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A study on dynamic characteristics test of anti-vibration material for shock and vibration reduction of railroad low-vibration logistics system

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ABSTRACT
The most important and essential factor of dynamic characteristics is damping capacity and natural frequency. Damping capacity improve performance for shock isolation, and it can avoid amplification due to resonance. Lower natural-frequency than dynamic-force frequency improve vibration transmissibility performance. The damping capacity test was conducted by using universal test machine and calculated from the hysteresis diagram. Natural frequency test was conducted by impact modal test. The specimen materials were classified into elastic mats, elastic mounts, micro anti-vibration mounts, wire-mounts, and air-mounts. Total 27 specimens were tested and the results were compared and evaluated. The dynamic characteristics of each material derived from this test will be used as a design parameter for railroad low-vibration logistic system along with the results of durability test and low temperature fatigue test proceeding later.
This study is the first year study of the 4th year study for the development of low vibration logistics system. In this study, the vibration characteristic profile of Korean road and railway was studied firstly, and the dynamic characteristic test was conducted to select anti-vibration material in order to reduce shock and vibration in a railroad freight cargo.

Keywords: Anti-vibration material, Low-vibration logistics, anti-shock, Hysteresis loop

1. INTRODUCTION

Until now, due to the limited geopolitical environment, Korea has been forced to depend entirely on oversea logistics movements, not on overland transportation but on maritime or airlines transportation. However, as the South-North korea railway and road connection are being discussed, there is growing expectation that it will be directly connected with Eurasia continent such as China and Russia through land route. With the

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change of geological environment, it is expected that the transportation of high value goods, which depend on the ship and airline, will be replaced by railroad transportation such as Trans-Siberian Railway (TSR) and Train China Railway (TCR). Therefore, there is a need to research a low-vibration and anti-shock logistics system in order to prepare for the future use of high - value transportation through continental railways.

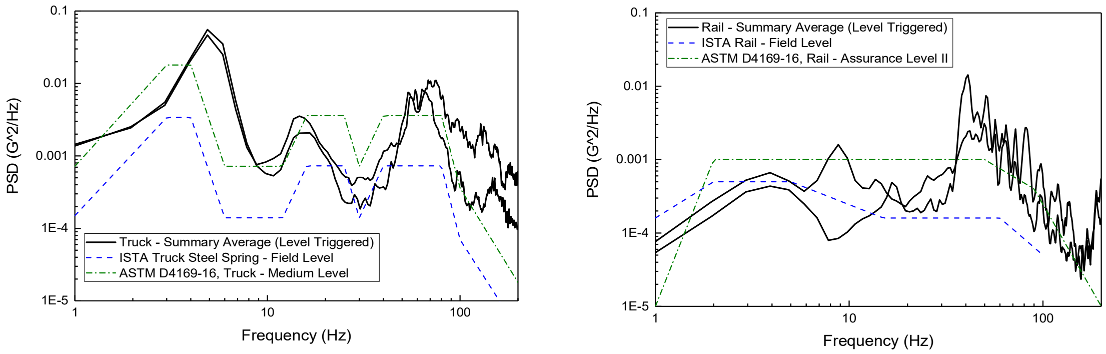
In the oversea nations such as US, EU, Japan, India, Thailand, and China are investing enormous budgets in researching complex transport infrastructure, integrated transportation infrastructure, safety transport, automation, modernization of logistics facilities and eco-friendly transportation support to develop logistic industry and improve logistic service quality. It is estimated that an average of 1,220 accidents occur on the basis of 200,000 containers. Among these, 305 cases of breakage accidents occurred, resulting in a loss 3 million USD per year on the basis of general cargo. Shippers depend primarily on packaging to prevent product damage, and there is no means to protect expensive products during product unloading and transport. South korea logistics agents impossible to invest in R&D such as container low-vibration technology development because of their small scale business. Therefore, there is a technical difficulty in the development of a logistics agents that does not have the technology to analyze the vibration and shock on the railway although their needs.

In order to secure competitiveness of the continental logistics market for the "Entry to Eurasia Logistics Market" and "Establishment of an Integrated Logistics Network on the Korean" of Korea, researches were planned for the fourth year. This paper is about the results of the first year of the initial study.

In this study, research securing the shock vibration characteristic suitable for Korean road and railroad environment. And in order to construct a low-vibration logistics system, it is important to select the suitable material for shock vibration characteristics by understanding the dynamic characteristics of various types of anti-vibration materials. The most important factor of dynamic characteristics is damping capacity, which is reducing vibration and amplification due to resonance. In this paper, studied the method of deriving the damping capacity among the dynamic characteristics of the anti-vibration material and derive the damping capacity of various materials.

