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Seismic behavior of RBS connections at near and far field earthquakes

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Abstract

Moment-resisting frames have extensive usage in earthquake-prone areas and high ability in energy dissipation. After the earthquake in Northridge 1994, Kobe 1995 fixed connections of steel structures have shown poor performance and generally they were caught brittle fracture of beam flange weld to the column. In order to remedy to avoid similar situations in future earthquakes, researchers introduced connection with reduced beam section in name of RBS(Reduced Beam Section),that stress concentration at the junction can be prevented by reducing the local section of beam in the vicinity column and location of plastic hinge transferred from connection to the distance from the column.

In this research, firstable the three special steel moment-resisting frames of three-dimension 5,10 and 15 story with seismic compressed sections as RBS was analyzed as time history by using SAP software at the near and far field earthquakes with and without considering the effect of vertical component,then a critical connections in each of the frames was modeled by ANSYS software and it was analyzed as dynamic under obtained loads from each record(in SAP).

The study results showed that the vertical component put negative effects on the performance of this type of connection in terms of concentration of stress, strain and ductility.It is necessary to say that the negative effect of the vertical component on the connections at near field earthquakes was comparatively more than at far field earthquakes.

Keywords: Near field, Far field, Reduced beam section, Vertical component, RBS connection.

1. Introduction

Earthquakes near fault, especially the path leading to rupture caused serious damage to structures, particularly structures with high period due to the movement of the pulse with high period, also the earthquakes Chi-Chi, Kobe, Duzce and Northridge was observed experimentally and also this caused the major factor as one of the determining factors in urban science be used.So,Smolka and Rauch(1996) presented in an article by studying the Northridge earthquake in California and Kobe in Japan that the modern urban areas are considered and Damage caused by these earthquakes, the effect of proximity to faults and placement of buildings on the fault rupture was introduced as one of the most important factors for future development of large cities[1].

Studies on the structural response earthquakes near fault is proved that the analysis is based on the time history is better than response spectrum Analysis because response spectrum analysis expresses the frequency domain specifications of the earthquake process which has a relatively uniform distribution of energy during movement [2].

Therefore, when the energy is concentrated in a few pulses of the movement, Resonance phenomenon that was supposed to show the response spectrum has no sufficient time to form[2].

Structures that are designed according to the ordinary basic forces presented in the current seismic regulations in no way cannot provide this required high displacement because displacement earthquakes near fault is high[3].Therefore, studying records near fault and put the effects of these records in seismic regulations and improve the capacity of structures for the needs of seismic near fault displacement has been the subject of research recent decade.

2. Design of specimens

The three special steel moment-resisting frames of 3-D 5,10 and 15 story were used. Used sections are designed as seismic compressed sections and for beams as Plate Girder and for columns from plate as Box.Span and height frames are respectively 5 and 3.3m.Gravity load on beam and shear and moment as Time History for each accelerograms(Tables 1 and 2) are taken from SAP and they are applied on the connections, the beams and columns in ANSYS. In ANSYS specimen was modeled the connection with the related beam and column.Column supports are as fixed and rolling and tip of beam support

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is as rolling too. Column height and beam length is respectively 6.6 and 2.5m (figures2,3 and 4).
An element Solid from workbench of ANSYS element library was used for the 3-D finite element modeling of the RBS with radius cut moment connection.

Table 1.Near field FD[1]-Pulse earthquakes[4]

Earthquake	Station	Magnitude	Distance(km)	Time(s)	Max PGA
Loma Prieta	LGPC	6.93	3.88	25	0.966g
San Fernando	Pacoima Dam	6.61	1.81	41.63	1.159g
Northridge	Pacoima Dam	6.69	7.01	39.98	1.585g
Tabas	Tabas	7.35	2.05	32.82	0.852g
Kobe	KJMA	6.9	0.96	47.98	0.821g
Kocaeli	Duzce	7.51	15.3	27.18	0.357g
Morgan Hill	Coyote Lake Dam SW	6.19	0.53	29.95	1.298g

Table 2.Far field earthquakes

Earthquake	Station	Magnitude	Distance(km)	Time(s)	Max PGA
Parkfield	Temblor	6.19	15.96	30.32	0.337g
Chi-Chi	TCU039	7.62	19.89	89.995	0.206g
Duzce	Lamont375	7.14	3.93	41.49	0.97g
San Fernando	Lake Huges#12	6.61	19.3	36.59	0.365g
Landers	Joshua Tree	7.28	11.03	43.98	0.284g
Loma Prieta	Anderson Dam	6.93	20.26	39.57	0.243g
Northridge	Pacoima Kagel Canyon SW	6.69	7.26	39.98	0.432g

