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Research Article

Evaluation of the modern architectural buildings in terms of sustainability: A case of Çorlu municipality building

Ahmet BAL[1], Ayşe KOPUZ[2*], Özlem GÜNEY[3]

[1]*Department of Technology of Civil Engineering, Tekirdağ Namık Kemal University, Technical Sciences Vocational School, Tekirdağ, Turkey*
[2]*Department of Architecture, Tekirdağ Namık Kemal University, Faculty of Fine Arts, Design and Architecture, Tekirdağ, Turkey*
[3]*Department of Industrial Productions Design, Tekirdağ Namık Kemal University, Çorlu Vocational School, Tekirdağ, Turkey*

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ABSTRACT

Çorlu municipality building was built in 1984, by famous architects Maruf Önal and Hakkı Önel through modern architecture signs in Turkey. It was designed with a modest and rational approach, with meticulous construction, although it is a public building in line with a modern style. In terms of location, the municipality building was built in front of today's Cumhuriyet square, between the Kumyol Street and Omurtak Street, in the period when Salih Omurtak Street was just opened, during the years when the construction in Çorlu was not concentrated yet. In the project area, it was decided to demolish the Sücaettin primary school building built in 1936 and the old reinforced concrete baths and cisterns belonging to the Çorlu municipality and replace them with the municipal structure, and they were placed in this area with the square in front of the municipality building. Around the building; the Military Hospital, the Officer's Club and the 5th Corps Command buildings were located which were built in the 1930s. The aim of the study is to preserve the building and to sustain its life longer by questioning constructional building systems. Therefore the target is to preserve the function of the building with the original architectural language and concept. To design a structural system that will increase the strength and similar characteristics of the existing structure to the previous level. Creating the level determined analytical and experimental means within the framework of current regulations and to ensure that the performance of the building is at a level that will prevent wholesale collapse in an earthquake. Therefore the structural systems of buildings are to be rearranged according to new earthquake regulations.

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***Corresponding author.**
*E-mail address: akopuz@nku.edu.tr

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1. INTRODUCTION

Especially in the 80s, the structures that pioneered the change of state are public structures that come up with new spatial arrangements. The most striking of these public buildings are the municipal buildings, which deal with a new spatial arrangement together with the art and theatre stages in their surroundings and interior arrangements. In this article, the architectural features and structural system of the municipality building, which was built in Çorlu in the 80s, is discussed.

The city of Çorlu, located in the Thrace Region, has a more crowded population than many provinces and districts with a population of 273.000 today. It is a frequent destination for many people due to its location on the way to Europe and its proximity to Istanbul. The expansion of the industry, the increasing socio-cultural, economic and technological developments also affected the architectural environment and it was decided to build a new municipal building for the city. During the mayor Seyfettin Meriç term, "Yıldız University Revolving Fund" proposed projects for the municipality and the projects were completed in February 1984. In the project working group, Prof. Maruf Önal, Assoc. Hakkı Önel, Assoc. Ali Duzgun and lecturer Radi Birol have been present. The design of the projects of the building took 4 years and was completed in 1984, 2 years after the completion of the design, the construction of the building officially started in 1986 [1].

As a location, it was built in front of today's Republic Square. In the project area, the old reinforced concrete baths and cisterns belonging to the Çorlu municipality and the Sücaettin primary school building were demolished and the municipality palace was decided to be built instead, and the square in front of the municipality building was placed in this area. The Military Hospital, which was built in the 1930s, is located around the 5th. Corps Command and Army House buildings are located. The south side of the building is designed as a street and the north side as a large square.

The municipality building shows its modernity not only in terms of exterior but also in terms of plan and interior design, by considering all kinds of architectural details. The most striking feature of the building is that there is a large atrium in both blocks on the ground floor. These atriums have increased the interior visually of the building incredibly. These spaces are shown as a social interaction section exemplified by the architects.

The mass of the municipial building is formed by the juxtaposition of two square prisms, which are basically a prime geometric form. In this building plan, it consists of a linear combination of offices placed symmetrically around the atrium, which is simple and widely used. Simplicity and simplicity are at the forefront both in the smooth and static mass of the building, as well as in the facades and plans.

