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On The Evaluation of Best Fit Hyper-Elastic Model for Sandwich Beam with SB Rubber Core.

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Abstract— The response of the system to the subjected to disturbing loads and vibrations can be controlled in many ways depending on weather active or passive vibration control. If the structure happens to be stiff enough then it would compensate for all vibration levels as its fundamental frequency is generally considered high. In the present scenario structures tend to be as light as, can be achieved at the expense of necessary lowering of stiffness even more than the mass is reduced, so that resonance frequencies often emerge where excitation frequencies are high. Layered composite beams that contain a damping core has been widely used in automotive and aerospace and even house hold electronic equipment to reduce the vibration effect. Analytical and numerical calculations on sandwich beams are cumber some. Therefore FEA software is widely used to solve the problems. An attempt is made to model three layered sandwiched beam with a rubber core exhibiting hyperelastic behaviour for which static and dynamic characteristics were found out,through which the most effective mathematical model is evolved at.

Index Terms— Hyper elasticity, strain rate, modeshapes, non linearity, composites, static, transient, Mooney 3parameter, Ogden 1st order, Polynomial 2nd order, Arruda Boyce.

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1 Introduction

THE Vibrations in a dynamic system can be controlled and reduced by a number of means. They are classified as active means, passive and semi active means. In the active means of vibration control, a wide variety of elements such as speakers, actuators and microprocessors are used to produce an out of Phase signal to cancel the disturbance. In passive methods of control some absorbers, mufflers and silencers are used to reduce the vibrations. In some cases by altering the system stiffness or mass, the resonant frequencies can be altered and thereby the unwanted vibrations can be reduced for a fixed excitation frequency.

However the vibrations need to be isolated or dissipated by using isolators or damping materials In semi active methods of controlling vibrations, a combination of active methods with passive elements is used to enhance their damping properties. Examples are electro-rheological damping, magneto-rheological systems and Active constrained layer damping (ACLD). Damping can be applied to any system by using special class of visco - elastic and Hyper elastic material as a part of Passive Vibration control in most of the machines of present day. Damping refers to the extraction or dissipation of mechanical energy from a vibrating system generally by converting into heat. Damping in general is of two types first being material damping and second being structural damping. Material damping involves the inherent property of the materials to dampen out the vibrations and Structural damping involves the damping of vibrations at various locations like base , joints etc.. Rubber is extensively used in damping the vibration of sandwiched beams and structure as a core material.The behav iour of the rubber is classified and Hyper elastic and Visco elastic. Elastomers , more precisely Rubber like materials usually have long molecular chains, which can with stand high strains and does not undergo permanent resilience and durability.These materials generally have a complicated behavior that generally exceed linear elastic theory and contain large deformations, plastic and visco –elastic properties There are three distinct categories of the stress-strain behaviour of elastomers which make engineering design with these material so challenging.they are: 1) cyclic property changes,2)large deformation response low-modulus response to applied loads or deformation.3)non-linearity of the stress-Strain curve.

Typical charecteristics of Rubber under loading include :

1). Low Elastic Modulus, High elongation at break and non-linearity.

2).Hysterisis (this behaviour could not be easily represented with conventional methods)

3).Stress relaxation

4).Creep

5). Mullins effect (large drop of stress between the successive loadings).

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2 Material model or constitutive equations

In FEA , the elastomers like rubber are generally modeled as hyper elastic . Hyper elastic prescribes a mathematical condition. To be hyper elastic, there must Exist a strain energy function.. This has two properties:

1).It is a scalar function of one of the strain or deformation tensor

2).Its derivative w.r.t. strain component determines the corresponding stress component.

The constitive equations corresponding to the material behavior will generally conform to

Stress .vs. Extension for smaller strains and Strain energy density .vs. strain invariants for higher strains.

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The simpler constitutive equations include ;

Neo - Hookean and 2-constant Mooney - Rivlin equations.

