Effect of Vertical Elastic Design Spectral Obtained According to Different Soil Classes on Beam Behavior and Comparison of Vertical Component of K.Maras Earthquake with Beam Effect

Furkan Sahin*, Ersen Arasli**

* Nisantası University, Department of Civil Engineering, Istanbul, Türkiye

** Nisantası University, Department of Civil Engineering, Istanbul, Türkiye
furkan.sahin@nisantasi.edu.tr, ersenarazli@gmail.com

ORCID* : 0000-0002-1661-5531, ** 0009-0002-2190-3965

‡ Corresponding Author; Furkan Şahin, Maslak Campus

furkan.sahin@nisantasi.edu.tr

Received: 09.07.2023 Accepted: 01.11.2023

Abstract- In practice and theory, many types of reinforced concrete slabs are used, such as beamed, beamless, and ribbed slabs. Beamed floors are connected to the columns by means of beams, and their vertical and horizontal loads are transferred to the columns through these beams. Therefore, beams are accepted as an important structural element by earthquake experts and many formulas and approaches have been developed in terms of horizontal and vertical load effects that occur in order to transfer the load transfer to the elements as desired. In this study, beam shear forces that occur under the influence of vertical earthquakes at the i and j ends of the beams of a fictional building whose floors are modeled according to the rigid diaphragm assumption in the ETABS were investigated. In this study, the shear forces that occur in the beams of a fictionally designed building under the effect of vertical earthquakes, and the floors carried by the beams are examined by designing with the assumption of a rigid diaphragm. The structure is designed with 3 openings in the X and Y directions and each opening is equal and 5 m. The 5-storey building has been designed to have equal floor heights of 3 m. The structure was obtained by using parameters belonging to 5 different soil classes as ZA, ZB, ZC, ZD, ZE, and 5 different vertical elastic design spectrums represented by the abbreviations EZ_ZA, EZ_ZB, EZ_ZC, EZ_ZD were activated in the ETABS. Seismic station coordinates numbered 4631 in K.Maras/Elbistan were used to obtain the parameters to be used in obtaining the vertical elastic design spectral of the structure. These coordinates were selected in order to compare the i and j end shear forces of the beam with the previously obtained beam i and j ends shear forces by influencing the Mw:7.6 Elbistan earthquake recorded by the seismic station to the building. Since the structure is symmetrical in both X and Y directions, the results obtained from beams B2, B3, B5, B19 represent the beam shear forces occurring at the i and j ends of all beams of the structure. As a result, it has been seen that the highest values of beam i and j end shear forces, obtained by affecting both the vertical elastic design spectral and the data of the vertical component of the Elbistan Mw:7.6 earthquake, were obtained on the 5th floor, which is the top floor of the building. The structure showed similar behavior among the different vertical elastic design spectral, and the highest value was obtained for each vertical elastic design spectrum at the 5th floor. Among these vertical elastic design spectral, the EZ_ZC spectrum gave the highest value at the 5th floor of the building. When the EZ_ZC vertical elastic design spectrum beam i and j end shear forces are compared with the beam i and j end shear forces of the vertical component data of the Elbistan Mw:7.6 earthquake, it is seen that the difference is not significant. It has been seen that the beam i and j end shear force value of the spectrum is higher than the shear force value.

Keywords: Shear force, TBER, Elbistan, Earthquake, Vertical Earthquake Component.

1. Introduction

The loads on which the structure will be constructed may vary according to the conditions of the region. These conditions that will affect the building are determined, regulated and published in a way that is closed to interpretation by the management of the region where the building is located. Mnistry of Environment, Urbanization and Climate Change has undertaken this task in Turkey and has published many regulations such as TS500, TS498, and Turkey Building Earthquake Regulation (TBER).

Although there are design, calculation and dimensioning codes of reinforced concrete structures according to the purpose and duration of use of the structure according to the TS500 standard, this standard does not cover the design of all reinforced concrete structures.[1] TS498 clarifies the definition of moving loads such as wind, snow and ice to be used in buildings. [2] TBER, on the other hand, includes methods and guidelines to be used in the design, calculation and dimensioning of structures under earthquake risk [3]. This standard clarifies the methods to be used for building structures intended to be designed in areas with earthquake risk. The first of the methods is to deal with the slab primarily according to the elastic design acceptance and to make the calculations in this way, and in the next step, where the earthquake load will be applied eccentrically in the regulation, the slab will be solved according to the rigid diaphragm acceptance and the data will be evaluated in this context. The second method is to dissolve the slab in a single step according to the rigid diaphragm acceptance. It is expected that the slab, which is expected to behave as a rigid diaphragm in these assumptions to be made in the design phase of the slabs, especially the horizontal loads will be transferred to the columns in proportion to the stiffness of the columns, so slab-column connections gain importance.

In this study, the shear force values occurring at the i and j ends of the beams of a fictional building whose floors are designed according to the rigid diaphragm assumption will be examined. The building to be modeled in the study has equal spans in the X and Y directions, and each span is determined as 5 m. Again, the building was designed as 5 floors and all floor heights were determined as equal and 3 m. In the first stage, 5 different vertical elastic design spectrums, represented by the abbreviations EZ_ZA, EZ_ZB, EZ_ZC, EZ_ZD, were obtained by using parameters belonging to 5 different floor classes as ZA, ZB, ZC, ZD, ZE, and in this article, 5 different vertical elastic design spectral were applied to the building with the Etabs program and for each floor. The shear forces at the beam i and j ends will be obtained. In the later stages of the study, the vertical component data of the 7.6 Mw earthquake in Elbistan will be affected by the seismic station 4631 and shear forces at the beam i and j ends will be obtained. In the conclusion part, the obtained data will be compared and analyzed.

Since the structure is symmetrical in the X and Y directions in the study, B2, B3, B5, B19 type beams represent the entire structure.

In beamed floors, floors are connected to the columns by beams and their horizontal and vertical loads are transferred through these beams. For this reason, beams are accepted as an important structural element by construction experts and methods to be used in design are investigated.

1.1. Literature Survey

It is seen that the studies carried out to understand the importance of the effect of the vertical earthquake component on the behavior of the structure and to emphasize this importance are limited in the literature records. However, even in these limited studies, it has been emphasized that the vertical seismic component is an important dynamic component in the building design. In this context, when we look at the records of the last 10 years, one of the most important studies;

The effect of the vertical earthquake component on the derailment of the railway vehicles was investigated and it was determined that the vertical earthquake component increased the probability of derailment of the railway vehicles [4].

In another study, firstly, the horizontal component of the acceleration records obtained from seven strong ground motions was applied to the 3- and 7-storey buildings, and then the vertical component was added to these forces. While it is assumed that the vertical component of the earthquake effect has a significant effect on the axial force of the column under study, it has been determined that there is no significant effect on the column shear force and nodal points [5].

In another work, the effect of the vertical earthquake effect on high-rise buildings was examined. According to the non-linear analysis results in the time domain, it was determined that vertical earthquake motion did not have a significant effect on the relative story drift, overturning moment and base shear force, and increased by 20% in both tensile and compressive stresses in the near-field regions in column axial forces. When only the increase in compressive stresses was observed, it was determined that the values of this increase were approximately 105%, 57% and 68% of the axial capacity of the column according to the A, B and C soil classes, respectively [6].