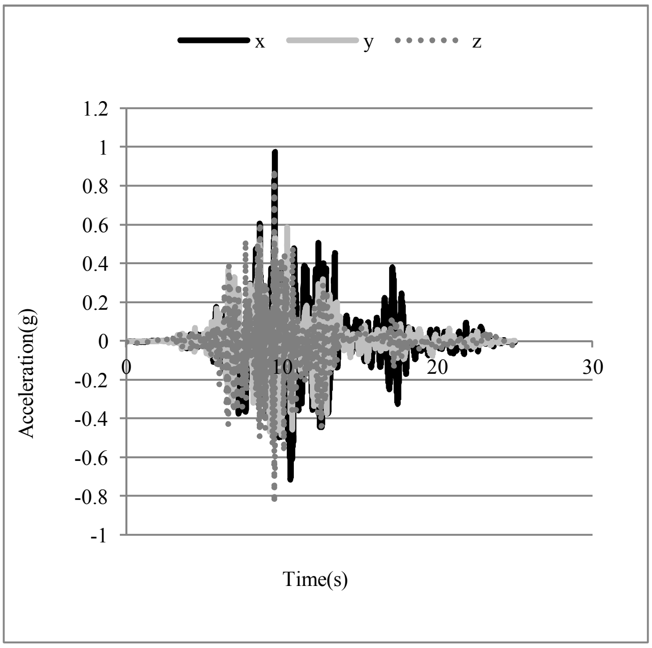

Figure 1. Acceleration Time History, Loma Prieta earthquake, (near field),horizontal and vertical directions

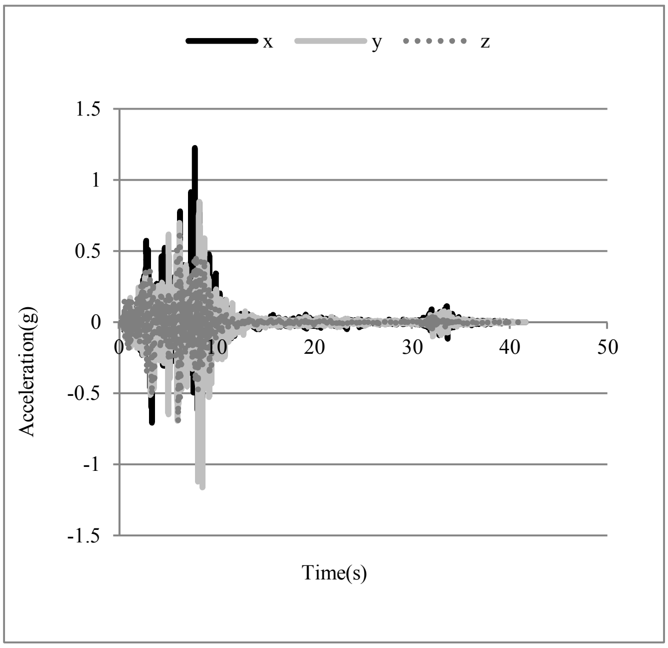

Figure 2. Acceleration Time History, San Fernando earthquake, (near field),horizontal and vertical directions

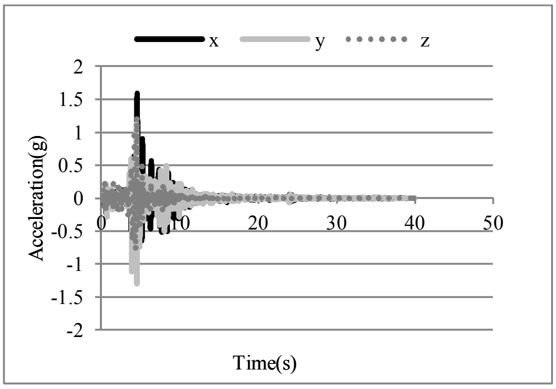

Figure 3. Acceleration Time History, Northridge earthquake,(near field),horizontal and vertical directions