A simpler Mooney-Rivlin case include :

$\sigma = 2(\lambda - \lambda\text{-}2)(C10 + C01/\lambda)$.. Where σ is the uni-axial tensile stress and λ is the extension ratio and C words are constants.

as an example C10 = -38.3 kpa and C01= 640.5kpa.

Higher order formulations include : Arruda- Boyce , Ogden etc

2.1 Feature on behaviour of solid rubber.

The material is close to ideally elastic, i.e. When deformed at constant temperture, stress is a function only of strain and independent of history or rate of loading. The behaviour is reversible. material strongly resists volume changes the material is very compliant in shear - shear modulus is of order 10-5 times the most of metals.

The shear modulus is temperature dependent. the material becomes stiffer when heated. When stretched the material gives off heat.

3 SCOPE OF THE PRESENT WORK

The present work is aimed at understanding the hyper elastic behaviour of rubber and studying the behaviour of rubber when used as sandwiched materials in forming a constrained layer damping. Further investigating the general behaviour of the sandwiched beam for which the behaviour of the core material is considered to be hyper elastic.

4 Finite Element Modeling

In the present work a sandwiched beam of 2.5 mm thick is considered in which there are two metal layers and in-between a layer of rubber is provided to compensate for the constrained layer damping . Initially the behaviour of rubber is considered as Hyper elastic and the best fit model to model the Hyper elastic behaviour is evolved. The same model is applied to study the behaviour of the sandwiched beam when subjected to the variation in the core layer thickness under constant load.

5 Results And Discussions

The beams with various boundary conditions are modelled and their deflections are studied .The effect of the thickness of the core material is also taken into consideration and incorporated in the work.

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TABLE 1

STATIC ANALYSIS CORE 2CM THICKNESS

NO DES	DEFLECTION AT NODES of Mooney	DEFLECTION AT NODES of Ogden	DEFLECTION AT NODES of Polynomial	DEFLECTION AT NODES of Arruda-Boyce
1	0.00719491	0.00719591	0.00718911	0.00720967
2	0.0044406	0.0044406	0.00443943	0.00444366
3	0.0209657	0.020967	0.02095	0.0210055
4	0.0139222	0.0139227	0.0139162	0.0139343
5	0.0262155	0.0262172	0.02621963	0.0262643
6	0.0262229	0.0262246	0.0262037	0.0262718
7	0.0262155	0.02662172	0.0261963	0.0262643
8	0.0155822	0.0155821	0.0155853	0.0155915
9	0.0130154	0.0130153	0.0130161	0.013016

static analysis of sandwich beam with core element thickness 2cm and other two layers are of 0.25cm each.

TABLE 2

STATIC ANALYSIS CORE 1.5CM THICKNESS

NO DES	DEFLEC-FLEC-TION AT NODES of Mooney	DEFLECTION AT NODES of Ogden	DEFLECTION AT NODES of Polynomial	DEFLECTION AT NODES of Arruda-Boyce
1	0.00719491	0.00719591	0.00718911	0.00720967
2	0.0044406	0.0044406	0.00443943	0.00444366
3	0.0209657	0.020967	0.02095	0.0210055
4	0.0139222	0.0139227	0.0139162	0.0139343
5	0.0262155	0.0262172	0.02621963	0.0262643
6	0.0262229	0.0262246	0.0262037	0.0262718
7	0.0262155	0.02662172	0.0261963	0.0262643
8	0.0155822	0.0155821	0.0155853	0.0155915

static analysis of sandwich beam with core element thickness 1.5cm and other two layers are of 0.5cm each.

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TABLE 3
STATIC ANALYSIS CORE SIZE 1

NODES	DEFLEC-TION AT NODES of Mooney	DEFLECTION AT NODES of Ogden	DEFLECTION AT NODES of Polynomial	DEFLECTION AT NODES of Arruda-Boyce
1	0.00125187	0.00125187	0.00125187	0.00125187
2	0.00947737	0.00947737	0.00947737	0.00947737
3	0.00189098	0.00189098	0.00189098	0.00189098
4	0.00188996	0.00188996	0.00188996	0.00188996
5	0.00222266	0.00222266	0.002222658	0.00222266
6	0.0022265	0.0022265	0.0022265	0.0022265
7	0.0022256	0.0022256	0.0022256	0.0022256
8	0.0016527	0.0016527	0.0016527	0.0016527

static analysis of sandwich beam with core element thickness 1cm and other two layers are of 0.75cm each.

