The Effect of Shape Memory Alloy in Composite Beam

Yatendra Saraswat, Sangam Yadav, Hemant Singh Parihar

Abstract*: This study deals with the static analysis of the effect of shape memory alloy using finite element analysis on ansys software.In this paper, a simply supported carbon/epoxy beam is considered.A point load of 10 KN is applied at the top layer of the carbon/epoxy carbon/epoxy beam. The boundary condition is same for with and without SMA wire. this research work involves analysis of the 1000mm length carbon/epoxy carbon/epoxy beam. the shape memory alloy wire is used at the top surface above the neutral axis of the carbon/epoxy beam. The shape memory alloy wire which is 10% by volume fraction of the whole carbon/epoxy beam. After performing analysis we compare both the result with SMA and without SMA wire. In this analysis we compare the maximum deformation, Equivalent (von-misses) stress and strain. From the above result, we have seen the effect of shape memory alloy wire on the carbon/epoxy beam. All the method which is used to analysis the carbon/epoxy beam is controlled by ansys software.

Key Words: Carbon/Epoxy, Shape Memory Alloy, ANSYS Workbench, Finite Element Analysis, Fiber Volume Fraction.

I. INTRODUCTION

In the past few decades, we saw that shape memory alloy(SMA) have the capability of supporting large inelastic strain (H., 1987). The mathematical modeling of the multi-dimensional and one-dimensional system made up of shape memory alloy have received their attention in the literature (Bernardini D, 2003). In this research paper, we analyze the carbon/epoxy carbon/epoxy beam with and without the use of shape memory alloy and compare the result for stress, strain. And displacement. the shape memory alloy wire is used is 10% by the volume fraction of the carbon/epoxy beam. The material properties used to analysis the composite beam is defined as the earlier researches to get the efficient result (S.M.R. Khalili, 2013).The goal of the study is to explore the effects for material shape memory alloy wire when 10% of volume fraction is used in the carbon/epoxy beam.

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Here in figure 1, we have the cross-section of the beam that is designed in the geometry.The elevation of the carbon/epoxy beam with SMA wire.In figure 2 we show the carbon/epoxy beam with SMA wire.In fig 3 we show the carbon/epoxy beam without SMA wire. The connections and supports are made in the beam.

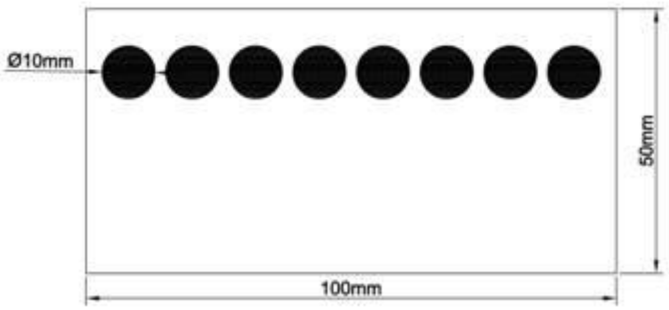

Fig.1. Elevation of SMA Carbon/epoxy Beam

Fig.2. Beam With SMA

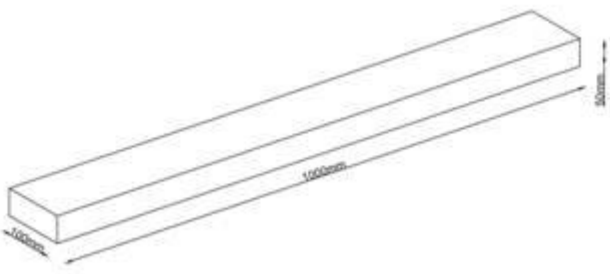

Fig.3. Beam without SMA

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II. MATERIAL PROPERTIES

THE MATERIAL PROPERTIES AND THEIR COEFFICIENT OF VARIATIONS ARE GIVEN BELOW IN TABLE 1.