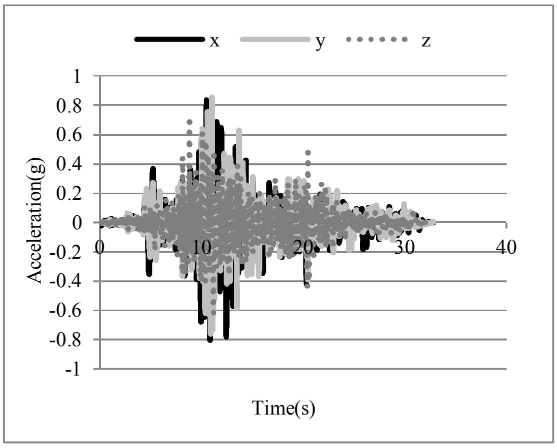

Figure 4. Acceleration Time History, Tabas earthquake,(near field),horizontal and vertical directions

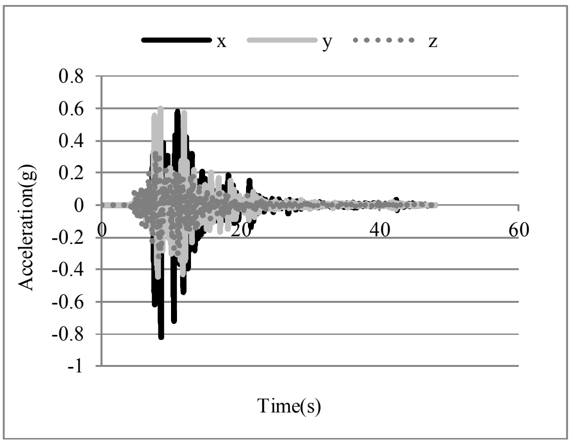

Figure 5. Acceleration Time History, Kobe earthquake,(near field),horizontal and vertical directions

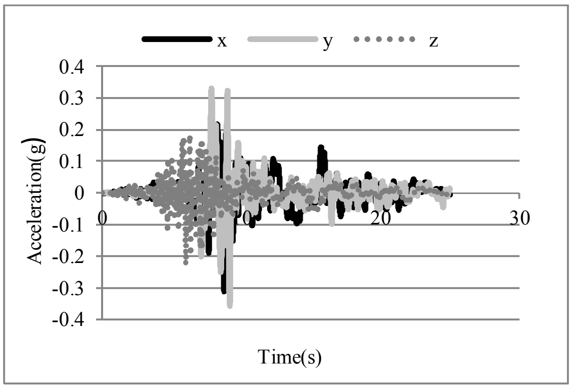

Figure 6. Acceleration Time History, Kocaeli earthquake,(near field),horizontal and vertical directions

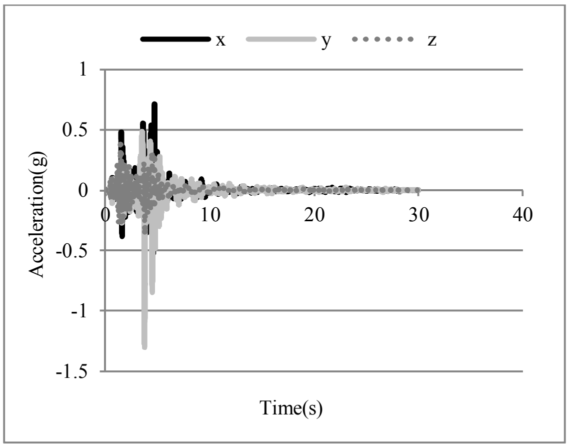

Figure 7. Acceleration Time History, Morgan Hill earthquake,(near field),horizontal and vertical directions

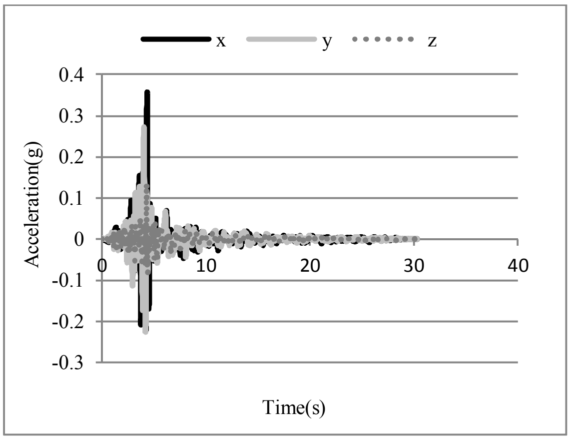

Figure 8. Acceleration Time History, Parkfield earthquake,(far field),horizontal and vertical direction

