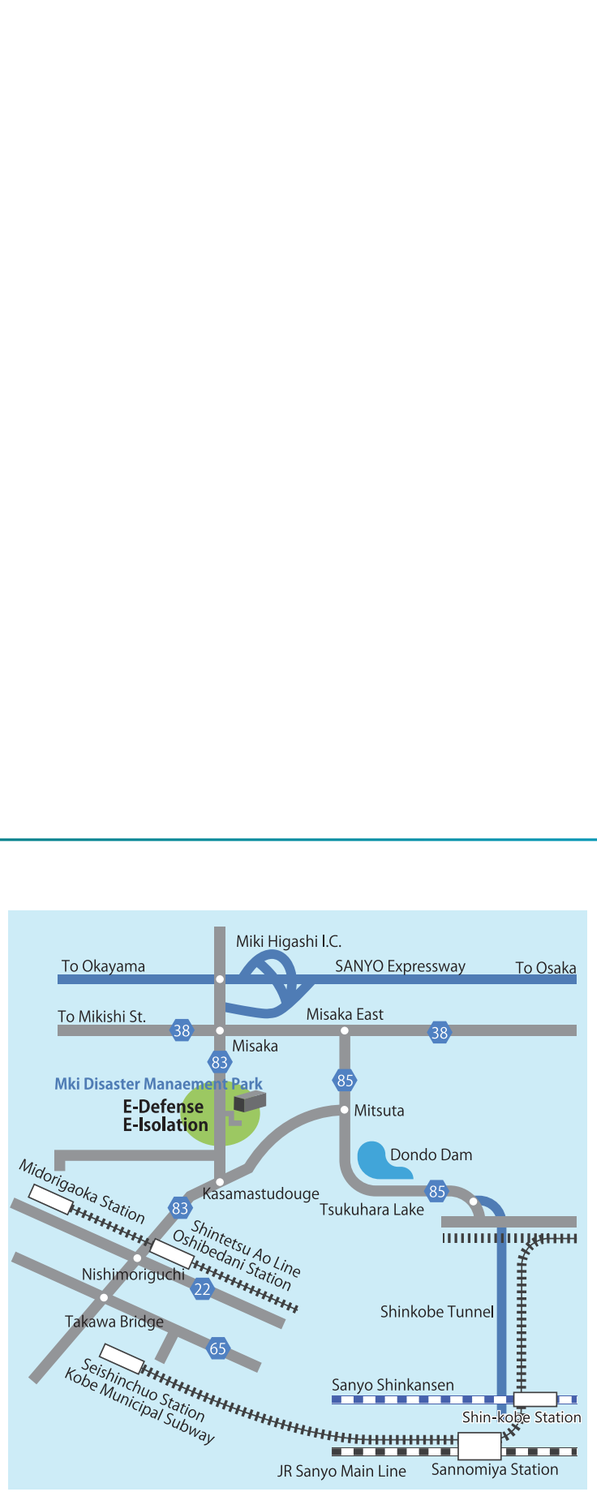


Access					
	JR	Shin-kobe Station	Taxi	⟶	about 40min
	Kobe Municipal Subway	Seishinchuo Station	Taxi	⟶	about 25min
	Shintetsu Ao Line	Oshibedani Station	Taxi	⟶	about 10min
	Shintetsu Ao Line	Midorigaoka Station	Taxi	⟶	about 10min
	Shintetsu Ao Line	Midorigaoka Station	Bus	⟶	about 20min

2023/03/Ver1.0 ENG

Further Development of Seismic Isolation and Response Control Technology

Establishment of Full-Scale Seismic Isolation Testing Facility

Tokyo Institute of Technology
Japan Seismic Isolation Laboratory
Japan Society of Seismic Isolation

The Strategic Innovation Program (SIP-2), Cabinet Office, Government of Japan

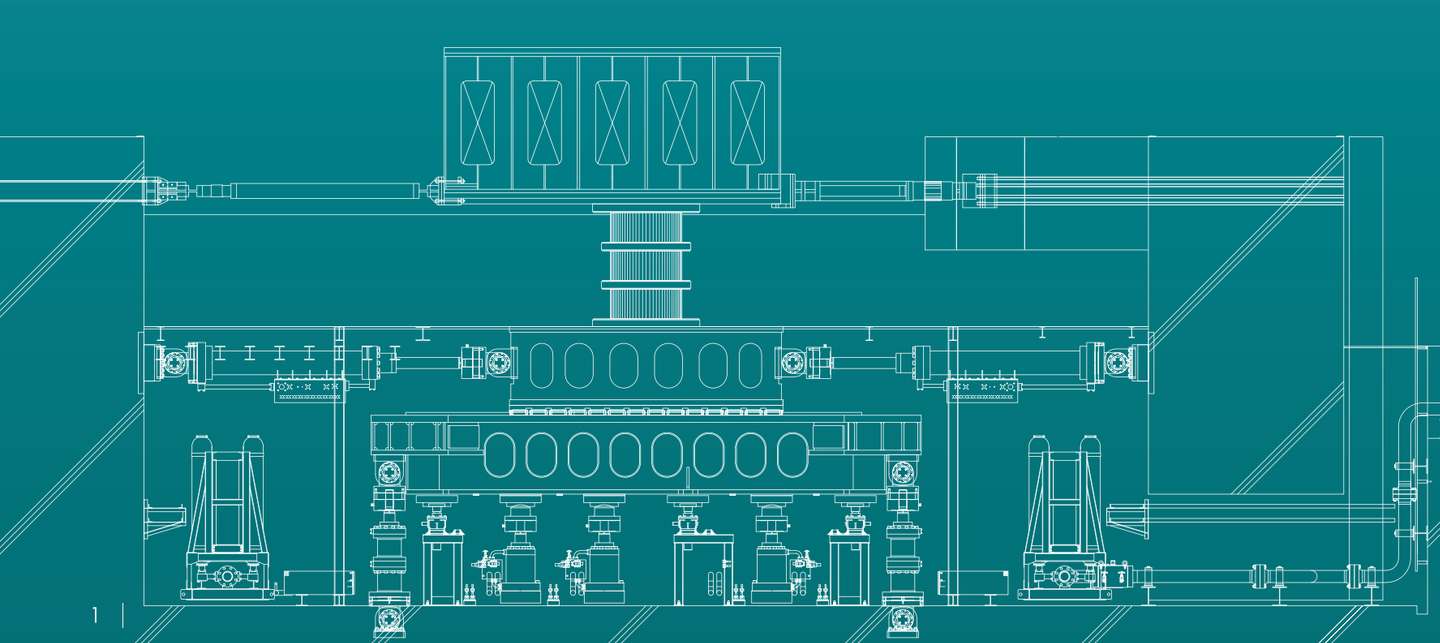
Kyoto University, Tokyo Institute of Technology, and the Japan Seismic Isolation Laboratory have applied to The Strategic Innovation Program (SIP-2) hosted by the Cabinet Office in the field of "Strengthening National Resilience (Disaster Prevention and Mitigation)" in 2021. The research project, "Development of Analysis Methods Using Dynamic Testing Machines with High-Precision Load Measurement Mechanisms," has been adopted as a result. We promote as subject of our research the development of large-size dynamic testing machine technology, and at the same time, we propose the use of the testing machine for verification as a joint-use facility for social implementation.

