Shape memory alloys (SMAs) are one of the most widely used smart materials in many applications because of their shape memory effect property and pseudo elastic behaviour. This paper describes numerical and experimental platform which analyzes and controls the vibration of a Shape Memory Alloy (SMA) actuated cantilever beam. The system consists of cantilever beam fixed with C Clamp. The shaker is used to generate real time vibration with the help of function generator. The SMA springs with mass is attached at the free end. The experiments were carried out by using SMA and conventional spring. The FFT, accelerometer and non contact type displacement sensor were interfaced with PAK software to note the results. According to the experimental setup the cantilever beam with spring mass system is modelled in ANSYS Workbench R15.0. And harmonic response analysis was done, and results are compared over range of frequencies.

**Keywords**: ANSYS, DVA, FFT, PAK Software, SMA spring.

**I. INTRODUCTION**

Metal alloys that are capable of reclaiming a certain shape when heated i.e. they can recover from large damages without permanent deformation is called a shape memory effect [1]. Shape-memory materials (SMMs) are one of the most important elements of intelligent/smart composites because of their different properties, such as the shape-memory effect (SME), pseudo elasticity or large recoverable stroke (strain), high damping capacity and adaptive properties which are due to the (reversible) phase transitions in the materials [2]. Shape memory effect and super elastic effect are the two wonderful behaviors of shape memory alloys (SMAs), which are directly dependent to temperature. The super elastic behavior of SMAs exhibits better recentering effect. This behavior has drawn much attention from civil engineers, particularly for earthquake resistant design of structures [3].

SMMs may sense thermal, mechanical, magnetic, or electric stimulus and disclose actuation or some preset response, making it possible to tune some technical parameters namely shape, position, strain, rigidity, natural frequency, damping, friction, and other static and dynamical features of material systems in response to the environmental changes [2]. Recently, in biomedical, commercial, and aerospace industries, several applications of shape memory alloys have been employed due to its higher quality and reliability, coupled with a considerable reduction in cost [4]. SMAs may also have
found applications in several areas due to their high power density, solid state actuation, high damping capacity, robustness, and fatigue resistance. When integrated with civil structures, SMAs can be passive, semi-active, or active components to diminish damage caused by environmental impacts or underground eruption [5].

There are two types of SMA (Shape memory alloy) they are

- One way shape memory
- Two way shape memory

1.1. One way shape memory

In one way shape memory the metal can be stretched or bend when that particular metal is in cold state ie. (Below Tc) This will retain the similar shape till the heating level reaches the transition temperature ie. (above Th). In this type the material can changes its properties when it is in cold condition and retain its original position when it is heated. Where Tc is said to be -150°C and 200°C & Th is said to be 2°C to 20°C

1.2. Two way shape memory

In this type, the material reflects one of its properties when it is in cold condition and reflects another property when it is heated.

SMAs are smart materials, and their physical properties vary as a function of temperature. The stiffness of the SMA spring can be controlled by varying the electrical current supplied to it. This causes the transition of the material phase from martensite to austenite phase which in turn increases the spring’s Young’s Modulus. This result in generation of great potential which can be used to control the vibration

II. EXPERIMENTAL SET UP

Wherever Times is specified, Times Roman or Times New Roman may be used. If neither is available on your word processor, please use the font closest in appearance to Times. The cantilever beam used in the experiment is made up of aluminum of length 600mm, breadth 40.08mm and thickness 6.1mm. SMA helical springs used in this experiment were procured from Dynalloy Inc, USA.

The wire diameter of spring is 0.75mm, Mean diameter is 6mm and the number of active turns is 20. The shaker is used to generate the real time vibration which is regulated by function generator. The cantilever beam used in the experiment is made up of aluminum of length 600mm, breadth 40.08mm and thickness 6.1mm. SMA helical springs used in this experiment were procured from Dynalloy Inc, USA.

The wire diameter of spring is 0.75mm, Mean diameter is 6mm and the number of active turns is 20. The shaker is used to generate the real time vibration which is regulated by function generator. The stiffness of the spring is calculated experimentally. An accelerometer of sensitivity 100 mV/g is attached to the beam which is coupled to the FFT to record the amplitude of vibration. The Non contact type displacement sensor of range ± 50mm is fixed over the beam. The FFT and non contact type displacement sensor are interfaced with computer along with PAK software. The force excitation frequency of cantilever beam is determine experimentally as 21.5 Hz so a frequency range of 18.5 Hz to 25.5 Hz is selected to check the capability of SMA spring to control the vibration. The experimental set up is shown in Fig 1.

![Experimental Set up](image)

**III. MEASUREMENT OF AMPLITUDE AND ACCELERATION USING CONVENTIONAL AND SMA SPRINGS**

The dimensions of the conventional spring are same as that of the SMA spring. The beam was excited over a frequency range of 18.5 Hz to 25.5 Hz and frequency Vs amplitude and acceleration Vs amplitude is recorded. The conventional spring is replaced by Single SMA spring, two SMA spring in parallel and three SMA spring in parallel and result are noted which is shown in following graphs.
Fig 2. Graphs of Frequency Vs Acceleration for 1 SMA spring

Fig 3. Graphs of Frequency Vs Acceleration for 2 SMA spring

Fig 4. Graphs of Frequency Vs Acceleration for 3 SMA spring

Fig 5. Graphs of Frequency Vs Acceleration for conventional spring

Fig.6. Experimental Comparison of Amplitude of Vibration for Without absorber, Conventional, 1 SMA, 2SMA in parallel and 3 SMA in parallel for cantilever beam at free end

IV. NUMERICAL ANALYSIS

According to the experimental setup the cantilever beam with spring mass system is modelled in ANSYS Workbench R15.0. Material properties were specified and fine meshing was done. The boundary conditions were defined and harmonic response analysis was carried out for different conditions and results were calculated for amplitude of vibration. The model and FEA results are as follows.

Fig.7. Application of force at center of cantilever beam

![Graph showing comparison of vibration amplitude for different configurations](image)

**Fig. 8.** FEA Comparison of Amplitude of Vibration for Without absorber, Conventional, 1 SMA, 2SMA in parallel and 3 SMA in parallel for cantilever beam at free end

V. CONCLUSION

This research work has been focused on numerical and experimental analysis of cantilever beam with conventional springs and shape memory alloy springs connected in parallel. The results demonstrate the effectiveness of using SMA springs based DVA for controlling vibration both in experimentally and numerically. The closely coil helical springs are used for conducting the experiment and it is noticed that SMA spring can generate large force and By using multiple SMA springs in parallel the vibration can be reduce up to 89%. The numerical results are closely mapping with the experimental results and percentage of error is less than 7%. The results demonstrate that the SMA springs are more effective in vibration control.

REFERENCES


