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Study of Multi Layered Composite Shell With Shape Memory Alloy

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Abstract: The use of special composite materials has been continuously growing in recent years. Although many applications for composite materials include identified. general research is still being carried out in order to expand this field. New materials and advancements have been explored. One such new application is the coordination of shape memory materials inside composite materials.

In this study certain parts of the dynamic conduct of a multilayered composite shell with shape memory combination wires have been examined. The influence of SMA wires, the orientation and the thickness to diameter ratio and different boundary conditions, on changes in critical load, the natural frequencies and modes of vibration of the shell have been studied and discussed in the present study. The results presented are obtained by the use of finite element method. The analysis both static and modal has been carried out using ANSYS 12.0.

The shape memory alloys possess the inherent ability to change their material properties in particularly their young's modulus, damping capacity as well as great capacity for the generation of large internal forces. Integrating SMA's within composite material structures potentially allow the active control of certain static and dynamic behaviour of the integrated structures.

1. INTRODUCTION

A Composite Material can be unmistakable as a mix of two or a larger number of materials that outcomes in preferred properties over those of the individual parts utilized alone. In refinement to metallic composites, every material holds its different compound, physical, and mechanical properties. The two constituent are supporting and a grid. The fundamental points of interest of composite materials are their high quality and solidness, imparted to low thickness, when contrasted and mass materials, considering a weight lessening in the completed part.

The fortifying stage gives the quality and solidness.. They might be round, platelets, or some other consistent or unpredictable geometry. Particulate composites have a tendency to be much weaker and less firm than nonstop fiber composites, however they are generally considerably less costly. Particulate fortified composites as a rule contain less support (up to 40 to 50 volume percent) because of preparing troubles and fragility.

A fiber has a length that is much more noteworthy than its width. The length-to-width (l/d) proportion is known as the perspective proportion and can differ significantly. Constant strands have long perspective proportions, while spasmodic filaments have short angle proportions. Ceaseless fiber composites typically have a favored introduction, while irregular strands by and large have an arbitrary introduction.

2. SHAPE MEMORY ALLOYS

Shape Memory Alloys

The shape memory result as the consequence of a manensitic change has been recognized following the mid 1950's, the point at which the impact was uncovered in copper base amalgams. In the close to the starting sixties scientists at the Naval Ordnance Laboratory found the shape memory impact in Ni-Ti composites (Nitinol-Ni-Ti Naval Ordnance Lab). Today, these amalgams are the most comprehensively utilized shape memory and super versatile composites, join the most proclaimed shape memory impact and super flexibility, consumption resistance and biocompatibility, and unrivaled designing properties. Copper based amalgams like Cu-Zn-Al and Cu-Al-Ni are financially accessible as well. These composites are not so much steady but

rather more weak than Ni•Ti and afterward. Albeit less costly have discovered just constrained acknowledgment. As of late, iron based shape memory combinations have been broadly promoted. In any case, with their constrained shape memory strain absence of pliability and other crucial properties, these composites will need to substantiate themselves as feasible designing materials.

3. Limited ELEMENT ANALYSIS

3.1 INTRODUCTION

It is a numerical system for investigating structures and continua. Generally the issue tended to is too confounded to be in any way explained attractively by traditional systematic strategies. The Finite Element technique produces numerous concurrent mathematical comparisons, which are created and comprehended on a computerized PC. The Finite Element Method began as a strategy for anxiety investigation. Today Finite Element Methods are likewise used to break down issues of warmth exchange, liquid stream, grease, electric and attractive fields. Limited elcment methodology are utilized as a part of configuration of structures, electric engines, heat motors, ships, air casings and shuttles.

The Finite Element Method, when all is said in done, models a structure as an array of little components. Every component is of straightforward geometry and in this way is much less demanding to dissect than the real structure.

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Numerous FEA programs likewise are prepared with the ability to utilize various materials inside the structure, for example,

Isotropic, indistinguishable all through

Orthotropic, indistinguishable at 90 degrees

General anisotropic, diverse all through

3.2 CONVERGENCE REQUIREMENTS:

In practice, mesh grading is frequently necessary and the isoparametric elements show particular flexibility in achieving compatible graded meshes.

Compatibility is satisfied if the elements have the same nodes on the common face and the coordinates and displacements on the common face are in each element defined by the same interpolation functions.

The particular problem is repeatedly analyzed, each time using a finer mesh of elements, to generate a sequence of approximate solutions. Then the required mesh is chosen whose sequence of solution converges with that of theoretical exact solution.