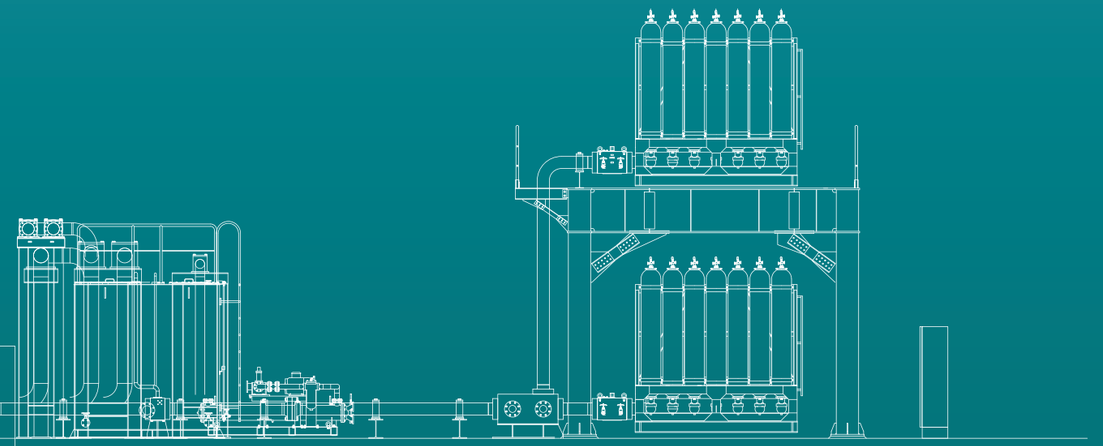
Japan Seismic Isolation Laboratory

The Research Promotion Organization for Seismic Isolation was established in April 2021 in order to operate the world's first full-scale seismic isolation testing facility with a high-precision load measurement mechanism. As seismic isolation and response control components are becoming larger and larger, our Organization aims at ensuring their quality by the effective use of our full-scale dynamic testing facility. Furthermore, we will make full use of the testing facilities to create a world-class research and education base for seismic isolation and response control structures.

Japan Society of Seismic Isolation

The Japan Society of Base Isolation was founded in June 1993, two years before the Great Hanshin Earthquake, with Dr. Kai Umemura as its first president, and is celebrating its 30th anniversary in the centennial year of the Great Kanto Earthquake. Many activities had been taking places since. Especially since the symposium “Requesting for the Installation Full-Scale Dynamic Loading Apparatus” in 2015, we have been working with many academic associations to communicate the need for full-scale testing equipment to ensure the reliable quality of seismic isolation and response control components, both domestically and internationally. In June 2000, we issued the "JSSI Standards for Seismic Isolation Components" for various components used in seismic isolation structures. In the future, full-scale dynamic testing will be available in Japan, and we are currently editing the "New JSSI Standards for Seismic Isolation and Response Control Components". We will also support the active promotion of the use of the Japan Seismic Isolation Laboratory.





Tests of reaction walls, PC steel strands, reaction beams,
rotationally constrained load measuring links, and seismic isolation members (laminated rubber)

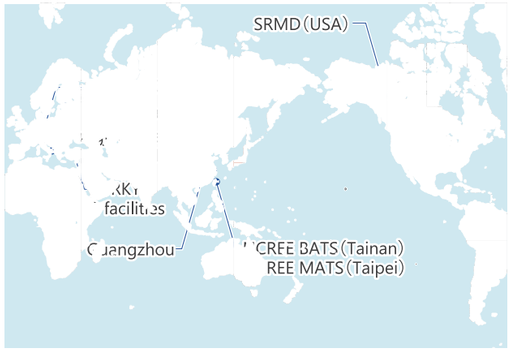
Aiming to develop reliable seismic isolation and response control technology that contributes to global safety

The history of seismic isolation structures in Japan dates back to 1983. The first seismic isolation structure was used in a two-story house built in Yachiyodai, Chiba Prefecture. The excellent performance of seismic isolation structures was confirmed in the 1995 Hyogo-ken Nanbu Earthquake, and seismic isolation structures rapidly became popular.

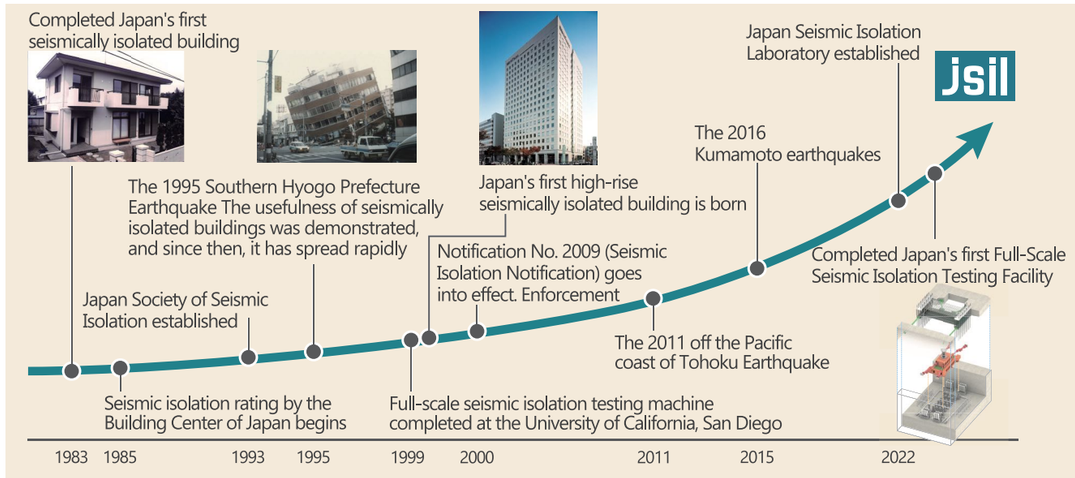
Seismic isolation structures in Japan have been in use for about 40 years, while response control structures, which numbers have been increasing since around 1995, and in use for 30 years. Although neither has a long history, the performance of these structures has been demonstrated in the wake of recent major earthquakes. The superiority of seismic isolation and response control structures has been recognized by society, and many technological developments are being promoted at the same time as they become more widely used.

