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3.11:
THE AFTERMATH

SoE As a Guiding Light, Spirited in Face of Disasters

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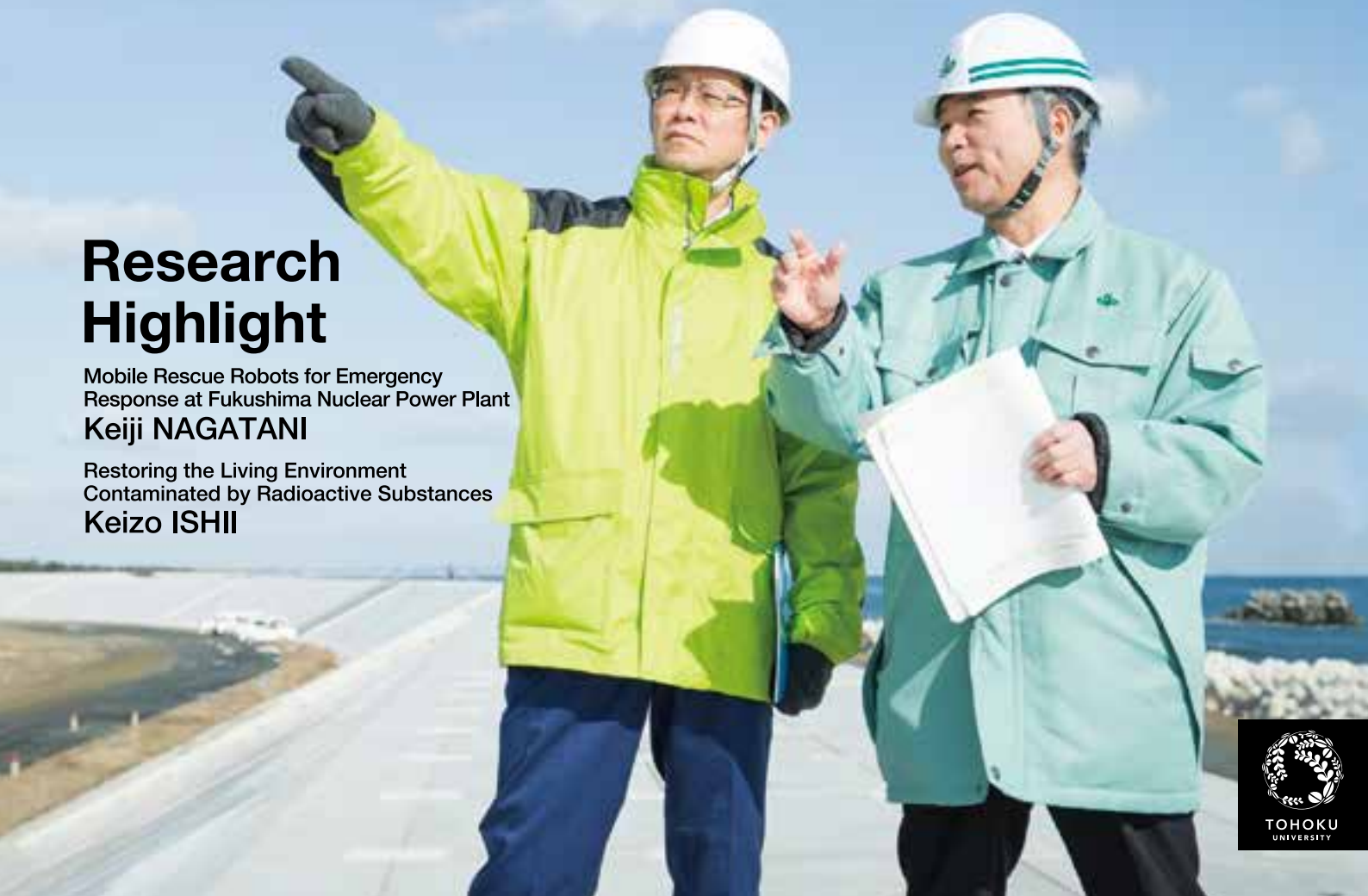

TOHOKU UNIVERSITY

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Re-construction for the Future

Welcome to the second issue of our new periodical, "Tune" – Tohoku University Research News of Engineering.
In this issue we focused on how School of Engineering (SoE)'s leading-edge R&D is being put to use in dealing with a wide range of Engineering problems emanating from 3-11. Even today, we are faced with many great challenges wrought by the disasters that slammed our hometown Sendai several years ago. Featured here are the fields of Civil Engineering as well as robotics, where our faculty members are paving the way into the future through application of various technologies. Also, our readers can access the "online-only" topics at Tune website[URL http://tune.eng.tohoku.ac.jp]. Besides this, there are many other technologies being born at SoE so this is just the tip of the iceberg. As noted in our inaugural issue, science and technology must deal with problems requiring an interdisciplinary perspective and global cooperation, not to mention intergenerational action. We aim to utilize this publication to shed a light on SoE's activities and international network, thus disseminating useful information widely around the world.

