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Analysis of Performance of FLD and CLD Technique

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Abstract

Vibration is undesirable, wasting energy and creating unwanted sound – noise. Sometimes these vibrations cause minor or serious performance or safety problems in engineered systems. Damping is one potential approach to reducing vibration level, in a structural system. Viscoelastic material among the damping materials is widely used to reduce the structural vibration.

This paper describes theanalysis of performance of free layer damping treatment and constrain layer damping treatment to attenuate vibration response amplitude. Measurements are performed on Oberst beam as per ASTM E 756-05 standard.[1] This detailed experimental program that was undertaken to characterize the damping loss factor of Styrene-Butadiene (SBR) as a composite materials.The FLD and CLD treatments are compared and analyzed in this paper.

Keywords: **:** Free layer damping (FLD); Constrained layer damping (CLD) ; Viscoelastic material (VEM) ; loss factor.

Introduction

Material damping can be defined as any material characteristic that allows for the conversion of mechanical energy into heat. this energy dissipation occurs through thermal diffusion across the specimen of heat created from internal friction. Damping treatment consists of application of viscoelastic material on the surface of the structure. Viscoelastic materials are elastomeric materials whose long-chain molecules cause them to convert mechanical energy into heat when they are deformed. In practice FLD and CLD, two types of damping treatment are used to reduce structural vibration.[2]

Types of damping

a) Free -layer Damping
b) Constrained layered Damping

a) Free -layer Damping: Damping material is applied to a surface via spray, roller or brush of which damping is to be achieved. This method is very useful for relatively thin structures. In these cases the applied Damping Material is often thicker than the structure itself.

b) Constrained Layered Damping: Constrained-layer damping is a mechanical engineering technique for suppression of vibration. Typically a viscoelastic or other damping material is sandwiched between two sheets of stiff materials that lack sufficient damping by themselves. In the constrained layer damping technique the damping Material is bonded to the structure similar to the free layer damping technique then an another constraining layer having very high stiffness is constrained over the damping material Utmost care should be taken while selecting the adhesive material; the adhesive material should have sufficient stiffness.

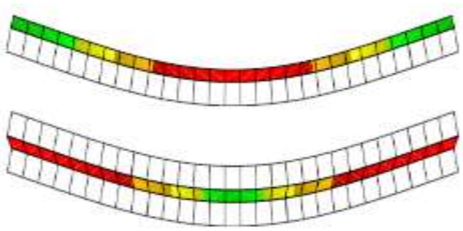

Fig.1a) Free layer & Constrained layer damping

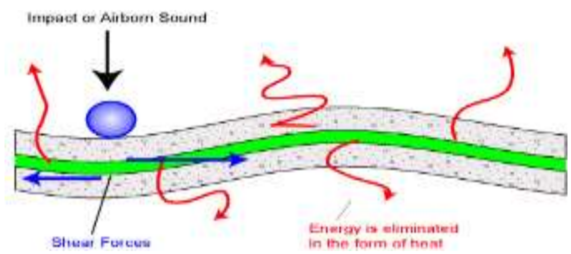

Fig.1b) Energy dissipation in Constrained layer damping.

Specimen preparation

The materialsStyrene-Butadiene (SBR) are tested as part of this effort, the material was obtained from well known rubber manufacturer and the properties are tested in recognised laboratory.

The specimen is prepared by standard process ASTM standard E-756(05). It consists of two layers of aluminum and the viscoelastic material in the core composed of a 3M High-Strength Acrylic double-face Adhesive. [1]

Experimental apparatus

For vibration damping testing, there are two primary considerations when designing fixturing for testing materials. First, it is necessary that the specimen be isolated from its surroundings. No vibrational energy from external sources should be allowed to influence the vibrational response of the specimen being tested. Accomplishment of this likewise infers that the vibrational energy imparted to the specimen will not be dissipated by the fixturing as the result of an energy transfer from the specimen. Secondly, care must be taken to minimize all other possible sources of energy dissipation so that the measured damping is the material inherent damping loss factor.[2]

To isolate the specimen from the surroundings, the specimen fixturing was attached to the load frame. This machine consists of a solid steel top attachmentplate to which the components for fatigue testing are attached.The damping test fixture that was designed and fabricated forthis program and used in subsequent testing of the compositematerials this consists of a steel base plate,which is welded tothe vertical plate. The vertical plate is attached with 35mm thick plate and other 35mm thick plate is bolted to base plate in which the test plate inserted for testing.

