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Analysis of PZT/PVDF Actuated Cantilever Beams

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Abstract

Recent advancement in the field of distributed sensor/actuators has led to the development of new structures called "smart structure". A smart/intelligent structure is able to sense, respond and control its own characteristics and states, so as to significantly improve its operational performance. A structure becomes smart when the load bearing part also called the substrate is composed of conventional structural material and is integrated with the distributed actuation/sensor maybe piezoelectric, shape memory alloys, electrostrictive materials, magnetostrictive materials etc. In the present work, a systematic modelling technique is proposed for static and dynamic analysis of beam coupled with piezoelectric sensors/actuators by using the finite element method if formulation. The sensor/actuator layer made of a piezoelectric/polymer called PZT/PVDF is considered.

Keywords: *Beams, Aluminium, PZT, electrical signals.*

INTRODUCTION

The purpose is to present a general framework for the analysis and design of engineering systems that incorporate smart materials. Smart materials are those that exhibit coupling between multiple physical domains. Common examples of these materials include those that can convert electrical signals into mechanical deformation and can convert mechanical deformation into an electrical output. Others that we will learn about are materials that convert thermal energy to mechanical strain, and even those that couple the motion of chemical species within the material to mechanical output or electrical signals. We focus on developing an understanding of the basic physical properties of different types of materials. Based on this understanding we develop mathematical models of these smart materials and then incorporate these models into the analysis of engineering systems. Through a basic understanding of smart material properties and how they are integrated into engineering systems, we will gain an understanding of engineering attributes such as range of motion, ability to generate force, and the speed of response of the materials. The development of methods for analyzing and designing systems that incorporate smart materials.

