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Structural Resistance of a Reinforced Concrete Building under Earthquake and Wind Loads in Isparta and Burdur Region

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Irregularity,
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Abstract: It has been clearly seen from building experiences and studies that lateral load effects such as earthquake load and wind load make building irregularities more obvious. Hence, it is of great importance to evaluate the regularity of the structural systems in accordance with the conditions determined by the building regulations. In this paper, irregularity effects were investigated according to Turkish Building Earthquake Regulation (TBEC) 2018. A reference building which have vertical setback irregularity were analzed under earthquake and wind loads. Etabs software were used for structural analyses. Response spectrum method were used for the seismic analysis and TS498 for Wind load analysis. Effective relative storey drift, A1 –Torsional irregularity and B2 – Soft Storey Irregularity are comparatively investigated and Irregularity values were determined.

Isparta ve Burdur Bölgesi'ndeki Betonarme Binanın Deprem ve Rüzgar Yükleri Altındaki Yapısal Dayanımı

Anahtar Kelimeler
Düzensizlik,
Deprem,
Rüzgar

Öz: Deneyimler ve yapılan çalışmalar, deprem ve rüzgar yükleri gibi yanal yüklerin yapılarda bariz bir şekilde düzensizliğe neden olduğunu göstermektedir. Bu nedenle yapının düzensizlik açısından şartlara uygun olarak değerlendirilmesi büyük önem taşımaktadır. Bu çalışmada 2018 TBDY'ne (Türkiye Bina Deprem Yönetmeliği) göre yapıların düzensizlik etkileri araştırılmıştır. Düşey düzensizliğe sahip bir yapı deprem ve rüzgar yükü altında analiz edilmiştir. Sismik analiz için tepki spektrum metodu ve rüzgar yükü analizi için TS498 kullanılmıştır. Etkin göreli kat ötelemesi, A1-Burulma düzensizliği ve B2-Yumuşak kat düzensizliği karşılaştırmalı olarak incelenmiş ve düzensizlik değerleri belirlenmiştir.

1. INTRODUCTION

Wind and earthquakes, coupled with aging and vulnerable buildings, pose the potential for damage and loss of life and property. Both hazards can wreak catastrophic damage to buildings. Winds and earthquakes cause the majority of property loss in the world from all natural disasters. Although an seismic hazard may be more significant than the other, the rapid population growth, highrise buildings and irregularity buildings have greatly increased the potential of exposure to multiple hazards[1]. The effect of wind and earthquake on structures may vary depending on wind load and seismic activity of the region, location and distance from the sea [2].

Turkey, one of the most seismically active countries of the world in terms of its geological features, is situated on an active area surrounded by active faults [3]. In the last century, destructive earthquakes have occurred along the North Anatolian Fault Zone (NAFZ) and East Anatolian fault lines where there are two active faults [4]. Earthquakes can not be prevented by human activity, these events occur as a result of a natural ground movement. Earthquake is one of the natural disasters that has caused the most destruction and loss of life for centuries [5] [6].

Many earthquakes occur every day in our country, where is about 92% of areas and about 95% of the population is on the earthquake zone. Therefore, all structures must be constructed against earthquake [7]. Although most of these earthquakes are of small intensity, sometimes large earthquakes occur. Such earthquakes cause loss of life and property and damage to structures. Some of these damages are irreparable depending on the current condition of the building and the nature of the earthquake [8]. However, with the necessary precautions, some of the negative consequences caused by earthquakes can be prevented or reduced [5]. The earthquake map of Turkey and the studied area in the study are given in Figure 1.

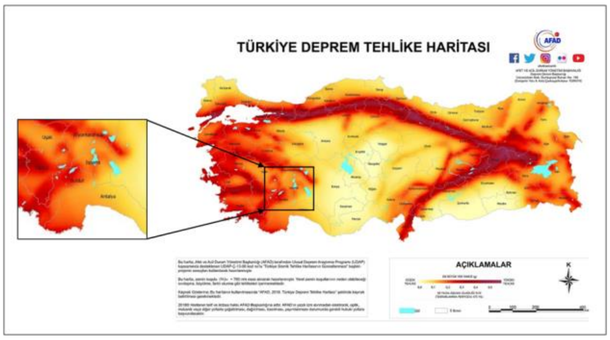


Figure 1. The earthquake map of Turkey and the studied area in the study [9]

Due to the shape formed by the fault lines in and around Isparta, this region is called the Isparta triangle or Isparta bend. The western edge of the Isparta Angle consists of the Fethiye–Burdur Fault Zone. The city of Isparta is located at the top of the triangle, below the point where the Burdur-Fethiye Zone intersects with the Akşehir Fault. Isparta and its surroundings are extremely sensitive against earthquakes. Isparta and its surroundings are extremely sensitive against earthquakes [8]. The earthquakes that occurred in Isparta and Burdur provinces are given in Table 1.

