Roundtable Discussion with Young Concrete Researchers: A glimpse of the future of Japanese concrete technology

Introduction:

Japan is a world leader in concrete-related research and technology. However, there is still a low level of global recognition for Japanese accomplishments in this area. For the sake of future exports of Japanese codes and technologies, it is necessary to promote awareness of Japan's current cutting-edge technologies and research. To increase recognition of Japan's current cutting-edge technologies among the world's researchers and engineers and attract worldwide attention to Japan's concrete technologies in the future, we invited some young researchers and working-level engineers who will be the leaders of the future to participate in a roundtable discussion to talk about cutting-edge Japanese research performed by their own research groups and their involvement in construction projects, describe the lessons they are learning and utilizing from the research and specifications of other countries, and discuss what will be needed in order to promote Japanese research, design, and other achievements on a global level.

Photo: Roundtable discussion

Roundtable participants

Young researchers and engineers:

Dr. Hiroshi Matsuzaki (Assistant Professor, Tohoku University)

Dr. Hiroshi Murata (Taisei Corporation Technology Center,
Member of International Affairs Subcommittee of JSCE)

Dr. Nobuhiro Chijiwa (Assistant Professor, Tokyo Institute of Technology
Former affiliation: University of Tokyo)

Dr. Shinichiro Okazaki (Assistant Professor, Ehime University)

Dr. Tatsuya Usui (Taisei Corporation Technology Center)

Dr. Yuichiro Kawabata (Port and Airport Research Institute)

Moderators:

Dr. Ryosuke Takahashi, Member of International Affairs Subcommittee of JSCE (University of Yamanashi)

Dr. Shingo Asamoto, Member of International Affairs Subcommittee of JSCE (Saitama University)

Content of roundtable discussion (titles of speakers omitted)

Takahashi: *This event, which is entitled "Promoting Diffusion of Reliable Japanese Concrete Technologies," has been organized to provide a forum for discussion of what young researchers and working-level engineers such as yourselves are thinking. First, I would like to hear from each of you about your own background and research topics.*

Usui: My name is Tatsuya Usui from the Taisei Corporation Technology Center. After receiving my master's degree from the University of Tokyo in 2006, I joined the staff of the Technology Center at Taisei Corporation, where I am conducting research in the area of concrete materials. I am doing laboratory research on topics such as thermal cracking of mass concrete, and I also have some experience with overseas projects, so I welcome the opportunity to talk about that during today's discussion.

Okazaki: My name is Shinichiro Okazaki from Ehime University. I received my doctorate from the University of Tokyo in 2008, and I have been an assistant professor at Ehime University since that time. My doctoral research was on liquid water behavior in concrete, and I focus more on the area of concrete material behavior. My main research topics at present are the study of nondestructive testing methods and ways to analyze material behavior using the results of nondestructive testing as input values. Thank you.

Kawabata: My name is Yuichiro Kawabata from the Port and Airport Research Institute. I received my doctorate from Kyushu University in 2008 and then joined the Port and Airport Research Institute. Originally, my research was in the area of concrete materials, especially the topics related to aggregate, but at present my research interests have shifted to structural design of port structures. Thank you. Thank you.

Chijiwa: My name is Nobuhiro Chijiwa. I'm an assistant professor at the University of Tokyo. I received my doctorate from the University of Tokyo in 2009, and I have been an assistant professor at the University of Tokyo since then. My dissertation was on evaluating the residual structural performance of structures that have experienced steel corrosion, so my studies were in the structural field. At present, I am studying how steel corrosion and structural performance change with the passage of time, and my research includes the evaluation of flexure due to long-term creep on actual bridges including the Tsukiyono Bridge. The measurement of flexure of actual bridges will continue for probably about the next 30 years, so I will be comparing the measured values to the results of analysis. Also, ever since my master's level studies, I have been researching the destruction of concrete using the properties of genetic recombination. This is the first time I have been invited to a roundtable discussion of this kind, and I'm glad to be here today.

Matsuzaki: My name is Hiroshi Matsuzaki from Tohoku University. I completed two years of the PhD program at Tohoku University and withdrew in February 2008, and then worked as an assistant professor at Tokyo Institute of Technology from that March until March 2012. In April 2012, I returned to Tohoku University as an assistant professor. My doctoral research concerns reliability-based design method, which is probabilistic design procedure. I have been studying design methods aimed at the integration of structural design and durability design, with consideration for the effects of ground motion, live load, salt attack, and other factors on concrete bridges, as well as the uncertainties involved in safety evaluation of structures. Since returning to Tohoku University, I have been doing research on structural performance evaluation and maintenance of deteriorated structures while also studying earthquake engineering. Thank you.