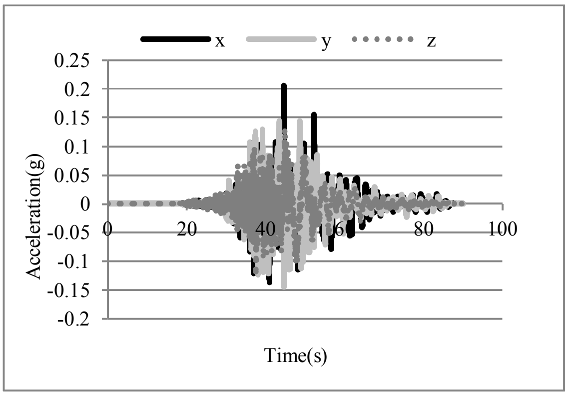

Figure 9. Acceleration Time History, Chi-Chi earthquake,(far field),horizontal and vertical directions

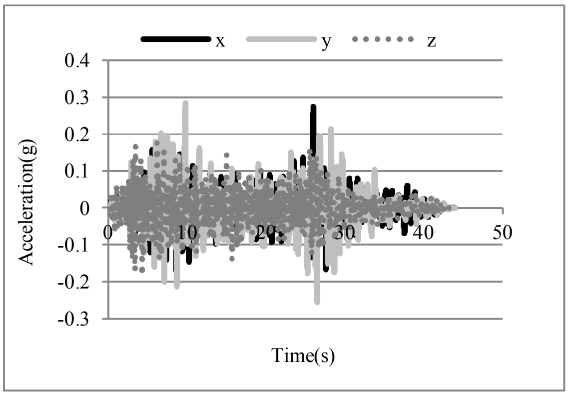

Figure 12. Acceleration Time History, Landers earthquake,(far field),horizontal and vertical directions

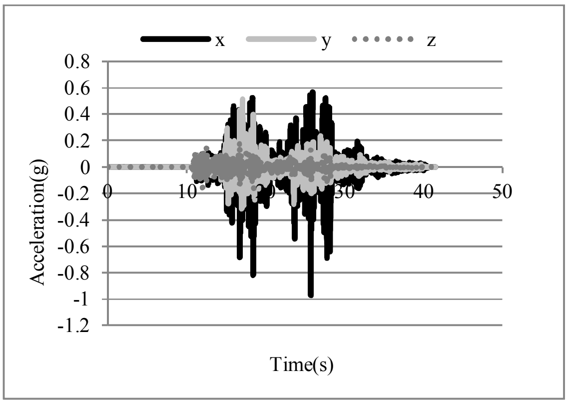

Figure 10. Acceleration Time History, Duzce earthquake,(far field),horizontal and vertical directions

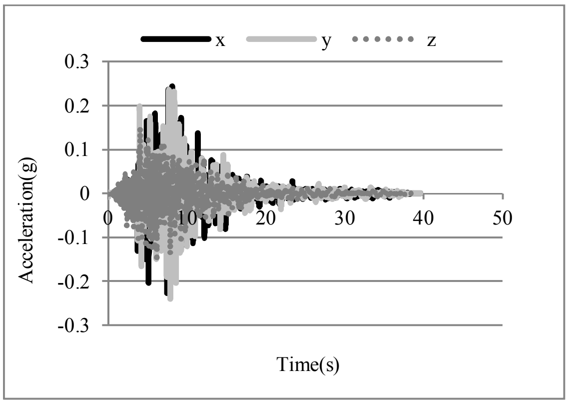

Figure 13. Acceleration Time History, Loma Prieta earthquake,(far field),horizontal and vertical directions

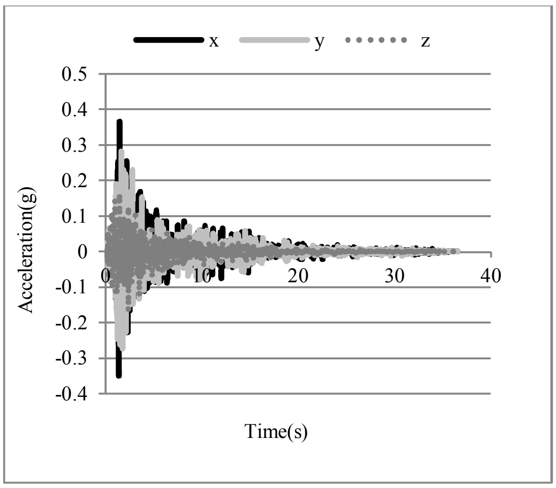

Figure 11. Acceleration Time History, San Fernando earthquake,(far field),horizontal and vertical directions