Table 1. The historical earthquakes that occurred in Isparta and Burdur [10]

Date	Region	Fault	M_s	I_0
End of 4th century BC	Dinar	?	?	?
88 BC	Dinar	?	?	IX-XI
AD 53	Dinar	?	?	VII-X
Beginning of 6th century AD	Isparta	?	?	VIII
Middle of 7th century AD	Isparta	?	?	IX-XI
AD 641–668	Isparta	?	?	VIII-X
1875	Dinar	Balkan Fault (20 km rupture)	?	IX-X
1889	Isparta	?	?	?
3 Oct. 1914	Burdur	Burdur Fault (23 km rupture)	7.1	IX
7 Aug. 1925	Dinar	Baklan Fault	6.0	VIII-IX
1933	Dinar	Baklan Fault	5.8	VIII
12 May 1971	Burdur	Burdur Fault	6.2	IX
1 Oct. 1995	Dinar	Dinar Fault (10 km rupture)	6.1	IX

Developments in structural materials and design technology in civil engineering have led to designs that satisfy strength requirements but are often flexible. This flexibility can cause unfavorable vibrations when the structure is subjected to wind or earthquake loads. These vibrations may lead to serious structural damage and affect the comfort of the occupants. Dynamics of buildings greatly depends on the characteristics of the external excitation as well as the physical properties of the building in terms of generalized masses, frequencies, and damping. Wind loads are characterized by low frequencies while earthquakes usually contain higher frequency load components [1].

On the other hand, besides the earthquake load, the wind load is also one of the important lateral loads that should be taken into account during the design phase of the building. Wind is a natural phenomenon that changes momentarily. Therefore, it is quite difficult to predict its properties such as intensity and direction. Analyzing how winds affect the structure dynamically and statically is a complex process [11].

In some cases, wind loads can be more critical to the carrier system and irreparable damage to the structure can occur if not taken into account during the design process. Wind load can cause serious damage especially in buildings which are high-rise and low cross-sectional areas [12]. With the increase in population, the number of high-rise buildings has increased considerably [13]. With the construction of high-rise buildings, the irregularity of the structure and its effects, which emerged as a result of wrong design, calculation, and application, started to become more evident.

Damages occurring in buildings after earthquake and wind loads may be caused by not taking into account irregularities such as A1 (Torsionally irregularity), A2 (Slab discontinuity), A3 (Existence of protrusions in the plan) and B1 (Strength irregularity between adjacent floors) and B2 (Soft story irregularity) during the design phase [9].

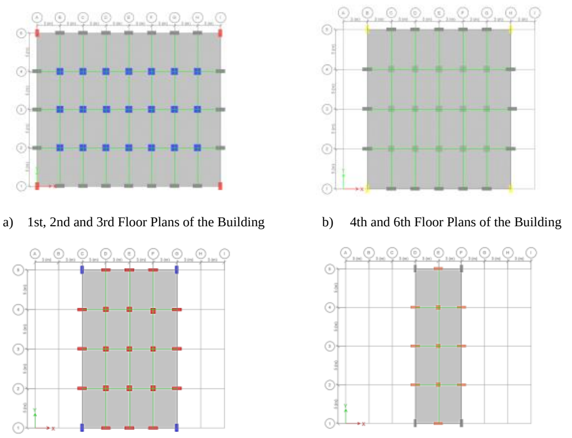
There have been many studies completed about seismic behavior of irregular structures. Demir et al. (2010) investigated horizontal seismic forces and torsional moments in different sites, the for the multiple storey structures [14]. Işık et al. (2018) examined the state of irregularity by the A3 plan in the TDBY of 2018[15]. Ilerisoy (2019) investigated vertical structural irregularities which are often inevitable due to building requirements and architectural imperatives, and having a major impact on building costs [16]. Ilgun et al. (2017) researched on A1 irregularity status in different spectral acceleration coefficients on reinforced concrete structures [17]. Keleş et al. (2021) and Uyan et al. (2021) investigated structural system safeties of 3, 5 and 7 storey existing reinforced concrete buildings having soft story irregularity according to TBEC-2018[18] [19]. Usta et al. (2022) analyzed regular and setback models of 5 storey, 9 storey, and 13 storey RC frames considered and the seismic risk effect over buildings that have vertical irregularity are investigated [20].