In addition, in a different study, when the effect of the vertical earthquake component on the steel-concrete plate composite beam bridge was investigated, it was determined that the axial force of the bridge columns and pillars was significantly higher than the shear force and bending moment. As a result of the studies, it was emphasized that the vertical earthquake component should be taken into account, especially in steel-concrete plate composite beam bridges in near-fault regions [7].

In the study conducted on inclined bridges, it was found that the lateral displacement of the bridge slab was 21% higher in case the ratio of the vertical component to the horizontal component values in earthquake components is 2/3 (V/H=2/3) in bridges with this form, and the impact frequency is found in different bridge piers. It has been found that different values were given [8].

The possible vertical split of the bridge and the structural damage in the split were calculated by superpositioning the calculations under the influence of vertical and horizontal earthquakes in the 2-span continuous bridge modeled by the researchers who theoretically examined the multiple splitting of the bridge under the influence of vertical earthquakes in the near region. In the calculations made using the transition wave characteristic function and indirect mode superposition methods, it has been observed that the splitting in high-pier bridges widens the deformation and even causes damage to the bridge pier. It has been determined that the seismic wave affects the deformation of the bridge piers in external effects such as the time to reach the structure and the strength of the supports, and in addition to these, the number of divisions will affect the seismic response occurring in the bridge pier [9].

In accordance with the observation of past earthquake effects, the seismic performance of the structure and the possibility of collapse were examined, especially by affecting the vertical earthquake effect on a reinforced concrete structure. For this purpose, the behavior of three high reinforced concrete frame-core wall structures under bidirectional ground motion is discussed. In the study, in which incremental dynamic analysis was applied, slenderness curves covering both horizontal and vertical earthquake effects were obtained. As a result, in the buildings where the vertical and horizontal earthquake effects were applied together, the collapse criteria were met at low density measurements; It has been seen that the risk of collapse increases due to the two-way earthquake effect that the structure is exposed to, and the seismic performance obtained in this way allows a more accurate evaluation [10].

2. Methology

2.1. Soil classes and other parameters according to TBER

Methods specified in TBER should be used to obtain the elastic design spectral of different soil classes. In order to obtain the earthquake design spectral of different soil classes by using the earthquake code, the properties of the ground on which the building will be built should be determined according to Table 2-I. In the next step, local ground effect coefficient Fs will be obtained by using Table 2-II and local ground effect coefficient F1 for 1s period will be obtained using Table 2-III.

Table 2 I. Local Ground Classification [1].

Local Ground Class	**Ground Type**	**Average in the upper 30 m**		
		(Vs)30 [m/s]	**(N60)30 [pulse/30 cm]**	**(Cu)30 [kPa]**
ZA	Solid hard rocks	>1500	-	-
ZB	Slightly segregated medium solid rocks	760-1500	-	-
ZC	Very tight layers of sand, gravel, and hard clay, or segregated, very fractured weak rocks	360-760	>50	>250
ZD	Medium-density sand, gravel or multi-layered clay layers	180-360	15-50	70-250
ZE	Profiles containing loose sand, gravel or soft-solid clay layers or a total of more than 3 meters of soft clay layer (Cu<25 kPa) satisfying PI>20 and W>40% conditions	<180	<15	<70
ZF	Soils requiring site-specific investigation and evaluation; 1)Soils requiring earthquake effect investigation and evaluation (liquefiable soils, highly sensitive clays, collapsible weak cement soils, etc.) 2)Clays with a total thickness of more than 3 meters of peat and/or high organic content, 3)Clays of high plasticity (PI>50) with a total thickness of more than 3 m, 4)Very thick (<35m) soft or medium solid clays ZD ZE ZF			

Table 2 II. Local ground effect coefficient for the short period region [2].

Local Ground Class	**Local ground effect coefficiency for short period region F_S**					
	$S_S \leq 0.25$	**$S_S = 0.25$**	**$S_S = 0.50$**	**$S_S = 0.75$**	**$S_S = 1.00$**	**$S_S = 1.50$**
ZA	0.8	0.8	0.8	0.8	0.8	0.8
ZB	0.9	0.9	0.9	0.9	0.9	0.9
ZC	1.3	1.3	1.2	1.2	1.2	1.2
ZD	1.6	1.4	1.2	1.1	1.0	1.0
ZE	2.4	1.7	1.3	1.1	0.9	0.8
ZF	Site-specific ground behavior analysis will be performed.					

Table 2 III. Local ground effect coefficient for 1 s period [2]

Local Ground Class	**Local ground effect coefficiency for 1 s period F_1**					
	$S_1 \leq 0.10$	**$S_1 = 0.20$**	**$S_1 = 0.30$**	**$S_1 = 0.40$**	**$S_1 = 0.50$**	**$S_1 = 0.60$**
ZA	0.8	0.8	0.8	0.8	0.8	0.8
ZB	0.8	0.8	0.8	0.8	0.8	0.8
ZC	1.5	1.5	1.5	1.5	1.5	1.4
ZD	2.4	2.2	2.0	1.9	1.8	1.7
ZE	4.2	3.3	2.8	2.4	2.2	2.0
ZF	Site-specific ground behavior analysis will be performed.					

The map spectral acceleration coefficient (Ss) for the short period and S1 for the 1 s period can be obtained from the website **(tdth.afad.gov.tr)** made available by AFAD. By using these obtained data, short period design spectrum acceleration coefficient SDS and design spectrum acceleration coefficient SD1 for 1 s period were obtained by using Equation X.x.

SDS=SS x FS 2.I [2]
SD1=S1 x F1 2.II [2]

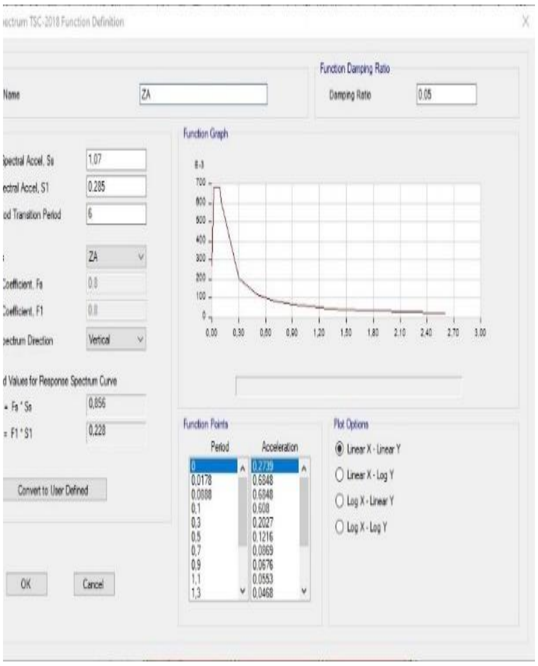
Design spectrum acceleration coefficients of 5 different soil classes, which were attained according to the earthquake code and entered into the ETABS to be used in the analysis, were given in Table 2-IV. In order to obtain these data, 37.38676 latitude and 37.13803 longitude coordinates belonging to the seismic station numbered 4631 were entered into the earthquake hazard map interface on website.

Table 2 IV. Spectrum acceleration coefficients attained according to different soil classes.

