Disaster Mitigation Research Building

— a Base for Research, Response, and Preparedness

Nagoya University

Disaster Mitigation Research Center | Disaster Management Office

Overview of the building

With its staggered facade and sharp louvered eaves that provide shade from the late afternoon sun, the appearance of the Disaster Mitigation Research Building makes it stand out even from a distance in times of emergency.

Appearance of the west side

Appearance of the south-west side

The area around the entrance on the south side
and the staggered facade on the west side

Appearance of the south-east side

Overview of the building

Building name
: Disaster Mitigation Research Building, Nagoya University
Location
: Furo-cho, Chikusa-ku, Nagoya
Major usage
: University facility
Area of the building
: 731.10 m^2
Total floor area
: 2,897.83 m^2
Owner
: Nagoya University
Design
: Facility Management Department, Nagoya University
Nikken Sekkei Ltd.
Supervision
: Facility Management Department, Nagoya University
Execution
: Shimizu Corporation (construction)
Construction period
: from May 2013 to March 2014
Size
: 5 floors above ground
Height
: SGL+25.65 m
Structure type
: Reinforced concrete
Base isolation system

Appearance of the south side

Three roles of the Disaster Mitigation Research Building

The Disaster Mitigation Research Building accommodates two organizations: the Disaster Management Office, which aims to mitigate disaster damages at Nagoya University; and the Disaster Mitigation Research Center, which aims to realize a resilient society that is geared for disaster mitigation through collaboration with various entities in the region. The Disaster Mitigation Research Building assumes the following three roles.

1 A facility for conducting various types of advanced research regarding natural disasters and disaster prevention and mitigation

The building itself serves as a place for implementing and demonstrating research and development regarding technologies relating to earthquake resistant structures, isolated structural systems, and vibration control systems. In addition to its elastic base isolation system, the building has a rooftop laboratory with a base isolation system. Various sensors have also been installed in the building, offering an environment that enables a diverse range of research and development and demonstrative experiments.

2 A facility for promoting awareness of disaster prevention and developing human resources, with the aim of achieving a population that is prepared for disasters

The building has the Isolation System Gallery through which anyone can view the base isolation system devices at any time, various hands-on experiment-based educational materials, and devices that allow visitors to experience shaking—thus offering experience-based learning on earthquake resistant structures and isolated structural systems. In addition to these facilities, the building regularly hosts a range of lectures and seminars for the public.

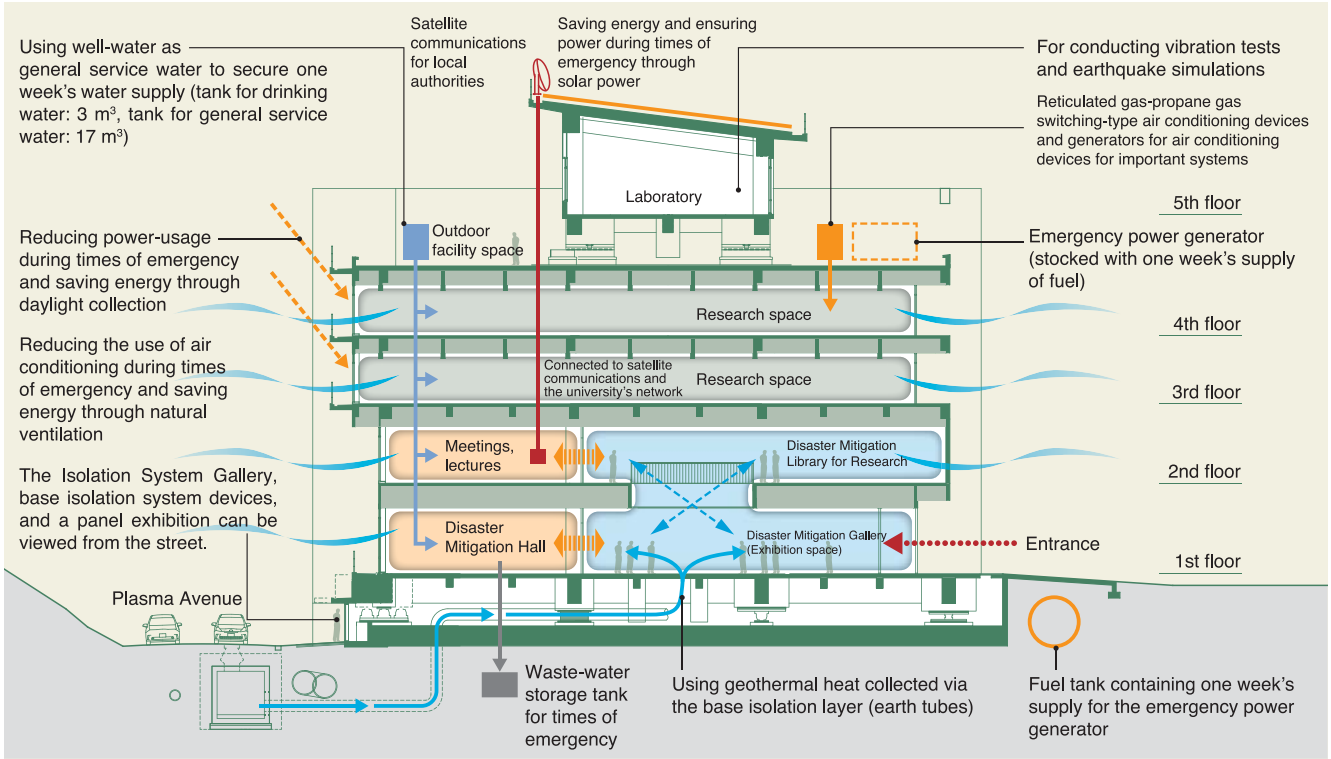
3 A facility for responding to disasters and protecting the region when disaster strikes

