International Journal of Research in Science & Engineering
ISSN: 2394-8299
Vol: 03, No. 03, April-May 2023
http://journal.hmjournals.com/index.php/IJRISE
DOI: https://doi.org/10.55529/ijrise.33.1.16

Dynamic Response of Reinforcement Concrete Buildings to Earthquake Excitation

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Received: 09 December 2022 **Accepted:** 28 February 2023 **Published:** 04 April 2023

Abstract: Today, design based on performance levels is particularly important in seismic areas. Considering the seismic criteria of the code is 2800. In this study, for this purpose, the two-dimensional model of a 6-storey building created as a 6-storey reinforcement concrete building has been evaluated utilizing nonlinear dynamic and static analysis. The nonlinear model of the building under study was created by sap 2000 software. After calculating the studied building's first mode and overlap curve, nonlinear dynamic analysis is also performed. According to these letters, the properties of nonlinear joints are assigned to thyrostone elements.
Furthermore, uniform and linear dynamic analysis of time history based on six earthquake records has been performed on the models. Amplitude system (SI) identification techniques and the influence of excitation force features on The performance of different methods were also examined. The finite element model was Building Uses SAP2000 to compare time history features with identified counterparts from the experiment. The findings demonstrated a strong correlation between modal factors identified by various.

Keywords: Time History, Sap 2000, Nonlinear Dynamic Analysis, Earthquake, 6-Storey Building, Amplitude System (SI).

1. INTRODUCTION

From the past to the present, many studies have been conducted on the influence of earthquakes near faults on steel and concrete structures, especially in earthquakes where the vertical component of acceleration has also been substantial in addition to the high horizontal component of acceleration. [1]. In recent years, studies have been conducted on three-

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dimensional models of reinforced concrete structures on rigid foundations, as well as studies on steel flexural frames under earthquakes near faults. [2-5] However, considering some simplifying expectations such as two-dimensional analysis, assuming elastic behavior for the structure, not considering the interaction of soil and structure, and causing the findings to be far from reality. [6, 7]. This investigation explores the factors of analysis and design of special reinforced concrete flexural frames in the three-dimensional state with a flexible substrate. Given the above, it is clear that three-dimensional modeling of seismic structures by considering the interaction of soil and structure under the influence of vertical and horizontal earthquake propagation near the site can create a more realistic understanding of the behavior of structures in such Conditions help to reduce the risks and damages and reduce casualties and increase the safety of designed buildings. [8, 9]. Utilizing an analytical model, they worked on the influence of the vertical earthquake component on the response of reinforced concrete frames. They demonstrated that the vertical component negatively influences reinforced concrete frames, especially on columns. They analyzed a five-storey back frame under static and step earthquake loads using an analytical model. [10]. The studies were performed in two cases without vertical earthquake load and by applying vertical earthquake load. Energy loss in columns is reduced and vice versa in valves is increased. [11]. Analyzed the dynamic behavior of three-dimensional concrete structures under vertical earthquake load. In this article, Lily has presented a technique for dynamic analysis of a three-dimensional structure under a vertical earthquake, and finally, recommendations for an acceptable dynamic analysis are provided. [12] y performing a large number of numerical analyzes, they provided formulas for estimating forces and Investigating the influence of frequency content of near-fault earthquakes on the response of structures. [13] They determine the range of frequency fluctuations with the structure's response. In the other region, the wings of the long period, they found that the elastic response spectrum of the structures against near-fault accelerometers has two stumps generally separated from each other. [14] It is low where the response range of the structures is mainly the mother of the high-frequency fluctuations in the mapping, and the wings have no influence on the non-response of the second miser, the area of relatively large intestines where the range of pulses determines the response. [8] Many factors, including magnitude, impact these input ranges and intrinsic values in those areas. Distance from fault, soil type, etc. [15] The behavior of the reinforced concrete structure, which was simultaneously impacted by the vertical and horizontal earthquake, was enchanted. [16] They studied the influence of vertical and horizontal acceleration masses on the vibration response of reinforced concrete buildings with national, semi-rigid, and pliable and with two types of mass distribution concentrated in floors and wide in the range of nonlinear analysis of column axial force changes and the influence of dynamic building features Examined the axial forces of the columns. [17] This study demonstrated that vertical earthquake substantially influences the axial forces of the columns. It may even increase the faulted column's axial force and the structure's overturning anchor. [18] It was also observed that structural fluctuations are likely to intensify. Have you noticed that the mass-concentrated mass model in the classes can lead to the estimation of larger values for the axial force of the columns?

