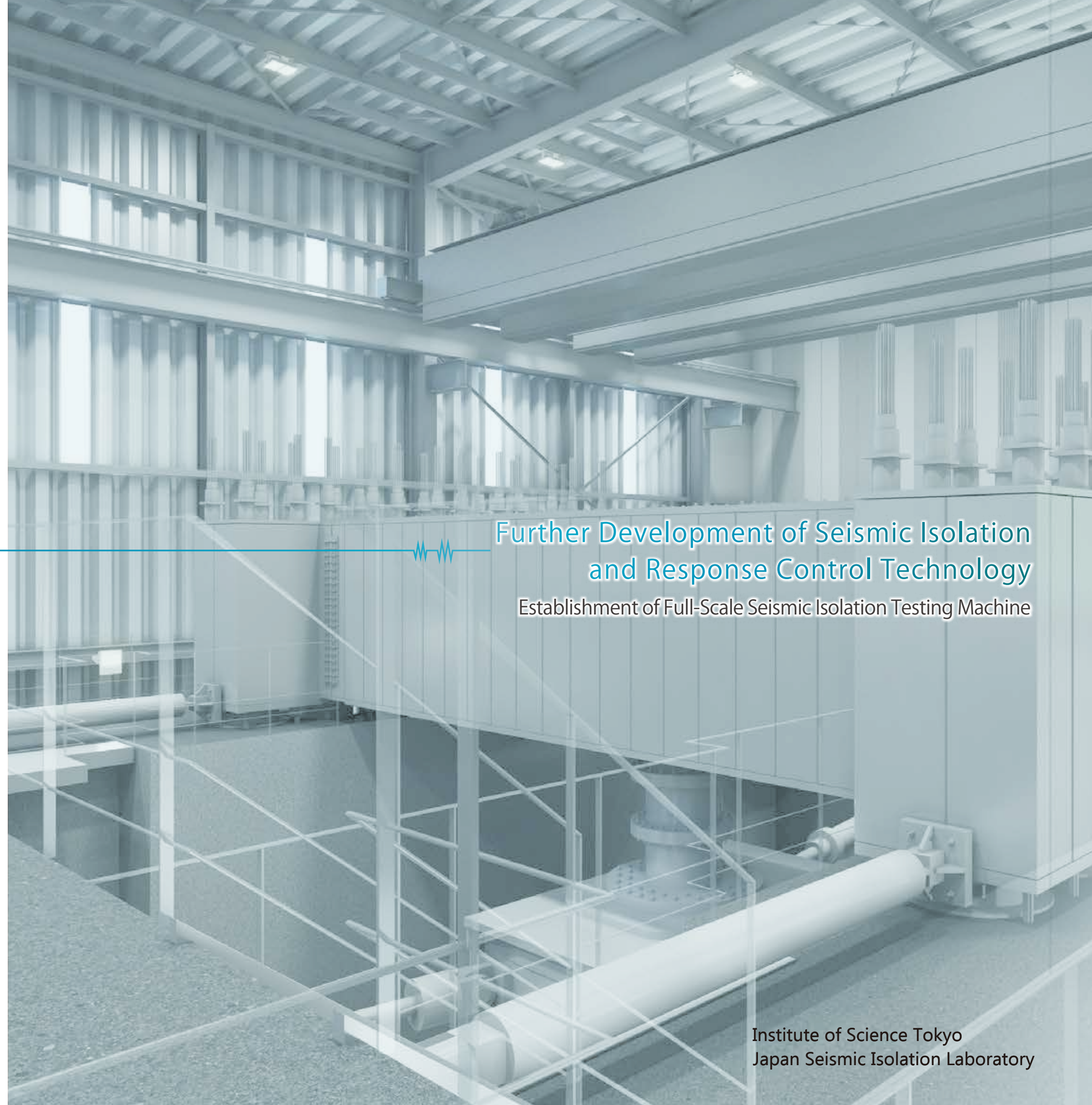
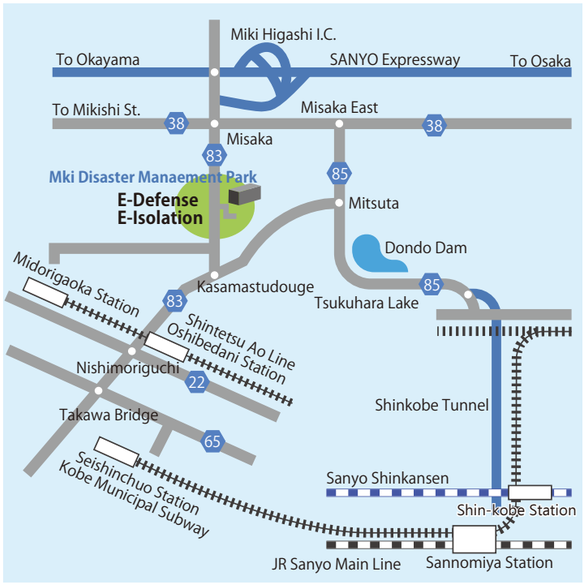


