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ULUSLARARASI MÜHENDİSLİK SEMPOZYUMU (IES'20)
INTERNATIONAL ENGINEERING SYMPOSIUM (IES'20)

BİLDİRİLERİ TAM METİN KİTABI
PROCEEDINGS FULL PAPER BOOK

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Evaluation of TEC 2018 and TEC 2007 Regulations in the Buildings Having B1 and B2 Irregularities in accordance with İzmir Earthquake (31.10.2020)

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Abstract

In the case of Izmir Earthquake occurred in 31.10.2020, it is observed that several buildings have structural defects. Weak story and soft story irregularities were among the significant structural defects recorded in İzmir Earthquake. For this reason, an 8-story building having weak and soft story irregularities were examined according to TEC 2018 and TEC 2007 codes. In this study, Time History analysis was performed by using acceleration records in Izmir. The analysis was conducted with a nonlinear analysis program and differences between the earthquake codes were studied. According the results, although the so-called spectral acceleration values are smaller than the design spectrum in the regulations, the regulation boundary conditions are exceeded in structures with soft story irregularities.

Keywords: Soft story, weak story, Izmir Earthquake, Time History Analysis, TEC 2018, TEC 2007

1. INTRODUCTION

Turkey is an earthquake country having 95% of its population lives under the threat of earthquakes. Many lives and property losses took place as a result of the major earthquakes that have occurred in recent years. When the damaged or collapsed buildings were examined, it was determined that the rules in the regulations were not followed properly. A significant part of the defects that cause damage or collapses are Soft Floor Irregularity and Weak Floor Irregularity [1,2].

In the building stock of Turkey, it is seen that the ground floors of many buildings are designed as workplaces. In these buildings, where the ground floor is a workplace, the walls on the ground floor are not taken into consideration due to reasons such as increasing the viewing angle, providing a spacious environment, and the interior architecture of the workplace. Wall load is not taken into account in lateral stiffness of static calculations and these considerations are not against the regulations. However, it is known that walls play an important role in lateral rigidity [3]. Due to the fact that the walls contribute to the lateral rigidity, it is inevitable that the soft floor and weak floor irregularities will occur in the case of the removal of the walls on the ground floor. There have been many studies on these irregularities and their elimination strategies [4]. Finally, the damages in the Izmir earthquake that took place on 30.10.2020 were examined and it was evaluated that most of the buildings having Soft Story and Weak Floor irregularities were

damaged (Figure 1). It has been observed that the buildings that were damaged in this earthquake were mostly built according to the old regulations. However, there were also damages in the buildings designed after TEC 2007.

Figure 1. Damaged buildings in İzmir Earthquake (photographed by authors)

In this study, a building is modeled through nonlinear analysis program. Since there are more buildings damaged in İzmir-Bayraklı district, the sample building is considered in the coordinates of Bayraklı / İzmir. Time History Analysis has been made by using the acceleration records of the earthquake that occurred in Izmir. The building was examined in accordance with the TEC 2007 and TEC 2018 regulations and the differences between the two regulations were investigated. In addition, the weak floor and soft floor irregularities were examined in this building and the discussions were made comparatively on the basis of regulations.

2. MATERIAL AND METHOD

In this study, Time History Analysis was made with the acceleration records obtained from Izmir Earthquake in the analyzed building. In addition, it is aimed to examine B1 and B2 irregularities according to old and new regulations. As considered building is designed as a ground floor office, no wall was designed. The building is symmetrical in X and Y directions, with 4 axes, 3 spans and ZD as the ground class. The floor height in the building was taken as 3 m and an 8-storey building was modeled. The distance between the axes of the building is designed to be 5 m, and the foundation-column junction area is defined as fixed support (Fig.2).