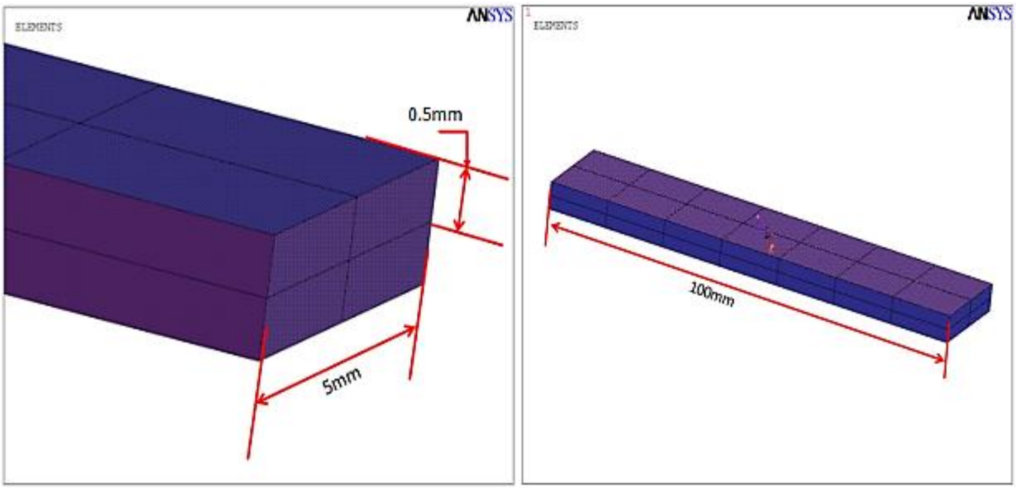


Figure 1: *Static analysis of Piezo electric bimorph beam.*

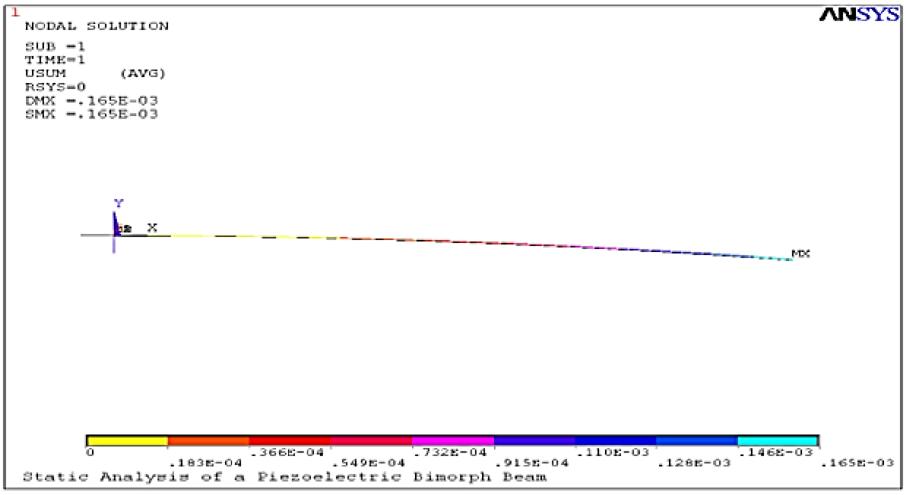


Figure 2: *Volt is applied across thickness.*

Table 1: *Deflection plot for 1 volt.*

Theoretical Solution	FEA solution
0.033mm	**0.033mm**

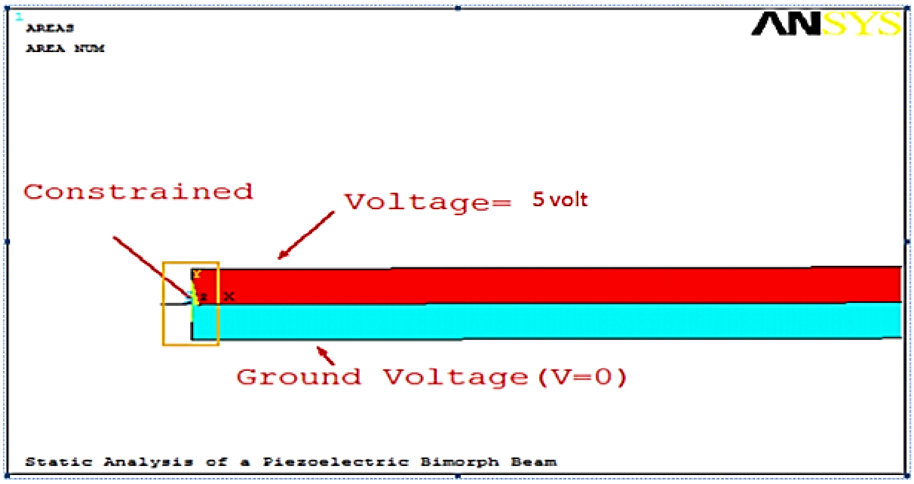


***Figure 3:** Volt is applied across thickness.*

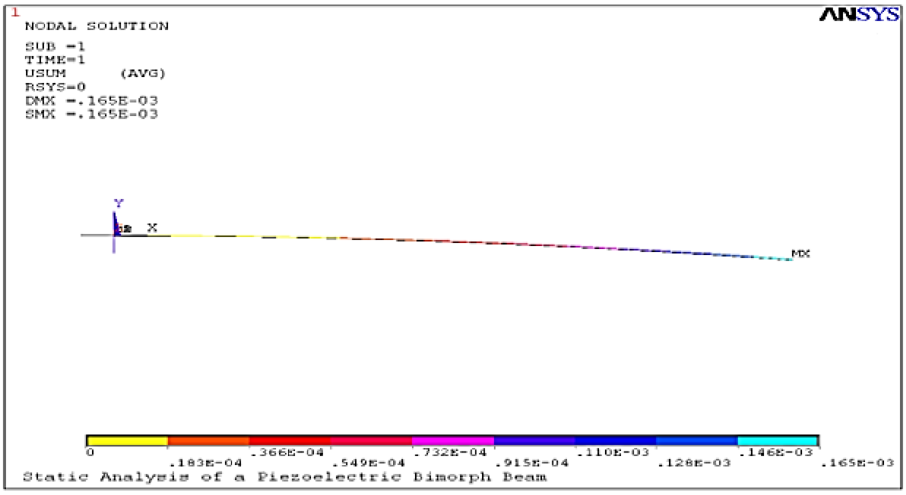


***Figure 4:** Deflection plot for 5 volt.*

Application of 10mm displacement to the tip node and checking for voltage generation