The superstructure of a seismic isolation structure rests on seismic isolators that support its weight and deform greatly in two horizontal directions, causing significant movement. However, this movement is slow and the horizontal force acting on the superstructure is small, and the columns, beams, and earthquake-resistant walls behave elastically. A limited number of seismic isolation members are subjected to large horizontal deformation, protecting hundreds or thousands of members in the superstructure, protecting people living in the building, and protecting social, economic, and other activities. Response-control structures incorporate steel dampers, oil dampers, and response-control walls throughout the entire framework to suppress seismic shaking and limit the behavior of the framework elastically.

In this way, buildings, towns, and cities are able to continue to function after an earthquake, but for this to happen, each and every seismic isolation and response control component must have reliable performance. Many people involved in the verification and study of the dynamic characteristics of seismic isolation and damping members have understood the need for full-scale dynamic tests.These tests require to reproduce the conditions that full-scale members are subjected to an actual earthquake. However, because there is no "large dynamic testing machine" in Japan that can verify the dynamic



properties of full-scale members, it was not possible to conduct tests on full-scale seismic isolation and response control members under actual velocity and deformation. On the other hand, in other countries such as the U.S., Italy, Turkey, China, and Taiwan, large dynamic testing machines have been installed and dynamic tests of full-scale components have been conducted. The long-awaited "full-scale seismic isolation testing facility" has now been installed and will begin operation at the end of March 2023. The true performance of seismic isolation and response control components must be clarified to further develop seismic isolation and response control technologies. These technologies will not only provide high performance during earthquakes, but also reduce the amount of steel, concrete, and other materials used in the initial construction of the structure. This alone will contribute to the Sustainable Development Goals (SDGs), but when these structures are subjected to an imminent major earthquake, they will be able to continue to be used without damage.Eliminating the need for "disuse, demolition, and reconstruction," as before, and making a significant contribution to achieving the SDGs. This investment will be an important quantifiable and measurable factor towards sustainable practices (ESG) for each company, taking into account environmental, social, and corporate governance. We look forward to working with you to build the next era in which people's lives as well as society's activities are able to continue without damage from a major earthquake.



S I P Research —— Development of analysis methods using dynamic testing machines with high-precision load measurement

In order to solve the problems faced by dynamic testing machines around the world, this research will address three issues.
A conceptual diagram showing the relationship between the three issues is shown below.

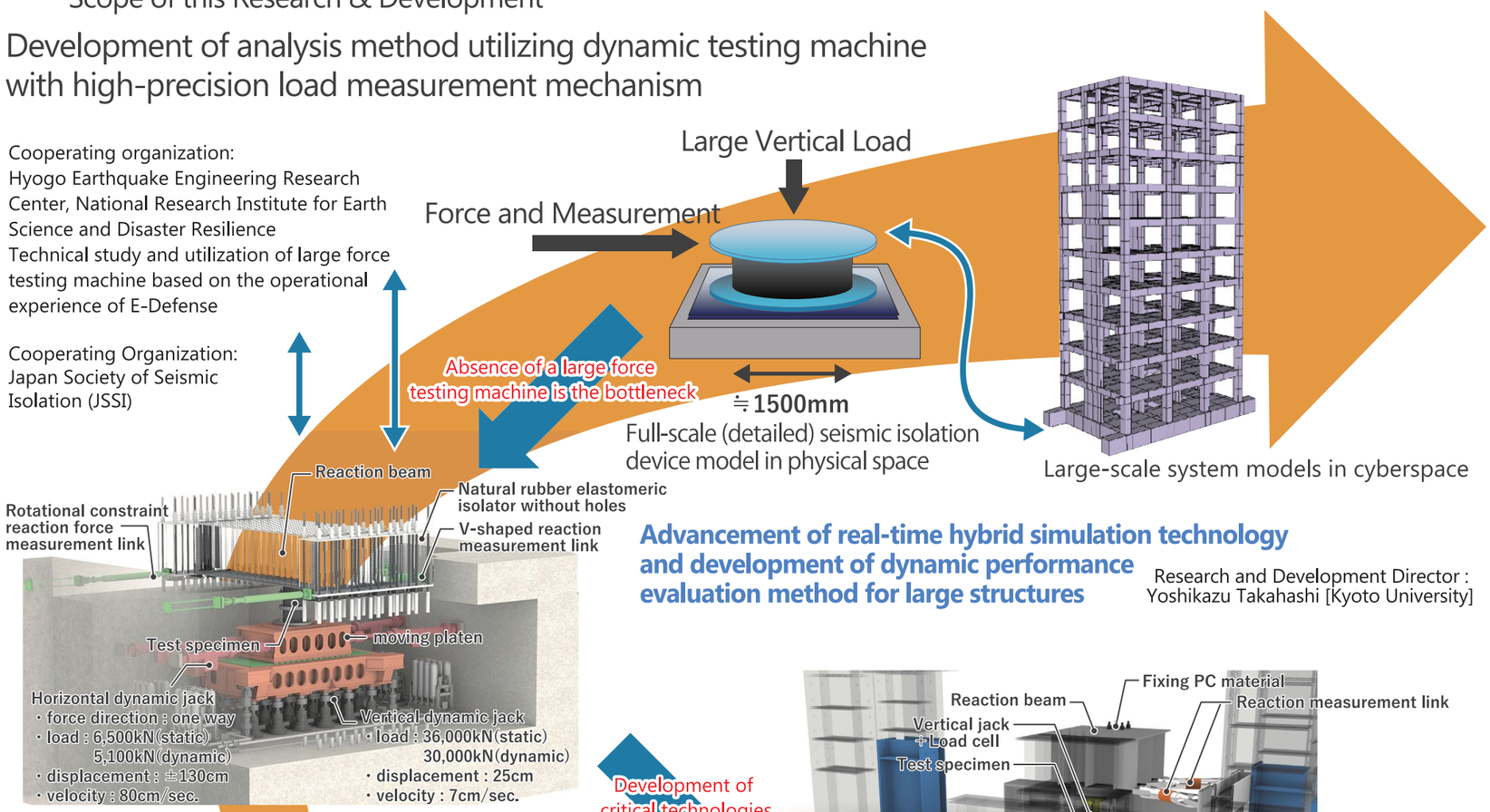
SIP Strengthening National Resilience (Disaster Prevention and Mitigation) IX
Development of a full-scale component seismic behavior analysis system

Scope of this Research & Development

Development of analysis method utilizing dynamic testing machine with high-precision load measurement mechanism

