



Analysis Of An Educational Building According To TEC2007 And TEC2018

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Keywords:

Analysis, Building importance coefficient Training building

Abstract

It was mentioned in Turkey Building Earthquake Regulation, which was published in 2018 and entered into force on 1 January 2019, that many changes have been made in many articles of (TDY 2007) for the buildings to be constructed in earthquake zones. One of these articles is the change of building importance coefficient according to purpose of the building use. Building importance coefficient is, a coefficient which is determined at designing stage according to the use of building after an earthquake load. According to the new regulation, School and education buildings and facilities, dormitories and dining halls, military barracks, prisons and classes of museums and so on, they have been changed as compulsory buildings after the earthquake. Within the scope of the study, ideal education building was analyzed in the program according to tdy 2007 and tbdy 2018 and the resulting data were compared.

43

Bir Eğitim Binasının TDY 2007 ve TBDY 2018'e Göre Analizi

Anahtar Kelimeler;

Analiz, Bina önem katsayısı, Eğitim binası

Özet

2018 yılında yayımlanan ve 1 Ocak 2019 tarihinde yürürlüğe giren Türkiye Bina Deprem Yönetmeliğinde (TBDY 2018) Deprem Bölgelerinde Yapılacak Binalar Hakkında Yönetmelik (TDY 2007)'e göre birçok alanda değişiklikler yapılmıştır. Bu alanlardan bir tanesi de binanın kullanım amacına göre belirlenen bina önem katsayısının değişmesidir. Bina önem katsayısı; tasarım aşamasındaki bir yapıda oluşan deprem yükünün depremden sonra kullanılma durumuna göre belirlenen katsayıdır. Okul ve eğitim bina ve tesisleri, yurt ve yatakhaneler, askeri kışlalar, cezaevleri vb. ve müzelerin kullanım sınıfları yeni yönetmeliğe göre depremden sonra kullanılması zorunlu binalar olarak değiştirilmiştir. Yapılan çalışma kapsamında; programda bulunan örnek eğitim binasının TDY2007 ve TBDY2018'e göre analizi yapılmış ve çıkan veriler karşılaştırılmıştır.

1 INTRODUCTION

Approximately 92% of our country's territory, 95% of the population, almost all of the industrial centers are located in the active earthquake zone (Taşan, 2012). Therefore, all structures must be constructed against earthquake (Öztürk 2005); (Nemrutlu and Sarı, 2018); (Tunc ve Tanfener, 2016). In 2018, a new earthquake regulation (TEC 2018) was published and the old earthquake regulation (TEC 2007) was repealed. With the new earthquake regulation that came into force in 2019, studies where two regulations were compared with each other started to be published (Haj Ahmet, 2018); (Ulutaş, 2018). One of the changes in the new regulation is the building importance factor, which is determined according to the purpose of use of the building. Educational buildings, dormitories, military barracks, prisons etc. usage classes have been changed to buildings that must be used after the earthquake according to the new regulation. The building importance coefficient of these structures has increased from "I" = 1.4 to "I" = 1.5.

In this study; A sample education building was analysed with the protastructure program. The building importance coefficient, which changed according to the new regulation, was analysed according to TEC 2007 and TEC 2018 and the data released were compared.

2 BUILDING INFORMATION

Number of Floors	= 7
Rigid basement	= 1
Concrete Class	= C30/37(Foundation)/ C5/45 (other stories)
Rebar Class	= B420C

Table 1. Building Parameters

Floor	Height (cm)	Elevation (cm)	Coefficient of Live Load
6	350.00	2450.00	0.30
5	350.00	2100.00	0.30
4	350.00	1750.00	0.30
3	350.00	1400.00	0.30
2	350.00	1050.00	0.30
1	350.00	700.00	0.30
Basement	350.00	350.00	0.30

Figure 1. 3D model of example building

The sample building shown in Figure 1 measures 56 * 24 * 24.5 m and consists of a basement and six floors.