2. STUDY ON VIBRATION CHARACTERISTICS PROFILE

In the first year, the vibration values of the trucks (Asan-Obong Station) and freight trains (Obong Station - Busan Station) were measured. As a result, the vibration level was high in the vertical direction. The truck was 0.66Grms and freight train was 0.46Grms. The measured maximum vibration during road transport may reach 30G and average vibration is 10 ~ 20G. The average vibration level is similar shown in the electronic product standard. Also, in the PSD(Power Spectral Density), the values in the 5-7 Hz band tend to be larger than those in ISTA and ASTM Truck. On the other hand, a somewhat larger part in the frequency band of 50 Hz or higher is less important than the low frequency band because it is relatively damped by the buffer material of the package cargo. In the railway, the vibration during transportation was relatively small and the maximum was 6G. Especially, it is considered that the separation of the locomotives is carried out in the way of connection with the wagons after stopping 1m before the locomotive separation connection. Instead, it was 12G at maximum vibration during transport. The PSD shows that the 8-9Hz band is slightly higher than the ISTA or ASTM Rail values and the high frequency band of 40-200Hz is somewhat larger. As mentioned above, the latter case is relatively less attenuated by the cushioning material of the packed cargo, so it is less important than the low-frequency 8-9 Hz band.



(a) PSD profile - Truck (b) PSD profile – Rail

Figure 1 PSD profile

3. EVALUATION OF ANTI-VIBRATION MATERIAL

3.1 Theory

A great number of laboratory tests shows that the cyclic stress-strain curves are high nonlinear and constitute a closed hysteresis loops. These testing results seem to indicate that damping properties are especially of hysteretic type, and not viscous as those corresponding to the Kelvin-Voigt model. Several methods use for damping evaluation of the experimental registered hysteretic loops and determine the damping ratio as:

$$D = \frac{1}{4\pi}\frac{\Delta W}{W} \tag{1}$$

Where D is Hysteretic damping and W is the maximum stored energy, ΔW is the energy loose per cycle represented by the area enclosed inside the hysteresis loop.

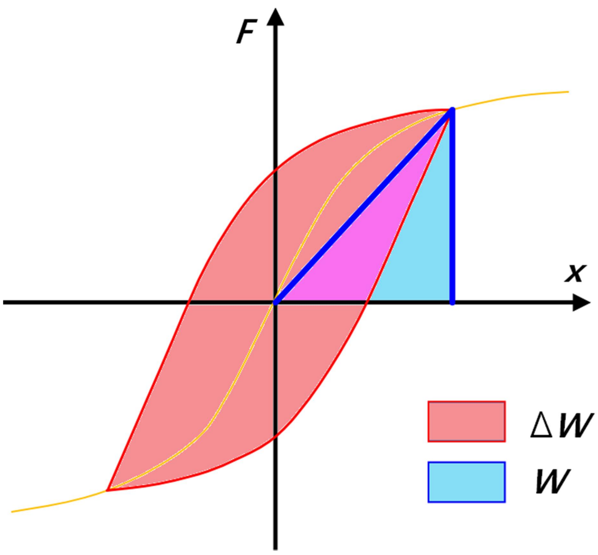
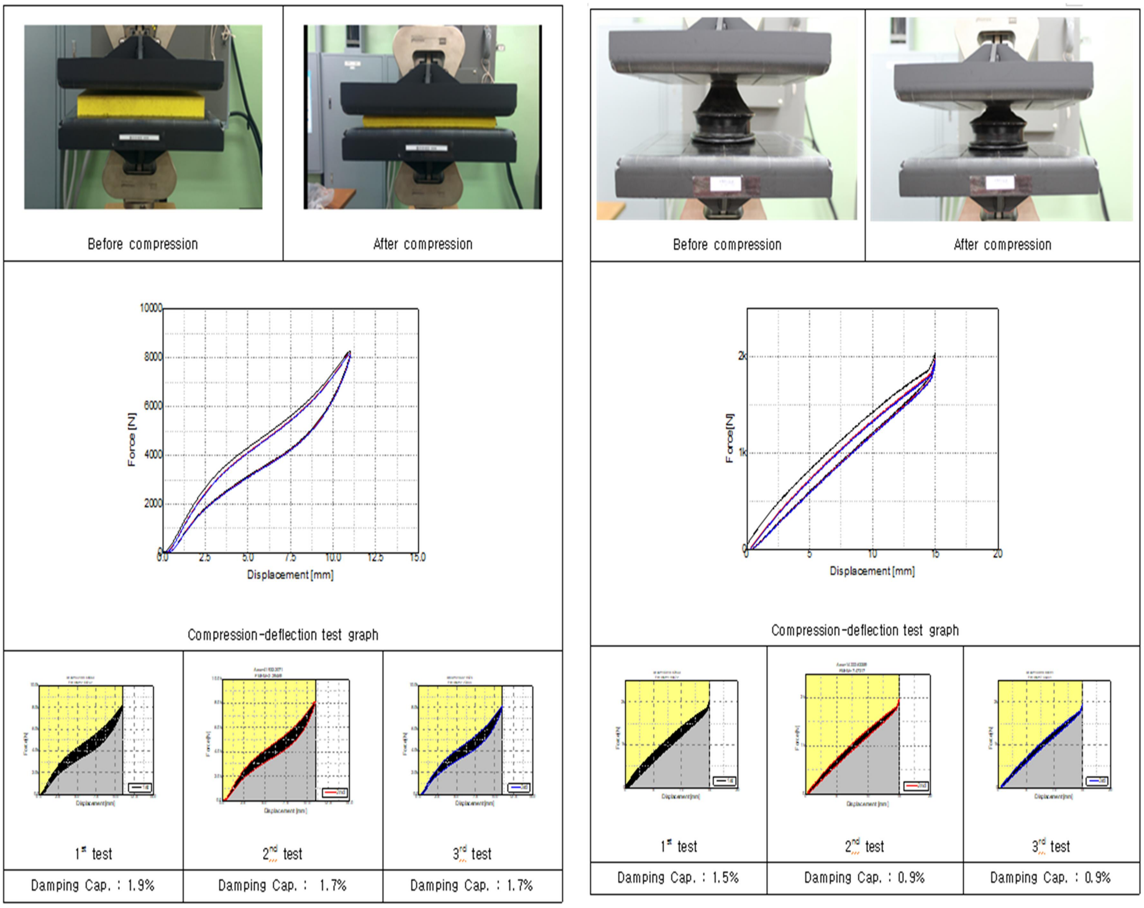


