Product Introduction

Passive Switching Type Oil Damper (Seismic Isolation Damper for Narrow Land in City)

NAKAHARA Manabu

1 Introduction

There are a number of measures taken to protect people and buildings from earthquake-related damage. “**Quake resistant** structure” reinforces "resilience and strength of buildings" to withstand the seismic force given to the buildings.

“**Vibration control** structure” weakens the seismic force given to the building with vibration suppression devices. We can say that they are both technologies used to respond to seismic force given to the building as much as possible.

On the other hand, “**seismic isolation** structure” refers to "evading (isolating itself from) the force itself that is given to the building" and drastically reduces building vibrations. Seismic isolation structures change strong and severe vibrations caused by earthquakes into big and slow vibrations. It not only prevents the building itself from being damaged but also prevents furniture and facilities/equipment within the building from moving/falling over. Seismic isolation has also been confirmed to be effective in actual earthquakes.

Quake resistance/vibration control/seismic isolation (Refer to Glossary "Quake Resistance, Vibration Control, Seismic Isolation" on P44)

The device called "isolator" is used to insulate the building from the ground. Isolator is made of seismic isolation rubber, slide bearing, and rolling bearing. By constructing a building on top of these isolators, they prevent the vibrations of the ground from directly affecting the building. However, it is not that they can completely float the building in the air like a magic carpet, so slow vibrations still affect the building, even if the seismic isolation structure drastically reduces the strong and severe vibrations of earthquakes. Isolators cannot stop the vibrations even after the earthquake stops.

KAYABA SYSTEM MACHINERY Co.,Ltd. manufactures dampers to quickly stop such vibrations in case of major earthquakes (Photo 1).

Photo 1 Example of a seismic isolation structure (KYB's plant)

2 Issues in Applying the Structures to Narrow Land

In order for buildings to evade earthquakes, seismic isolation structures help buildings to freely move in isolation from the ground; however, but this means that the buildings would move from the ground. The conventional seismic isolation structures require at least 60 cm margin around the building (movement limit for the current isolator - especially seismic isolation rubber for buildings - is 60cm). However, it is difficult to secure the margin that is required by seismic isolation structures in urban areas, due to the fact that high-rise buildings are built closely together.

In general, a building's movement can be reduced by increasing the number of dampers and increasing the stopping force (damping force), but the building movement and acceleration have an antinomic relationship (quickly stopping the movement within a small distance creates larger reaction). If you increase the number of dampers to reduce the margin around the building, it doesn't achieve the effect of not transmitting the vibration of small to medium earthquakes, which are relatively frequent, which is the purpose of seismic isolation.

3 Objectives of the Product

"Passive Switching Type Oil Damper (Seismic Isolation Damper for Narrow Land)", which is introduced in this review, was jointly developed with Taisei Corporation. With the aim of resolving the aforementioned antinomic relationship, we aimed to improve the seismic isolation structure with the following objectives.

3.1 Objectives of seismic isolation structure for narrow land

1. Provide buildings with the optimal seismic isolation structure with the margin of 30cm or less. (Half of what is conventionally required as margin)
2. Sufficiently exert the functions of seismic isolation, which prevents vibrations from earthquakes from being transmitted to the building, up to intensity 5.

3. In major earthquakes, it bring out great damping force to control the vibrations before the building hits the walls of a narrow isolation layer.

Fig. 1 shows the comparison of earthquake scale and effect between the conventional seismic isolation structure and seismic isolation structure for narrow land.