2. MATERIALS AND METHODS

In this study, through the examination of municipality structure in the city of Çorlu, on-site observations were made across the building and its surroundings, detailed photographs were taken, and documents were created about the interior and exterior architecture of the building. Old photos taken during the construction period of the building have been obtained to have a strong idea of buildings' production survey. Moreover the building structural system is modelled in the structural analysis program.

3. STRUCTURAL SYSTEM OF MUNICIPALITY BUILDING

Çorlu Municipality Building is a nine-storey building with a high entrance, two and a half floors below ground level, and six floors above ground floor including the attic. This building, which is located on a sloping area, was made with reinforced concrete construction technique and is a public building with a regular geometric shape. There is a large square on the front of the building, that is, on the north side, and a clock tower in the middle of the square. The height of the building is 24 meters and the width is 42 meters [1].

The building has two and a half floors of basement. On the basement floor, there is a theatre, artist rooms and archive-storage sections. Besides them, there is a sitting area, a theatre stage and a seminar room. On the ground floor, there are shops, entrance hall and cashiers. 1st floor is presidential floor, 2nd floor is science-calculation floor, 3rd floor is water-bus, 4th floor is legal affairs floor and there is an attic at the top.

In our country, which is located on an active seismic belt, devastating earthquakes have occurred in short time intervals. With the development of new technologies, changes were made in the regulations after these earthquakes. In the period when Çorlu municipality building was built, the 1975 earthquake regulation was active in our country.

According to this map, our country; First degree, Second degree, Third degree, Fourth degree earthquake zone and Safe zone divided into five regions (Fig. 1). In this regulation (1975 Earthquake Regulation), the effect of the ground is considered in more detail in the earthquake calculation. The acceleration spectrum coefficients were determined, and it was requested to take them into account while calculating the earthquake forces. However, the current regulation is more detailed [2, 3].

The risk status for Çorlu/Tekirdağ according to Turkey Earthquake Zones Maps 1972 is the third-degree earthquake zone (Fig. 2). 2018 Turkish Earthquake Code has been officially enforced as of January 1, 2019.

Four different earthquake ground motion levels are specified in Turkey Building Earthquake Code 2018. DD-2: 10% probability of exceeding in 50 years, corresponding to a return period of 475 years. This earthquake ground motion is also called standard design earthquake ground motion [4].