The building houses a disaster management headquarters, which will serve as a base for responding to large-scale disasters that occur in the Tokai region. In addition to its high-performance isolated structural systems, the building is equipped with a range of equipment, machinery, and materials that will help maintain its functions when a disaster occurs.

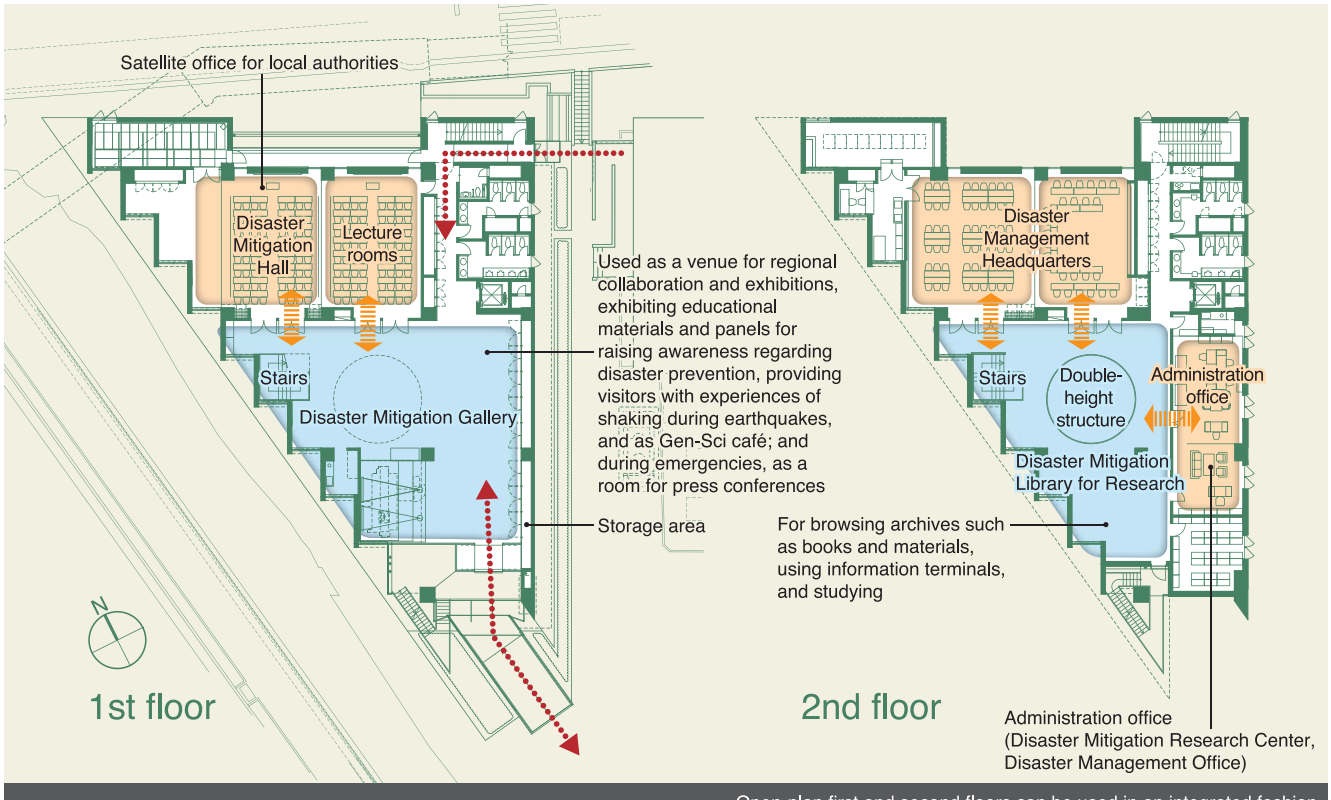
Features of the construction plan

In its day-to-day capacity, the building functions as an open venue for education, awareness-raising, and research on disaster mitigation; but in times of emergency, it functions as a base for disaster response. It is clearly divided into three zones: a zone for experience and learning on the first floor, a zone for the exploration of knowledge and disaster-management on the second floor, and a research zone on the third and fourth floor.