As seen, many studies have been conducted to investigate the effect of earthquake and wind. But there are less studies in which the structure is examined comparatively in terms of earthquake and wind load. In this study, it has been analyzed how earthquake and wind load that may occur in the Isparta and Burdur regions of Turkey will affect the performance of the structure which is located in these areas.

In the present context of study an reinforced concrete building is taken into consideration and the analysis is done as per the Turkish Standard. This building does not represent a particular real structure that has been built or proposed. However, the dimensions, general layout and other characteristics have been selected to be representative of a building for which the have vertical setback irregularity.

2. MATERIAL and METHOD

The aim in study is investigate the effects of earthquakes and wind loads. The building is considered to be located in Isparta and Burdur cities. For this purpose, a 12-storey reinforced concrete building was approached. The reinforced concrete building, having vertical setback irregularity. The building was dealt with the help of a ETABS software program [21]. Analysis and Irregularity controls of building were made under the earthquake and wind loads. The storey plans of the building are shown in Figure 2.a, Figure 2.b, Figure 2.c and Figure 2.d.



a) 1st, 2nd and 3rd Floor Plans of the Building b) 4th and 6th Floor Plans of the Building

c) 7th, 8th and 9th Floor Plans of the Building d) 10th, 11th and 12th Floor Plans of the Building

Figure 2. Floor plans of the building

The storey heights in the building are the same on each storey and are taken as 3 meter. Columns were designed in different sizes depending on the storey to catch optimum design and economy. Columns were chosen as 50x100 cm, 45x100 cm, 40x100 cm, 35x100 cm, 120x50 cm, 120x45 cm, 120x40 cm, 120x35 cm, 90x90 cm, 80x80 cm, 70x70 cm and 60x60 cm. Beams were chosen as 50x60 and 60x60. All slabs in the reinforced concrete building were formed with a thickness of 20 cm after analyzed according to TS 500/2000.

The dead load on the floors in the reinforced concrete building was G=3.5 kN (m2)-1 and the live load was taken as Q=2 kN (m2)-1. The dead load on the attic in the reinforced, concrete building was G=5 kN (m2)-1 and the live load was taken as Q = 1.5 kN (m2)-1 the modulus of elasticity was E=34000 MPa,

In order to represent other available buildings, the ground floor height was considered as 3 m. The building is unsymmetrical in Z direction. The distance between the axes of the building is designed 6 m intervals and the base-column joint area is defined as a fixed-support. The 3D view of the referenced building is given in Figure 3.

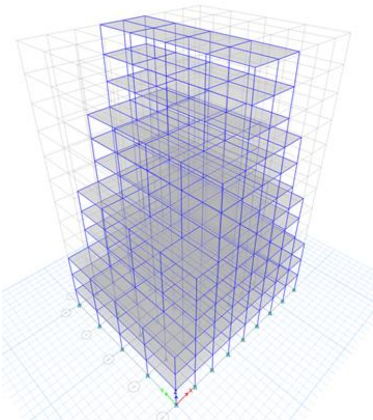


Figure 3. 3D View of the referenced building

The seismic design and examination of the structure was carried out according to TS 500. For this reason, the building importance coefficient, the structural system behavior coefficient, and the excess strength coefficient were taken as (I)=1, (R)=8, and (D)=3, respectively. Thus, the performance of a reinforced concrete structure with irregularity has been determined as a result of wind and earthquake load effects.

2.1. Earthquake Analysis and Definitions

Determining the earthquake behavior of the modeled reinforced concrete structure, the coordinates of the building were taken into consideration, and according the Turkey Building Earthquake Regulation 2018, the acceleration records were determined by selecting Central Düzce from the Disaster and Emergency Management Centre (DEMC) Earthquake Zones Map. Accordingly, the earthquake load coefficients used in the analyzes for the DD-2 (earthquake ground-motion level, probability of exceedance of which is 10% in 50 years) earthquake level Isparta and Burdur provinces are given in Table 2. In addition, the horizontal elastic design spectrum of Isparta and Burdur provinces defined in ETABS are given in figure 4 and figure 5, respectively.