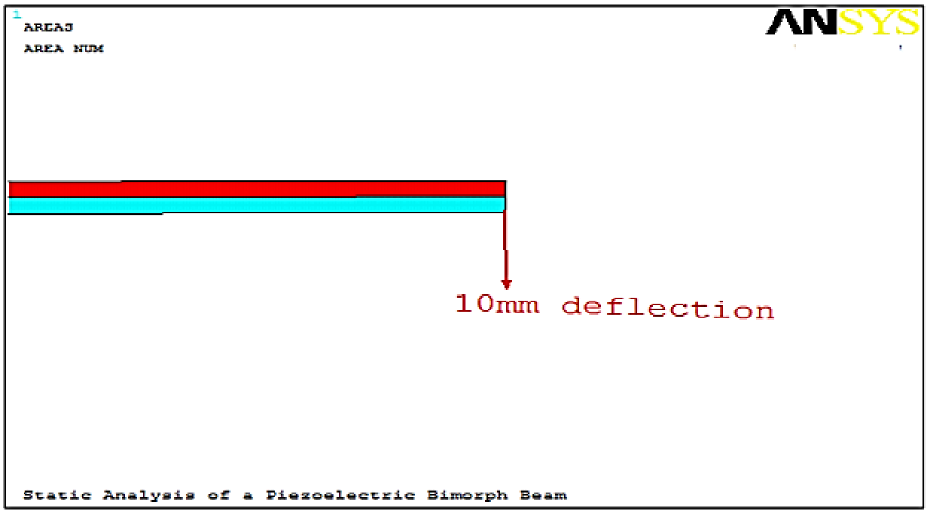


***Figure 5:** Application of displacement 10mm.*

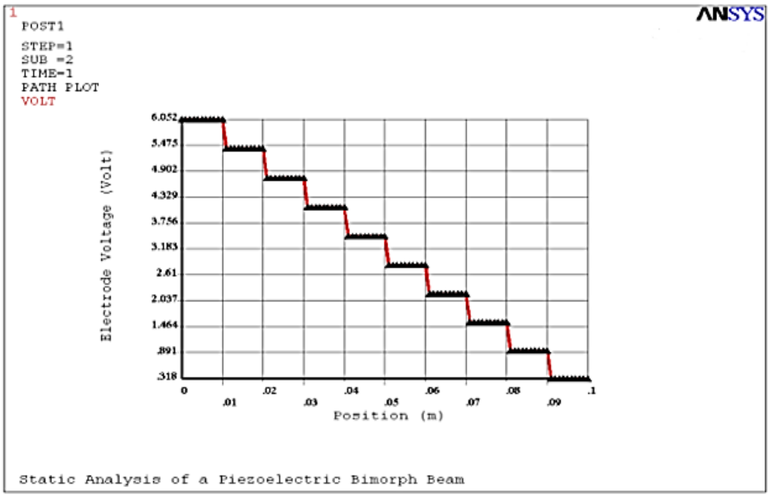


***Figure 6:** Voltage generations along length.*

Application of Displacement 20mm

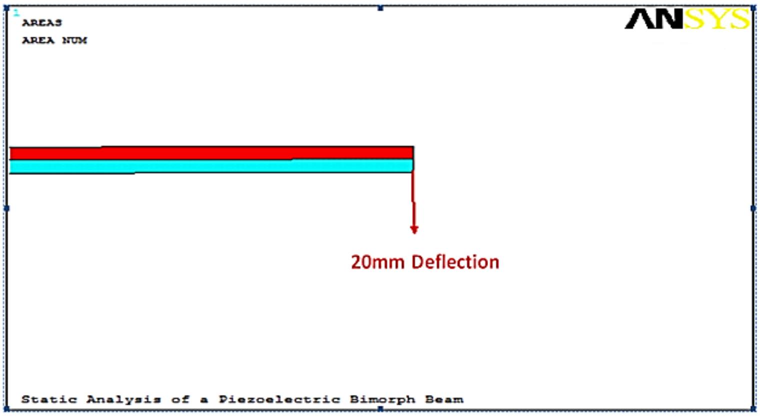


Figure 7: *Application of displacement 20mm.*

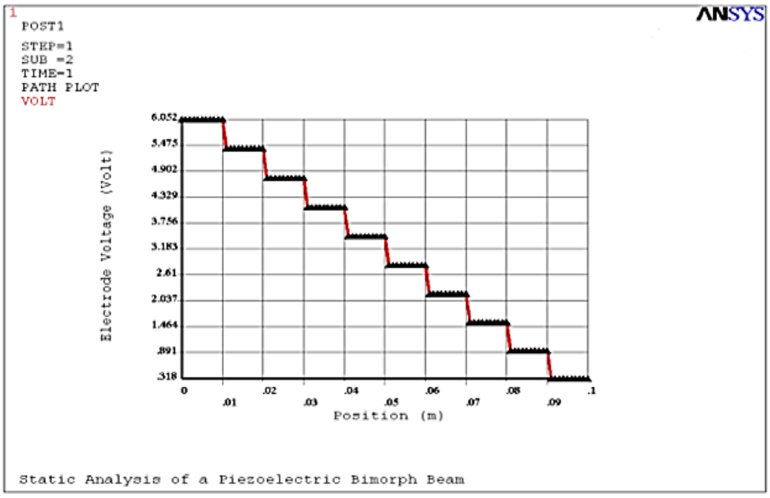


Figure 8: *Voltage generations along length.*

ANALYSIS OF PIEZO ELECTRIC COMPOSITE

Using Aluminum substrate

Finding the natural frequency of a composite shell made of three layers comprising piezo electric material along with a bonding agent and aluminum substrate.

