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Analysis of 3 and 5 Story Frame Structure Based on TBEC-2018 Code

Veysel Demir[1], Abdulhalim Karasin[1]
[1] *Dicle University Engineering Faculty, Civil Engineering department. Turkey*
Corresponding Author: Abdulhalim Karasin

Abstract: *Two typical three and- five-storey reinforced concrete frame system buildings with.identical floor plan areas were selected in order to examine the earthquake effects with respect to the new Turkish Building Earthquake Code (TBEC-2018) The differences in the structural performance levels determined for the structural elements. The samples have analyzed with Idecad 10 software according to the Turkish Building Seismic Code and Turkish Standards 500. The two selected reinforced concrete framed structures have been dimensioned according to the design rules given in the relevant sections of the codes to ensure high ductility conditions for C30 concrete and of S420 reinforcement materials. The ground class has been selected as ZB. Earthquake ground motion level has been selected as DD-2. The spectrums used in building designs were selected for the Dicle University Faculty of Engineering zone. Buildings designed as residences are ground plus three floors and ground plus five floors. These buildings are designed in accordance with the values predicted in the design, taking into account the current cross-section size, concrete type, reinforcement diameter and number, have been analyzed by using methods such as; linear elastic assessment method, nonlinear static incremental equivalent seismic load method and nonlinear multimode static incremental equivalent earthquake in earthquake engineering literature method. The design spectrum analysis of the structures has been done and compared.*

Keywords: *Structural Analysis; Reinforced Concrete Frame; TBEC-2018 code.*

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I. INTRODUCTION

As a result of the industrial revolution that started in the 18th and 19th centuries caused significant increase in migration mobility from rural area to urban the migration increasrd the need for housing emerged above the housing construction rate of that period. As cities rise above their natural borders, the need for multi-storey buildings has increased. It has become necessary to develop stronger materials and different techniques to construct these structures. As the development of cement, which was also used as a binding and insulating material in the Romans and previous civilizations, and the processing of iron became easier, reinforced concrete (RC) technology began to be discussed.

One of the important consideration for existing buildings is to represent the structural behavior properly integrated into the system. Earthquakes in recent years have caused socio-economic destructive effects, the need to quickly determine the, earthquake strength of the existing building stock in earthquake risk zones and make decisions to strengthen or destroy the inadequate ones (Dogangun, 2002). However, since it is known that the number of buildings that will face earthquake damage due to project and construction errors will be a lot, an effective and practical assessment of earthquake safety and system analysis has been needed. Seismic vulnerability assessment of RC buildings according to codes contributed in many studies (Onat et al., 2018; Karasin et al., 2018; Isik et al.,2018; Yon, 2020). In theory, dynamic analysis methods in the field of nonlinear time definition give the possibility to solve the problem described above in a way that is closest to reality, as it can accurately describe the nonlinear behavior of the structure. However, the fact that the method requires a large number of earthquake acceleration records, and difficulties in defining nonlinear behavior make the method impractical.