Investigated the influence of pen quakes on irregularly bent frame structures. [19] This study analyzed several bar structures under various acceleration maps with various vertical and horizontal bay intensities. [20] These studies focused on the changes in axial force under the influence of various factors. These studies found that the axial forces of the internal and external columns demonstrate substantial changes under the influence of vertical earthquakes. [21 Today, one of the main ways to achieve this goal is to apply and present new techniques in the seismic design of structures and quality improvement of consumables [22]. A structure designed for an area with strong earthquake risk. It must have two important features. First, it must be rigid enough to control the lateral displacement of the building to prevent damage to non-structural and structural components in moderate but frequent earthquakes. [23] Second, it must have adequate ductility and strength to prevent the collapse of the building under severe earthquakes. [24] However, in this case, limited non-structural and structural damage is allowed. Becautilize it is not economically viable to design structures to survive strong earthquakes with low resilience probabilities [25] In conventional techniques, the building demonstrates earthquake resistance by utilizing a combination of stiffness and ductility as well as energy dissipation. The amount of damping in such buildings is very low, so the energy consumed in the elastic behavior range of the structure is negligible. Their inelastic displacement capabilities remain stable. [26], These inelastic displacements cause plastic joints to form locally at points in the structure, which in turn increase ductility as well as increase energy dissipation. The side of the structure is depreciated. [27,28] Due to the distribution of energy in a structure, today in the world, another technique to reduce the influences of earthquakes has been considered. During an earthquake, much energy is imposed on the structure. [29] This input energy appears in the form of kinetic and potential in the structure, which must be absorbed or consumed somehow. If there is no damping, the structure vibrates to infinity. [30–38] It continues, but in practice, due to the properties of the structure, some damping is created in it. Which causes a reaction against the vibration of the structure and its damping. The efficiency of the building can be increased by adding energy attractions (formable elements) to the building. In this way, these devices absorb and consume part of the input energy of the earthquake alone. The energy amount applied to the structure during the earthquake is directly associated with the rotation time of the structure and its ratio to the dominant period of ground movement. Also, the damage to the structure is due to the amount of hysteresis energy absorbed under the inelastic forms of the structural members. [39–43].. Accordingly, a structure must be designed so that the deformation required by each member is in balance with the change in its capacitive deformation so that during an earthquake, the energy in the member is dissipated reliably.[44] Small earthquakes should not cause any damage to structural or non-structural members. - Moderate earthquakes should be the basis of design, and the building must be designed so that it can easily withstand the cause of the earthquake without seeing substantial damage. - Strong earthquakes may cause serious damage to the building but do not cause the collapse and loss of life of its occupants. The above trend seems suitable for most ordinary buildings. However, it can be considered a safer process for designing more important buildings or buildings that must provide services after an earthquake. In improving the structures, , it has improved substantially. We can have more confidence in the performance of the new regulations. However, on the other hand, there is an issue called evaluating the performance of buildings designed based on the old technique or the same design based on force; considering that almost all existing buildings in our country are included in this

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category, this issue has It is important, and the need for research with a guided process is obvious. [45]

Testbed Building Explanation

This investigation focuses on a frame of a 6-storey reinforced concrete building under Northridge, hill, lahobra mommoth, Parkfield,friuli, and Imperial with Sap 2000 software under nonlinear dynamic and static analysis (Fig. 1).

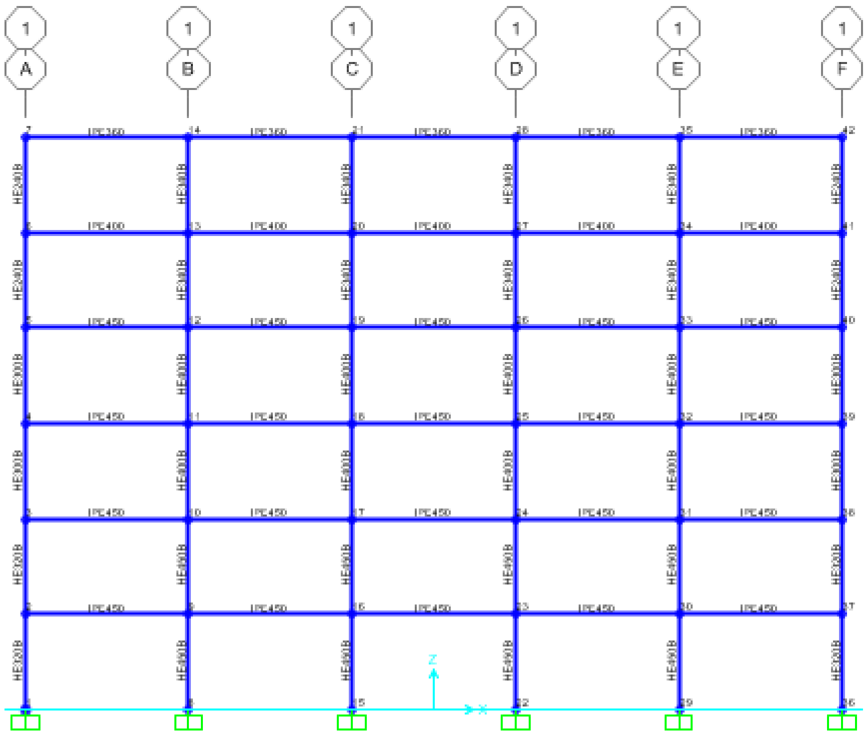

Fig. 1. Frame of a 6-storey reinforcement concrete building

Experimental Procedure

Forced Vibration Testing Procedure

An eccentric masses shaker placed in the store room on the fourteenth level of the high rise in the 1980s was utilized to perform a vibrational test on the structure in 2002 [46]. Since the eccentric masses shaker displayed in Figure 2 is 1.77 meters away from the geometrical center of the structure and perpendicular to the north-south excitation vector, it was possible to characterize both the translational and torsional modes of the building's movement. It generated a horizontal sinusoidal force in a north-south direction throughout a frequency range of 0.15-10 Hz. A max force magnitude of 13 kN (peak to peak of 26 kN) has been utilized to prevent any possible damage to the structure. The shaker was equipped with three distinct sets of masses weighing 10, 20, and 40 kg to generate a range of forcing magnitude transmitted to the structure.