Murata: My name is Hiroshi Murata from the Taisei Corporation Technology Center. I joined Taisei Corporation after receiving my doctorate from the Tokyo Institute of Technology in 2007. My dissertation was about composite structures using ultra-high-strength fiber-reinforced concrete (UFC) as a web member. I was studying whether UFC could be used as a substitute for steel, since an increasing number of concrete and steel hybrid structures are being built with corrugated steel plate webs and steel truss webs, etc. Since joining the company, I have done almost no research on UFC, but I have been studying structures using fiber reinforced concrete, such as applications of SFRC in shield tunnels. I am also doing research on the earthquake resistant performance of bridge piers using high-strength rebar SD490 and USD685. My specialization is in the field of concrete structures. Thank you.

Takahashi: *Thank you, everyone. There have been many topics related to maintenance in recent years, and several of you have mentioned that as an area of your research. I would like to hear about your views on the research while discussing the subject of maintenance. I think that the fields of materials and structure will need to be more closely related in maintenance, and I expect that you all feel the same way. What are your views? Let's start with you, Dr. Kawabata, since you did your doctoral research in the field of materials and are now working in the structural field.*

Kawabata: I think materials field and structural field should be integrated without separating them into different categories. As long as the framework for evaluating a structure's performance is established, without getting hung up on which field it is, then in the area of maintenance as well, we will be able to figure out how to perform inspections and how to carry out maintenance works.

Also, especially with regard to maintenance, I feel that there is a gap between research and practice concerning how to evaluate structural performance. For example, there has been a great deal of research and proposals on using numerical analysis for the structural performance evaluation of the deteriorated structures, but during on-site inspections, the grade of deterioration is evaluated based on visual information. I think we will need to find ways to close that gap.

Takahashi: *The behavior of a structure is determined by the behavior of its materials, so in the end, it's impossible to understand structural performance without understanding material behavior. In that sense, it may be problematic to consider materials and structure as two separate fields, as you indicated.*

There is a gap between the approach taken by researchers and the approach of practitioners on the ground, as Dr. Kawabata indicated. When the tendency is to ultimately choose methods that are simple and inexpensive, I think a question arises as to just what kind of accuracy is being pursued by those sophisticated techniques.

There are high expectations for reliability design and the like in relation to maintenance techniques, but I have heard it said that the degree of error in input values such as ground motion is so large that the degree of error in evaluation by numerical analysis is insignificant by comparison. Even if the accuracy of deterministic calculations of yield strength is improved by numerical analysis when pursuing reliability design in the future, these efforts may not be rewarded.

Matsuzaki: In terms of the structural response subjected to ground motions, variation in response analysis is generally quite small in comparison to variation in evaluation of ground motions. However, when evaluating the performance of deteriorated structures, I think that variation in evaluating deterioration is a significant factor. For example, the diffusion coefficient of chloride ions varies about one order of magnitude, and as a result, even if an environmental action is deterministically applied, the factor of how chloride ions penetrate, or variation in the response to that action, becomes very significant. So the effect of variation in response evaluation is dramatically more important when predicting the progress of material deterioration than it is in the case of evaluating the mechanical response of structures.

If one considers the whole range from evaluation of action to structural response and structural safety, the question of what component technologies can ultimately result in a significant improvement to structural safety is made clear through study based on action, response, and safety assessment overall; and I have realized through various researches that because the variation in evaluation of action is excessively large, significantly increasing capacity will considerably lessen the probabilities of reaching a limit state, more than improving the accuracy of response evaluation. The knowledge gained through such researches makes it possible to quantify the importance of significantly increasing the actual capacity of members through the development of new technologies and new materials, and I believe that this may provide motivation for research to develop these kinds of new materials and new types of structures.

On the other hand, I do not believe it is necessarily the case that the effect of large action variations always eclipses the effect of improving variation in response evaluation. For example, considering flexural behavior, and phenomena such as brittle shear failure and failure of steel bars, there is not much variation in response evaluation for flexural behavior, which is a stable type of behavior; but when it comes to phenomena such as shear failure which are directly affected by the brittleness of materials, I believe that there is still potential for major reductions in the variation of response evaluation and the evaluation of load carrying capacity and deformation capacity. In fact, through reliability analysis, it can be clearly demonstrated that it is possible to rationally achieve improvements in structural safety by reducing the extent of variation in safety evaluation processes which involve large amounts of variation.