In addition, the building makes use of the shape of the staggered wall on the west side to provide space for exhibitions and research rooms. In the case of a disaster, the plan is that the first floor can be used freely by local government and mass media organizations, the second floor will be used by Nagoya University to respond to the disaster, and the third and fourth floors will be used as a base from which researchers from across Japan can survey the damage.



Cross-sectional structure in which each floor has a different function

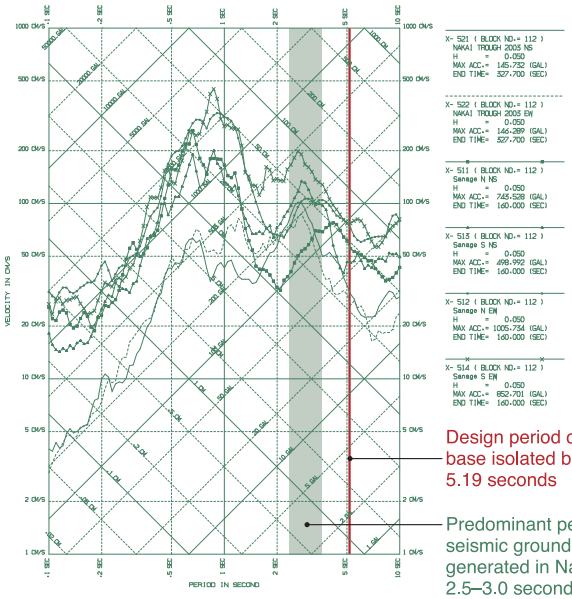


Open-plan first and second floors can be used in an integrated fashion

Features of the base isolation system of the Disaster Mitigation Research Building

Base isolation system providing linear restoring force characteristics with a natural period of 5.2 seconds

- The predominant period of long-period ground motion ranges from 2.5 to 3 seconds at the site. The natural period of the base isolated building was adjusted to 5.2 seconds in order to enhance the response reduction effects.
- The restoring force characteristics of the base isolation system have been linearized through the adoption of laminated natural rubber bearings, cross linear sliders, and oil dampers in the base isolation layer. This basic vibration condition provides flexible options for future technical developments.
- In case of unexpected resonance issues, a clearance of 90 cm and equivalent damping ratio of about 30% were adopted.
- The safety of the building was verified using design ground motions 1.5 times greater than the normal level 2 ground motions, as well as seismic ground motions of a Nankai Trough megathrust earthquake of the maximum class.
- Given that an elastic base isolation system with low stiffness was adopted, free vibration experiments of the building can now be conducted with the oil jack loading system placed in the base isolation layer.