Experimental procedure

The size of beam under investigation is 400 mm in length and 50 mm in width. The thickness of base structure, constraining layer is 2 mm and thickness of VEM layer is 1mm.The material of base structure, constraining layer is aluminium .The density of VEM is 1485 Kg/m^3.

Fig. 2. Test Rig for Modal Analysis

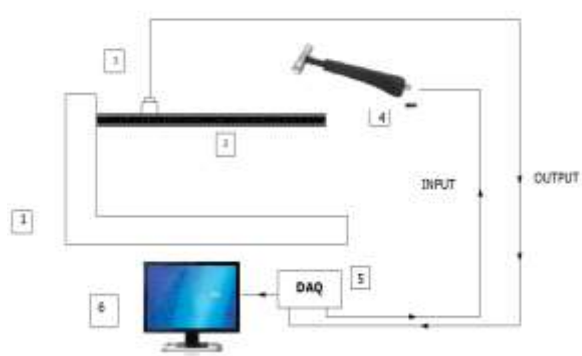

Fig. 3. Experimental Apparatus

1. Clamping test bench	4.Impact Hammer
2. Test Specimen	5.Data acquisition system
3. Accelerometer	6.Display

For experimental analysis, accelerometer model uniaxial type 4515 (B&K) make, Impact Hammer 8206-002 (B&K) make and 4 channel FFT analyzer (B&K Photon +All in one) are used. [3]
Connect the Accelerometer to the DAQ system with the help of the cables.Connect the Impact hammer to the DAQ system with the help of the cables.Connect the DAQ system to the Computer with the help of USB port of the computer.Keep the Accelerometer

on the vibrating surface whose modal parameters are to be estimated. Now, impact the impact hammer on to the plate to produce excitation of the plate.Repeat the procedure at different points on the plate; this is done to increase the accuracy of output.Observe, the patterns generated by the software in the computer.Generate a numerical report of the same to compare it with the finite element software.

The results of beam Frequency Response Function are shown in RT Pro software [8]. By analyzing the resonant peak for a particular mode, the loss factor, a measure of damping, is obtained from the response spectrum. These curves shown in Fig.6 are presented using Matlab software. [4]

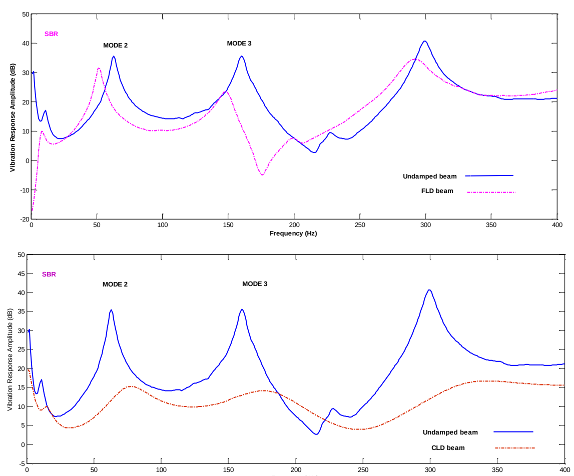

Fig.4. Comparison of frequency response curves (FRF) of FLD and CLD beam

Finite element analysis

Modelling of sandwich structures requires that the strain energy due to shearing of the core be accurately represented. this be done with minimum increase in computation cost relative to a uniform, single-layer model. In this section, a modelling method is described that is reasonably efficient and has the important advantage of being readily implemented in MSC/NASTRAN, a widely available code.