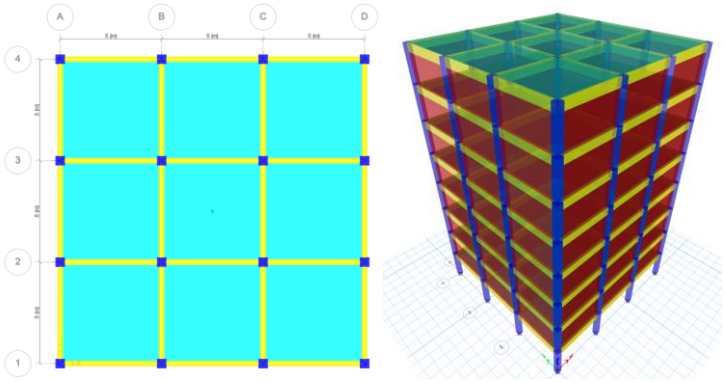


Figure 2. 3D ETABS model of the building

It is assumed that the building taken into account is located in Bayraklı / İzmir (Fig. 3), as previously detailed. For this reason, Bayraklı / İzmir was selected from the AFAD Map of Earthquake Zones and the relevant outputs were obtained [5]. It is considered that the building is used as a residence. Spectral acceleration values obtained from AFAD official website were

determined as S_{DS} = 1.171, S_1 = 0.559, respectively, depending on the location and ground class of the relevant building. Design acceleration and Izmir earthquake pseudo-acceleration spectrum values were defined according to TEC 2018 and TEC 2007 for İzmir province, Bayraklı district. The comparison of the values can be seen in Figure 4.

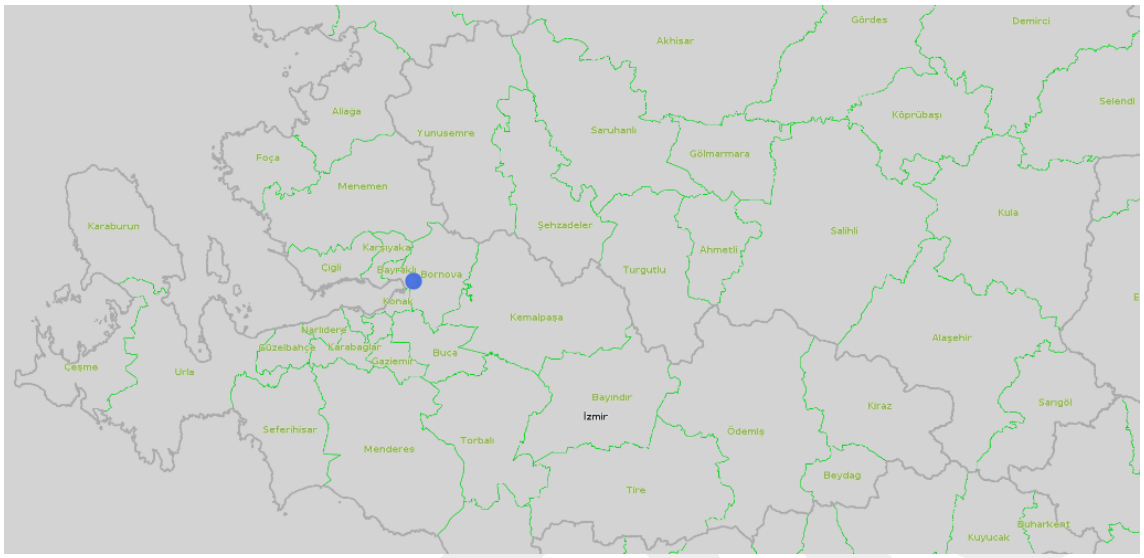


Figure 3. Location of the model building.

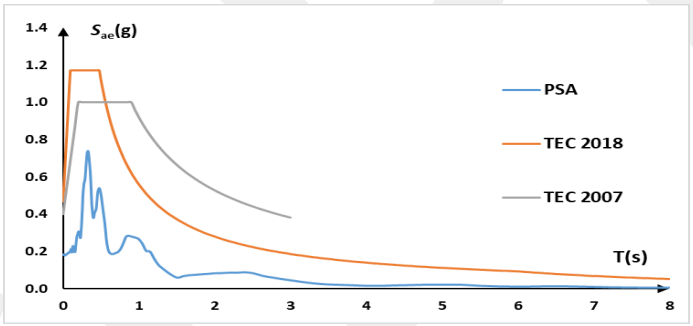


Figure 4. The values of design acceleration and Izmir earthquake pseudo-acceleration spectrum according to TEC 2018 and TEC 2007