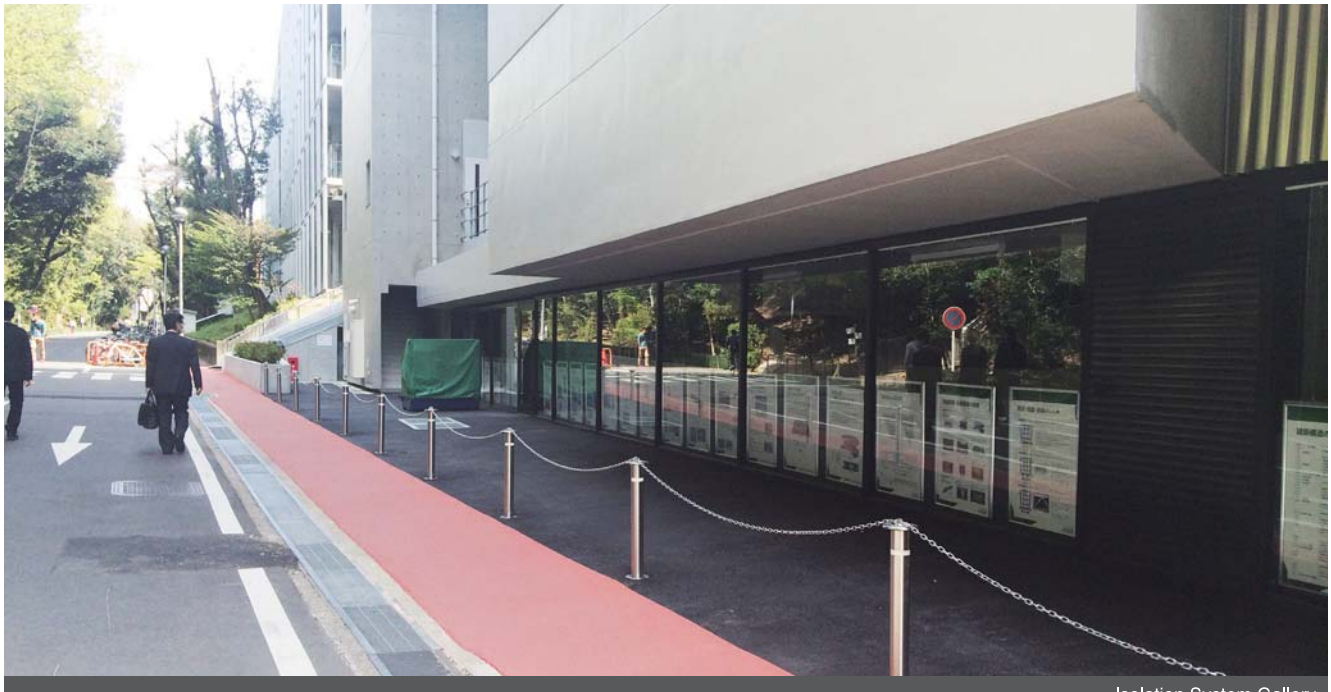

Laminated rubber bearing Φ1,400 mm


Oil damper


Cross linear slider

The Isolation System Gallery draws attention to the base isolation system

- Taking advantage of the difference in elevation at the base of the building allowed for the creation of a large space for the Isolation System Gallery, where the base isolation layer can be viewed at any time. The panels exhibited behind the glass walls of gallery house present the history of the development of the technologies behind earthquake resistant structures, base isolation systems, and vibration control systems.


Isolation System Gallery

Technologies to reduce shaking through the use of isolation structures both in foundations and on rooftops

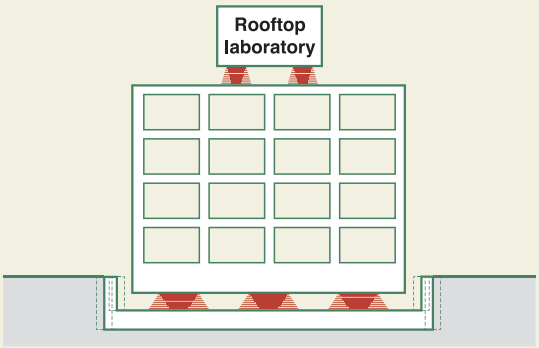
The earthquake resistant structures, base isolation systems, and vibration control systems incorporated in the building allow the entire building to function as an experimental facility for the development of technologies to reduce shaking.

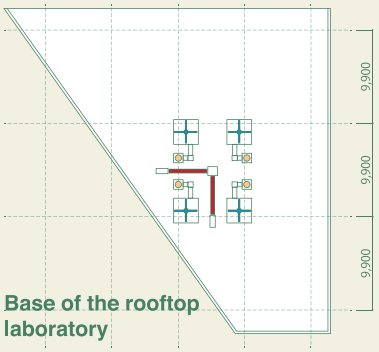
Rooftop laboratory for disaster mitigation and experimentation

Specifically,

- A 410 ton base isolation system with the same period (i.e. 5.2 seconds) as the base isolation system of the building has been placed on the rooftop (usually fixed with shear pins). This system can be used as an experimental laboratory for disaster mitigation through the use of the actuator vibration system.
- By applying a small level of cyclic forces to the rooftop laboratory at the natural period of 5.2 seconds, the resonance phenomenon generates amplified shaking of about 100 gal and vibration force of about 50 tons. In return, the reaction from the rooftop laboratory generates shaking in the main building—weighing more than 5,000 tons—with a force of just 10 gal, thereby allowing vibration experiments on the entire building.
- In the future, there are plans to establish an additional oil damper on the rooftop laboratory in order to demonstrate the effects of a vibration control system, which employs a base isolation system and a TMD, for cases when the damper is used as a TMD for typhoons.
- The use of monitoring sensors and the actuator vibration system makes it possible to conduct demonstrative experiments for examining the effectiveness of a base isolation system equipped with an AMD.
- The entire building can be oscillated by the jack loading system in the base isolation layer. Resonance experiments, where the main building is represented as “a ground” and the rooftop laboratory as “a building”, and research and development of devices for preventing resonance have been conducted.