Cooperating organization:
Hyogo Earthquake Engineering Research Center, National Research Institute for Earth Science and Disaster Resilience
Technical study and utilization of large force testing machine based on the operational experience of E-Defense

Cooperating Organization:
Japan Society of Seismic Isolation (JSSI)



Advancement of real-time hybrid simulation technology and development of dynamic performance evaluation method for large structures

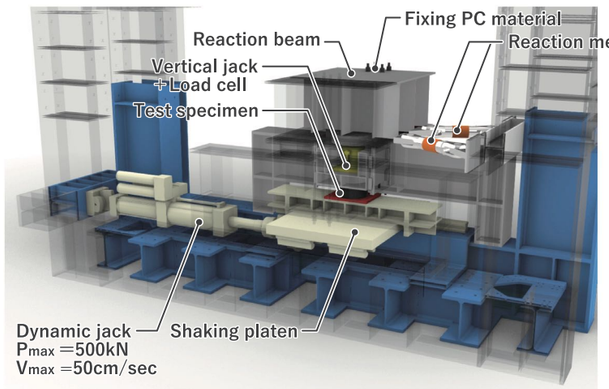
Research and Development Director :
Yoshikazu Takahashi [Kyoto University]

Development of large dynamic force testing machine technology to excite specimens under large vertical loads, high velocities, and large deformations

Social Implementation Leader: Akira Wada [JSIL]

- Although full-scale seismic isolation testing equipment exists in the world today, it takes time to obtain accurate measurements of specimens (sometimes several months)
- There is no measurement system with real time removal of frictional and inertial forces in dynamic tests under large vertical loads

Development of critical technologies



Development of a technique for removing frictional and inertial forces in three-directional dynamic force testing machine measurements of seismic isolation members supporting high vertical loads

Leader：Toru Takeuchi [Tokyo Institute of Technology]

The Future of National Resilience

Academia

- Promotion of basic research in the field of disaster prevention (integration with applied research)
- Promotion of scientific research on disaster prevention and mitigation employing advanced technologies

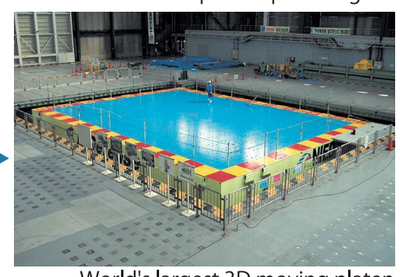
Industry

- Improvement of reliability through performance testing of full-scale seismic isolation and response control components
- Proactive investment in disaster prevention through fair competition in technological development
- Global standardization of testing and evaluation methods

Global center of excellence for seismic research

- Japan's world-class collaboration between cyberspace and physical space

Supercomputer Fugaku


World's largest 3D moving platen

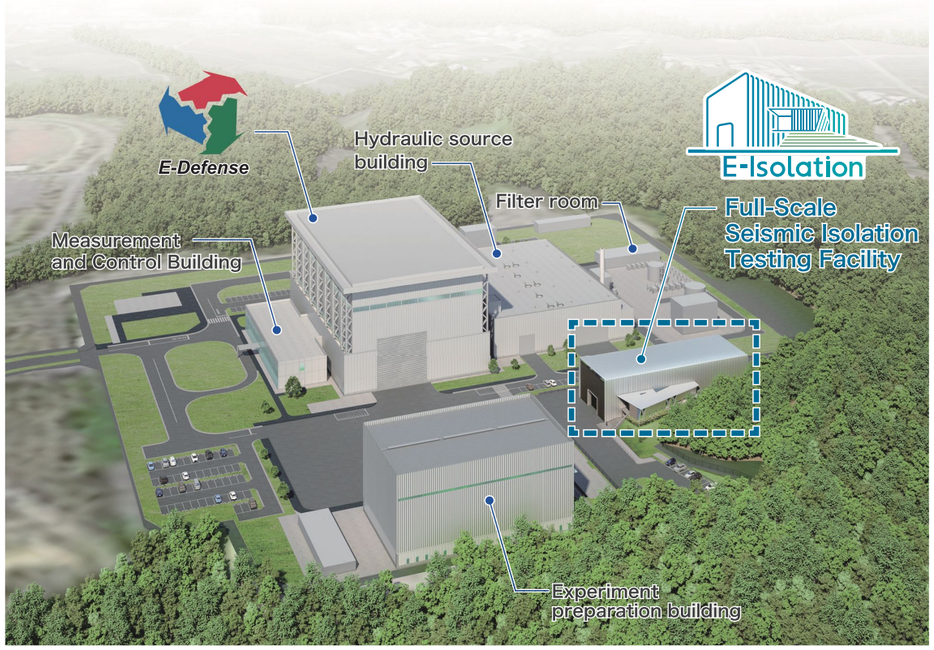
Infrastructure supporting Society 5.0 will be able to continue functioning even during earthquakes

Establishing Japan's first full-scale seismic isolation testing facility

Japan's first full-scale dynamic testing facility for seismic isolation and response control components will be established on a site adjacent to **E-Defense**, which was constructed in 2005.

E-Defense and Full-scale seismic isolation testing machine aim to become the world's base for seismic research

Full-Scale 3D Dynamic Damage Testing Facility in E-Defense is the world's largest 3D shaking platen, which can directly subject full-scale buildings weighing up to 12,000 kN to earthquake ground motion to study the behavior, damage, and collapse processes in detail.
The newly installed large dynamic-loading testing facility is capable of high velocity, large-amplitude excitations experienced by actual seismic isolation bearings under vertical loads of up to 30,000 kN dynamically and 36,000 kN statically.
It is said that 10% of the world's earthquakes occur in Japan. Miki City, Hyogo Prefecture, will be hosting a large shaking platen and full-scale seismic isolation testing machine (large dynamic loading testing machine), and is expected to become a world center for research on earthquake-resistant structures.