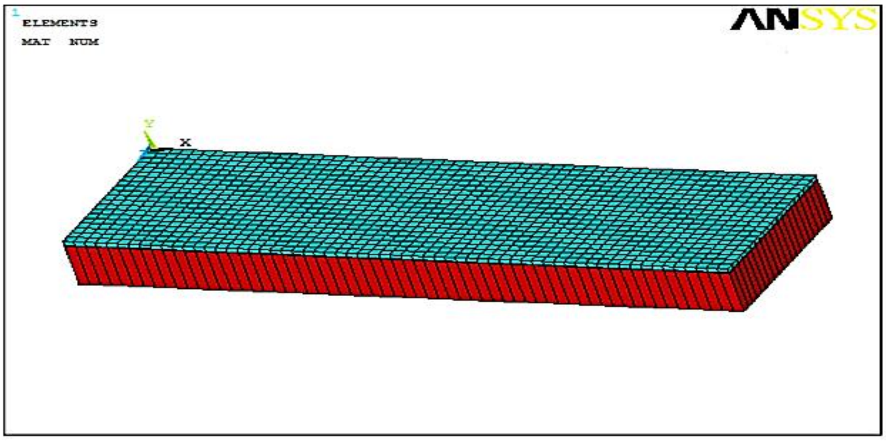


Figure 9: *Geometrical representation of the problem.*

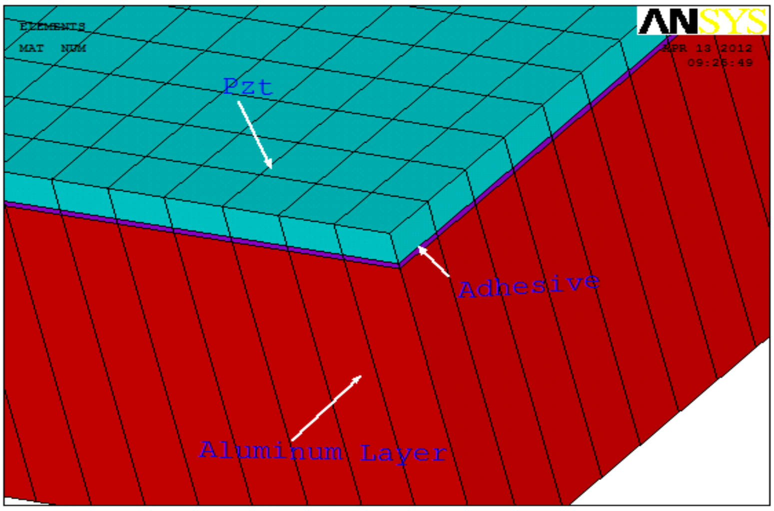


Figure 10: *Layer sequence of geometric.*

Mode shapes for Al Substrate

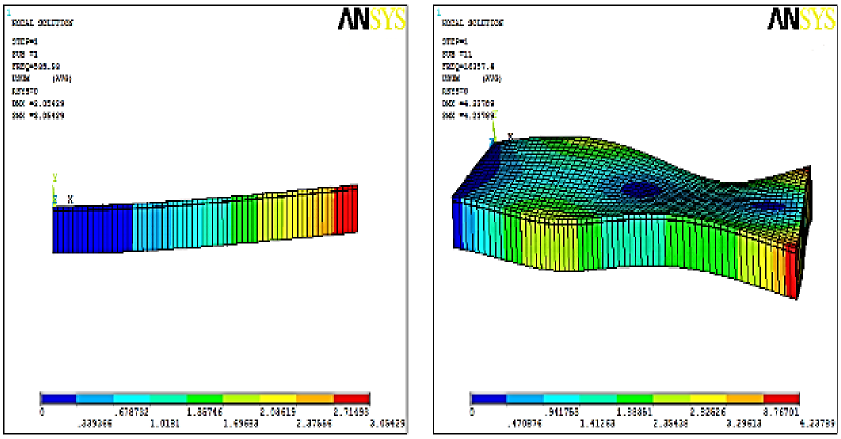


Figure 11: *Mode shape for AL.*