The columns of building are designed as 45x45 cm and beams as 25x60 cm. 8ø20 longitudinal reinforcement and ø 10 / 15 confinement reinforcement bars were used in the columns. All slabs were designed with a thickness of 14 cm in the reinforced concrete building. In addition, the walls used in the building are modeled with a thickness of 20 cm. In the model of reinforced concrete building, the concrete class has been taken as C30 (fck = 30 MPa) and the reinforcement class as S420 (fy = 420 MPa, fu = 500 MPa). In the model, the dead load on the storey is taken as g=3 kN/m2 and the live load as q=2 kN/m2, respectivelty. The model of reinforced concrete building has been modelled through a non-linear analysis program [6]. After defining the material and section properties in the analysis program, the model of the building was designed. The loads affecting the building were evaluated and these loads were considered in the non-linear analysis program. In addition, the spectrum curve values obtained depending on the location of the building were defined in the program. In addition, the acceleration records of the İzmir Earthquake were introduced to the program for time history analysis (fig. 5).

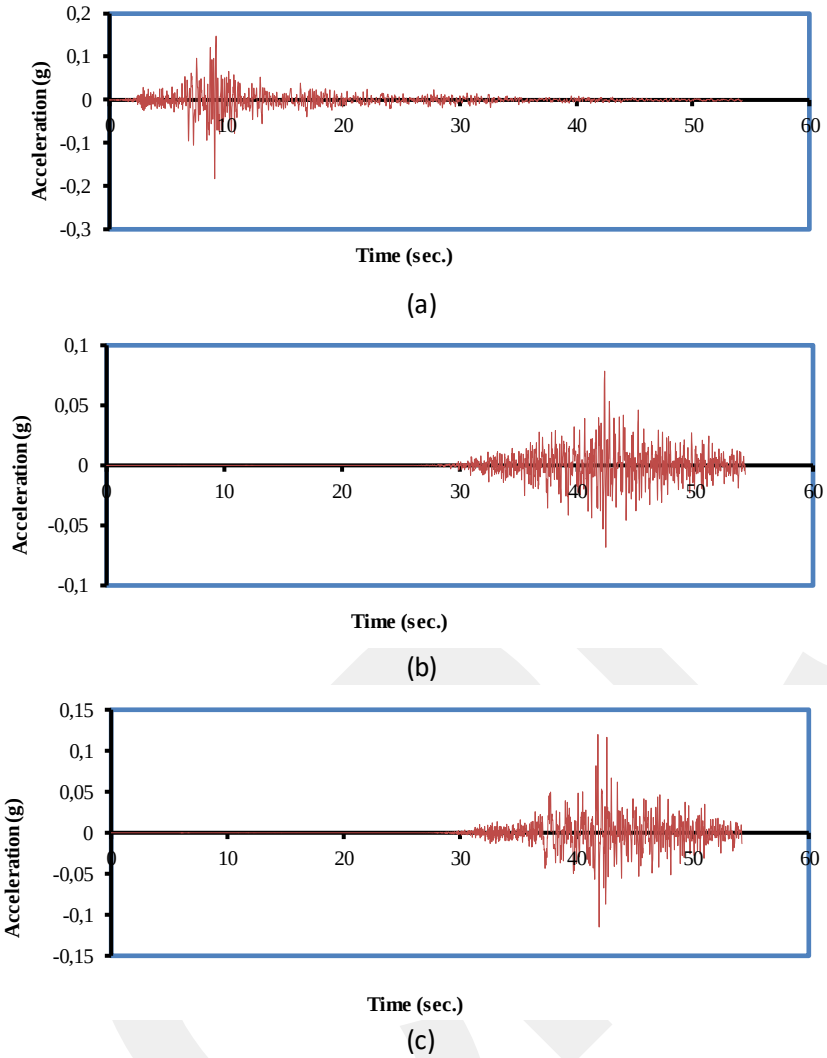


Figure 5. Raw acceleration values of (a) North-South (b) Vertical (c) East-West directions

3. RESULTS AND DISCUSSION

In this study, an 8-storey building having soft story irregularity was analyzed in the time domain according to Izmir earthquake acceleration records based on the location in the province of Izmir. According to the analysis results, the base shear force was found to be 3570.84 kN and 3967.36 kN according to TEC 2007 and TEC 2018, respectively. Base shear force was obtained as 5994.51 kN from Time History Analysis. Although the so-called spectral acceleration values obtained according to the acceleration record for the Izmir earthquake are quite small according to both regulations, the response of a structure having B2 type irregularity was not promising. The reason can be ascribed to vibration of the whole building from the 1st floor due to the lateral displacement rigidity provided by the walls in the upper floors. In Figure 6, the floor shear forces acting on the building are shown according to the analysis in both regulations and time domains.

