Damping Characteristics of Rivetted Beam

Amit Patil
Department of Mechanical Engineering
Vidyavardhini's College of Engineering and Technology
University of Mumbai, Vasai, Maharashtra, India

Deepak Chaudhari
Department of Mechanical Engineering
Vidyavardhini's College of Engineering and Technology
University of Mumbai, Vasai, Maharashtra, India

Abstract

The present investigation highlights the effect of diameter of rivet and number of rivets on the damping of layered cantilever beams jointed with rivets undergoing free vibration. Thesis consists of two different parts: a software analysis of the problem and and experimental work. The logarithmic decrement technique has been used for measuring the damping from the time history curve of the decaying signals recorded on the screen of digital storage oscilloscope. The experimental results are compared with the corresponding result on ANSYS for establishing the authenticity of the theory developed. Finally, useful conclusions have been drawn from both the software and experimental results. This conclusion is very useful for the structure working under vibration so that failure of structure can be avoid.
Keywords: 3D Model of Beam, CRO, Damping Characteristics of Rivetted Beam

I. INTRODUCTION

A. *Overview*

Problems involving vibration occur in many areas of mechanical, civil and aerospace engineering. Engineering structures are generally fabricated using a variety of connections topic of special interest due to their strong influence in the performance of the structure as bolted, riveted, welded and bonded joints etc.. This is because uncontrolled vibration creates dynamic stresses and strains which can cause fatigue failure in structures, fretting corrosion between contacting elements and noise in the environment Also it can impair the function and life of the structures or its components. The knowledge of structural dynamics is very essential to make accurate predictions under a variety of circumstances. The final purpose of the structural design is to control the vibration of structures at a desirable level. In most cases, the vibration level should be kept as low as possible so that the performance and the cost of the structure are not severely affected. In practice, the excitation can only be reduced, but it is almost impossible to eliminate completely. When a structure with low inherent damping is excited at one of its natural frequencies, violent vibration is inevitable. This causes serious problems leading to ultimate failure of the structures.

B. *Objective*

The prime reason for selecting rivets as compared to welding or bolting is that the riveted connections are largely used in structural designs. For example, trusses, aircraft, pressure vessels, robots and many other applications use riveted joints in one form or another. The damping characteristics in jointed and riveted structures are influenced by the intensity of pressure distribution, relative dynamic slip and kinematic coefficient of friction at the interfaces and their correct assessment is very important to understand the mechanism of damping in such structures. All the above vital parameters being largely influenced by the thickness ratio of the beam, this aspect has been critically studied in subsequent chapters. This thesis consists of two parts: ANSYS analysis and experimental work. Both the ANSYS and experimental results will be compared for authentication. Finally, useful conclusions will have been drawn from both the ANSYS and experimental results.

C. *General Assumptions*

Certain assumptions are made in the present analysis while treating joint dynamics.
These include:
1) Each layer of the beam undergoes the same transverse deflection.
2) The initial excitation at the free end of the beam is of small amplitude.
3) There is no gross or macro-slip in the joint.
4) The local mass of the joint area is not considered as significant in altering the behavior of the beam.
5) The circular holes for inserting rivets on the test specimens are completely filled by the rivets.
6) There is no displacement and rotation of the beam at the clamped end.
7) The Coulomb law of friction is used.
8) The material behaves linearly.
9) The deflections are small compared to the beam thickness.
10) 10 The effects of rotary inertia and shear deformation are neglected.