3.3 BASIC CONCEPT OF FEM:

In this method of analysis

1. A complex region defining a continuum is discretized into simpler or smaller geometric shapes called finite elements.
2. Simple functions known as shape functions are chosen to approximate of variations actual displacements within each element in terms of the displacement at the nodes of the element.
3. The stresses and strains within an element are also expressed in terms of the nodal displacements.
4. Then the principle of virtual displacement or minimum potential energy is used to derive the equations of equilibrium for the element and the nodal displacements will be the unknown in the equation.
5. The equation of equilibrium for the entire structure or body are then obtained by combining the equilibrium equation of each element such that the continuity of displacement is ensure at each node where the elements are connected.
6. The necessary boundary conditions are imposed and the equations of equilibrium are solved for nodal displacements, which are the primary unknowns.

4. ANSYS

4.1 INTRODUCTION:

ANSYS is a general-purpose predetermined Element computer program for the solution of structural and heat transfer engineering analyses. ANSYS solution capability include: Static analysis, elastic, plastic, thermal stress, stress stiffened, large deflections, bilinear elements; dynamic analysis, modal (natural frequencies and mode shapes), harmonic response, linear time history, nonlinear time history; heat transfer analysis, conduction convection, radiation, coupled to fluid flow, coupled to electric flow; sub structures. Analyses can be made in one, two or three dimensions, including axisymmetric and harmonic element options. ANSYS also contains a complete graphics package and extensive pre and post processing capabilities.

In general, a finite element solution may be broken into the following three stages. This is a general guideline that can be used for setting up any finite element analysis.

PREPROCESSOR:

The pre-processor stage in general FE packages involves the following:

- **SPECIFYING THE TITLE:**

This is giving name for the problem. This is optional but very useful, especially if a number of design iterations are to be completed on the same base model.

- **SETTING THE TYPE OF ANALYSIS:**

To simulate the conditions properly, correct type of analysis method /solver /tool need to be used, e .g., structural, fluid, thermal or electromagnetic, etc ., (this can Sometimes done by selecting a particular element type).

- **CREATING THE MODEL:**

Modal is drawn in 1D, 2D, 3D space in the appropriate units (M, mm, in, etc.,). The modal may be created in the pre-processor, or it can be imported from another CAD drafting package via a neutral file format. (IGES, STEP, ACIS, Para solid, DXF, etc).

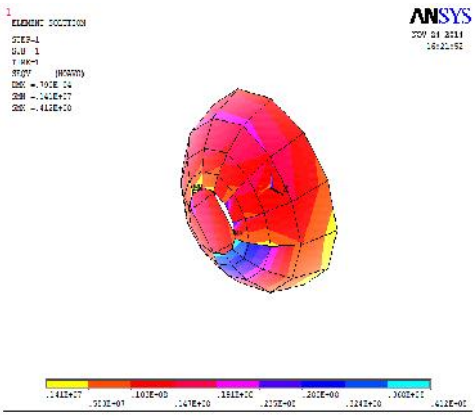
- **DEFINING THE ELEMENT TYPE:**

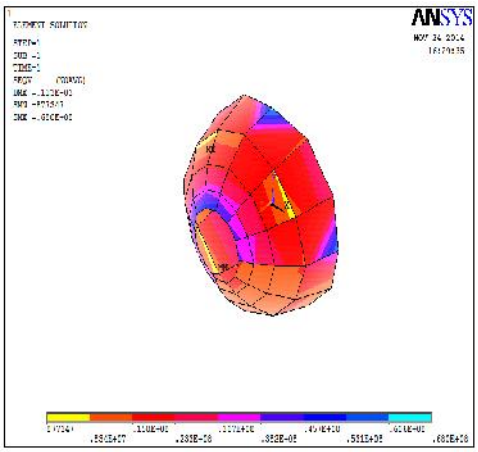
This may be 1D, 2D, 3D and specific to the analysis type being carried out. (Thermal elements should be known to do thermal analyses).

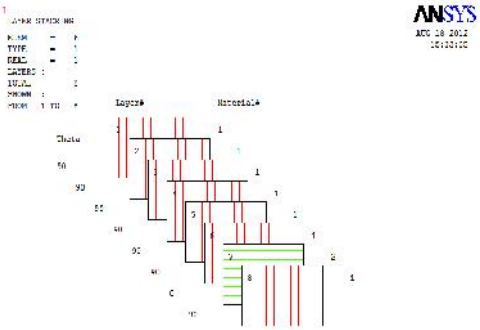
- **MESH GENERATION:**

Mesh generation is the process of dividing the analysis continuum into number of discrete parts of finite elements. The finer the mesh, the better the result, but the longer the analysis time. Therefore, a compromise between accuracy and solution speed is usually made. The mesh may be created manually or generated automatically.

