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# THE EFFECT OF AMD ON THE MODAL PARAMETERS OF THE REINFORCED CONCRETE BUILDING BY FINITE ELEMENT METHOD

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**ABSTRACT:**

**Earthquake engineers have taken many precautions in their building designs to protect and minimize destructive effects. In this way, many new design and reinforcement methods have been developed against seismic loads. The use of an active mass damper (AMD) is one of the developed methods. One of the most important negative aspects of the use of AMD is the increase in the structural period. Therefore, in this study, the effects of AMD on periods and mode shapes in symmetrically reinforced concrete building model were investigated. For this, two models with and without AMD were created by the finite element method and modal parameters were compared. As a result of the data obtained, it has been observed that the RC building model makes more balanced displacements, as can be understood from the mode shapes, without increasing the period of the RC building to a dangerous level. It is known that AMD reduces the seismic effect by acting in the opposite direction to the seismic effect on the structure. Active mass damper can be used in reinforced concrete buildings, provided that it does not increase period too much.**

**Keywords: Active mass damper; mode shape; period; RC building; FEM.**

## I. INTRODUCTION:

Most of the structures found in earthquake hazardous areas are subject to various destructive effects caused by seismic loads.[1],[2],[3],[4],[5]. Buildings located in seismically active regions are under high risk of severe damages caused by harmful earthquake loads. [6]. In recent years, in the world and our country, the determination of the effect of vibrations on structures and structural behavior has become very important. [7]. An active mass damper (AMD), also known as a harmonic absorber or seismic damper, is a device mounted in structures to reduce mechanical vibrations, consisting of a mass mounted on one or more damped springs. Its oscillation frequency is tuned to be similar to the resonant frequency of the object it is mounted to, and reduces the object's maximum amplitude while weighing very much less than it. AMDs can prevent discomfort, damage, or outright structural failure. They are frequently used in power transmission, automobiles and buildings. Because they reduce the sensitivity of the structure to mechanical vibrations, they are often installed in high-resistance materials such as torsional steel, where most vibrations are absorbed or attenuated. The device can have a large effect on certain kinds of vibrations (such as those from one resonant piece of machinery or an open-span bridge), but may have only a minor effect on the response of a structure to other types of vibrations. AMDs have most often been used in architecture for structures such as office buildings, bridges, and industrial facilities. Advanced applications include system-level AMDs that damp all vibrations in a building by integrating actuators within the building structure itself, to reduce vibrations in areas not usually affected by mechanical damping devices (such as ceilings). While there are a number of technological variations on the concept, the most common form consists of a mass on a balance spring, which moves under a carrier (the diaphragm) to a position determined by the geometry of the system. Each mass is paired with a driver (often spring cylinders) to alter the position of the mass in response to vibrations in the spring. Common designs use dry weights (such as lead or iron) and damping rods, which are the main components of the diaphragm. Common names for these mass damping systems include: mass damper, self-damping mass damper, damper, active mass damper (AMD), and mass-damping springs. Early in their development, AMDs could only damp single modes of vibration, but modern models are capable of damping multi-mode vibrations. The device itself typically dampens only the lowest harmonics of vibration, but other components of the structure may include damping devices that damp lower harmonics. For example, a bridge may have mass dampers for vibration in the main supports and dampers for vibration in the cable girders. AMDs may be used as a vehicle safety technology to reduce harsh vibrations from motor vehicles.

