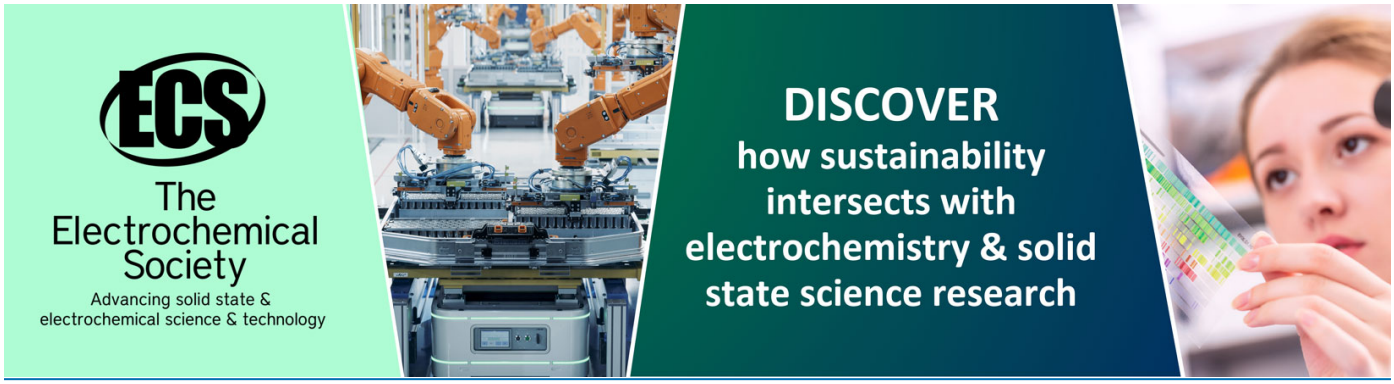
The behaviour of reinforced concrete structure due to earthquake load using Time History analysis Method



The behaviour of reinforced concrete structure due to earthquake load using Time History analysis Method

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Abstract. Earthquakes are one of the most dangerous, destructive and unpredictable natural hazards, which can leave everything up to a few hundred kilometres in complete destruction in seconds. Indonesia has a unique position as an earthquake prone country. It is the place of the interaction for three tectonic plates, namely the Indo-Australian, Eurasian and Pacific plates. Banda Aceh is one of the cities that located in earthquake-prone areas. Due to the vulnerable conditions of Banda Aceh some efforts have been exerted to reduce these unfavourable conditions. Many aspects have been addressed, starting from community awareness up to engineering solutions. One of them is all buildings that build in the city should be designed as an earthquake resistant building. The objectives of this research are to observe the response of a reinforced concrete structure due to several types of earthquake load, and to see the performance of the structure after earthquake loads applied. After Tsunami in 2004 many building has been build, one of them is a hotel building located at *simpang lima*. The hotel is made of reinforced concrete with a height of 34.95 meters with a total area of 8872.5 m2 building. So far this building was the tallest building in Banda Aceh.

Introduction

In more than 300 natural disasters in year 2011, over 30,000 people lost their lives and 206 million people were affected and $366 Billion were the economic losses, which made it the costliest year in the history of the catastrophes [1]. Indonesia has a unique position as an earthquake prone country. It is the place of interaction for three tectonic plates, namely the Indo-Australian, Eurasian and Pacific plates. Banda Aceh is one of the cities that located in earthquake-prone areas. Due to the vulnerable conditions of Banda Aceh some efforts have been exerted to reduce these unfavorable conditions. Many aspects have been addressed, starting from community awareness up to engineering solutions. One of them is all buildings that build in the city should be designed as an earthquake resistant building.

The objectives of this research are to observe the response of a reinforced concrete structure due to several types of earthquake load, and to see the performance of the structure after earthquake loads applied. Observation will be done on the story displacement, story drift, and base shear. Hotel building

in Banda Aceh will be used as an object of the research. The building will be loaded by 4 types of big earthquake data that have occurred in the world.
Response of Hotel Building will be observed by using Time History Analysis Method. Time-history analysis provides for linear or nonlinear evaluation of dynamic structural response under loading which may vary according to the specified time function. STERA (Structural Earthquake Response Analysis) 3D ver.7.1 developed by Prof. Taiki Saito from Toyohashi University of Technology, Japan, will be used in this research.