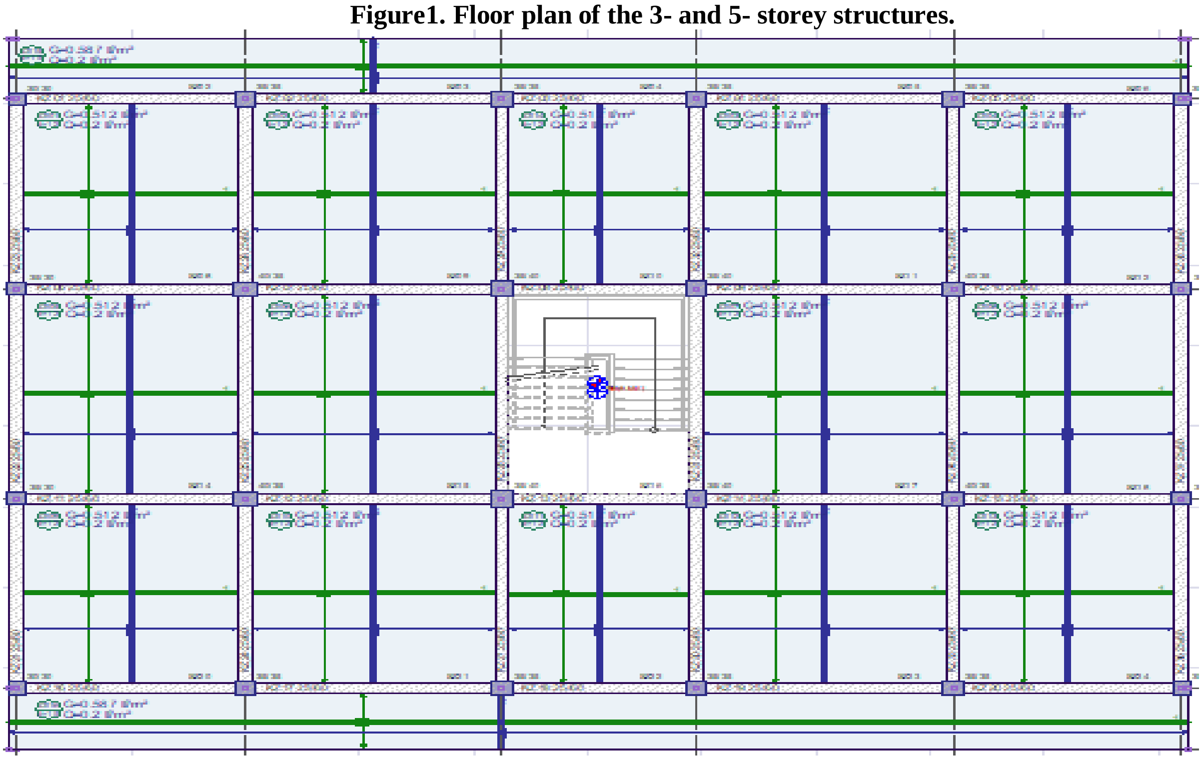
All studies focused on both linear elastic and linear non-elastic methods that can be used in accordance with the principles of the performance-based assessment approach after realizing that the methods used in the new building design were insufficient to determine structural damage (Ugurlu et al., 2017; Erdil et al., 2018; Isik et al., 2020; Karasin et al., 2020). The main difference between these two main methods is that linear elastic methods define structural cross-section damage in terms of force, and linear non-elastic methods define this damage in terms of shape change. In recent earthquakes, the fact that a significant part of the structural damage is caused by large deformations and displacements has brought non-linear analysis methods into the forefront. The general purpose of these methods is to obtain values that are close to the results of nonlinear time history analysis method using more practical calculation principles. In addition, these methods provide significant advantages over linear-elastic calculation methods. These are many important information about the behavior of the structure beyond elastic, such as elastic and non-elastic stiffness, the limit of elastic behavior, the limit load value of the structure's migration state, the amount of displacement at the moment of migration, and the demands of shape change and ductility of elements (Genc, 2007).

In general, damage limits and structural damage levels, which are the main components of performance-based analysis, can be determined with sufficient accuracy for both existing and newly designed structures under the influence of earthquakes that are thought to affect the structure.

II. ANALSIS PROCEDURE

In this study, displacement analysis, natural period analysis were performed for three-and five-storey reinforced concrete frame system with two plan symmetry and the same floor plan area to examine the earthquake effects on building elements and the differences in structural performance levels to be determined. The floor formwork plan is 20.65 meters in the X direction and 17.6 meters in the Y direction, and the formwork plan is 363.4 square meters. Floor formwork plans is given in Figure 1.

Figure1. Floor plan of the 3- and 5- storey structures.



The analysis are performed by IDECAD 10 software (Idecad,2018) according to TBEC-2018 (Turkey Building Erthquaqe Code, 2018) and TS500 (TS500,2000) codes. The two selected reinforced concrete frame structures are sized in accordance with the design rules given in the relevant sections in TS-500 and TBEC-2018 to ensure high ductility conditions. These sized buildings were analyzed by using space modeling and finite element method, taking into account the current cross-section size, concrete type, reinforcement diameter and number in accordance with the values seen in the design. At the next stage, the DD-2 earthquake level was selected for the performance point determined by the finite element method. DD - 2 earthquake ground motion qualifies rare earthquake ground motion, where the probability of spectral magnitudes exceeding 50 years is 10% and the corresponding repetition period is 475 years. This earthquake ground motion is also called the standard design earthquake ground motion. With these design conditions, the total quantity of structures was compared; displacement analysis, natural period analysis were performed and compared. In addition, a comparison of total quantity was made.