Takahashi: *Since the subject of variation has come up, I'd like to hear from Dr. Okazaki. In maintenance, variation in the input data poses a problem when considering structural performance evaluation based on numerical analysis. The input data is obtained through investigation, and Dr. Okazaki is attempting to obtain that data through nondestructive testing. My understanding is that this involves quite a large amount of variation. What is the current status of this?*

Okazaki: Yes, there is a considerable degree of variation in the data from nondestructive testing. Nondestructive testing basically determines the behavior of materials, so it evaluates the micro level performance of members, rather than the performance of the members themselves. It is difficult to use this in performance evaluation for an overall structure. Different nondestructive tests may be needed for the evaluation of structural performance; for example, this could include measuring the natural frequency of a structure when a car passes over it. However, although this approach can indicate the behavior of the overall system, it cannot easily find the local damage of each member. I believe that it may be possible to make maintenance a bit more sophisticated if we can properly link the behavior of the overall system to local damage in each member.

Takahashi: *Dr. Chijiwa, since you are also an expert in deteriorated structures, I assume you use input data that has a great deal of variation in your analyses.*

Chijiwa: I agree that variation is an important key. Under the present analytical system, for example, the process is that salt penetrates from the surface and reaches the rebar after a number of years, causing corrosion and expansion. We can say that this kind of deterioration will occur if the structure was built in accordance with the design; however, there can be a significant impact due to construction error and material error, and if salt actually penetrates more quickly than anticipated in some spots, the structure's behavior may be quite different than predicted by the analyses. In such a case, it is necessary to use the probabilistic kind of approach mentioned by Dr. Matsuzaki.

Takahashi: *Local behavior is important when conducting behavior analysis with consideration for variations in material characteristics, as in the case of deteriorated structures. There are other reasons as well, but when taking the averages of constitutive laws and elements based on newly built structures, as in the finite element method (FEM), I think that increasingly, these are actually handled as discrete subjects. Considering that, whether it's new construction or existing construction, the ultimate ideal may be to deal with more and more finely detailed elements and constitutive laws. This could end up at the molecular level, and beyond that to the dynamics of the elementary particle level, or in other words, quantum mechanics and astrophysics. Dr. Kawabata, I have heard that you see a connection between your own research and the universe. Is that the same sort of idea?*

Kawabata: My research deals with geology and petrology. My original research area was alkali-aggregate reaction, and aggregate is composed of many different

types of minerals. When you consider the minerals genesis, it makes you think about the origins of earth or universe, and if you study them further, they may lead you to the big bang.

Asamoto: *I had studied molecular dynamics and tried to simulate the water behavior in fine pores using it, but I felt that it would be difficult to relate that to the evaluation of macro behavior that is required from an engineering standpoint. I am also studying the mechanisms of shrinkage, and we often debate that shrinkage is affected by microscopic behavior such as capillary pressure and disjoining pressure, but such discussion might not be useful for practical design, although our motivation to study the mechanism is ultimately to develop an admixture that would eliminate shrinkage and to apply it to the site. There are difficulties in applying the results of detailed studies to practical purposes, and there is a risk that it could end up as a purely academic pursuit.*

Takahashi: *Engineering is a practical science, so the research has to be related to practical purposes. Still, if we don't think about anything other than practical applications, our work will be too devoid of dreams. I'm sure that you all have dreams for your own work. What are your thoughts on how your own research could change the future?*

Murata: Well, just as an example, at present, all of our work on using testing and inverse analysis to determine fracture energy with steel fiber reinforced concrete (SFRC) is conducted in the laboratory. It isn't all that difficult to estimate tension softening curves using inverse analysis, but no employees outside the laboratory know how to do it, and most of them do not even understand what we are doing. In the interest of improving skill levels, and also in the interest of promoting the use of this technology because I believe that increasing the use of fibers will lead to lower costs, I wish that employees of general contractors would have at least a general understanding of inverse analysis. Since it involves extra steps in addition to ordinary flexural capacity calculations to be able to calculate the flexural capacity of SFRC members, this cannot be calculated using commercially available design software, and everyone except laboratory scientists cannot calculate flexural capacity. However, I think that at least the employees of the design department should be able to handle it, so I have begun some activities at Taisei such as explaining how to solve inverse analysis.

Okazaki: I have proposed an original air permeability test, but as in the case mentioned earlier, it would still be difficult to use it in evaluating the performance of an overall system. Therefore, I would like to build a system where you would attach several accelerometers and apply vibrations and analyze the response of each member and the response of the whole, making it possible to evaluate the performance of each member and the performance of the whole, and you would then be able to identify the local damage of certain members very simply and relatively accurately by taking that as an inversion problem.

Matsuzaki: I think that we must not focus only on matters related to the overall framework of structural design method, which includes evaluating actions, responses and structural performance, and safety, if it means neglecting research on new technologies for each components of the framework. We need to consider the accuracy needed for each component technology as part of the whole and apply that knowledge in a suitable manner as we pursue research on new component technologies.