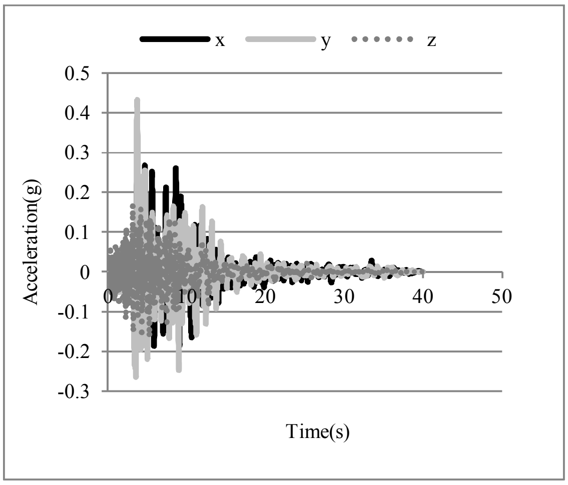

Figure 14. Acceleration Time History, Northridge earthquake,(far field),horizontal and vertical directions

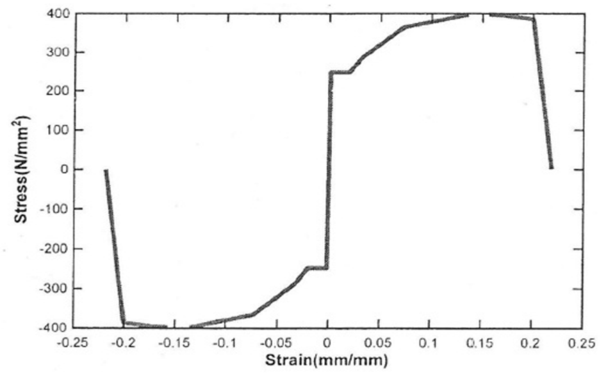

Figure 15. A36 Steel material stress-strain curve[5]

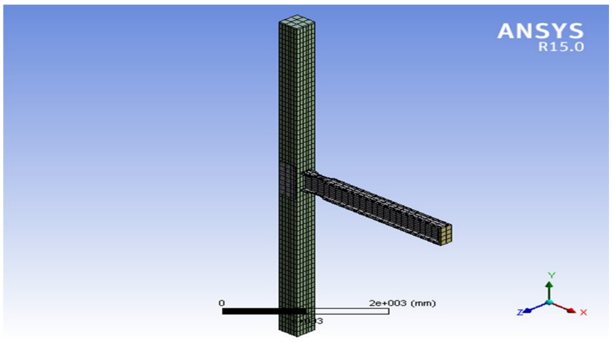

Figure 16.Example of meshing corner connection of RBS with radius cut in the5-story frame

Table 3.Select members for corner connection of RBS with radius cut in the5-story frame[6,7]

Profile	Member	RBS dimensions(cm)			
		a	b	c	R
Box300PL18	Column	-			
P.G (2*180*12+340*10)	Beam	9	30.94	4.5	28.84
P.L(700*270*10)	Double Plate	-			

a=The distance from the corner of the connection to the start of the RBS cut
b=The length of the RBS cut
c=The depth of the RBS cut
R=The radius of the RBS cut

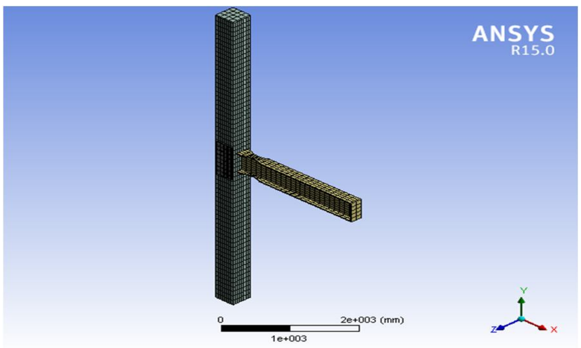

Figure 17.Example of meshing corner connection of RBS with radius cut in the 10-story frame

Table 4.Select members for corner connection of RBS with radius cut in the10-story frame[6,7]

Profile	Member	RBS dimensions(cm)			
		a	b	c	R
Box350PL25	Column	-			
P.G (2*200*18+400*15)	Beam	10	37.06	5	36.83
P.L (750*320*10)	Double Plate	-			