II. DAMPING CHARACTERISTICS

D. Logarithmic Dreecment (δ)

The logarithmic decrement method is the most widely used time-response method to measure damping from the free-decay of the time history curve. When the structure is set into free vibration, the fundamental mode dominates the response since all the higher modes are damped out quickly. The logarithmic decrement represents the rate at which the amplitude of a free damped vibration decreases. It is defined as the natural logarithm of the ratio of any two successive amplitudes. Thus, the logarithmic decrement δ is obtained as;

$$\delta = \ln\frac{x1}{x2} = \frac{2\Pi\xi}{\sqrt{1-\xi 2}}$$

E. Damping Ratio (ξ)

The damping ratio is another way of measuring damping which shows the decay of oscillations in a system after a disturbance. Many systems show oscillatory behavior when they are disturbed from their position of static equilibrium. Frictional losses damp the system and cause the oscillations to gradually decay to zero amplitude. The damping ratio provides a mathematical means of expressing the level of damping in a system. It is defined as the ratio of the damping constant to the critical damping constant. The rate at which the motion decays in free vibration is controlled by the damping ratio ζ, which is a dimensionless measure of damping expressed as a percentage of critical damping. It is observed that the amplitude of vibration decays more rapidly as the value of the damping ratio increases.

III. EXPERIMENTAL ANALYSIS

A. Introduction

In practice, the experimental study of damping becomes necessary as the theoretically computed results of a machine or structure may be different from that of the actual values due to the various assumptions made in the analysis. A number of experiments have been conducted using mild steel beam specimens to find logarithmic decrements and damping ratio undergoing free vibration .After finding Dimension and Parameters of Beam and Rivet,we manufactured it.Whole experiment is to analyze the variation of damping characteristic with change in diameter of rivet and number of rivet use in joining the plates. Experiment consist of 10 beams in which 5 beams have different no of rivet with constant diameter of rivet and remaining 5 beam have different diameter of rivet with same number of rivets.

1) 5 Beams with Different Number of Rivets with Constant Diameter Of Rivet of 10 Mm:

Dimension of plate(length*width*thickness) all in mm	No of rivets
371.25*41.25*4	12
371.25*41.25*4	11
371.25*41.25*4	10
371.25*41.25*4	9
371.25*41.25*4	8

2) 5 Beams with Different Diameter of Rivets with Constant 10 Rivets:

Dimension of plate(length*width*thickness) all in mm	Diameter of rivets in mm
371.25*41.25*4	12
371.25*41.25*4	10
371.25*41.25*4	8
371.25*41.25*4	6
371.25*41.25*4	5

B. Layered Beams with Rivetted Joints

Fig. 1: Beams

C. Schematic Diagram of Experimental Setup

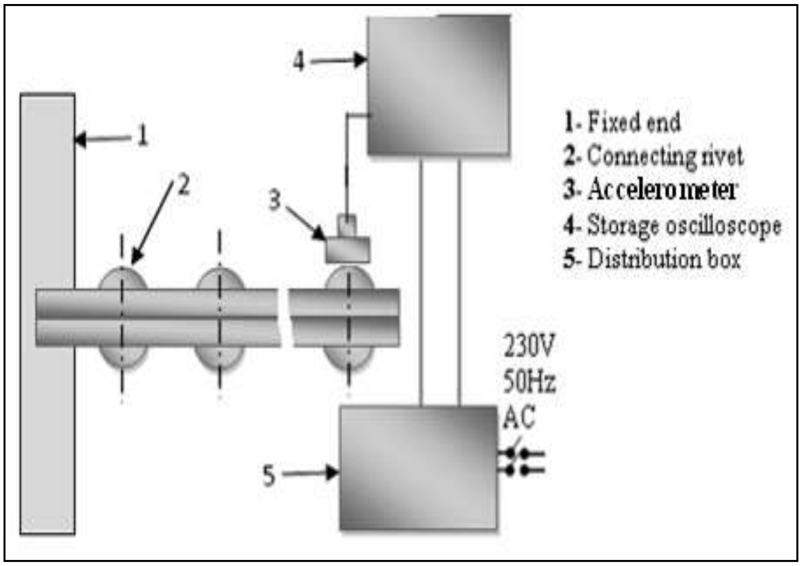

Fig. 2: schematic diagram of experiment setup

D. Description of the Experimental Set-Up

The setup of the experimental analysis includes the following apparatus:

1) Digital storage oscilloscope
2) Accelerometer/Vibration pick-up (contacting type magnetic probe)
3) Clamping device for beam.