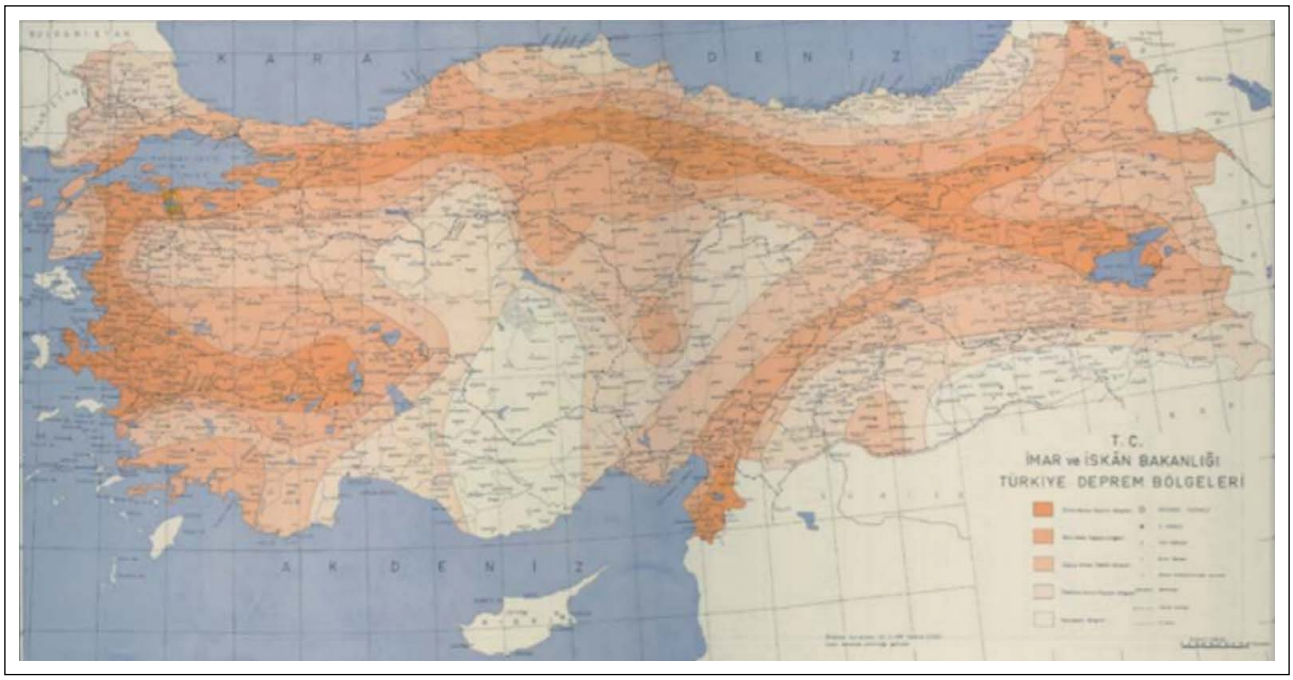


Figure 1. Turkey earthquake zones map of 1972.

Figure 2. Çorlu municipality building area.

For the coordinates where Çorlu Municipality Building is located, the maximum ground acceleration (PGA) for ZD soil type (Tight layers of sand, gravel, or very solid clay) was determined as 0.332g from the AFAD Turkey Earthquake Hazard Maps Interactive Web Application [5]. The maximum ground speed (PGV) is 20.397 cm/sec.

3.1. Structural System Properties of the Building

Geometric Information about floor levels of Çorlu municipality building

Number of floors: 8
Effective number of floors: 8
Number of rigid basement floors: 3

• RC Frame system was used in the plan design of Çorlu Municipality Building.

• The structural system of the building is Reinforced Concrete with Frame System.

• Cartesian grids were used on the facade of the building

The building importance coefficient is I=1.5 for municipal administration buildings according to TBDY2018. The building use categories coefficient is BKS=1. The building use categories is determined according to the building importance coefficient. Buildings that need to be used after an earthquake, buildings where people stay for a long time and intensely, buildings where valuable goods are stored and buildings containing dangerous substances are within the scope of BKS=1.

The concrete class used in the building is C30 according to the current project. Detailed information could not be obtained for foundations and other structural elements. According to its current project, the steel class is B225.

According to the Turkish Building Earthquake Code 2018, vertical and horizontal irregularities are defined in the buildings. However, such irregularities were not found in the Çorlu municipality building.

According to the Turkish Building Earthquake Code 2018, the structural system behaviour coefficient has been determined as R=4 and Overstrength Factors as D=2.5 for buildings where all the earthquake effects are covered by reinforced concrete frames with limited moment-transmitting ductility level.

Unfortunately, devastating earthquakes have occurred in our country, especially in the last century. Building earthquake codes were updated after these earthquakes. Until the 1949 Earthquake Regulations, did not fully mention reinforced concrete buildings in the regulations. Due to the fact that reinforced concrete buildings are not widely used, there are no studies on earthquake calculation in these regulations. Although the first earthquake calcula-

Figure 3. Turkey earthquake zones map of 2018.