Further Development of Seismic Isolation and Response Control Technology

Establishment of Full-Scale Seismic Isolation Testing Machine



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

2024/11/Ver5.0 ENG

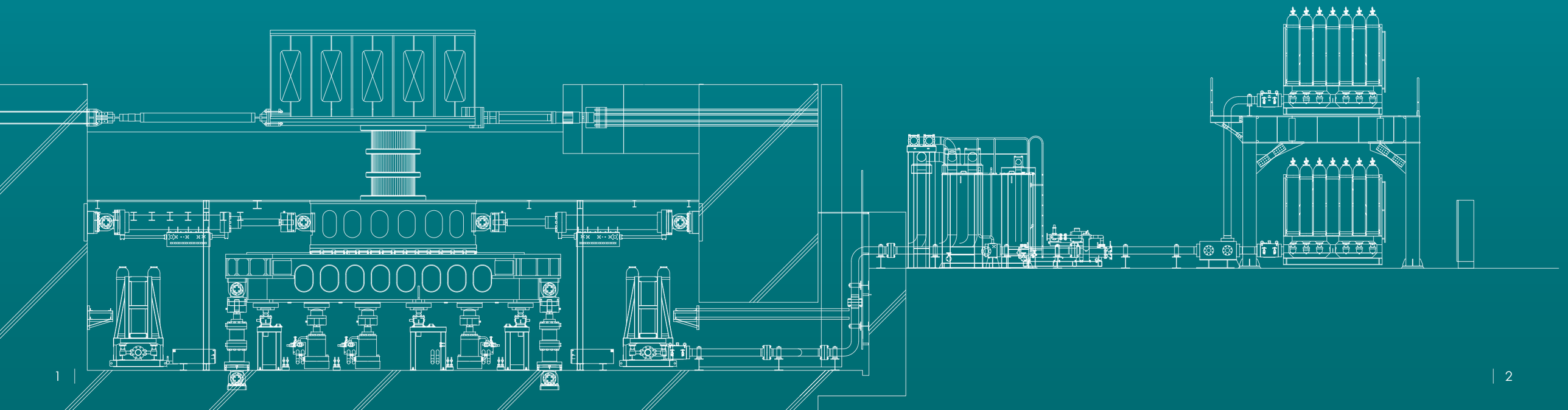
Institute of Science Tokyo
Japan Seismic Isolation Laboratory

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

Kyoto University, Institute of Science Tokyo, 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.

jsil 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.



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

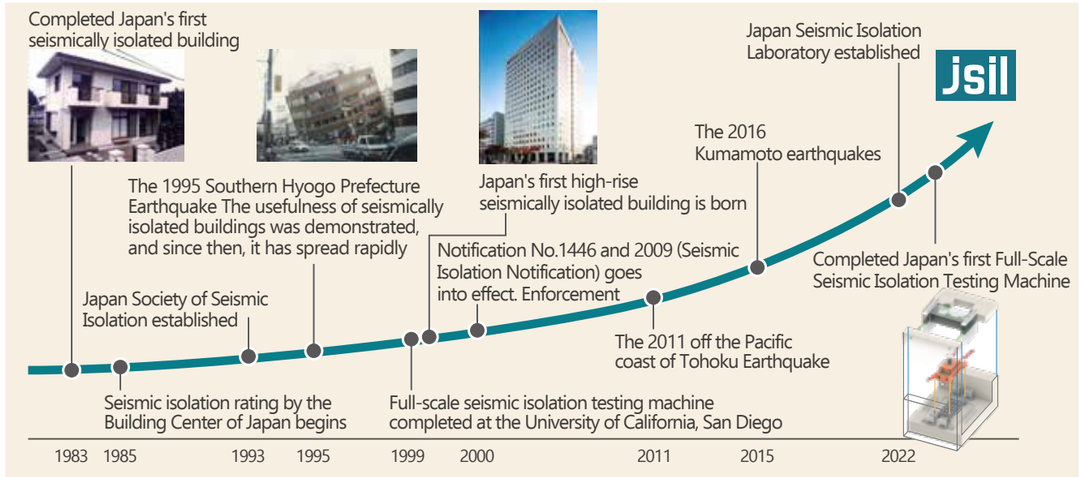
The history of seismic isolation structures in Japan dates back to 1983. The first seismic isolation structure was used in a two-story house built in Yachiyodai, Chiba Prefecture. The excellent performance of seismic isolation structures was confirmed in the 1995 Hyogo-ken Nanbu Earthquake, and seismic 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 order countries such as San Diego, Messina, Pavia, Eskisehir, Ankara, Beijing, Shanghai, Wuhan, Guangzhou, Taipei, Tainan large dynamic testing machines have been installed and dynamic tests of full scale components have been conducted. For more than 20 years, the Japan Society of Seismic Isolation have been making efforts to construct such facility.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.