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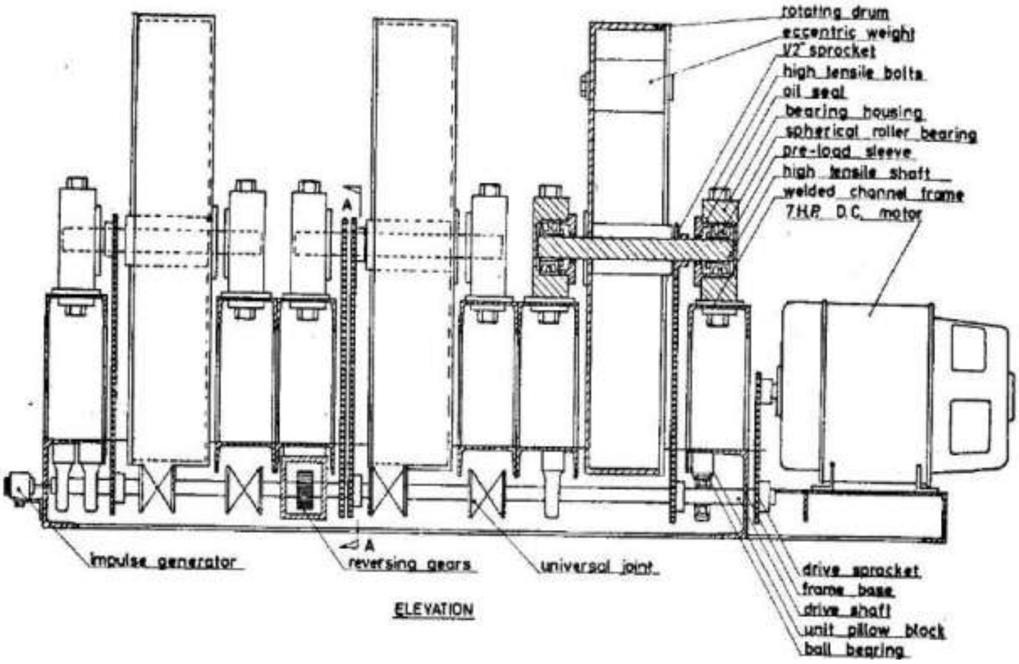

Fig. 2. Original drawing of the eccentric mass exciter [46].

Tests, free vibration decay tests, and frequency sweep tests to achieve modal factors have been three various groups of vibrational tests that have been carried out, with the first two being utilized to measure the resonant frequency and damping proportion and the third being utilized to estimate the mode shape in both torsional and translational directions [46]. The eccentricity mass shaker had been employed to produce steady-state movement at the building's resonance frequencies and then abruptly cut off to conduct free vibration decay testing. Throughout the forced vibration testing, building accelerations have been measured utilizing LCF-100-14.5 uniaxial servo accelerometers with an operational range of 0.25 g and a sampling rate of 1000Hz. Six inertial sensors have been put all around the structure to measure the modal features associated with the initial torsional and translational modes for the frequency sweep tests. An accelerometer has been mounted on level 13 and three accelerometers was placed on level 12 for the second torsional and translational modes. Three inertial sensors have been mounted at level 12 to detect the first torsional mode. Two were placed at levels 12 and 13 to measure the first translational mode for the free vibration decay 8 test. Five accelerometers were placed on levels 13, 12, 9, 6, and 4, and one accelerometer was placed at level 1 to detect the translational modes for the mode shape tests. Two inertial sensors on level 6 and three on level 12 of the building were placed for torsional modes. It ought to be mentioned that to get the mode forms, the structure was agitated at its native frequencies.

Earthquake ground movement sequences

Seismic evaluation of structures requires a correct understanding of the structure's behaviour and ground movements. [47]. The location of some large and industrial communities in earthquake-prone areas of the world and the vicinity of active faults [48] has made the design