Mass damping effects are a tradeoff between mass and damping function. The mass damping factor is the ratio of the mass to the damping factor; it controls how much mass is required to damp the motion of a mass. Generally, mass-damping damping functions are preferred to damping functions with a lower mass-damping factor. The mass-damping damping function is often considered to be most important for buildings and bridges, while the damping function is most important for transportation systems. Mass damping is especially important on ships and offshore structures. The mass-damping damping ratio affects the design of the device, because of the requirements of the resulting damping factor. The design must accept an expansion of the mass of the diaphragm with every oscillation, or vice versa. The damping ratio is set up to accommodate the mass expansion or contraction and the damped vibration. Some devices achieve the required damping ratio by damping rods, which oscillate to equalize the mass of the diaphragm to the vibrational energy of the mass damping element. This is a conservative approach, because it prevents the construction of mass-damping mechanisms that are particularly vulnerable to recontamination of the object under construction. Plasma-heated diaphragms are used to dampen low-frequency vibration in highly stressed load-bearing structural members. They are employed in high-rise building applications as in wind tunnels, cranes, and bridges, because of the high frequency, small mass ratio, and high tensile strength of these members. The principle involves a non-Newtonian fluid subjected to high voltage. When voltage is applied across the diaphragm, it is heated to its vaporization temperature, which is one of the most stable, highest-amplitude piezoelectric thermal vibrations in solids. When the diaphragm moves, the vaporized material melts into the surrounding air, and its thermal conductivity cools its surroundings by convection. The fluid within the diaphragm quickly cools, and the diaphragm returns to its original position.

Researchers have carried out many studies using both the finite element method and the finite element method. There are many studies by the authors using the finite element method before. In this study, studies [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19] on the use of the finite element method were used. In addition, the authors have comparative studies [20], [21], [22], [23], [24], [25] using more than one method, including the finite element method. In these studies, the effect of the finite element method was compared with the operational and experimental modal analysis method. With all this knowledge, this new study has been carried out. Researchers have conducted studies [26], [27], [28], [29], [30], [31], [32] about active mass damper (AMD).

The aim of this study is to observe the effects active mass damper (AMD) effect to the modal parameters (mode shapes and periods) of reinforced concrete building with the finite element method. For this purpose, a concrete reinforced building model was created and a modal analysis of the building model created by the finite element method was carried out.

## II. DESCRIPTION OF RC BUILDING:

It is a 5-storey reinforced concrete building with two spans (5 m) in x and y directions, with a floor height of 3 m. Columns and beams are 35x70 cm, floor thickness is 20 cm. The building has been designed symmetrically to better detect the effects of active mass damper use. The concrete class of the RC building was chosen as C30/37. The steel rebar class of the RC building was chosen as S420. The reinforced concrete building finite element model was created using the SAP 2000 package program. The finite element model of the building is given in figure 1.

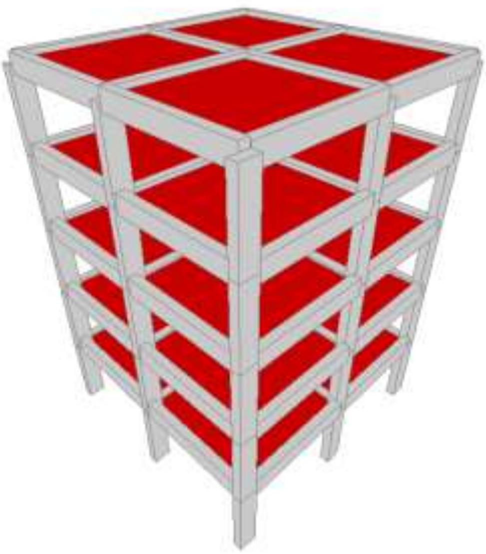

Fig. 1. 3D Finite element model of the reinforced concrete building

## III. DESCRIPTION OF AMD:

It is placed horizontally at the midpoint of the 5th floor, has a mass of 25 kN, fixed in the x-y-z axes, has a stiffness of 1000000 kN/m and a damping of 500 kNs/m. Location of AMD in building is given in figure 2.

