Vibration Analysis of Composite Beam Structures

Piyush Pathak, Rahul Satbhaiya

M.Tech Scholar Dept. Of Civil Engineering, Infinity Management & Engineering College Sagar, M.P. India
Head of Dept. Of Civil Engineering, Infinity Management & Engineering College, Sagar, M.P. India

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Abstract - - *Glass fibre reinforced polymer composites (GFRP) are being widely used in many applications because of their light weight, high stiffness and good damping properties. Their use in both offshore and onshore applications is becoming inevitable because of their excellent anti corrosive behavior. These composites are subjected to severe loading and environmental conditions during their service. The behavior of the composites under certain environmental conditions is to be studied for proper functioning and to avoid possible failure of the component. Also during the lifetime of the composite there is a possibility that the composite may be subjected to different environments than that it is being presently used for. Under all these conditions it becomes imperative that the behavior of the composite be studied for safe design. Damping is one such property that needs to be studied for assessing the vibrational behavior of the composites.*

In the first part of the work, an attempt is made to study the variation of damping of GFRP composite subjected to different environmental conditions. Three different liquid environments; Seawater, saline water, and normal water were used for the study to assess the damping behavior of the composite. The damping variation of the composite was studied for every 15 days of immersion in the respective medium up to a maximum of 60 days using free vibration decay method. Specimens treated with seawater exhibit more damping capacity than other specimens. The maximum increase was around 37%. Saline and normal water treated specimens showed reduction in the damping well below the untreated specimens of the order of around 47% and 32% respectively. This contrasting behavior is attributed to the difference in the chemical structure of the immersion mediums.

***Key Words*:** Reinforced Cement Concrete (RCC), steel bars, corrosion, steel reinforcement, Glass Fibre Reinforced Polymer and Carbon Reinforced Fibre Polymer (GFRP).

1. INTRODUCTION

Any motion that repeats itself after an interval of time is called vibration or oscillation. Most human activities involve vibration in one form or other. For example people hear because the eardrums vibrate and see because light waves undergo vibration. Breathing is associated with the vibration of lungs and walking involves oscillatory motion of legs and hands. In recent times, many investigations have been motivated by the engineering applications of vibration, such as the design of machines, foundations, structures, engines, turbines, and control systems.

Most prime movers have vibrational problems due to the inherent unbalance in the engines. The imbalance may be due to faulty design or poor manufacture. Imbalance in engines causes groimd waves sufficiently powerfiil to create a nuisance in urban areas. The structures designed to support heavy centrifugal machines, like motors and turbines, or reciprocating machines, like steam and gas engines and reciprocating pimips, are also subjected to vibration.

A turbine may fail due to blade and disk vibration. In all these situations, the structure or machine component subjected to vibration can fail because of material fatigue resulting from the cyclic variation of the induced stress. Furthermore, the vibration causes more rapid wear of machine parts such as bearings and gears and also creates excessive noise. In machines, vibration causes fasteners such as nuts to become loose. In metal cutting processes, vibration can cause chatter, which leads to a poor surface finish.

Whenever the natural frequency of vibration of a machine or structure coincides with the frequency of the external excitation, resonance occurs which leads to excessive deflections and failure. Because of the devastating effects that vibrations can have on machines and structures, vibration testing has become a standard procedure in the design and development of most engineering systems.

In many engineering systems, a human being acts as an integral part of the system. The transmission of vibration to human beings rhesus in discomfort and loss of efficiency. The vibration and noise generated by engines causes annoyance to people and, sometimes, damage to property. Vibration of instrument panels can cause their malfunction or difficulty in reading the meters. Thus one of the important purposes of vibration study is to reduce vibration through proper design of machines and their mountings.

2. PROPOSED WORK

Based on the above objectives, the study plan was to measure the damping of the glass fibre-reinforced composites immersed in different aqueous environments for different soaking times using logarithmic decrement method. Secondly, performing SENB and SENT tests using Universal Testing Machine on the GFRP composites to evaluate the fracture toughness under different environmental conditions and immersion periods and find its relationship with damping. Lastly, conducting Izod and Charpy tests on the GFRP composites to evaluate impact properties under varied environmental conditions for different immersion periods and find the variation of impact energy with damping.

