Messages from Modern Inventors to the Next Generation

Season 2

8. *Attaining the Ultimate in Seismic-isolation and Vibration-control Technology*

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Everybody knows for a fact that buildings shake when earthquakes occur. But Mr. Katsumata and his colleagues, in response to requests from the medical field and precision manufacturing facilities, faced the challenge of developing the technology to prevent buildings from shaking during earthquakes. Today, there are many buildings that use “seismic-isolation” systems. These are systems that separate buildings from the ground on which they lie so that the movements from earthquakes do not get passed on to the buildings. There are also buildings with “vibration-control” systems, which focus on immediately stopping vibrations in buildings when growing.

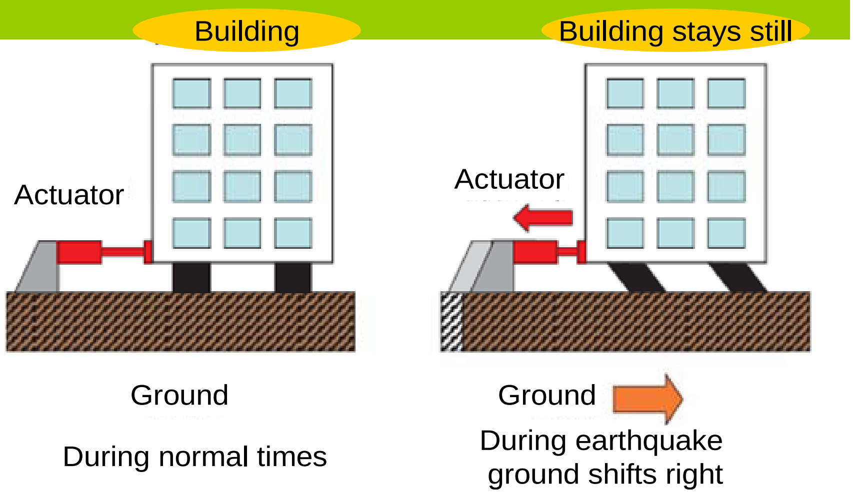
It took more than twenty years before “active seismic base isolation” technology could be put into practical use. This is technology that is a combination of both “seismic-isolation” and “vibration-control” technologies mentioned above. In this report, Mr. Katsumata, the developer, tells us about his long struggle, and his pleasure in succeeding, after so many years of hard work.

About the Product and Technology

Our active seismic base isolation technology is called Laputa 2D, which is a system that combines both seismic-isolation and vibration-control technologies. We were the first in the world to use this system in a real building. Let me explain the basic principle of the system. Suppose, for example, that the ground moves to the right by 10cm due to an earthquake. The vibration-control system immediately moves the 1st floor of a building equipped with seismic-isolation rubber bearings to the left by exactly the same 10cm. As a result, the building essentially stops moving and remains motionless.

How Laputa 2D Works

Based on the Laputa 2D system, the building experiences absolutely no shaking, as if it were floating in the air. This is because when a sensor detects shaking, the system causes the actuator to move in the opposite direction of the ground movement (toward the left, as seen below in the illustration on the right).



What inspired you to invent and develop the product and technology?

Buildings installed with modern seismic-isolation systems were developed in the 1980s. Some people years ago used to believe that if soft rubber was placed underneath buildings, seismic movements wouldn’t be transferred to the buildings. We know, however, that by doing this, the buildings would sink. In this context, laminated rubber bearings were developed. These are pieces of rubber that have been reinforced by inserting layers of steel sheets between the layers of rubber. These rubber bearings successfully isolate buildings from earthquakes that move the ground back and forth horizontally.

Despite the rubber absorbing the ground-shaking motion, the residual movement in the buildings still continued because the buildings themselves remained attached to the ground. This residual movement in the buildings was noticed in items that move on wheels such as carts and gurneys that moved in hospitals during earthquakes. This problem could be fatal, jeopardizing human life.

