EXPERIMENTAL INVESTIGATION OF SOUND TRANSMISSION ON FERROCEMENT PANELS USING STATISTICAL ENERGY ANALYSIS

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Abstract: Ferrocement panels have been used in low cost housing in developing countries. This study focuses on the functional performance of sound transmission on ferrocement elements (roofs, wall members) in buildings. In this study three different types of ferrocement panel elements have been cast and tested in transmission loss suite specially designed for testing their sound reduction index experimentally. The results are then compared with the existing conventional building material.

1. Introduction

Ferrocement panels are one of the common forms of material used for construction in developing countries like India. This is because of its low cost in manufacturing and does not require any technical skills in the process of construction. The material by itself has a better performance than the conventional brickwork and concrete structural members because of its high flexural strength and modulus of elasticity[3]. Hence they are used both as load bearing and non-load bearing members in low cost housings in India.

This work mainly deals with the sound transmission performance of ferrocement panel members for their sound reduction index behavior. The panels have been tested for their sound transmission performance for the first time as their usage in construction industry has increased a lot and hence their acoustical performance has to be studied with respect to conventional building materials.

The size of the panels cast are as follows:

(a) Panel without stiffener =1800x1200x20mm
(b) Panel with stiffener =1800x1200x20mm Beam thickness=50mm
(c) Panel with stiffener and cavity insulation =1800x1200x20mm 2 nos.with 25mm cavity thick and filled with 25mm high density(42kg/m^3) of polyester foam.
(d) Panel with cavity (20mm thick cavity)
(e) Panel with cavity ties (double triangle ties 4 Nos.)

Cement mortar of 1:2 ratio has been used in casting the specimens. Sound transmission studies have been conducted in the ferrocement panels for the first time since it is a main lightweight material used in low cost housing construction.

2. Experimental Investigations

The sound insulation characteristics of ferrocement panels depends on the variation in bending stiffness and material properties [1,4]. To facilitate this study a horizontal transmission loss suite consisting of two rooms namely the source room and the receiver room of volumes 32m^3 and 38m^3 respectively have been designed and constructed based on the guidelines prescribed by ISO140-3-1984 specifications[2].The receiver room is completely isolated from the vibration and flanking transmission from the roof as well as from the ground by providing vibration isolation flooring and box in box type panels on the side walls. The test opening is constructed in between the two rooms on a different foundation and is connected to the roof. The test opening is made of two walls of 112.5 mm thick with an air gap of 15mm between them to prevent flanking and direct transmission through the wall. To prevent the flanking transmission from the roof box in box type design has been done , with an air gap of 25mm backed by wooden battens of 50x50mm thick followed by high density mineral wool of 75mm backed by 12.5mm thick plaster boards of two layers both in the side walls and the roof. This prevents the transmission coming from the roof.

Ferrocement panel specimens are constructed in the test opening and plastered to the side walls with cement mortar. The gaps or leaks between the wall and the specimen are closed by using mastic seal on all the sides. Sound reduction index measurements have been conducted on all the specimens. An average sound pressure level has been determined at three points both in the source room and in the receiver room. Difference in levels gives the average sound reduction index 'R' of the material.

Total loss factor(TLF) measurements have been conducted on the panels. This is done by checking the structural reverberation time of the panel.

The longitudinal wavespeed (c_L) of the panels has been measured by taking the flytime of the wave passing through a known separation distance and the time taken is measured using a dual channel oscilloscope.

3. Effect of panel stiffeners and cavity absorption

More detailed measurements have been carried out on the panel members with effect of stiffeners and cavity absorption. Stiffeners of 50mm thick and 20mm depth have been added to the plate. This resulted in the increase in stiffness and there by a increase in sound reduction index.

In a similar way two panels with stiffeners with an air gap of 25mm between the two plates. The air cavity is then filled with high density polyester foam of 25mm thick for absorption. The air gap is filled with the absorptive material to see the performance of the panel with cavity absorption. Sound reduction index has been measured again presence of cavity has increased the sound reduction index to a maximum extent.

Two panels of 20mm thick with an intermediate air gap or cavity of 20mm has been constructed and SRI has been measured to determine its efficiency of the panel. In the similar way panel with intermediate cavity ties of 70mm in length and 4mm thick Fig.3. of 4Nos. have been constructed to determine its sound reduction index.

Measurements of sound reduction index have been made on these panels. Factors which include total loss factor (TLF) η,internal loss factor, longitudinal wave speed (c_L) of the panels and velocity level difference on either side of the panels for an airborne source have been measured. The total damping loss factor and longitudinal wave speed of the panels have been measured based on the above methods. The density of the panel increases from the normal plate to panel with intermediate cavity and stiffeners (2500 to 2600kg/m^3).

The longitudinal wave speed (c_L) of the panel has been measured by taking the flytime of the wave between the two accelerometers placed parallel and in plane to the wall surface with a known separation distance in the horizontal and vertical direction. Measurements of c_L along the horizontal direction for all the three combinations are as follows:1860;1900;2100m/sec and in the vertical direction it is 1940;2000;2400m/sec.

4. Results

It is seen from Fig.1. that the sound reduction index (SRI) 'R' of the panel increases from the plane panel to panel with stiffener to panels with an intermediate air gap filled with cavity insulation. The coincidence dips are more dominant in the low and high frequency regions.

In the case of normal panel the dips are more prominent in the low frequency regions. Increase in the sound reduction index is mainly due to addition of stiffeners and cavity insulation resulting in the higher sound reduction index.

From Fig.2. it is seen that there is a prominent increase in the loss factor η of the panels. Loss factor increases from the panel to additional structural elements in the panel.

From Fig.4. it is seen that there is a increase in the sound reduction index of the panels with cavity when compared to a panel with cavity ties. In the low frequency region resonant frequency plays an important part whereas the high frequency region the coincidence dips are not more prominent with respect to cavity panel. From Fig.5. it is seen that the loss factor of the panel with cavity is higher than with the panel with ties.

5. Conclusions

There is a good agreement that SRI of the ferrocement panels with cavity are much higher than the panel with cavity ties and other configurations. Also SRI increases from the panel to panel with stiffeners and cavity insulation to panel with cavities. Loss factor also follows the same trend, as is the case of SRI.

Acknowledgments:

The author wishes to acknowledge his fruitful discussions and assistance with Dr. Sean Smith pertaining to this work. He also thank Mr. P.S.Subramanian, Chairman of P.S.Subramanian Associates for providing funding for this work.

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