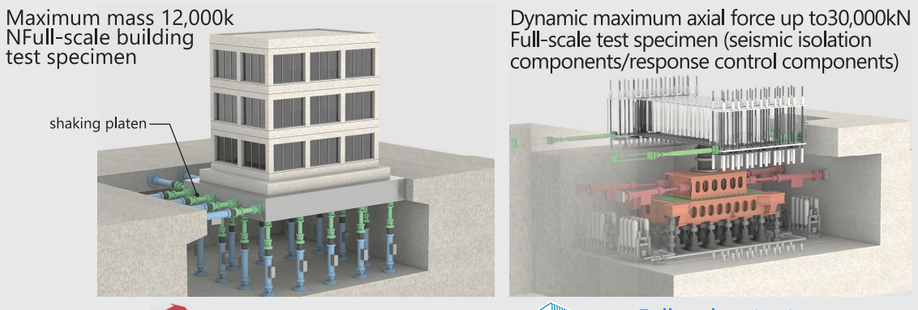


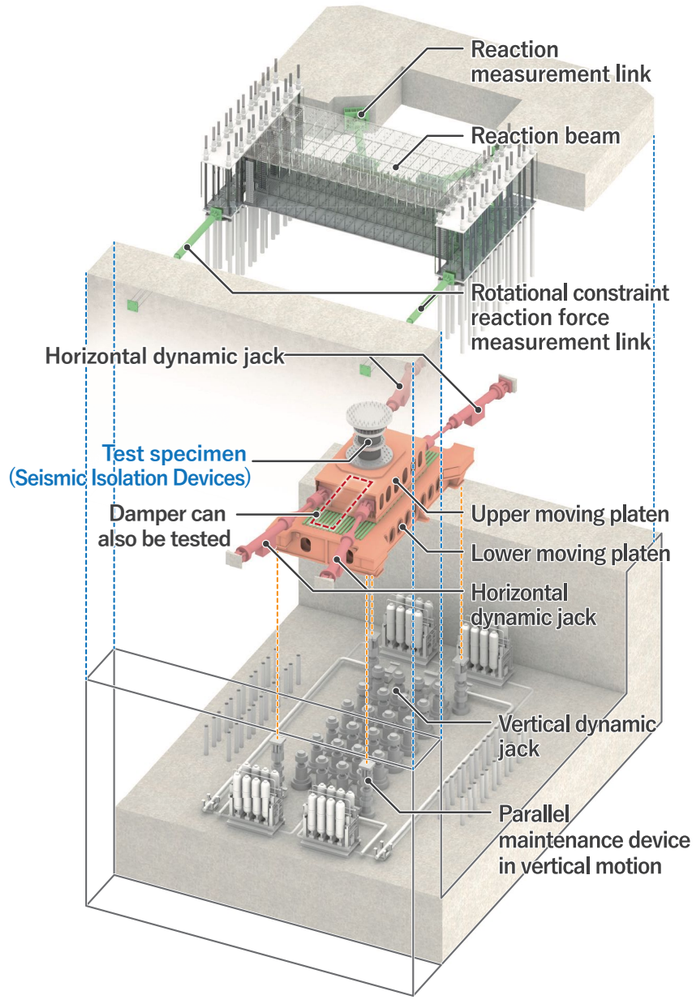
Image of the oil damper installed between the reaction wall and the upper moving platen in the foreground during testing
Reaction wall, reaction beam, vertical dynamic jack, horizontal dynamic jack, rotational constraint reaction force measurement link,and Reaction force measurement link (green) beyond the reaction beam

A control and measurement room for the testing machine is planned in close proximity, facing the full-scale seismic isolation testing machine.
The test specimen under dynamic loading can be directly observed.

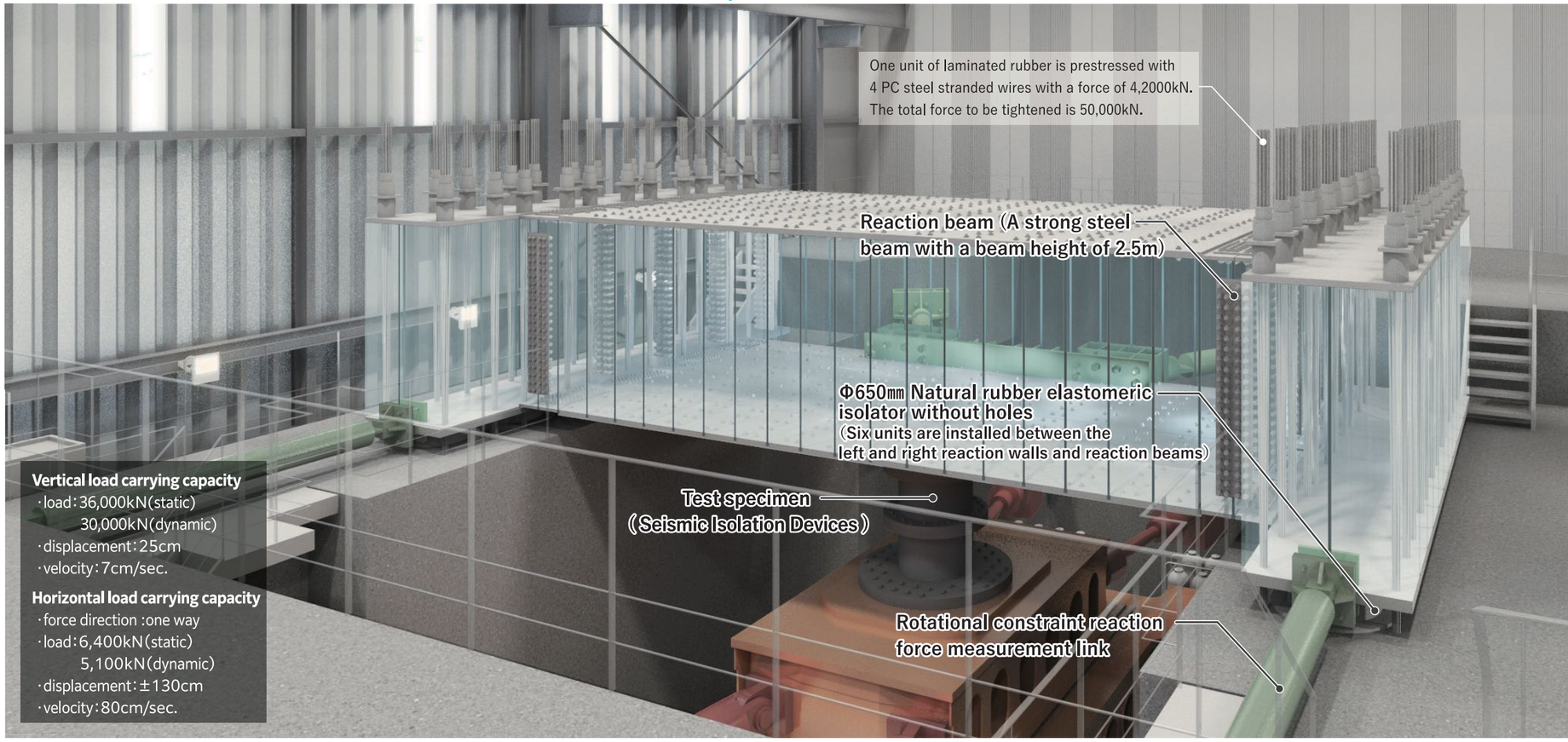
The facility is in harmony with the natural environment of the Miki Disaster Prevention Park and takes advantage of the natural surroundings