2. Literature review

2.1. Stera 3D

STERA_3D (Structural Earthquake Response Analysis 3D) is integrated computer software for the seismic analysis of steel and reinforced concrete buildings in three dimensional spaces developed by T. Saito and distributed for free for research and educational purposes [2]. The software was developed since 2007. STERA_3D has a visual interface to create a building model and show the results easily and rapidly. Figure 1 shows the element models used in STERA_3D. A beam is modelled as a line element with nonlinear flexural springs at both ends. The degrading tri-linear slip model is used for the hysteresis. A column is modelled in a similar manner, and nonlinear interaction between axial force and moment is expressed using axial springs of concrete and steel arranged in sections at both ends [3]

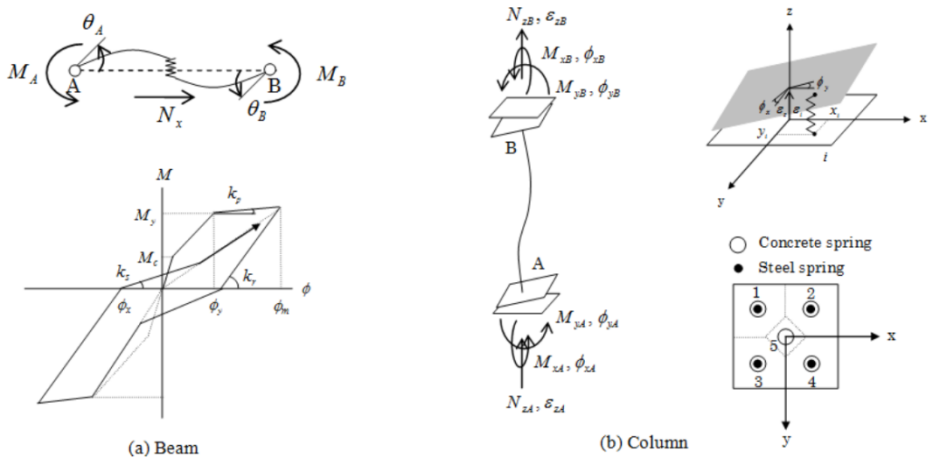
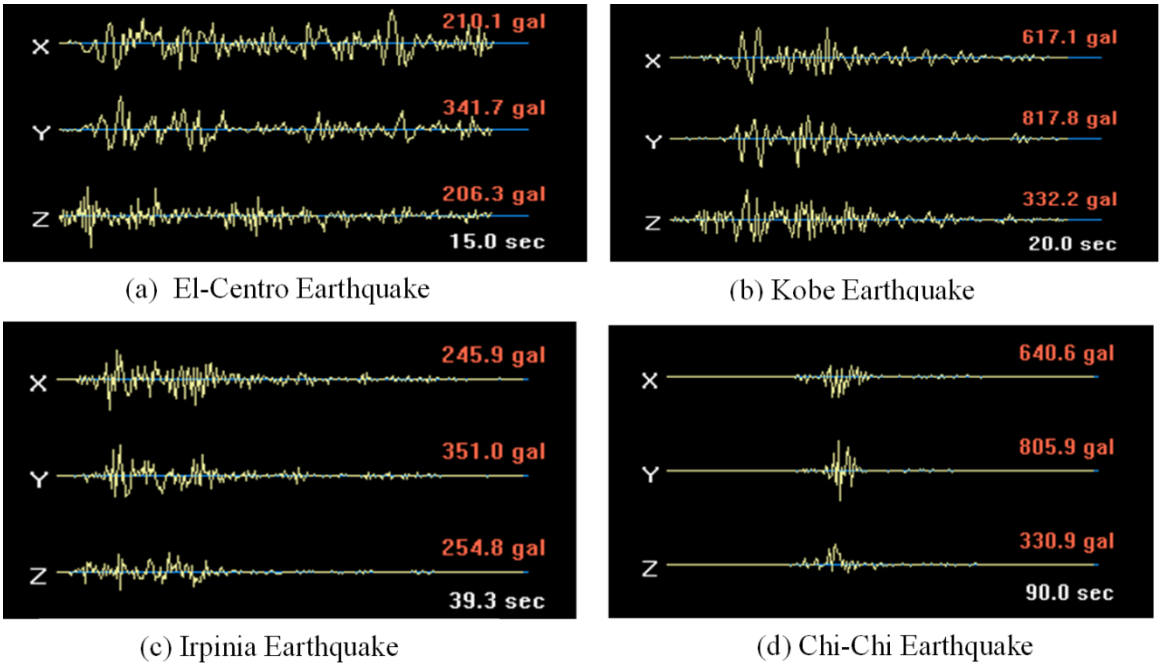