DAMPING CHARACTERISTICS OF BEAM USING F.E.M TECHNIQUE

Damping Characteristics of Al beam

Aluminum Beam without PZT

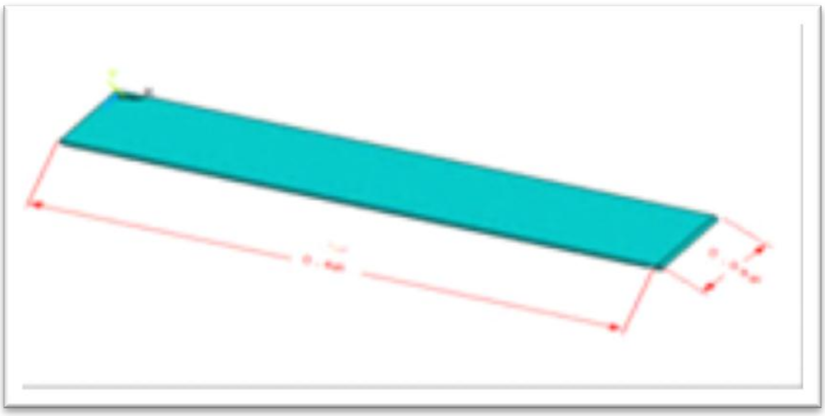


Figure 12: *Dimensional plot for Al beam.*

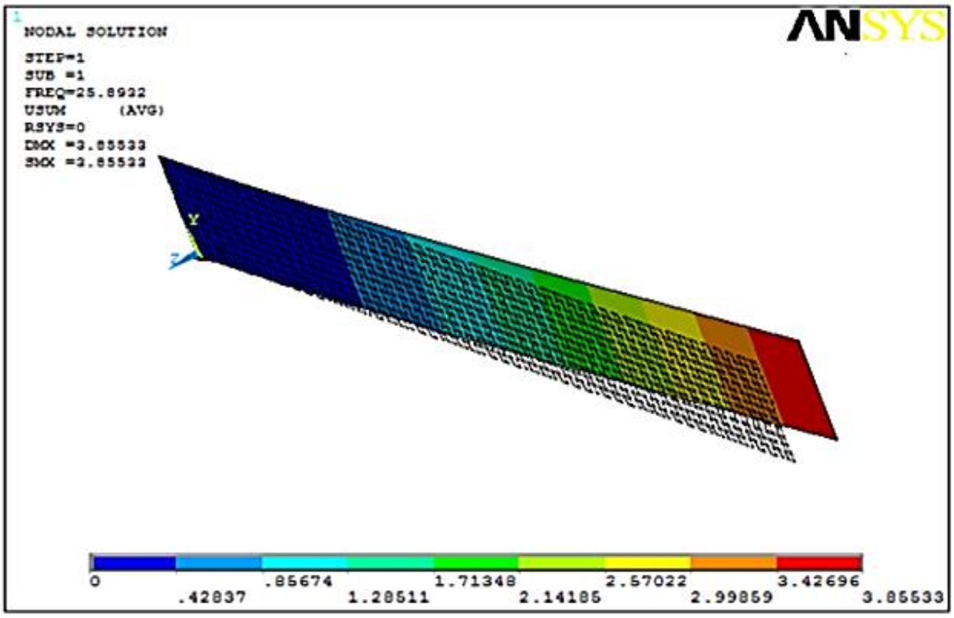


Figure 13: *Deformed and un-deformed shape*

Undamped Response of Aluminum Beam