The plans examined in this section have been prepared and analyzed using the IdeCAD Static v10.14 structure analysis program. The values obtained as a result of the analysis were compared by means of graphics.With 5 spans in the X direction, Lx1: 4m, Lx2: 4.5m, Lx3: 3.4m, Lx4: 4.5m, Lx5: 4m; Three spans in the Y direction are respectively Ly1: 4.7m, Ly2: 5.2m, Ly3: 4.7m and consoles 1.5m long with a height of 2.7 m. The building is designed in residential type. Building usage class is BKS = 3, building importance coefficient is taken as I = 1. Earthquake ground motion level DD-2 has been selected. The local ground class ZB, Dicle University Faculty of Engineering for the design spectrum SUR / values are taken from the map of the address

DIYARBAKIR Turkey earthquake hazards. The materials are selected as C30 for concrete and S420 for reinforcements. The load-bearing system behavior coefficient is taken as R = 8 for frame type structure and the strength excess coefficient as D = 3 for frame type structure.

The dimensions of the columns in the building are arranged in 4 different types as 300x300 mm, 350x350 mm, 350x300mm, 400x350mm. All beams in the building are 250 mm x 600 mm, slab thickness is 120 mm, and console slabs are 150 mm. On the other hand the three-dimensional image of the 3- and the image of the 5-storey reinforced concrete frame structure is shown in Figure 3.

Figure 2. Cross-sections of the column

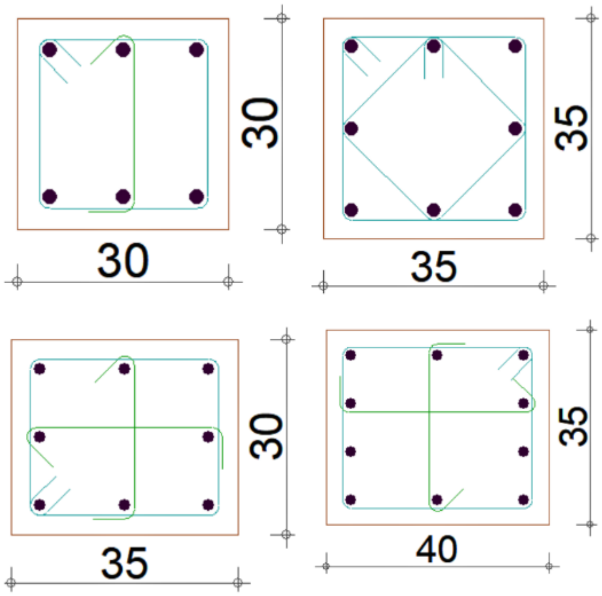
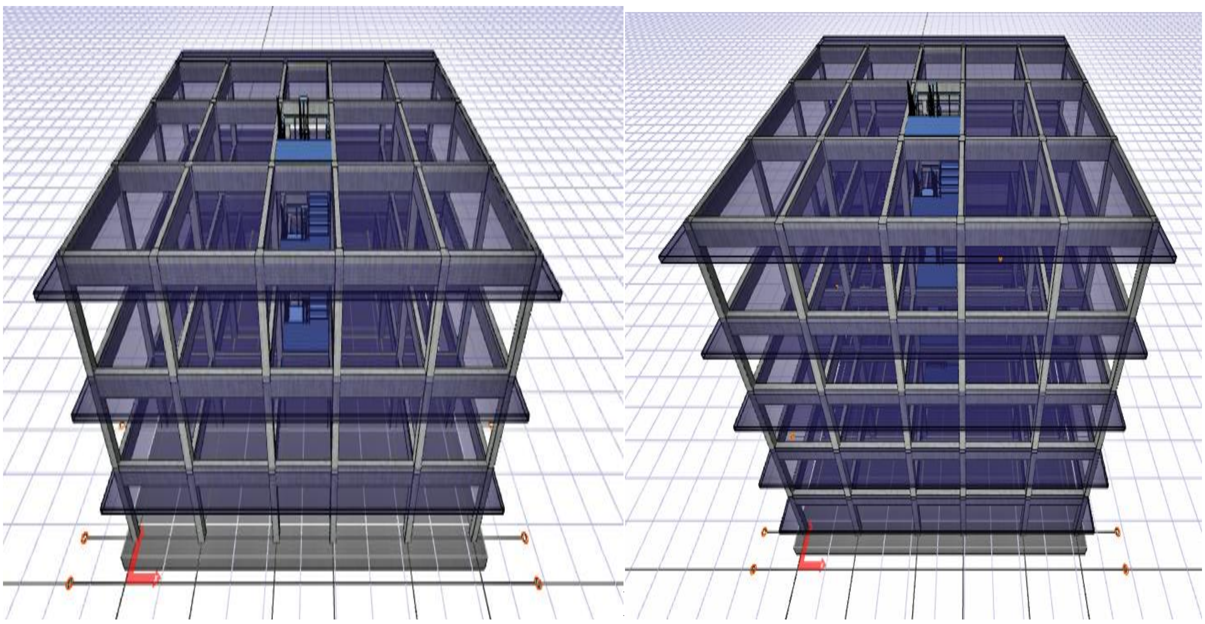


