DYNAMIC ANALYSIS ON STEEL FIBRE CONCRETE BEAMS

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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 paper 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 of beam by Harmonic analysis using ANSYS

Key words: Modal Analysis, Harmonic Analysis, Damping Ratio


OBJECTIVES

The main objective of this work is to estimate the natural frequency and damping ratio of a concrete cantilever beams with varying steel fibers 0-2 percentages and with varying depth 100mm - 200mm of beam by Modal analysis and Harmonic analysis using ANSYS.
METHODS
Using Modal analysis finding the mode shapes, natural frequency by Harmonic analysis and by Half power Bandwidth method Damping ratio will be calculate by varying depth beam size and percentage of steel fibers.

FINDINGS
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 depends on depth of the beam. At constant depth with increase in fiber percentage the highest natural frequency value gets decreases. 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.

IMPROVEMENTS
The natural frequency increases at constant fibre percentage at depth of beam increases and capacity of material increases at constant depth increases in fibre percentage.

INTRODUCTION
DYNAMIC ANALYSIS
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 behaviour of the system.
MODAL ANALYSIS
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. The results of a modal analysis help determine whether a model requires more or less damping to prevent failure. 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 (or displacement) 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.

![Mode shapes of the cantilever beam with varying steel fibre percentages.](Image)

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 allows only the mode superposition method.

![Graph](image)

**Figure 2** Harmonic Response of cantilever beam

The frequency response function represents the ratio of output over input signals. The frequency response is a function of frequency and reaches its maximum value at natural frequency. It is clear from the figure that resonant occurs at frequency 57 Hz.

![Graph](image)

**Figure 3** Percentage of steel fibers Vs Natural Frequency

The percentage of steel fibers Vs natural frequency figure with 100 mm to 250 mm depth of the beams. At constant depth with increase in fiber percentage the highest natural frequency value gets decreased. DAMPING RATIO

The Vibration characteristics (& damping ratio) of cantilever beam with varying steel fibers from 0% to 2% of length 1200mm, width 150mm and depth varying from 100-250mm with an interval of 50mm have been determined by Frequency Response Curves between amplitude in terms of displacement and excitation frequency. Damping ratio is calculated with the help of half power bandwidth method.
Dynamic Analysis on Steel Fibre Concrete Beams

![Graph showing the relationship between frequency and damping ratio.](image)

**Figure 4** Half-power Bandwidth Method.

There is a peak value in frequency response curve corresponding to this peak value the amplitude is taken as $x_{\text{max}}$ and natural frequency is taken as $\omega_n$. There are two points corresponding to half power point ($x_{\text{max}}/\sqrt{2}$) which are noted as $\omega_1$ and $\omega_2$ as shown in the figure below.

<table>
<thead>
<tr>
<th>% Steel fibers</th>
<th>Damping ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0.00614</td>
</tr>
<tr>
<td>0.5%</td>
<td>0.00714</td>
</tr>
<tr>
<td>1%</td>
<td>0.00982</td>
</tr>
<tr>
<td>1.5%</td>
<td>0.01</td>
</tr>
<tr>
<td>2%</td>
<td>0.0136</td>
</tr>
</tbody>
</table>

**Table 1** Damping ratios for 100mm depth beams

**CONCLUSION**

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. 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.
REFERENCES