Local Ground Class	**S1**	**SS**	**F1**	**FS**	**SD1**	**SDS**	**TA**	**TB**	**TL**	**TAD**	**TBD**	**TLD**
ZA	0.285	1.07	0.8	0.8	0.228	0.856	0.053	0.266	6	0.018	0.089	3
ZB	0.285	1.07	0.8	0.9	0.228	0.963	0.047	0.237	6	0.016	0.079	3
ZC	0.285	1.07	1.5	1.2	0.428	1.284	0.067	0.333	6	0.022	0.111	3
ZD	0.285	1.07	2.03	1.072	0.579	1.147	0.101	0.504	6	0.034	0.168	3
ZE	0.285	1.07	2.875	1.044	0.819	1.117	0.147	0.733	6	0.049	0.244	3

2.2. Defining Response Spectral in ETABS

Design spectrum acceleration coefficient values for five different soil classes were defined in the fields specified in the response spectrum definition interface of Etabs, and vertical elastic response spectral were obtained for five different soil classes.



Name: ZA

Damping Ratio: 0.05

pectral Accel, Ss: 1.07

ectral Accel, S1: 0.285

od Transition Period: 6

ZA

Coefficient, Fs: 0.8

Coefficient, F1: 0.8

pectrum Direction: Vertical

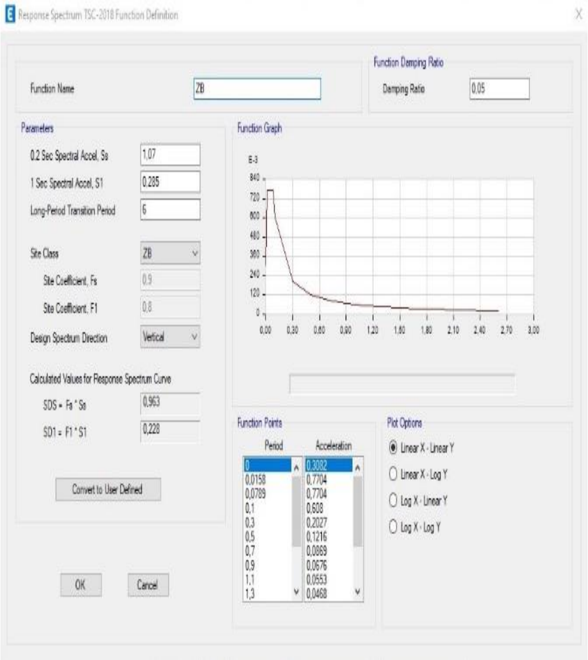
d Values for Response Spectrum Curve

= Fs * Ss: 0,856

= F1 * S1: 0,228

Period	Acceleration
0	0,2739
0,0178	0,6848
0,0888	0,6848
0,1	0,608
0,3	0,2027
0,5	0,1216
0,7	0,0869
0,9	0,0676
1,1	0,0553
1,3	0,0468

● Linear X - Linear Y
○ Linear X - Log Y
○ Log X - Linear Y
○ Log X - Log Y



Function Name: ZB

Damping Ratio: 0,05

0.2 Sec Spectral Accel, Ss: 1,07

1 Sec Spectral Accel, S1: 0.285

Long-Period Transition Period: 6

Site Class: ZB

Site Coefficient, Fs: 0.9

Site Coefficient, F1: 0.8

Design Spectrum Direction: Vertical

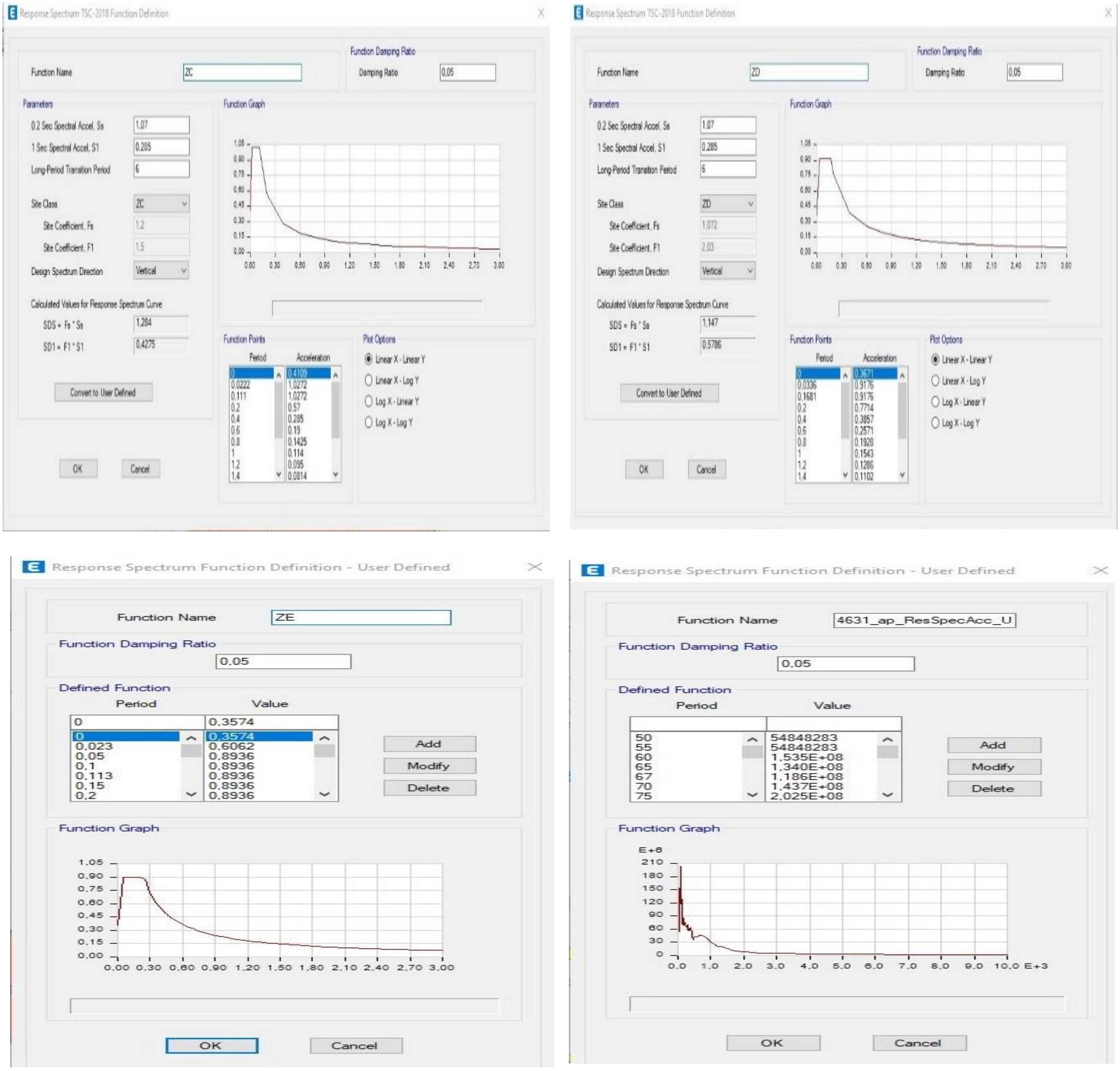
Calculated Values for Response Spectrum Curve