Figure 2 Hysteretic damping definition

3.2 Procedure of test

Compression-displacement tests using a universal testing machine were conducted to test the physical properties of 27 types of anti-vibration materials. The test was used to derive the displacement with respect to the load, and the available load range for each anti-vibration material was determined. Hysteresis damping capacity was derived from the compression-displacement graph. In the case of the air mount, because the load range varies according to the internal air pressure, two compressed air pressures were selected and tested. The test for 27 anti-vibration materials were carried out under the same conditions and the results for the total of 3 repetitive compressions were derived. The damping capacity was calculated separately using each test data, and the data were compared and evaluated by averaging the three damping capacities.



(a) Chloroprene mat test

(b) Rubber mount test

Figure 3 Compression-deflection test

3.3 Results

The test results show that the arithmetic mean damping capacity shows the distribution of Table 1. The results showed that the damping capacity of chloroprene mats was the highest and the foam rubber was the second highest. The wire mount was also found to have a damping capacity close to the chloroprene mat and foam rubber. In the case of air mounts, which are theoretically known to have small damping ratios, some of the test results show somewhat higher damping capacity. The accuracy of this test will be verified by comparing with the damping ratio derived from the half-power bandwidth method through the impact test. In addition to damping capacity, dynamic characteristics such as natural frequency and dynamic elastic modulus of anti-vibration material will be studied and it will be used as a key factor in designing low-vibration logistics system.

Table 1 Hysteretic damping test results

Specimen	Detail Specification		Damping Capacity [%]
Foamed Polyurethane mat	220k		3.3
	300k		1.7
	400k-1		2.3
	400k-2		2.0
	500k		1.3
Foamed rubber mat	SHB 30t		3.1
	SHB 50t		3.7
	SMB 25t		4.1
	SMB 30t		3.1
	SHB 30t		2.5
	SHB 50t		2.4
	SMB 30t		2.2
Chloroprene mat	25t 80k		2.4
	50t 80k		3.6
	50t 110k		5.0
NDI-Polyurethane mount	H=45		1.5
	H=50		1.3
	H=60		1.8
	H=70		1.8
Elastic mount	-		1.1
Wire –mount	Helical type 120kg		3.7
Air mount	Style #116-1	40 psi	2.9
		80 psi	4.5
	Style #113	40 psi	1.3
		60 psi	2.7
	Style #153-2	20 psi	1.2
		40 psi	1.5

4. CONCLUSION

Through this study, initial vibration characteristics profiles for Korean roads and railroads were derived. Such a vibration characteristic profile is expected to be used not only as a material for the development of a low - vibration logistics system but also to be used in various other industrial fields. In this paper, the method of calculating the damping capacity of the anti-vibration material by using the hysteresis loop is presented, and the damping capacity is derived by the method of testing various types of anti - vibration material. The test values calculated by the test will be verified by comparing the damping ratio derived from the impact test with the half-power bandwidth method.

The damping value calculated through the comparative verification will be used as a design parameter for the development of a low-vibration logistics system.

5. ACKNOWLEDGEMENTS

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