Figure 1. Nonlinear model used in STERA_3D

2.2. Time history analysis

There were four types of earthquake history recorded from PEER Ground Motion Database Application [4]. Those are El-Centro earthquake that occurred in California in 1940, Irpinia earthquake that occurred in Italy in 1980, Kobe earthquake that occurred in Kobe Japan in 1995, and the Chi-Chi earthquake that occurred in Taiwan in 1999. El-Centro earthquake has 6.4 SR magnitudes with 9 km depth from epicenter, and 15 second period of time. Irpinia earthquake has 6.9 SR magnitudes with 22.5 km depth from epicenter, and 39.3 second period of time. Kobe earthquake has 6.9 SR magnitudes with 7.1 km depth from epicenter, and 20 second period of time. Chi-Chi earthquake has 7.3 SR magnitudes with 9.6 km depth from epicenter, and 90 second period of time. Figure 2 shows all the acceleogram of each earthquake.



(a) El-Centro Earthquake (b) Kobe Earthquake

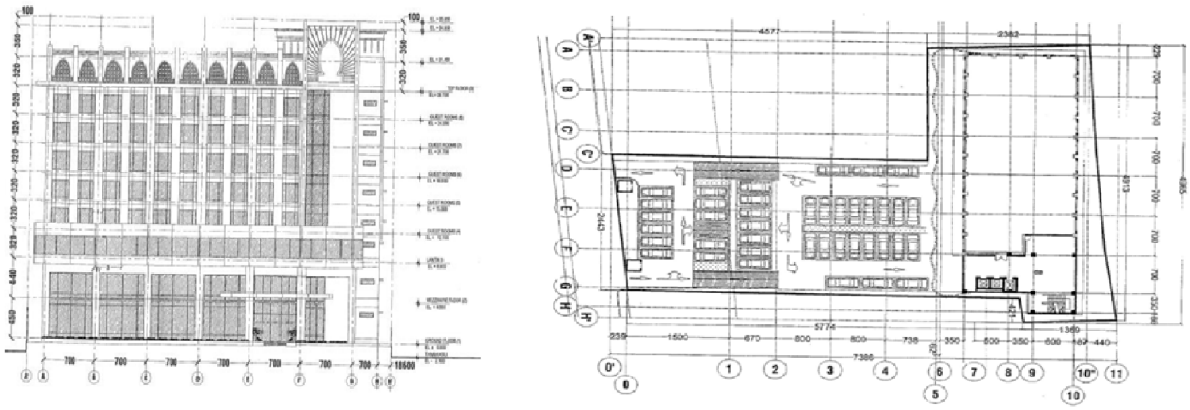
(c) Irpinia Earthquake (d) Chi-Chi Earthquake

Figure 2. Acceleogram for each earthquake

3. Methodology

3.1. Object Introduction

The object is a hotel located in *simpang lima* Banda Aceh city, Aceh Province. The hotel is made of reinforced concrete with a height of 34.95 meters with a total area of 8872.5 m^2 building. So far this building was the tallest building in Banda Aceh. Compressive strength of concrete is 30 MPa, tensile yield strength for main reinforcement is 400 MPa, on the other hand for shear reinforcement is 240 MPa.



FRONT OF VIEW PLAN OF VIEW

Figure 3. Front of View and Plan of View of the hotel

3.2. Model Calculation

The object is modelled by using STERA_3D software. All procedure to create the model and how to input the earthquake loading is shown in Figure 4. Starting with giving the length and depth of building, then following with entering the dimension of beams and columns including the number of reinforcement, concrete cover, and material properties. Dimension for beams and colomn just following dimension in as built drawing.