A ramp is provided at the entrance to ensure barrier-free access

You can observe the actual loading status of the test while checking the control screen



Implementation of a full-scale seismic isolation testing machine with the world's first reaction force measurement system



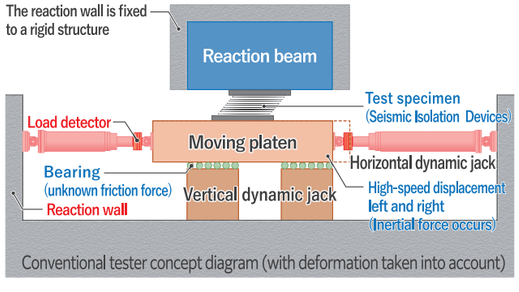
Full-scale seismic isolation testing machine

A completely new load measurement mechanism for testing machines

Existing testing machines installed overseas measure the value of the load detector installed on the side of the horizontal dynamic jack. This measurements account for the force acting on the seismic isolator, as well as for the frictional force at the bearing and the inertia of the moving platen. The latter results must be removed after the test, which is not an easy task and can take significant time (several months).

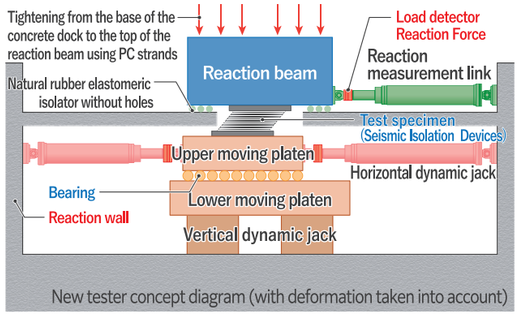
In contrast, the new testing machine installed at this facility measures directly the load acting on the specimen without including frictional and inertial forces, by measuring the force generated in a horizontally rigid steel pipe installed on the side of the reaction beam, towards the upper part of the specimen. This makes it possible to measure the force acting on the specimen instantaneously and accurately.

Existing

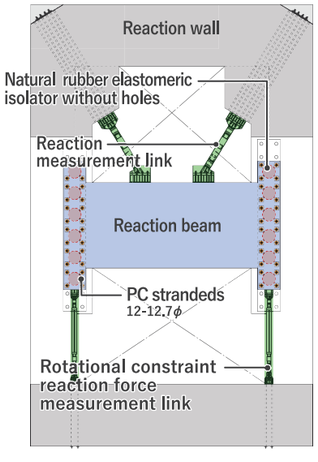


Conventional tester concept diagram (with deformation taken into account)

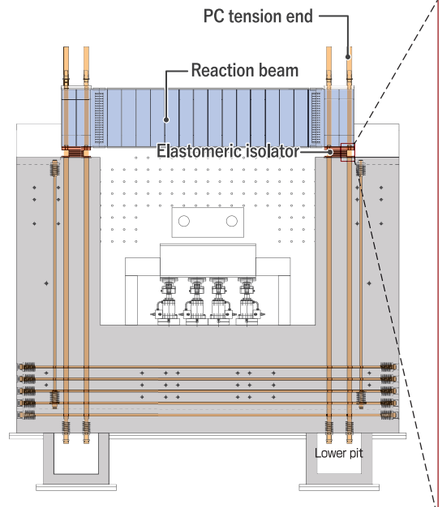
New



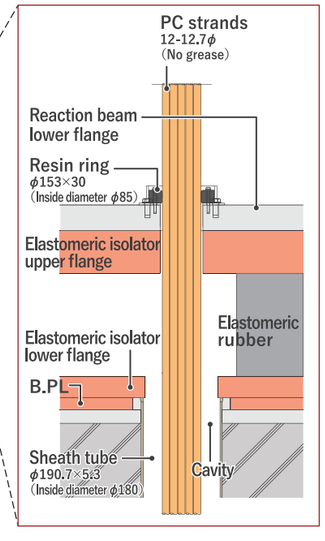
New tester concept diagram (with deformation taken into account)



Plan view of the testing machine



Cross-sectional view of the testing machine



PC tension end detail drawing

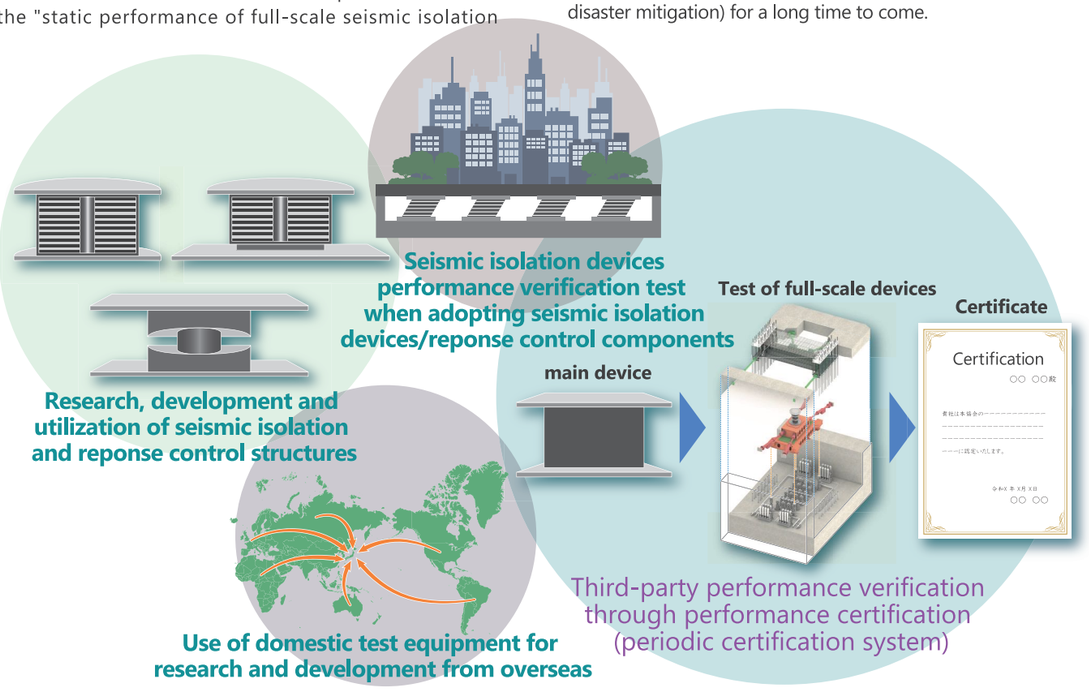
The “Certificate", a unique performance certification from our full-scale seismic isolation testing facility, enhances the reliability of seismic isolation and response control components

Society is now highly IT-oriented through the Internet, and from the perspective of Business Continuity Plan (BCP), damage to nonstructural components during an earthquake can have a significant impact on business. The full-scale use of seismic isolation is still in its infancy. There is a need to ensure more reliable performance as to secure BCP mitigation measures. In order to sustain economic activities at any time in one of the world's most earthquake-prone countries, we are preparing various styles of utilization so that everyone can freely use this facility.