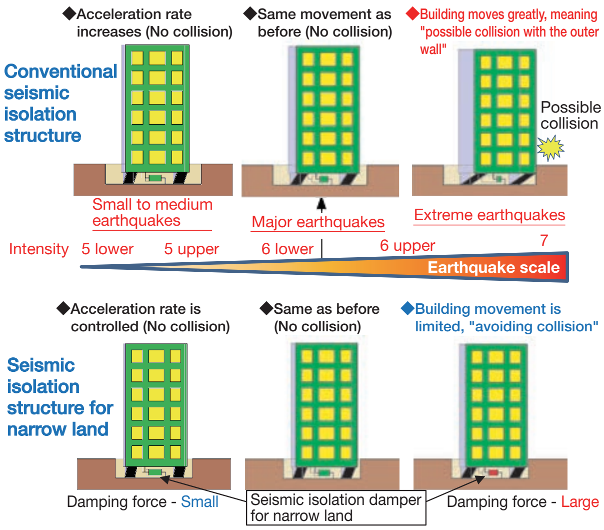

Fig. 1 Comparison of earthquake scale and effect between regular seismic isolation structure and seismic isolation structure for narrow land

3.2 Requirements for seismic isolation damper for narrow land

1. One damper must possess the 2 properties of high damping force, which is brought out to prevent buildings from collision during major earthquakes, and low damping force, which is effective in small to medium earthquakes.
2. Switching of the above high damping force and low damping force must be mechanically done in the given displacement (damper stroke) without using electric signals.

By using this damper, the maximum seismic isolation effect can be achieved in small to medium earthquakes, which are frequent. It can also prevent damage from building collision in areas with less margin around the building in case of major earthquakes, which are rare.

4 Structure of the Developed Damper

Fig. 2 shows the basic hydraulic circuit diagram for this developed damper. You can switch between 2 types of damper force. (Although this circuit diagram has been simplified for this review, this has already been released as Japanese Unexamined Patent Application Publication No. 2014-159850)

The area in the two-dot chain line indicated in (1) uses the same damper as KYB's standard seismic isolation damper BDS-type oil damper (Building Damper hi-Speed type). We call the state, in which the damping force is brought out solely by this section, “high damping mode”.

The area in the two-dot chain line indicated in (2) is the valve block that is specially installed on this damper. This

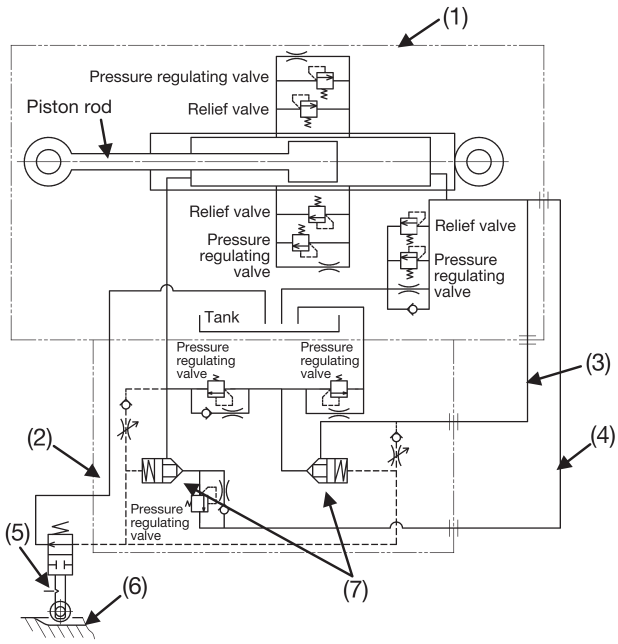

Fig. 2 Hydraulic circuit diagram

valve block is connected to (1) damper via the (3) and (4) pipes.

When oil runs through the (2) valve block, the amount of oil that runs through the valve for damping force installed on the (1) damper is reduced, resulting in smaller damping force even if the damper functions in the same speed. We call this state the “low damping mode”.

The valve that switches between the “high damping mode” and the “low damping mode” is the (5) shut-off valve (mechanical). This switches the oil flow by pressing the plunger sticking out of the valve chassis.

In this damper, this is normally open to let oil flow. However, it is set so that oil flow is shut off when the plunger is pressed. (6) Detection rod is installed to pair with this (5) shut-off valve.

