Infrastructure Maintenance, Renovation, and Management

Developing Technologies to Support Sustainable, Safe and Secure Infrastructure Systems, Driven by Five Research Projects

From roads to harbors, railways to airports, infrastructure is the fundamental element of modern society that supports our life and social activities. A sustainable economy, productivity, and the wellbeing of a nation depend heavily on the reliability and sustainability of its infrastructure. A large portion of today's infrastructure was built during the period of high economic growth. In recent years, numerous cases of infrastructure deterioration have surfaced, leading to major accidents. Many other problems include the cost for social capital repairs and maintenance across ten different sectors (roads, flood control, sewage systems, harbors, public housing, parks, seashores, airports, sea marks, and government facilities). Estimates suggest these costs will reach between ¥4.3 and ¥5.1 trillion in fiscal year 2023, and between ¥4.6 and ¥5.5 trillion in fiscal year 2033. In the face of such circumstances, many are looking toward infrastructure maintenance, renovation, and management technologies as a strategy to prevent accidents and reduce the burden of repairs and maintenance.

Program Director

Yozo Fujino

Yokohama National University
Institute of Advanced Sciences
Distinguished Professor

Profile

After completing the Master of Engineering program in the Department of Civil Engineering at the University of Tokyo in 1974, Yozo Fujino studied at the University of Waterloo, Canada and received his Ph.D. in civil engineering in 1976. He then returned to Japan in 1977 and served as a research associate at the Earthquake Research Institute of the University of Tokyo. In 1978, he joined the Department of Structural Engineering at the University of Tsukuba as an assistant professor. Fujino joined the Department of Civil Engineering at the University of Tokyo in 1982 as an associate professor. In 1990, Dr. Fujino became a full professor of civil engineering at the University of Tokyo. Professor Fujino took an appointment from the Yokohama National University in November 2014. Professor Emeritus, the University of Tokyo. Among other honors, Professor Fujino was awarded the Medal with Purple Ribbon from the Emperor of Japan in 2007 and the Hokokai Award (Hattori Hokokai Foundation) in 2015.

Research and Development Topics

1. Research and development on inspection, monitoring, and diagnostic technologies

Develop technologies that provide efficient and effective inspection and monitoring capabilities to assess infrastructure damage.

2. Research and development on structural material, deterioration mechanism, repair, and reinforcement technologies

Develop simulation technologies to assess deterioration mechanism of structural materials; create a structural deterioration forecast system.

3. Research and development on information and communications technologies

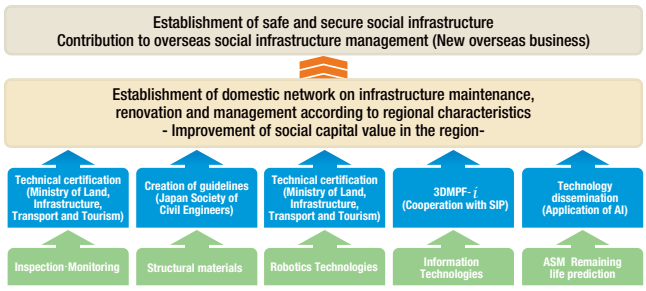
Develop data management technologies utilizing the enormous volume of information generated by infrastructure maintenance, management, renovation, and repair systems.

4. Research and development on robotics technologies

Develop robotics technologies to inspect, diagnose, operate, manage, and repair infrastructure elements efficiently and effectively; develop robots to perform surveys and excavation in dangerous situations such as disaster areas.

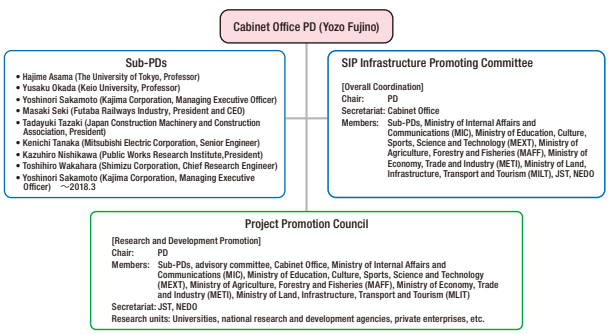
5. Research and development on asset management technologies

Implement infrastructure management for the technologies produced from topics 1. through 4. above. Develop asset management technologies for efficient operations management making the most of limited financial and human resources.



Implementation Structure

The SIP Infrastructure Promoting Committee is led by the Program Director (PD) and Cabinet Office, with participation by sub-PDs, concerned government ministries and agencies, the Japan Science and Technology Agency (JST) and the New Energy and Industrial Technology Development Organization (NEDO). Project Promotion Council meetings are held in cooperation with universities, national research and development agencies, private enterprises, and others as the main research units. The PD, sub-PDs, advisory committee members, and concerned government ministries and agencies advise research units on research and development. At the same time, they examine intellectual property strategies, including standardization strategies for developing nations and other foreign countries.