Property	Shape memory alloy
Density(kg/m^3)	6450
Young modulas(Pa)	6.7E+10
Poission ratio	0.33
Sigma SAS(MPA)	100
Sigma FAS(MPA)	170
Sigma SSA(MPA)	239
Sigma FSA(MPA)	170
Epsilon(mm^-1)	0.067
alpha	0

Table 1. Properties Shape Memory Alloy

$E_1(N/M^2)$	144.8e9
$E_2(N/M^2)$	9.65e9
$E_3(N/M^2)$	9.65e9
$G_{12}(N/M^2)$	4.14e9
$G_{12}(N/M^2)$	3.45e9
$G_{13}(N/M^2)$	4.14e9
μ_{12}	0.3
ρ(KG/M^3)	1389.23

Table 2. Properties Of Carbon/Epoxy

III. MODELLING AND LOADING

For getting accurate results of the analysis, the Finite element software ANSYS Workbench is used. The highlights and details for modeling and load application are explained here.

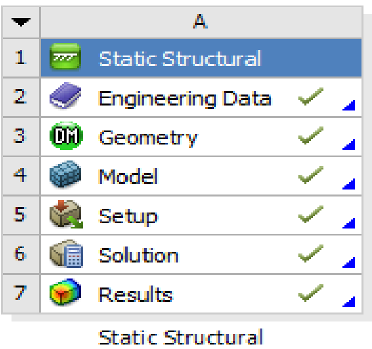

Fig.4. Schematic Chart Of Analysis.

A. Modelling

The schematic procedure for Finite element analysis of composite beam on ANSYS Workbench is given below:

Step-1: Given engineering data

Step-2: Preparation of geometry

Step-3: Connections

Step-4: Meshing

Step-5: Boundary conditions and load application

Step-6: Solutions and results.

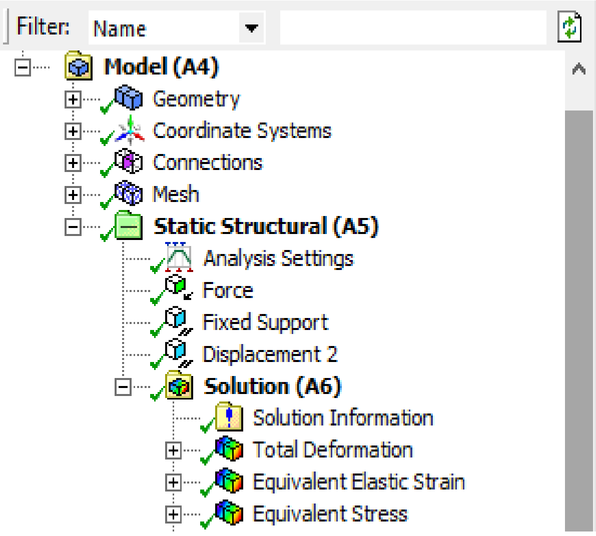

Fig.5. Schematic Procedure

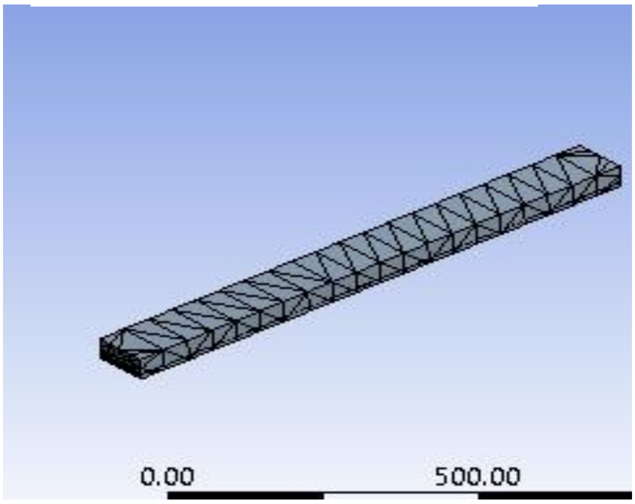

Fig.6. Meshing With SMA

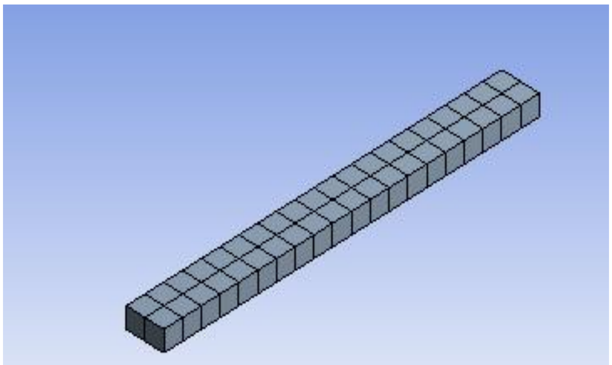

Fig.7. Meshing Without Shape Memory Alloy

B. Loading

As loading is given in (S.M.R. Khalili, 2013) we apply a loading the beam and boundary condition for both the beam given below.

