STUDY OF CANTILEVER BEAM BEHAVIOR WITH MODAL ANALYSIS USING ANSYS WITH DIFFERENT PROPORTIONS OF STEEL FIBERS

K Sahithi[1], Sk.Nasrath Anjum[2]
[1](Asst.Professor, Universal College of Engineering and Technology)
[2](M.Tech Student, Universal College of Engineering and Technology)

Abstract— *In this study Dynamic property of a structural element which is frequency, damping and mode shapes are described by a process called modal analysis. Structural condition can be monitored by analyzing the changes in frequencies and mode shapes. All materials possess certain amount of internal damping. Similarly steel fibers also produce some internal damping. A system is a combination of elements, for example a structure is a system whose elements are beams, columns, slabs, footings .etc. In all those elements I have selected beam elements. Many research works are conducted on different type of materials under dynamic loading. This thesis presents the variation of dynamic characteristics of a steel fiber concrete cantilever beam in which steel fibers are used as a damping material. The main objective of this work is to estimate the natural frequency and damping ratio of a concrete cantilever beams with varying steel fiber percentages and with varying depth.*

1. INTRODUCTION

Vibration is the motion of a particle or a body or system of connected bodies displaced from a position of equilibrium. Most vibrations are undesirable in machines and structures because they produce increased stresses, energy losses, increase bearing loads, induce fatigue, create failure of structures and structural elements, and absorb energy from the system. Vibration occurs when a system is displaced from a position of stable equilibrium. The system tends to return to this equilibrium position under the action of restoring forces. The system keeps moving back and forth across its position of equilibrium. A system is a combination of elements intended to act together to accomplish an objective. For example, a structure is a system whose elements are beams, columns, slab etc., . A static element is one whose output at any given time depends only on the input at that time while a dynamic element is one whose present output depends on past dynamic. In the same way we also speak of static and dynamic systems. A static system contains all elements while a dynamic system contains at least one dynamic element. A physical system undergoing a time-varying interchange or dissipation of energy among or within its elementary storage or dissipative devices is said to be in a dynamic system. All of the elements in general are called passive, i.e., they are incapable of generating net energy. A dynamic system composed of a finite number of storage elements is said to be lumped & discrete, while a system containing elements, which are dense in physical space, is called continuous system. The analytical description of the dynamics of the discrete case is a set of ordinary differential equations, while for the continuous case it is a set of partial differential equations. The analytical formation of a dynamic system depends upon the kinematic or geometric constraints and the physical laws governing the behavior of the system.

2. ANALYTICAL MODELLING

Modal analysis is the study of the dynamic properties of structures under vibration Excitation. The frequency and mode shape of a model is determined by modal analysis. When the models are subjected to cyclic or vibration loads, the dynamic response of structures due to these external loads acting, which include resonance frequencies (natural frequencies), mode shape and damping, are estimated. Natural Frequency: All models have a natural frequency. If a model is subjected to dynamic load that is close to its natural frequency, the model oscillates to a large extent than in normal condition. Modal analysis can be used to find the frequency at which resonance occurs, under specific constraints. Modes: Modes measure the vibration of an object at a particular frequency. Each mode is assigned a number. The lowest speed at which a structure vibrates after all external loads are removed is assigned to mode 1. This mode is called the free vibration mode because it is not damped. Mode shape: In the study of vibration in engineering, the expected curvature of a surface at a particular mode due to vibration is the mode shape. To determine the vibration of a system, multiplying the mode shape by a time-dependent function, the vibration if a system is found out. Thus the mode shape always describes the time-to-time curvature of vibration where the magnitude of the curvature will change. The mode shape depends on two factors: 1) On the shape of the surface 2) The boundary conditions of that surface.

3. MODEL

In this modeling a concrete cantilever beam having length 1200mm, width 150mm with varying depth from 100mm – 250mm at an interval of 50mm.With varying steel fibers percentages (0%, 0.5%. 1%, 1.5%) damping ratios and natural frequencies are compared for all beams. The analytical and theoretical natural frequencies are compared.

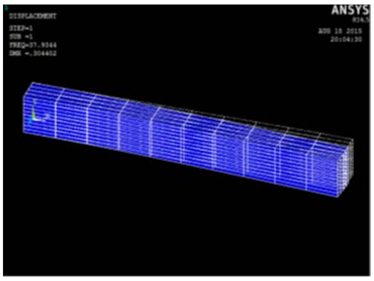
4. HARMONIC ANALYSIS

Any sustained cyclic load will produce a sustained cyclic response (a harmonic response) in a structural system. Harmonic response analysis gives the ability to predict the sustained dynamic behaviour of structures, thus enabling to verify whether or not designs will successfully overcome resonance, fatigue, and other harmful effects of forced vibrations. Harmonic response analysis is a technique used to determine the steady state response of a linear structure to loads that vary sinusoidal (harmonically) with time. The idea is to calculate the structure's response at several frequencies and obtain a graph of some response quantity (usually displacements) versus frequency. "Peak" responses are then identified on the graph and stresses reviewed at those peak frequencies. This analysis technique calculates only the steady-state, forced vibrations of a structure. The transient vibrations, which occur at the beginning of the excitation, are not accounted for in a harmonic response analysis. Three harmonic response analysis methods are available: full, reduced, and mode superposition. (A fourth, relatively expensive method is to do a transient dynamic analysis with the harmonic loads specified as time-history loading functions). The ANSYS/Linear Plus program allows only the mode superposition method.