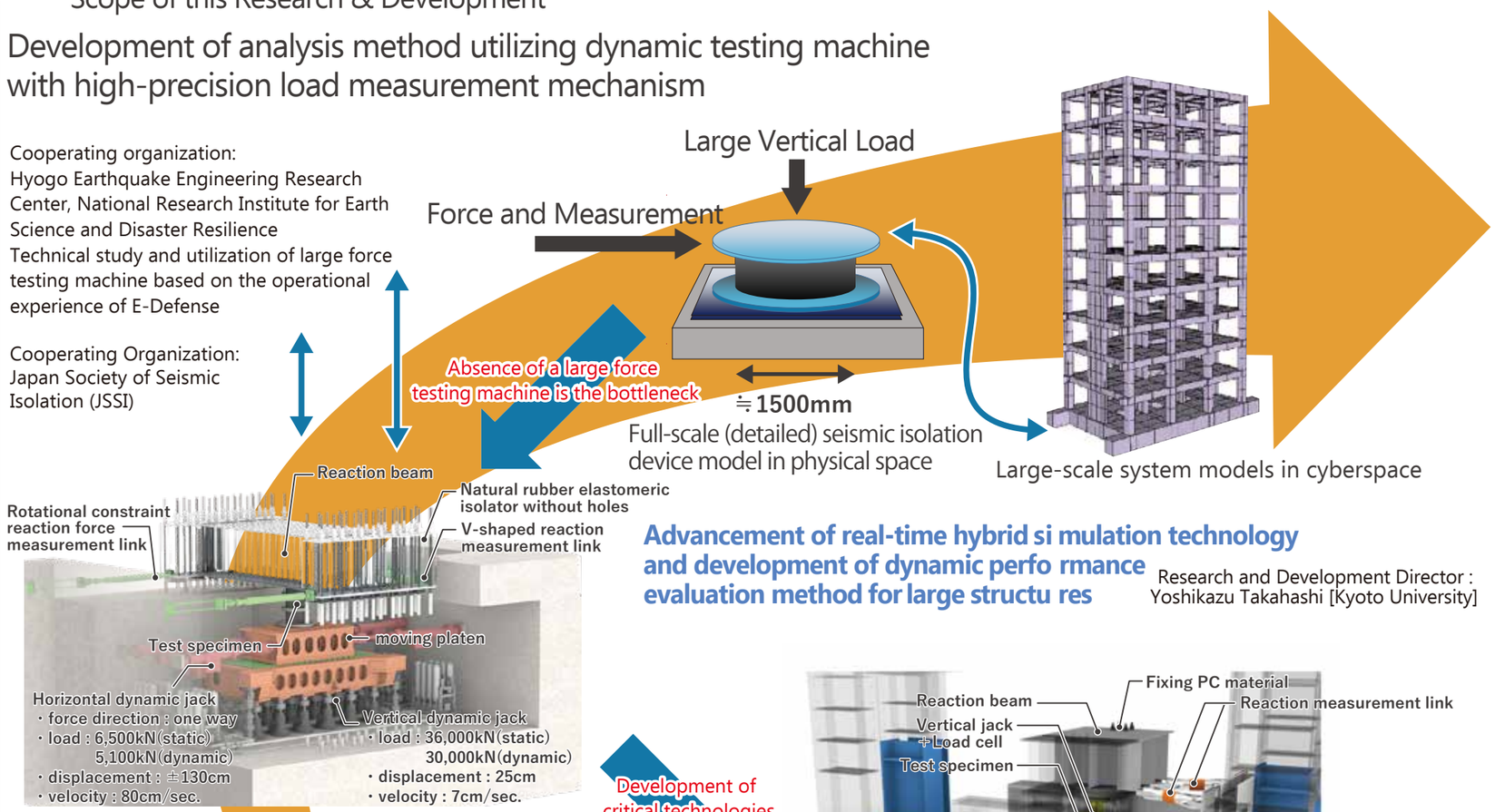
SIP Strengthening National Resilience (Disaster Prevention and Mitigation) IX
Development of a full-scale component seismic behavior analysis system

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 si mulation technology and development of dynamic perfo rmance evaluation method for large structu res

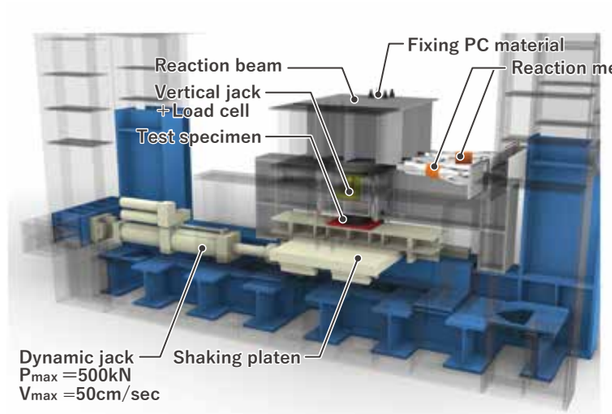
Research and Development Director :
Yoshikazu Takahashi [Kyoto University]