1. The beam is simply supported with one edge is fixed.
2. The other edge of the composite beam as (X=0, Y=0, Z=free).
3. The load of 10KN is acting top of the beam.

IV. RESULTS AND COMPARISON

Several results are available after simulation of the carbon/epoxy beam with and without SMA by using 10% of SMA by volume. The main focus was on the total deformation, equivalent (von-misses) stress and elastic strain.

Results obtained are as follows:-

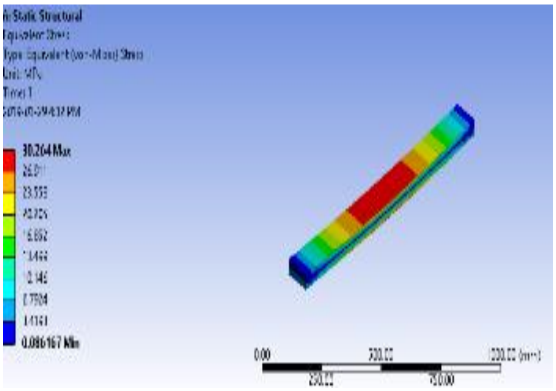

Fig.8. Equivalent Stress Without Shape Memory Alloy

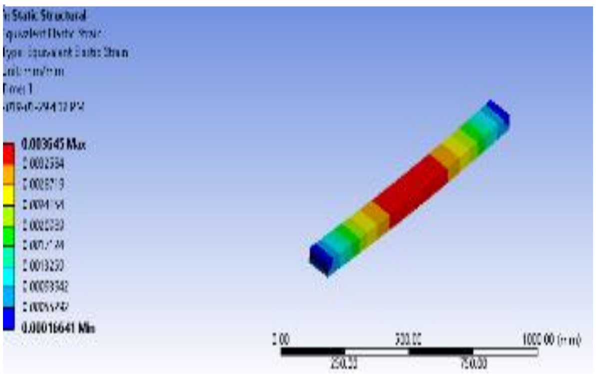

Fig.9. Equivalent elastic strain without SMA

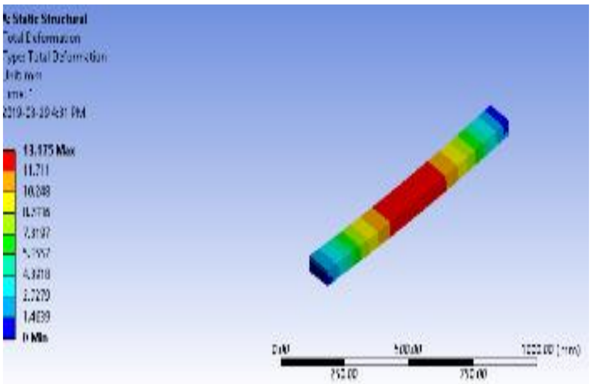

Fig.10. Total Deformation Without SMA.