Exit Strategies

Active use of new technologies

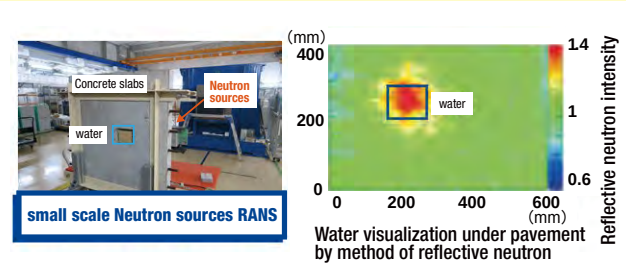
National government will actively adopt and assess new technologies; demonstrate the outcomes to regional public bodies that will eventually generate nationwide rollouts; build a support and management structure; train and educate human resources.

Standardization of useful new technologies for international expansion

Create international standardization of useful new technologies through domestic use and evaluation for global rollout; create an integrated system for introduction and localization for targeted countries.

Progress to Date

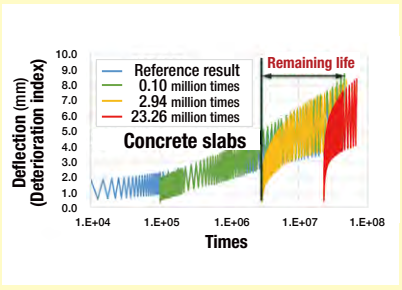
The technology developed in this project has excellent performance and can be confidently recommended.
For example, one of them is visualization technology of the state of rebar inside concrete using X-rays. We can use neutron to visualize cavities and water inside the concrete.
There are many subjects to practical use of these results, but there is no doubt that it is the world's most advanced technology.
There are many promising technologies such as the measurement system with compact probe capable of easy measurement of plate thickness and crack by high sensitivity magnetism, the world's first system capable of detecting the internal defect of the deck by electromagnetic wave radar radiating from a car traveling at speed of 80 kilometers per hour, the life expectancy system of concrete floor slab and inspection support systems for tunnels and bridges.



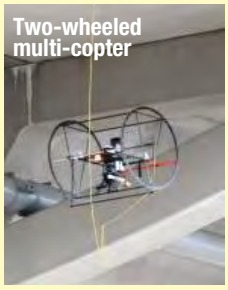
•Water Visualization System Using Small Scale Neutron Sources

•Ultrasensitive Magnetic Nondestructive Testing

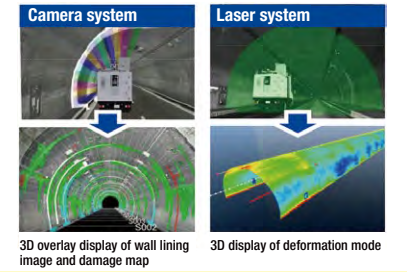
•High Speed Scanning with 3D Radar



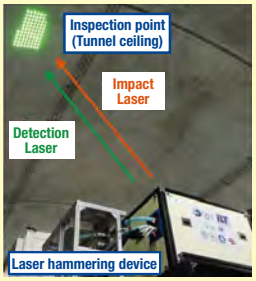
•Remaining Life Prediction of Concrete Slabs



•Bridge Inspection Support Robot System



•Inspection for Tunnel Using a Rapidly Scannable Non-contact Radar



•High Speed Inspection System by Laser Hammering

•Activities of the Regional Implementation Support Team

Program Director **Yozo Fujino** Interview

Promoting Implementation by Regional Governments, which Account for 80 Percent of Infrastructure

Civil infrastructures, including roads, railways, airports and harbors, play an essential role in supporting functionality of modern society. Our research and development is designed to prevent the physical degradation of infrastructure from becoming a major accident, so that it can be passed onto future generations. These efforts are consistently producing results that can be put into practice in the real world.

Implement Innovative Diagnostic Technologies

Infrastructure maintenance, renovation, and management technologies are the way to keep the aging of civil infrastructure from becoming major sources of accidents, while reducing the cost of repairs and maintenance. Program Director Yozo Fujino is in his final year overseeing the program as its PD. In this interview, Dr.Fujino looks back on the progress of this program and stated about its achievement as follows.

"Fiscal year 2016 was the third year of the program, and marked the halfway point. Following a Stage-Gate process in order to select and focus on development topics with a view toward practical implementation, we narrowed down our topics and direction for the future. Leveraging the steady progress made in onsite verifications in cooperation with MLIT and the new Regional Implementation Support Team, we stepped up efforts to refine the development into technologies that businesses can use, and actually want to use, in the real world. As a result, we improved the accuracy and efficiency of the maintenance cycle."

Let's look at the current results of the program in each of its focus areas.