2. SEISMIC PARAMETERS

Analyze Type	= Static Analyze
Degrees of Freedom	= X, Y and Rotation
Rigid zones in the junction	= Will be reduced by 25%
Earthquake Code	= TEC 2007 / TEC2018
Earthquake Zone	= 1. Zone
Effective ground acceleration(Ao)	= 0.40 (TDTH, 2020).
Structural system type	= 1.4/1.5
Structural system concrete frames beam	= Buildings where seismic effects are met by reinforced with high ductility level transmitting momentum and bond (hollow) reinforced concrete curtains with high ductility level
S.S. behavior coefficient, (R)	= 6.66
Ductility Level	= High
Building Purpose	= School
Eccentricity, (%)	= 5.0
Soil Class	=Z2/ZB

3. ANALYSIS CHECKS

Table 2. Comparison of analysis results according to two codes

TEC2007	TEC2018
No (B2) Soft Story Irregularity	No Soft Story Irregularity ✓
<p>(A1) Torsional irregularity control</p> <p>$\eta_C : \Delta_{max} / \Delta_{ort}$</p> <p>A1 irregularity in 1 direction (0.00 degrees with X-Axis)</p> <p>It was detected in the 2 direction (90.00 degrees with X-Axis) irregularity in A1.</p> <p>Max. Torsional Irregularity Coefficient = $1.640 \leq 2.0$</p> <p>The building was re-analyzed by applying Additional Eccentricities. ✓</p>	<p>(A1) BURULMA DÜZENSİZLİĞİ KONTROLÜ:</p> <p>$\eta_C : \Delta_{max} / \Delta_{ort}$</p> <p>No A1 torsional irregularity in 1 direction (0.00 degrees with X-Axis)</p> <p>In the direction of 2 (90.00 degrees with X-axis), there is a torsional irregularity in the structure. Max. Torsional Irregularity Coefficient = $1.668 \leq 2.0$</p> <p>Earthquake Design Class: DTS = 1a</p> <p>Building Height Class: $BYS=5 \geq BYS=4$ ($H_n = 21.00$ m) (TBDY 2018 - Article 4.6.2.2) The building was re-analyzed by applying Additional Eccentricities.</p>
-----	<p>BUILDING BASE AND BUILDING HEIGHT CONTROL:</p> <p>$T_{p,all} / T_{p,up} = 1.0000 \leq 1.1$ ✓</p>
<p>STRUCTURAL SYSTEM CONTROL:</p> <p>1 direction (0.00 degrees with X-Axis)</p> <p>$\alpha_S = V_p / V_t = (E+) = 0.67 \leq 0.75 / (E-) = 0.67 \leq 0.75$</p> <p>Structural System can be accepted as Shearwall + Frame. ✓</p> <p>2 direction (90.00 degree with X-Axis)</p> <p>$\alpha_S = V_p / V_t = (E+) = 0.83 > 0.75 / (E-) = 0.83 > 0.75$</p> <p>Structural System Behavior Coefficient: $R = 10 - 4$</p> <p>$\alpha_S = 6.66$ was used.</p> <p>Relative floor shifts control:</p> <p>Relative Floor Shifts provide Limit Values in 1 and 2 directions. OK. ✓</p>	<p>STRUCTURAL SYSTEM CONTROL:</p> <p>1 direction (0.00 degrees with X-Axis)</p> <p>$\alpha_M = M_{Dev} / M_o = 0.53 < 0.75$</p> <p>Structural System: It can be accepted as A15. ✓</p> <p>$R = 7.00$ and $D = 2.50$ will be used in the calculation of the design results.</p> <p>2 direction (90.00 degree with X-Axis)</p> <p>$\alpha_M = M_{Dev} / M_o = 0.71 < 0.75$</p> <p>Building Carrier System: It can be accepted as A15. ✓</p> <p>In the calculation of the design results: $R = 7.00$ and $D = 2.50$ will be used</p> <p>Relative floor shifts control:</p> <p>Relative Floor Shifts provide Limit Values in 1 and 2 directions. OK. ✓</p>
<p>533/5000</p> <p>EARTHQUAKE STATUS BUILDING TILTING CONTROL:</p> <p>Earthquake effects F1 and F2 were calculated using $R = 6.664$.</p> <p>ACTIVE EFFECTS: Total M_{a1} (kN.m): 293135.95</p> <p>M_{a2} (kN.m): 341575.12</p> <p>EFFECTS AGAINST TIPPING (Negative Earthquake Direction): M_{p1} (kN.m): $3.295E + 06$</p> <p>M_{p2} (kN.m): $1.412E + 06$</p> <p>EFFECTS AGAINST TIPPING (Positive Earthquake Direction): M_{p1} (kN.m): $3.857E + 06$</p> <p>M_{p2} (kN.m): $1.653E + 06$</p> <p>Roll Over Control: Direction 1 ... $M_{p1} / M_{a1} = 3.295E + 06 / 293135.95 = 11.2404 \geq 2.0$ OK. ✓</p> <p>Tip Over Control: Direction 2 ... $M_{p2} / M_{a2} = 1.412E + 06 / 341575.12 = 4.1342 \geq 2.0$ OK. ✓</p>	<p>EARTHQUAKE STATUS BUILDING TILTING CONTROL:</p> <p>Earthquake effects F1 and F2 were calculated using $R = 7.00$.</p> <p>ACTIVE EFFECTS: Total M_{a1} (kN.m): 113493.53</p> <p>M_{a2} (kN.m): 148 347.26</p> <p>EFFECTS AGAINST TIPPING (Negative Earthquake Direction): M_{p1} (kN.m): $3.295E + 06$</p> <p>M_{p2} (kN.m): $1.412E + 06$</p> <p>EFFECTS AGAINST TIPPING (Positive Earthquake Direction): M_{p1} (kN.m): $3.857E + 06$</p> <p>M_{p2} (kN.m): $1.653E + 06$</p> <p>Roll Over Control: Direction 1 ... $M_{p1} / M_{a1} = 3.295E + 06 / 113493.53 = 29.0323 \geq 2.0$ OK. ✓</p> <p>Tip Over Control: Direction 2 ... $M_{p2} / M_{a2} = 1.412E + 06 / 148347.26 = 9.5191 \geq 2.0$ OK. ✓</p>