SoE As a Guiding Light, Spirited in Face of Disasters

Text by S."Tex" POMEROY / Photographs by Masayoshi HARABUCHI

The most powerful earthquake on record in Japan, a 9.0 magnitude undersea tremor with an epicenter 70 km from the northeast shores of Miyagi Prefecture on March 11, 2011. This subsequently generated a tsunami which devastated a wide expanse along the Pacific coastline, including the city of Sendai. Tohoku University and SoE was not exempt from damage. Yet, despite the disasters, SoE – led by the Hisada lab – took on the challenge of finding a method to recycle waste materials, adding up in millions of tons. A consortium set up by Prof. Hisada, who heads up his namesake lab centered on Civil engineering research, in particular concrete, has to date been able to clear up a huge amount of such waste. Working together with Mr. Sasaki of the Miyagi Prefectural Government charged with the clean-up (who happens to be an SoE alumni) the lab has accomplished much. We herewith offer another fact that should be written into the record books.

A Ten-meter "Wall of Water"

— Mr. Sasaki, can you tell our readers what happened on that fateful day of March 11 , 2011?

Mr. Sasaki: Well I was inside the prefectural building that day. Sendai, as a city located right on the coast of Miyagi, had been struck by a tidal wave about 10 meters high, as generated by a massive earthquake. A ten-meter "Wall of Water" washed ashore from the Pacific, entering about 4 km inland to inundate a dozen square kilometers. After destroying many buildings, the retreating water carried away people as well as about two-fifths of the resulting debris amounting to 15 million tons. Still, it left in its wake an estimated 9 million tons of debris to be dealt with. The debris waste strewn across the Sendai coastline totaled at nearly double the amount of garbage produced by Tokyo in a year.

The earthquake had also led to the ground level falling by 40 to 80 cm, so we needed to fill in the lost ground with something sturdy. We had to find a way to turn an incredible amount of debris into usable items as building materials, to work together to find a viable solution. The waste materials from the Great Kanto earthquake in 1923 were used to produce a waterfront park in Yokohama while those from the Great Hanshin-Awaji earthquake in 1995 were used as Osaka Bay landfill, but we did not have such major landfill option available to us so we had to think of other methods.

— Can you tell us about how you came to be involved in the current efforts?

Mr. Sasaki: As a public servant we spent the first month after 3-11 searching for survivors, then the next two removing the debris, in line with Japanese government policy. The national policy of recycling as much as possible of the waste and debris from three months later was implemented by the prefectural government. This was because some small municipalities were unable to cope with management due to loss of personnel, including top people for certain locations.
Prof. Hisada: In my case, I had been involved closely with the Japan Society of Civil Engineers (JSCE) so I wanted to make sure the network of experts could bring their knowhow to good use. Since I was in Tokyo on a business trip when I felt the seismic shock, I returned to Sendai to find that the city's infrastructural damage was extensive indeed. Since concrete is my selected field of research, I wanted to find out if the remaining structures were still strong enough to enable the city to be rebuilt based upon them.
Mr. Sasaki: We had to clear things up as soon as we could because of potential hazards like spontaneous combustion as well as the gas and odor being produced by the organic materials contained in the debris – we looked to process most of recyclable items within 3 years … thus we hit upon the idea of creating a consortium to bring together all available technical resources from public and private sectors.

M.HISADA × G.SASAKI

Makoto HISADA

Dr. Makoto Hisada, is Professor, Graduate School of Engineering at Tohoku University and Director of Infrastructures Management Research Center. After graduating from Kyoto University in 2002. He worked as a construction company engineer before becoming a Tokyo Institute of Technology research associate; he then served as Associate Professor of Niigata University, Senior Researcher of Public Works Research Institute, Tsukuba and Associate Professor of Tohoku University.

His research field includes construction materials, in particular concrete engineering. His research interest centers on durability, deterioration and maintenance technologies of concrete structures, having authored more than a hundred related papers.