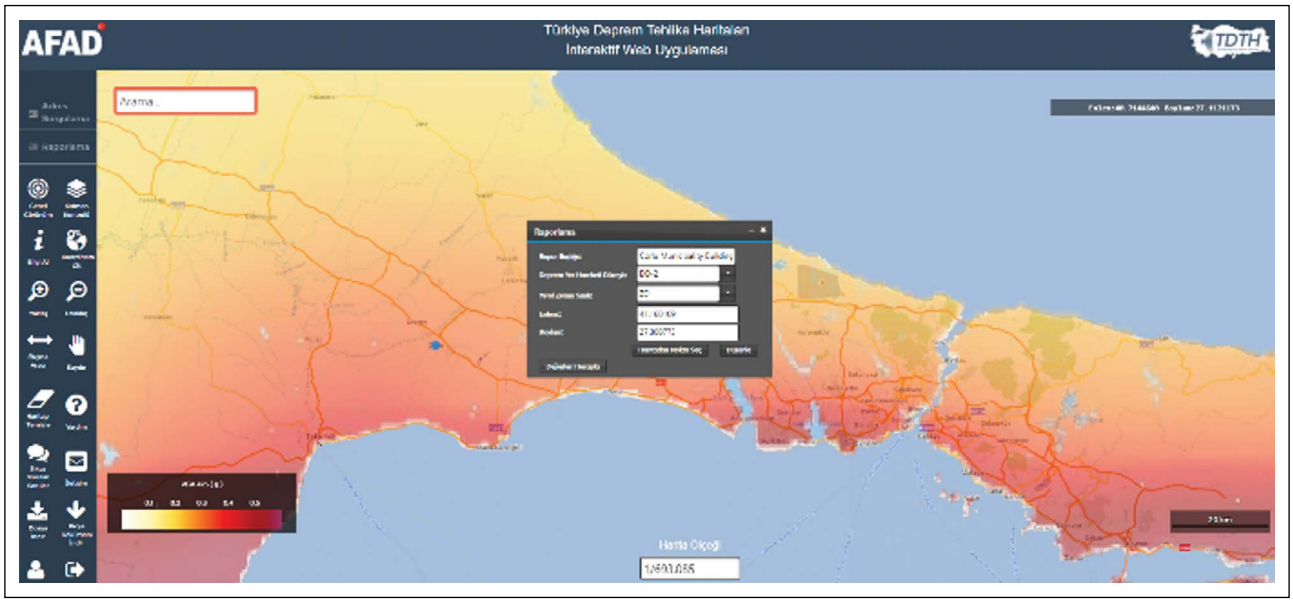


Figure 4. AFAD Turkey earthquake maps interactive web application.

tion is very simple, it is available in the 1949 Earthquake Code. In later regulations, earthquake calculations became more and more detailed. Also in Turkey Earthquake Code 2007, methods for the evaluation and retrofitting of existing structures was introduced. Push-over & capacity spectrum method was introduced (Fig. 3, 4).

