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Performance of Friction Dampers and Rotational Friction Dampers

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ABSTRACT

Friction Dampers (Frictional Dampers) operate based on the principles of a Coulomb damper or a friction pad that converts kinetic energy into heat through friction. Essentially, friction dampers help a structure to elastically vibrate and dissipate seismic energy in a reversible manner.In recent years, research has shown that the use of friction dampers is one of the most effective methods for absorbing and dissipating earthquake energy. They are also among the simplest types of energy dissipation devices used in structures. The mechanism and operation of these friction dampers involve converting the kinetic energy generated by an earthquake into thermal energy through the friction between the damper plates. During this process, the energy is dissipated, and the resulting hysteresis loops represent the energy dissipation capacity of the system.

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Introduction

The objective of the present study is to introduce a new friction damper with low manufacturing and installation costs and high efficiency. This friction damper is constructed from standard steel profile components and brake pads, commonly referred to as the Friction Brake Pad (FBP). This friction device dissipates vibrational energy through the friction generated by the sliding of the brake pads against steel surfaces, producing stable hysteresis curves.

The damper essentially functions as a simple connection with a friction bolt. Naturally, the friction between the contact surfaces prevents relative movement of the connection; however, when slipping occurs, a portion of the input energy is expended in overcoming the frictional force, resulting in the generation of heat energy. In other words, a fraction of the input energy is dissipated within the connection.

These dampers, in addition to their simple design, can be produced and installed at a very low cost. By utilizing the prestressing force of bolts, the friction force can be effectively controlled.

Friction dampers are among the simplest types of energy dissipation devices used in structures. These devices are designed with friction connections accompanied by oblong holes. When the applied force on the friction connection exceeds the slip force of the connection, the surfaces suddenly begin to move. After movement, depending on the material properties of the contact surfaces, the friction force changes relative to the initial slip force, and the range of displacement over which these changes occur also varies. Therefore, if a specific friction force can be established in a connection or structural member such that this force is controllable, the desired damper is effectively produced. Types of friction dampers include rotational and translational friction dampers.

Some of the advantages of these dampers are as follows:

- Highly effective absorption of seismic energy and reduction of structural damage;
- No change in behavioral characteristics and slip level over time due to the rotational mechanism;
- No need for maintenance or servicing after installation;
- No need for replacement after the main earthquake and sustained performance during aftershocks;
- Simple and quick installation;
- Ability to adjust or replace after an earthquake;
- More economical compared to similar systems worldwide;
- Ideal for retrofitting existing structures;
- Versatile applications and suitability for exposed use due to their aesthetically pleasing appearance;

- Control of lateral displacement of the frame, increased energy dissipation within the system, enhanced lateral stiffness of the frame, and consequently, reduction of the structure's fundamental period.

Pal Friction Damper

This system was first introduced by Pal. The mechanism of this system involves creating sliding friction surfaces at the intersections of bracing members. For building frames, these dampers can be used in X-bracing tension members, single diagonal braces, and chevron braces. This type of damper is composed of several sets of steel plates that provide a large frictional surface area and are fastened together by high-strength steel bolts. These dampers do not slip under wind loads; however, under significant seismic excitations and for an optimal load level for which they are designed, they slip before the structural members yield.

They become active and dissipate a significant portion of the earthquake energy. This process allows the structure to remain elastic and delays its yielding until a more severe earthquake occurs. Another characteristic of a structure equipped with friction dampers is that its natural period changes with the amplitude of vibration[1], thereby preventing the phenomenon of resonance.

Figure 1. Pal Friction Damper Used in Diagonal Bracing

Rotational Friction Damper

The sliding surfaces in rotational friction dampers are always protected due to their rotational operating mechanism and are not exposed to environmental conditions. Therefore, it can be expected that the sliding zone behavior of this damper remains unaffected by environmental factors

1. Resonance

over time and exhibits stable performance.In contrast, in Pal translational friction dampers, part of the friction area is always exposed to

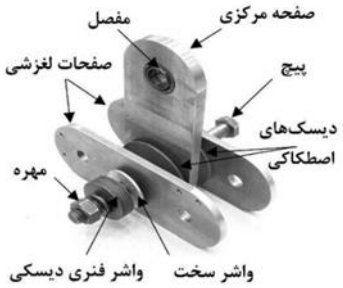

Figure 2. Components of the Rotational Friction Damper

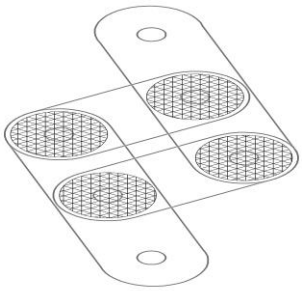

Figure 3. Schematic View of Protected Friction Plates in the Rotational Friction Damper

Figure 4. View of Rotational Friction Dampers in Chevron Bracing

Tests Conducted on Friction Dampers

Thanks to friction pads with advanced technology, friction dampers can be used for thousands of cycles with only a 2 to 5 percent reduction in seismic performance. Although such a number of

cycles is unlikely to occur during the actual lifetime of an earthquake, the tests demonstrate high reliability and very low uncertainty in exhibiting the desired behavior over various cycle counts.

Figure 5. Friction Damper

Figure 6. Sample Test Conducted on a Rotational Friction Damper in Japan

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