The accelerometer is a device that transforms changes in mechanical quantities (such as displacement, velocity or acceleration) into changes in electrical quantities (such as voltage or current).

The digital cathode ray oscilloscope (CRO) is a device used to give time history curve from decaying signal. The signal will be generated from the vibration of the beam and the input is provided by contact-type accelerometer

E. Experimental Procedure

The excitation is imparted for a range of beam-tip amplitude of 1mm. For a particular test specimen, the beam is deflected and released to oscillate at its first mode of free vibration. The beam response is sensed by a contacting-type accelerometer attached to the tip of the beam. One end of the accelerometer is held magnetically to the vibrating surface of the specimen and the other is connected to one of the connectors of the storage oscilloscope. The output from the accelerometer is proportional to the frequency and amplitude of vibration. This output signal is fed to a digital storage oscilloscope for processing and display. The data is then analyzed to determine the logarithmic decrement of the beam structure.

F. Experimental Observation

1) Result of beam having diameter 10 mm but different no of rivetts:

no.	*dimension of plate*	*no of rivett*	*logarithmic decrement*	*damping ratio*
1	*371.25*41.25*4*	*12*	*0.6933*	*0.10967*
2	*371.25*41.25*4*	*11*	*0.6811*	*0.1077*
3	*371.25*41.25*4*	*10*	*0.6534*	*0.1034*
4	*371.25*41.25*4*	*9*	*0.5783*	*0.09165*
5	*371.25*41.25*4*	*8*	*0.5242*	*0.08314*

2) Result of beam having no of rivets 10 but different no diameter of rivet:

no.	*Dimension of plate*	*diameter of rivet in mm*	*logarithmic decrement*	*dampig ratio*
1	*371.25*41.25*4*	*12*	*0.8872*	*0.1398*
2	*371.25*41.25*4*	*10*	*0.6534*	*0.10343*
3	*371.25*41.25*4*	*8*	*0.5623*	*0.0891*
4	*371.25*41.25*4*	*6*	*0.4122*	*0.06546*
5	*371.25*41.25*4*	*5*	*0.3233*	*0.05138*

IV. MODELLING AND ANALYSIS

A. 3D Model of Beam

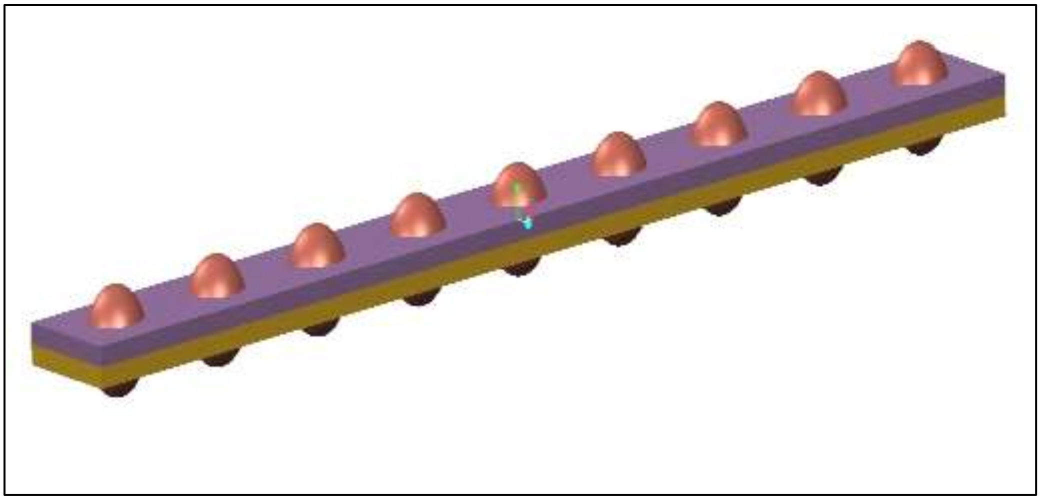

Fig. 3: 3D model of beam

B. Ansys Analysis

The transient analysis of beam is done for 1 second under the deflection of 1 mm. The transient graph obtained from the analysis is as follows:

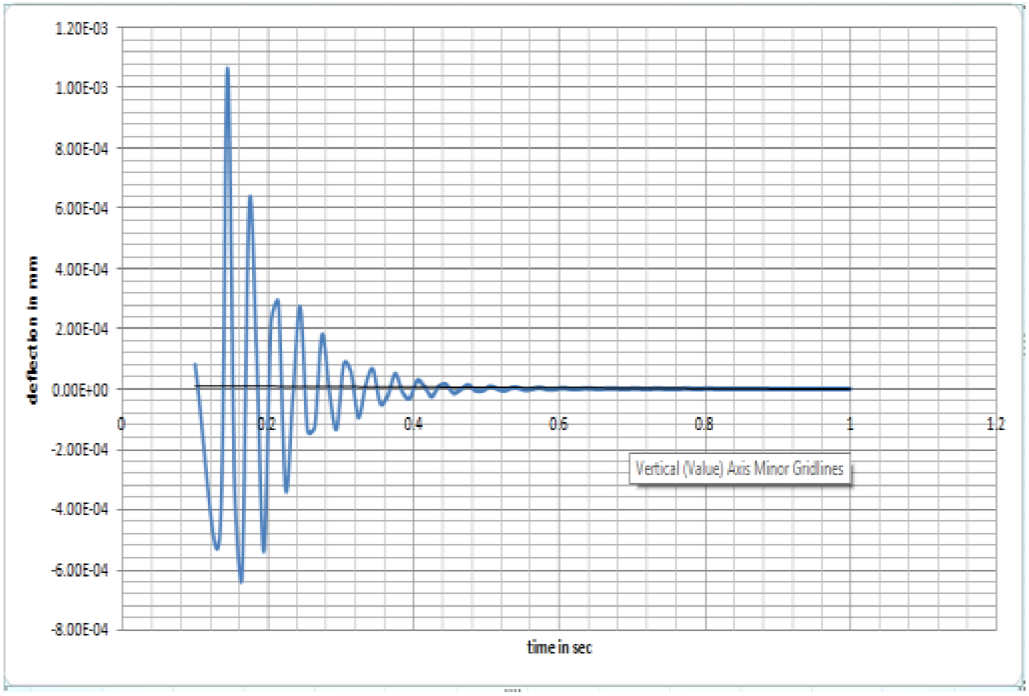

Fig. 4: transient curve

C. Result of Ansys Analysis

1) Result of beam having diameter 10 mm but different no of rivetts:

no.	dimension of plate in mm*mm*mm	no of rivett	logarithmic decrement	damping ratio
1	371.25*41.25*4	12	0.5411	0.08580
2	371.25*41.25*4	11	0.4902	0.077778
3	371.25*41.25*4	10	0.4805	0.076251
4	371.25*41.25*4	9	0.4705	0.07467
5	371.25*41.25*4	8	0.4595	0.07298

2) Result of beam having no of rivets 10 but different no diameter of rivet:

no.	Dimension of plate in mm*mm*mm	diameter of rivet in mm	logarithmic decrement	dampig ratio
1	371.25*41.25*4	12	0.65866	0.10425
2	371.25*41.25*4	10	0.4805	0.07625
3	371.25*41.25*4	8	0.3431	0.05452
4	371.25*41.25*4	6	0.1630	0.02593
5	371.25*41.25*4	5	0.1107	0.0176

V. COMPARISON OF EXPERIMENTAL AND ANSYS RESULTS

The ANSYS results obtained by this method in conjunction with the corresponding experimental ones have been shown in Figs.5 to 8 for comparison. The plots show the variation of logarithmic decrement with respect to several influencing parameters mentioned earlier. Both the curves are close to each other with maximum variation of 15.46%.