Figure 3. The three-dimensional image of the 3- and the image of the 5-storey structure



III. RESULTS AND DISCUSSIONS

The results were compared in order to examine the behavior changes of 3 and 5 storey buildings with the same formwork plan. Results of the modal analysis for storey forces, periods, displacements in X and Y directions are compared separately shown in figures 4 to 9.

Figure 4. Natural Periods of the 3-Storey Reinforced Concrete Frame System

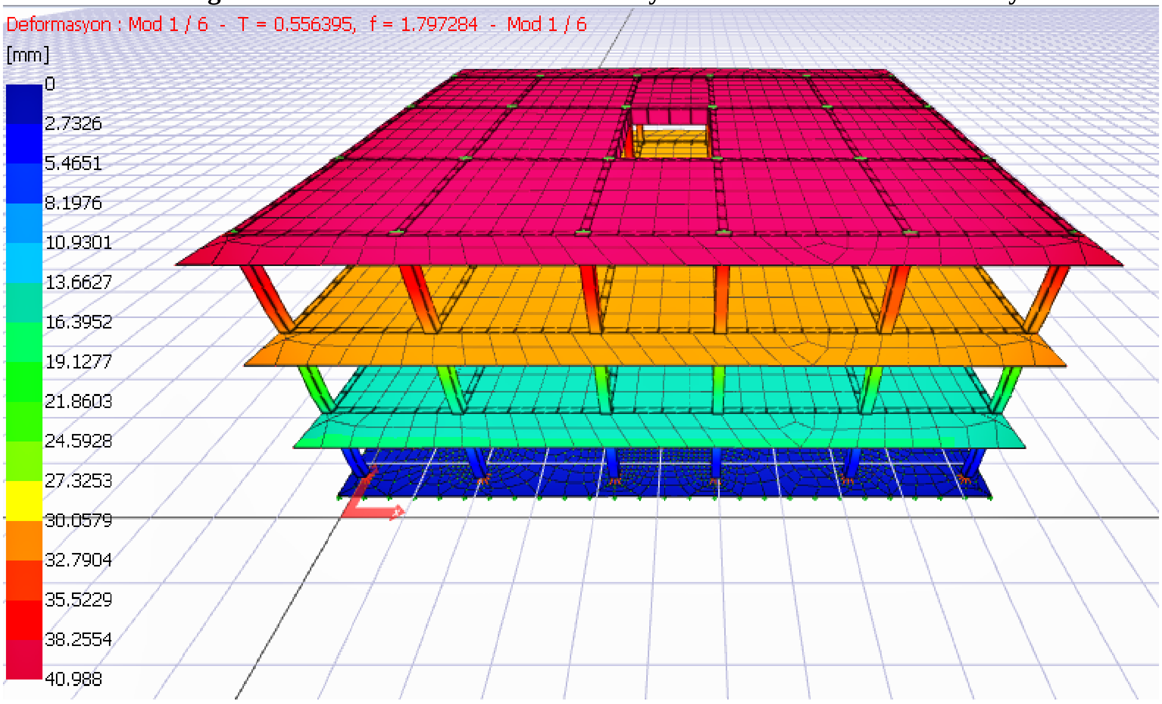


Figure 5. Natural Periods of the 5-Storey Reinforced Concrete Frame System

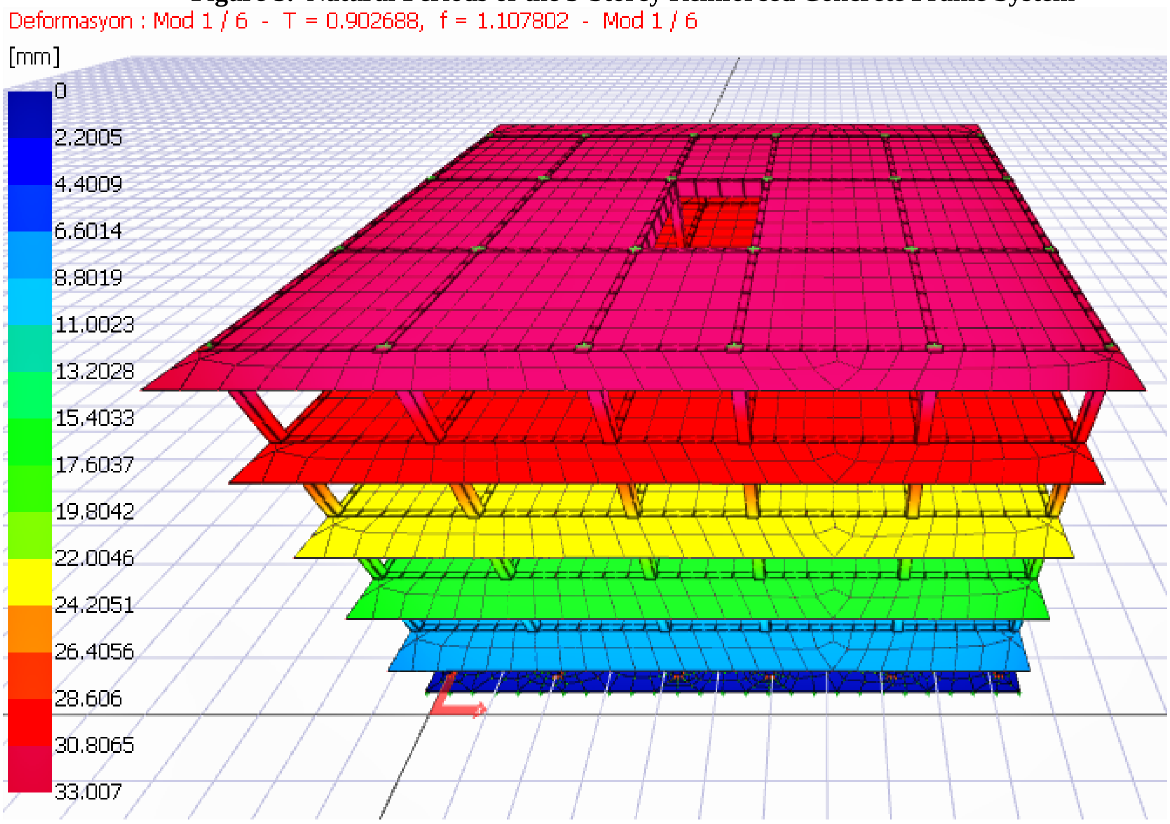