In the course of research and development for inspection, monitoring and diagnostic technologies, we have produced more than 30 technical developments. These successes provide efficient and effective inspection and monitoring capabilities to capture infrastructure damage as data. A number of these developments are nearly complete for real-world implementation. One example is a system that uses non-contact radar while traveling at high speeds through tunnels and similar locations to diagnose internal defects. Other technology uses on-vehicle ground-penetrating radar to find deteriorations on bridge slabs. This technology, too, works while on the move at relatively high speeds. Another technology uses X-ray and neutron to visualize concrete interior. The program has also achieved developments of outstanding convenience and simplicity, including completion of a compact device capable of detecting thickness and cracks concealed under a coating of paint using ultrasensitive magnetic nondestructive testing; as well as development of less labor-intensive technology capable of detecting internal defects in concrete by using lasers to vibrate the surface of the concrete. The method of predicting the fatigue life of the RC bridge slabs from the crack information on the inside of bridge slabs and the back side of the deck is almost practically used. To date, Japan is the only country in the world that explore these technologies. In the future, we would be introducing these technologies to the rest of the world.

Adapting Research Results for Recovery in Tohoku and Kumamoto

The next focus area is research and development of technologies for structural materials, deterioration mechanisms, repair, and reinforcement. In particular, the program has seen positive results in the development of precast components using ultra-durable concrete. Fujino says, "We have concrete that is five times as durable against salt and frost damage. It will be extremely effective when repairing and upgrading concrete, which makes up 80% of the structural materials in Japan's infrastructure."

The project is also developing a variety of robots that can inspect bridges, tunnels and other social infrastructure safely and economically. This includes a flying robot system that uses acoustics technology to perform inspections. Semi submerged work robots are also being developed and improved for remote control operation. At the same time, the project is building systems that manage the information from these civil infrastructure robots through a central system.

The research results discussed above are already being implemented in actual infrastructure management. The program is also seeing specific results from asset management technologies,which provide systems for efficient maintenance and management. One such research result relates to enhancing the durability of concrete structures. This technology has been implemented in the Tohoku region of Japan for roads reconstruction and reconstruction of support roads. This development is used in infrastructure recovery support for the regions affected by the Kumamoto earthquakes of April 2016.

Regional Governments' Infrastructure Maintenance

Dr. Fujino says, "Regional governments manage 80% of all infrastructure. The question is how to get them to adopt our project results. To get there, we'll need completely new types of partnerships. Therefore, we will be working to provide

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technologies with local universities acting as the hubs for regional development, moving from there to developing businesses.” In order to make the results of SIP infrastructure useful when local governments operate infrastructure asset management, the regional implementation support team focusing on local universities has conducted analysis to solve problems peculiar to the area and has proposed solutions. Some new technologies will not meet conventional standards. So, the program has started an initiative for technology certification in cooperation with MLIT. Fujino stresses, “certification from MLIT will provide reassurance in using the new technologies.”

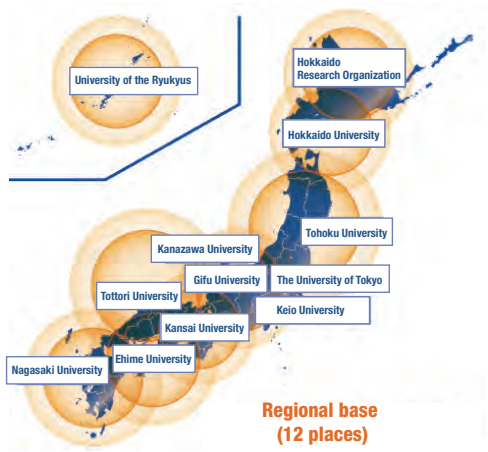
Thanks to the activities of the regional implementation support team, we were able to get in close contact with regional governments.

Society 5.0 and AI

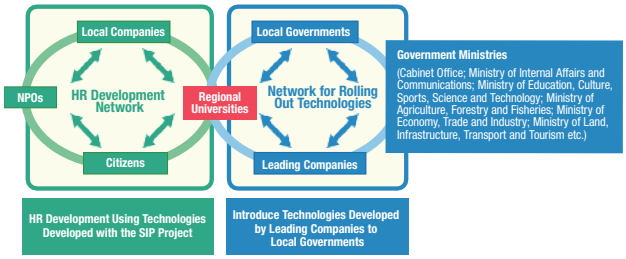
Acoustic analysis of concrete hammer sound, leak detection, detection of cracks in concrete, etc. were technically developed using AI from the beginning. And looking at the coming Society 5.0, we are developing new technologies such as remaining life diagnosis of concrete bridge slabs considering AI. Dr. Fujino says,“There is no doubt that AI is a powerful technology, but nothing is solved by AI at once. In order to make the best use of AI, it is essential to gather a large amount of good quality data at high cost.”

Finally, Fujino says, “Infrastructure stock in Japan is said to exceed the total amount of 800 trillion yen. Infrastructure is used for decades. Taking over infrastructure that the next generation can use safely is our responsibility to the future. I would like to broadly use and utilize the results of "SIP infrastructure" that contributes to the establishment of sustainable safety and security.”

•Regional Implementation Base (12 places)



•Roll Out Infrastructure Maintenance and Renovation Management in the Regions



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