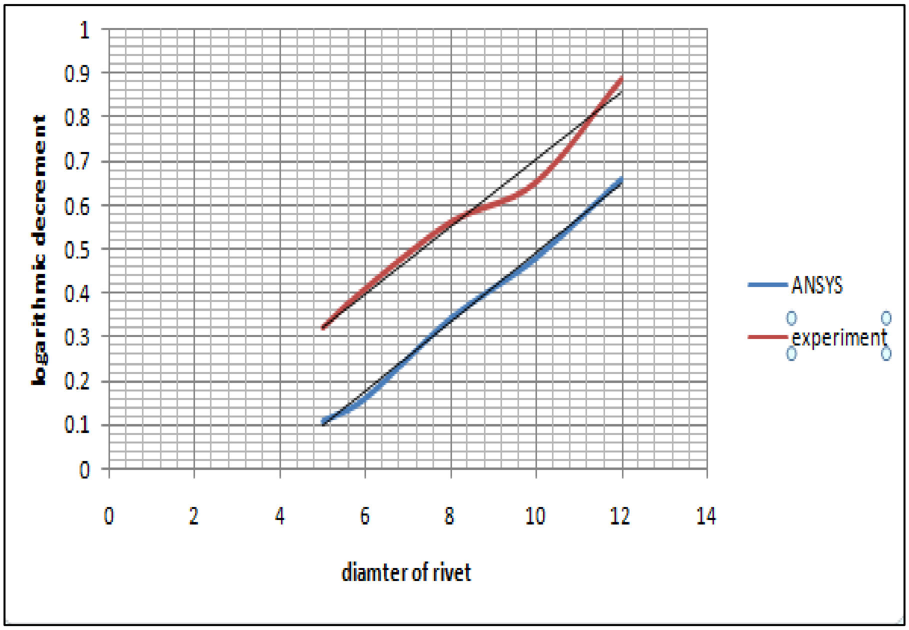

Fig. 5: Variation of logarithmic decrement with diameter of rivet

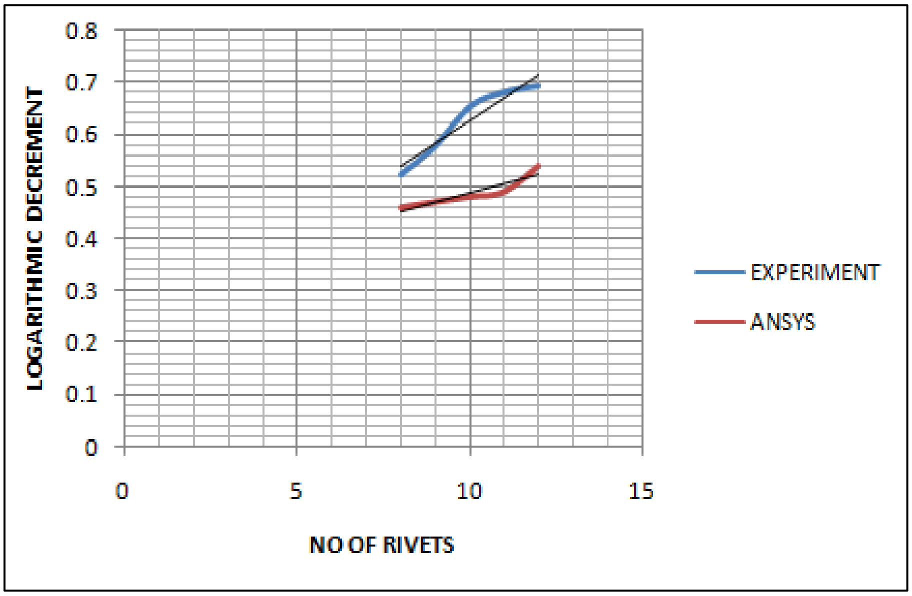

Fig 6 variation of logarithmic decrement with number of rivets

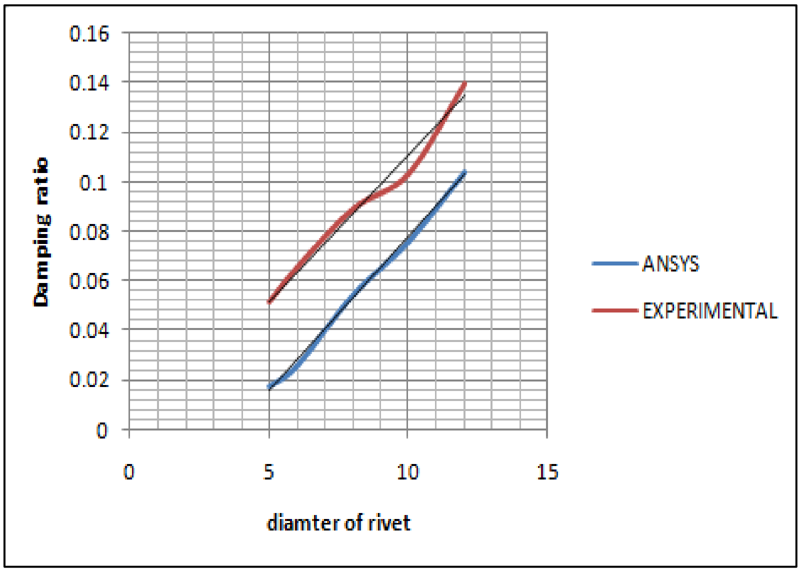

Fig. 7: Variation of damping ratio with the diameter of rivet

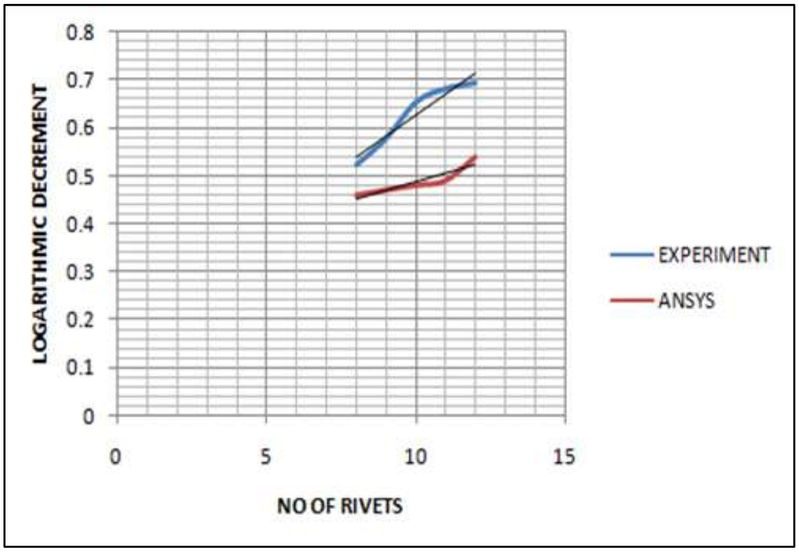

Fig.8 Variation of damping ratio with number of rivet

VI. Conclusion

Extensive studies have been made to find out the effects of various influencing parameters on the damping capacity of layered and jointed structures. The damping of jointed structures in the present work has been examined for the following variables: numbers of rivets and diameter of rivett. The effect of all these parameters on the damping capacity of layered and jointed riveted structures is enumerated from the ansys and experimental results as detailed below.

A. Effect of Diameter of Rivet

The use of rivets of larger diameter increases the preload on the rivets, thereby increasing the normal force and the energy loss at the. Moreover, the increase in the diameter of the rivet is accompanied by an increase in the static bending stiffness which introduces more input strain energy into the system. But the energy dissipation due to interface friction occurs at a higher rate compared to the input energy, thereby causing a net increase in the logarithmic decrement.

B. Effect of Number of Rivet:

by increasing number of rivet or decreasing distance between rivet the logarithmic decrement increases so damping is increases. So if structure with riveted joints is failing under vibration we can avoid it by changing the parameter if diameter of rivets and number of rivets.

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