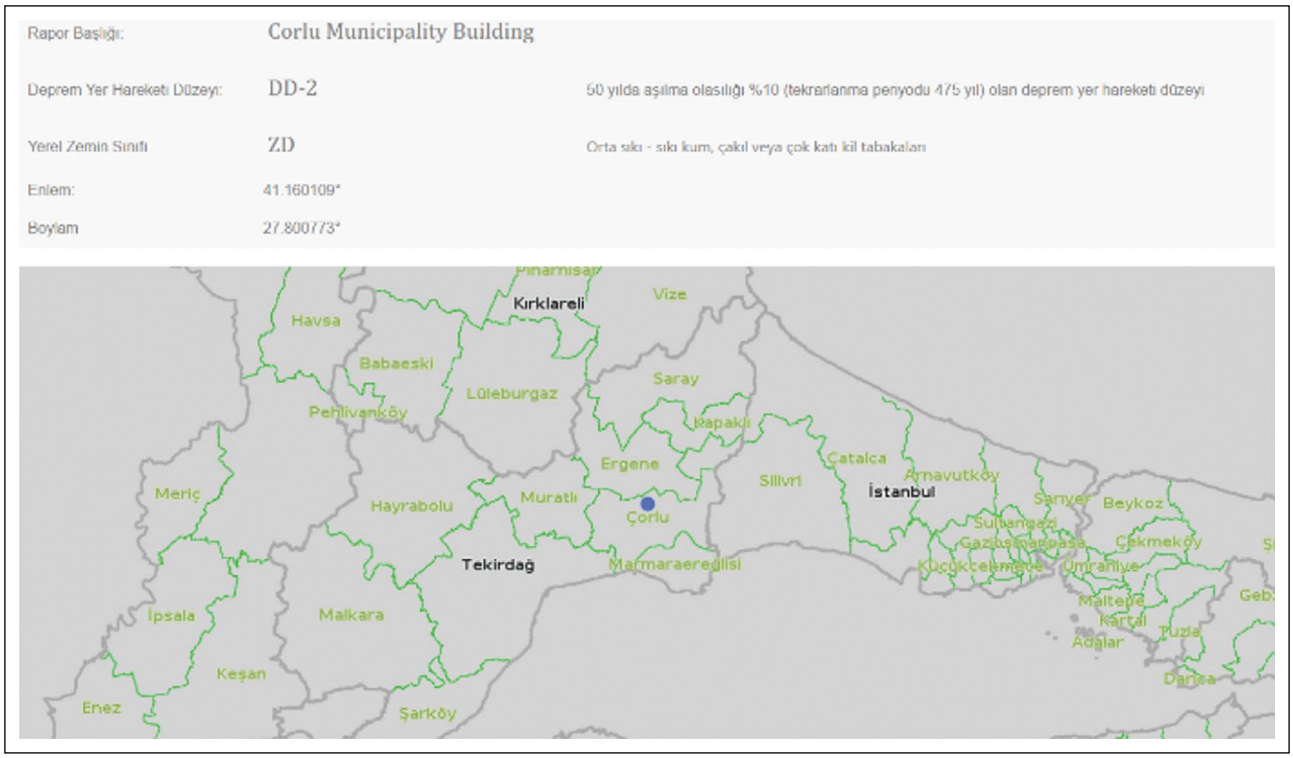


Figure 5. AFAD Turkey earthquake maps interactive web application - Corlu municipality building.

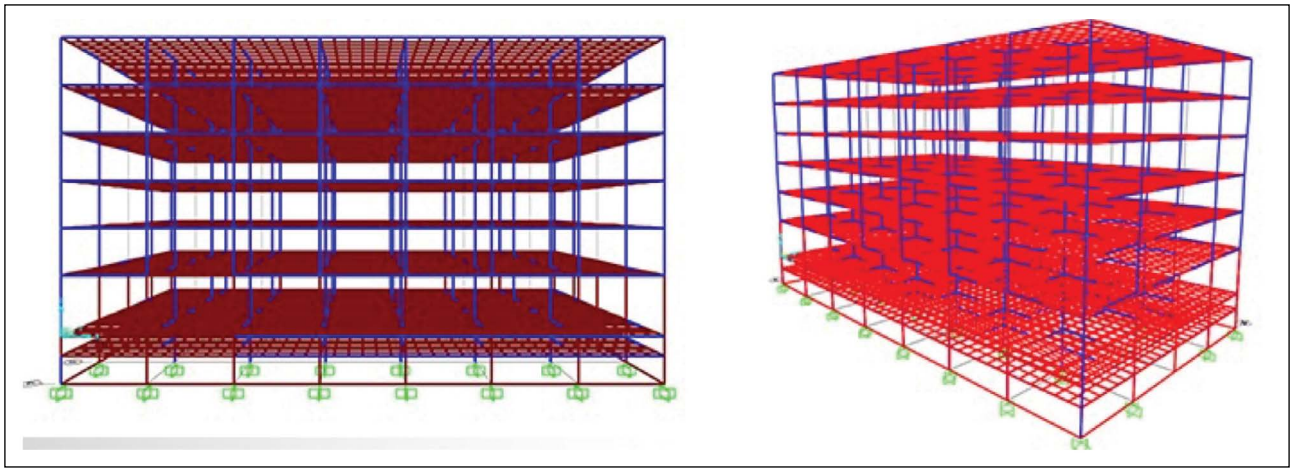


Figure 6. Structural system of the building with two dimensions.

Earthquake hazard maps also show that the earthquake risk prepared for the same region in those years is quite low compared to the Turkey Building Earthquake Code 2018 (Fig. 5).

Çorlu Municipality Building is reinforced concrete buildings with frame system as in most of the building stock in our country (Fig. 6, 7). When we look at the years of construction, it is estimated that the buildings was built in accordance with the Turkey Earthquake Code 1975 (Table 1). Due to the fact that earthquake regulations have become more detailed, earthquake safety of existing building should be checked and retrofitted according to new regulations.

It is known that in earthquakes, structures reach the collapse zone due to the formation of some or all of the three main elements: Insufficient lateral stiffness, insufficient ductility and insufficient strength. Retrofitting: is the study carried out to bring the rigidity and ductility of a structure to its pre-damage state or to increase it above the current state [6].