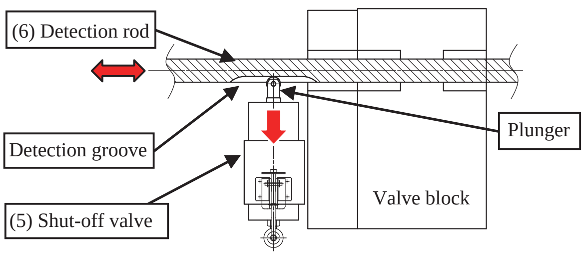

Fig. 3 (5) Shut-off valve and vi. detection rod

Fig. 3 shows how the (5) shut-off valve and (6) detection rod are installed. The detection rod comes with a groove (detection groove) in the middle. The tip of the plunger rests within this detection groove in a normal state, and the plunger is not pressed. So this is in the “low damping mode”. The (6) detection rod is installed on the damper's piston rod and moves in the same movement as the piston rod. When the piston rod moves more than the length of the detection groove (in major earthquakes), the part of the (6) detection rod without the groove moves to where the plunger is. When this happens, the plunger is pressed by the outer surface of the (6) detection rod, switching the (5) shut-off valve and shutting off the oil flow.

The (5) shut-off valve comes with the detent mechanism and maintains the switched state.

(5) Shut-off valve only shuts off the flow channel in the back of the (7) logic valve. This flow channel leads to the tank room, and oil normally flows without resistance. In this state, the (7) logic valve moves freely and guides the oil, which comes from the (3) and (4) pipes, to the valve within the (2) valve block.

Since (5) shut-off valve shuts off the oil channel in the back of the (7) logic valve, (7) logic valve can no longer move. It stops the oil, which comes from the (3) and (4) pipes, and stops the oil flow to the valve within the (2) valve block.

As a result, force is only created with the (1) internal valve, switching from the “low damping mode” to the “high damping mode”.

Below is the summary:

1. Damper's piston rod in the low damping mode moves more than the length specified for the detection groove due to a big earthquake.
2. The detection rod, which is attached to the piston rod, presses the plunger for the shut-off valve.
3. The shut-off valve switches and stops the logic valve's movement by shutting off the oil flow.
4. Due to the fact that the logic valve cannot move, the flow of the oil, which was flowing in the low damping mode, to the valve within the valve block stops.
5. Since oil does not flow to the valve within the valve block, the valve within the damper alone processes the oil flow, bringing out damping force.

Photo 2 shows the appearance of the damper. You can see the valve block, pipe, and the detection rod on the outside of the damper.

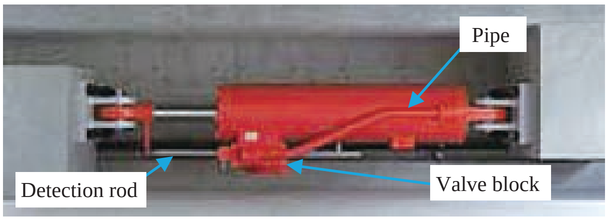

Photo 2 Appearance of a seismic isolation damper for narrow land

5 Comparison of Damping Capabilities

I would like to compare the difference in the effect between this developed damper, which possesses the function to switch the damping force, and KYB's standard damper.

Fig. 4 shows how a standard damper works. This diagram shows a graph, which is part of the analysis drawing. It indicates the movement (displacement/damper stroke) gradually being increased. When the displacement increases, the speed also increases, resulting in greater damping force; therefore, the analysis result looks like a swirl.

Fig. 5 shows a graph comparing the developed damper and standard damper.

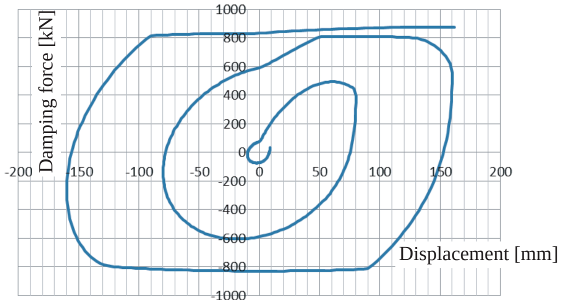

Fig. 4 Diagrammatic drawing for displacement - damping force of a standard damper

The graph was drawn under the same condition as Fig. 4. However, unlike Fig. 4, this shows a section immediately after the vibration start in which the damping force was low. This is the “low damping mode” segment. In this graph, the switching point to the “high damping mode” is 50mm, so you can see that the damping force suddenly increases where it is indicated with a red circle.