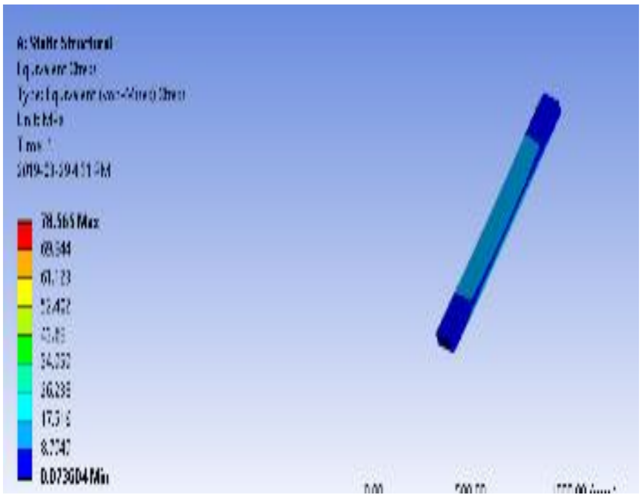

Fig.11. Equivalent stress with sma

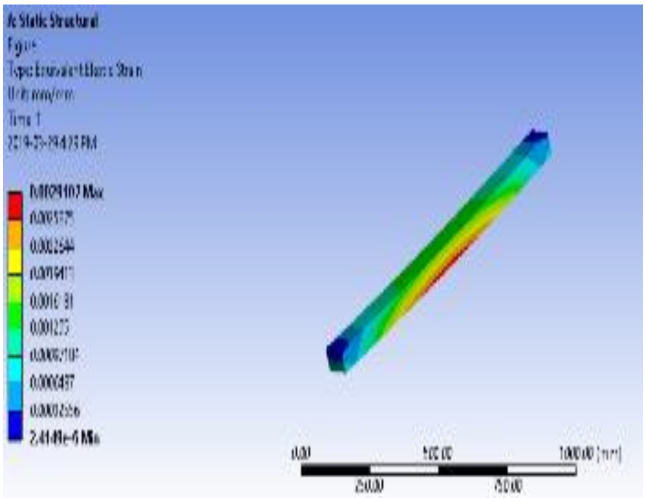

Fig.12. Equivalent Elastic Strain With SMA

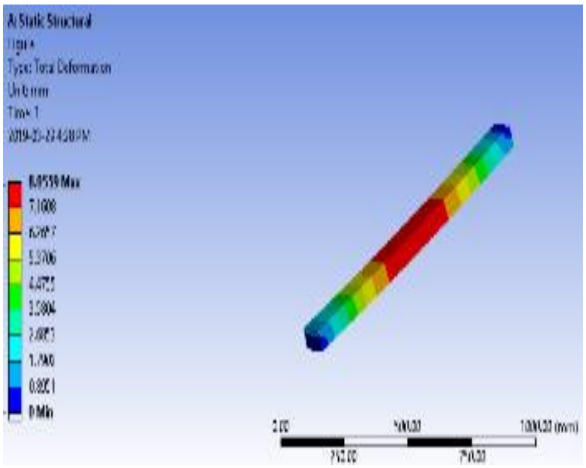

Fig.13. Total Deformation With SMA

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Table 3. The Result Are As Follows

Result	Carbon /epoxy	
	With SMA	Without SMA
force (KN)	10	
Total deformation max	8.0559 mm	13.175 mm
Equivalent (von-misses) stress max	78.565 MPa	30.264 MPa
Equivalent (von-misses) stress min	7.3604e-002 MPa	8.6167e-002 MPa
Equivalent elastic strain(max)	2.9107e-003 mm/mm	3.645e-003 mm/mm
Equivalent elastic strain (min)	2.4149e-006 mm/mm	1.6641e-004 mm/mm

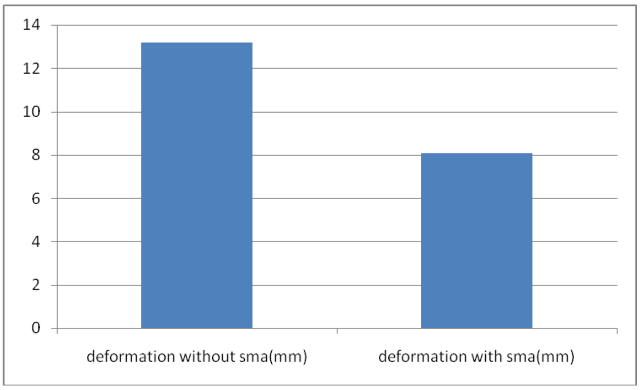

Fig.14. Comparative Representation Of Deflection.