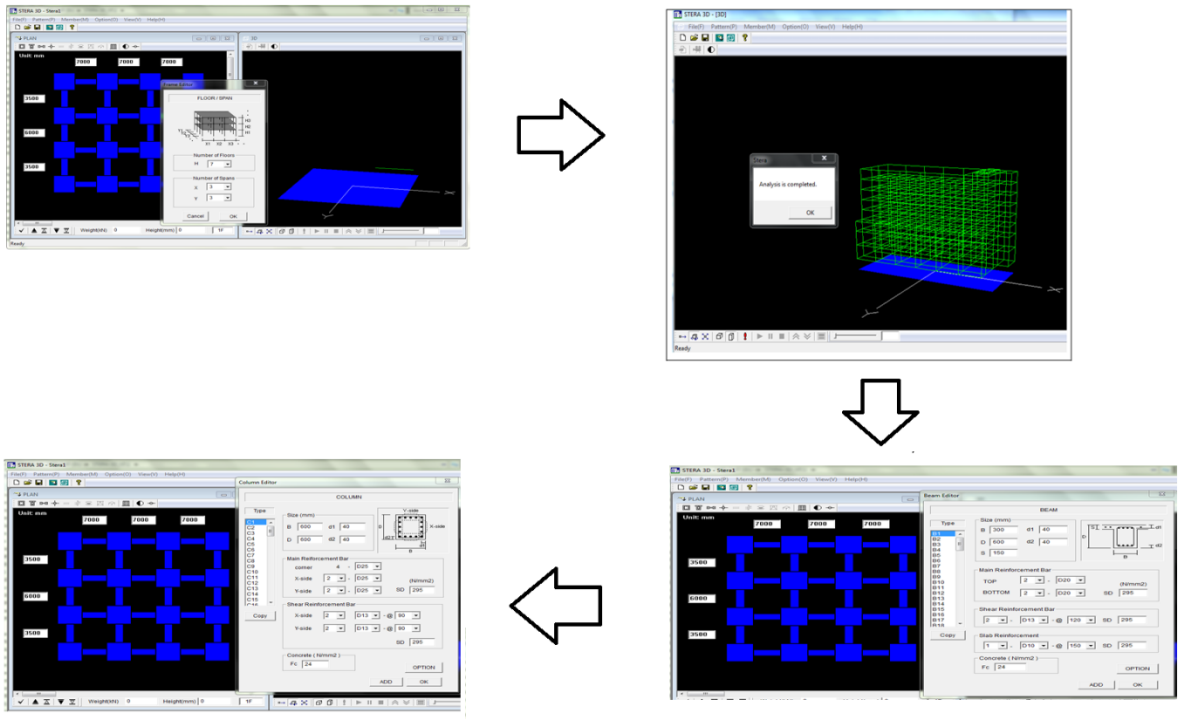


Figure 4. Procedure how to create the model

Dead load, live load, and wind load will be applied manually. Earthquake load will be applied by using four types of earthquake history recorded from PEER Ground Motion Database Application as shown in Figure 2. Procedure to input earthquake load in STERA_3D is shown in Figure 5.

