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The effect of Vertical component of earthquake on the long span frames

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ABSTRACT: Registered records in the near-by fault areas indicate sever vertical ground motion. The near areas' earthquakes, due to their destructive effects , are distinguished from the far areas' ones. The importance of this issue will be more noticeable in the seismic survey about long span frames. In this approach, the effect of vertical earthquake component on the long span frames is considered by simulating of 2 structures with different spans and by using Sap and Perform software. In such a way that at first we put structures under effect of vertical earthquake components and we measure the value of anchor, shear, axial force of column, crater fall etc. At next stage, we add horizontal earthquake component and then consider again mentioned values. By comparing, it is concluded that the vertical earthquake component had increasing role at above mentioned values.

***Keywords*:** Vertical component of earthquake, Horizontal component of earthquake, The long span frame.

INTRODUCTION

In the recent years, researchers have conducted a lot of research about the effects of vertical earthquake component on the seismic response of structures. Many researchers consider the effects of this component as a coefficient of the horizontal component of earthquake (V / H). One of the first person who examined the ratio of vertical and horizontal components was Newmark. He introduced this ratio, equal to 0.67 (Gonzales et al. 2005). Investigation show that the ratio in distances far from the fault is conservative and in close distances, is in a lower level. In some cases, the effect of vertical earthquake component is considered as a percentage of dead load. But it has a lot of error because the different part of structures are not on the same ratio of the dead load and vertical earthquake component.(SadrAra, 2013)

Background research

Ruiz and Sariya, (2004) were who studied the effect of horizontal and vertical earthquake components on Industrial large frames of industrial crater. They examined the seismic response of structure by inserting the earthquake component on the frame of a building by SAP2000 software and finally, They achieved some results that are followed in near field structures, the effect of vertical component is more than the horizontal earthquake component . And The long span structures can be have a critical damping factor which is less than 5% (about 1.5 to 2%). Because losing energy can cause to allotment reduction in some members

Mazza and Vulcano, (2004) in an article titled: the Effects of the Vertical Acceleration on the Response of Base-Isolated Structures Subjected to Near-Fault Ground Motions, examined a five story building with a base isolated system in a high seismic risk, they studied the vertical to horizontal values of acceleration at the peak. The conclusions show that, when vertical component of ground motion are considered, the separator can tolerate tension loads. Histogram indicates that, when the place of separator is ignored, the load varies. Beresno et al, (1997) studied the vertical vibration of 5 earthquakes in California and tried to conclude that compressing P waves ranged at alternative term, less than 0/1s and the shear S waves ranged at different periods more than 0/1 s, can affect on vertical earthquake component.

Robinson, (1993) studied the effects of vertical earthquake component in frames through an article. He examined the effect of horizontal and vertical components of Elcentro earthquake in the 4, 12 and 24 storey building by modeling and analysis. He concluded that the vertical component of earthquake increases the shear force, bending moment of beams and the axial force of columns. So these factors must be considered in design.

Huldar and Reyes-Salazar, (2000) examined the effect of vertical earthquake component on the seismic response of structures in both Mexico and NEHRP regulations. In this study, they concluded that these regulations are remarkably underestimated the axial forces of columns. The underestimation of the axial load columns increases with the development of plastic hinge frames. The underestimation for interior columns is greater than exterior columns.

Ghafouri Ashtiani and Singh, (1984) studied the effect of six correlation components on the seismic response of structures. In their studies, they offered a method for calculating the structural response under the influence of six correlation earthquake components and noted that in the Panzin and outabe's model the correlation between the components of the rotational and translational motion is correlated. The rotational component of ground motion can be expressed as a function of vibration by transmission components. The share of the rotational component of ground motion can have a vast effect on the structural responses and increases the speed of shear waves which is reduced the effect of rotational component.