Prof. Hisada: In response, we at Tohoku University helped form the "Consortium on the Utilization Management of Disaster Waste and Unused By-product Resources"; I was certain that Tohoku University could fill the role of principal organizer because not only were we "neutral" but many of the SoE alumni could be found in both private and public sectors, including academia.

At the onset, we brought together general constructors like Kajima and companies with local presence such as Mitsubishi Materials to become members of the consortium. We asked for a membership fee of 1,000 USD (we now have some 80 members) so we could coordinate the research activities within the disparate group. This coordination not only enabled researchers at SoE but those from other Tohoku University faculties as well as those from the private sector to work together closely upon trying to "coagulate" solutions.

Looking for Solutions

— It must have been hard going, trying to deal with the situation from scratch...

Prof. Hisada: Fortunately for me, I expanded on my previous research work such as trying to find ways to mitigate the effects of acid rain on concrete, and the additional R&D support plus funds from the Consortium helped push the experimentation further. Not that my work was made easier … I had to work harder now to produce results. I am even today having problems dealing with difficult-to-handle flyash. We had a varied lot of waste, we obviously needed to sort and select carefully, trying to remove or neutralize as much as possible the salt from seawater.

As it was, materials experts from both academia and industry were familiar with the properties of different materials, and we soon found that if we place these under heat and pressure, they would become well-bonded enough despite comprising everything from ash to sludge. In this manner, a cement containing a variety of materials as glass and paper was born, usable as roadbed materials among other applications (it is also being used as base portion of the new tsunami defense wall, a photo of which is to be found herewith). To date we have recycled approximately 60% of the debris waste, just three years after the disaster.

— So nearly two-thirds of the debris is gone. Yet you must have taken much care in dealing with the waste materials.

Prof. Hisada: Yes, the post-quake debris this time contained some radioactive materials, so I also called upon JSCE experts to come up with guidelines such as monitoring methodology to separate out contaminated items. The decontamination efforts implemented have reduced the becquerel levels to the acceptable 8,000 ones per kg as well. It is our intermediate goal to achieve the consortium's aim of recycling 80% of uncontaminated debris over the next five years.

A Pleasant Surprise Finding

— I understand there were some interesting results due to the research work.

Mr. Sasaki: The main thing I was concerned about was the quality of the concrete since some of the waste had been soaked in brine (seawater diluted by freshwater such as those from rivers and rainfalls). I also thought some materials just might not be conducive to producing high-quality concrete. However it seems I was overanxious. Furthermore, there were added findings made during our R&D efforts. For example, we ascertained the fact that brine being used for producing cement, hitherto considered to be a very difficult task, is not as detrimental to the overall structural soundness of the resultant concrete. Moreover, the recycling process seems not to take but a few months.

Prof. Hisada: Yet, I am told that findings such as the use of certain amount of brine as mentioned above by Mr. Sasaki upon mixing cement for concrete production could be very useful for other purposes. I understand there are many countries around the world that cannot produce quality concrete due to lack of usable freshwater. As noted by others, perhaps it can be used worldwide in locations like those facing desertification, not to mention Middle Eastern countries. Member firms like Showa Concrete and Taiheiyo Cement might also be able to work together with marine constructors for improvements in building activities.

Mr. Sasaki: Let me note the fact that the Japanese government has just decided the data obtained and archived will form the basis for dealing with similar disasters in the future. Underlying the momentum behind getting results was the fact that there are SoE graduates found in abundance in the industries, like Nippon Paper and Mitsubishi Materials, as well as the government offices in the Tohoku region. The networking effected by the SoE under Prof. Hisada's direction, along with support from his colleagues in the JSCE, whose subcommittee formed the original basis for the consortium establishment in 2012, helped push the agenda forward even further. I am very happy to have been associated with the Hisada lab at my alma mater as well.

Prof. Hisada: The new consortium to deal with the debris waste, established in face of such a widespread disaster, shows that Japan can make Industry-Academia-Government alliance work well, and quickly too. It must of course be a sustained effort since the issue of dealing with radioactive contaminants, albeit at minimal level, is an intricate part of the endeavor. I am of course still investigating other recycling processes, as I wish to increase the percentage of debris recycled as much as possible.

In Conclusion

— So, what is the next step?

Mr. Sasaki: The city of Sendai will soon host the Third World Conference on Disaster Risk Reduction, backed by the United Nations. Participants will see that we're not only recovering but expanding, with a new subway line being opened before year-end. I hope all those gathering at the International Convention Center will note that even while dealing with the aftermath of disasters, an effective countermeasure has been found right near them at SoE.