TABLE 4
STATIC ANALYSIS CORE 0.5CM THICKNESS

NODES	DEFLEC-TION AT NODES of Mooney	DEFLECTION AT NODES of Ogden	DEFLECTION AT NODES of Polynomial	DEFLECTION AT NODES of Arruda-Boyce
1	0.00057212	0.00057215	0.000572153	0.00057215
2	0.00057569	0.00057569	0.000575687	0.00057569
3	0.00057791	0.00057791	0.00057791	0.00057791
4	0.00132067	0.00132037	0.00132037	0.0013337
5	0.00133115	0.0013316	0.0013316	0.00133396
6	0.0013389	0.00133902	0.00133902	0.00134138
7	0.00134251	0.00134252	0.00134252	0.00134252
8	5.95E-05	5.95E-05	5.95E-05	5.71E-05

static analysis of sandwich beam with core element thickness 0.5cm and other two layers are of 1cm each.

TABLE 5
STATIC ANALYSIS CORE SIZE 0.25

NODES	DEFLEC-TION AT NODES of Mooney	DEFLECTION AT NODES of Ogden	DEFLECTION AT NODES of Polynomial	DEFLECTION AT NODES of Arruda-Boyce
1	0.00029353	0.00029359	0.000293591	0.00029354
2	0.00029266	0.00029416	0.000293419	0.00029599
3	0.00028822	0.00029056	0.000293319	0.00029587
4	0.00085758	0.00085106	0.000849135	0.00085579
5	0.00085626	0.00085693	0.000854473	0.00085611
6	0.00084486	0.00085636	0.0008449	0.0008611
7	0.00036644	0.00036897	0.000368969	0.0003671
8	0.00063726	0.00064557	0.000645573	0.00064745

static analysis of sandwich beam with core element thickness 0.25cm and other two layers are of 1.125cm each.

TABLE 6
TRANSIENT ANALYSIS CORE SIZE 2

NODES	DEFLEC-TION AT NODES of Mooney	DEFLECTION AT NODES of Ogden	DEFLECTION AT NODES of Polynomial	DEFLECTION AT NODES of Arruda-Boyce
1	2.50E-11	2.50E-11	2.52E-11	2.45E-11
2	1.34E-10	1.34E-10	1.34E-10	1.35E-10
3	6.00E-11	5.99E-11	6.06E-11	5.85E-11
4	3.20E-11	3.19E-11	3.27E-11	3.20E-11
5	5.18E-11	5.18E-11	5.26E-11	5.00E-11
6	3.20E-11	3.19E-11	3.27E-11	3.02E-11
7	5.82E-10	5.82E-10	5.81E-10	5.83E-10
8	6.75E-10	6.75E-10	6.75E-10	6.77E-10

Transient analysis of sandwich beam with core element thickness 2cm and other two layers are of 0.25cm each.

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TABLE 7
TRANSIENT ANALYSIS OF CORE 0.25CM THICKNESS

NODES	DEFLECTION AT NODES of Mooney	DEFLECTION AT NODES of Ogden	DEFLECTION AT NODES of Polynomial	DEFLECTION AT NODES of Arruda-Boyce
1	1.22E-11	1.22E-11	1.19E-11	1.22E-11
2	1.23E-11	1.23E-11	1.1928 E-011	1.23E-11
3	1.21E-11	1.21E-11	1.18E-11	1.21E-11
4	2.82E-11	3.13E-11	3.11E-11	3.19E-11
5	2.88E-11	2.88E-11	2.80E-11	2.88E-11
6	3.14E-11	3.14E-11	3.06E-11	3.14E-11
7	1.30E-11	1.30E-11	1.28E-11	1.30E-11
8	2.35E-11	2.35E-11	2.30E-11	2.35E-11

static analysis of sandwich beam with core element thickness 0.5cm and other two layers are of 1cm each.