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 tech nique for removing frictional and inertial forces in th ree-directional dynamic force testing machine measu rements of seismic isolation members supporting h igh vertical loads

Leader：Toru Takeuchi [Institute of Science Tokyo]

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

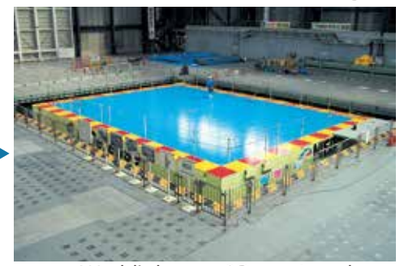
Industry

- 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

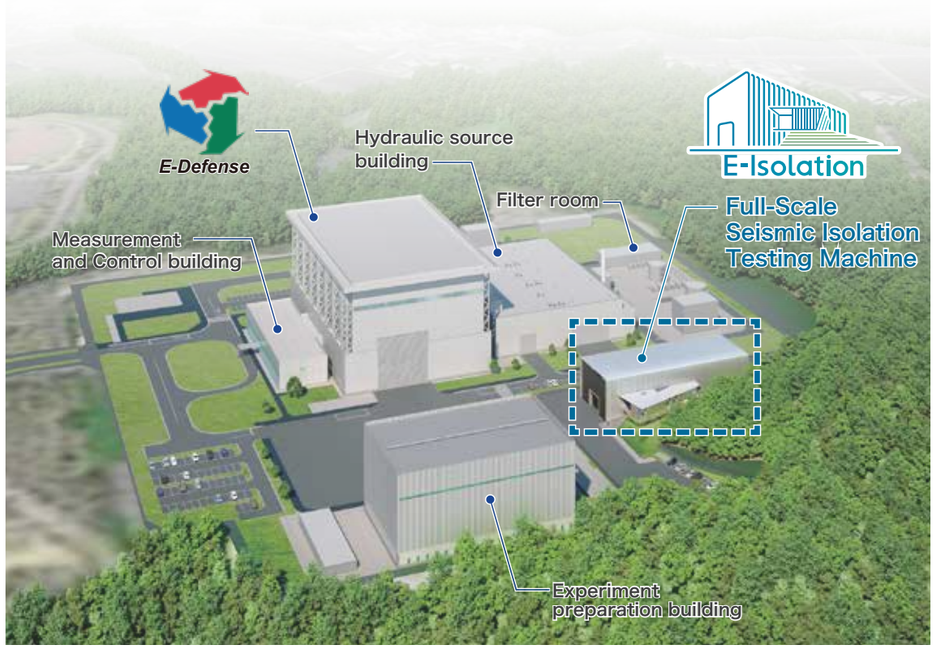
Infrastructure supporting Society 5.0 will be able to continue functioning even during earthquakes

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

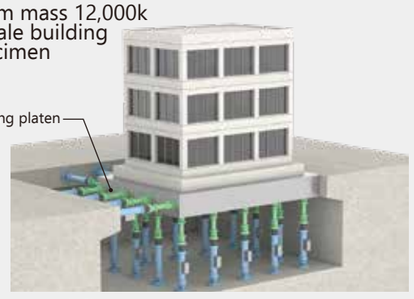
Japan's first full-scale dynamic testing machie for seismic isolation and response control components will be established on a site adjacent to **E-Defense**, which was constructed in 2005.

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.



Maximum mass 12,000k NFull-scale building test specimen



E-Defense (shaking platen)

Dynamic maximum axial force up to30,000kN Full-scale test specimen (seismic isolation components/response control components)