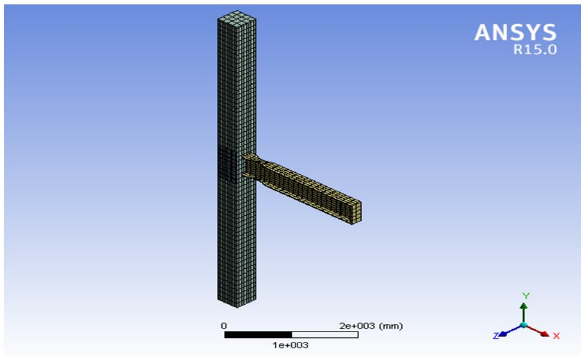

Figure 18.Example of meshing corner connection of RBS with radius cut in the 15-story frame

Table 5.Select members for corner connection of RBS with radius cut in the 15-story frame[6,7]

Profile	Member	RBS dimensions(cm)			
		a	b	c	R
Box400PL25	Column	-			
P.G (2*200*16+400*10)	Beam	10	36.72	5	36.21
P.L(750*370*10)	Double Plate	-			

3. Study accomplished analyses by ANSYS

In the following figures, Results von-mises stress and plastic strain of accomplished dynamic analysis on RBS connections at near and far field earthquakes has been compared together.

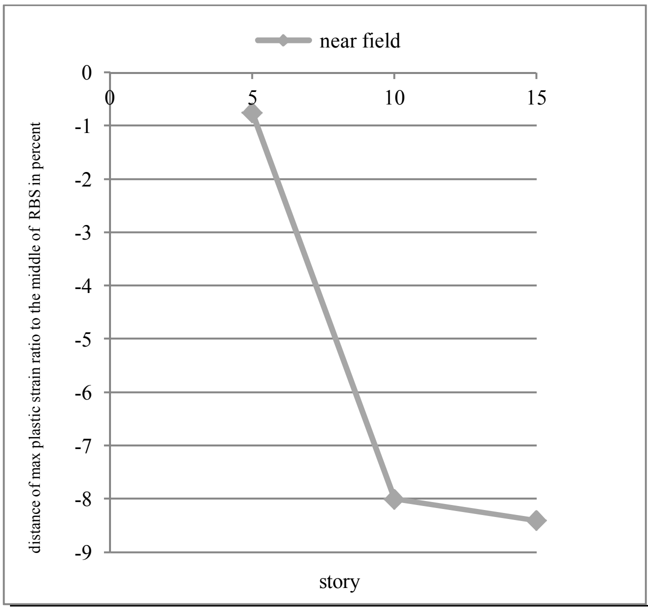

Figure 19.Averagedistance of max plastic strain ratio of the distance to the middle of RBS in the corner connections of5,10 and 15-story frame at near field earthquakes with considering vertical component to without considering vertical component

According to Figure 19, the vertical component had have a negative effect in three connections,Of course this negative effect in connections of 10 and 15-story frame is more than connection of 5-story frame.

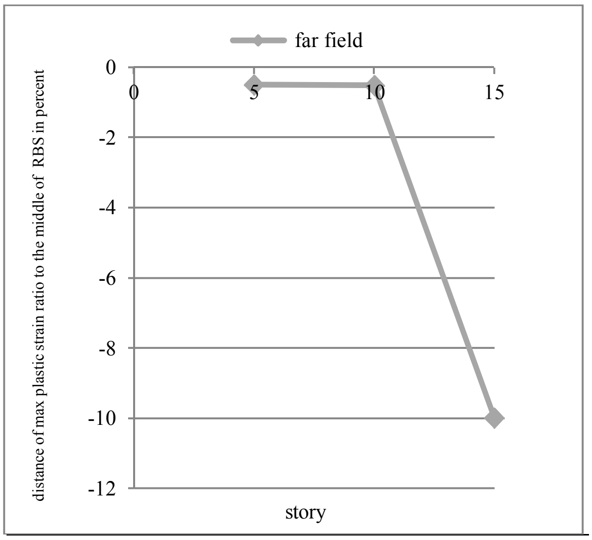

Figure 20.Average distance of max plastic strain ratio to the middle of RBS in the corner connections of 5,10 and 15-story frame at far field earthquakes with considering vertical component to without considering vertical component

According to Figure 20, the vertical component had a negative effect in three connections,of course this negative effect in connections of 10 and 15-story frame is negligible but for connection of 5-story frame is noticeable.