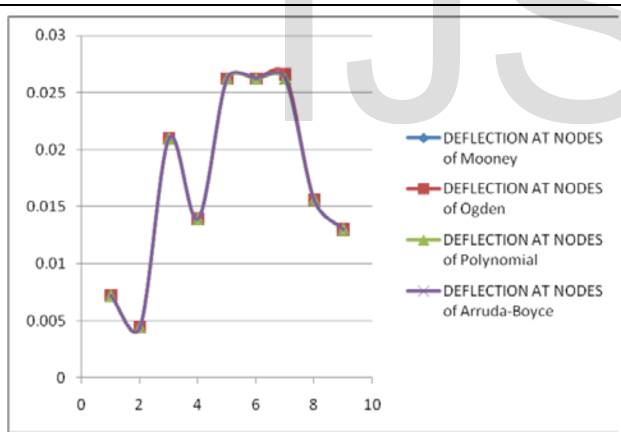

Fig. 1. Represent deflection curves with respect to node numbers.x-axis represents node numbers and yaxis represent deflection for constant load 20newtons and with core thickness 2cm core

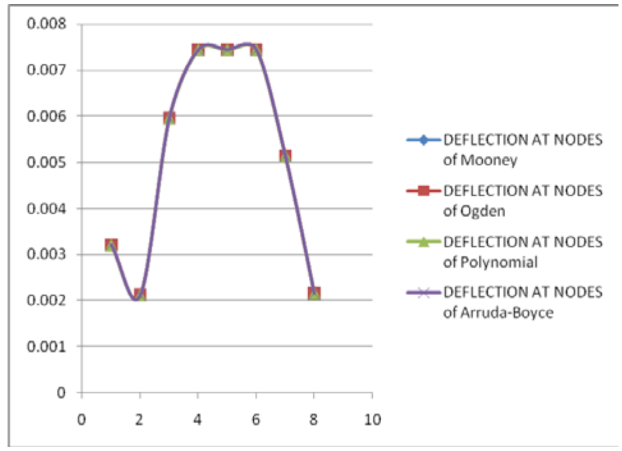

Fig. 2. Represent deflection curves with respect to node numbers.x-axis represents node numbers and yaxis represent deflection for constant load 20newtons and with core thickness 1.5cm core

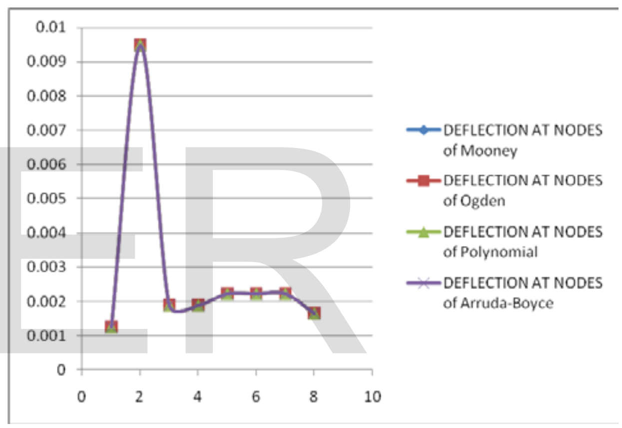

Fig. 3. Represent deflection curves with respect to node numbers.x-axis represents node numbers and yaxis represent deflection for constant load 20newtons and with core thickness 1cm core

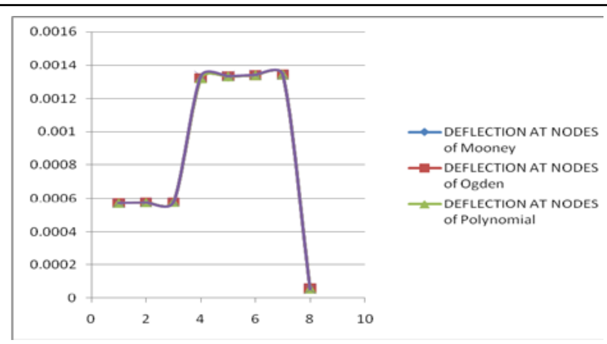

Fig. 4. Represent deflection curves with respect to node numbers.x-axis represents node numbers and yaxis represent deflection for constant load 20newtons and with core thickness 0.5cm core

