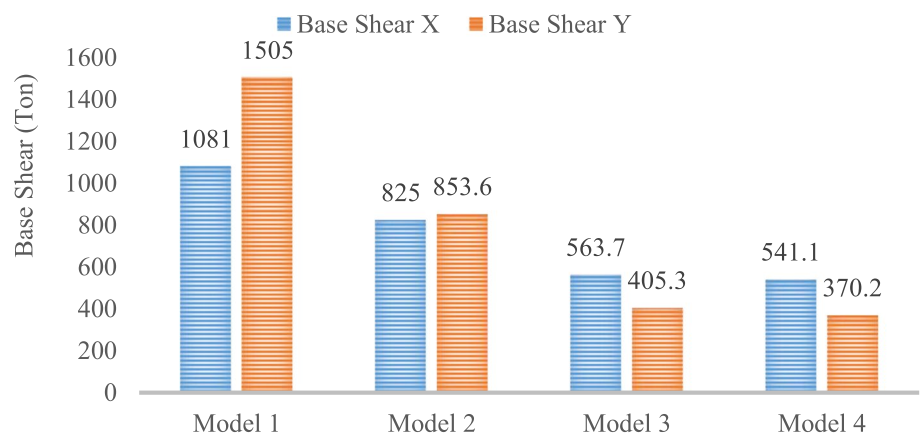


Fig. 22 The results of base shear of the bridge in longitudinal (X) and transversal (Y) directions under the influence of the Tabas earthquake

$$E = Ek + Es + Eh + Ed \tag{1}$$

The input and kinetic energy rates for the studied models subjected to the Tabas earthquake are shown in Fig. 21. The isolated bridge's stiffness is lower than the integrated bridge. Due to this reason, the isolated bridge absorbs more energy than the integrated bridge.

7.3 Results of base shear

The results of base shear for integrated and isolated bridges under the Tabas earthquake are shown in Fig. 22. The base shear for the first model in the directions x and y is equal to 1081 and 1505 tons, respectively. In the second model, by using elastomeric bearing, the base shear of the bridge is reduced and got to 825 and 853.6 tons, respectively. In the third model, by using LRB in the bridge, the base shear of the structure is reduced and reaches 563.7 and 405.3 tons, respectively. The base shear in the fourth model, which uses FPB in the bridge, in the directions x and y is equal to 541.1 and 370.2, respectively.

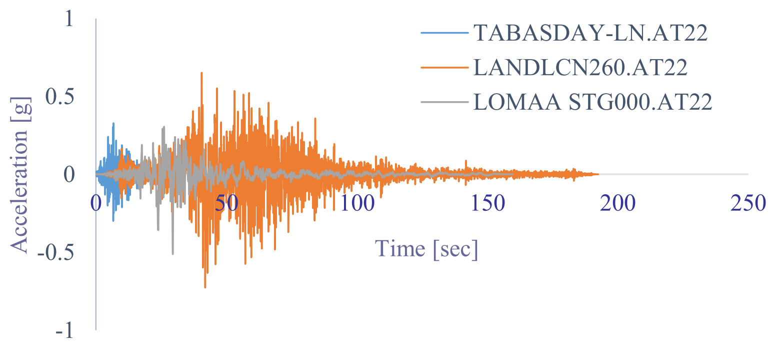


Fig. 23 The comparison of the first horizontal record of the Tabas earthquake, Landers earthquake, and Loma Prieta earthquake

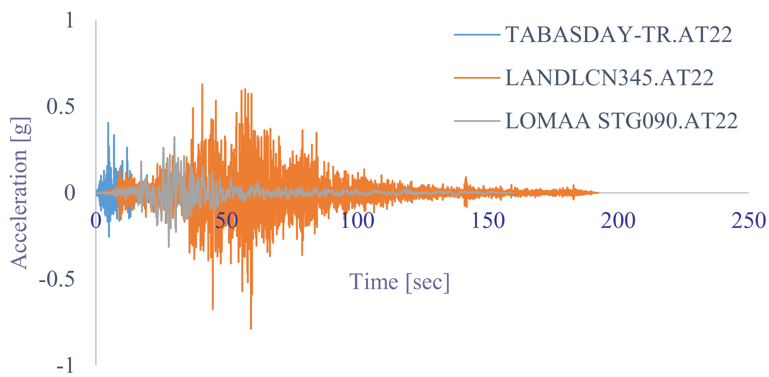


Fig. 24 The comparison of the other horizontal record of the Tabas earthquake, Landers earthquake, and Loma Prieta earthquake

The results showed that using seismic bearings in bridges reduces structures' seismic response compared to the integrated bridge. This result is vital because the bridge's seismic capacity of structural elements is limited.