SDS = Fs * Ss: 0,963

SD1 = F1 * S1: 0,228

Period	Acceleration
0	0,3082
0,0158	0,7704
0,0789	0,7704
0,1	0,608
0,3	0,2027
0,5	0,1216
0,7	0,0869
0,9	0,0676
1,1	0,0553
1,3	0,0468

● Linear X - Linear Y
○ Linear X - Log Y
○ Log X - Linear Y
○ Log X - Log Y



Response Spectrum TSC-2018 Function Definition

Function Name: ZC
Damping Ratio: 0,05
0.2 Sec Spectral Accel, Ss: 1,07
1 Sec Spectral Accel, S1: 0,285
Long-Period Transition Period: 6
Site Class: ZC
Site Coefficient, Fs: 1,2
Site Coefficient, F1: 1,5
Design Spectrum Direction: Vertical
SDS = Fs * Ss: 1,284
SD1 = F1 * S1: 0,4275
● Linear X - Linear Y
○ Linear X - Log Y
○ Log X - Linear Y
○ Log X - Log Y

Period	Acceleration
0	0,4109
0,0222	1,0272
0,111	1,0272
0,2	0,57
0,4	0,285
0,6	0,19
0,8	0,1425
1	0,114
1,2	0,095
1,4	0,0814

Response Spectrum TSC-2018 Function Definition

Function Name: ZD
Damping Ratio: 0,05
0.2 Sec Spectral Accel, Ss: 1,07
1 Sec Spectral Accel, S1: 0,285
Long-Period Transition Period: 6
Site Class: ZD
Site Coefficient, Fs: 1,072
Site Coefficient, F1: 2,03
Design Spectrum Direction: Vertical
SDS = Fs * Ss: 1,147
SD1 = F1 * S1: 0,5786
● Linear X - Linear Y
○ Linear X - Log Y
○ Log X - Linear Y
○ Log X - Log Y

Period	Acceleration
0	0,3671
0,0336	0,9176
0,1681	0,9176
0,2	0,7714
0,4	0,3857
0,6	0,2571
0,8	0,1928
1	0,1543
1,2	0,1286
1,4	0,1102

Response Spectrum Function Definition - User Defined

Function Name: ZE
Function Damping Ratio: 0.05

Period	Value
0	0.3574
0	0.3574
0.023	0.6062
0.05	0.8936
0.1	0.8936
0.113	0.8936
0.15	0.8936
0.2	0.8936

Response Spectrum Function Definition - User Defined

Function Name: 4631_ap_ResSpecAcc_U
Function Damping Ratio: 0.05

Period	Value
50	54848283
55	54848283
60	1,535E+08
65	1,340E+08
67	1,186E+08
70	1,437E+08
75	2,025E+08

Figure 2 1. Vertical elastic design spectral and spectrum definition for Elbistan earthquake.

3. Modeling of the Building And Assigning Loads To Structural Elements

The columns of the building to be used in the analysis were chosen as 40x40 cm type columns. The beams of the building to be used in the analysis were determined as 25x50 cm type beams. Floor thickness was determined as equal and 12 cm slab for each floor. No foundation design was made for the building, and the columns were fixed to the ground with built-in supports. Earthquake curtains were not used in the building. The loads on the structure have been determined by considering the TS498 standard. Loads on the structure are given in Table 2-V.

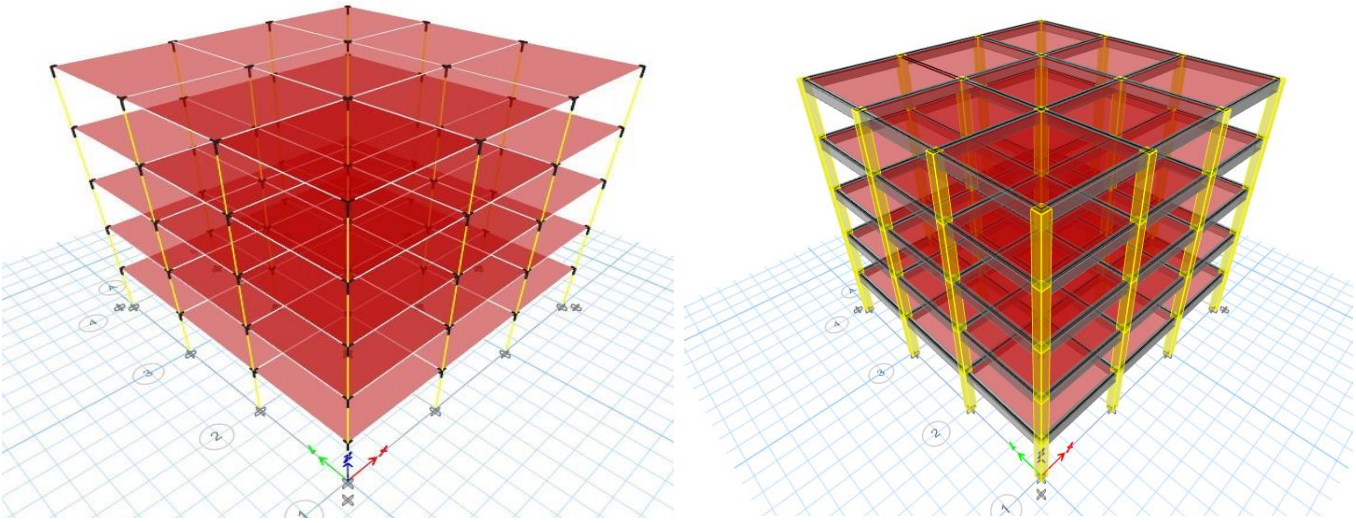


Figure 3 1. Bar model of the building to be used in the analysis and its visualization in 3D in the ETABS.

