VIBRATION DAMPING OF CONCRETE BY MEANS OF A VISCO ELASTIC LAYER

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1. Introduction

An efficent way to achieve high internal damping in concrete is to apply a thin layer of viscoelastic material in the concrete slab in such a way that a sandwich construction is formed.

The viscoelastic layer may be applied as a special carpet, suitable for embedment in a concrete floor etc. A prefabricated wall element may consist of two slabs adhered to each other by the viscoelastic material.

2. Effects of increasing the internal damping of building constructions

In the general case it is difficult to predict the total effects of increasing the internal damping in building constructions. Principally, however, it is possible to predict with reasonabel accuracy the effects on the sound propagation by the dominant sound paths.

The impact noise isolation and the transmission loss above the concidence frequency will increase by 10 dB for an increase of the loss factor by the factor of 10.

The propagation damping (in dB) will increase by a factor 10 for an increase of the loss factor by 10.

3. Experiments

At AKUSTIKBYRÅN AB practical research has been done in the field the field of sandwich damping of concrete and lightweight concrete materials.

The research work has essentially been divided into two parts. The first part was to find adequate damping materials suitable for application in concrete and lightweight concrete materials. The second part was to develop methods to apply the damping materials in these building materials.

3.1 Properties of damping materials

An adequate damping material must have godd damping properties and suitabel shear modulus in the frequency and temperature range of interest.These ranges are in most cases 15 - 25°C, and 200 - 1000 Hz.

The material must also meet certain environmental and strength claims concerning for example temperature, and fire resistance, toxicity, chemical reactions between the damping layer and the concrete, durability, strength and mecanical stability.

3.2 Preparation of specimens

For investigations on materials small beams were prepared from steel and light metal. Each beam consisted of two equal part with the thin damping layer in between.

For the application tests small beams were prepared of concrete and lightweigt concrete.

Finally tests with reinforced concrete and lightweight concrete beams were performed. These specimens had a length of 2 m and a total thicknes of 0.1 to 0.15 m.

3.3 Measurements of damping

For a number of reasons the following measuring methods were chosen. The small beams were suspended in rubber bands conected to the beam in the two modal lines corresponding to the lowest mode of a free-free beam. The beam was exited with an impact. The response was detected by an accelerometer and the decaying acceleration was registered on an oscilloscope with a memory function. The loss factor and the resonance frequency could be determined very easily from the screen of the oscilloscope. The frequency was varied through succesiv cutting of the specimen.

The big beams were put on resilient mountings. At one end the beam was exited sinusoidally by a vibrator. At the resonance frequencies of the beam the decaying vibrations after swich-off were registred on the screen of an oscilloscope. The method mentioned above for small beams was used as well. See fig.1.

3.4 Theory

The theory of the general sandwich constmuction is rather complex and will not be treated in this paper but in the special case of a very thindamping layer located in the middle of the sandwich plate the theory is very simple. This theory makes it easy to see how different parameters influence the damping properties.

Consider a beam performing free flexural vibrations. Shear in the damping layer results in damping.

The following formulas express the dynamic properties of the beam:

$$f_{opt} = \frac{2G_2}{7,7d_2}\sqrt{\frac{1+\eta_2^2}{E_1\varrho_1}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$\eta_{max} = \frac{3\eta_2}{5+4\sqrt{1+\eta_2^2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

$$\eta = \frac{3\eta_2}{5 + 2\left(\frac{f}{f_{opt}} + \frac{f_{opt}}{f}\right)\sqrt{1+\eta_2^2}} \qquad \text{................(3)}$$

(3) - (5) are valid only if

$$f \ll \frac{1}{2\pi} \sqrt{\frac{6G_2}{d_2 \varrho_1 h_1}} \qquad \text{................(4)}$$

where

E_1 is the modulus of elasticity of the plates

ϱ_1 is the density of the plate material

G_2 is the shear modulus of the damping layer

d_2 is the thickness of the damping layer

η_2 is the loss factor of the damping layer

η is the loss factor of the sandwich element

η_{max} is the maximum loss factor of the sandwich element

f_{opt} is the frequency where $\eta = \eta_{max}$

The limit given by (4) corresponds to the transverse resonance frequency for the two plates as masses in the sandwich construction with the damping layer as a spring. Because of this very little shear will appear in the damping layer.