The protostructure outputs of the analysis results are given in figure 2 and 3.

Analysis of An Educational Building According To TDY2007 and TBDY2018

O Z D E G E R S I S T E M M O D A L C A S E S : MODALALL

DENKLEM SAYISI : 34005
 KUTLE SAYISI : 21
 OZDEGER SAYISI : 6

O Z D E G E R L E R V E F R E K A N S L A R

MODE SAYISI	PERIYOD (SN)	FREKANS (ÇEVİRİM/SN)	ACISALFREKAN (RAD/SN)	OZDEGER (RAD/SN)**2
1	0.595772	1.678495	10.546297	111.224386
2	0.561554	1.780771	11.188916	125.191847
3	0.463156	2.159101	13.566032	184.037216
4	0.181818	5.500009	34.557576	1194.226036
5	0.158449	6.311173	39.654268	1572.460979
6	0.111633	8.957893	56.284103	3167.900277

K A T K I C A R P A N I

MOD	PERIYOD	X-YON	Y-YON	Z-YON	X-DON	Y-DON	Z-DON
1	0.595772	0.915148E-04	-0.180238E-03	0.000000	0.000000	0.000000	1606.287592
2	0.561554	99.191185	0.111732E-04	0.000000	0.000000	0.000000	-141012E-02
3	0.463156	-0.891801E-05	98.202012	0.000000	0.000000	0.000000	0.350918E-03
4	0.181818	-0.185084E-04	0.606666E-03	0.000000	0.000000	0.000000	-591.888440
5	0.158449	39.985172	0.749131E-05	0.000000	0.000000	0.000000	-284979E-03
6	0.111633	-0.344255E-05	48.361780	0.000000	0.000000	0.000000	-0.550152E-02