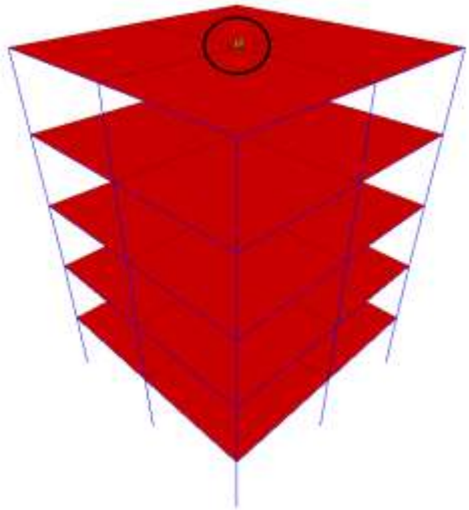

Fig. 2. Location of AMD

## IV. ANALYSIS AND RESULTS:

The RC building was first analyzed in its current state using SAP2000 with the finite element method, then AMD was added to the top floor and the same analysis was repeated and the results were compared.

### A. Results of the Model RC Building without AMD:

The RC building was analyzed without adding active mass damper (AMD) by finite element method. The first 5 modes were taken into account in the analysis. Obtained results are presented in figures 3,4,5,6,7 as periods and mode shapes.

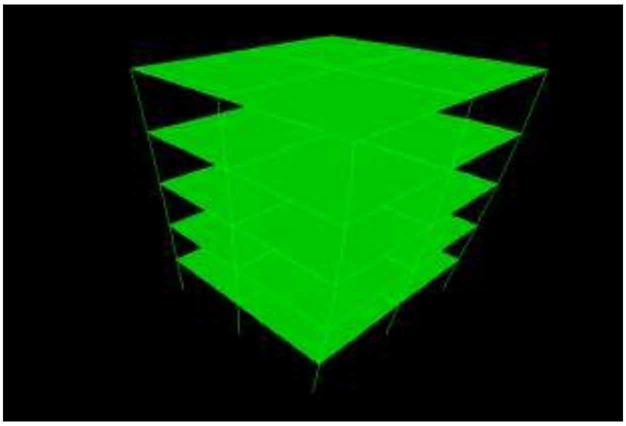

Fig. 3. Mode Shape and Period of Mode 1= 0.5425 s

It is seen that Mode 1 is translational mode shape.

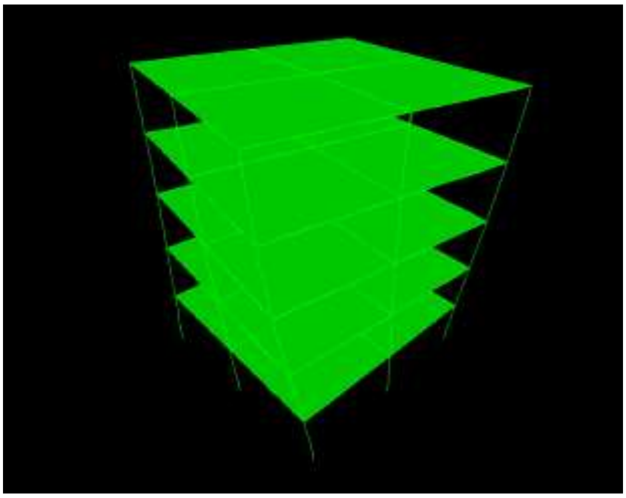

Fig. 4. Mode Shape and Period of Mode 2= 0.3906s

It is seen that Mode 2 is torsional mode shape.

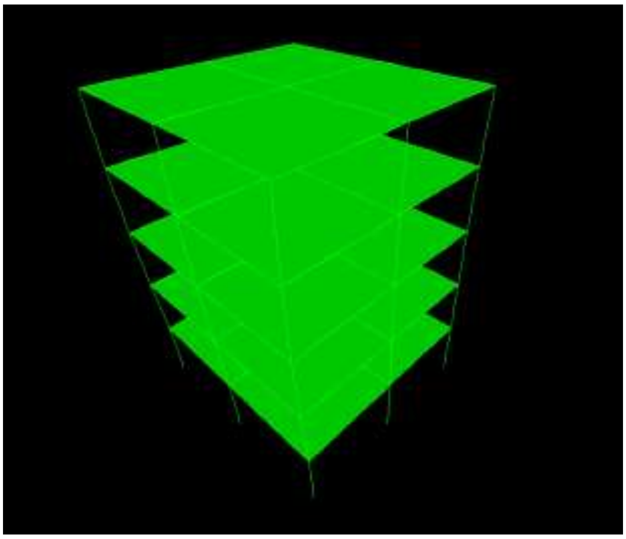

Fig. 5. Mode Shape and Period of Mode 3= 0.3756s

It is seen that Mode 3 is translational mode shape.