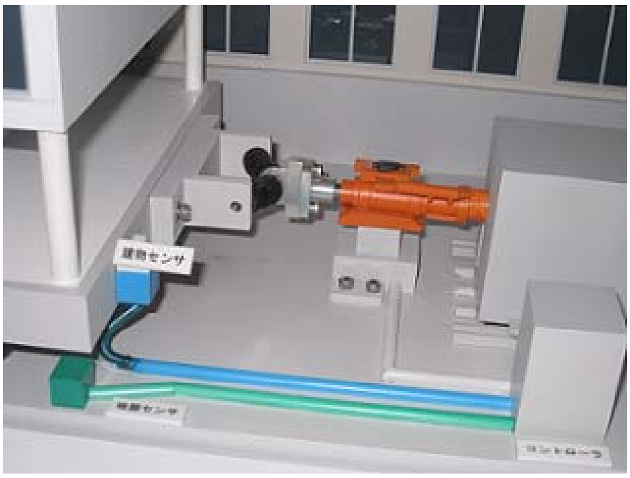
Then one of our research members, in considering how we could further reduce seismic movement, had an idea around 1987 or 1988. The idea was to move buildings the same distance (in the opposite direction) that the buildings were moved by earthquakes. In tests, we successfully reduced the amount of seismic movement in buildings to about 1/50 of the actual ground shaking.

What specific ideas and difficulties have you faced in inventing or developing the product?

We activated actuators by using computer signals in order to test scale-model buildings equipped with active-base-isolation systems. When we did this, we found that abnormal movements occurred. After much trial and error, we learned that the actuators turned out to work well when we inserted soft springs between them and the buildings, and that they did not work properly when connected directly to the buildings. Later, we learned that this type of active vibration-control technology using actuators was practically a standard feature in the field of automobiles and train cars, etc., and so studied very hard about it.

Unfortunately, however, computers at that time did not have the speed to instantly calculate the distant that the earth moved. In addition, there weren’t actuators big enough to move the buildings the precise amount necessary. Furthermore, due to the level of engineering technology at the time, it was practically impossible to use on actual buildings. As a result, this technology didn’t get to see the light of day for 20 years. Nevertheless, active vibration-control technology was being used over the years to stop vibrations in skyscrapers caused by wind. Plus, by applying friction, we were able to advance technology that reduces shaking in skyscrapers caused by earthquakes.

Over time, we sensed a strong surge in demand from people wanting to continue using buildings during earthquakes in the same way that they do when there are no earthquakes. As a result, we continued to make more attempts. Then, at last, with the 20 years of advances made in technology, we were able to create buildings that don’t shake even in earthquakes, fulfilling our longtime dream.



A model actuator (in orange)

What is fun and enjoyable for you as an inventor, researcher, and developer?

Over time, proven technologies are gradually put into actual use in buildings, which are structures that last for many, many years. On the other hand, new technologies require a long time period of time before they can be proven, so are less likely to be used. Good ideas, while they sound good, are not immediately put to use, so this results in a lot of frustration for us. That's what made me all the more happier when our long-nurtured technology was finally adopted. As it is today, new technology that can be put to use quickly on actual projects is being developed. It’s a joy to me to see newly developed technology being put to practical use on actual buildings.

There aren’t that many opportunities to witness the actual performance of anti-earthquake technology. If we ever get the chance to experience this technology in action during weak earthquakes that cause little harm to lives and livelihoods, we would be really lucky. It is during destructive, huge earthquakes, especially those which harm people’s lives, when these quakeproof technologies get a chance to perform to their full potential. But no one ever wants a big earthquake to happen, so it’s a paradox! Our research team has been working on the task of protecting human lives during great earthquakes that happen once every a 100 years. Unfortunately, we still haven’t been able to reach any conclusion. Therefore, just like we were handed down this task from our predecessors, so will we need to pass it on to you, the next generation. We, along with our predecessors, will be looking forward to the day an outcome is reached. Until that time comes we will be waiting with excitement, possibly from our graves, however.