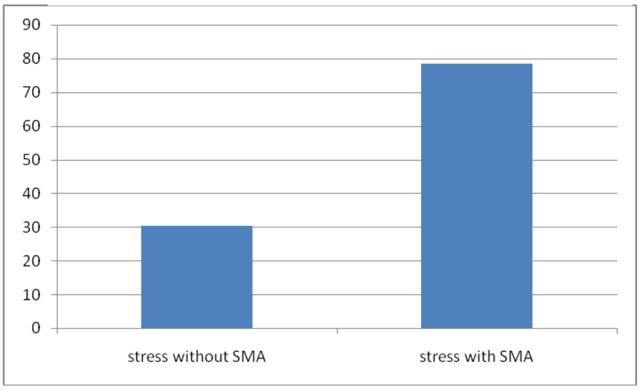

Fig.15. Stress Diagram

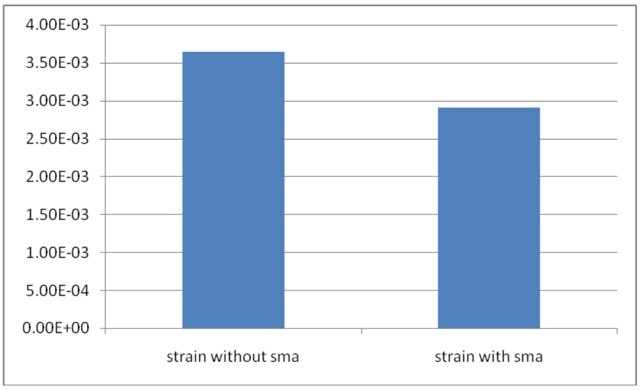

Fig.16. Strain Diagram

V. CONCLUSION

On the basis of the above results, it is concluded that:

1. The deformation is about half by using the shape memory alloy wire in the beam.
2. We will get about more than twice stress by using shape memory alloy wires.
3. The strain is reduced by 1.25 times by using SMAs wires in the carbon/epoxy beam.

In future work, we are increasing the percentage of shape memory alloy in the top and bottom of the carbon/epoxy beam which decreases the deformation.

REFERENCES

1. H., F. (1987). SHAPE MEMORY ALLOY. GORDON AND BREACH SCIENCE PUBLISHERS .
2. S.M.R. KHALILI, M. D. (2013). MODELING AND TRANSIENT DYNAMIC ANALYSIS OF PSUDOELASTIC SMA HYBRID COMPOSIITE BEAM. APPLIED MATHEMATICS AND COMPUTATION .
3. YAHYA BAYAT, H. E. (2019). A NON LINEAR STUDY ON STRUCTURAL DAMPING OF SMA HYBRID COMPOSITE BEAM. THIN WALLED STRUCTURE , 18-28.
4. ANSYS Mechanical APDL Structural Analysis guide & ANSYS Reference Guide.
5. Brinson LC, Lammering R.Finite elemant analysis of the behavior of Shape memory alloy and their applications,Int J Solid Struct 1993;4;229-242
6. Bathe K-J. Finite Element Procedures, Cambridge University Press: 2007.
7. Zhu S,Zhang Y.A Thermomechinical Constitutive Model For Superelacticity SMA Wire With Strain- Rate Dependence. Smart Materialstructure 2007;16:1696-707
8. B.T. Lester, T. Baxevanis, Y. Chemisky, D.C. Lagoudas, Review and perspectives: shape memory alloy composite systems, Acta Mechnica 226 (2015) 3907–3960.
9. Y. Bayat, H. EkhteraeiToussi, Exact solution of thermal buckling and post buckling of composite and SMA hybrid composite beam by layerwise theory, Aerosp. Sci. Technol. 67 (2017) 484–494.
10. S. Hassanli, B. Samali, Buckling analysis of laminated composite curved panels reinforced with linear and non-linear distribution of shape memory alloys, ThinWalled Struct. 106 (2016) 9–17.
11. S.M.T. Hashemi, S.E. Khadem, Modeling and analysis of the vibration behavior of a shape memory alloy beam, Int. J. Mech. Sci. 48 (2006) 44–52.
12. FINITE LEMEMT ANALYSIS THEORY AND APPLICATION WITH
13. Ansys,Third Edition ,Pearson Education,Inc,2008

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