8 Discussion

The magnitude of the Landers and Tabas earthquakes was 7.3 Richter. However, the duration and intensity of the Landers earthquake are higher than the Tabas earthquake. The magnitude of the Loma Prieta earthquake is 6.7 Richter. However, the duration and intensity of the Loma Prieta earthquake are higher than the Tabas earthquake. This study shows that duration and intensity are two vital factors in the seismic response of structures. Because of these reasons, magnitude is an insufficient criterion for selecting earthquakes. Considering magnitude, duration, and intensity are suitable criteria for selecting earthquakes for seismic retrofit and seismic design of structures.

According to Figs. 23 and 24, the records of transitional components of the Landers earthquake, Loma Prieta earthquake, and Tabas earthquake are investigated and compared, and the PGA, duration, and intensity of strong ground motion are evaluated. The duration of strong ground motion in the Landers earthquake and Loma Prieta earthquake are much larger than the same value in the Tabas earthquake. Besides, the duration and intensity of the Landers earthquake are much larger than the Loma Prieta earthquake.

Investigating the records of the Tabas earthquake indicates that the PGA of the components of horizontal orthogonal is 0.328 g (component DAY-LN) and 0.406 g (component DAY-TR), respectively. Also, the examination of the Landers earthquake records shows that the PGA of components of horizontal orthogonal is 0.727 g (component LCN260) and 0.789 g (component LCN345), respectively. In addition, for the Loma Prieta earthquake, the PGA of the components of horizontal orthogonal is 0.512 g (component STG000) and 0.323 g (component STG090), respectively.

The isolated bridges are unstable under the Landers earthquake and the Loma Prieta earthquake. Because the PGA, duration, and intensity of the Landers earthquake and Loma Prieta earthquake records are much larger than similar values in the Tabas earthquake. Due to this reason, the deck in isolated bridges has lateral displacements higher than allowed displacements.

9 Conclusions

On the one hand, seismic bearings are very useful and practical for the seismic retrofit of bridges. On the other hand, there are vital features in far-fault earthquakes that are ignored in selecting earthquakes to design and seismic retrofit structures in seismic codes, such as duration and intensity. In this paper, the effects of magnitude scale, duration, and intensity were investigated on the seismic response of retrofitted RC bridges, and the following results were obtained:

- Using seismic bearings can lead to seismic retrofit of bridges and reduce the seismic response of structures. The results showed that to use these seismic bearings, the site conditions should be checked regarding the amount of seismic risk. If there is no proper estimation of the seismic risk of the studied site, the use of this equipment may lead to the instability of the structures against strong earthquakes, and the bridge deck will fall under the effect of strong ground motions.
- One of the essential steps in the design and seismic retrofit of structures is the selection of earthquakes based on the actual conditions of the structure and site. According to most seismic regulations, the selection of earthquakes for the design and seismic retrofit of structures is based on magnitude scale and PGA. In this paper, this issue was investigated. The results indicate that the magnitude scale and PGA are insufficient to select far-fault earthquakes to design seismic retrofit structures. Simultaneously, the magnitude, duration, and intensity parameters should be considered.
- The uncertainty of earthquake characteristics and paying attention to economic conditions showed that considering the duration and intensity limits according to the structure's importance and the site's characteristics is vital.
- Ignoring the duration and intensity parameters in selecting far-fault earthquakes can lead to the instability of isolated bridges against earthquakes with significant duration and intensity rates.

- These issues show that the seismic regulations need a fundamental revision in terms of the selection parameters of earthquakes.
- The magnitude of the Landers earthquake and Tabas earthquake is the same (7.3 Richter), and the magnitude of the Loma Prieta earthquake is 6.7 Richter. However, isolated bridges are unstable under the Landers earthquake and the Loma Prieta earthquake, and these bridges are stable under the Tabas earthquake. By comparing the characteristics of these earthquakes, it is clear that the duration and intensity of the three earthquakes are very different. The duration and intensity of the Landers earthquake and Loma Prieta earthquake are higher than the Tabas earthquake, and therefore the Landers earthquake and Loma Prieta earthquake lead to instability of the isolated bridges. This issue indicates that the magnitude parameter as the only criterion for selecting earthquakes is unsuitable for seismic design or seismic retrofit of structures. In far areas of faults, it is crucial to consider the duration and intensity of earthquake records. In addition, the mere use of seismic bearings on structures does not cause seismic retrofit of structures. It is essential to study the different characteristics of the reviewed sites, the seismic risk rate, and the studied structures and mechanical equipment features.

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Conflict of Interest
The authors declare that they have no conflict of interest.

Authors' contributions
SM: Conceptualization, Methodology, Software, Validation, Formal Analysis, Investigation, Data Curation, Writing—Original Draft Preparation, Visualization. DPNK: Conceptualization, Methodology, Validation, Investigation, Writing—Original Draft Preparation, Visualization, Writing—Review and Editing, Supervision, Project Administration. MP: Conceptualization, Methodology, Investigation, Writing—Original Draft Preparation, Writing—Review and Editing. All authors read and approved the final manuscript.

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