Figure 6. Deformations in x-direction for the 3-storey structure

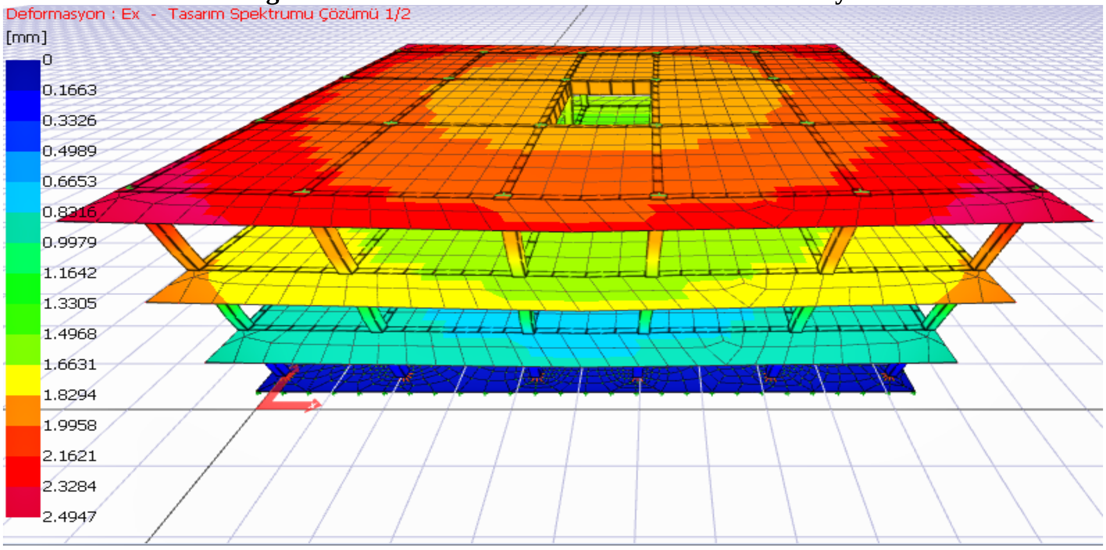


Figure 7. Deformations in x-direction for the 5-storey structure

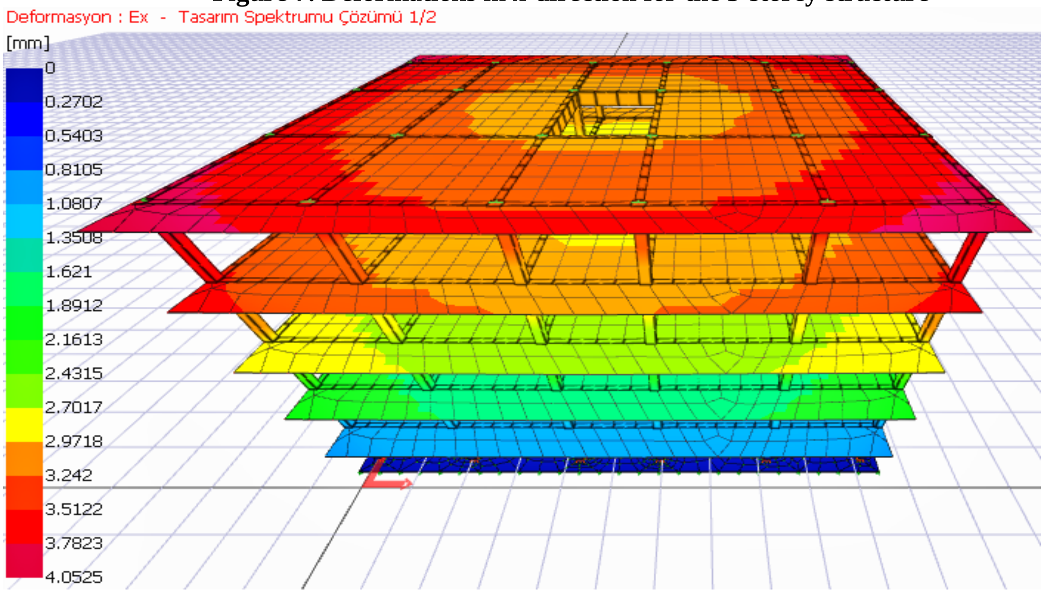


Figure 8. Deformations in y-direction for the 3-storey structure

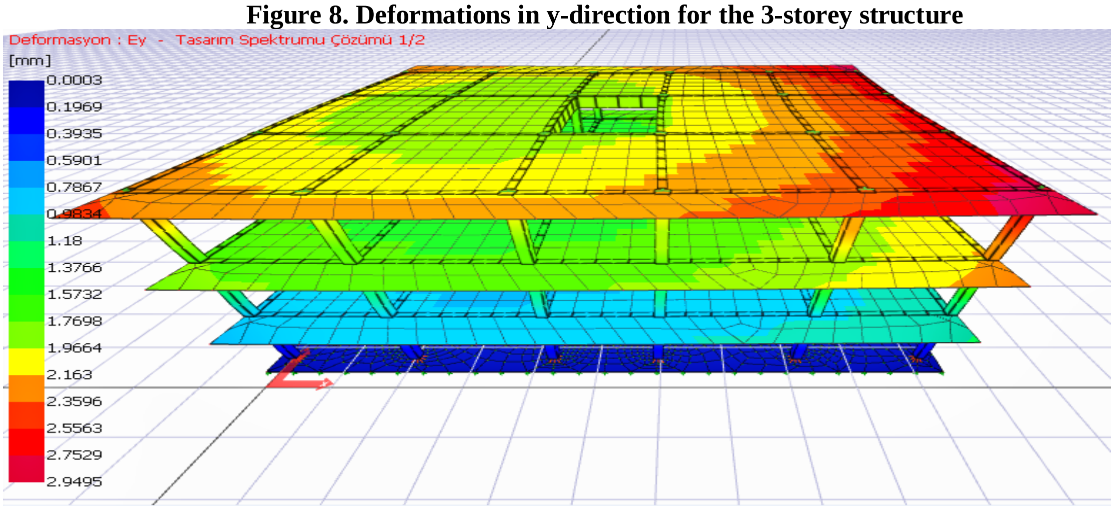
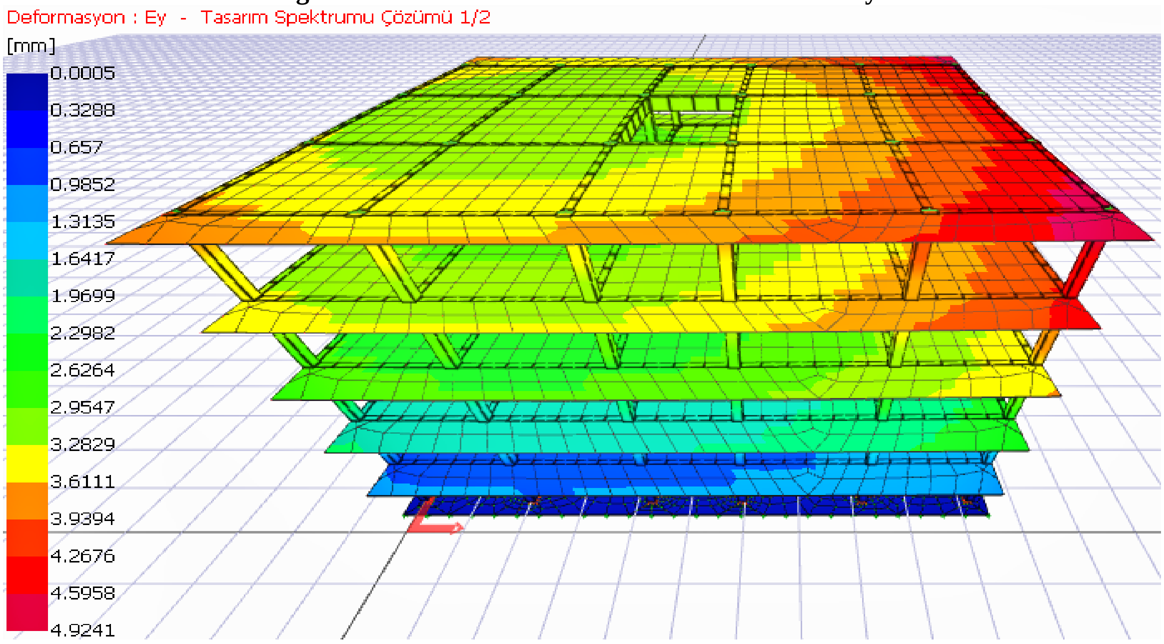


Figure 9. Deformations in x-direction for the 5-storey structure



The results obtained according to the design spectrum separately in the X and Y directions. For the 3-storey structure, the maximum peak displacement value in X direction was 2.49 mm, while in Y direction, this value was calculated as 2.95 mm. As a result of the analysis for the 5-storey structure, the maximum peak displacement in X direction was calculated as 4.05 mm and the maximum peak displacement in Y direction was calculated as 4.92 mm. The natural period of the 3-storey structure was T=0.556 and the maximum peak displacement value was 40.988 mm, while the natural period of the 5-storey structure was T=0.902 and the maximum peak displacement value was 33.007 mm

IV. CONCLUSION

The analysis performed and the systemic deficiencies of the frame structures were checked and compared with the results. It is noted that the results of the analysis with respect to the TBEC-2018 shows a high sensitivity of lateral displacements with height of buildings. The maximum peak displacements increases rabidly in both x and y directions as number of storey increases 3 to 5. similarly The natural period of the 3-storey structure also increase from T=0.556 to T=0.902 sec for that of the 5-storey structure. As a result the necesities of shear wall to increase lateral stifness have great importance to eliminate lateral weakness of frame structures for rise buildings to resist lateral earthquake loads.

Conflict of interest

There is no conflict to disclose.

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