These traditional retrofitting methods cannot create optimum solutions due to both the long application and construction periods and the high cost level. In addition, these methods create situations that prevent the building from fulfilling its architectural functions [7, 8].

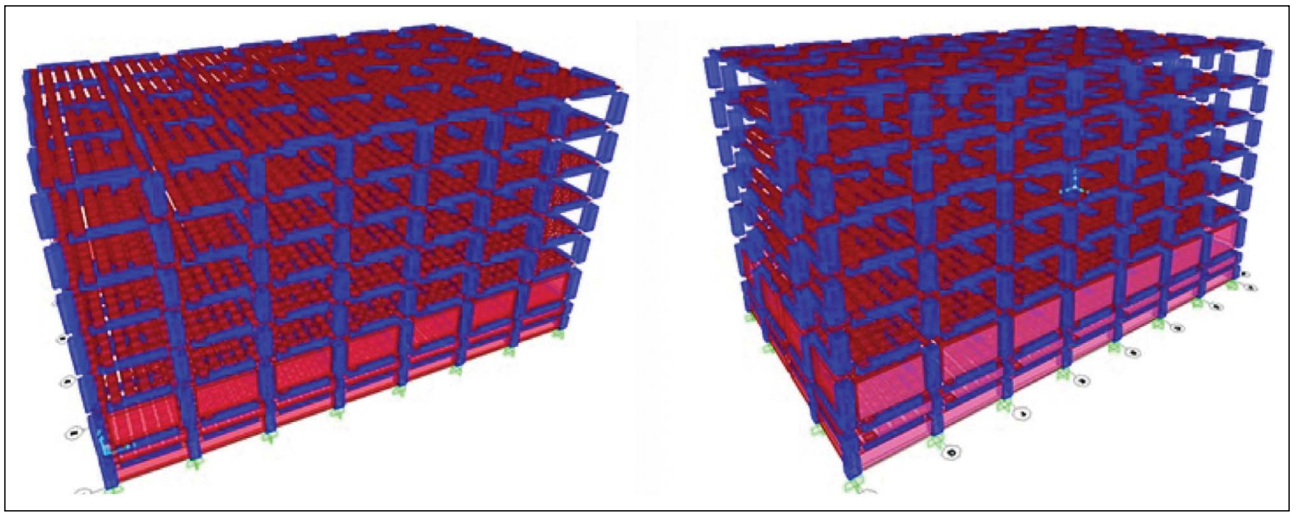


Figure 7. Structural system of the building with three dimensions.

Table 1. General structural information about Çorlu municipality building

Municipality building	Data
The place of hotel	Corlu/Tekirdag (1984)
The usadge of the building	Municipality Building
Altitude	173 mt
Building importance coefficient	1.5
Ground type	ZD
Ground safety tension	30 KN/m^2
Foundation depth	Front part 5,60 mt-back part 10,60 mt
Material	Reinforced concrete
Steel class	B225
Earthquake motion level	DD2 (TBDY 2018 2.2.2. article)
Height of the building	41,43 mt
PGA 475	0,332 g
PGV	20,397 cm/sn

Table 2. Iinformation about FRP type [9]

FRP type	Modulus of elasticity (kN/mm^2)	Tensile strength (N/mm^2)
Carbon	230-640	2500-4000
Aramid	120-130	2900
Glass	70-90	2000
Steel St37	210	370

Retrofitting technique with fibrous polymer, one of the new generation methods; is a system that increases the strength, ductility and rigidity capacities of the structure, obtained by bonding high-strength fibers such as carbon, glass, aramid with resins to the surfaces of building elements with different methods and shapes (Fig. 8, 9) [9].