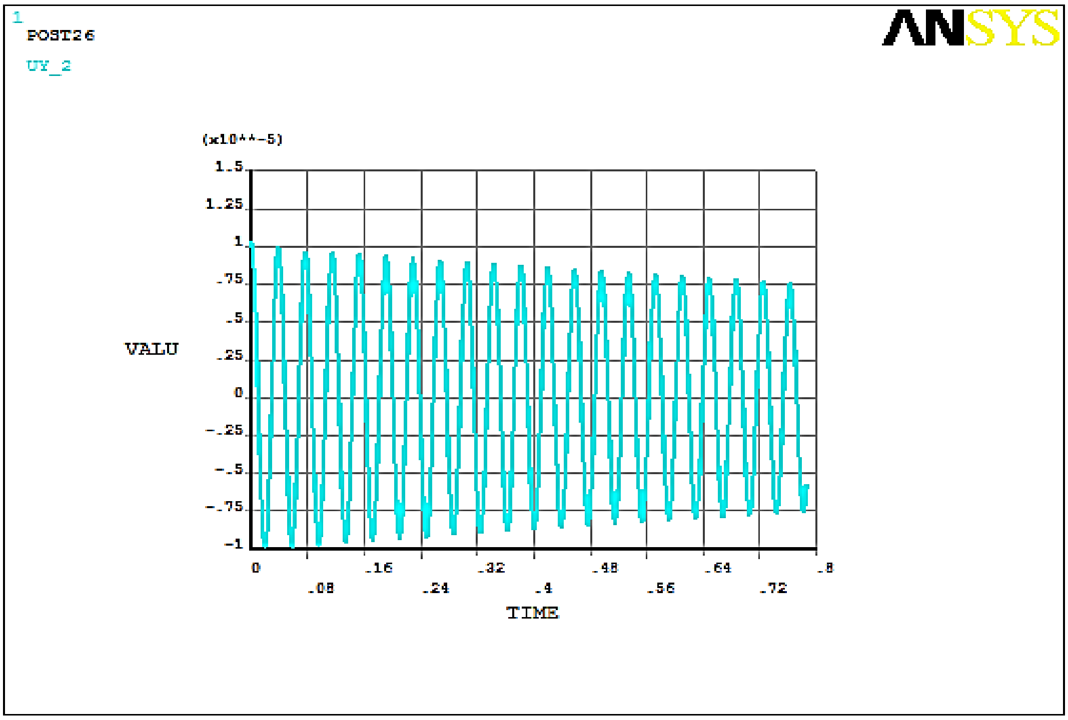


Figure 14: *Response of Al under un-damped condition.*

Table 2: *Modal frequency.*

Set No	Mode Frequency(Hz)
1	25.893
2	162.13
3	253.46
4	394.52
5	452.08

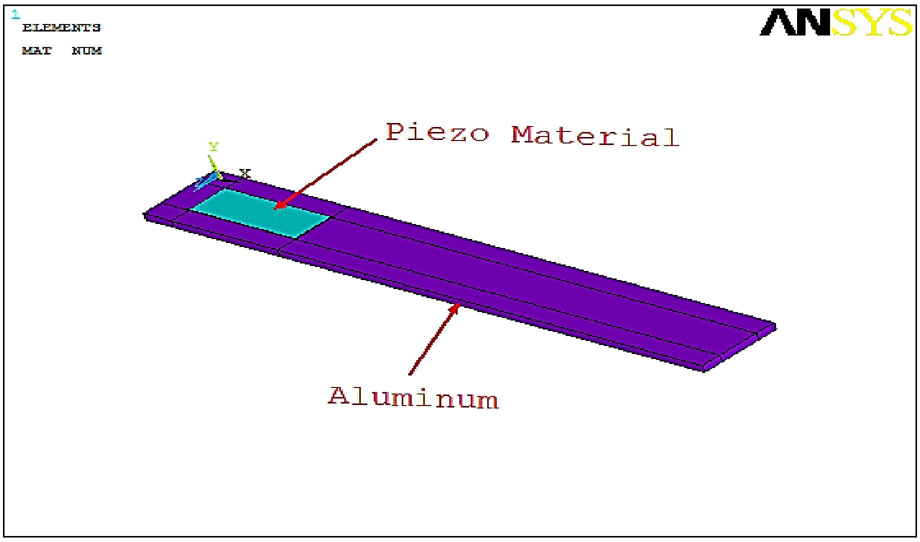
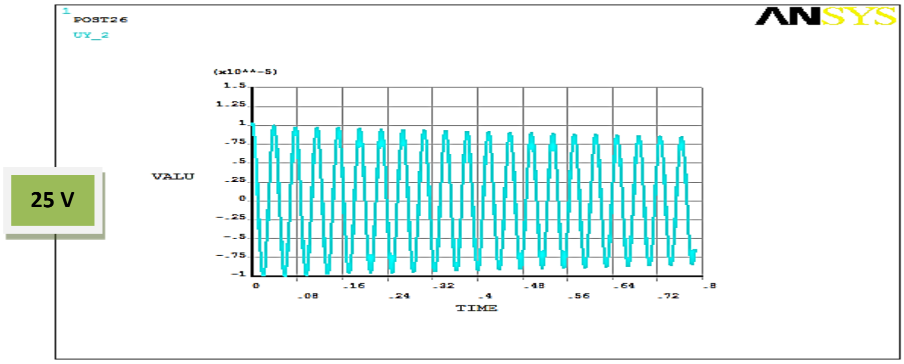
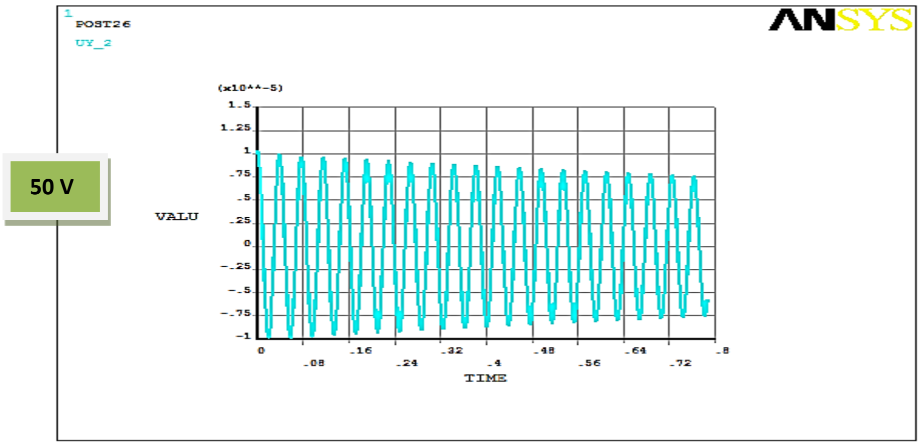