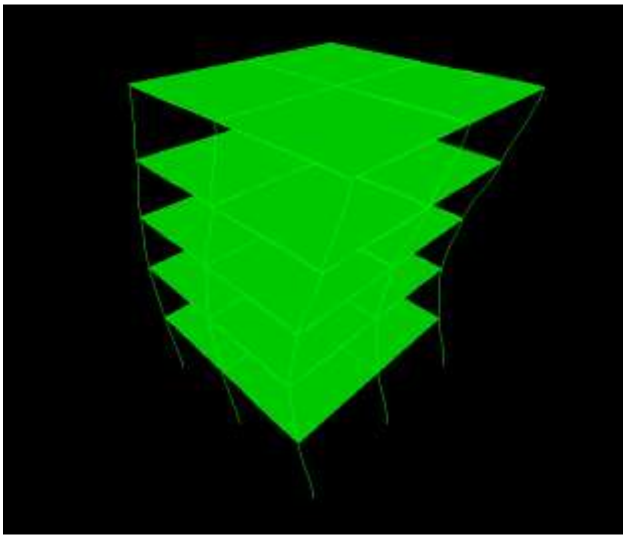

Fig. 6. Mode Shape and Period of Mode 4= 0.1807s

It is seen that Mode 4 is translational mode shape.

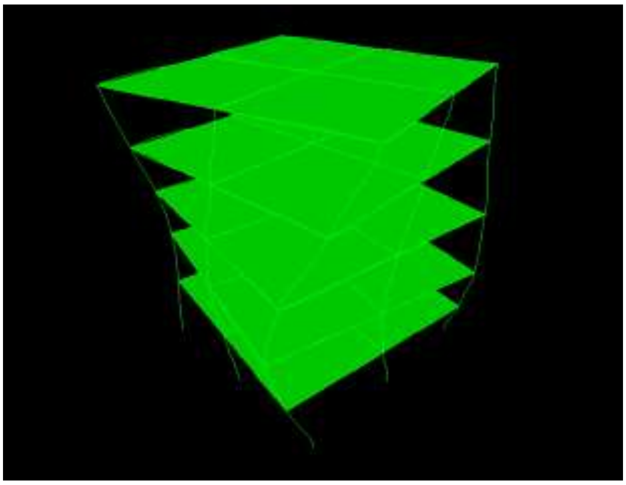

Fig. 7. Mode Shape and Period of Mode 5= 0.1266s

It is seen that Mode 5 is torsional mode shape.

### B. Result of the Model RC Building with AMD:

The building was analyzed with adding active mass damper (AMD) by finite element method. The first 5 modes were taken into account in the analysis. Obtained results are presented in figures 8,9,10,11,12 as periods and mode shapes.

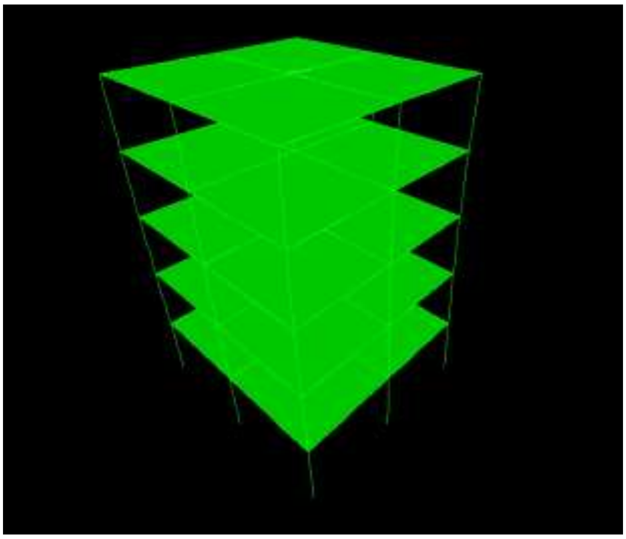

Fig. 8. Mode Shape and Period of Mode 1= 0.5685 s

It is seen that Mode 1 is translational mode shape.