Glass fibre-reinforced composites are used in many onshore and offshore applications because of their excellent corrosive resistant properties. Since these are subjected to severe environmental and dynamic loading conditions during their service, their vibrational behavior becomes very important for their design. This study has been carried out to address this issue taking into consideration three environmental conditions. The damping study made here gives an insight into the behavior of the composite when subjected to severe aqueous environments which are very much essential for better design of composite structures. Also the study focused on finding the variation of fi-acture toughness/impact energy with damping. This study becomes imperative considering the importance of fracture mechanics in the design of composites structures. The studies made here regarding the damping and fracture toughness/impact energy can possible lead to establishing a relationship/correlation between the two parameters.

3. EXPERIMENTAL SETUP & PROCEDURE

In this research work experimental analysis was carried out to study the vibration and fracture behavior of GFRP composite under varied environmental conditions. Also experimental studies were conducted to study the variation of the damping behavior of the composites with fracture toughness in bending, and tension, and with impact energy using both Izod and Charpy tests. All the test specimens were soaked in three different liquid media viz. Seawater, normal water and saline water to assess the vibration and fracture behavior of the composites. Five different types of composites were fabricated by varying the fibre volume and all were subjected to different liquid environments. The effect of the service environments on these composites was evaluated. The experimental work and analysis carried out as a part of this research work is discussed in this chapter. Natural seawater from the sea was collected and used for soaking the specimens. The saline water used for soaking was the liquid containing sodium chloride of 0.9gm per 100ml of water used for medical applications. The normal water was the water collected directly from the tap which is used for domestic use.

- **Vibration Test Specimens and Procedure**

The vibration specimen used for obtaining the damping of the composite is shown in Fig.1. The length, width and thickness of the specimens were 330mm, 50mm and 3mm respectively. The thickness of the specimen varied between 2.9nun to 3.1mm for all the specimens. This variation is due to the hand lay-up procedure.

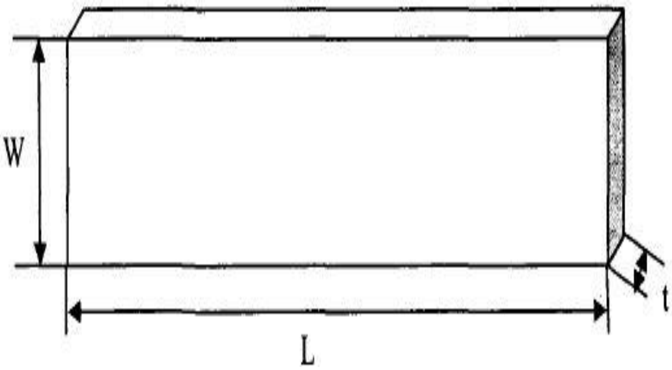

Fig. 1 Vibration test specimen used in damping analysis

4. CONCLUSION

Damping analysis of the GFRP composite subjected to three different Liquid medixuns (seawater, saline water and normal water) was carried out. Since the damping observed is small (under damping) logarithmic decrement method was used to find the damping of the composite at regular time periods. To study the variation of damping with fi-acture toughness, four additional tests were performed to calculate Fracture toughness and impact energy at regular immersion periods. These were analyzed in the previous chapters (5-8). Fracture toughness and impact energy were calculated fi-om these tests. Further, these test results were used to study the variation of damping with Fracture toughness and impact energy.
The observations drawn while studying the damping behavior of the composite subjected to three different media of immersion for different immersion periods are summarized below:

- For initial period of immersion in seawater, increase in the damping of the composite was observed. This increase continued up to 30 days of soaking and fiirther soaking reduced the damping of the composite. The decrease in the values of the damping obtained here were less than other medium treated specimens.

- Specimens treated with saline water showed decrease in the damping value well below the untreated specimens. There was no increase in the damping of the composite even up to 60 days of soaking. A small increase was observed at end of the soaking period but this was well below the untreated specimens.
- Normal water treated specimens showed similar results as the saline water treated specimens. The damping of the composite reduced for all the immersion periods below the untreated specimens. Here also increase in the damping was observed after some immersion period which was less than the dry specimens.
- Even though seawater and saline water have salt content, the damping behavior in both the medium present different results. Perhaps the chemical composition and its interaction with the composite play a major role in deciding the damping behavior of the composite.
- For increase in mass one would expect the damping to increase which is a logical one. But here even though mass increased due to water uptake the damping of the composite in some immersion mediums did not increase. This is an important observation made in this investigation.

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BIOGRAPHIES

Piyush Pathak is an M.Tech Scholar & currently researching on the Vibration Analysis of Composite Beam Structures A part from this he is studious & have sound knowledge of the subject.