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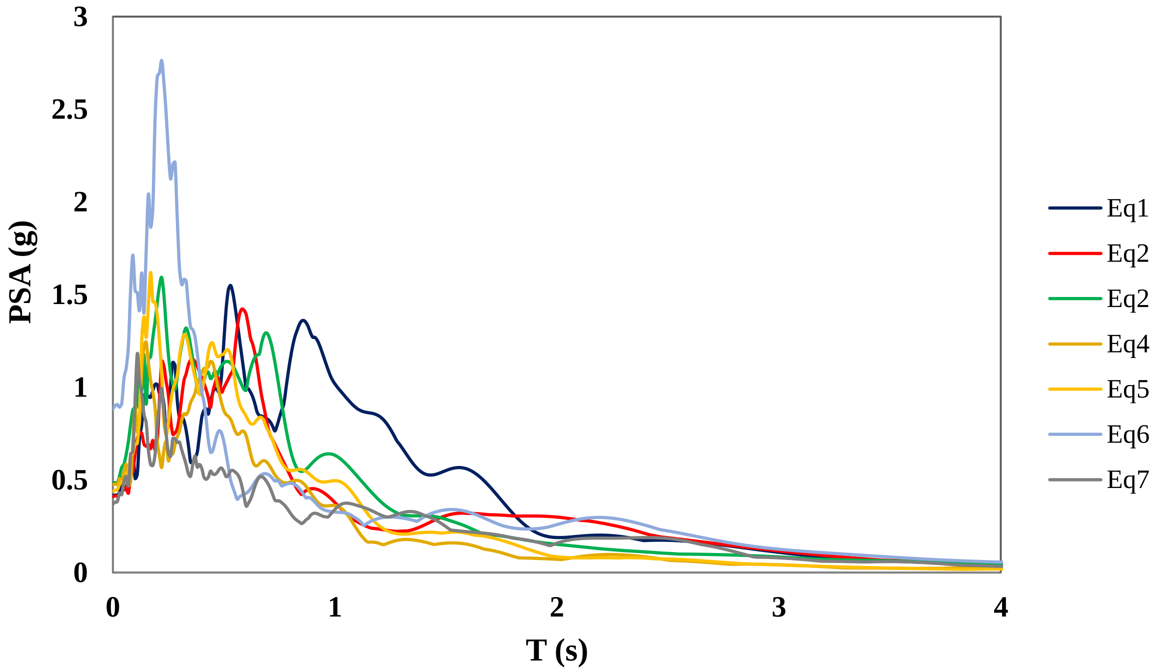
of earthquake-resistant structures to increase the safety of people and reduce damage to infrastructure inevitable. [49]. Therefore, identifying and determining the factors impacting the behavior of the structure is one of the principles of designing and evaluating the seismic performance of the structure and its elements. Structure and earthquake In determining the effective factors, the acceleration maps of past earthquakes are generally used. Factors such as distance, fault rupture mechanism, nature of ground movements, earthquake magnitude, and construction conditions are sometimes of special importance. Simulated ground movements are also utilized where access to sufficient information is limited due to a lack of measuring instruments. [50-53] In the last two decades, various investigations have been performed on the behavior of various structures under earthquake stimuli in near and far faults. Due to the greater impact of near-field earthquake records on structures, many researchers have accepted that the existence of velocity pulses is a good indicator of the nature of near-fault maps. [54] It studies the factors related to structures' inelastic and elastic responses to these maps. Hence, as discussed below, many mathematical models were advanced to obtain these goals.[55]. As can be seen in this frame, seven acceleration, Northridge, hill, lahobra mommoth, parkfield, friuli, and Imperial are utilized, and comparison, the response spectrum for soil II according to fig.3



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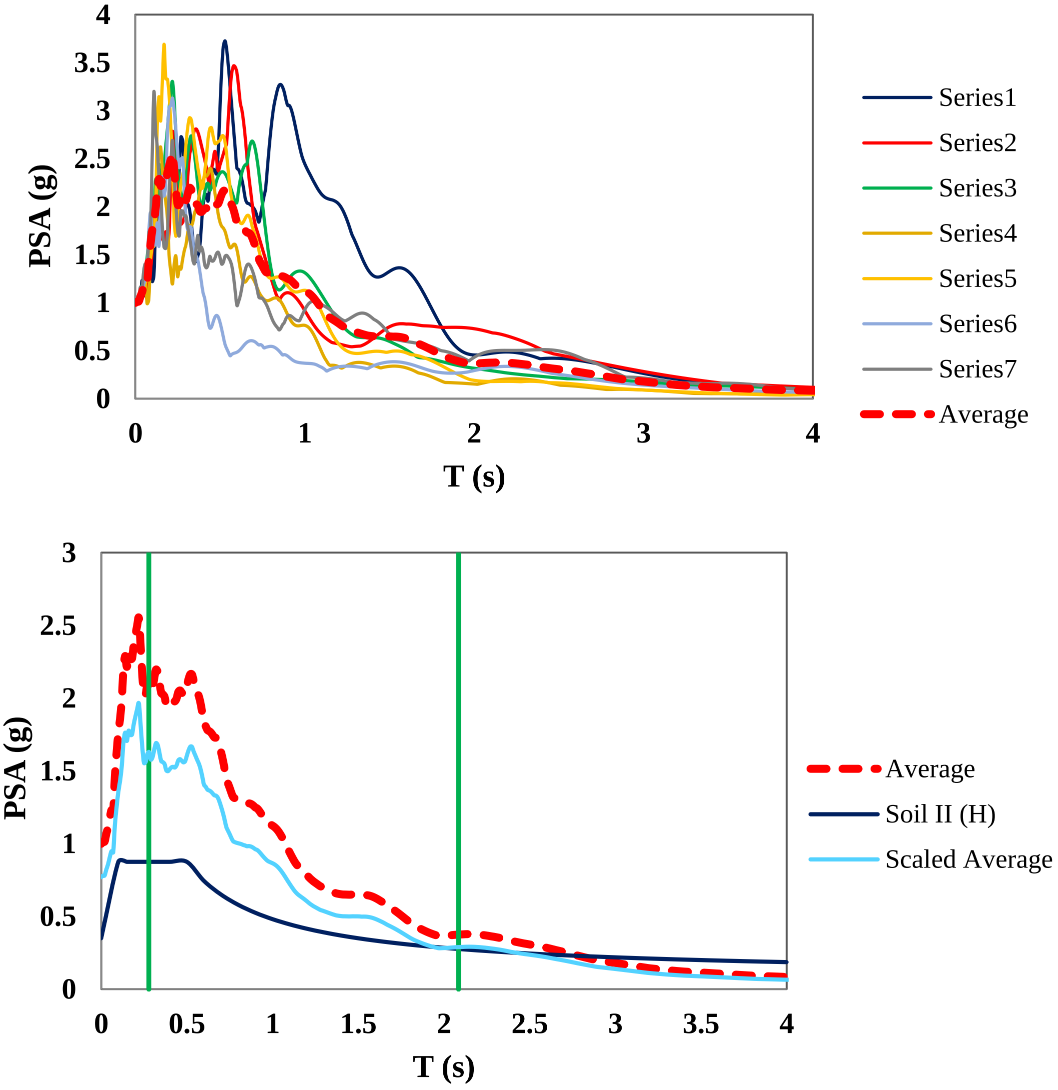