E T K I N K U T L E O R A N I - (%)

MOD	PERIYOD	X-YON	Y-YON	Z-YON	X-DON	Y-DON	Z-DON
1	0.595772	0.596358E-10	0.231323E-09	0.000000	0.000000	0.000000	65.574966
2	0.561554	70.060107	0.888947E-12	0.000000	0.000000	0.000000	0.505362E-10
3	0.463156	0.566318E-12	68.669742	0.000000	0.000000	0.000000	0.312971E-11
4	0.181818	0.243930E-11	0.262074E-08	0.000000	0.000000	0.000000	8.903714
5	0.158449	11.384726	0.399613E-12	0.000000	0.000000	0.000000	0.206403E-11
6	0.111633	0.843889E-13	16.654408	0.000000	0.000000	0.000000	0.769231E-09

T O P L A M E T K I N K U T L E O R A N I - (%)

MOD	PERIYOD	X-YON	Y-YON	Z-YON	X-DON	Y-DON	Z-DON
1	0.595772	0.596358E-10	0.231323E-09	0.000000	0.000000	0.000000	65.574966
2	0.561554	70.060107	0.232212E-09	0.000000	0.000000	0.000000	65.574966
3	0.463156	70.060107	68.669742	0.000000	0.000000	0.000000	65.574966
4	0.181818	70.060107	68.669742	0.000000	0.000000	0.000000	74.478680
5	0.158449	81.444833	68.669742	0.000000	0.000000	0.000000	74.478680
6	0.111633	81.444833	85.324150	0.000000	0.000000	0.000000	74.478680

O Z D E G E R S I S T E M M O D A L C A S E S : MODALSUPER

DENKLEM SAYISI : 34005
 KUTLE SAYISI : 18

O Z D E G E R L E R V E F R E K A N S L A R

MODE SAYISI	PERIYOD (SN)	FREKANS (ÇEVİRİM/SN)	ACISALFREKAN (RAD/SN)	OZDEGER (RAD/SN)**2
1	0.595769	1.678503	10.546348	111.225453
2	0.561545	1.780801	11.189100	125.195952
3	0.463107	2.159327	13.567453	184.075781
4	0.181806	5.500362	34.559792	1194.379233
5	0.158402	6.313065	39.666156	1573.403940
6	0.111211	8.991907	56.497819	3192.003497

K A T K I C A R P A N I

MOD	PERIYOD	X-YON	Y-YON	Z-YON	X-DON	Y-DON	Z-DON
1	0.595769	0.910600E-04	-0.139413E-04	0.000000	0.000000	0.000000	1603.437888
2	0.561545	98.932816	0.108754E-04	0.000000	0.000000	0.000000	-140919E-02
3	0.463107	-0.896862E-05	97.551779	0.000000	0.000000	0.000000	0.208549E-03
4	0.181806	-0.172941E-04	-0.397468E-05	0.000000	0.000000	0.000000	-581.428020
5	0.158402	38.880664	0.615046E-05	0.000000	0.000000	0.000000	-286993E-03
6	0.111211	-0.390090E-05	44.503453	0.000000	0.000000	0.000000	-0.595475E-04

E T K I N K U T L E O R A N I - (%)

MOD	PERIYOD	X-YON	Y-YON	Z-YON	X-DON	Y-DON	Z-DON
1	0.595769	0.691243E-10	0.162024E-11	0.000000	0.000000	0.000000	83.313908
2	0.561545	81.593557	0.985979E-12	0.000000	0.000000	0.000000	0.643505E-10
3	0.463107	0.670542E-12	79.331472	0.000000	0.000000	0.000000	0.140938E-11
4	0.181806	0.249327E-11	0.131698E-12	0.000000	0.000000	0.000000	10.954817
5	0.158402	12.602087	0.315348E-12	0.000000	0.000000	0.000000	0.266904E-11
6	0.111211	0.126854E-12	16.510588	0.000000	0.000000	0.000000	0.114905E-12

T O P L A M E T K I N K U T L E O R A N I - (%)