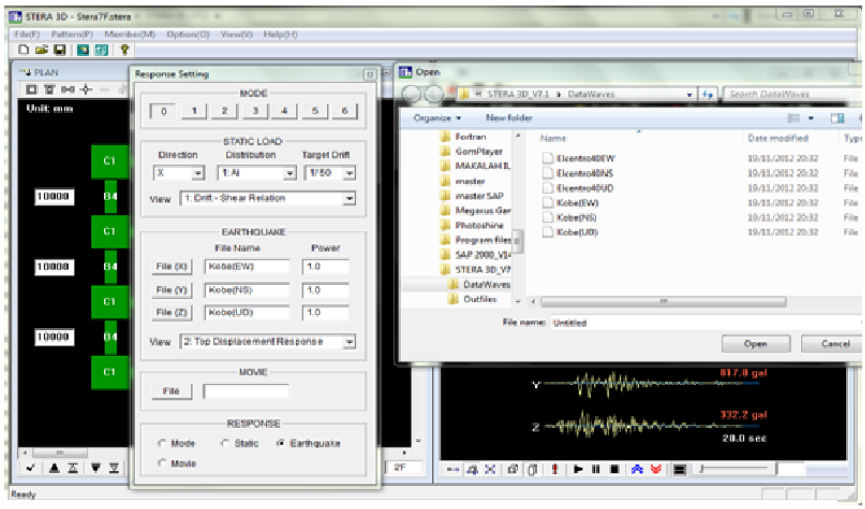
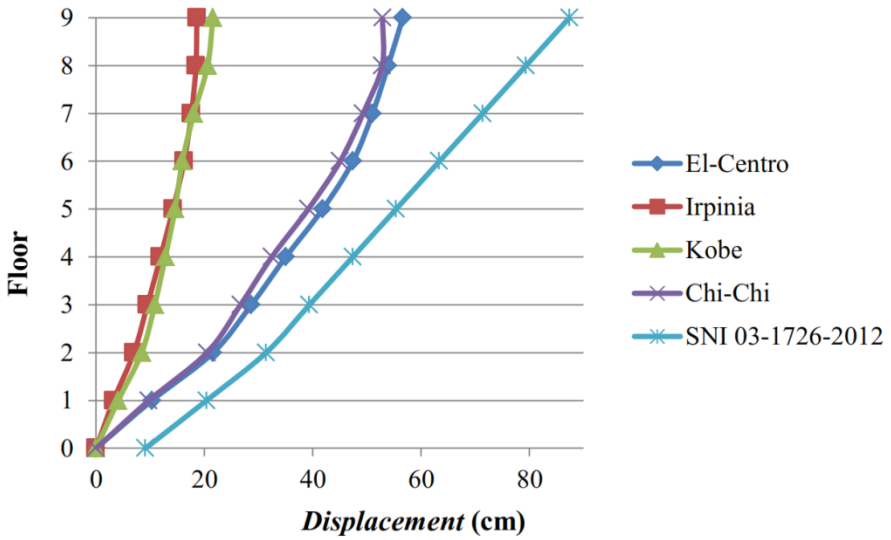


Figure 5. Procedure how to input earthquake load

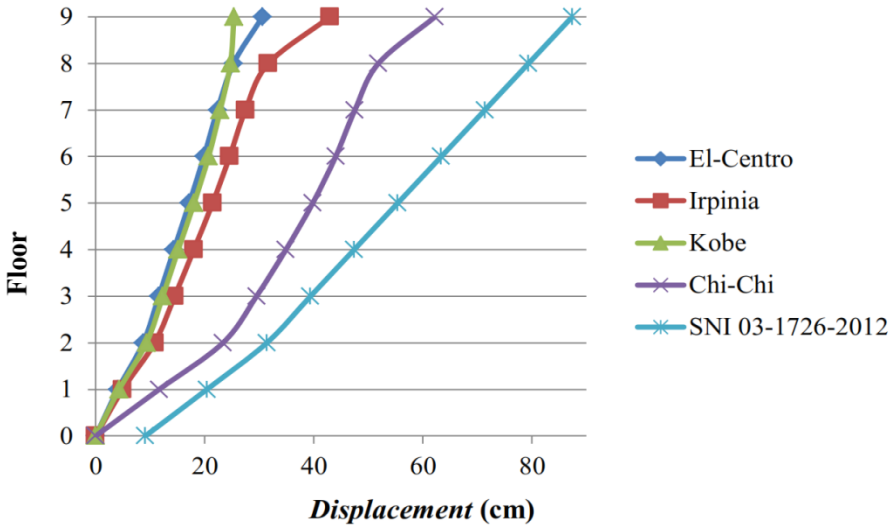
4. Results and Discussion

4.1.Story Displacement

Story displacement result for X and Y direction is shown in Figure 6. It can be seen from the figure that the largest story displacement in X direction occurred was 56.64 cm due to El-Centro earthquake, followed by Chi-Chi earthquake, Kobe earthquake, and Irpinia earthquake. In Y direction the largest story displacement was 62.24 cm due to Chi-Chi earthquake, followed by Irpinia earthquake, El-Centro earthquake, and Kobe earthquake. Based on Indonesian standard SNI-1726-2012, it can be seen that the hotel building is in safe condition, because all the largest displacement was less than 87.4 cm**.**