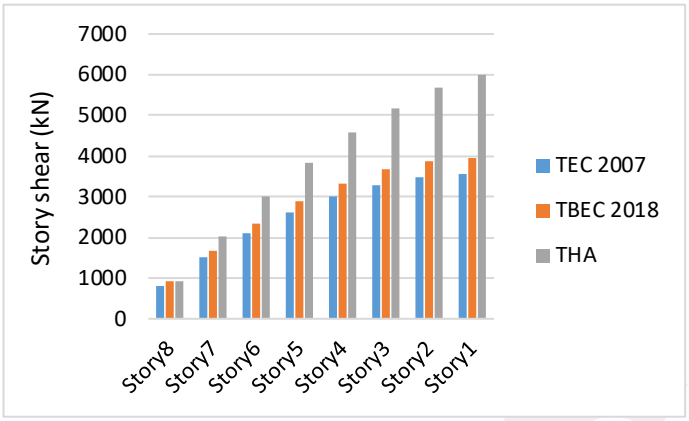


Figure 6. Shear forces of stories

During examination of the results, the recorded stress conditions were examined in the building. For this purpose, the stress levels obtained from the non-linear analysis program are given in Figure 7. As seen in Figure 7, only the ground floor is damaged and it is anticipated that the ground floor column ends will be hinged under earthquake loads and the collapse then can be possible for the building.

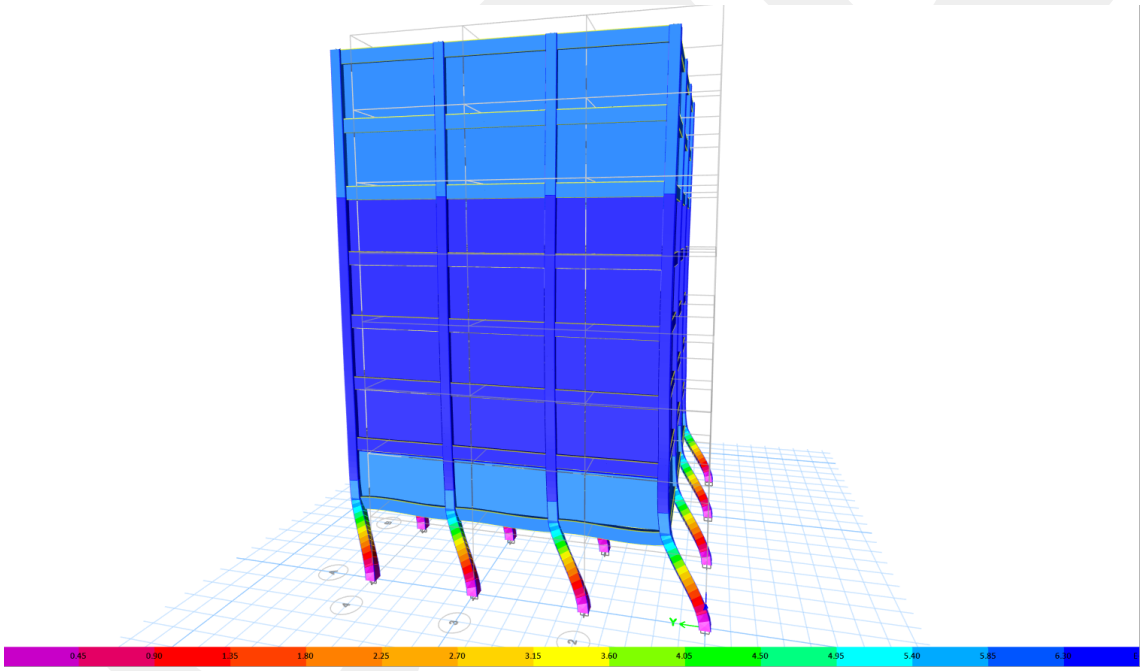
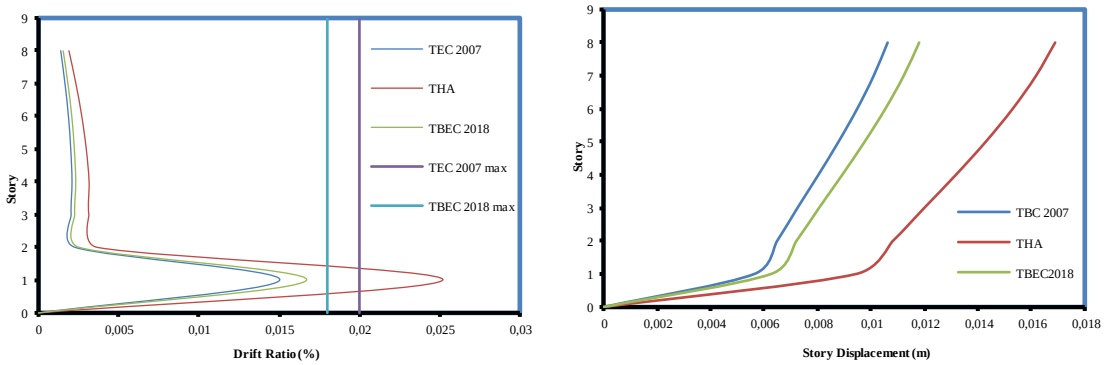