Prof. Hisada: We have seen great results because everyone worked together to surmount this hardship, having the same school and hometown we all wished to see resurrected. Again, the majority of all debris waste has now been reutilized. Yet our ambition is the aim of the consortium is to rid 80% of the disaster-spawned debris waste by 2020. The byproducts from the effort are seen to improve things for the future, which SoE can be proud of in the years to come. I think our combined work exemplifies what is best with our school and community.

Gen SASAKI

Mr. Gen Sasaki is Deputy Technical Director-General of Miyagi Prefectural Government Treasury Department, graduated from Tohoku University Dept. of Civil Engineering in 1979. A Professional Engineer (construction sector), his graduation thesis theme was "Durability of High-strength-concrete against Freezing and Thawing"; he has been engaged in road construction, landslides prevention works and various other projects.
He has worked as Director of Tobu Public Works Office in the Ishinomaki Area and also as Deputy Director-General of Miyagi Prefectural Government Environment Department's "Earthquake Disaster Waste Policy Division".

NEXT TALK **Spintronics**

The 1988 discovery of giant magneto-resistance won the Nobel Prize in Physics; science and technology for better understanding plus control of the electron spin has now grown into a field called spintronics. Spintronics encompasses many disciplines offering new horizons and very promising applications, not only in information and communication technologies but also in many other areas. The next issue of Tune will uncover some major applications seen transforming our society.

Photographs by Masayoshi HARABUCHI

Mobile Rescue Robots for Emergency Response at Fukushima Nuclear Power Plant

Associate Professor Keiji Nagatani (center) with his collaborators, Professor Satoshi Tadokoro (right) and Associate Professor Kazunori Ohno (left), Graduate School of Information Sciences (GSIS), Tohoku University

Keiji NAGATANI

Associate Prof. Keiji Nagatani received his Ph.D. degree from the University of Tsukuba, in 1997. He was a Postdoctoral Fellow at Carnegie Mellon University, from 1997 to 1999, and he was a Lecturer at Okayama University, from 1999 to 2005. Currently, he is an Associate Professor in the Graduate School of Engineering, Tohoku University. His research interest is focused on the field of robotics, in particular tele-operation of tracked vehicles for search and rescue missions, as well as the development of mobile robots to explore volcanic areas. He is a Member of RSJ, SICE, JSME, JSASS and IEEE.

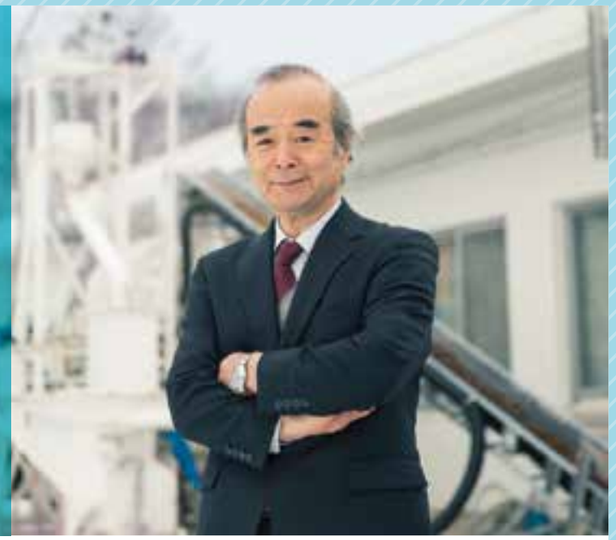
On 11th March, 2011, a massive earthquake and accompanying tsunami hit the Tohoku region of eastern Japan. The result was that Fukushima Daiichi Nuclear Power Plants faced a crisis because of loss of all power, setting the stage for meltdowns. It was very dangerous for humans to enter the nuclear reactor buildings to conduct damage assessment due to radioactive materials.

We checked the radiation tolerance of electronic components in our mobile rescue robot, called Quince, with irradiation tests at Japan Atomic Energy Agency (JAEA); our commercial electronic devices worked more than 100 h at a 10% safety margin in the target environment (100 mGy/h), without any lead shielding. Next, we tested the wireless communication function for operating Quince under such environments, including at Hamaoka Daiichi Nuclear Power Plants, which indicated that robust wireless communication was not possible in reactor buildings due to thick concrete. We thus adopted a wired communication system (wire length: 500 m). The wire was reeled out as the robot goes forward and rewound upon moving backward. Finally, we mounted surveillance devices such as dosimeter on it. While such preparations were ongoing, prospective robot operators from Tokyo Electric Power Company (TEPCO) trained under mock-up setting.