Fig. 5 shows the arrangement for modelling of a three layer sandwich. The face sheets are modelled with quadrilateral beam elements producing stiffness at two rotational degrees of freedom per node. The viscoelastic core is modelled with solid elements producing stiffness at three translational degrees of freedom per node. All nodes are at element corners are HEXA and 3D element type 160 in MSC/NASTRAN. In the present analysis, Poisson's ratio of the core elements is taken to be 0.49. [5]

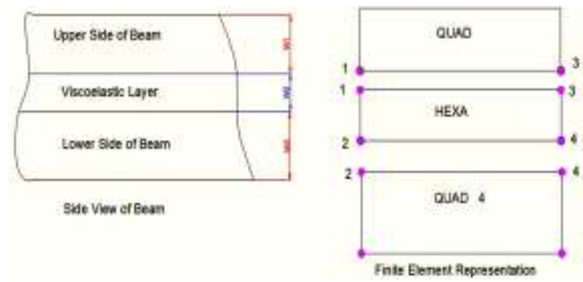

Fig. 5. Finite element representation of beam

Once the model is assembled, either direct frequencyresponse or modal strain energy analysis can be performed. The results are shown in the following figure and the table no.1

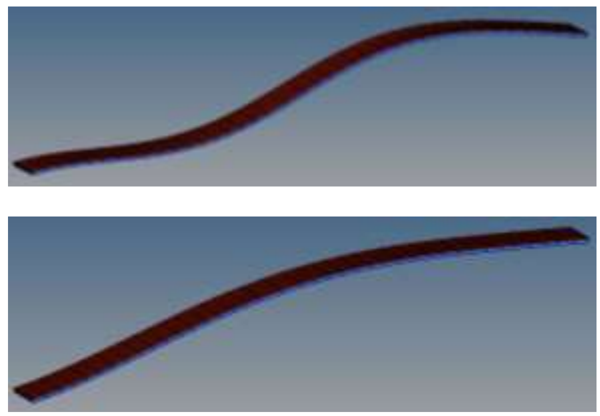

Fig.6. Frequency response of FLD beam at mode 2 and mode 3

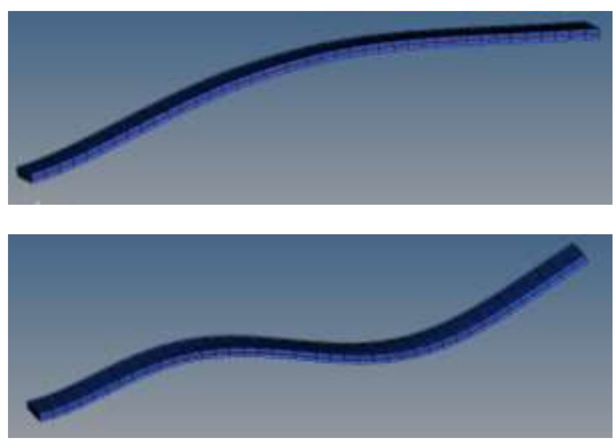

Fig. 7. Frequency response of CLD beam at mode 2 and mode 3

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Results and discussion

The experimental results in terms of the vibration response amplitude and loss factor for FLD and CLD beams corresponding to mode 2 and mode 3 are found by half power bandwidth method using above FRF curve[10].

The results obtained by experimental method are shown in Table 1.

Table 1. Performance of damping

	Types of Beam	Mode2		Mode 3	
		Loss Factor (η)		Loss Factor (η)	
		By FEA	By Experiment	By FEA	By Experiment
1	FLD	0.1056	0.1153	0.0859	0.0608
2	CLD	0.3407	0.3896	0.2869	0.3011

Conclusions

The performance of FLD and CLD treatment on vibration response amplitude is presented. From comparison of result obtained by Experimental investigation and FEA analysis , it is observed that the modal loss factor of CLD beam are found to increase than FLD beam.

Hence for attenuation of structural vibration CLD treatment is more effective as compare to FLD treatment over an operating medium frequency range.

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