Fig. 3. Comparison of the response spectrum for soil II

Investigation of seismic analysis techniques

There are several techniques for seismic analysis. The variance between these techniques is in the expectation of linear behavior for structural elements and how seismic force is applied. In linear models, the structural elements are assumed to have unlimited strength and constant stiffness during the analysis. In contrast, the reduction of structural strength and stiffness during the analysis is considered in nonlinear models. Also, in static analyses, seismic force is applied to the structure by a static loading pattern, while in dynamic analyses, earthquake loading is done dynamically and based on certain records.

Accordingly, the techniques of analysis are:

1- Dynamic and static line
2- Dynamic and static nonlinearity

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In linear analyzes (behavior of linear materials), only the stiffness and strength of the main members are modeled. Enter.

Although elastic analysis and linear evaluation provide a good view of the capacity of the structure and the position of the first point of surrender, it is nevertheless able to predict the mechanism of structural failure and how redistribution of forces during The surrender is not sequential and do not provide reliable findings on the extent of plastic deformation and consequent structural damage. Therefore, the analysis and design of new and old structures can not be justified with the findings of linear analysis. On the other hand, for a damaged building whose dynamic properties have changed substantially after the earthquake, as well as for buildings that are to be reinforced with new seismic techniques, it is necessary to study the nonlinear behavior of the structure. [56]

Linear Analysis Techniques (LAP)

The accuracy of this technique depends on the degree of irregularity in the building as well as the degree of nonlinearity of the behavior of its components. The ratio of force to member capacity (DCR) can be used to consider these cases.. If applied to the structural model, the deformations resulting from the model analysis are as close as possible to the actual deformations. [57].

Nonlinear Static Technique (NSP)

Nonlinear static analysis and introduction of joint factors can be done in two complete and simplified techniques:

1- In the simple technique, only the main members are modeled, and the reduction influences are ignored (by giving the coordinates of point A and angle α in the form of a two-line diagram).

2- In the complete technique, the main and non-main members are included in the model, and their non-linear behavior is as close to reality as possible. Also, the reduction influence must be somehow entered into the calculations [58].

Nonlinear Dynamic Technique (NDP)

2. SUMMARY AND CONCLUSION

Fiber analysis

Contact with sulfates, chlorides, and other corrosive chemicals has caused catastrophic damage to several reinforced concrete buildings all over the globe. Due to this, replacement, rebuilding, or repairing damaged buildings now comes at a great cost. This problem and its influences are sometimes seen as major societal and technical problems. Millions of dollars have been lost globally as a finding of repairing damaged concrete buildings. Almost 40 percent of roadway bridges in America must be rebuilt or replaced. The cost of renovating or repairing parking structures in Canada is estimated at C $ 4 billion to C $ 6 billion. The cost of repairing highway bridges in the United States is estimated at $ 50 billion. While rebuilding all reinforced concrete structures damaged in the United States due to the problem of corrosion of rebars is estimated

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to have an astronomical budget of 1 to 3 trillion dollars needed! In various parts of Iran, the destructive influences of invasive chlorides and sulfates in marine and coastal environments on bridges, reservoirs, dams, and reinforced concrete canals that cause corrosion of concrete steel cause high costs for the repair or reconstruction of buildings. Now,

Fiber Reinforced Polymers (Plastics) are highly resistant to corrosive environments such as saline and alkaline. FRP composites are the subject of extensive research as a replacement for steel parts and rebars, and prestressed cables. Such research has received considerable attention, especially for structures near water, especially in marine and coastal environments. FRP composite products with excellent resistance to corrosion in harsh and corrosive environments, the attention of many researchers and engineers worldwide as a suitable substitute. Steel parts and steel rebars have attracted water in adjacent structures. Although the main advantage of FRP products is their resistance to corrosion, other characteristics, including high tensile strength, acceptable elastic modulus, low weight, good resistance to fatigue and creep, good insulation and adhesion to concrete, and durability Very well, it is very important and has added to their attractiveness. However, some of the drawbacks and disadvantages of this material, such as the problems associated with bending FRP rods at the reinforcement site, the variance between their thermal properties and concrete, and their linear elastic behavior until failure, should not be overlooked. In general, paying more attention to using FRP composite products in concrete structures built in harsh and corrosive environments, such as aquatic, coastal, and marine structures, will prevent premature and unintended damage and failure of reinforced concrete structures since the corrosion of rebars. [60] Indicates according to Fig. 4. Reinforced concrete frame with FRP under the first mode and plastic hing، Fig. 5. Reinforced concrete frame with FRP under Static analysis and plastic hing.

