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THE EFFECT OF CFRP REINFORCED CONCRETE CHIMNEY ON MODAL PARAMETERS USING FINITE ELEMENT METHOD

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ABSTRACT

A variety of methods are used in the repair and strengthening of structures. Some of them use traditional materials, but in cases where they are insufficient, new materials are used. Some interventions may take the form of repairs to several elements, while others strengthen the structure as a whole. CFRP reinforcement method is one of these reinforcement methods. The method of strengthening with CFRP has been used in many studies recently. Therefore, this study was conducted. In this study, as a result of the reinforcement made by wrapping 2.5 mm thick CFRP fabric into the 20 m height concrete chimney structure. The differences between modal parameters of the concrete chimney and CFRP reinforced concrete chimney were compared. These modal parameters are period and mode shapes. The first 5 modes of the situation with and without CFRP were examined with finite element method. A difference of 4.58% - 25.32% was observed in the periods of the first 5 modes. Reinforcement with CFRP has been observed to be positive for safety on the concrete chimneys.

KEYWORDS: CFRP, Concrete Chimney, Modal parameters, FEM, Reinforcing

INTRODUCTION

CFRP is used in many sectors due to its various advantages. Marine (ships, shipyards), electric-electronics (solar collectors, wind turbines), aircraft, cars, various products (sports equipment) and buildings (buildings, highways, bridges, harbors, waterways, water and solid waste recycling facilities, etc.) has been increasing its usage area in recent years. Its properties such as high strength / weight ratio, corrosion resistance, resistance to external influences (salt water, acid) and low thermal conductivity are effective in its use in the building industry. Our country is one of the countries in the active earthquake zone. It is very important to strengthen the buildings before the earthquake or to repair and strengthen them after the earthquake. There are many methods developed for repair and strengthening. These have their advantages and disadvantages. One of them is the reinforcement made with CFRP reinforcement material. CFRP (Carbon Fiber Reinforced Polymers) is a material that has been used in many countries around the world today.

Historical buildings are used in many areas, especially bridges. One of its most important features is that it can be applied while the building is in use, or the building can be opened for use shortly after it is applied. It does not impose an extra load on the structure and does not cause image distortion thanks to its thin structure.

Surface preparation is very important for CFRP materials. Surface preparation is very important for CFRP materials. In reinforced concrete structures, steel does not show different behavior than peeling and concrete since it remains in the concrete. The most important problem in the application of CFRP in structures is the stripping of the material or separating the concrete by taking the cover layer.

DESCRIPTION OF CARBON FIBER REINFORCED POLYMER

Carbon Fiber Reinforced Polymers (CFRP), commonly used by FRP for reinforcement, are still tested in the experimental environment and the strengthening provided to masonry buildings is evaluated. In our thesis topic, we will try to get an idea by comparing the rigidity of the stacking dome. Considering that the tensile strength is high and there is not much extra load due to its lightness to the structure, it is thought that the stability will increase. Their resistance to environmental conditions provides an ideal protection for the element from external influences, especially moisture protection and corrosion. Considering that chimney height affects modal loads negatively in chimneys, it is evident that the ductility of the building will increase and affect their behavior against earthquake loads positively. [12],[14].

CFRP fabrics are made ready for use on the job site. While epoxy is applied to the surface prepared area, CFRP fabric is pressed in a flat epoxy filled container. In order for the fabric and epoxy to form a composite material and move together, care should be taken that there is no air gap in the fabric. [6], [7], [14].

Figure 1. CFRP Fabric

With CFRP fabrics (fig 1), the outer surfaces of concrete structures, arches, vaults and domes are wrapped in appropriate direction and width to increase their carrying capacity and ductility under existing loads. Preparation of the surface before the application of all dust and free of material to remove the material between CFRP fabric and structure that will affect the adherence of any dust particles should be careful. [6], [7], [14].

The most important advantage of CFRP fabrics is that it gives a much more rigidity than conventional methods with a few millimeters of material reinforced to the structure. [6],[7].