Full-scale seismic isolation testing machine

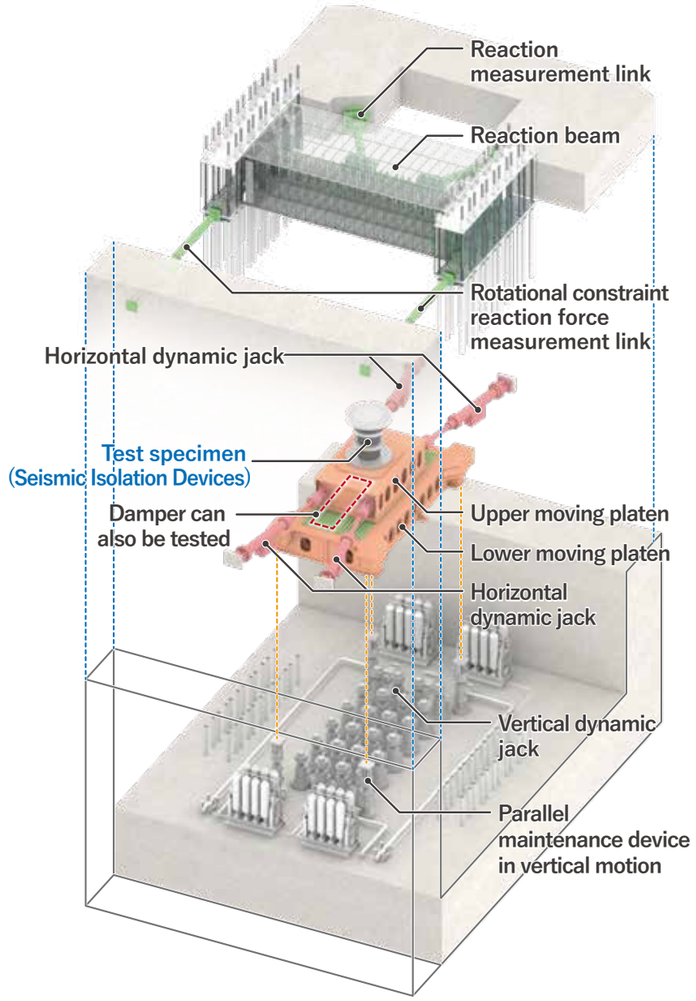
Image of the oil damper installed between the reaction wall and the upper moving platen in the foreground during testing
Reaction wall, reaction beam, vertical dynamic jack, horizontal dynamic jack, rotational constraint reaction force measurement link and Reaction force measurement link (green) beyond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

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

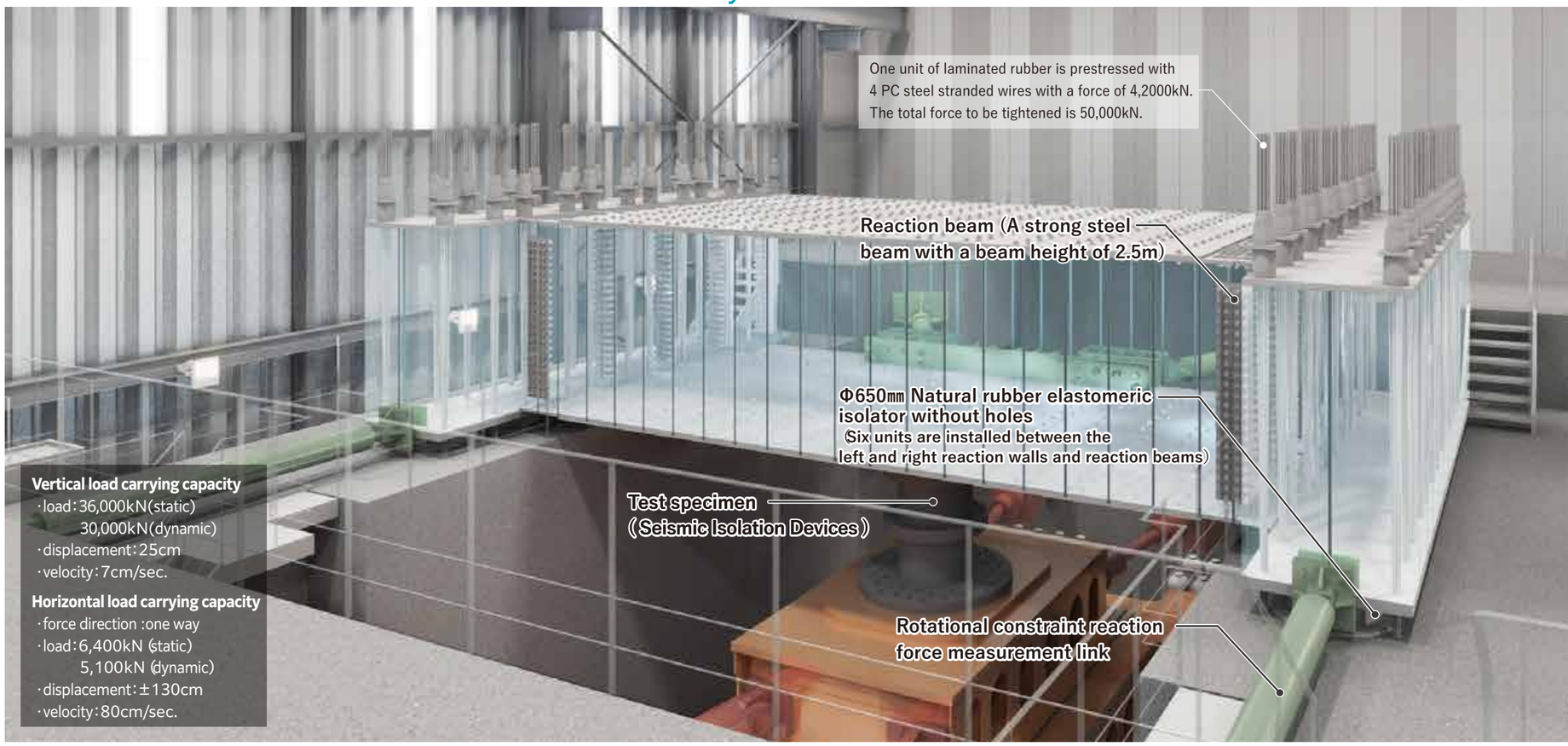
The facility is in harmony with the natural environment of the Miki Disaster Prevention Park and takes advantage of the natural surroundings