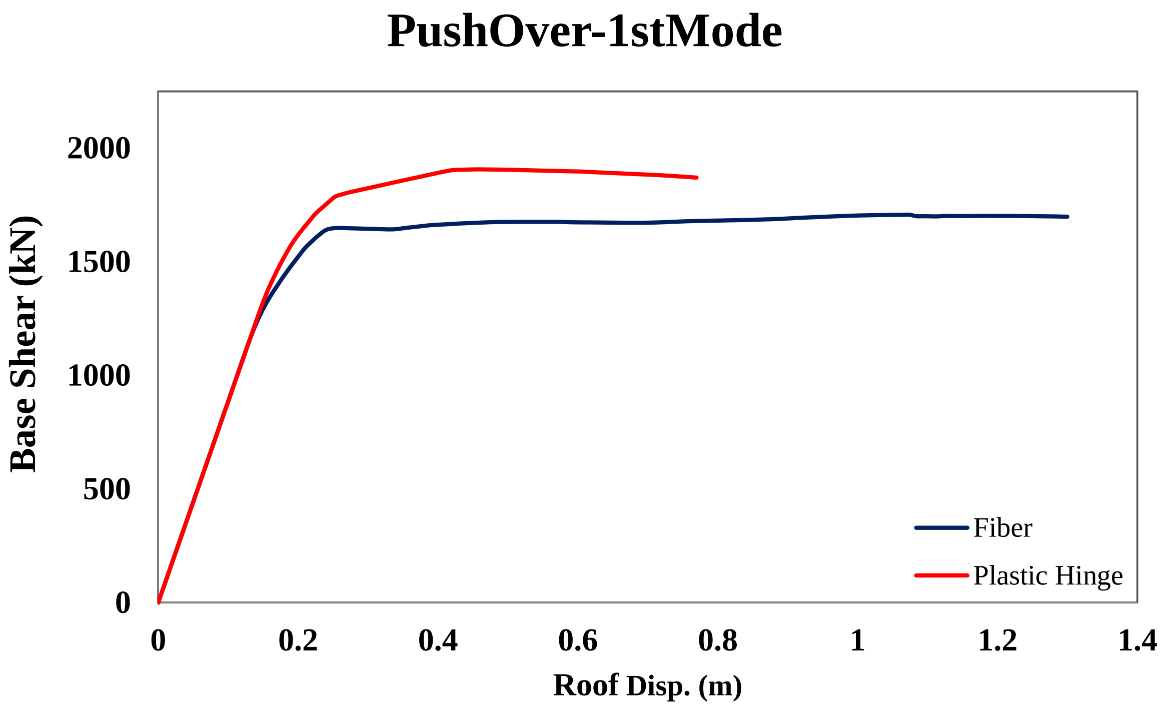

Fig. 4. Reinforced concrete frame with FRP under the first mode and plastic hing

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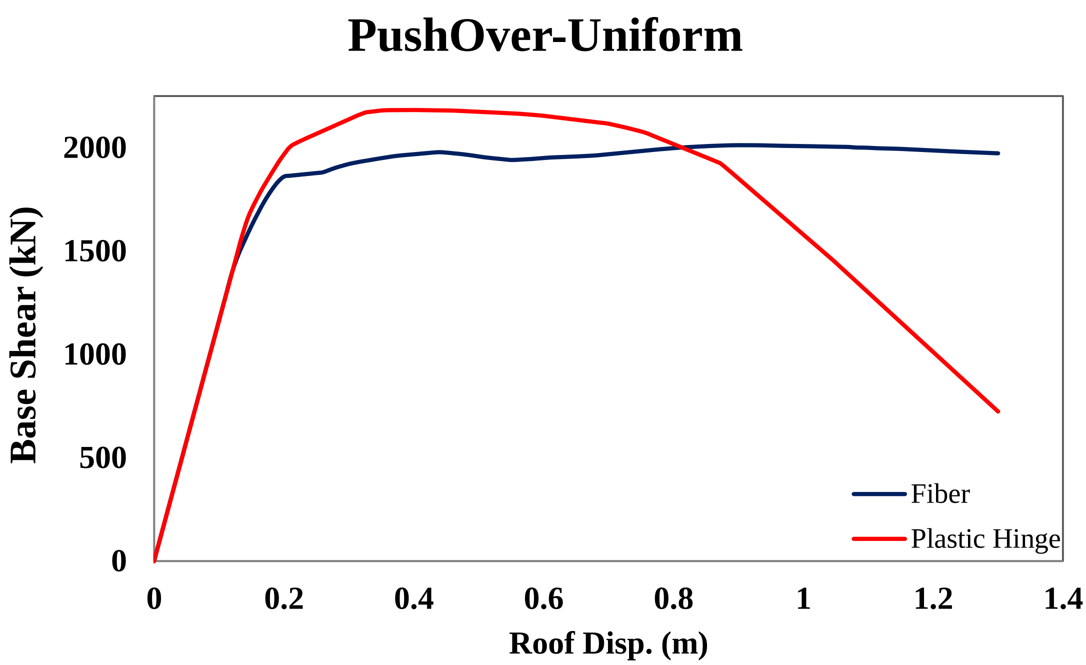