At last, one of the robots was delivered to the Fukushima on 20th June, 2011, and it contributed significantly to surveillance missions at the plant. One of the biggest successes in the missions was that TEPCO came to understand the health of the core spray plant and its low dose rate in building #3. After the mission, the plant was re-activated immediately by workers to cool the reactor core directly. We still have much research issues to improve the robot, so we will continue research on remotely-operated mobile robot technologies.

Reference: Keiji Nagatani, Satoshi Tadokoro, et al, ``Emergency Response to the Nuclear Accident at the Fukushima Daiichi Nuclear Power Plants using Mobile Rescue Robots'', Journal of Field Robotics, Volume 30, Issue 1, pp.44-63 (2013-01)

Restoring the Living Environment Contaminated by Radioactive Substances



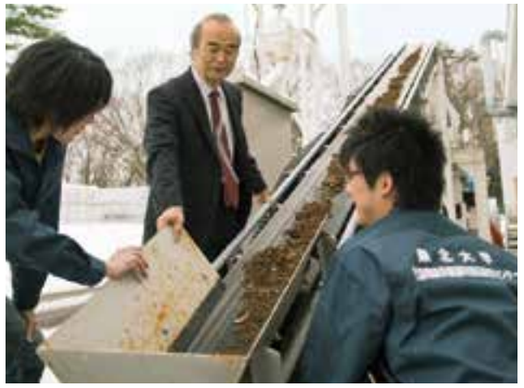
Keizo ISHII

Prof. Keizo Ishii received his Ph.D. degree in Science from Graduate School of Science, Tohoku University. From 1976 to 1977, he worked as Probationer at the National Center for Scientific Research, Cyclotron Center, France. Then he became Assistant Professor of Tohoku University, Cyclotron and Radioisotope Center, followed by appointment as Associate Professor there; he thereafter became Professor of Tohoku University, School of Engineering. He is now Research Professor of Tohoku University, Director of Research Center for Remediation Engineering of Living Environments contaminated with Radioisotopes and Radiation and Protection Supervisor at Graduate School of Tohoku University. He is also a decontamination adviser to Miyagi Prefecture.

My research work started from studying nuclear physics and atomic physics. In particular, I studied Particle Induced X-ray Emission (PIXE) and applied it to trace elemental analysis, by which elements from Na to U can be analyzed simultaneously, the so-called PIXE method. Furthermore, I developed the micro-PIXE analysis by which the spatial distributions of the elements in a living cell can be investigated. In parallel to the research on PIXE, I have developed Positron Emission Tomography (PET) which can image the function of a living body. Recently, I succeeded in developing a super-high resolution semiconductor PET which provides photography of a 1 mm-sized cancer for the first time in the world.

At present, I am carrying out R&D on technologies that produce early restoration of the living environment contaminated by the accident of the Fukushima Daiichi nuclear power plant after the Great East Japan Earthquake on 11 March, 2011. I found that the activity of soil decreased 1/25 by washing the soil three times with the water and radioactive substances enveloped in clay. Based on this result, I and my colleagues decontaminated approximately 7000 m^2 of the school grounds at two elementary schools and two kindergartens in Marumori town by removing contaminated soil and washing it to reduce its volume. Here we used a compact mixer to wash soil and put muddy water into filter cloth sacks used in brewing alcohol. We then spun the sacks in a washing machine to remove the water content and took out clay that contained large amounts of radioactive Cesium. Now, to make this method practical on a large scale, we are developing a miniature decontamination plant.

The space dose rate in Fukushima Prefecture decreased little by little due to the decay of radioisotopes and the weathering effect from wind and rain as well as other reasons (spread of



mushroom spores, movement of microbes, etc.). In order to predict the recovery of agricultural and forestry-related industries in the disaster-stricken area, we developed a system for precisely measuring how the radiation levels changed over time in the mountains of Fukushima Prefecture.

Analyzing an ear of rice grown in soil containing Cesium by the micro-PIXE method, we could ascertain that Cesium had accumulated in the rice bran and embryo.