- **Research and development use of seismic isolation and reponse control structures**
- **Performance verification tests of seismic isolation and response control components in actual projects**
- **R&D use from overseas**
- **The"Certificate" for performance of seismic isolation and response control components**

The "Certificate" is a performance test and certification system for seismic isolation and damping members conducted by the Japan Seismic Isolation Laboratory under the auspices of the Japan Society of Seismic Isolation. Conventional quasi-static large testing machines can carry large vertical loads, but are limited to testing at low velocities on the horizontal plane (approximately 2 cm/sec.). In addition, although small testing machines are able to be used for horizontal loading at high speeds, size of the vertical axial forces are also small. Hence, dynamic performance verification was only available for reduced-size specimens. Therefore, for a long time, the dynamic performance of full-scale seismic isolation members was predicted based on the "static performance of full-scale seismic isolation members" and the "dynamic performance of reduced-size specimens" by the advanced judgment of engineers and extrapolation of the dynamic performance of full-scale seismic isolation members.

The Japan Seismic Isolation Laboratory periodically conducts full-scale dynamic tests on a number of models of major seismic isolation and response control components from various manufacturers using full-scale seismic isolation testing machines, and issues a performance certification for components which have been confirmed to have the prescribed performance. Standardization of testing methods will be discussed in cooperation with a committee of the Japan Society of Seismic Isolation. This will make it possible to directly examine the seismic performance of many seismic isolation and response control components, further increasing the reliability of seismic isolation and response control structures. At present, seismic isolation and response control structures are used mainly in large cities, but we hope that they will eventually be used in a wide variety of structures, including those in small and medium-sized cities, thereby contributing to the creation of a society in which earthquakes will never impair the safety and security of people or disrupt the continuation of social activities. Although this facility will be constructed with support from the government, its operation will depend on the active use of many people. As a measure to ensure the stable operation of the facility, the Japan Seismic Isolation Laboratory will invite members who agree with the above-mentioned purpose of the facility operation, so that the facility can contribute to national resilience (disaster prevention and disaster mitigation) for a long time to come.



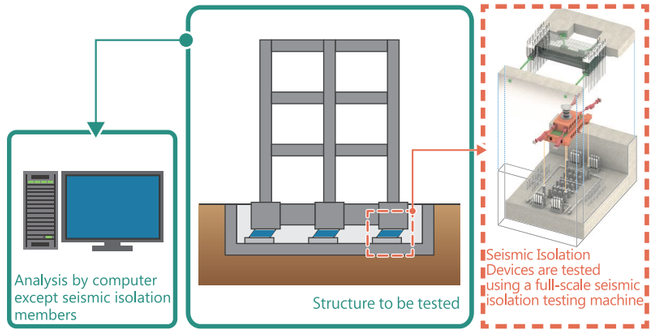
Supporting the research and education of young researchers and designers who will lead the future

The installation of the full-scale seismic isolation tester will enable us to conduct various studies on seismic isolation and response control technologies that could not be conducted in Japan until now. We will support the research and development required by future researchers and structural designers, such as bearings that absorb vertical movement that cannot be proficiently designed in the current testing environment, and the challenge of planning dream structures.

Various experimental studies that were not possible in Japan are now possible

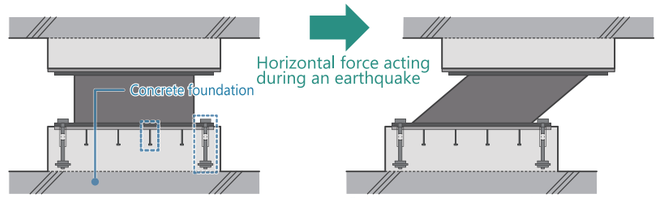
Ex.1 Hybrid simulation using seismic isolation components

Hybrid simulation is a method of structural testing that combines physical testing and computer modeling. The installation of this testing machine will make it possible to conduct experiments that combine "structural testing of seismic isolation members using full-scale seismic isolation testing machines" and "structural analysis of buildings modeled by computer". In the future, we aim to conduct a hybrid experiment combining a full-scale seismic isolation test at this facility and an experiment at E-Defense.



Ex.2 Dynamic force testing including joints between seismic isolation and response control members

Since a 2.1 m clearance is provided between the reaction beam and the upper moving platen, it is possible to plan an integrated test specimen that includes the foundation frame along with the seismic isolation members. Dynamic tests on the full-scale specimen, including the joints and foundation frame, will provide more detailed information on stress transfer paths.



Studs and anchor bolts for fastening seismic isolation device to concrete

Complicated forces are applied to the joints as the seismic isolation member deforms Seismic Isolation Devices

The dynamic behavior of the specimen can be visually observed from the control and measurement rooms adjacent to the testing room

Until now, there was no testing equipment in Japan capable of dynamically loading full-scale seismic isolation members, and many young engineers have conducted research and design without having seen the actual behavior of the specimens. The full-scale seismic isolation testing facility is designed in such a way that the testing can be observed, allowing engineers who witness the testing to gain firsthand experience.

Interior view of the open space

Wood is used as a user-friendly testing facility to create a comfortable space

View from the open space from

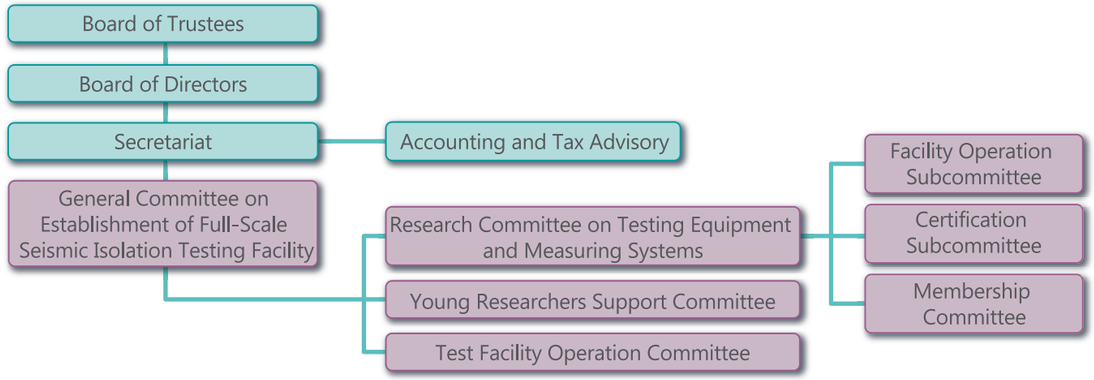
The testing equipment can be viewed from the open space