The expression (3) shows the dependency of frequency on the total loss factor. In practise the shear modulus G_2 of materials with high internal damping will increase with the frequency. Because of that the total loss factor η is almost independent of the frequency. This theoretical fact is also supported by practical experiments. The influence of temperature is often much more pronounced.

The formulas expressing the total loss factor for sandwich constructions with an asymmetrically located layer are rather complex but the following values can be given. When the ratio beetwen the thickness of the two plates is 1:2 the maximum total loss factor is about 75% of the one in the symmetric case. At a ratio of 1:4 the figure is 50%. In the latter case the optium frequency fopt is only 35 % higher than that of the symmetric case.

5.4 Results

Many damping materials have been investigated with respect to different properties mentioned in 3.1. In this paper only the final test will be described.

5.4.1 Specimens made of lightweight concrete

Two specimens were made of lightweight concrete 2,15 m in lenght, 0,3 m in width and with a total thickness of 0,14 m. One of the beams was provided with a two components plastic damping layer 1 mm thick located in the center of the beam and acting as a glue keeping the two parts of the beam together.

When applied in lightweight concrete this damping material has a tensile strength of 100 - 200 kN/m^2 perpendicular to the surface of the elements. Its creeping properties are very good and it is a wellknown material in the building industry.

The other specimen was the reference object. It had exactly the same dimensions as the damped specimen but was undamped.

In fig 2 the total loss factor η versus the frequency f is plotted for the damped and undamped beams. The loss factor η increases 6 - 9 times when the beam is damped. It is not very dependent of the frequency in the range of interest and is greater than 0,1.

5.4.2 Specimens made of reinforced concrete

Two specimens were made of reinforced concrete 2 m in length 0,3 m in width and with a total thickness of 0,10 m.

One of the beams was provided with a special damping carpet located in the center of the beam and constructed in such a way that it could be applied in the concrete during the casting of the element. The damping layer was 0,6 mm thick.

When applied in concrete this damping carpet has a tensile strength of about 50 - 150 kN/m^2 perpendicular to the surface of the studied concrete element.

The other specimen was the referens object.

In fig 2 the loss factor η versus the frequency f is plotted for the damped and undamped beams. The loss factor η increases also in this case about 6 - 9 times as a result of damping.

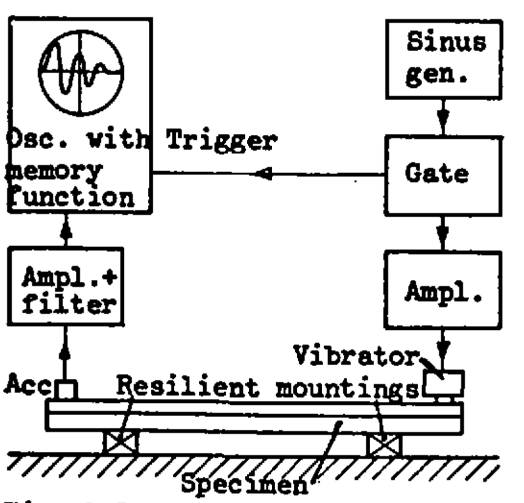

Fig. 1 The experimental system for damping measurement

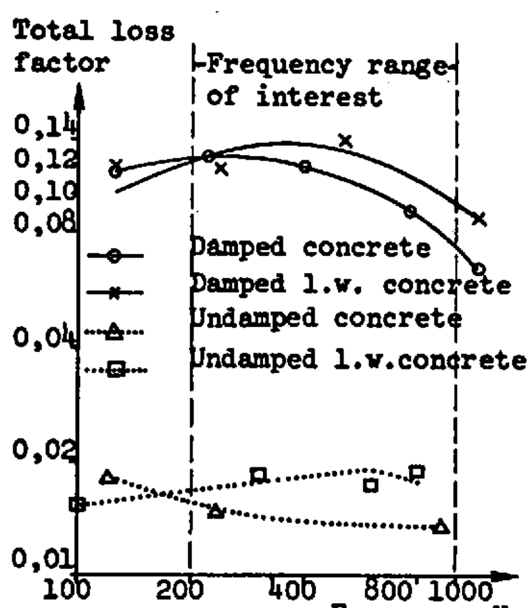

Fig. 2 Experimental results with damped concrete and lightweight concrete beams