Plan of installed devices at the base of the rooftop laboratory and in the base isolation layer





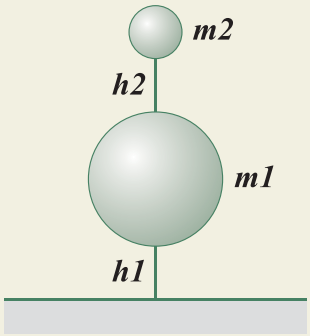
Cross linear slider
Base of the rooftop laboratory: CLB133
Base isolation layer: CLB500, 780

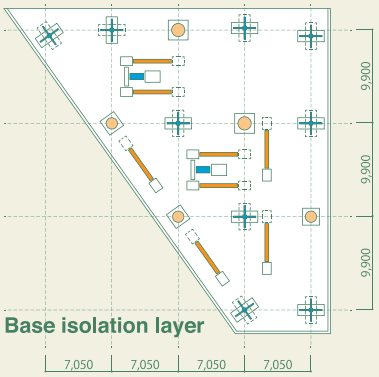
Laminated natural rubber bearing
Base of the rooftop laboratory:
Two in-series 400Φ isolators
Base isolation layer: 1,200Φ, 1,400Φ

Actuator
Rated capacity: 81 kN, 88 kN

Oil damper
Base isolation layer: 1,000 kN

Jack: Two units in the X direction

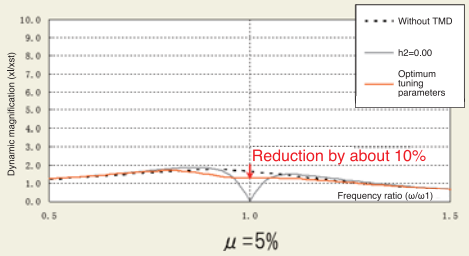


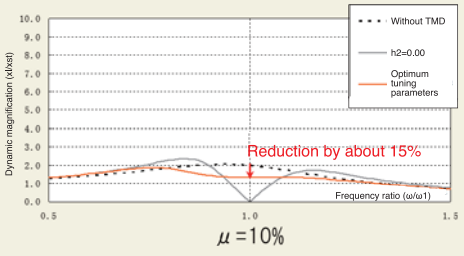


Actuator at the base of the rooftop laboratory

Jack installed within the base isolation layer

Verification of the TMD response reduction effects (in the case that the damping ratio of the main structure is h1=30%)





Den Hartog’s optimum tuning parameters

$$T_2=(1+\mu)\cdot T_1$$

$$h_2=\sqrt{\frac{3\mu}{8\cdot(1+\mu)^3}}$$

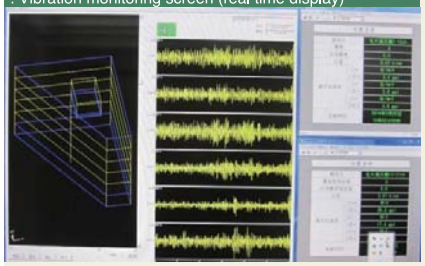
Verification of the TMD response reduction effects

Research Hub
2. Development of new technologies through the use of the shaking building

Among other things, it has been decided that the shaking building will be used and the earthquake resistant performance and vibration characteristics of the building are assessed. Furthermore, the durability and changes over the years of devices in the base isolation system will also be assessed, and technologies for vibration health monitoring will be developed.

- In the Disaster Mitigation Research Building, various types of high-accuracy accelerometers, displacement gauges, and earth pressure gauges are incorporated. These provide a system for measuring building vibration and the earth pressure around the foundation during earthquakes and forced vibration events applied to the building. There is a small amount of data available in relation to the characteristics of dynamic earth pressure around the retaining walls of the base isolation layer during earthquakes. This test system, where the source of vibration is evident, may provide useful data to identify such problems.
- The data on deterioration and fatigue in the base isolation devices will be acquired based on a number of repeated experiments by utilizing the rooftop laboratory.
- The data on changes over the years in the base isolation devices will be acquired based on periodical free vibration tests that use the jack loading system in the base isolation layer.
- Lifecycle monitoring technologies can be developed by utilizing networks of various types of inexpensive sensors.

Ground motions
: Vibration monitoring screen (real time display)



Earth pressure
: Earth pressure gauge (in contact with the earth on the outside of the wall)