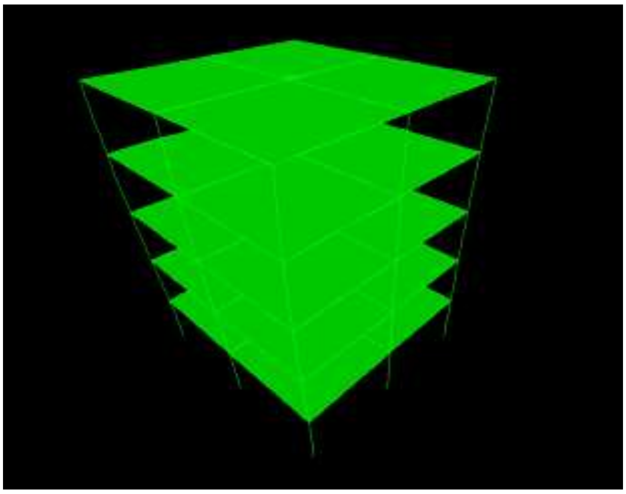

Fig. 9. Mode Shape and Period of Mode 2= 0.3946 s

It is seen that Mode 2 is translational mode shape.

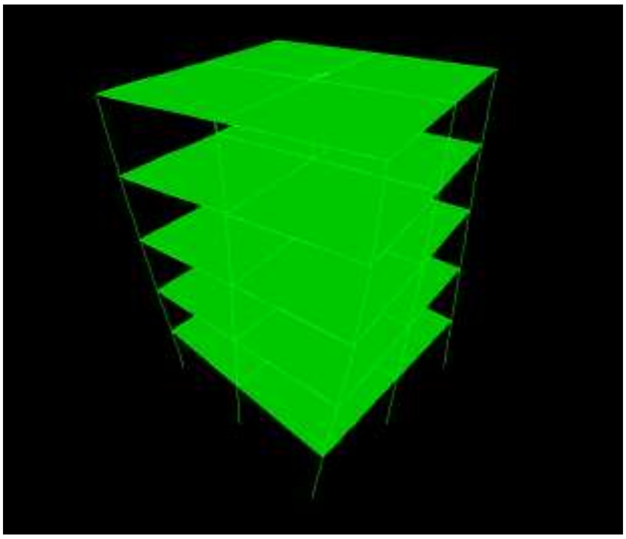

Fig. 10. Mode Shape and Period of Mode 3= 0.3908 s

It is seen that Mode 3 is torsional mode shape.

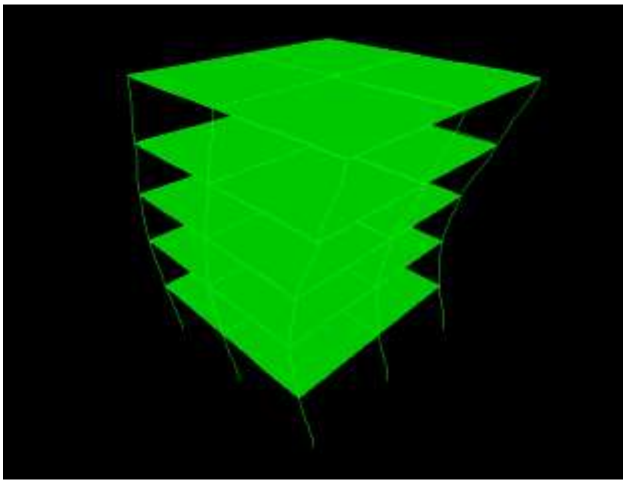

Fig. 11. Mode Shape and Period of Mode 4= 0.1878s

It is seen that Mode 4 is translational mode shape.