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



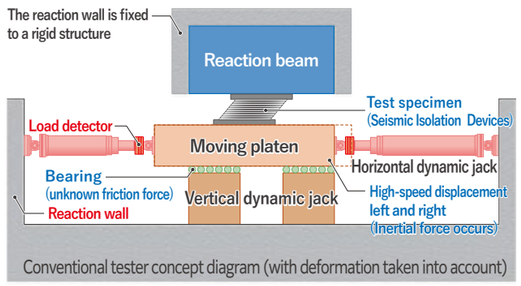
Full-scale seismic isolation testing machine

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).

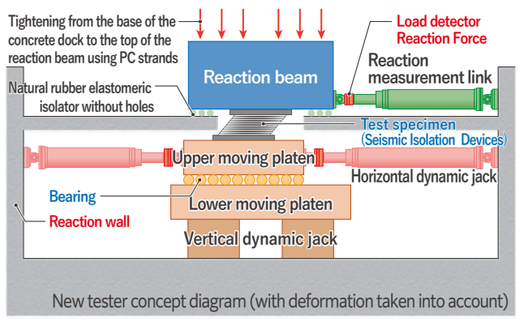
In contrast, the new testing machine installed at this facility measures directly the load acting on the specimen without including frictional and inertial forces, by measuring the force generated in a horizontally rigid steel pipe installed on the side of the reaction beam, towards the upper part of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

Existing

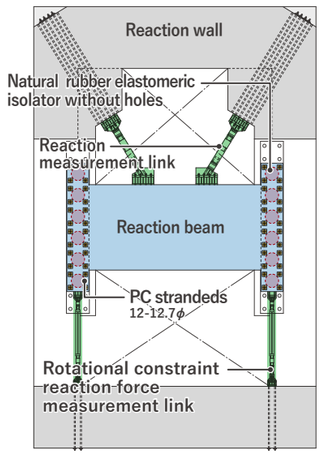


Conventional tester concept diagram (with deformation taken into account)

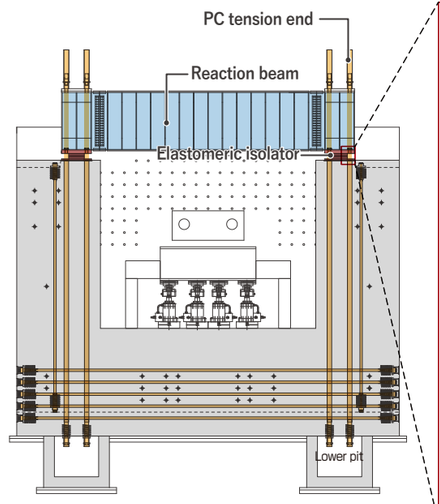
New



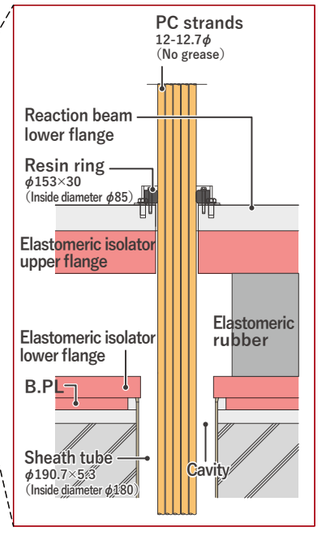
New tester concept diagram (with deformation taken into account)



Plan view of the testing machine



Cross-sectional view of the testing machine



PC tension end detail drawing

A dynamic performance certification system based on third-party testing using a full-scale seismic isolation testing facility, enhances the reliability of seismic isolation and response control components

Seismic isolation and response control components (also known as seismic isolation and response control materials/devices) are incorporated into buildings and stand quietly in standby until the moment a major earthquake occurs. These materials and devices must perform as intended in the event of a major earthquake. The building must demonstrate its performance as intended at the time of a major earthquake. Before a major earthquake occurs, it is essential to test full-scale members with actual loads, displacements, and velocities. Since this testing machine has not been available in Japan until now, it can be used in various ways as follows.