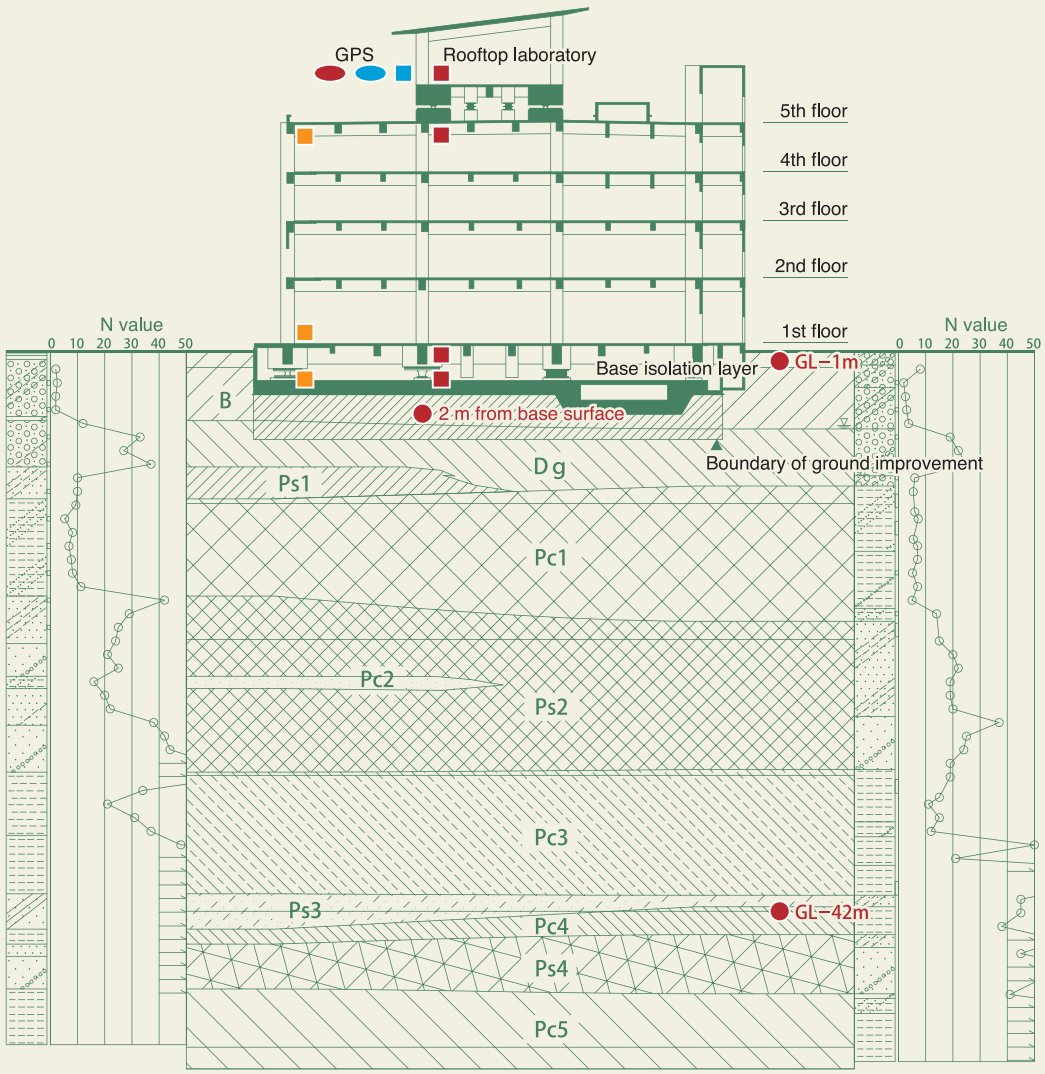
Displacement of the base isolation layer
: Displacement gauge (with a stretched string)

Mobile accelerometer

Mini-accelerometer

Floor-type accelerometer

In-ground-type accelerometer



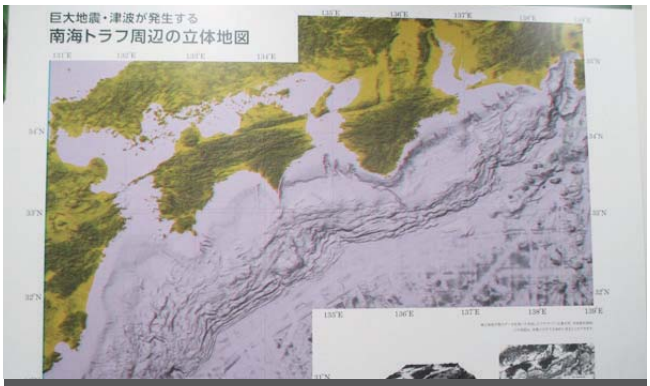
Disaster Mitigation Research Building monitoring systems

Disaster Preparedness Hub

1. Learning about earthquakes, earthquake resistant structures, and isolated structural systems through lectures and observation of actual devices

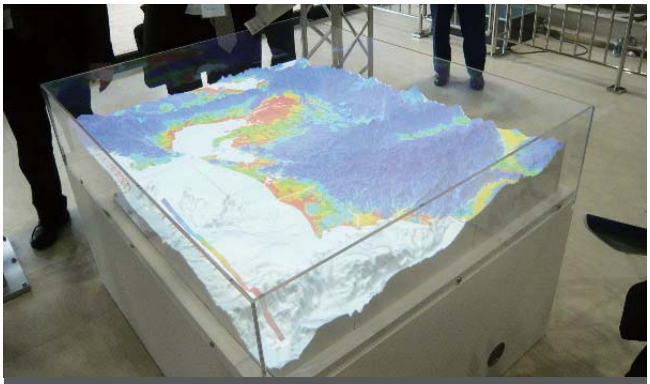
At the Disaster Mitigation Research Building, visitors can view actual devices for earthquakes and earthquake resistant structures or isolated structural systems / vibration control systems, and thereby understand their significance. They can also learn through participation in a range of seminars and human resource development programs.

