Study of the Impact of Pounding of Steel Moment Frames due to Sequential near- and far-fault Earthquakes

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ABSTRACT

Seismic codes, the pioneers in presenting seismic criteria in the nonlinear behavior of structures, usually address less the two main factors. The first accident hits adjacent structures, which can be a severe nonlinear cause, and regulations are usually used to execute the program on adjacent structures, a discontinuous seam between two adjacent structures, but if necessary, the effect of adjacent buildings with discontinuous joints is recommended. Or, no suggestion is made and second, the sequence is executed. In this paper, in order to investigate the impact of adjacent steel bending structures due to successive earthquakes near and near the fault, six pairs of steel frames with different heights, with and without height differences on the ground floor have been used. These frames have been evaluated using nonlinear time history analysis under the effect of 24 consecutive earthquakes in the near and far faults in the form of three sequential seismic composition scales that have been scaled according to the fourth edition of the 2800 standard. The results of the study showed that the seam of the regulation did not prevent adjacent frames from colliding with each other and needed to be reviewed, but compared to the frames in contact, which in most cases led to the collapse of the frame, it is more suitable and reduces damage. . Impact force changes the behavior of adjacent colliding frames relative to the expected behaviors of the frames without impact (separate frames) and exhibits different responses.

KEYWORDS

Discontinuous joint, Gap element, Sequential earthquake, Far fault, Near fault.

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1 Introduction

Numerous parametric studies have been performed on the collision responses of buildings as well as proportionate measures to reduce the risk of seismic damage in adjacent buildings. The impact effect is investigated using a linear and nonlinear contact force model for different separation distances. Impact intensity depends on the dynamic properties of adjacent buildings in combination with seismic properties [١]. The acceleration and shear stress forces created by the collision at different levels of the floor are greater than those obtained from the non-collision mode, while the relative displacement depends maximally on the input excitation properties. Also, increasing the seam width will probably be effective when sufficient separation is intended to eliminate the impact [٢] . In addition, the provision of a shock absorber system to reduce the impact effects between adjacent buildings with seismic joints was considered effective and the impact force applied to adjacent buildings was satisfactorily reduced. The study of damage estimation in steel buildings in the main earthquake-aftershock sequences has been considered by other researchers [٣]. They presented a framework for estimating the damage of steel structures under the main earthquake-post-earthquake sequence, showing that the maximum relative displacement between the obtained classes in nonlinear dynamic analysis is used as an engineering demand parameter to determine the damage status. Even if aftershocks have little influence on structural behavior, their impact on seismic damage due to uncertainty in damage condition and cost estimation may still be significant [٤].

2 Material and Method

The impact force of a frame is applied to the adjacent frame in a short period of time, part of the impact force of each frame is consumed between the two frames and the other amount, depending on the condition of the structures, causes the destruction of the structure or non-structural elements. For this reason, studies on impact force between adjacent structures have been of particular importance.

In some studies, the link element at the point of collision of two structures has been used to estimate the impact force, while the impact results of this element have not always been error-free due to the nature of tensile-compressive behavior. This caused the chat element to be used between structures instead of the link link element. The difference between this element and the link link element is that the chat element does not store any force in the tensile behavior of the link link element and practically ignores the tensile behavior. The structure is more compliant.

The studied models are two three-dimensional models with the letters FA and FB, 4 floors, with an opening (floor height 0.15 m, width of each opening 0.2 m and depth 0.15 m) which in SAP2000 software [۵] were modeled. In the F-A model, the added mass is equivalent to 6.5 kg per floor. For the column sections, steel (S400) with modulus of elasticity $2.05 \times 10^{11} N/m^2$ and poisson coefficient of 0.3 has been used. The cross section of the column is rectangular in size (0.03m x 0.015m).

The distances between the two models (discontinuous seam width) are 2, 5 and 7 mm, respectively. The stiffness of the element is equal to K=0.7GN/m. Nonlinear time history analysis is direct integration. The number of time steps (Time step data) is equal to 60,000 with a step of 1/10000.

3 Results and Discussion

The study shows that in a pair of 5-story frames adjacent to 3 floors, the results showed that in longer frames, the combination of seismic loads, including near-ground earthquakes in the contact mode of two frames, increases maximum frame displacement and in long-range earthquake loads reduces maximum long frame displacement. And by observing the seam of the code between the two frames for a longer frame, except for the combination of earthquake loads B3 and C3, no significant changes were observed. In the shorter frame, in both contact frame and frame, observing the seam of the regulation, it was observed in the analysis that the maximum displacement of the frame in the combination of distant earthquakes increased the displacement and in the combination of near earthquakes decreased the displacement.

In the pair of 8-story frames adjacent to the 3-story frame, the results showed that in the taller frame, the frame was in contact with the frame and the frame was reduced by displacing the seismic loads in the combination of far and near earthquakes. It should be noted that the reduction in the displacement of a maximum of one frame indicates the inadequacy of the seam of the regulation and the occurrence of repeated unprofessional collisions of the face in a forward motion or the face of one frame behind the other frame in a one-way motion.

In some scenarios, the structure collapses when the adjacent frames strike in contact mode under sequential earthquake. The results of the analysis show that the response of adjacent structures is very sensitive to the size of the discontinuous joint and by changing the discontinuous joint in the range of impact, the lateral displacement of the structure changes. The lateral displacement of each adjacent frame is sensitive to the earthquake scenario. For example, the scenario that causes the maximum displacement of the taller frame may not be the same as the scenario that causes the maximum displacement of the short frame.

4 Conclusion

The results showed that in most sequential earthquakes whose main earthquake is close to the type of earthquake, the highest amount of impact has occurred. In general, the absence of discontinuities between the frames in contact, which have different dynamic properties, made the impact of the frames on each other more critical, and in some cases, the combination of sequential Observing the seam of the regulations in adjacent frames in all cases has not prevented the adjacent frames from hitting each other and needs to be reviewed, but it has reduced the number of frames hits over time due to the earthquake and the structures will not collapse. The difference between the critical seismic compositions that produce the maximum impact force of adjacent frames to each other indicates the sensitivity of the impact phenomenon to the composition of adjacent frames and sequential earthquake records as well as where the frames collide with each other. earthquakes caused the structure to collapse.

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