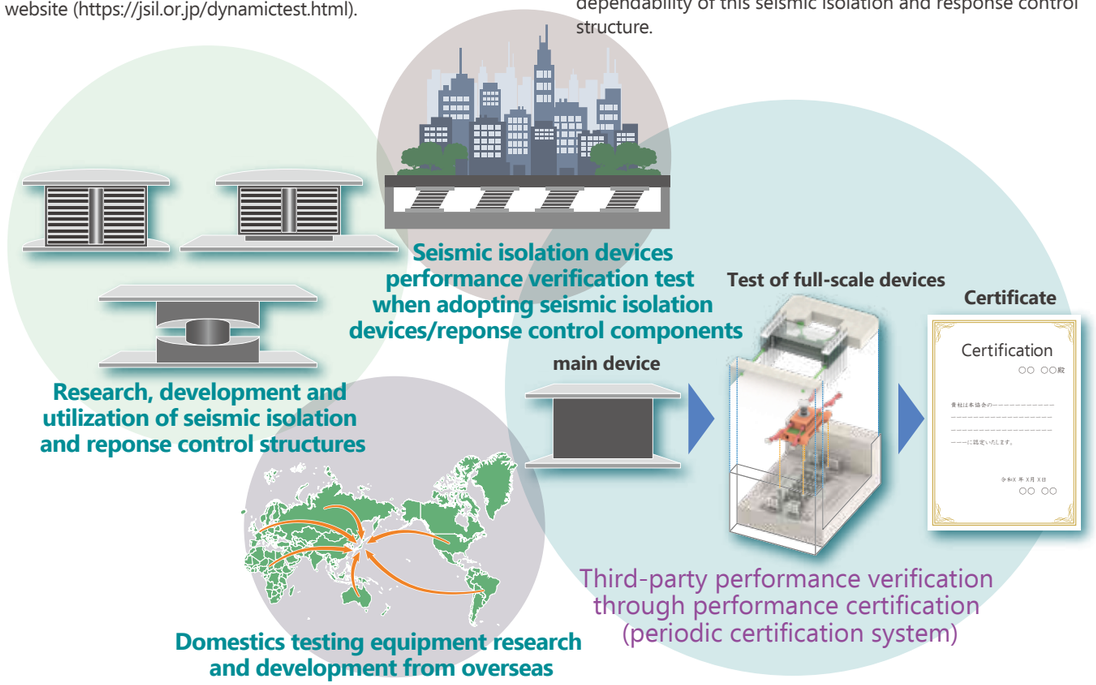
- **Research and development use of seismic isolation and reponse control structures**
- **Dynamic performance certification of seismic isolation and response control components**
- **R&D use from overseas**

We have started "Dynamic Performance Certification System" for seismic isolation and response control devices from July 1, 2024. As a third-party organization, we will conduct dynamic tests of seismic isolation and response control devices at full scale, actual load, actual displacement, and actual velocity. The Dynamic Performance Certification Committee will ascertain and review their dynamic performance and submit a "Dynamic Performance Certification" and "Test Report. The purpose of this certification is to improve the reliability of seismic isolation and response control devices themselves, as well as seismic isolation and response control structures. Furthermore, to promote the use of these structures both domestically and internationally. A detailed explanation is available on our website (https://jsil.or.jp/dynamictest.html).

The "Dynamic Performance Certification System" includes two types of certification: Dynamic Performance Certification and Individual Dynamic Performance Certification. We hope that the passage of years will accumulate test results for both types of certification and deepen the trust and understanding of seismic isolation and response control devices.

Dynamic Performance Certification
At the request of the manufacturer, we certify the dynamic performance of seismic isolation and response control devices. Various static and dynamic tests are conducted on three products of the same model number using a full-scale seismic isolation facility. Based on the results of these tests, the dynamic performance of the product will be certified. The certification will be valid for three years, and periodic dynamic performance certification will ensure the long-term reliability of this seismic isolation and response control device. The dynamic performance of each size product in the same series can be estimated from the dynamic performance of the size product tested for certification.

Individual Dynamic Performance Certification
This certification is for the dynamic performance of seismic isolation and response control devices installed in individual building projects. A portion of the products to be incorporated into actual buildings are selected. Their dynamic performance is determined and certified using full-scale seismic isolation facility. This allows for greater reliability of this seismic isolation and response control structure. In the case of a large building project, it is even more significant to manufacture as many as two of the same product to be installed and perform various limit tests as well as dynamic performance certification to ensure the dependability of this seismic isolation and response control structure.



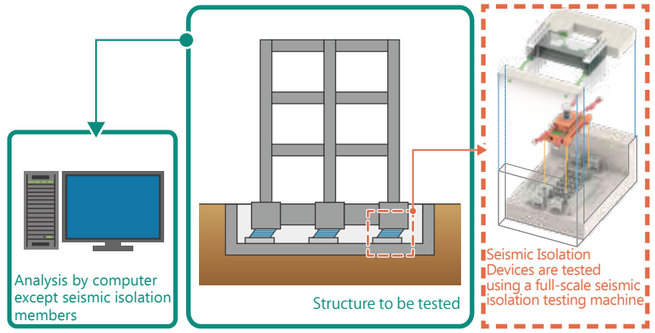
Supporting the research and education of young researchers and designers who will lead the future

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

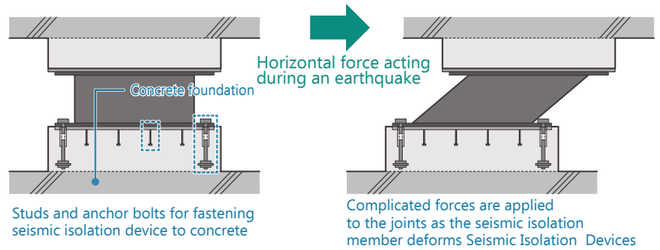
Ex.1 Hybrid simulation using seismic isolation components

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.