Table 2. Earthquake Load Coefficients for Isparta and Burdur Provinces

	S_S	S_1	S_{DS}	S_{D1}	Soil Class
ISPARTA	0.612	0.148	0.551	0.118	ZB
BURDUR	0.980	0.226	0.882	0.181	ZB

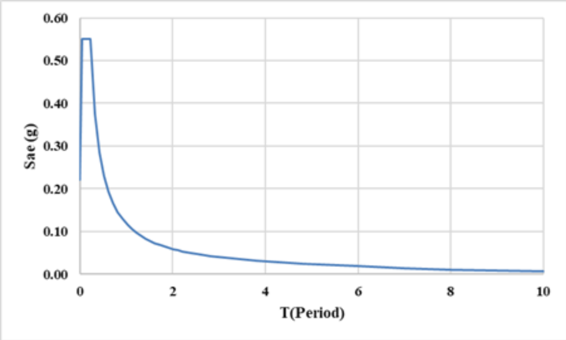


Figure 4. Horizontal elastic design spectrum of Isparta

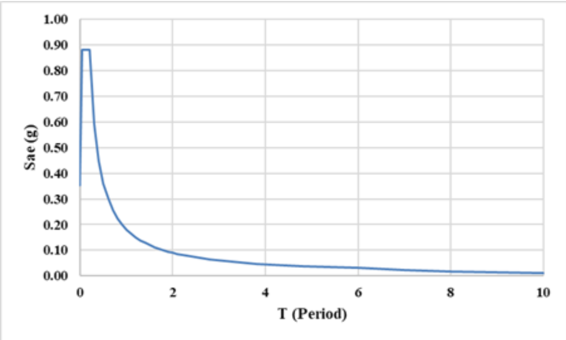


Figure 5. Horizontal elastic design spectrum of Burdur

In the 2018 Turkey Building Earthquake Regulation, there is a separate section for irregularity control of buildings. This section will be considered for irregularity checks as to the structure in the study.

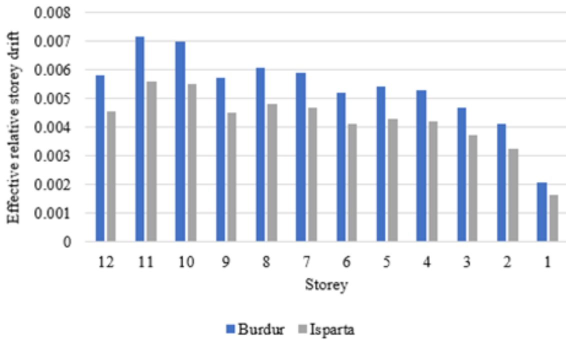
To make a comparison between different cities, the analysis of building structure was performed by using ETABS software program for the elastic response of spectra data of Turkish standards codes. Natural vibration period for x and y direction is obtained from mode 1 and mode 2 respectively. The first mode (T1=0.975s) mode indicates the elastic state of the structure. The bending vibration is typical and parallel to the long span of the structure.

2.1.1. Effective relative storey drift

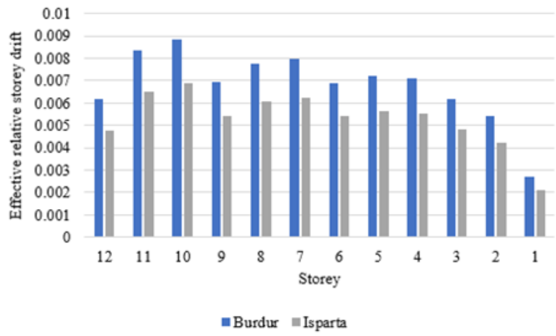
The Effective relative storey drift calculation is an important factor to control the stiffness of the structures during the design phase. An equation and a limit value are specified in the 2018 Turkish building earthquake code for the Effective relative storey drift control of the structures at the design stage. This equation and the limit value are shown in equation 1.

$$\lambda \frac{\delta_{imax}^{(x)}}{h_i} \leq 0.008\kappa \quad (1)$$

For the Effective relative storey drift calculation, the fundamental vibration period of the building was determined for the provinces of Isparta and Burdur in the direction of the earthquake. The coefficients λx and λy were calculated for the fundamental period and then the effective relative storey drift ratios were found by using equation 1. Effective relative story drift analysis for earthquak load was made according to Equation 1. The results obtained are given in Figure 6.



a) Effective relative storey drift for the X-direction



b) Effective relative storey drift for the Y-direction
Figure 6. Effective relative storey drift for the Isparta and Burdur according to earthquake load