Using PET technology, we developed "Continuous Individual Non-destructive Type Radioactive Contamination Inspection Equipment" for marine products. Fish are placed intact on a conveyor belt approximately 12 meters in length, and the system measures the concentration of radioactive Cesium in the fish using 120 individual detection devices. This system can examine the fish without destroying them, and if nothing was abnormal the fish can then be shipped on afterwards. This system enables inspection of a maximum of 1400 fish per hour. This system is also used to inspection of bamboo shoots and supports shipping of bamboo shoots in Marumori town. We developed "Complete Rapid Contamination Inspection Equipment" which can precisely examine and measure radioactive substances without damaging the food and with a precision comparable to the nearly conventional methods. About twenty of this inspection equipment are running in Fukushima city and other places.

News

Launch of Asteroid-bound Satellite

"Hayabusa 2" was successfully launched at 1:22 p.m. on December 3, 2014. It began its 6-year, 5.3 billion kilometers journey, which will take it to asteroid 1999 JU3 and back. Like its predecessor "Hayabusa", it is an asteroid sample return mission that will deploy mini-lander "Minerva 2" on the asteroid to survey its surface. "Hayabusa 2" will afterwards collect sample material from asteroid 1999 JU3, to be sent back to Earth. Delivery is scheduled for December 2020. "Minerva 2", which stands for Micro/Nano Experimental Robot Vehicle for Asteroid, is the successor to "Minerva" of the "Hayabusa" mission. Like its predecessor, "Minerva 2" is not a wheeled rover but is to land and hop around on the asteroid's surface while collecting photographs and temperature readings. "Minerva 2" has been developed in the frame of a university consortium, including Tohoku University.

Lecture by Nobel Laureate Nakamura

Professor Shuji Nakamura, from the University of California, Santa Barbara, is one of the three Japanese recipients of the 2014 Nobel Prize in Physics "for the invention of efficient blue light-emitting diodes, which has enabled bright and energy-saving white light sources" . He gave a lecture at Tohoku University on January 31, 2015. At the end of the talk, a Question/Answer session was held with members of the public including from preliminary school to graduate school student. He gave a message to young people to work harder on things that you like the best and that will open your possibilities in the future.

For Better Electric Vehicles of Tomorrow

Under auspices of the "Next Generation Automobiles in Miyagi" project, a prospective visit by a large delegation of its member took place in Ishinomaki on February 17, 2015. This endeavor involving industry, academic and governmental institutions, of which Tohoku University is a founding member, aims to realize an advanced region enabling better integration of the automobile atop ruins resulting from the 2011 Tohoku earthquake. The visit comprised gathering testimonies related to expectations for the car of the future and advantages of such a car could offer society.

ElyT Workshop

The Engineering and Science Lyon Tohoku Laboratory (ElyT Lab) has organized its 7th annual workshop on Comprehensive Research and Materials, Systems and Energy for Sustainable Future. The event took place in Matsushima just north of Sendai from February 19 to February 21, 2015. ELyT Lab is a French-Japanese joint research laboratory involving the French National Center for Scientific Research (CNRS), Ecole Centrale de Lyon, INSA de Lyon and Tohoku University. In addition to fostering research between the city of Lyon and Tohoku University, the Summer Schools "ELyT School" are organized every year alternating between France and Japan with the aim of presenting the partners institutions to students from the other country.

Opening Ceremony of the Qatar Science Campus Hall

The ribbon-cutting ceremony of the Qatar Science Campus Hall (QSCH) took place on February 21, 2015, in the presence of representatives from the State of Qatar, Tohoku University and Miyagi Prefecture including the Minister of Foreign Affairs of the State of Qatar Dr. Al-Attiyah and Tohoku University President Satomi. The old building of the School of Engineering, which was damaged by the 2011 Tohoku earthquake, has been renovated thanks to the Qatar Friendship Fund. The originally large meeting room has been turned into a versatile hall, able to host various types of event aimed at promoting science to children. The QSCH has the ambitious goal of nurturing as well as inspiring the next generation of engineers and researchers in the Tohoku region.

Upcoming Events in Sendai

Spintronics: From Mathematics to Devices

A series of International Workshops on Spintronics will be held in Sendai under the leadership of the World Premier International (WPI) Advanced Institute for Materials Research (AIMR) and the Top-Global Graduate School of Spintronics of Tohoku University.
This series of events will span from September 14 to December 11, 2015 and will focus on selected topics related to spintronics.
Please check the list of Workshops at the Tohoku Forum for Creativity official website.

http://www.tfc.tohoku.ac.jp/program/2127.html

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Office of Research Strategy, School of Engineering, Tohoku University

E-mail : eng-ken@bureau.tohoku.ac.jp
Tel/Fax : +81-22-795-5807
Address : 6-6 Aramaki, Aoba-ku Sendai 980-8579, Japan

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