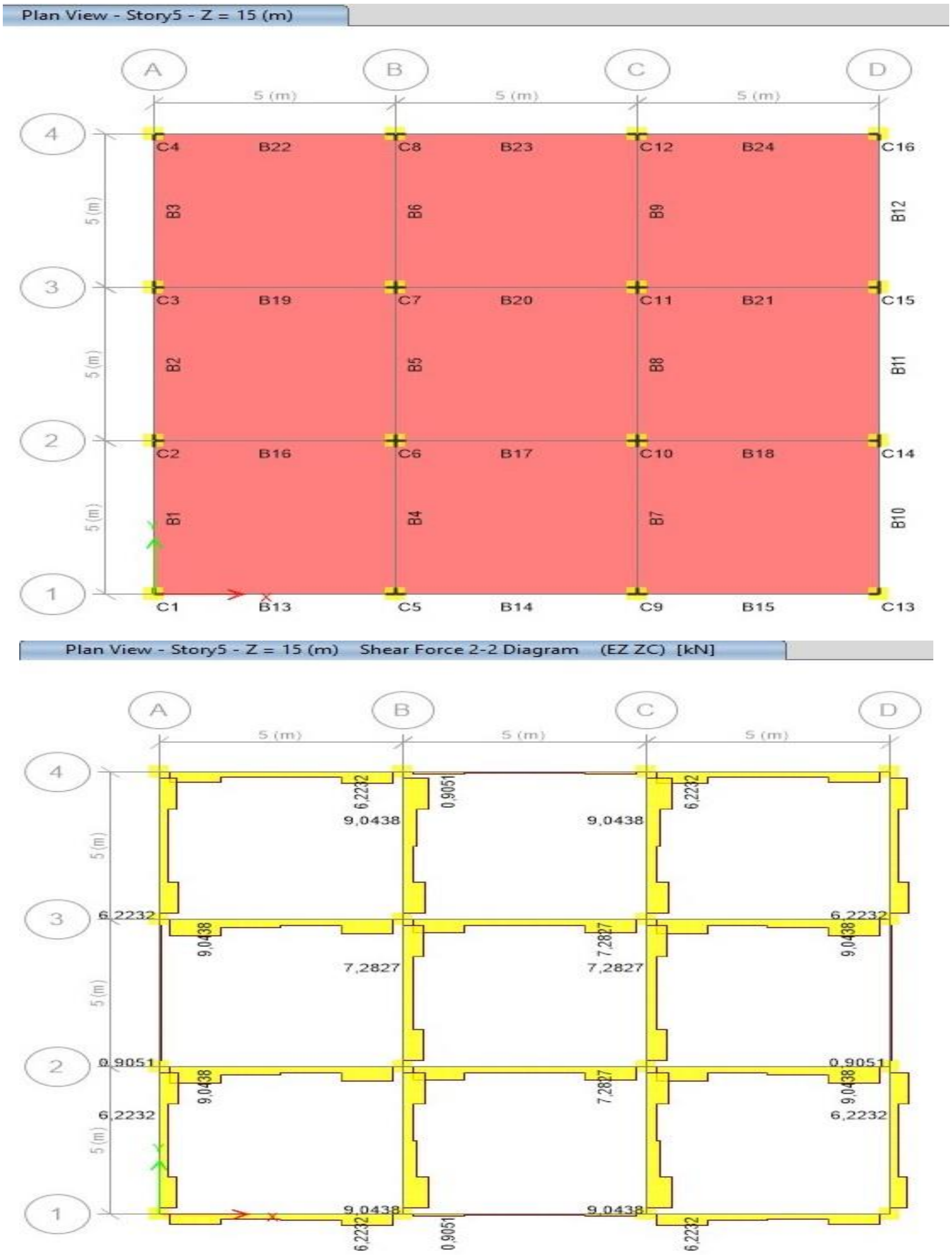
Table 3 V. Loads on the structure and their values.

Load Type	**Symbol**	**Unit**	**Magnitude**
Self–Weight	G	kN	software-defined
Live load (floor)	Q	kN	2
Live load (Roof)	Q	kN	1.5
wind Load	W	kN	software-defined
Snow Load	S	kN	1.48
Super Dead Load	Wall	kN/m	1.5
Super Dead Load	Cover	kN/m^2	0.25

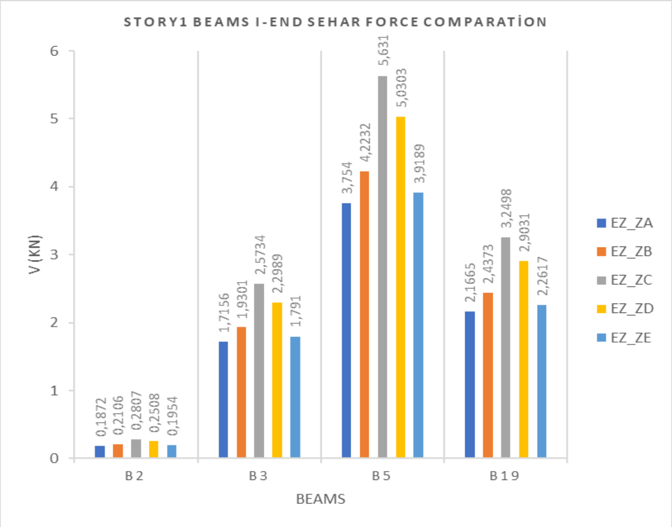
4. Conclusion

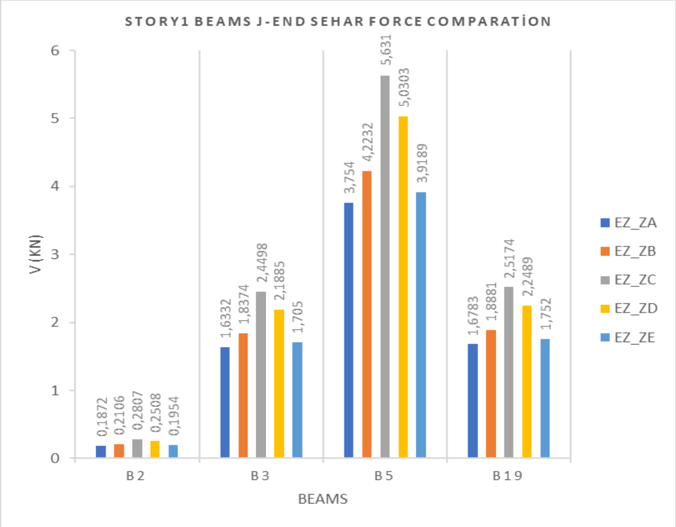
As a result of the analysis, the vertical elastic design spectrum obtained by using the ZC soil class with the highest shear force at the beam i and j ends was obtained in B2, B3, B5, B19 type beams at the 5th floor by the effect of EZ_ZC. Under the influence of the vertical elastic design spectrum, the shear forces at the beam i and j ends are visualized in Graph 3-1. When the values in Chart 3-1 are examined, the highest shear forces at beam i and j ends at the first, second, third and fourth floors under the influence of EZ_ZC vertical elastic design spectrum are 4.61 kN, 5.28 kN, 5.93 in B5 beam, respectively. kN was determined as 5.63 kN. In the fifth floor, under the effect of EZ-ZC spectrum, the highest shear force at beam i and j end was obtained in B19 beam as 7.93 kN. For B3 and B19 beams, the shear forces of beam i and j end were obtained differently at each floor. However, the behavioral responses of the beams under the influence of the vertical elastic design spectral at each floor are the same, and the shear forces of the beam i and j ends can vary according to the quantitative values of the spectrum. In other words, the most stressed beam on any floor is the same for all design spectral, but the most stressed beam on every floor is not the same.