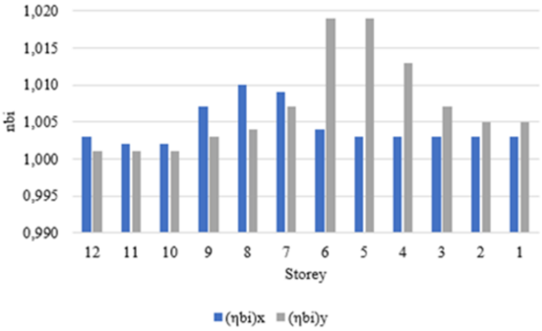
As a result of the earthquake force applied in the X direction, the maximum effective relative storey drift ratio was observed at the 11th floor and its value was calculated as 0.005610 for the Isparta. For Burdur, the maximum effective relative storey drift ratio was observed at the same floor and its value was calculated as 0.007176. The maximum effective relative storey drift ratio in the Y direction for the province of Isparta was observed at the 10th floor and its value was calculated as 0.006858. The maximum effective relative storey drift ratio for the province of Burdur was calculated as 0.008794 at the same floor. Obtained findings were examined. As a result of the examination, it was determined that it was within acceptable limits in terms of TBEC 2018.

2.1.2. A1 –Torsional irregularity

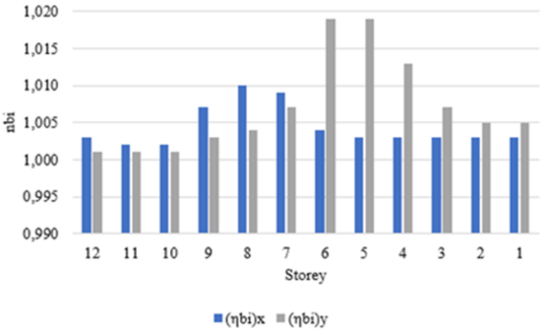
A1-Torsional irregularity is seen frequently in structures. In order to control the torsional irregularity, the torsional irregularity coefficient must be calculated. Torsional irregularity is the ratio of maximum interstory drift value to the average interstory drift value at each story and given in equation 2. Torsional irregularity occurs when ηb value is between 1,20 and 2,00 in a structure.

$$\eta_{bi} = \frac{\Delta i_{max}}{\Delta i_{ort}} > 1.2 \quad (2)$$

The Torsional irregularity values obtained from the calculations are given in the Figure 7 according to the cities and X and Y directions.



a) A1-Torsional irregularities for Isparta in the X -Y direction



b)A1-Torsional irregularities for Burdur in the X -Y direction
Figure 7. A1-Torsional irregularity

As the figure 7 is examined, it is seen that the data obtained from the structure as a result of the analysis remain within the specified limit values in terms of A1-Torsion irregularities control.

It can be said that the model structure provides sufficient safety against torsional irregularity under the acceleration values in the study.

2.1.3. B2 – Soft storey irregularity

With respect to the TBEC 2018, the soft-storey irregularity plays an important role when choosing the seismic-analysis method different from the other moderncountries' codes. According to the regulation, if the average relative displacement rate of 5% horizontal force eccentricity on a floor is more than 2.0 value, B2-Soft Storey irregularity case occurs in the building. The soft-storey conditions from the TSC 2018 are expressed with Equations (3) and (4):

$$\eta_{ki} = \frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i+1}/H_{i+1})_{ort}} > 2.0 \quad (3)$$

$$\eta_{ki} = \frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i-1}/H_{i-1})_{ort}} > 2.0 \quad (4)$$

The soft storey irregularity values obtained from the calculations are given in the Table 3 according to the cities and X and Y directions.

Table 3. B2- Soft storey irregularity
a)B2- Soft Storey Irreularity for Isparta City in the X -Y direction

		X Direction				Y Direction			
Storey	H_i (m)	$(\Delta_i)_{ort}$ (m)	$(\Delta_i)_{ort}/H_i$	$\frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i+1}/H_{i+1})_{ort}}$	$\frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i-1}/H_{i-1})_{ort}}$	$(\Delta_i)_{ort}$ (m)	$(\Delta_i)_{ort}/H_i$	$\frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i+1}/H_{i+1})_{ort}}$	$\frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i-1}/H_{i-1})_{ort}}$
12	3	0.041	0.014	-	0.812	0.043	0.014	-	0.734
11	3	0.051	0.017	1.231	1.017	0.059	0.020	1.362	0.946
10	3	0.050	0.017	0.983	1.213	0.062	0.021	1.057	1.272
9	3	0.041	0.014	0.824	0.936	0.049	0.016	0.786	0.893
8	3	0.044	0.015	1.068	1.020	0.055	0.018	1.120	0.970
7	3	0.043	0.014	0.981	1.128	0.057	0.019	1.031	1.135
6	3	0.038	0.013	0.887	0.968	0.050	0.017	0.881	0.958
5	3	0.039	0.013	1.033	1.029	0.052	0.017	1.044	1.024
4	3	0.038	0.013	0.972	1.143	0.051	0.017	0.977	1.160
3	3	0.033	0.011	0.875	1.138	0.044	0.015	0.862	1.139
2	3	0.029	0.010	0.879	1.980	0.039	0.013	0.878	2.001
1	3	0.015	0.005	0.505	-	0.019	0.006	0.500	-