(a) X Direction

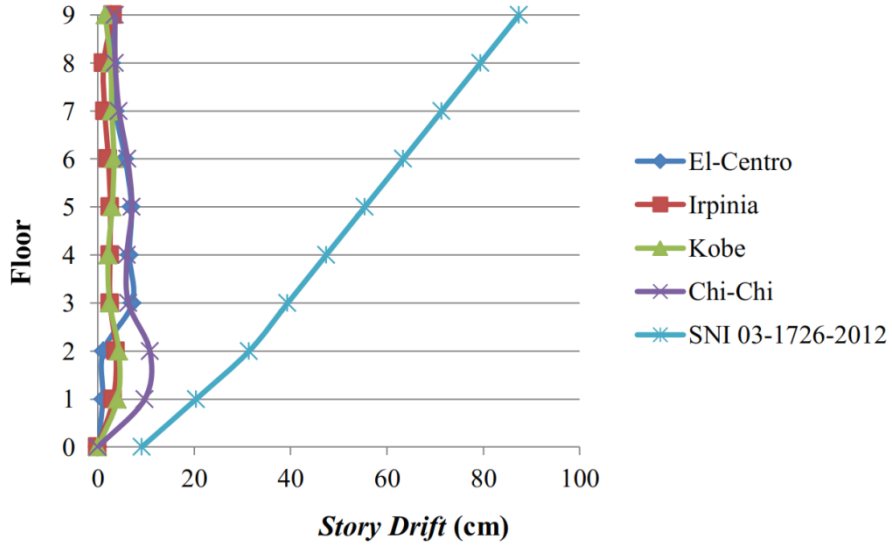


(b) Y Direction

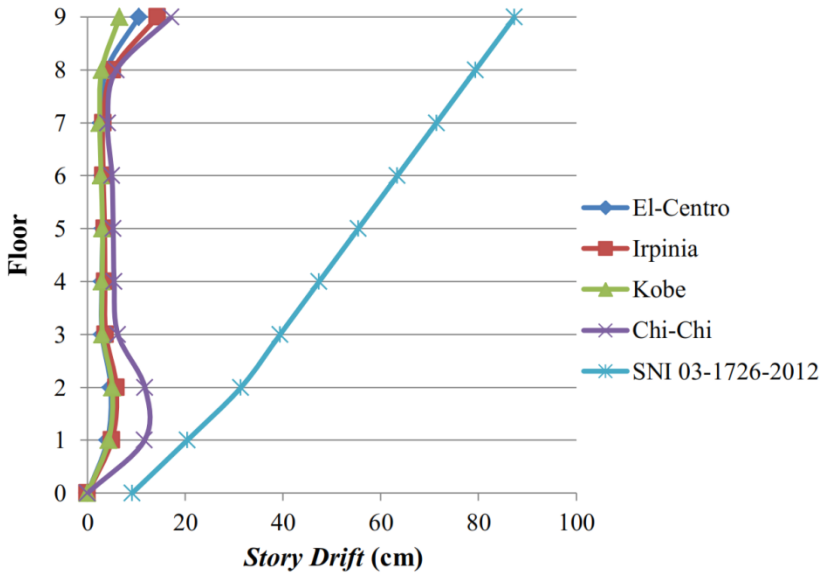
Figure 6. Story Displacement for X and Y Direction

4.2.Story Drift

Story drift result for X and Y direction is shown in Figure 7. It can be seen from the Figure that the largest drift in X direction occurred was 9.74 cm on between base floor and first floor due to Chi-Chi earthquake. Based on Indonesian standard SNI-1726-2012, the maximum allowable story drift was 11.30 cm, so the hotel building is in safe condition.