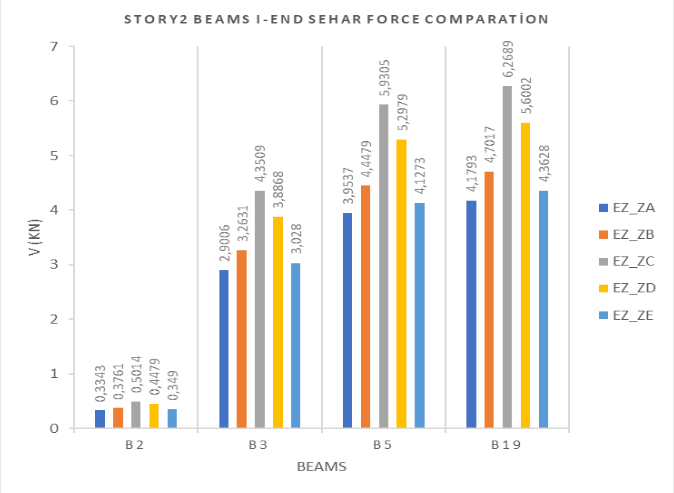
The next stage of the study is the analysis made by influencing the vertical response spectrum obtained using the vertical earthquake component of the Mw:7.6 Elbistan earthquake. By influencing the vertical response spectrum of the Elbistan earthquake, the highest beam i and j end shear forces were again obtained on the 5th floor of the building. From this point of view, when the beam i and j end shear forces obtained by influencing the vertical response spectrum of the 5th floor Elbistan earthquake and the beam i and j end shear forces obtained by effecting the EZ_ZC spectrum are compared, it is seen that the difference is negligible. Table 3-I. However, the highest value of the beam i and j end shear forces obtained with the vertical elastic design spectral and the Elbistan earthquake vertical earthquake spectrum used in the study was obtained by influencing the Elbistan earthquake vertical earthquake spectrum.

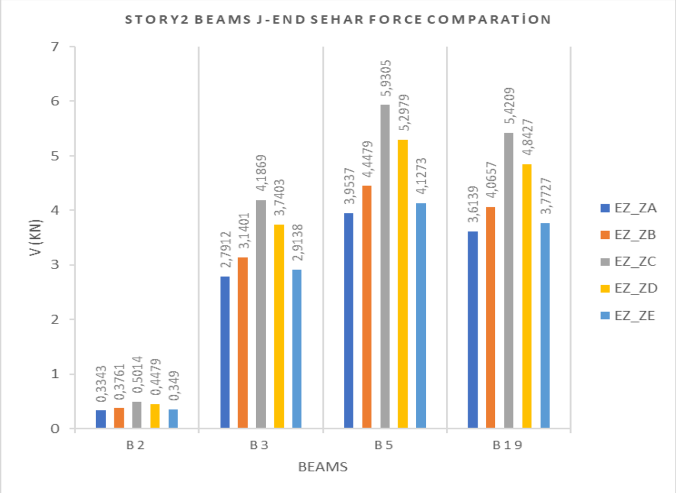


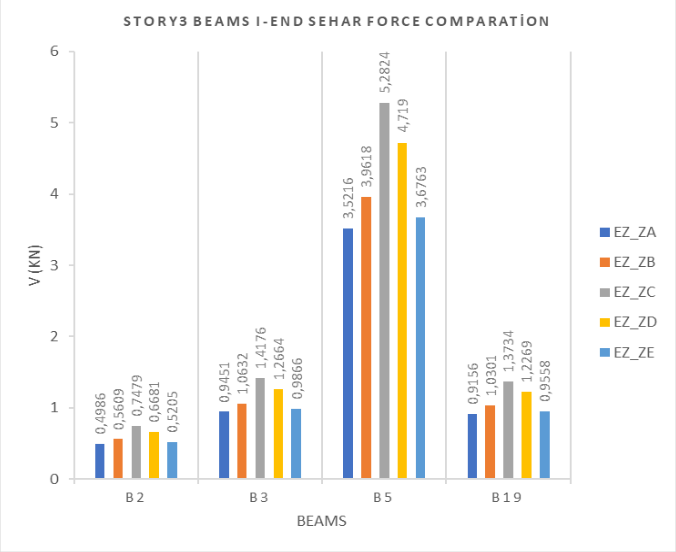
Figüre 4 1. Plan view and shear force values of beam i and j ends (Story 5).

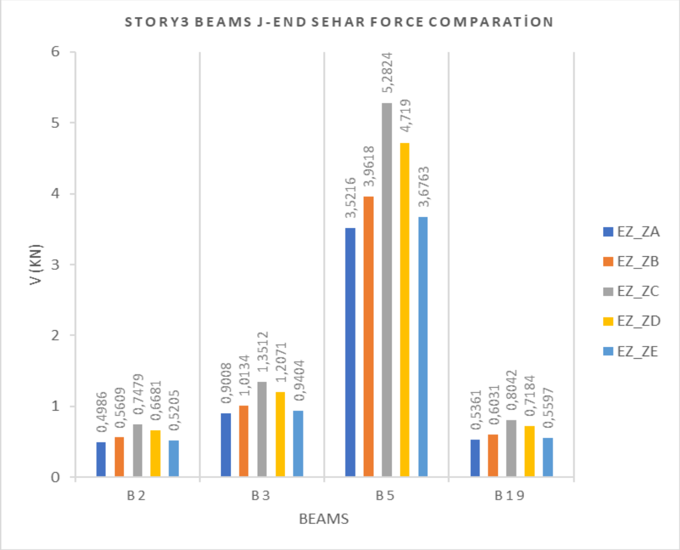

STORY1 BEAMS I-END SEHAR FORCE COMPARATİON
V (KN)
0
1
2
3
4
5
6
0,1872
0,2106
0,2807
0,2508
0,1954
1,7156
1,9301
2,5734
2,2989
1,791
3,754
4,2232
5,631
5,0303
3,9189
2,1665
2,4373
3,2498
2,9031
2,2617
B2
B3
B5
B19
BEAMS
EZ_ZA
EZ_ZB
EZ_ZC
EZ_ZD
EZ_ZE


STORY1 BEAMS J-END SEHAR FORCE COMPARATİON
V (KN)
0
1
2
3
4
5
6
0,1872
0,2106
0,2807
0,2508
0,1954
1,6332
1,8374
2,4498
2,1885
1,705
3,754
4,2232
5,631
5,0303
3,9189
1,6783
1,8881
2,5174
2,2489
1,752
B2
B3
B5
B19
BEAMS
EZ_ZA
EZ_ZB
EZ_ZC
EZ_ZD
EZ_ZE


STORY2 BEAMS I-END SEHAR FORCE COMPARATİON
V (KN)
0
1
2
3
4
5
6
7
0,3343
0,3761
0,5014
0,4479
0,349
2,9006
3,2631
4,3509
3,8868
3,028
3,9537
4,4479
5,9305
5,2979
4,1273
4,1793
4,7017
6,2689
5,6002
4,3628
B2
B3
B5
B19
BEAMS
EZ_ZA
EZ_ZB
EZ_ZC
EZ_ZD
EZ_ZE


STORY2 BEAMS J-END SEHAR FORCE COMPARATİON
V (KN)
0
1
2
3
4
5
6
7
0,3343
0,3761
0,5014
0,4479
0,349
2,7912
3,1401
4,1869
3,7403
2,9138
3,9537
4,4479
5,9305
5,2979
4,1273
3,6139
4,0657
5,4209
4,8427
3,7727
B2
B3
B5
B19
BEAMS
EZ_ZA
EZ_ZB
EZ_ZC
EZ_ZD
EZ_ZE


STORY3 BEAMS I-END SEHAR FORCE COMPARATİON
V (KN)
0
1
2
3
4
5
6
0,4986
0,5609
0,7479
0,6681
0,5205
0,9451
1,0632
1,4176
1,2664
0,9866
3,5216
3,9618
5,2824
4,719
3,6763
0,9156
1,0301
1,3734
1,2269
0,9558
B2
B3
B5
B19
BEAMS
EZ_ZA
EZ_ZB
EZ_ZC
EZ_ZD
EZ_ZE