Vertical component of earthquake

Profile of Vertical earthquake Component is different from the horizontal component. Vertical earthquake component occurs when the compression P waves are separated. Whereas the horizontal component occurs as the shear S waves are separated. the frequency content of vertical earthquake component is higher than the horizontal component. The higher frequency content leads to magnification in short periods. Since the natural frequency of structures in the vertical direction is more than one in the horizontal direction, these factors may cause the resonance in the structures. It should be noted that in order to examine the effects of vertical earthquake component on the structures, the first step is, identifying the stimulating source of vertical earthquake component, response spectrum of vertical component and affecting parameters on the vertical component. (SadrAra, 2013)

Models studied

In this study, in order to consider the influence of vertical earthquake component, two types of structures (8, 10 story) with 10, 15 and 20 meters large curved frames are used. The bracing steel frame system with long span beams has been used for designing the structures. In an 8 story building, a hall on the base story is included that the long span frames are used for required open space in the story; But in the first to eight story which is the office space, The columns available in upper stories are made in a way that, after reaching to the long span frame of the base story, will be cut off and the structure will stand on peripheral columns of long span frames.

It is obvious that the long span beams that the columns located on them must have enough strength and be able to endure the load of them and prevent it from excessive deflection, settlement and collapse in them.

In 10 story, the structure was consistent in the base story to the second floor, but an empty space was intended between the second floor and the sixth, and from eighth to ninth, the empty space is re-filled and continued to be attached. In the middle of roof of sixth story, long span beams is used to fill the empty space.

Earthquakes in used

In this study, the six types of models with 15 and 20 meters of long span frames are used. Structures at first are modeled by SAP software and designed against the effect of the gravity loads and lateral forces, according to provisions of regulations. Then models will be transferred to PERFORM software. By introducing earthquake to the structures in a nonlinear timely-history (histogram) analysis, behavior of the structures are studied under the influence of various earthquakes.

Modeling

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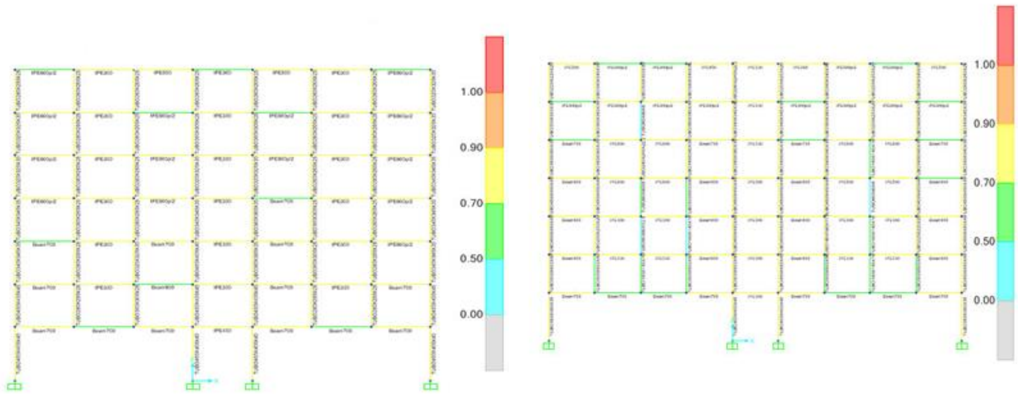

Figure 1. The 8 story structure with 15 and 20 meters of long span frame on the roof of base story in SAP software

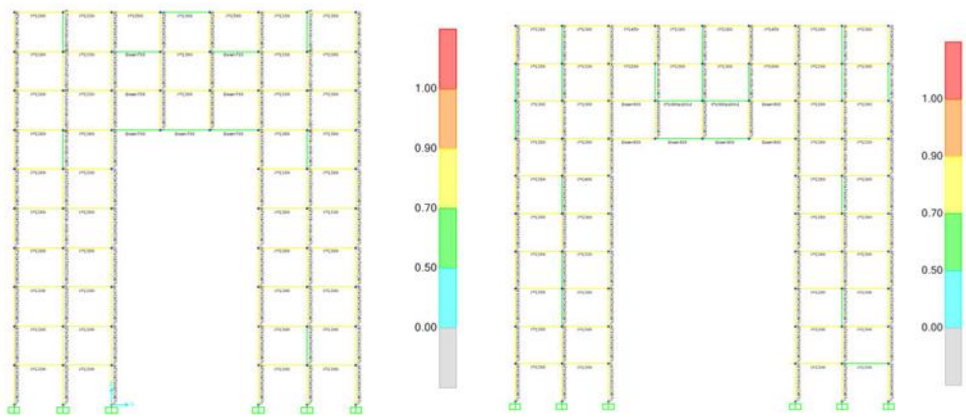

Figure 2. The 10 story structure with 15 and 20 meters of long span frame on the roof of six story in the SAP software