Figure 15: *Analysis of Al Beam with PZT without load.*

Table 3: *Al material with a Piezo patch.*

Set No	Mode Frequency(Hz)
1	26.302
2	179.28
3	256.45
4	395.65
5	706.98





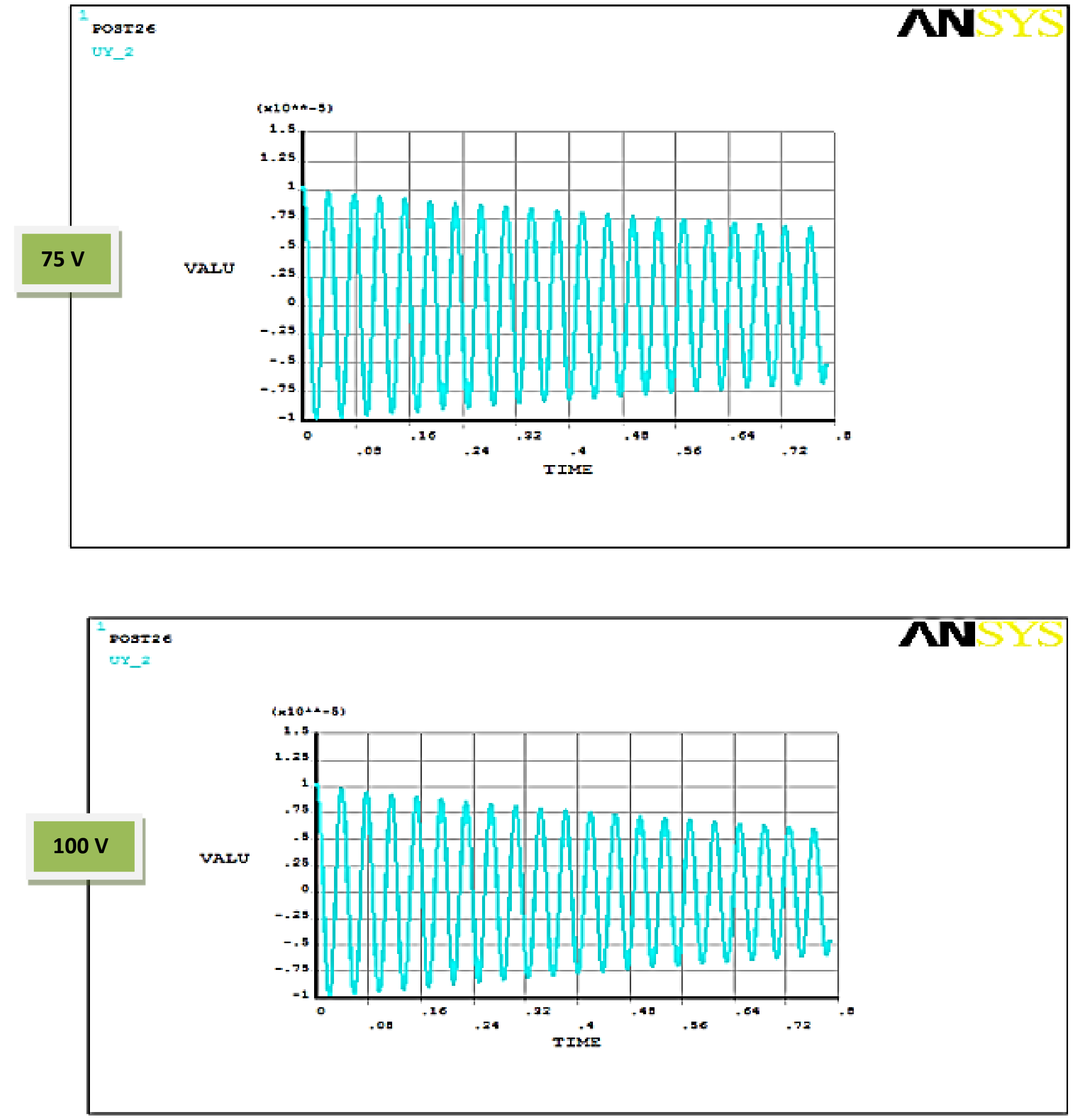


Figure 16: *Aluminum beam with PZT with load damped response.*

Table 4: *Results summary for aluminum beam.*

Damping Ratio	Beta d (10^{-5})	Amplitude of Vibration	% reduction
0	0	10.29	-
0.95	1.0971	9.97	3.1
1.777	2.18	9.86	4.18
2.68	3.29	9.816	4.6
3.59	4.41	9.79	4.9