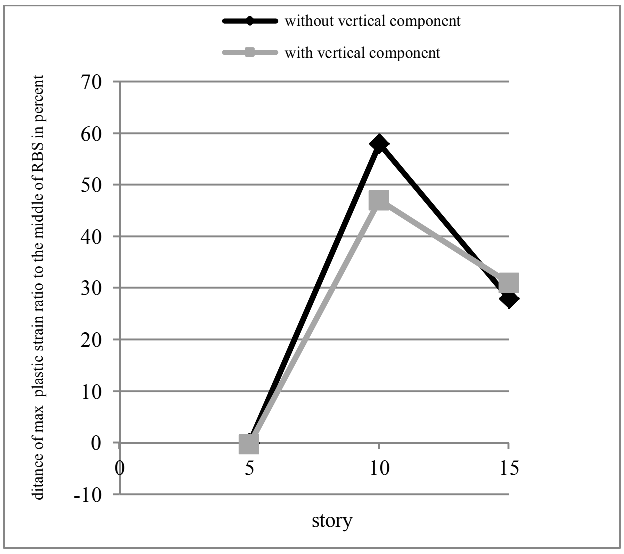

figure 21.Average distance of max Plastic strain ratio to the middle of RBS in the corner connections of 5,10 and 15-story frame at near field earthquakes with and without considering vertical component to similar connections at far field earthquakes with and without considering vertical component

According to Figure 21,It can be seen that the negative effect of the vertical component in the corner connection of 10-story frame with a difference of about 13%over the same connection without vertical component is obvious.

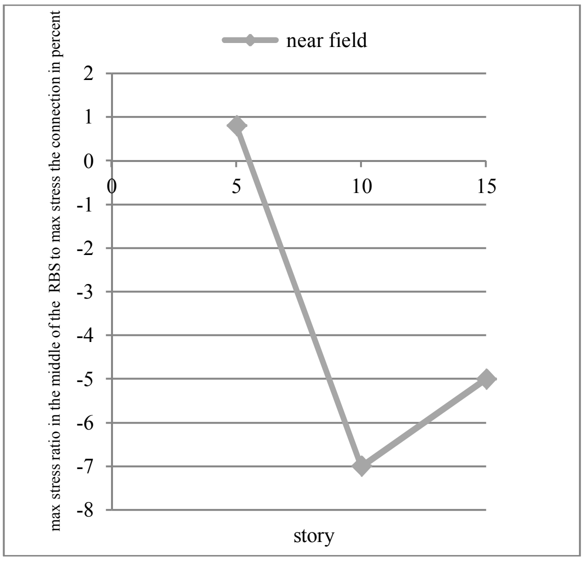

Figure 22.Average max stress ratio in the middle of the RBS to max stress in the beam-column connection in the corner connections of 5,10 and 15-story frame at near field earthquakes with considering vertical component to without considering vertical component

According to Figure 22, the vertical component had have a negative effect in connections of 10 and 15-story frame,of course this negative effect in connections of10-story frame is more than 15-story frame.