4.2 ANSYS MODEL DIAGRAMS







5. RESULTS AND DISCUSSIONS

STATIC RESULTS:

LAYER LOCATION:

The SMA when fixed in location the value of maximum stress was found to be 0.21040E+08 in container of bolted condition and 0.1 1094E+08 in container of fixed condition. Similarly different values where observed with different fixation of SMA layers but the maximum stress was found in 7th layer with the maximum value of 0.2671 IE+08 in container of bolted condition and 0.19709E+08 in container of fixed condition. So, maximum stress was observed in container of 7th layer in both the boundary conditions.

DEGREE OF ORIENTATION:

The SMA layer being fixed and different orientations of CE were observed from 0 to 90 degrees then it was observed that at angle of 90 degrees we obtain a value of 0.21241E+08 which is the minimum value in container of bolted condition and 0.10635E+08 in container of fixed condition. So,

minimum stress was observed at 90 degrees in both the boundary conditions.

T/D RATIO:

As T/D ratio increases the stress values were found to be decreased. When TID ratio is 0.01 the stress value was observed to be 0.99499E+08 in case of bolted condition and 0.4972E+08 in case of fixed condition, but as T/D ratio increased to a value of 0.08 it was found that stresses decreased and reach a value of 0.8759E+07 in case of bolted condition and 0.86672E+08 in case of fixed condition.

MODAL RESULTS:

LAYER LOCATION:

The SMA when placed in layer theist mode of frequency was observed to be 106.42 and 10th mode of frequency was 296.02, but the layer location changes the modes of frequencies increased to a value of 117.68 in case of 1st mode 323.08 in case of 10th mode in bolted condition. Similarly in fixed the value of 1 and 10th modes increased from 203.68, 576.56 to 208.08 and 555.12.

DEGREE OF ORIENTATION:

The SMA being fixed in the 7th layer and different orientations of CE from 0 to 90 degrees it was found that maximum values were found at 90 degrees with a value of 363.04 in case of bolted and 599.31 in case of fixed boundary conditions.

TID RATIO:

An increase in T/D ratio increases the frequency values for different modes. When T/D ratio is at 0.01 the value of 1st mode was 32.546 and 10th mode was 122.94 in case of bolted condition and 76.325, 230.88 for the 1st and 10th modes in case of fixed condition. As the TID ratios increased to 0.08 the values of and 10th modes in case of bolted condition increased to 280.88, 701.96 and in case of fixed condition the values of 1st and 10th modes increased to 566.15 and 1133.

STATIC RESULTS OF STRESSES (VONMISES) IN BOLTED CONDITION:
LAYER LOCATION:

LAYERS	MINIMUM VALUE	MAXIMUM VALUE
8CARB	7.80E+0	2.10E+07
1ST	6.72E+0	2.32E+07
2nd	6.89E+0	2.26E+07
3rd SMA	6.99E+0	2.26E+07
4th SMA	7.04E+0	2.30E+07
5th SMA	7.07E+0	2.39E+07
6th SMA	7.07E+0	2.51E+07
7th SMA	7.03E+0	2.67E+07
8th SMA	5.83E+0	2.61E+07

DEGREES OF ORIENTATION:

DEGREES	MINIMUM VALUE	MAXIMUM VALUE
10	5.44E+06	2.62E+07
20	4.81E+06	2.31E+07
30	4.79E+06	2.74E+07
40	4.14E+11	3.24E+07
50	5.38E+06	3.28E+07
60	7.30E+06	2.93E+07
70	7.69E+06	2.44E+07
80	5.80E+06	2.18E+07
90	7.67E+06	2.12E+12

INCREASE IN T/D RATIO:

T/D RATIO	MINIMUM VALUE	MAXIMUM VALUE
0.01	1.69E+07	9.95E+07
0.02	9.87E+06	4.28E+07
0.03	7.00E+06	2.66E+07
0.04	5.53E+06	1.88E+07
0.05	4.66E+06	1.43E+07
0.06	4.08E+06	1.14E+07
0.07	3.66E+06	9.85E+06
0.08	3.34E+06	8.76E+06

MODAL RESULTS OF NATURAL FREQUENCY IN BOLTED CONDITION: LAYER LOCATION:

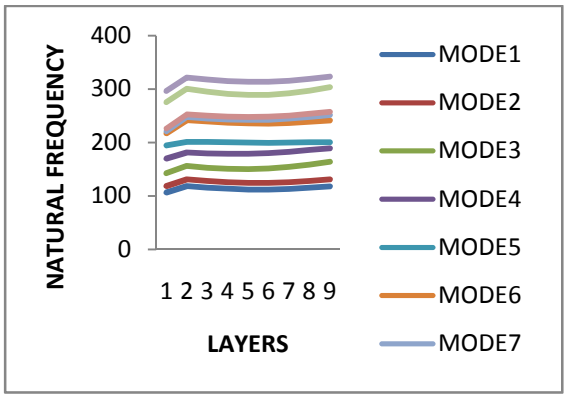
LAYERS	MODE1	MODE2	MODE3	MODE4	MODE5	MODE6	MODE7	MODE8	MODE9	MODE10
8CARBON EPOXY	106.42	118.26	142.52	170.01	194.14	216.96	220.71	226.14	275.05	296.02
1ST SMA	118.32	130.92	155.8	180.96	201	241.46	247.46	252.57	300.45	321.37
2nd SMA	115.54	128.08	152.62	179.67	200.96	239	245.01	250.35	294.71	317.6
3rd SMA	113.29	125.79	150.55	178.67	200.21	236.73	243.09	248.62	290.67	314.8
4th SMA	111.98	124.5	150	178.63	199.54	235.33	242.18	247.87	288.73	313.4
5th SMA	111.87	124.48	151.21	179.92	199.38	235.14	242.61	248.47	289.08	313.64
6th SMA	112.98	125.73	154.16	182.47	199.79	236.18	244.45	250.48	291.75	315.54
7th SMA	115.05	127.96	158.51	185.73	200.44	238.19	247.5	253.62	296.59	318.84
8th SMA	117.68	130.71	163.7	188.87	200.68	240.66	251.33	257.44	303.24	323.08

DEGREES OF ORIENTATION:

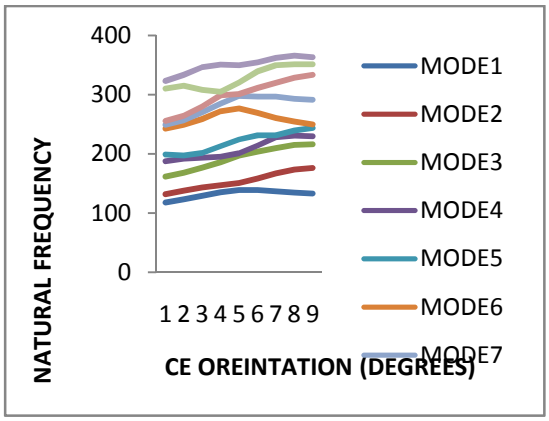
DEGREES	MODE1	MODE2	MODE3	MODE4	MODE5	MODE6	MODE7	MODE8	MODE9	MODE10
10	117.91	131.75	161.67	187.59	199.06	242.5	249.12	255.81	309.97	323.06
20	123.49	137.75	168.38	191.87	197.29	248.89	256.49	264.69	314.72	333.21
30	129.4	143.09	177.06	193.83	201.66	258.81	270.06	280.24	307.71	346.53
40	135.1	146.82	186.22	195.07	212.87	271.73	284.64	298.77	304.53	350.92
50	138.83	150.83	196.91	201.34	224.3	276.39	297.87	300.86	320.56	349.95
60	138.72	158.49	203.77	213.96	231.31	268.94	297.05	311.23	339.58	354.68

70	136.87	167.1	210.02	228.46	231.32	260.25	296.73	319.93	349.69	362.41
80	134.32	173.65	215.36	231	239.53	254.36	293.19	328.56	351.13	365.98
90	132.78	176.18	216.34	230.18	243.71	249.52	291.59	333.32	351.33	363.04

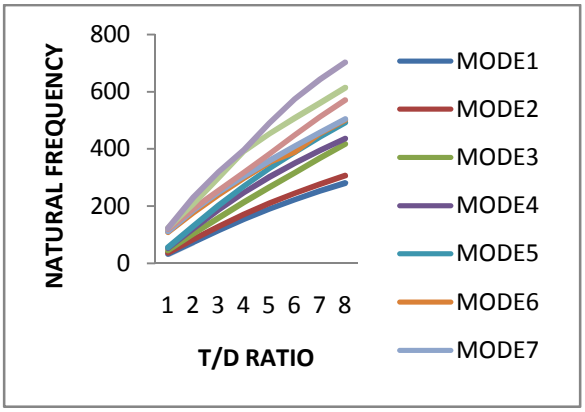
GRAPHICAL REPRESENTATION OF MODAL RESULTS IN BOLTED CONDITION:



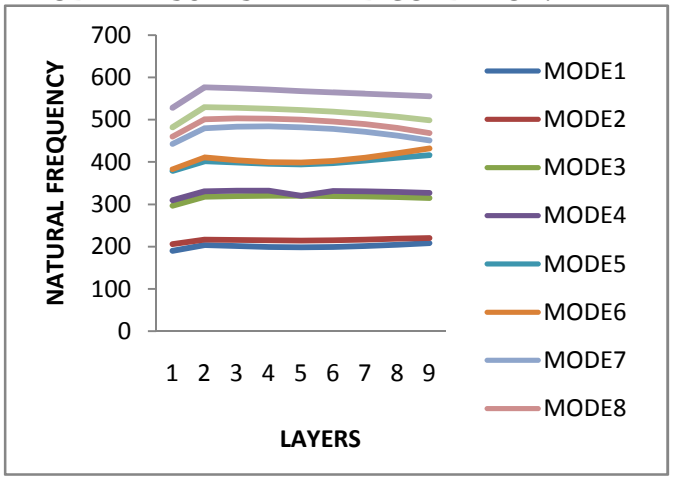
LAYERS VS NATURAL FREQUENCY



CE ORIENTATION VS NATURAL FREQUENCY

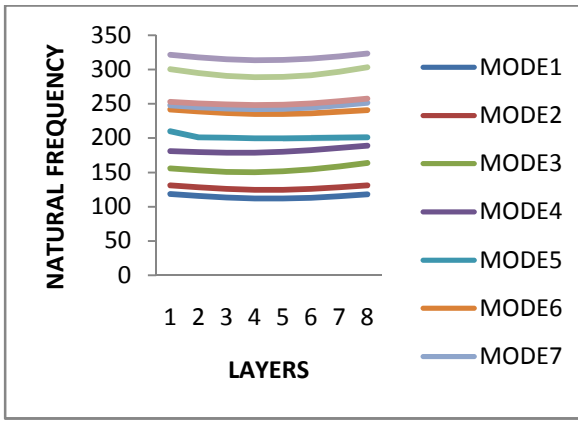


GRAPHICAL REPRESENTATION OF MODAL RESULTS IN FIXED CONDITION:



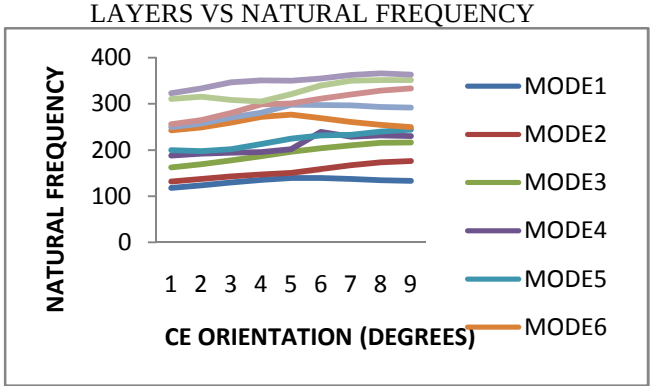
LAYERS VS NATURAL FREQUENCY

GRAPHICAL REPRESENTATION OF MODAL RESULTS IN BOLTED CONDITION: (AT P=147.15E4 NIM2)



T/D RATIO VS NATURAL FREQUENCY

LAYERS VS NATURAL FREQUENCY



CE ORIENTATION VS NATURAL FREQUENCY

CONCLUSION

FEA consists of a computer representation of a material or design that is stressed and analyze for specific results. It is use in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the clients specifications prior to manufacturing or construction. modify an accessible product or structure is utilize to qualify the produce or structure for a new service condition. In container of structural failure, FEA may be use to help determine the design modification to meet the new provision. FEA use a complex system of points called nodes, which make a grid call a mesh. This mesh is automatic to contain the material and structural properties, which define how the structure will react to certain loading conditions. Nodes are assign at a certain density all through the material depending on the anticipated stress levels of a particular area. region, which will receive large amount of stress usually, have a higher node density than those, which experience little or no stress. Points of interest may consist of fracture point of previously tested material, fillets, corners, complex detail, and high stress areas. The mesh act like a spider web in that from each node, there extend a mesh element to each of the nearby nodes. This web of vectors is what carries the material properties to the object, creating many elements

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