MOD	PERIYOD	X-YON	Y-YON	Z-YON	X-DON	Y-DON	Z-DON
1	0.595769	0.691243E-10	0.162024E-11	0.000000	0.000000	0.000000	83.313908
2	0.561545	81.593557	0.260622E-11	0.000000	0.000000	0.000000	83.313908
3	0.463107	81.593557	79.331472	0.000000	0.000000	0.000000	83.313908
4	0.181806	81.593557	79.331472	0.000000	0.000000	0.000000	94.268726
5	0.158402	94.195644	79.331472	0.000000	0.000000	0.000000	94.268726
6	0.111211	94.195644	95.842061	0.000000	0.000000	0.000000	94.268726

Figure 2; Analysis results according to TEC2007 (ProtaStructure, 2020).

Analysis of An Educational Building According To TDY2007 and TBDY2018

O Z D E G E R S I S T E M M O D A L C A S E S : M O D A L A L L

DENKLEM SAYISI : 34005
 KUTLE SAYISI : 21
 OZDEGER SAYISI : 6

O Z D E G E R L E R V E F R E K A N S L A R

MODE SAYISI	PERİYOD (SN)	FREKANS (ÇEVİRİM/SN)	ACISALFREKAN (RAD/SN)	OZDEGER (RAD/SN)**2
1	0.891391	1.121842	7.048743	49.684785
2	0.869012	1.150732	7.230261	52.276678
3	0.668903	1.494986	9.393274	88.233589
4	0.263695	3.792255	23.827441	567.746964
5	0.238491	4.193034	26.345607	694.090989
6	0.158845	6.295458	39.555529	1564.639905

K A T K I C A R P A N I

MOD	PERİYOD	X-YON	Y-YON	Z-YON	X-DON	Y-DON	Z-DON
1	0.891391	0.001283	-0.144556E-03	0.000000	0.000000	0.000000	1594.403766
2	0.869012	98.677253	0.658245E-05	0.000000	0.000000	0.000000	-0.020446
3	0.668903	-0.442246E-05	97.999572	0.000000	0.000000	0.000000	0.382424E-04
4	0.263695	-0.876685E-04	0.596530E-03	0.000000	0.000000	0.000000	-606.169157
5	0.238491	40.406931	0.679631E-05	0.000000	0.000000	0.000000	-1.60414E-02
6	0.158845	-0.191085E-05	48.549361	0.000000	0.000000	0.000000	-5.22057E-02

E T K İ N K U T L E O R A N I - (%)

MOD	PERİYOD	X-YON	Y-YON	Z-YON	X-DON	Y-DON	Z-DON
1	0.891391	0.117285E-07	0.148799E-09	0.000000	0.000000	0.000000	64.608266
2	0.869012	69.335993	0.308532E-12	0.000000	0.000000	0.000000	0.106245E-07
3	0.668903	0.139268E-12	68.386913	0.000000	0.000000	0.000000	0.371690E-13
4	0.263695	0.547283E-10	0.253390E-08	0.000000	0.000000	0.000000	9.338543
5	0.238491	11.626162	0.328905E-12	0.000000	0.000000	0.000000	0.653998E-10
6	0.158845	0.260002E-13	16.783853	0.000000	0.000000	0.000000	0.692670E-09

T O P L A M E T K İ N K U T L E O R A N I - (%)

MOD	PERİYOD	X-YON	Y-YON	Z-YON	X-DON	Y-DON	Z-DON
1	0.891391	0.117285E-07	0.148799E-09	0.000000	0.000000	0.000000	64.608266
2	0.869012	69.335993	0.149107E-09	0.000000	0.000000	0.000000	64.608266
3	0.668903	69.335993	68.386913	0.000000	0.000000	0.000000	64.608266
4	0.263695	69.335993	68.386913	0.000000	0.000000	0.000000	73.946810
5	0.238491	80.962155	68.386913	0.000000	0.000000	0.000000	73.946810
6	0.158845	80.962155	85.170766	0.000000	0.000000	0.000000	73.946810