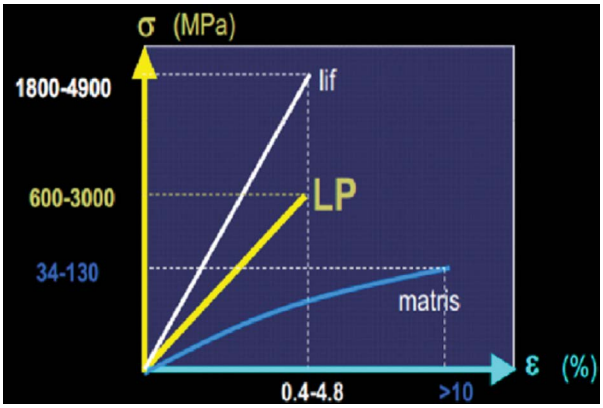
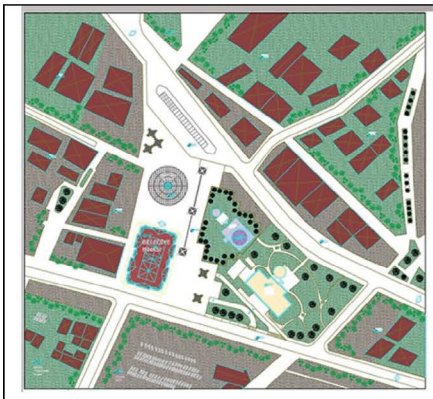
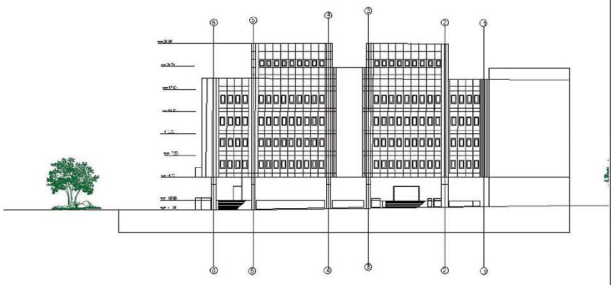
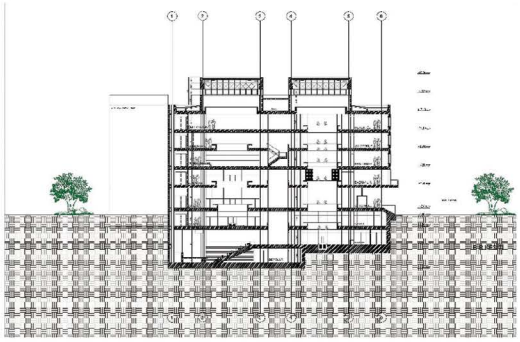
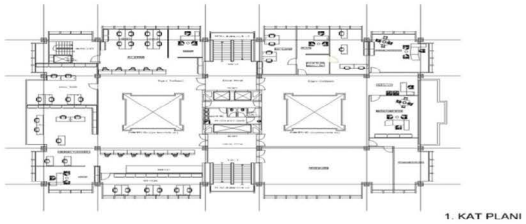
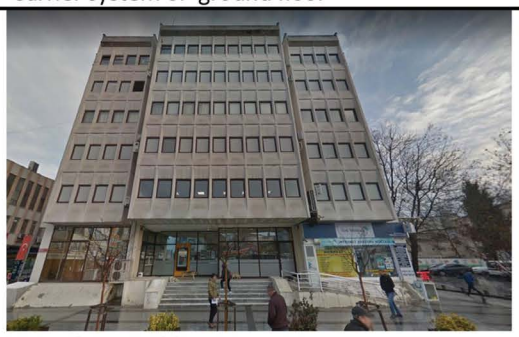


Figure 8. FRP composite properties.

Figure 9. FRP composite.

The fibers are the load-bearing component with a high modulus of elasticity. It can be based on glass, aramid and carbon (Table 2). The fibers are attached to the reinforced concrete surface with epoxy etc. bonds with a matrix and

Table 3. Architectural Information of the building

Corlu municipality building	
General information about architectural drawings and photos of the building Location: Çorlu, Tekirdağ, Turkey date of construction: 1984 architect: Maruf ÖNAL	
 Site plan	 Elevation of the building
 Section of the building	 Carrier system of ground floor
 Views from Building	 Views from Building
 Views from Building	 Views from Building

creates a composite section behaviour. Fiber reinforced polymers increase the strength and ductility of the building elements and increase the ductility of the structure under the effect of earthquakes.