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

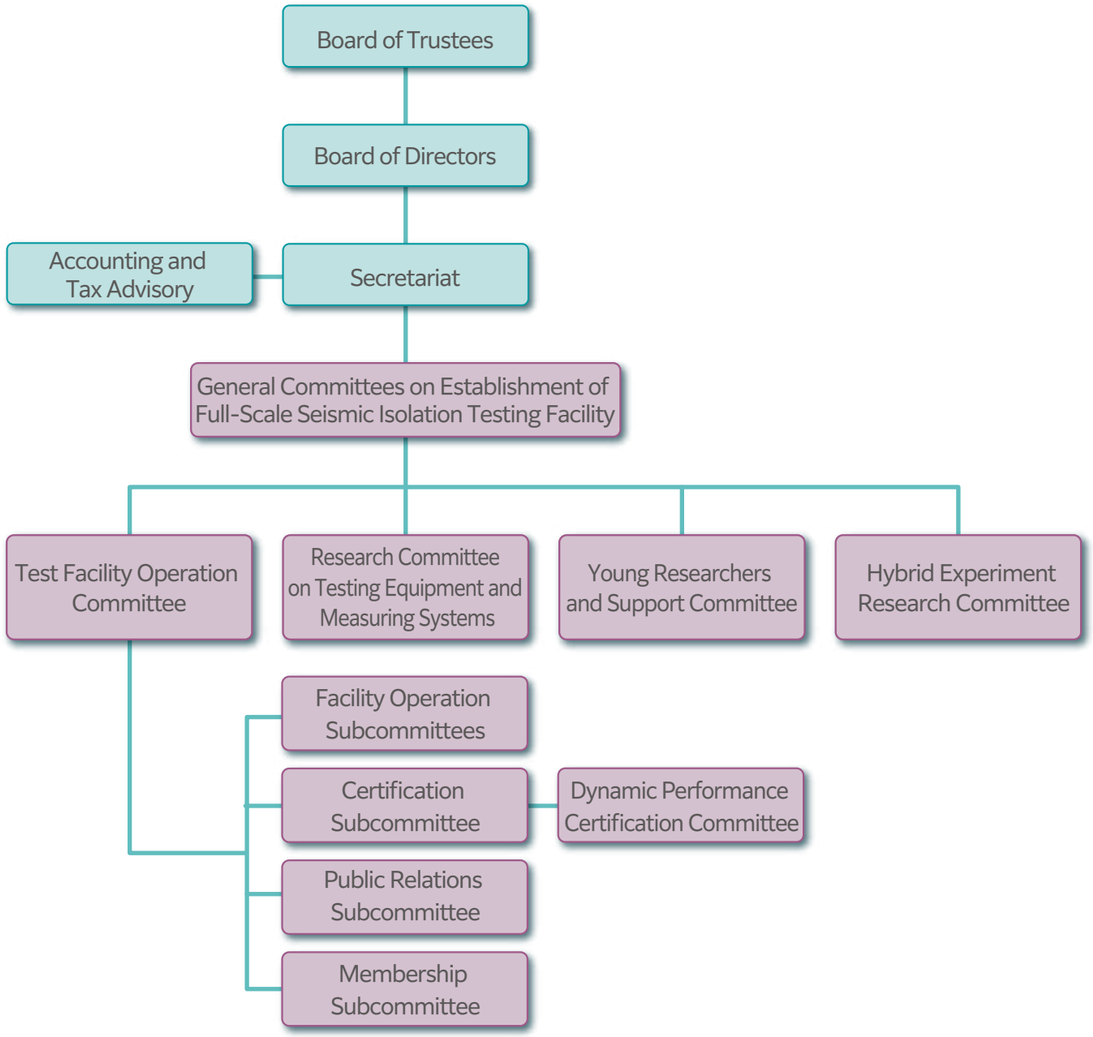
The testing equipment can be viewed from the open space

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

2024 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.

Accumulation of aging data on seismic isolation and response control components

Laminated rubber and Response Control dampers are manufactured in a factory by complex precise process and using many materials. There is still insufficient knowledge on the degree to which the performance of actual equipment changes over time. The Japan Seismic Isolation Laboratory will accumulate each various types of experimental 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

Japan Seismic Isolation Laboratory 1503-13 Mitsuta-Nishikameya, Shizomecho, Miki 673-0515, Japan

TEL. +81-794-70-8440

jsil Japan Seismic Isolation Laboratory