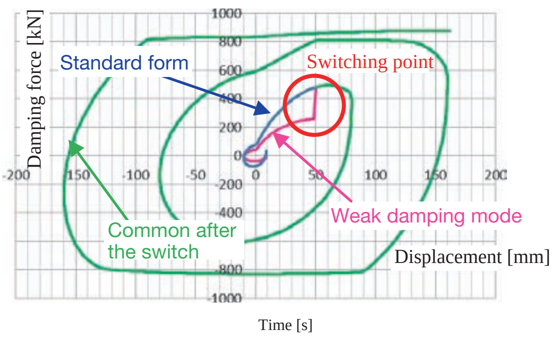

Fig. 5 Diagrammatic drawing for displacement - damping force to compare seismic isolation damper for narrow land and standard damper (overwritten)

Fig. 6 indicates the horizontal axis in the result of Fig. 5 shown in terms of time. The graph shows the displacement and damping force. You can see that the damping force greatly increases halfway, while the displacement change is constant (in other words, the speed is consistent).

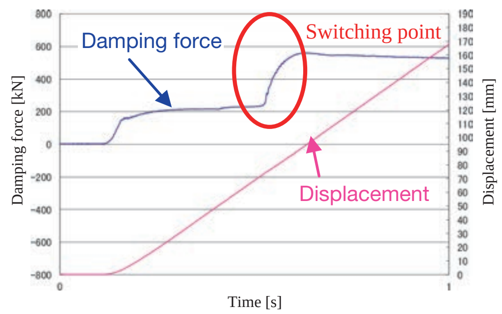

Fig. 6 Diagrammatic drawing for damping force and displacement

6 Installed Buildings

There are several buildings in which this developed damper was used. I'd like to introduce some examples.

6.1 ZEB for the Taisei Technology Center of Taisei Corporation (Photo 3)

This building is the evaluation/experimentation facility “Zero Energy Building”(ZEB) of Taisei Corporation, which is a joint developer, and Taisei Corporation received the 16th Japan Society of Seismic Isolation Prize with this building.

Photo 3 Appearance of ZEB for the Taisei Technology Center of Taisei Corporation

6.2 Hulic Shinjuku Building (Photo 4)

This "urban seismic isolation" utilizes a seismic isolation structure that enables them to effectively use the valuable land in Central Tokyo.

It is the building at the center of the picture, but you can see that the surrounding buildings are close.

This building uses a natural ventilation system as a means to care for the environment and uses only natural ventilation between seasons. It also takes in sunlight via the ceiling of the rooms at all times regardless of the changing seasons/time (position/height of the sun) by using the natural lighting system (specially-designed fixed louver) without using power.

This building received "5 stars" from the Development Bank of Japan Inc., which is the highest ranking of the "DBJ Green Building Certification".

Photo 4 Hulic Shinjuku Building appearance

7 In Closing

I would like to express my deepest gratitude for everyone who has provided support for this development, including departments of KYB, relevant affiliates, and the Engineering Research Institute of Taisei Corporation.

The developed damper was approved by the Ministry of Land, Infrastructure, Transport and Tourism as a seismic isolation component at the end of last year (certificate number: MVBR-0498). If you are considering buildings with seismic isolation structures in areas with closely built buildings, please don't hesitate to contact KYB.

Finally, I would like to express my appreciation for those who kindly gave me the permission to use these pictures.

Author

NAKAHARA Manabu

Joined the company in 1991.
Joined Engineering Dept. in KAYABA SYSTEM MACHINERY Co.,Ltd.
Engaged in oil damper development work.