Tensile strength of FRP components is ten times that of St37 steel. Strength and ductility values of the structure to be retrofitted should be improved on an element basis. For this purpose, after determining the demands of the building under the effect of earthquake and vertical loads, the increase in the element capacities of these demands can achieved with the FRP application.

4. CONCLUSION

Çorlu Municipality Building shows that the modern language in architecture has been shown on the facades and architecture of the building. We can see modern architecture signs on the building. In particular, the window edges on all facades are deepened with deep joint gaps, and their deletions and geometries are continued on four floors, eliminating the floor levels as an interesting detail in the plastic of the building. This dominant plastic pursuit ends with a clean flat surface on the last floor. Moreover, the interpretation of the multi-storey, grid-fronted monoblock architecture of single modern buildings draws attention in this building. While both rationalism and functionalism principles come to the fore in the spatial setup of the building, there is also a harmonious composition of geometric volumes seen as in nationalist architectural period Turkey (Table 3) [10].

Earthquake is the heaviest loading situation encountered by the structures during their lifetime. It is known that due to insufficient ductility, insufficient strength and insufficient rigidity in reinforced concrete structures, damages occur under the influence of earthquakes and even the structures reach the point of collapse. In order to restore the building safety and to continue the existing architectural functions of the building, the entire load-bearing system and damaged elements must be repaired and retrofitted.

There are different retrofitting alternatives, especially in reinforced concrete structures that constitute the majority of the building stock in our country. New generation retrofitting methods are behavior controlled techniques (active and passive dampers etc.) and fiber reinforced polymers. Retrofitting technique with fiber reinforced polymer, one of the new generation methods; ıt is a system that system that increases the strength, ductility and rigidity capacities of the structure with epoxy etc. of high strength fibers such as carbon, glass, aramid.

Retroffing of reinforce concrete frame type structure with fiber polymers is a very effective method due to both rapid application and not changing the architectural functions. In buildings that is important in terms of architectural heritage, such as the Çorlu Municipality Building examined, this application can be used to ensure earthquake safety.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

FINANCIAL DISCLOSURE

The authors declared that this study has received no financial support.

PEER-REVIEW

Externally peer-reviewed.

REFERENCES

[1] Durukan Kopuz, A. (2017). A Modernist Structure Example, Corlu Municipality Building. *Journal of Balıkesir Science Knowledge*, 19(2), 200–213. [CrossRef]

[2] Alyamaç, K.E., & Erdoğan, A.S. (2005). *Disaster Regulations from past to present and design errors encountered in practice*, 23-25 March 2005 Earthquake Symposium, Kocaeli.

[3] Özmen, B. (2012). Historical development of Turkey earthquake zone maps. *Turkish Geology Bulletin*. 55, 1, 43–55.

[4] TBEC-2018. *Turkish Building Earthquake Code*. T.C. Resmi Gazete: Ankara, Turkey, 2018.

[5] AFAD. *Deprem sorgulama*. https://tdth.afad.gov.tr. Accessed on Feb 02, 2020.

[6] Bal, A., & Kılıç, A.M., (2018). *Investigation of Strenghtening An Existing Five-Storey Rc Residential Structure With Fiber Reinforced Polymers*, 2nd International Architecture and Design Congress.

[7] Bal, A., & Kılıç, A.M., (2019). *Comparıson of Cfrp and Steel Jacketing Methods Applications for Retrofitting an Existing Concrete Industrial Structure in Earthquake Effect*, IESKO 2019 VI. International Earthquake Symposium Kocaeli 2019 September 25-27, 2019, Kocaeli, Turkey

[8] Bal, A., (2015). *Investigation of Reinforcement of Short Consoles in Prefabricated Industrial Buildings Against Earthquake Effect with FRP (Fiber Polymers)*, 5th International Earthquake Symposium Kocaeli.

[9] BASF (2012). Fibrous Polymer (FRP) Reinforcement System.

[10] Durukan Kopuz, A. (2021). *The rise of nationalist tendencies in the 1940s; Second national architectural movement.* In: Ozyavuz, M., editor. Theories, Techniques, strategies" for spatial planners & designers planning, design, applications. Peter Lang.