The material to be used for the planned reinforcement is given in figure 1. The thickness of the CFRP fabric to be used is designed as 2.5 mm. The parameters of the material are given separately under "Mechanical Properties of CFRP Material".

MECHANICAL PROPERTIES OF CFRP MATERIAL

The mechanical properties of the CFRP material were entered into the SAP 2000 program as follows.

Mass and Weight of Material:

1- Unit Volume Weight = 1600,55 kgf / m^3,

2- Unit Volume Mass = 163.15 kgf / m^3.

Mechanical Properties of Material:

1- Elasticity Module:

E1 = 13766,17 kgf/mm^2, E2 = 13766,17 kgf/mm^2, E3 = 1019,7 kgf/mm^2.

2- Poison Rate:

U12 = 0,3, U13 = 0,3, U23 = 0,022.

DESCRIPTION OF CONCRETE CHIMNEY

First, the features of the concrete chimney and the properties of the CFRP material were entered into the SAP 2000 program. In this study, CFRP material will be applied to the entire surface. Thus, all cracks on surface will be closed. The bottom diameter of the concrete chimney is 1.25 m. The top diameter of the concrete chimney is 0.25 m. The height of the concrete chimney is 20 m. The concrete used in the concrete chimney is C20/25. Concrete thickness of the concrete chimney is 0.01 m.

In this study, the analysis was made using the finite element method for the current state and the state after reinforcement, respectively. The studies have been examined under separate titles and the data obtained have been presented. In both cases, the mode shapes and the period values of the mode are given separately and compared.

The concrete chimney wall thickness and CFRP thicknesses to be used are given in Table 1.

Table 1. Thickness of Concrete Chimney and CFRP Layers

Material Name	**Thickness (mm)**
Concrete Chimney	100
CFRP	2,5

ANALYSIS OF CONCRETE CHIMNEY WITHOUT CFRP

The finite element model of the concrete chimney is shown in figure 2. The finite element model of the concrete chimney given in Figure 2 is the current situation. In other words, it is not CFRP reinforced. Reinforcement is planned on this concrete chimney model. CFRP fabric technique is used in this study as this reinforcement method. As a result of the modal analysis, the first 5 modes were taken into account in both cases. SAP2000 package program was used to obtain the analysis data.

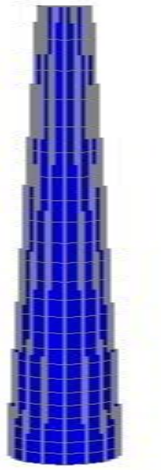

Figure 2. Concrete Chimney Finite Element Model without CFRP

Modal analysis results before applying CFRP to the concrete chimney are given in Table 2 and mode shapes given figure 3.