Table 5: *Modal frequency.*

Set No	Mode Frequency(Hz)
1	25.668
2	160.73
3	251.26
4	391.10
5	450.14

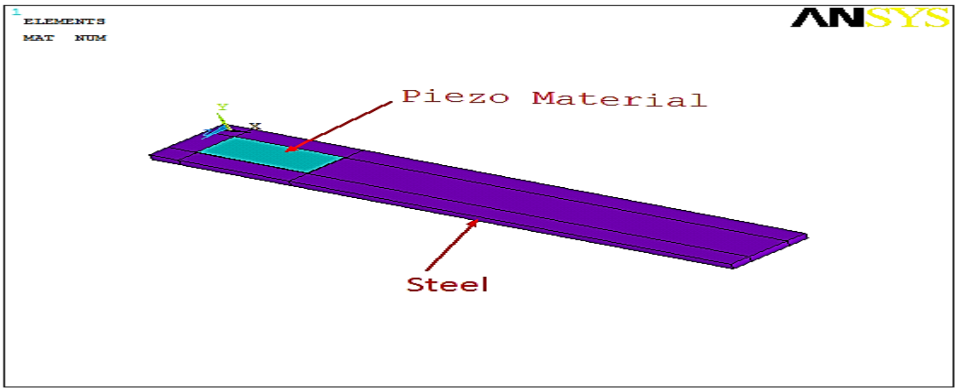


Figure 17: *Analysis of Al Beam with PZT without load.*

Table 6: *Al material with a Piezo patch.*

Set No	**Mode Frequency(Hz)**
1	26.136
2	178.66
3	255.04
4	393.31
5	718.14

Table 7: *Performance of damping.*

Voltage (v)	**Al –Piezo – Beam (% Reduction)**
25	3.1
50	4.18
75	4.6
100	4.9

CONCLUSION

A finite element procedure for 2-D composite beam structure with surface bonded or embedded piezo electric material is developed, subsequently; it is validated with available bench mark problems. It has been found that results have good correlation with the practical results. Thus, help us in analysis of 2-D composite beam structures using PZT. Based on piezoelectric technology various physical quantities can be measured, and they can be widely used in vibrational analysis of various systems. The technologies using smart materials are useful for both new and existing constructions. A finite element code is developed for 2D beam structure. This work can extend to 3D problem. In the present work, thermal properties are not considered in the formulation. One can consider these properties and develop smart-electro-thermo mechanical beam.

REFERENCES

1. Bruant, G Coffignal, "Active control of beam structures with piezoelectric actuators and sensors modelling and simulation", *Journal of Smart Materials and Structures*, Volume 10, Issue 200
2. Uew Stobener, Lothan (April 20000), "Gaul modal vibration control for PVDF coated plates", *Journal of Intelligent Material System and Structures*.
3. V. Balmurugan, S. Narayanan (2001), "Shell infinite element for piezoelectric composite Plate/shell structures and its applications to the study of the active vibration control", *Journal of Finite Elements in Analysis and Design*, Volume 37.
4. S. Vardarajan, K Chandrashekhar (September 1998), "Adaptive shape control of laminated composite plates using piezoelectric materials", *AIAA*

Journal, Volume 36, Issue 9.

5. Bahu Sun, Dahuang (2001), "Vibration suppression of laminated beams with a piezoelectric Damping layer" J of composite structures, Volume 53, pp. 437–447.
6. KIM-Hoip, Ping-Cheung TSC (2001), "Optimal configurations of a piezoelectric damping layer", *Journal of Composite Structures*, Volume 53, pp. 437–447.
7. A. Benjeddou, M.A Trindade (March 2000), "New shear actuated smart structure beam finite element", *AIAA Journal*, Volume 37, Issue 3.
8. B.L Wang, N Noda (2001), "Design of smart functionally graded thermo piezoelectric composite structure", Volume 10
9. S.Y Wang, S.T Quek, K.K Ang (2001), "Vibration control of smart piezoelectric composite plates", *Journal of Smart Materials and Structures*, Volume 10, pp. 637–644.