b) B2- Soft Storey Irreularity for Burdur City in the X -Y direction

		X Direction				Y Direction			
Storey	H_i (m)	$(\Delta_i)_{ort}$ (m)	$(\Delta_i)_{ort}/H_i$	$\frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i+1}/H_{i+1})_{ort}}$	$\frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i-1}/H_{i-1})_{ort}}$	$(\Delta_i)_{ort}$ (m)	$(\Delta_i)_{ort}/H_i$	$\frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i+1}/H_{i+1})_{ort}}$	$\frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i-1}/H_{i-1})_{ort}}$
12	3	0.064	0.021	-	0.815	0.067	0.022	-	0.737
11	3	0.078	0.026	1.228	1.022	0.091	0.030	1.357	0.950
10	3	0.077	0.026	0.978	1.219	0.096	0.032	1.053	1.274
9	3	0.063	0.021	0.820	0.937	0.075	0.025	0.785	0.892
8	3	0.067	0.022	1.068	1.020	0.084	0.028	1.122	0.971
7	3	0.066	0.022	0.980	1.129	0.087	0.029	1.030	1.135
6	3	0.058	0.019	0.886	0.970	0.076	0.025	0.881	0.958
5	3	0.060	0.020	1.031	1.030	0.080	0.027	1.044	1.026
4	3	0.058	0.019	0.971	1.141	0.078	0.026	0.975	1.161
3	3	0.051	0.017	0.876	1.134	0.067	0.022	0.862	1.137
2	3	0.045	0.015	0.882	1.977	0.059	0.020	0.880	1.998
1	3	0.023	0.008	0.506	-	0.030	0.010	0.501	-

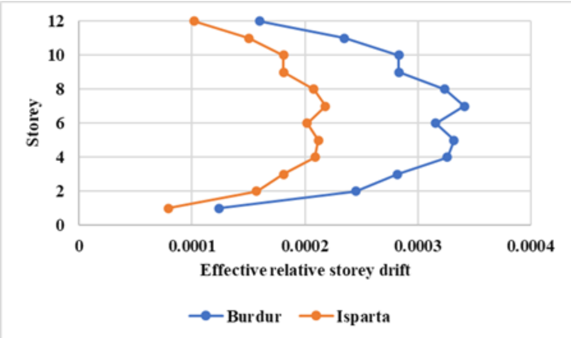
As the table 3 is examined, it is seen that the data obtained from the model structure as a result of the analysis. It is seen that B2-Soft Storey irregularity was observed only in Isparta Y direction.

2.2. Wind Analysis and Definitions

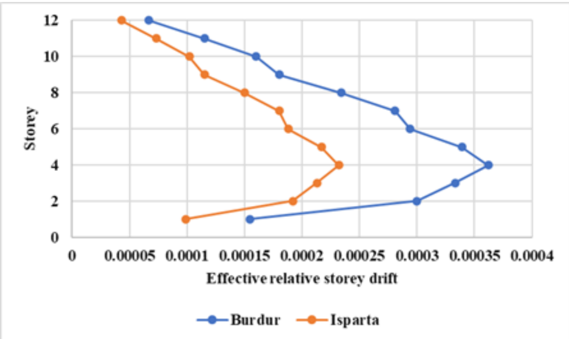
As mentioned before, in cases where the wind load is not taken into account in the design of the structures, permanent and high damages may occur in the structures. For this reason, the behavior of the model structure under the influence of wind load, which is discussed in the article, is also examined. The design of wind load was calculated based on TS498. Although Eurocode is generally used in wind analysis, TS498 was chosen in this study. The ETABS software program is selected to perform analysis and Wind analysis was carried out for the model structure of Isparta and Burdur Cities. The wind speed was determined as 40 m/s and 50 m/s, respectively based on the Republic of Turkey Ministry of Environment and Urbanization Meteorology. The land regions in which the structures are located were selected as the 2nd region also based on TS498

2.2.1. Effective relative storey drift

Analyzes were made for the Isparta and Burdur model structures and the effective relative storey drift values were calculated according to the wind loads. Effective relative story drift analysis for wind load was made according to Equation 1. The results obtained are given in Figure 8.