OZDEGER SAYISI : 6

O Z D E G E R L E R V E F R E K A N S L A R

MODE SAYISI	PERİYOD (SN)	FREKANS (ÇEVİRİM/SN)	ACISALFREKAN (RAD/SN)	OZDEGER (RAD/SN)**2
1	0.891387	1.121847	7.048772	49.685183
2	0.869001	1.150746	7.230352	52.277994
3	0.668838	1.495130	9.394178	88.250576
4	0.263679	3.792494	23.828945	567.818622
5	0.238430	4.194096	26.352280	694.442687
6	0.158266	6.318496	39.700280	1576.112213

K A T K I C A R P A N I

MOD	PERİYOD	X-YON	Y-YON	Z-YON	X-DON	Y-DON	Z-DON
1	0.891387	0.001279	0.568192E-05	0.000000	0.000000	0.000000	1591.797315
2	0.869001	98.450801	0.633206E-05	0.000000	0.000000	0.000000	-0.020407
3	0.668838	-0.451432E-05	97.376119	0.000000	0.000000	0.000000	-0.636227E-04
4	0.263679	0.839277E-04	0.547029E-05	0.000000	0.000000	0.000000	595.791677
5	0.238430	39.391164	0.547233E-05	0.000000	0.000000	0.000000	-1.58862E-02
6	0.158266	-0.259854E-05	44.757805	0.000000	0.000000	0.000000	-3.89060E-04

E T K İ N K U T L E O R A N I - (%)

MOD	PERİYOD	X-YON	Y-YON	Z-YON	X-DON	Y-DON	Z-DON
1	0.891387	0.136435E-07	0.269132E-12	0.000000	0.000000	0.000000	82.108622
2	0.869001	80.800423	0.334245E-12	0.000000	0.000000	0.000000	0.134953E-07
3	0.668838	0.169887E-12	79.046027	0.000000	0.000000	0.000000	0.131171E-12
4	0.263679	0.587199E-10	0.249457E-12	0.000000	0.000000	0.000000	11.502761
5	0.238430	12.935189	0.249643E-12	0.000000	0.000000	0.000000	0.817811E-10
6	0.158266	0.562902E-13	16.699855	0.000000	0.000000	0.000000	0.490508E-13

T O P L A M E T K İ N K U T L E O R A N I - (%)

MOD	PERİYOD	X-YON	Y-YON	Z-YON	X-DON	Y-DON	Z-DON
1	0.891387	0.136435E-07	0.269132E-12	0.000000	0.000000	0.000000	82.108622
2	0.869001	80.800423	0.603378E-12	0.000000	0.000000	0.000000	82.108622
3	0.668838	80.800423	79.046027	0.000000	0.000000	0.000000	82.108622
4	0.263679	80.800423	79.046027	0.000000	0.000000	0.000000	93.611382
5	0.238430	93.735612	79.046027	0.000000	0.000000	0.000000	93.611382
6	0.158266	93.735612	95.745882	0.000000	0.000000	0.000000	93.611382

Figure 3; Analysis results according to TEC2018 (ProtaStructure, 2020)

4. CONCLUSION

In this study, a sample education building was analyzed under the same conditions according to TEC2007 and TEC2018 and the results were compared. The results of the analysis showed that the numerical data have changed somewhat. No significant difference was observed in the general situation of the building. Some period difference in the earthquake report results draw attention. The reason for the period difference is that in TEC2007 only the horizontal spectrum is created for one earthquake. In the new regulation, both horizontal and vertical spectra are created for repetition periods of 2475 years, 475 years, 72 years and 43 years. In the new regulation, the fixed displacement plateau and the TL (transition period to the fixed displacement zone) determining this plateau are included in the spectrum. In TEC2018, this period is considered as 6s. Thus, displacement request does not increase uncontrolled. In addition, in the new earthquake regulation, the results are more sensitive since the earthquake parameters that affect the account are taken on the coordinate, that is, a more realistic calculation approach.

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