Performance Evaluation of Friction Slip Damper with Sets of Disc Springs and Bolt for Bridge

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Summary

Introduction of vibration control systems for bridges have advantages in terms of both seismic performance and construction cost. In applying the bridge vibration control system, it is necessary to use an appropriate model of the damper for design. The purpose of this paper is to establish the design model for the friction slip damper. The damper tests subjected to calculated response displacements for design earthquake motion were carried out, and the damping force-displacement relation was evaluated. As a result, design model for the damper were proposed.

Keywords: friction slip damper; design model; velocity dependency; hysteretic absorbed energy.

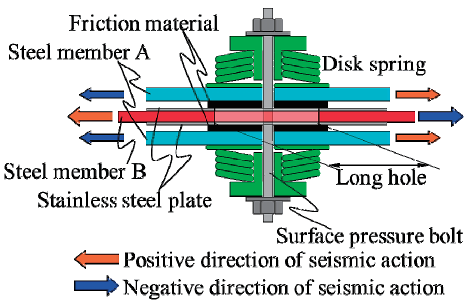

Fig.1: Disc springs/bolt set

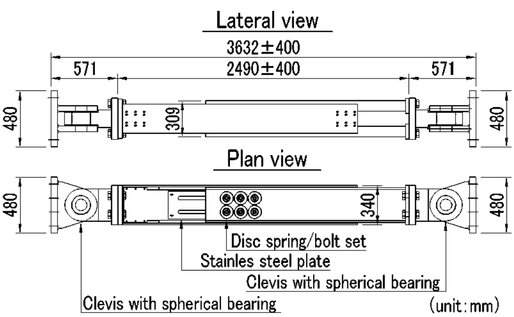

Fig.2:Friction Slip Damper Used in the Experiment

1. Introduction

This paper attempts to develop a design model for a friction-slip damper with sets of disc springs and bolts (hereafter, 'brake damper') considering various dependencies. The study was based on the results of experiments involving forced deformation of a full-size device. The device's fundamental characteristics were confirmed by sine wave input, and then its performance during an earthquake was evaluated by inputting seismic response waves obtained by analysis.

2. Overview of brake damper

Fig.1 shows the basic structure of the friction-slip damper (hereafter, 'disc springs/bolt set') used in this paper. The friction material fixed to steel member A and the stainless steel plate fixed to steel member B slide over each other in response to cyclic loading in the positive and negative directions shown in the figure, and vibrational energy is converted to frictional heat energy. A normal force on the friction surface is generated by tightening the surface pressure bolt (high-strength bolt), and this normal force is stabilized by the disc springs. A long hole corresponding to the stroke is created in steel member B and the stainless steel plate so that they are not struck by the bolt. Phenolic

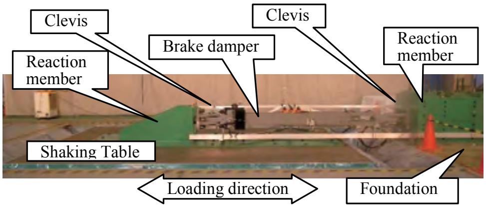

Fig.3: Experimental Method

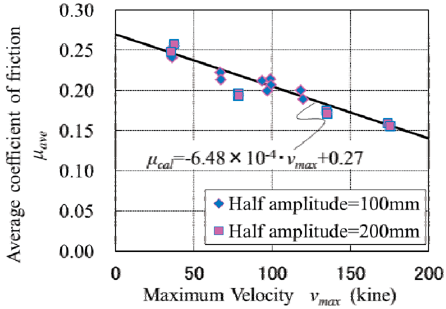

Fig.7: Average coefficient of Friction - Maximum Velocity Relationship

resin with high durability and abrasion resistance is used in the friction material. If necessary, it is possible to increase the number of friction surfaces.

The sliding frictional force can be easily calculated multiplying coefficient of friction by number of friction surfaces, number of disc springs/bolt sets and tightening force per surface pressure bolt.

Fig.2 shows the friction-slip damper used in the experiment.

3. Experimental Study of Basic Performance

This experiment was carried out in order to understand the basic performance of the brake damper. It was carried out by dynamically inputting forced displacements using the real brake damper shown in *Fig. 3*.

Fig.7 shows the relationship between average coefficient of friction and maximum velocity v_{max}. The relationship between average coefficient of friction and maximum velocity is almost linear. Whereas the coefficient of friction for static action is 0.34, the average coefficient of friction at, for example, 154 kine, is half that; and so it is clear that velocity dependence must be evaluated appropriately in bridge design. With regard to displacement dependency the difference in average coefficient of friction can be considered small in cases with identical maximum velocity.

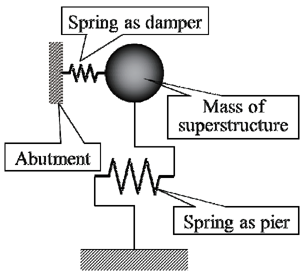

Fig.10: Single Degree of Freedom system

4. Evaluation of coefficient of friction during earthquake

The previous section identified velocity dependency as properties of the brake damper. Using the same experimental method as in the previous section, forced input of seismic response wave displacement was conducted to evaluate coefficient of friction during an earthquake. Seismic response waves were created by calculating using the single degree of freedom system shown in *Fig.10*, assuming that the damper is inserted between the superstructure and the bridge abutment. The input conditions for the seismic response analysis were combinations of seismic motion, natural period of the pier, seismic intensity of pier yielding.

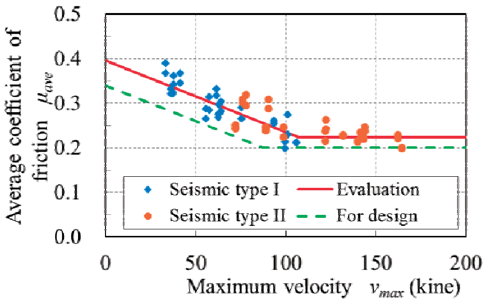

Fig.12: Average Coefficient of Friction - Maximum Velocity Relationship

Fig.12 shows the relationship between average coefficient of friction μ_{ave} and maximum velocity. It is possible to draw the evaluation formula line and design formula line in safety aspect, shown in *Fig.12*.

5. Conclusion

This study conducted an experiment to verify the performance of a damper. As a result, design model for the damper were proposed.