View from the control and measurement room

From the control and measurement room, the behavior of the test specimens can be observed through the window

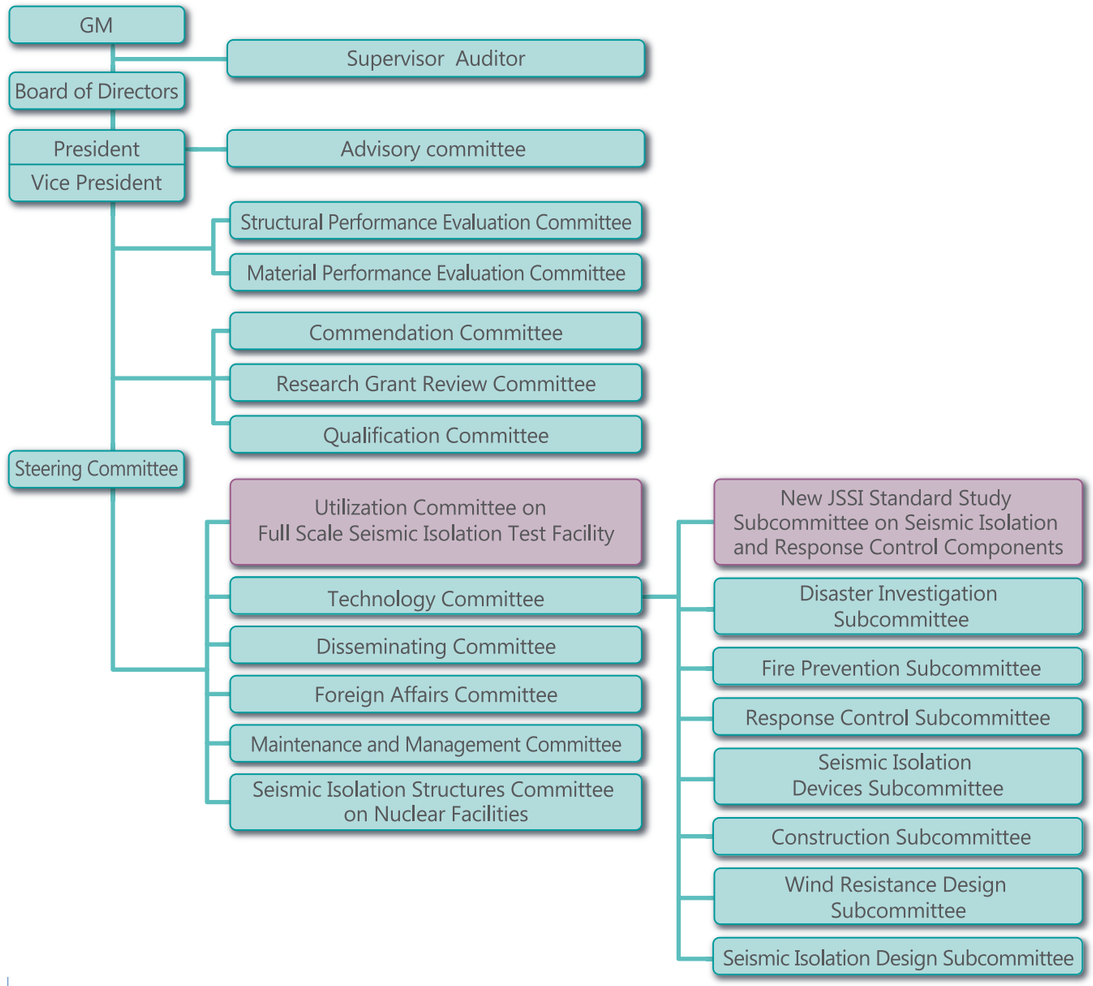
Japan Seismic Isolation Laboratory

2022 Organizational Structure



Japan Society of Seismic Isolation

2022 Organizational Structure



Providing a variety of up-to-date information to our members

Timely delivery of the latest information on seismic isolation and response control

The latest information, such as new findings obtained through full-scale tests of seismic isolation and Response Control members, the status of seismic isolation and damping members after major earthquakes, and research cases in Japan and abroad, will be provided in a timely manner through our newsletters and symposiums.

Receive real-time movies of full-scale seismic isolation tests

For structural tests conducted using full-scale seismic isolation testers that are open to the public, we will provide real-time (or on-demand) movies of the tests to our members.

In the first year, members will be given priority to participate in construction tours and briefings at the test facility currently under construction

The full-scale seismic isolation testing machine, the first of its kind in Japan, is composed of various research and development elements, such as "a completely new load measurement mechanism," "force technology that excites the test specimen under large vertical loads, high speed, and large deformation," "a rigid concrete frame construction method that prevents cracking even under high axial forces," "a steel reaction beam design that supports large axial forces," etc. In FY2022, we plan to hold a briefing session on the details of these research and development subjects and the construction status, as well as a tour, and members will be given priority to participate.

Periodic reporting of aging data on seismic isolation and response control components

Since laminated rubber and Response Control dampers are mechanical parts made mainly of polymer compounds, changes in performance and deterioration are unavoidable compared to structural members such as concrete. They will eventually need to be replaced. On the other hand, there is still insufficient knowledge on the degree to which the performance of actual equipment deteriorates over time. The Japan Seismic Isolation Laboratory will periodically report data on the aging of seismic isolation and Response Control components.

Support for formulation of dynamic properties of seismic isolation and response control members

With the development of the testing environment at this facility, it is expected that the end-state properties on an actual equipment basis, including hardening, etc., will be clarified one after another. The seismic isolation research promotion organization supports the formulation of these properties.

By bringing together researchers and designers from academia and industry to form a third-party organization, we can contribute to the development of seismic isolation and response control technologies

The Japan Seismic Isolation Laboratory has an important role as a "third-party organization" that directly examines the performance of seismic isolation and Response Control components. By bringing together researchers and designers from academia and industry, proactively testing performance and sharing the latest information as needed, we can contribute to the sound development of seismic isolation and Response Control technology.

Admission Guide

If you wish to become a member,
please fill out the attached application form and send it by e-mail or mail to

E-mail jsil@jsil.or.jp

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jsil Japan Seismic Isolation Laboratory