EXPERIMENTAL INVESTIGATION OF TEMPERATURE DEPENDENCY ON RUBBER BEHAVIOUR

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1.0 Introduction

The use of seismic isolation rubber bearings for bridges and buildings provide a very effective passive method to suppress hazard from earthquake-induced vibrations. High damping rubber (HDR) is smart material especially used in those bearings. The rubber in bearings is subjected to cyclic loadings and dissipated considerable amount of heat increasing its body temperature. Mechanical properties of rubber materials strongly depend on the temperature[1)]. This study is to experimentally investigate the thermo-mechanical behavior of HDR under the cyclic loadings. The data obtained in this study can be used to develop a temperature and time dependent constitutive model for the rubber material.

2.0 Experimental outline

Cyclic displacement control simple shear and uniaxial tension tests were conducted. However, in this paper, discussion is limited to cyclic simple shear test since it is enough to show temperature and loading frequency dependency on the behavior. Details of the experiments conducted for simple shear test is given Table 1. Schematic of the test setup is shown in Fig. 1 and additionally; infrared camera was setup for the temperature measurements. Loading pattern of each specimen is shown in Fig. 2.

3.0 Measurement of temperature field

Various devices have been used for temperature measurements such as thermometers, thermo couples etc, but most of such devices can be used to measure the temperature at a point at a time. However, in our study, the device called infrared camera is used for the temperature field measurements, which has capability of real time measurements. Infrared thermographs can be obtained from the device so that temperature can be measured at any point of the surface of the body. In this study, Nikon thermal vision (LAIRD3A-S) infrared camera is used and our thermal measurement system is capable to capture 60 thermal images per second. Fig. 3 shows a thermal image that is captured during the cyclic shear deformation.

4.0 Results

Fig. 4 shows variation maximum temperature of rubber surface with time, for different frequency of loading. It is clear that as time goes heat losses to the outside. But at higher frequency such as 1 Hz almost actual heat dissipated (shown as temperature) can be measured, it is also shown that temperature increases about 20° C from the initial due to cumulative heat dissipation within short period. The increase of the temperature of the rubber body at frequency 0.1 Hz is 7° C and other frequencies such as 0.01 Hz and 0.001 Hz is around 3° C.

Fig.5 shows an example of total energy dissipation (area of hysteresis loop) versus loading maximum shear strains, for different frequency of loadings. It is clear that hysteresis loops for different frequency is changing and directly proportional to heat dissipation (temperature) of the body. These results precisely described that these variation are directly related to changing the properties of rubber such as stiffness and damping. In other hand, temperature of the body and frequency of loading are directly related to each other and they are responsible for the changing the mechanical properties of the material. The results show that thermo-mechanical behavior of rubber is an important phenomenon to further study. Next is modeling of the thermo-mechanical behavior of the rubber in the line of this research.

Keywords: High damping rubber material, thermal image, temperature field, damping
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5.0 Conclusions

Thermo-mechanical behaviors of the HDR material were studied. Experimental results precisely described that temperature dependency is considerable on rubber behavior. Thermo-mechanical behavior of rubber is an important phenomenon to further study on the line of this research.

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References

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Tables and Figures

Table 1: Tests descriptions

Type of rubber material	High damping rubber
Shear Modulus (Mpa)	0.98
Loading frequency (Hz)	1, 0.1, 0.01, 0.001
Maximum average shear strain for a given cycle of loading	50%, 141%, 264%, 346%
Number of continuous cycle of each amplitude	3

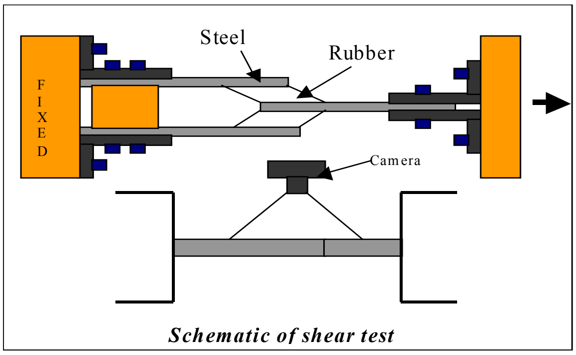

Fig. 1: Schematic of simple shear test

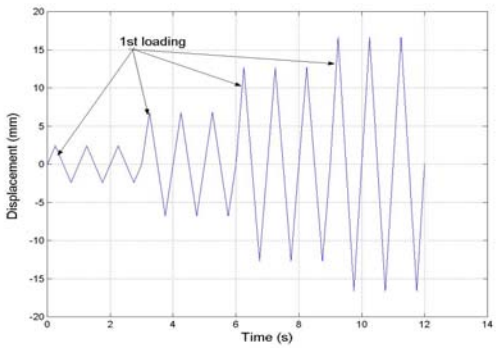

Fig. 2: Loading pattern

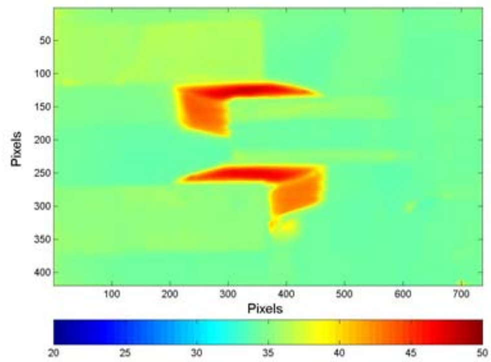

Fig. 3: Temperature field (cyclic shear)

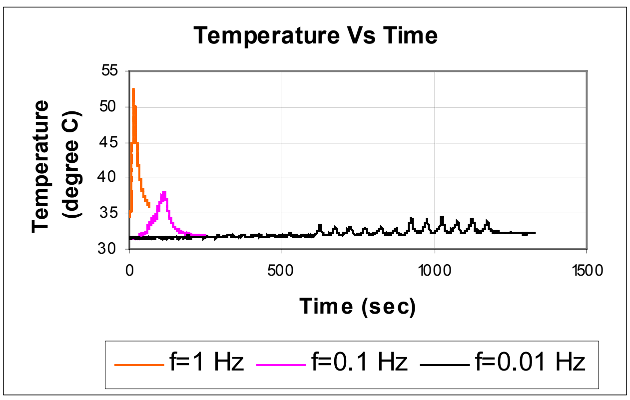

Fig. 4: Maximum temperature variation

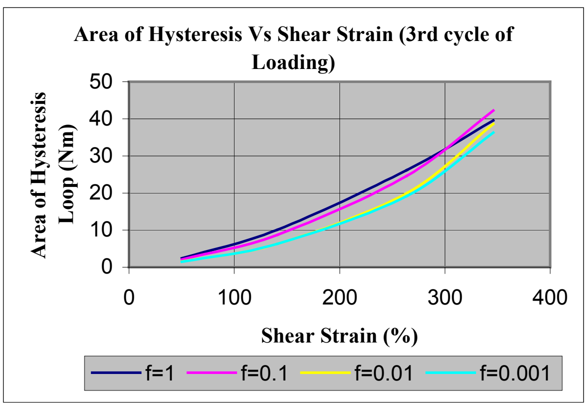

Fig. 5: Total energy dissipation Vs maximum shear strain