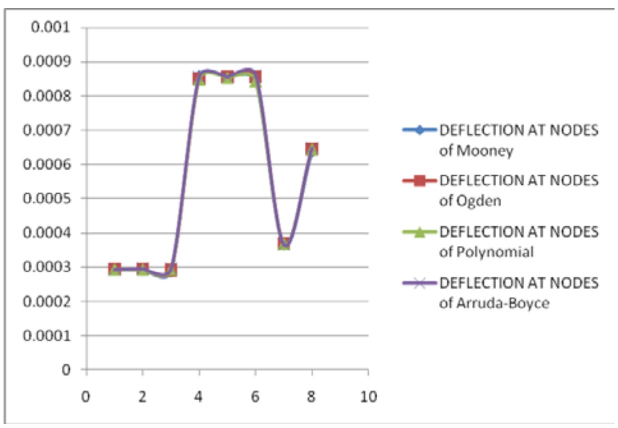

Fig. 5. Represent deflection curves with respect to node numbers.x-axis represents node numbers and yaxis represent deflection for constant load 20newtons and with core thickness 0.25cm core

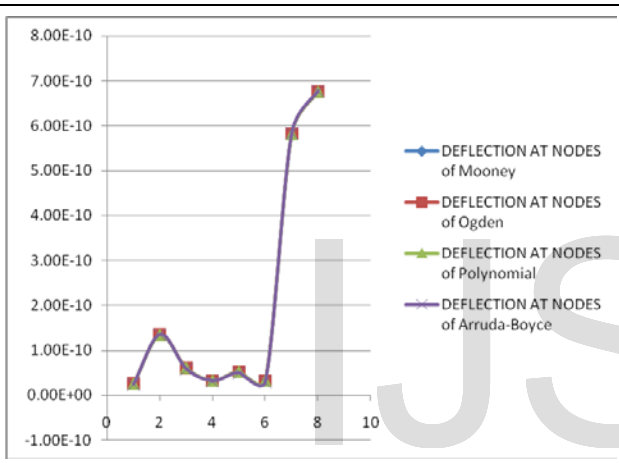

Fig. 6. Represent deflection curves with respect to node numbers.x-axis represents node numbers and yaxis represent deflection for constant load 20newtons and with core thickness 2cm core

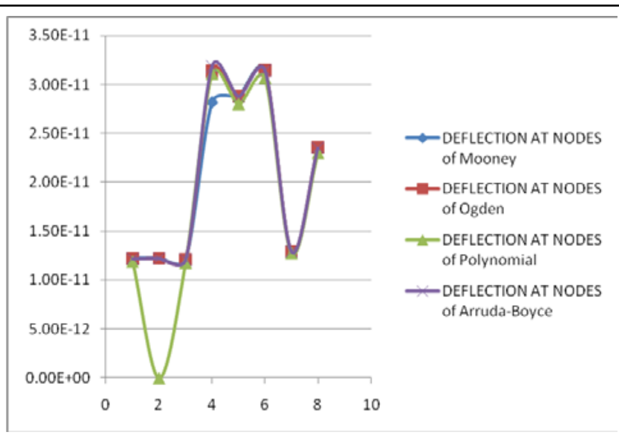

Fig. 7. Represent deflection curves with respect to node numbers.x-axis represents node numbers and yaxis represent deflection for constant load 20newtons and with core thickness 0.25cm core

6 CONCLUSIONS

The present work is aimed at studying the Hyper elastic damping characteristics of a sandwiched beam with Hyper elastic core for varying thickness of the core material..The difference in boundary conditions has a large effect on the static deflection and dynamic response are absorbed. Increase in the core thickness has resulted in decrease in the deflection of the sandwiched beams in static and transient analysis.

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