Fig. 5. Reinforced concrete frame with FRP under Static analysis and plastic hing

Static analysis
In this project, the frame undergoing static analysis can be viewed according to Fig. 6. And according to Fig. 7. P- Delta and without considering P- Delta.

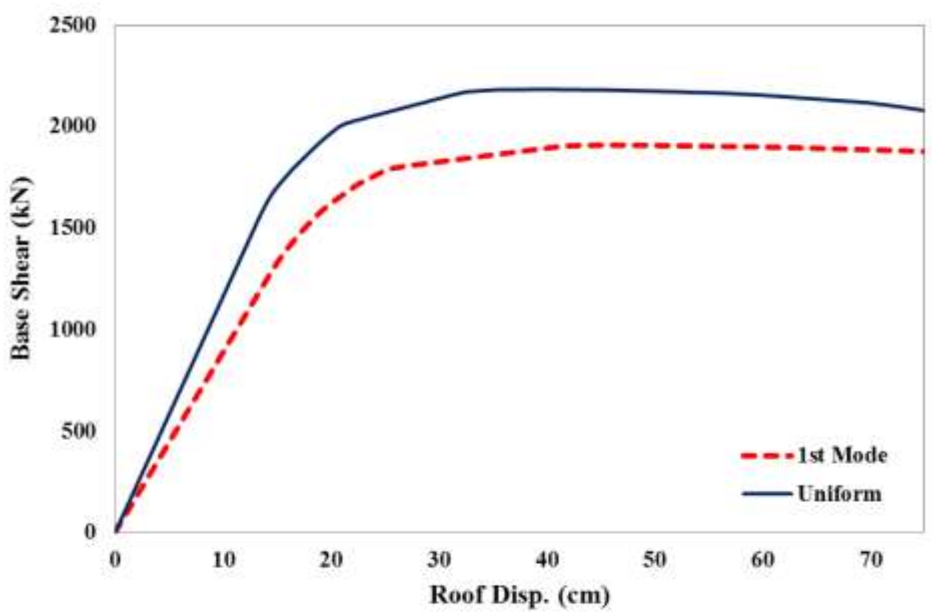

Fig. 6. Reinforced concrete frame under the first mode and push over

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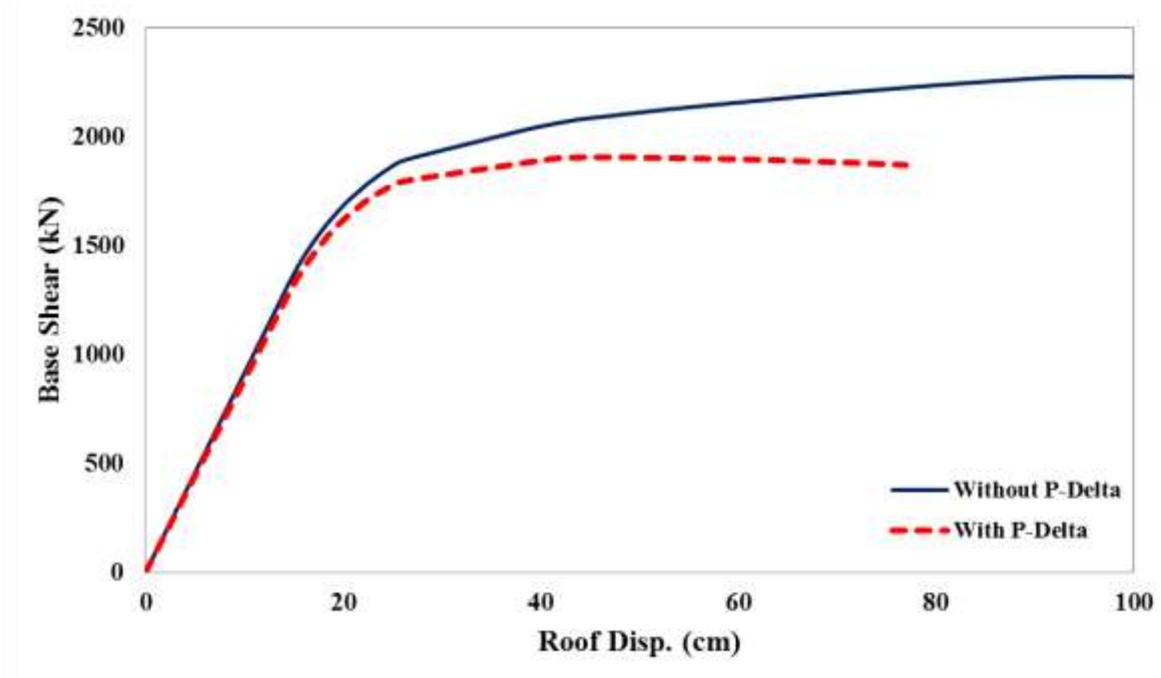

Fig. 7. P- Delta and without considering P- Delta

Nonlinear dynamics analysis (earthquake excitation)

In this project, the frame of a 6-storey reinforcement concretes building under earthquake Northridge hill lahobra mommoth Parkfield friuli Imperial with Sap 2000 software under nonlinear dynamic analysis and its findings can be seen in the displacement and force diagrams according to the following Fig. 8,9.