Nonlinear time history analysisIn

To examine the effect of vertical earthquake component on the various span frames in the time history (histogram) analysis, at first the building with three components, X , Y and Z is studied. At next step, the same earthquake has been studied without considering the effect of vertical earthquake component and behavior of structure.

In each models above-mentioned, moment shear, axial force and drift of long span frames caused by horizontal component and exerting vertical and horizontal components, have been studied. in the tables, these values are shown both cases in two models. The values indicate that the vertical earthquake component is very effective on increasing the mid-span moment. However, this component does not have much impact on increasing the shear of span. Also, the component increases the axial force in long span frame in adjacent columns. Also, drift values increases due to the effect of these components.

by comparing the values at Tables, it is concluded that the effect of vertical earthquake component increases the moment of long span frame up to 50%. Also, it increases the axial force of lateral columns up to 40% and it increases drift of long span beams to 30%. Also the values of moment, the axial force and the drift are increased by increasing the length of long span beams.

Table 1. Increased values of moment, shear, axial force and maximum drift of the 15 meters long span beam in the effect of the horizontal and vertical component of earthquake in the 8 story (%)

	Gazli	Imperial Valley	Northridge	Tabas
Moment of middle span	28	24	26	22
Moment of side span	19	17	16	14
Shear of middle span	3.1	2.5	2.9	2.6
Shear of side span	2.8	2	3	2.9
Axial force of column	180	205	172	181
Maximum drift of middle span	15	14	16	13

Table 2. Increased values of moment, shear, axial force and maximum drift of the 20 meters long span beam in the effect of the horizontal and vertical component of earthquake in the 8 story (%)

	Gazli	Imperial Valley	Northridge	Tabas
Moment of middle span	32	28	27	24
Moment of side span	24	21	20	22
Shear of middle span	3.6	4	3.6	4
Shear of side span	3.2	5	3.4	3.2
Axial force of column	200	210	190	185
Maximum drift of middle span	20	17	18	19

Table 3. Increased values of moment, shear, axial force and maximum drift of the 15 meters long span beam in the effect of the horizontal and vertical component of earthquake in the 10 story (%)

	Gazli	Imperial Valley	Northridge	Tabas
Moment of middle span	19	21	17	18
Moment of side span	15	16	14	13
Shear of middle span	1.5	1.2	1.8	2
Shear of side span	1.7	1.4	1.9	2.1
Axial force of column	146	192	182	145
Maximum drift of middle span	8	10	7	9

Table 4. Increased values of moment, shear, axial force and maximum drift of the 20 meters long span beam in the effect of the horizontal and vertical component of earthquake in the 10 story (%)

	Gazli	Imperial Valley	Northridge	Tabas
Moment of middle span	27	24	29	22
Moment of side span	19	17	21	16
Shear of middle span	2.2	1.9	2.4	2.5
Shear of side span	2.1	1.8	2.3	2.4
Axial force of column	187	201	187	160
Maximum drift of middle span	14	12	10	11

SUMMARY AND CONCLUSION

In this study, the effect of the vertical earthquake component on the long span frames has been investigated. To achieve this goal, six structures are designed in two types of 8 and 10 story modeled with the long span frame of 15 and 20 meters and the horizontal and vertical earthquake components have been studied in the time history(Histogram) analysis. The studies show that by applying the vertical earthquake component, the moment of the middle long span frame is increased around 50%, shear values beams are almost constant and axial force increases about 40% and column and maximum drift of the middle span has been increased about 30%. Also the values of moment, axial force and the drift are increased by increasing the length of long span beams.

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