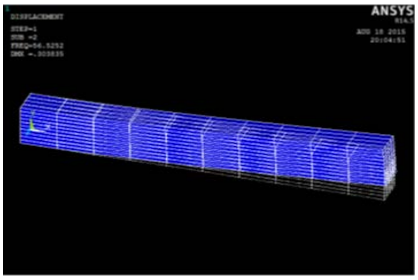
5. RESULTS AND DISCUSSIONS

From the analytical program we calculated the mode shapes, natural frequencies and damping ratios for the cantilever beams with steel fibres varying from 0% to 2% having 1200mm length, 150mm width with varying depth from 100mm to 250mm with an interval of 50mm.The following are the results for the cantilever beams from modal analysis.

The first Five Natural Frequencies obtained from modal analysis:



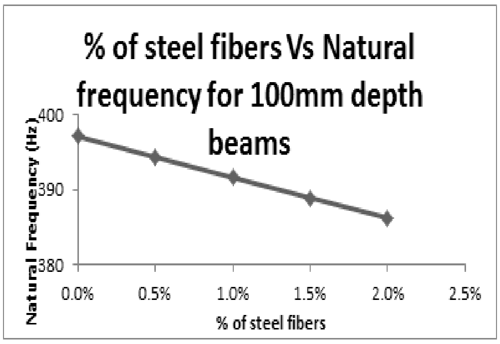
Mode shapes for A1 Beam



Second mode for A1 beam

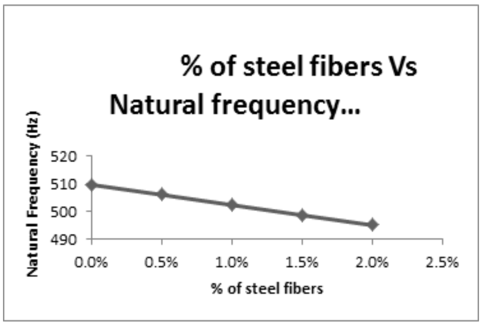
Natural Frequencies for 100mm depth beams

% of Steel fibers	Natural Frequency (Hz)
0%	397.12
0.5%	394.35
1%	391.54
1.5%	388.94
2%	385.28



Natural Frequencies for 150mm depth beams;

% of Steel fibers	Natural Frequency (Hz)
0%	428.42
0.5%	425.51
1%	422.53
1.5%	419.78
2%	415.97



FREQUENCY RESPONSE CURVE (FRC) OBTAINED FROM ANSYS:

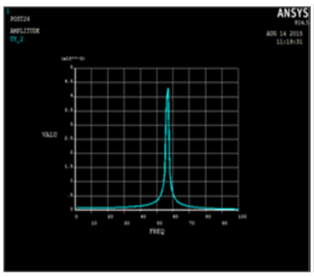


Fig.5.27 FRC for the beam A1

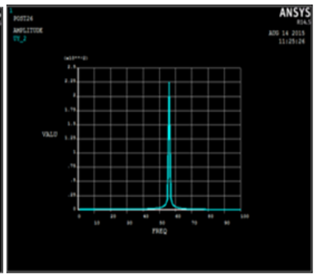


Fig.5.28 FRC for the beam A2

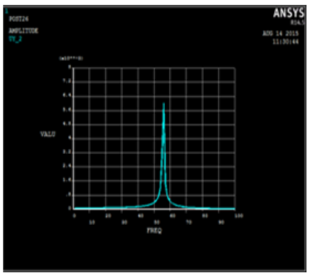


Fig.5.29 FRC for the beam A3

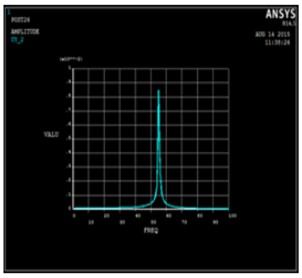


Fig.5.30 FRC for the beam A4

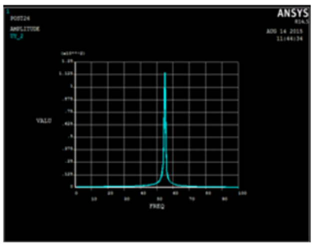


Fig.5.31 FRC for the beam A5

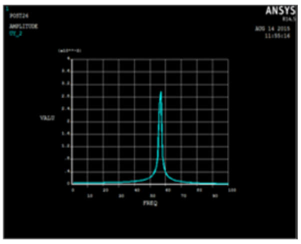
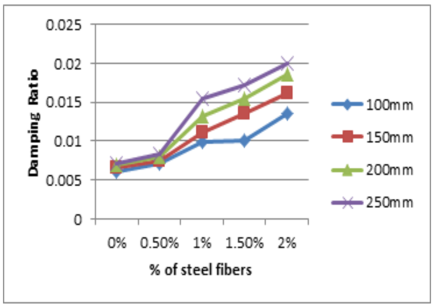


Fig.5.32 FRC for the beam B1

Damping Ratios Vs percentage of steel fiber beams

% of steel fibers	**100mm Depth beam**	**150mm Depth beam**	**200mm Depth beam**	**250mm Depth beam**
0%	0.00614	0.00653	0.00693	0.00714
0.5%	0.00714	0.00753	0.00792	0.00833
1%	0.00982	0.0112	0.0132	0.0155
1.5%	0.01	0.0135	0.0154	0.0172
2%	0.0136	0.0161	0.0186	0.02



6. CONCLUSIONS

- With increase in fiber percentage at constant depth damping ratio increases. This means the resisting capacity of the material increases.
- With increase in depth of the beam at constant fiber percentage damping ratio remains constant. From this we can say that damping ratio does not depend on depth of the beam.
- At constant depth with increase in fiber percentage the highest natural frequency value gets decreased. This means the resisting capacity of the material gets increased, hence damping ratio increases.
- At constant fiber percentage with increase in depth of the beam the natural frequency value gets increases. Because with increase in depth of the mass and stiffness of the beam increases hence natural frequency also increases.

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