Table 2. Period of Concrete Chimney without CFRP

MODE	**1**	**2**	**3**	**4**	**5**
PERİOD (s)	0,41799	0,11526	0,05011	0,02780	0,01777

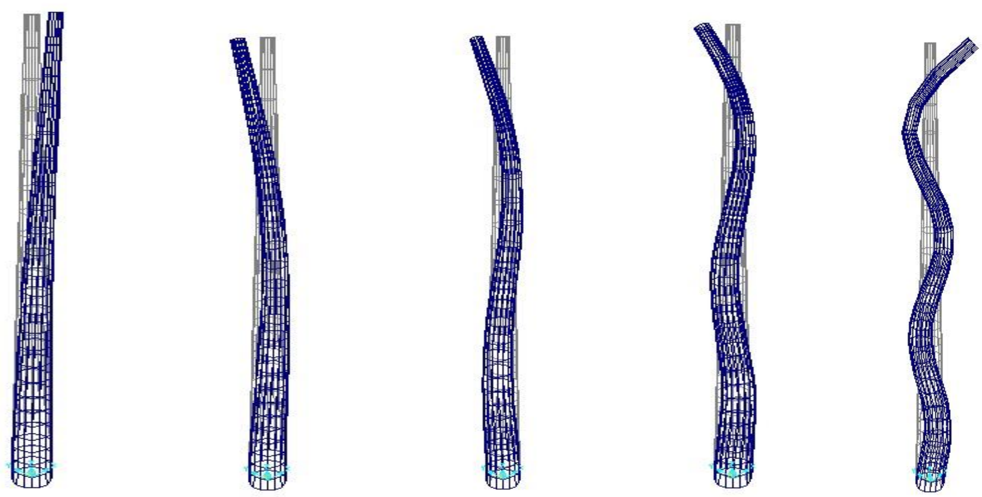

Figure 3. Mode Shapes of Concrete Chimney without CFRP

ANALYSIS OF CONCRETE CHIMNEY WITH CFRP

The finite element model of the reinforced concrete chimney is shown in figure 4. The finite element model of the concrete chimney given in Figure 4 is the reinforced situation. In other words, it is CFRP reinforced. CFRP fabric technique is used in this study as this reinforcement method. CFRP fabric thickness is 2,5 mm. CFRP fabric is applied to the entire outer surface. SAP2000 package program was used to obtain the analysis data.

Figure 4. Concrete Chimney Finite Element Model with CFRP

Modal analysis results after applying CFRP to the concrete chimney are given in Table 3 and mode shapes given figure 5.

Table 2. Period of Concrete Chimney without CFRP

MODE	**1**	**2**	**3**	**4**	**5**
PERİOD (s)	0,39886	0,10969	0,04753	0,02626	0,01672

Figure 5. Mode Shapes of Concrete Chimney with CFRP

COMPARISON OF ANALYSIS RESULTS

The comparison of period of the model with CFRP and without CFRP model is given in Table 4.

Table 4. Comparison Period of without CFRP Model and with CFRP Model

MODE	**1**	**2**	**3**	**4**	**5**
WİTHOUT CFRP PERİOD (s)	0,41799	0,11526	0,05011	0,02780	0,01777
WİTH CFRP PERİOD (s)	0,39886	0,10969	0,04753	0,02626	0,01672
DİFERENCE (s)	-0.01913	-0,00557	-0,00258	-0,00154	-0,0045
DİFERENCE (%)	4,58	4,83	5,15	5,54	25,32

When the mode shapes are examined, the modal shapes are similar in both cases. A huge difference between them was not observed. However, when analyzed as animation, it was seen that large displacements were replaced by torsions.

CONCLUSIONS

In this study, as a result of the reinforcement made by wrapping 2.5 mm thick CFRP fabric into the 100 mm thick concrete chimney structure, the percentage changes in the parameters of the structure are listed below.

In the mode 1, the period difference between non-CFRP and CFRP status was obtained as -0.01913 s. The effect of CFRP reinforcing as a percentage was determined as 4.58%.

In the mode 2, the period difference between CFRP and non-CFRP status was obtained as -0,00557 s. The effect of CFRP reinforcing as a percentage was determined as 4,83%.

In the mode 3, the period difference between CFRP and non-CFRP status was obtained as -0,00258 s. The effect of CFRP reinforcing as a percentage was determined as 5,15%.

In the mode 4, the period difference between CFRP and non-CFRP status was obtained as -0,00154 s. The effect of CFRP reinforcing as a percentage was determined as 5,54%.

In the mode 5, the period difference between CFRP and non-CFRP status was obtained as -0,0045 s. The effect of CFRP reinforcing as a percentage was determined as 25,32%.

With the reinforcement of the concrete chimney with CFRP, a decrease in the periods is clearly visible. Especially when the dominant period is analyzed, a 4,58 percent decrease is observed. It is also known that the reduction in periods removes the structure from the resonance range and increases the stiffness.

When the analysis results are examined, it is clearly seen in this study that reinforcing the concrete chimney with CFRP makes the concrete chimney safer.

In the light of all these findings, CFRP reinforcement method can be used in concrete chimneys.

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