Figure 7. Stress levels of the building

When the rates of relative story drifts between floors are examined, the building meets the relative story displacement limit according to both regulations. However, the limits of both regulations are exceeded in the time domain according to analysis. In Figure 8, relative story drift ratios and boundary conditions were given together with story displacements of the building.



(a) (b)

Figure 8. (a) Story drift ratios and (b) story displacements of the building

4. CONCLUSION

Investigations were carried out after the Izmir earthquake and it was observed that most of the buildings with soft story irregularities had damages in their ground floors. For this purpose, an 8-story building with soft story irregularity was modeled and analyzed in the Time Definition.. The findings obtained within the scope of the study are as follows;

- The so-called spectral acceleration graph of the earthquake remained below the TEC 2007 and TEC 2018 design spectral acceleration graph. Therefore, study reveals that the design spectrum chart of the region included in the regulations covers the earthquakes that will probably to occur.
- In the case of base shear forces, obtained shear forces in the time definition analysis resulted in more unfavorable results compared to both regulations due to presence of structural irregularities.
- Relative floor drift boundary conditions could not be met according to the analysis in the time definition area.
- In the case of floor shear forces, obtained values from the regulations and the time history are close to each other in the upper floors. However, the floor shear forces obtained from the analysis in the lower floors are quite high according to the relevant regulations in the time domain.
- Due to the soft floor irregularity, the displacement ratio of the ground floor is significantly higher than the other floors. This reveals that the damage can probably be concentrated on this floor.

5. REFERENCES

[1] T.B.S.C-2018, Turkish Building Seismic Code, Disaster and Emergency Management Presidency (in Turkish, AFAD) (2018).
[2] TEC2007 (2007).Turkish Earthquake Code. 159 İzmir: Bayındırlık ve İskan Bakanlığı.
[3] Oinam, R. M. & Sahoo, D. R. (2018). Numerical evaluation of seismic response of soft-story RC frames retrofitted with passive devices. Bulletin of Earthquake Engineering 16(2): 983-1006.
[4] Ünal, A . (2020). An Analytical Investigation Of A Building Having Soft Storey Irregularity Strengthened With Concentrically Steel Braces. Konya Mühendislik Bilimleri Dergisi , 8 (1) , 91-102 . DOI: 10.36306/konjes.698661
[5] AFAD (2020),https://tdth.afad.gov.tr/TDTH/main.xhtml
[6] ETABS.v18. CSI-Structural Software for Building Analysis and Design, ETABS v.18. Retrieved from https://www.csiamerica.com/products/etabs