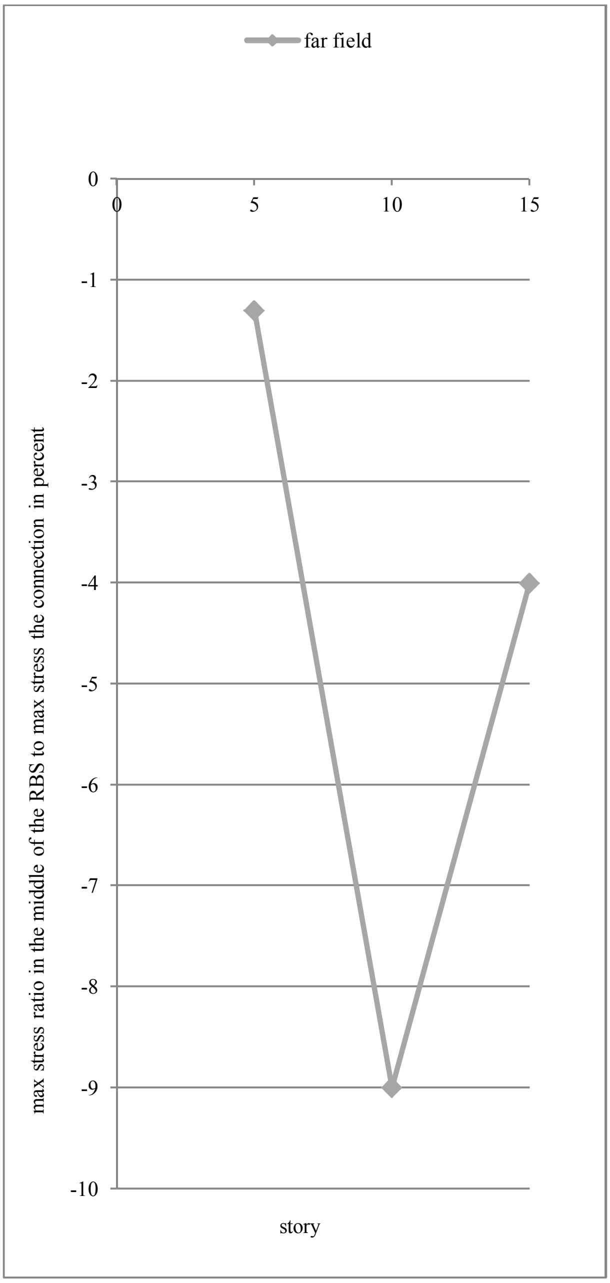

Figure 23.Average max stress ratio in the middle of the RBS to max stress in the beam-column connection in the corner connections of 5,10 and 15-story frame at far field earthquakes with considering vertical component to without considering vertical component

According to Figure 23, the vertical component had have a negative effect in three connections, that this negative effect in connection of 10-story frame is more than two other connections.

According to Figure 24, It can be seen that the vertical component for near and far fields in the corner connection of mentioned frames has had a little difference with ratio of without vertical component for near and far fields in the corner connection of the same frames.

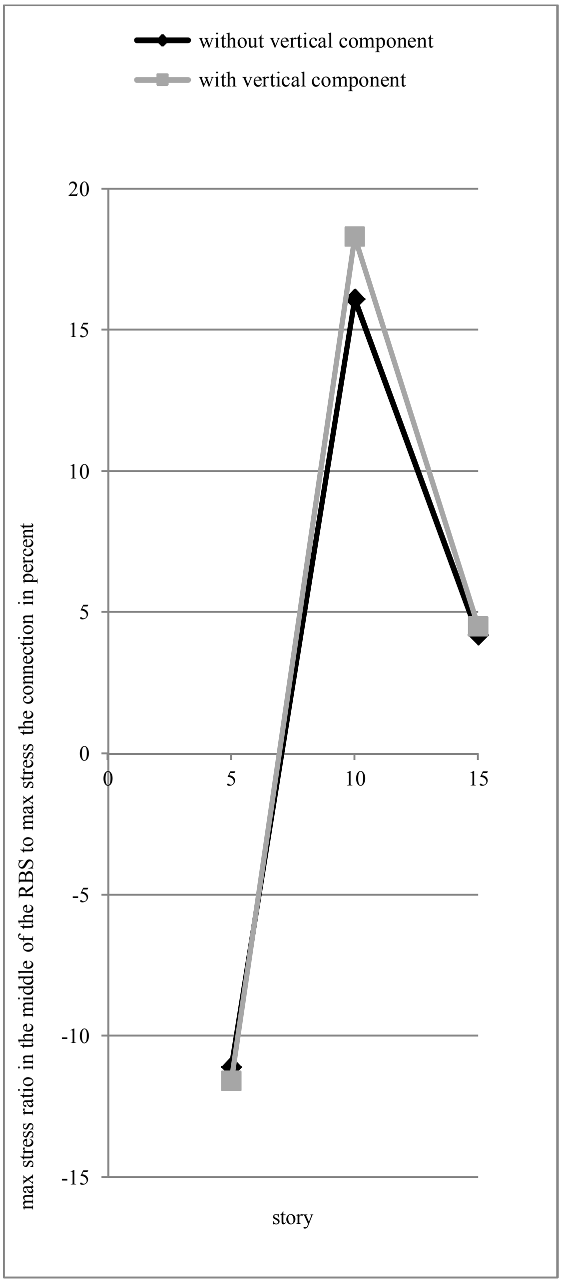

Figure 24.Average max stress ratio in the middle of the RBS to max stress in the beam-column connection in the corner connections of 5,10 and 15-story frame at near field earthquakes with and without considering vertical component to similar connections at far field earthquakes with and without considering vertical component

4. Conclusions

According to mentioned items, the impact of near field earthquakes compared with far field earthquakes in the range of assumptions is as below.

1. Corner connection of 10 and 15-story frame at near and far field earthquakes without considering vertical component have shown better performance in terms of stress and strain compared to corner connection

similar frames at near and far field earthquakes without considering vertical component,so it shows vertical component has negative effects on the performance of structures during an earthquake.

2. Negative effect of vertical component at near field earthquakes was comparatively more than connection mentioned frames at far field earthquakes.

3. Plastic hinge is formed out of reduced section when gravity load place on the beam with RBS connection.

5. References

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