- Open to the public from Tuesday to Saturday between the hours of 13:00 and 16:00, the building is a venue for gallery talks featuring different content every day.
- At the Isolation System Gallery on the north side of the building, visitors can learn about the principles and history of earthquake resistant structures, isolated structural systems, and vibration control systems while looking at actual base isolation system devices.
- Visitors can learn the principles of isolated structural systems, vibration control systems, and resonance by watching the shaking miniature of the Disaster Mitigation Research Building.
- Visitors can view an anaglyph of the terrestrial and ocean floor topography in order to see the reality of the Nankai Trough and active faults, and thereby understand the probability of earthquakes occurring.
- Visitors can see an actual piece of liquefied ground from the Tensho Earthquake of 1586, which was excavated in an archaeological survey—thereby feeling the effects of liquefaction. They can also learn the history behind the relocation of the main center of the Owari region from Kiyosu to Nagoya in 1610.
- Visitors can learn the history of earthquakes and flood disasters in Japan and Aichi Prefecture, as well as historic earthquake-related sites in the prefecture.
- Every month, the Disaster Mitigation Research Building runs several programs aimed at helping the Tokai region to enhance its earthquake resistance. These include the Disaster Prevention Academy and the Gen-Sci Café for citizens, the Disaster Mitigation Learning House for students and researchers, ESPER for engineers, and NSL for media and governments.
- The building also functions as a venue for activities to develop local human resources for disaster prevention in the region. Such activities include the biannual Aichi Disaster Prevention and Mitigation College, which is run through collaboration between the business, government, public sectors, and the university; the Disaster Prevention Seminars for High School Students, which are held through collaboration between universities and high schools; and the Earthquake Resistance Advisor Training Course for construction engineers.



Stereoscopic view of terrestrial and ocean floor topography


A piece of the ground from Kiyosu castle, which suffered liquefaction during the Tensho Earthquake in 1586


Stereoscopic view of hazard information through projection mapping


Disaster Prevention Academy, Nagoya University


Gen-Sci Café

Disaster Preparedness Hub

2. Experiencing earthquake resistance and ground motion through experiments

At the Disaster Mitigation Gallery, visitors can have hands-on experience of earthquakes, ground motion, earthquake resistant structures, isolated structural systems, and vibration control systems through the use of a range of educational materials designed to promote the development of earthquake resistant structures, thereby learning how to build earthquake-proof buildings.

- By using experimental tools for studying earthquakes on plate boundaries, motion propagation, tsunami, liquefaction, and earthquake early warning systems, visitors can acquire experiment-based learning on the occurrence and propagation of earthquakes and earthquake ground motion.
- By looking at miniatures of wooden-framed buildings, earthquake-resistant reinforced buildings, damaged houses and so on, visitors can learn about the structure of buildings and earthquake damage.
- By using devices such as BiCURI—a long-stroke long-period shaking table that can simulate long-period seismic ground motion—and a long-period pendulum that uses a six-meter climbing rope, visitors can experience how buildings respond to earthquakes.
- Through Bururu, an experiment-based educational resource for learning about earthquake resistance, visitors can learn about differences in earthquake-resistant performance due to structural balance and the weight of the roof, amplification of ground motion, and resonance response between the ground and a building.
- By using a wagon-type shaking table, visitors can learn the importance of preventing furniture from falling.
- At the Kids Space, children and parents can learn about earthquake resistance through crafts such as making houses from straws and clips or making a paper Bururu, or by joining in illustrated story-telling sessions and playing disaster-prevention card-games.
- At the disaster mitigation and experimental laboratory on the rooftop, visitors can experience earthquakes by feeling the ground motion, viewing images, and hearing sounds. This will motivate them to take action for disaster mitigation.

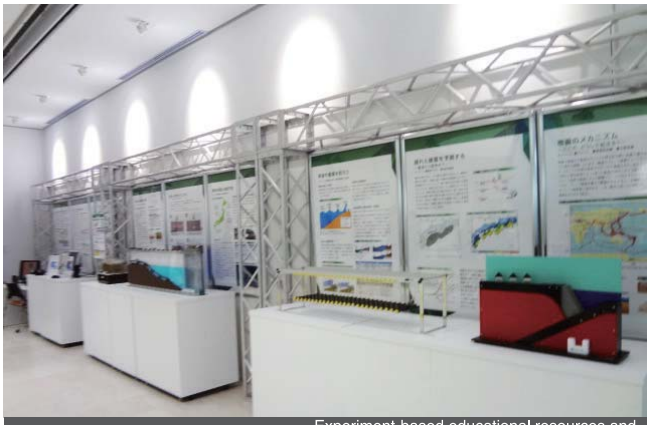
Feeling the ground motion, viewing images, and hearing sounds in a simulated earthquake experience at the laboratory on the rooftop

Shaking table to enable visitors to experience long-period ground motion

Bururu, an experiment-based educational resource for learning about earthquake resistance

Experiment-based educational resources that simulate the motion of the ground and buildings during an earthquake

Introducing the paper Bururu on our Web site



Experiment-based educational resources and panel exhibition on earthquakes and tsunami

Disaster Preparedness Hub

3. Providing access to a range of information about the building premises

At the Disaster Mitigation Library for Research on the second floor of the Disaster Mitigation Research Building, visitors can access a range of information about the building premises, on which its earthquake-resistant design is based, presented in various media.