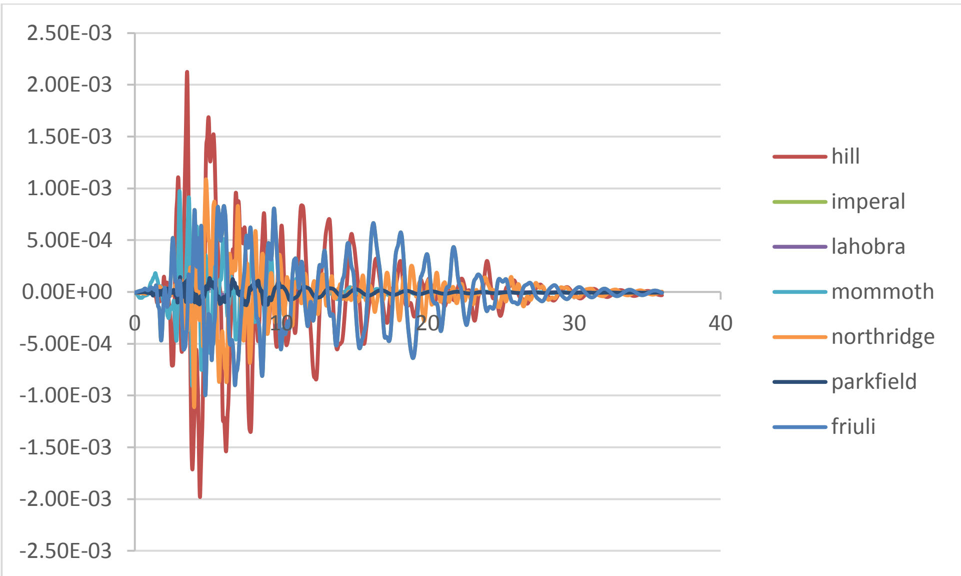

Fig. 8. Displacement of the reinforced concrete frame under earthquake excitation

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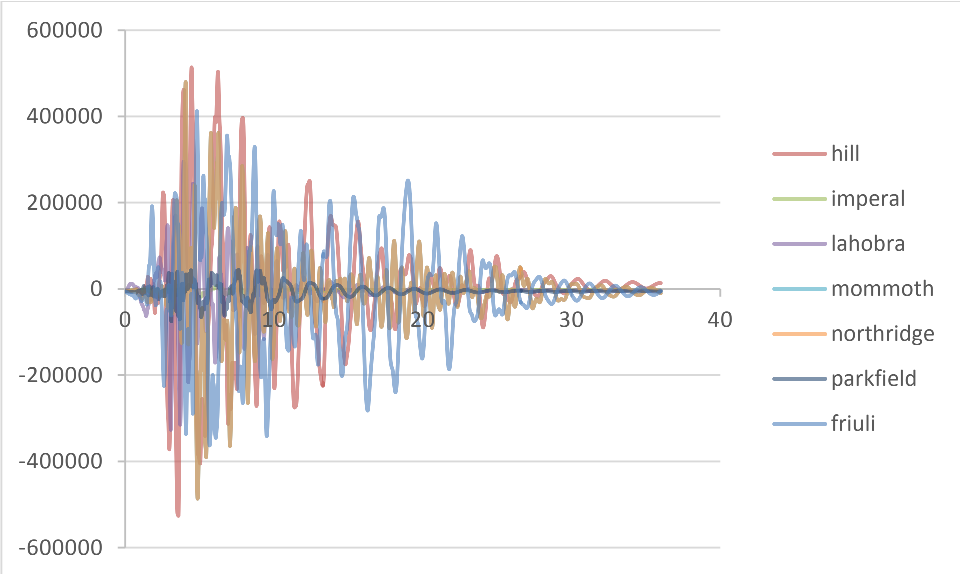

Fig. 9. Force of reinforced concrete frame under earthquake excitation

In this project, according to the above figures, it is concluded that the reinforced concrete frame under the earthquake hill has the most displacement and force in the earthquake. There is much stress on the structure. With an increasing displacement of the structure, internal forces also demonstrate more changes. In most cases, the bending anchor changes of the beams are similar to the changes in the axial force of the columns, except that the anchors increase with greater intensity. By changing the ratio of height to width of the structure in a structure with a certain height, the amount of drift due to seismic load demonstrates little change. Seismicity is completely unpredictable and depends on the applied acceleration map. The variance between the findings related to various acceleration maps is due to the variance in their frequency content. By removing the vertical earthquake's components, the horizontal displacement of the structure without The change remains. Removing the vertical earthquake's components reduces the internal forces of the beams and columns by 10 to 30%.

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