STORY3 BEAMS J-END SEHAR FORCE COMPARATİON
V (KN)
0
1
2
3
4
5
6
0,4986
0,5609
0,7479
0,6681
0,5205
0,9008
1,0134
1,3512
1,2071
0,9404
3,5216
3,9618
5,2824
4,719
3,6763
0,5361
0,6031
0,8042
0,7184
0,5597
B2
B3
B5
B19
BEAMS
EZ_ZA
EZ_ZB
EZ_ZC
EZ_ZD
EZ_ZE

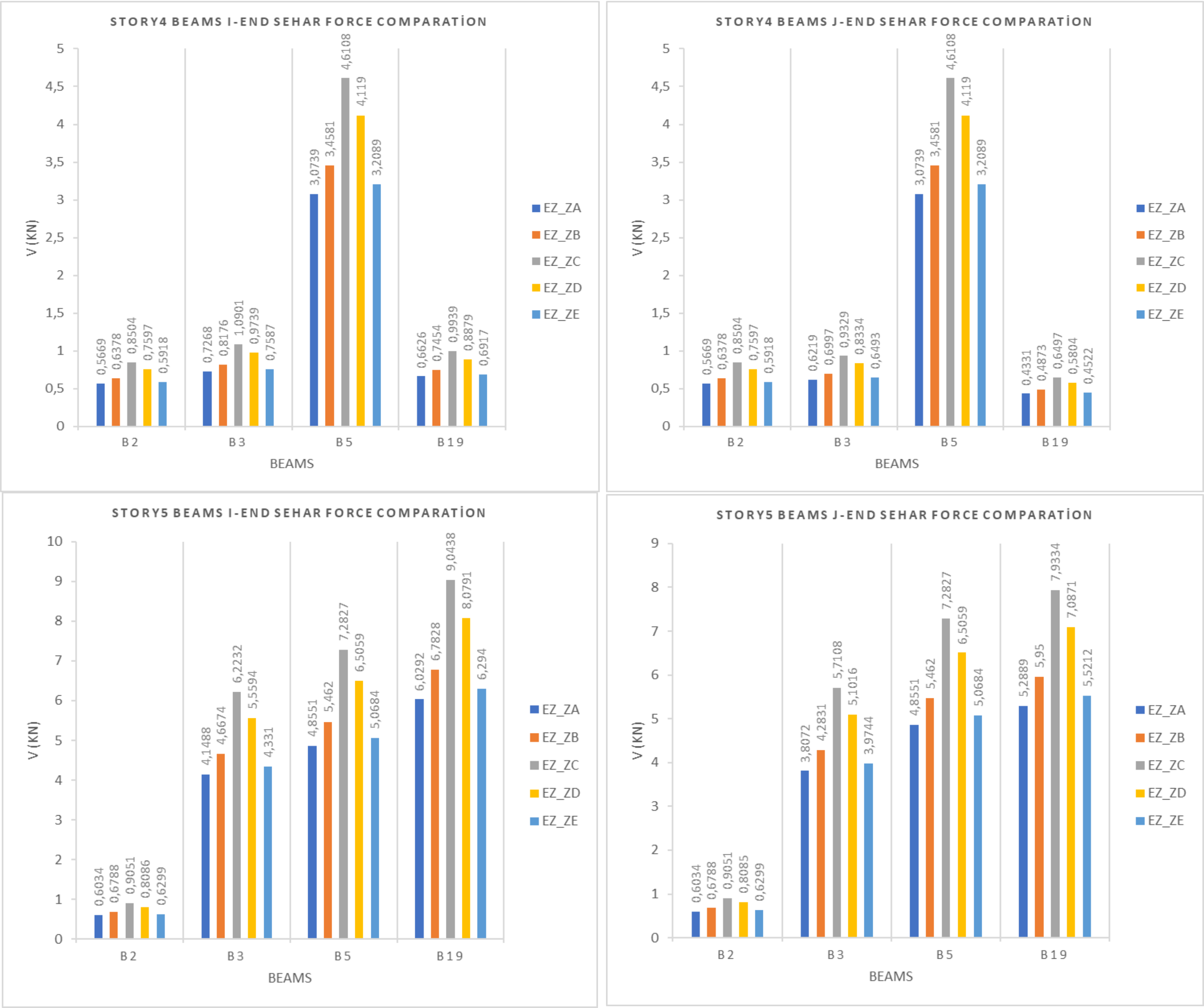


Figure 4 1. Comparison of the i and j ends shear force of B2, B3, B5, B19 type beams for all floors.

Table 4 I. Numerical comparison of the beam i and j end shear force values obtained at the 5th floor using the Elbistan vertical earthquake spectrum and the EZ_ZC spectrum.

	Ground Class = ZC		**Location = K.Maras**		**Ratio**	
Beams	**i**	**j**	**i**	**j**	**c/a**	**d/b**
İndex	**a**	**b**	**c**	**d**		
B1	5.71	6.22	5.91	6.44	1.03	1.03
B2	0.91	0.91	0.94	0.94	1.04	1.04
B3	6.22	5.71	6.44	5.91	1.03	1.03
B4	9.04	7.93	9.36	8.21	1.03	1.04
B5	7.28	7.28	7.51	7.51	1.03	1.03
B6	7.93	9.04	8.21	9.36	1.04	1.03
B7	9.04	7.93	9.36	8.21	1.03	1.04
B8	7.28	7.28	7.51	7.51	1.03	1.03
B9	7.93	9.04	8.21	9.36	1.04	1.03
B10	5.71	6.22	5.91	6.44	1.03	1.03
B11	0.91	0.91	0.94	0.94	1.04	1.04
B12	6.22	5.71	6.44	5.91	1.03	1.03
B13	5.71	6.22	5.91	6.44	1.03	1.03
B14	0.91	0.91	0.94	0.94	1.04	1.04
B15	6.22	5.71	6.44	5.91	1.03	1.03
B16	9.04	7.93	9.36	8.21	1.03	1.04
B17	7.28	7.28	7.51	7.51	1.03	1.03
B18	7.93	9.04	8.21	9.36	1.04	1.03
B19	9.04	7.93	9.36	8.21	1.03	1.04
B20	7.28	7.28	7.51	7.51	1.03	1.03
B21	7.93	9.04	8.21	9.36	1.04	1.03
B22	5.71	6.22	5.91	6.44	1.03	1.03
B23	0.91	0.91	0.94	0.94	1.04	1.04
B24	6.22	5.71	6.44	5.91	1.03	1.03