- The library has amassed historical data on the municipalities in the four prefectures of the Tokai region, regional disaster-prevention plans, and hazard maps. Visitors can research the history of disasters for each municipality and their hazard levels regarding earthquake and floods.
- The library has collected old maps, photographs, ukiyo-e, drawings, and materials stating the origins of various place names, enabling visitors to see how the land-use of the premises of the building has changed over time. In addition, through the present-history mapping system that converted the aforementioned data to GIS data, visitors can study the relationship between the building's premises and geographical and hazard information.
- The library has amassed materials regarding earthquakes that mainly took place in the Tokai region at a time when modern measuring devices were not available ("historical earthquakes"). Old documents have been scanned and included into the database.
- The library has collected data on about 100,000 bores taken in the Tokai region. Visitors can see an outline of the underground structure around the premises of the building.
- Visitors can watch videos of lectures held at the Disaster Prevention Academy—more than 100 lectures recorded over a ten-year period.
- Over the course of a decade, the library has collected various articles about earthquakes, disaster prevention, and earthquake resistance. These articles can be easily searched using the library's news article search system.
- Visitors can browse reports and introductory books regarding disaster prevention and mitigation.

Municipality history space for learning about the region

Present-history mapping system for learning about changes in land use over time

Historical earthquake space for learning the history of disasters in the region

Cover shot of the Disaster Mitigation Library for Research

Disaster Response Hub

The Disaster Mitigation Research Building is set up to serve as a hub for the Tokai region and Nagoya University for responding to disasters. In addition, the building introduces case examples of the facilities that other disaster response hubs must have.

- In order to function as a disaster management headquarters, in addition to adopting the base isolation system, the building is fitted with 150 kVA diesel-powered electric generators that can run continuously for one week, 10 kW solar power generators, reticulated gas-propane gas switching-type gas-powered air conditioning devices, and power supply boards for connecting to power-supply vehicles, thereby ensuring an energy supply during times of disaster.
- To ensure that waterworks and sewage systems will function during times of disaster, the building has a 3 m3 tank for drinking water—enough to supply 100 people for ten days— as well a 17 m3 tank for general service water, tanks for waste-water, and so on. It also holds an ample supply of food, bedding, fixtures, and medicine.
- Satellite antenna dishes for local authorities and a long-distance wireless LAN that connects the building with the Chubu Regional Development Bureau have been established to ensure information flow during times of disaster.
- On the second floor, the Nagoya University Disaster Management Headquarters has been established to protect the university's 24,000 educational staff and students. The office collects earthquake measurement information and other disaster-related information, and by using facilities such as the university-wide broadcast system, provides an appropriate disaster response.
- The Disaster Mitigation Hall and the Disaster Mitigation Gallery on the first floor will be open to local government and media organizations, and the third and fourth floors can be used freely by researchers from across Japan for disaster response.
- When disasters occur in other areas, this office will serve as a hub for collating information, functioning as a clearing house.

Disaster management headquarters

Disaster preparation materials such as food stocks

Drill at the disaster management headquarters

Water supply

Volume
: 3 m³ of drinking water and 17 m³ of general service water (two systems)
During a disaster
: 100 personnel for ten days
Pump
: Compatible with emergency power sources
Other
: The tank for receiving drinking water has been fitted with emergency isolation valves and faucets for collecting water, enabling manual access to clean water.

Solar power generation

Volume : 10 kW

Satellite communication facilities

Emergency power generator

Output : 150 kVA
Operation time : 1 week or more
Fuel : Light oil, 7,000 ℓ in an underground fuel tank
Activation
: Generators will be activated after about 10 seconds, and after another 10 seconds, the power supply will start.
Floors to be supplied
: Part of the hall on the 1st floor, the whole of the 2nd floor, and parts of the 3rd and 4th floors
Other
: Solar power generation will be used through a separate system, system can be switched to accept power supplied from external power-supply vehicles

Rooftop facilities

Nagoya University

Disaster Mitigation Research Center | Disaster Management Office

Furo-cho, Chikusa-ku, Nagoya, JAPAN 464-8601

http://www.gensai.nagoya-u.ac.jp/

NAGOYA UNIVERSITY

April.2019