(a) X Direction

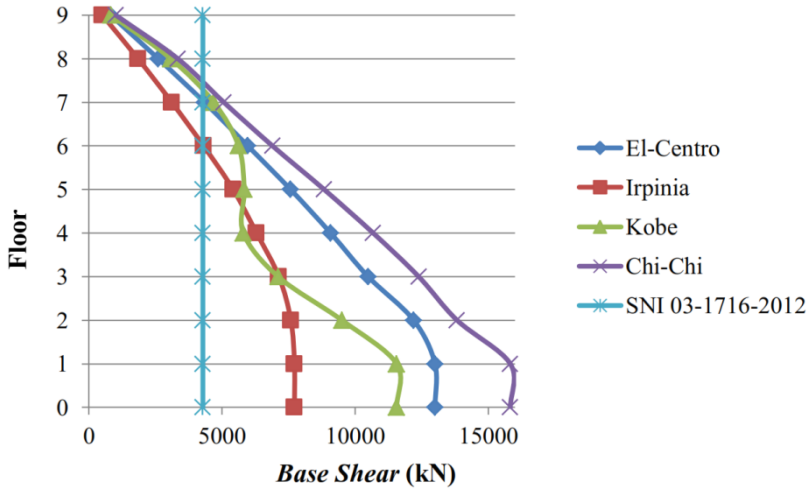


(b) Y Direction

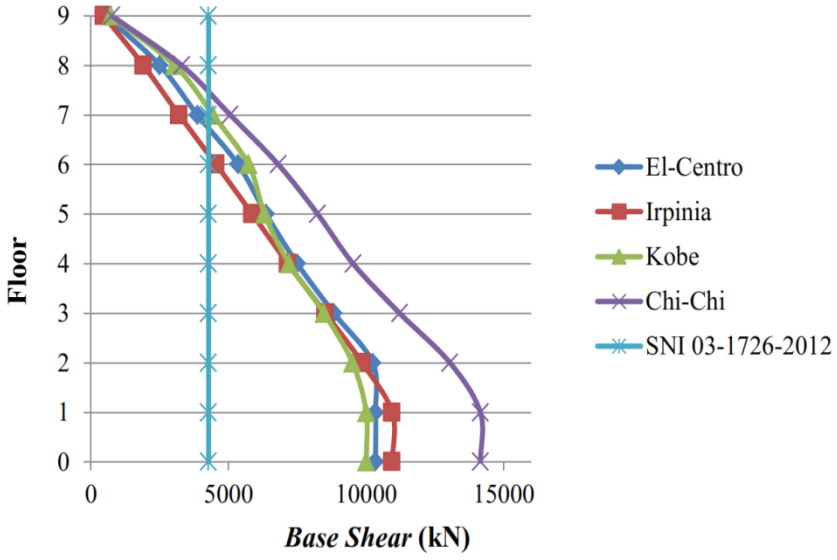
Figure 7. Story Drift for X and Y Direction

4.3.Base Shear

Base shear result for X and Y direction is shown in Figure 8. It can be concluded from the Figure that the largest base shear in X direction occurred was 15,830 kN due to Chi-Chi earthquake, followed by El-Centro earthquake, Kobe earthquake, and Irpinia earthquake. In Y direction the largest story displacement was 14,160 kN due to Chi-Chi earthquake, followed by Irpinia earthquake, El-Centro earthquake, and Kobe earthquake. Based on Indonesian standard SNI-1726-2012, it can be seen that the hotel building is in safe condition, because all the base shear is larger than 4,280.02 kN.



(a) X Direction



(b) Y Direction

Figure 8. Base Shear for X and Y Direction

5. Conclusions

1. Based on the results, it can be concluded that all response of the hotel structure are still comply with the requirement in Indonesian Standard SNI-1726-2012.

2. The largest story displacement in X direction was 56.64 cm, and in Y direction was 62.24 cm, those value still less than 87.4 cm as required by SNI.

3. The largest drift in X direction was 9.74 cm on between base floor and first floor, this value was less than 11.30 cm as required by SNI.

4. The largest base shear in X direction was 15,830 kN, and in Y direction was 14,160 kN, those values larger than 4,280.02 kN as required by SNI.

5. Finally, it was found that hotel building is in safe condition after loaded by 4 types of earthquake loads.

References

1. EM-DAT, 2001, Internasional Disaster Database, The OFDA/CRED Belgium.
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3. T. Saito., 2016, Response of High-Rise Buildings under Long Period Earthquake Ground Motions., *International Journal of Structural and Civil Engineering Research*, **Vol. 5, No. 4**, pp. 308-314.
4. Anonymous, 2011, PEER Ground Motion Data Base web Application.