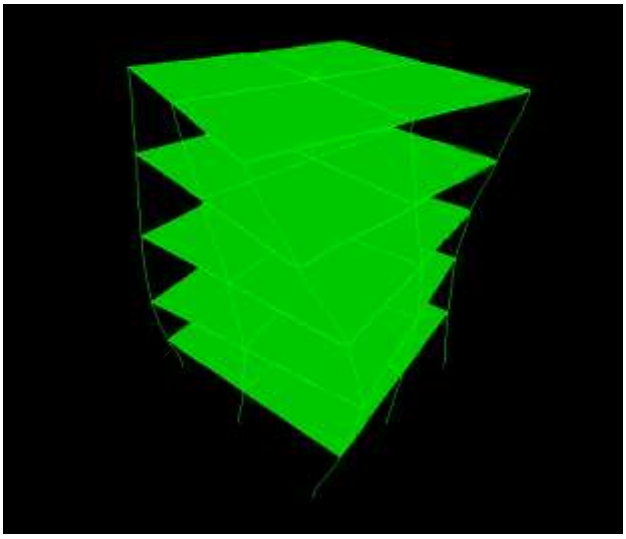

Fig. 12. Mode Shape and Period of Mode 5= 0.1268 s

It is seen that Mode 5 is torsional mode shape.

### C. Comparison of Analysis Results:

The comparison of period of the model with AMD and without AMD model is given in Table 1.

TABLE I. COMPARISON PERIOD OF WITHOUT AMD MODEL AND WITH AMD MODEL

| Mode | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Without AMD Period (s)** | 0.5425 | 0.3906 | 0.3756 | 0.1807 | 0.1266 |
| **With AMD Period (s)** | 0.5685 | 0.3946 | 0.3908 | 0.1878 | 0.1268 |
| **Difference (s)** | 0.0260 | 0.0040 | 0.0152 | 0.0071 | 0.0002 |
| **Difference (%)** | 4.79 | 1.02 | 4.05 | 3.93 | 0.16 |

The comparison of mode shapes of the model with AMD and without AMD model is given in Table 2.

TABLE II. COMPARISON MODE SHAPES OF WITHOUT AMD MODEL AND WITH AMD MODEL

| Mode | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Without AMD Mode Shapes** | Translational | Torsional | Translational | Translational | Torsional |
| **With AMD Mode Shapes** | Translational | Translational | Torsional | Translational | Torsional |

## V. CONCLUSIONS:

The percentage changes in the parameters of the model RC building are listed below.

In the mode 1, the period difference between non-AMD and AMD status was obtained as

0.0260 s. The effect of AMD reinforcing as a percentage was determined as 4.79%.

In the mode 2, the period difference between non-AMD and AMD status was obtained as 0.0040 s. The effect of AMD reinforcing as a percentage was determined as 1.02%. In addition, when the mode shape is examined, it is seen that it transforms from torsion to translation.

In the mode 3, the period difference between non-AMD and AMD status was obtained as 0.0152 s. The effect of AMD reinforcing as a percentage was determined as 4.05%. In addition, when the mode shape is examined, it is seen that it transforms from translation to torsion.

In the mode 4, the period difference between non-AMD and AMD status was obtained as 0.0071 s. The effect of AMD reinforcing as a percentage was determined as 3.93%.

In the mode 5, the period difference between non-AMD and AMD status was obtained as 0.0002 s. The effect of AMD reinforcing as a percentage was determined as 0.16%.

As a result of the study, it has been observed that the RC building model makes more balanced displacements, as can be understood from the mode shapes, without increasing the period of the RC building to a dangerous level It was observed that the period values increased only 4.79 percent at the most and 0.16 percent at the least. AMD reduced the seismic effect by acting in the opposite direction to the seismic effect on the structure. It can be used in AMD reinforced concrete buildings, provided that it does not increase the period too much.

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