a) Effective relative storey drift ratio in the X direction



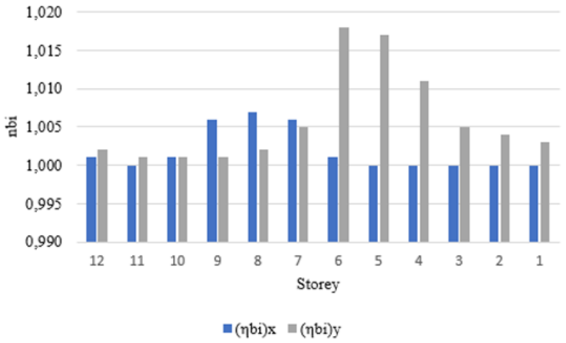
b) Effective relative storey drift ratio in the Y direction

Figure 8. Effective relative storey drift ratio in Isparta and Burdur provinces according to wind load

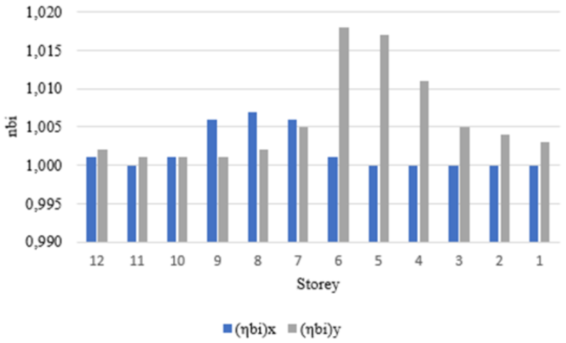
For Isparta X direction, the maximum effective relative story drift ratio was calculated as 0.000218 at the 7th storey, according to the wind load. For Burdur province, the maximum effective relative story drift ratio was calculated as 0.000341 at the 7th Storey. For Isparta Y direction, the maximum effective relative story drift ratio was calculated as 0.000232 at the 4th storey. The maximum effective relative story drift ratio for the province of Burdur was calculated as 0.000362 at the 4th storey. As the results of the analysis are evaluated in generally, it is seen that the effective relative storey drift for both cities is within the TBEC specified limits.

2.2.2. A1 – Torsional irregularity

Equation 2 was used to analyze the A1-torsion irregularity case in the Isparta and Burdur Cities according to the wind loads and the obtained values are given in Figure 9.



a) A1-Torsional irregularities for Isparta in the X -Y direction



b) A1-Torsional irregularities for Burdur in the X -Y direction
Figure 9. A1-Torsional irregularity

As the figure 9 is examined, it is seen that the data obtained from the structure as a result of the analysis remain within the specified limit values in terms of A1-Torsion irregularities control. It can be said that the model structure provides sufficient security against torsional irregularity under the wind loads values in the study.

2.2.3. B2- Soft storey irregularity

Equation 3 and 4 were used to analyze the B2-Soft Storey irregularity case in the Isparta and Burdur Cities according to the wind loads and the obtained values are given in Table 4.

Table 4. B2-Soft Storey Irregularity
a) B2- Soft Storey Irreularity for Isparta City in the X -Y direction

		X Direction				Y Direction			
Storey	H_i (m)	$(\Delta_i)_{ort}$ (m)	$(\Delta_i)_{ort}/H_i$	$\frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i+1}/H_{i+1})_{ort}}$	$\frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i-1}/H_{i-1})_{ort}}$	$(\Delta_i)_{ort}$ (m)	$(\Delta_i)_{ort}/H_i$	$\frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i+1}/H_{i+1})_{ort}}$	$\frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i-1}/H_{i-1})_{ort}}$
12	3	0.003	0.001	-	0.678	0.001	0.0004	-	0.582
11	3	0.005	0.002	1.474	0.832	0.002	0.001	1.719	0.719
10	3	0.005	0.002	1.202	1.002	0.003	0.001	1.391	0.887
9	3	0.005	0.002	0.998	0.875	0.003	0.001	1.127	0.770
8	3	0.006	0.002	1.142	0.949	0.004	0.001	1.299	0.836
7	3	0.007	0.002	1.053	1.072	0.005	0.002	1.196	0.966
6	3	0.006	0.002	0.932	0.953	0.006	0.002	1.035	0.867
5	3	0.006	0.002	1.049	1.018	0.006	0.002	1.153	0.930
4	3	0.006	0.002	0.983	1.155	0.007	0.002	1.075	1.083
3	3	0.005	0.002	0.866	1.153	0.006	0.002	0.923	1.104
2	3	0.005	0.002	0.867	1.975	0.006	0.002	0.906	1.943
1	3	0.002	0.001	0.506	-	0.003	0.001	0.515	-