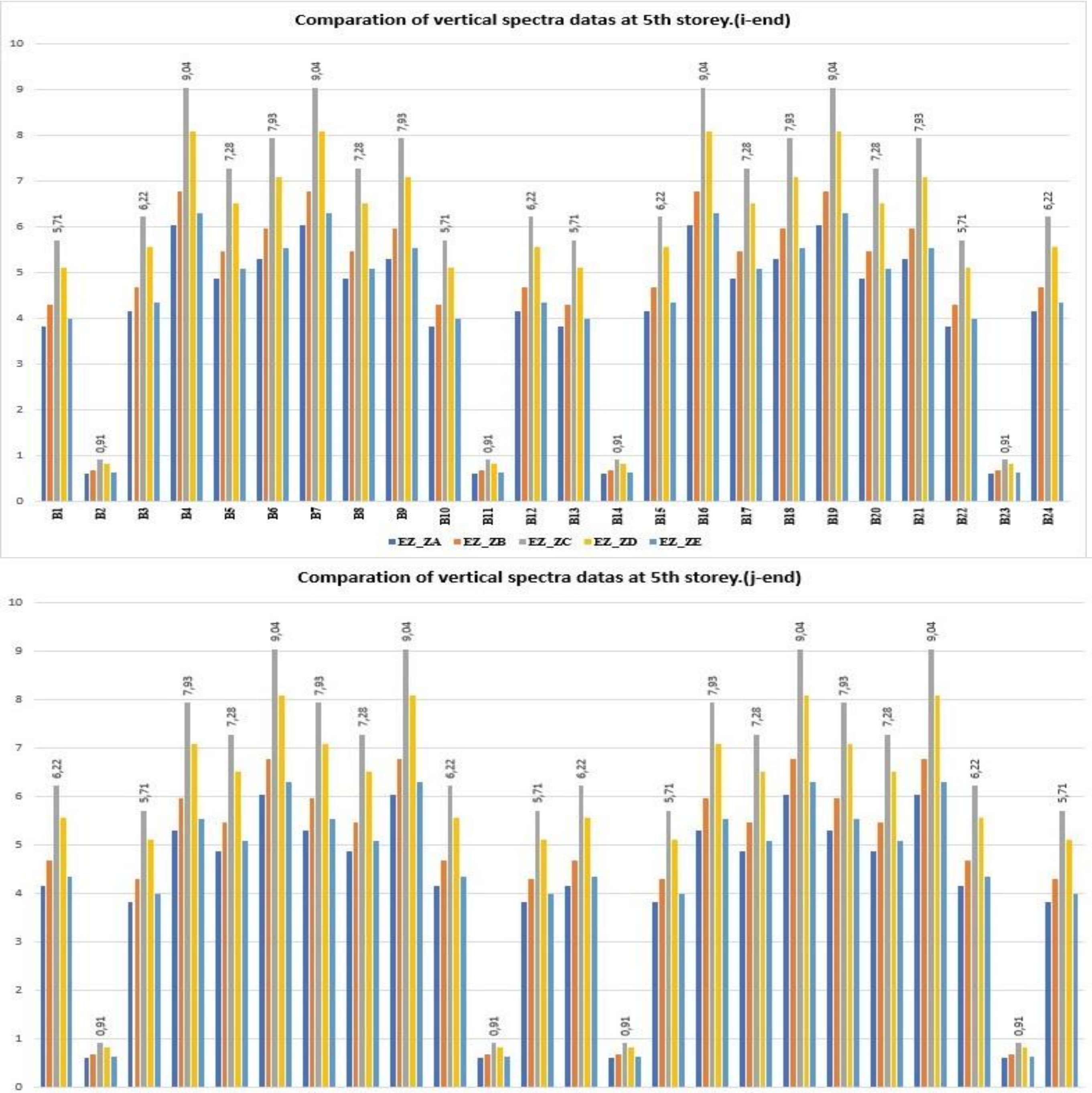


Figure 4 2. Comparation of vertical spectrum effect at i and j ends of beams for 5th floors.

5. Discussion

In the study, the shear forces at the i and j ends of certain beams were examined within the scope of the finite element method by influencing the vertical elastic design spectral attianed by using parameters belonging to different soil classes, and the vertical earthquake data of the Mw:7.6 Elbistan earthquake recorded by the seismic station 4631. It has been seen that the values obtained for each floor are different, and the highest values are obtained on the fifth floor, that is, on the top floor of the building. The occurrence of such a strain on the top floor of a building-type structure due to the vertical earthquake effect may cause the design capacity to be exceeded, and the floor collapses on the top floor of a building floor that has not been designed considering the vertical earthquake impact. This collapse, which will occur on the top floor of the building, will cumulatively affect the lower floors as an undesigned sudden load and may cause sudden wholesale collapses in the building. In further studies, in addition to this study, the shear stresses that occur in the beams of a building-type structure, whose foundation design has been made and whose soil properties have been determined, will be examined under the influence of vertical earthquakes.

References

[1] AFAD, «https://tdth.afad.gov.tr/,» AFAD. [Çevrimiçi].

[2] *TBER,* Istanbul, 2018.

[3] S. J. Kim, C. J. Holub ve A. S. Elnashai, «Analytical Assessment of the Effect of Vertical Earthquake Motion on RC Bridge Piers,» *Journal of Structural Engineering,* pp. 252-260, Şubat 2011.

[4] Z. Jin, S. Pei, X. Li, H. Liu ve S. Qiang, «Effect of Vertical Ground Motion on Earthquake-Induced Derailment of railway vehicle over simply-supported bridges,» *Journal of Sound and Vibration,* pp. 277-294, Ağustos 2016.

[5] R. Lİ ve C. Yao, «Effects of Vertical Earthquake Ground Motions on Seisminc Response of Steel-Concrete Plate Cosmosite Beam Bridgese,» %1 içinde *2020 International Conference on Intelligent Transportation, Big Data & Smart City (ICITBS)*, 2020.

[6] S. Chen, H. Xia, W. An ve Y. Wen, «Theoretical Investigation on Multiple Separation of Bridge under Near-Fault Vertical Ground Motion,» *Hindavi, Mathematical Problems in Engineering,* pp. 1-15, 25 Ağustos 2021.

[7] A. Talsimi ve M. Tehranizadeh, «The Effect of Vertical Near-Field Ground Motion on the Collapse Risk of High-Rise Reinforced Concrete Frame-Core Wall Structures,» *Advances in Structrual Engineering,* pp. 410-425, 2022.

[8] M. Alizadeh, «The Effect of Vertical Earthquake Componenet on Structural Behaviour in Multi-Story Structures,» Istanbul, 2019.

[9] E. Keskin, *Effect of Vertical Ground Motion on the Performance of High-Rise Building,* Ankara: Middle East Tecnical University, Naturaş and Applied Sciences Insitute, Published Master Degree Thesis, 2020.

[10] S. Tamaddon, M. Hosseini ve A. Vasseghi, «Effect of Non-Uniform Vertical Exitation on Vertical Pounding Phenomenon in Continuous-Deck Curved Box Girder RC Bridges Subjected to Near-Source Earthquake,» *Journal of Earthquake Engineering,* pp. 5361-5383, February 2021.

[11] *TS498,* Ankara: Institute of Turkish Standarts, 1997.

[12] *TS500,* Ankara: Institute of Turkish Standarts, 2000.

[13] E. Keskin, *Effect of Vertical Ground Motion on the Performance of High-Rise Building,* Ankara: Orta Doğu Teknik Üniversitesi. Yayınlanmış Yüksek Lisans Tezi, 2020.

[14] S. Tamaddon, M. Hosseini ve A. Vasseghi, «Effect of Non-Uniform Vertical Exitation on Vertical Pounding Phenomenon in Continuous-Deck Curved Box Girder RC Bridges Subjected to Near-Source Earthquake,» *Journal of Earthquake Engineering,* pp. 5361-5383, 01 02 2021.