b) B2- Soft Storey Irreularity for Burdur City in the X -Y direction

		X Doğrultusu				Y Doğrultusu			
Kat	H_i (m)	$(\Delta_i)_{ort}$ (m)	$(\Delta_i)_{ort}/H_i$	$\frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i+1}/H_{i+1})_{ort}}$	$\frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i-1}/H_{i-1})_{ort}}$	$(\Delta_i)_{ort}$ (m)	$(\Delta_i)_{ort}/H_i$	$\frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i+1}/H_{i+1})_{ort}}$	$\frac{(\Delta_i/H_i)_{ort}}{(\Delta_{i-1}/H_{i-1})_{ort}}$
12	3	0.005	0.002	-	0.678	0.002	0.001	-	0.581
11	3	0.007	0.002	1.475	0.832	0.003	0.001	1.720	0.718
10	3	0.008	0.003	1.201	1.002	0.005	0.002	1.392	0.890
9	3	0.008	0.003	0.998	0.875	0.005	0.002	1.123	0.769
8	3	0.010	0.003	1.143	0.951	0.007	0.002	1.301	0.835
7	3	0.010	0.003	1.052	1.072	0.008	0.003	1.197	0.965
6	3	0.009	0.003	0.933	0.952	0.009	0.003	1.036	0.867
5	3	0.010	0.003	1.051	1.018	0.010	0.003	1.153	0.930
4	3	0.010	0.003	0.982	1.156	0.011	0.004	1.075	1.084
3	3	0.008	0.003	0.865	1.153	0.010	0.003	0.923	1.106
2	3	0.007	0.002	0.868	1.978	0.009	0.003	0.904	1.940
1	3	0.004	0.001	0.505	-	0.005	0.002	0.516	-

As the table 4 is examined, it is seen that the data obtained from the model structure as a result of the analysis. It can be said that the model structure provides sufficient security against Soft Storey irregularity under the wind loads values in the study.

3. RESULTS

It is important to state that, even if the interstory drift ratios in buildings may be relatively small with no significant risk issues for the main force resisting system of the structure, nonstructural systems represent a high percentage of loss exposure of buildings to earthquakes [1]. Hence, all risk issues, all extra additioanal loads in structures must be carefully considered.

In this study, the vertical setback irregularity, formed because of the various design reasons was investigated.a reference building were compared in term of city, earthquake and wind load. The analyses were done using the ETABS structural analysis program. In this context, in a building model a vertical setback irregularity was deliberately formed.

It is stated in the 2018 TBEC that all structures to be built in earthquake zones should be designed by taking into account the irregularity conditions and evaluating within certain limits. In this paper, the building model with setback irregularity was discussed. The structure was examined according to the located in two different cities, Isparta and Burdur, and exposured to earthquake and wind loads. For this, ETABS structural analysis program has been used to evaluate the results by the referenced building. During examination of the result analyses, torsional irregularity, soft storey irregularity, and effective relative storey drift conditions occurring in the building were examined and compared.

According to the results obtained from the response spektrum analysis, it is seen that the effective relative storey drift and A1-torsion irregularity in both cities meet the regulation limit values. In B2-Soft Storey irregularity control, the value obtained in Isparta Y direction for the 2nd floor was found to be higher than the limit values of the regulation. In addition, it is seen that the effective relative storey drift values are higher in Burdur city than Isparta city. The reason for this is that the earthquake accelerations of Burdur city are higher compared to Isparta.

Besides the earthquake analysis, the results obtained from the wind load analysis, which is the second most important horizontal load acting on the structure, were compared in terms of torsional irregularity, soft story irregularity and effective relative story drift. According to the results obtained, it is seen that the effective relative storey drift, torsional irregularity and soft storey irregularity meet the regulation limit values for both cities according to the X and Y directions.

As the values obtained as a result of response spectrum and wind analysis were compared, the values obtained in the wind load analysis were lower than the values obtained from the earthquake analysis.

The acceleration values that change according to the location and coordinates of the cities and the annual wind average have been effective on this situation. For this reason, it is possible to obtain more critical results in studies to be carried out for different regions and different heights, unlike the results obtained from this study.

As a result, It seems that reinforced concrete buildings designed for earthquake and wind are safe under moderate earthquake loads. Nevertheless, it is important to, even if the interstory drift ratios in buildings may be relatively small with no significant apparent issues for the main force resisting system of the structure, nonstructural systems may represent a high percentage of loss exposure of buildings to earthquakes and winds. Hence, it is necessary to design by considering the wind load, especially in some regions in our country and appropriate regular design techniques are should recommended for the reduction under wind and earthquake loads.

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