Kawabata: We need whole system that deals with design, construction, and maintenance in an integrated way, instead of separating them. We should think about the time-dependency of the performance of a structure. I think it's important to take an overall view. It is necessary to establish design method considering time-dependency of a structure. And we need to create rational system that can clearly convey design concepts including life-cycle management to construction stage and maintenance stage.

We also need systems that can achieve accountability; what is the required performance of a structure and what must be done to satisfy those requirements. It is necessary to consider not only the performance of the structure, but also role and function of the structure in the civil infrastructure. We deal with infrastructure, and if we pursue research with the recognition that what we are working on is part of a much larger whole, that will help us to see the path ahead more clearly. I think it's important for me to take a broader perspective because I belong to a research institute which support contractee and administrator. However, in some cases we may need to play politics, because there are limits to what we can do in our current position.

Usui: It is important to take a systematic view as technology develops, but taking a longer perspective on the future of Japan, there is also concern that Japan will have fewer engineers due to its declining birthrate and aging population. For example, there are fewer engineers who are able to determine the causes of problems like honeycomb and large variations in strength related to instability in fresh concrete properties when using special concrete made with fibers. There is a declining number of engineers who can determine questions such as how material behavior will change in relation to mix proportions, and it seems that more and more engineers are not even able to design concrete mix proportions. I think we will need to make efforts such as sharing technical understanding in order to stop this situation where increasing numbers of engineers lack knowledge of concrete. In other countries, both the aggregate and the cement are different from those of Japan, and engineers have to determine mix proportions that will satisfy the performance requirements. It is necessary to have skills such as being readily able to produce concrete with ordinary mix proportions,

including concrete for overseas projects, as these are expected to increase in the future. In other words, I believe that it is important for us to promote broader awareness of current technologies.

Chijiwa: I also agree with Dr. Kawabata, and I would like to bring up a couple of points. One is that more parts of Japan are becoming underpopulated as the country's population shrinks, and decisions will need to be made about how to handle the infrastructure in those areas. There is definitely no way that all of Japan's infrastructure could be maintained and managed in a uniform manner, and I think that we have to let the residents of those areas make the decisions about how to address their structures. In bridge building in the past, the categories were first-class bridges or second-class bridges, and local government organizations had the authority to decide which type of bridge to build, instead of a national government agency. The main difference between the two categories was their fatigue strength, and local governments made decisions about bridge construction by choosing first-class bridges for roads where large traffic volumes were anticipated and second-class bridges for ordinary roads. At some point, bridge types came to be determined by a formula, instead of the past criterion of traffic volume. This is a fair approach, but it also means that local residents have less control over decision-making. I think we should find a way to return this decision-making power to localities.

Also, it is said that we are currently in an era of maintenance. However, because it is not possible to repair or reinforce every structure, decisions are needed as to whether structures should be kept or removed. The other point I'd like to mention is that we need to act as doctors for structures, as Prof. Maekawa, who was my supervisor in University of Tokyo, used to say. Instead of practicing Western medicine, we need to be practitioners of Oriental medicine who can make comprehensive diagnoses and confidently decide which ailments need to be treated and which can be left alone. There are many different types of structural deterioration; there is good deterioration and bad deterioration, and in some cases, the damage and deterioration is so extensive the repair is urgently required. Prof. Maekawa told us that we needed to develop the ability to take in a variety of information and make a comprehensive diagnosis as to whether a structure can be left alone for another ten years or needs to be immediately closed to further use. I think it is important to know how to properly use a variety of analytical data and other information as analytical tools.

Takahashi: *It seems that Japanese research and technologies are not very well known internationally because few articles in English are submitted to foreign journals on these subjects. Do you conduct your research or other activities with an eye to international communication?*

Matsuzaki: In the area of reliability-based design, there isn't much difference in the level of technical expertise between Japan and other countries, but more research is being done

overseas than in Japan, and design methodology is based on a probabilistic approach in other countries. Probabilistic hazard assessment of ground motion was initially studied primarily in the U.S., and by applying that approach, I have been involved in research on the prediction of deterioration with consideration for variation in environmental actions, starting with quantitative hazard assessment of airborne chlorides. In order to take my research a step further than merely proposing a framework, I have made an effort to pursue probabilistic assessment based on experimental data and the results of measurements on actual structures whenever possible.

Okazaki: I give presentations at international conferences, but I rarely write articles for foreign journals. However, I think that I ought to submit more articles to foreign journals in the future, because Japan is on at least the same level as other countries in research on nondestructive testing.

Chijiwa: I have given lectures at the Sirindannhorn International Institute of Technology (SIIT) of Thammasat University in Thailand. Even though Thailand is friendly toward Japan, I was impressed to find what a very good impression the people there had of Japan. The subject of my lectures at SIIT was not about concrete, but Japanese cutting-edge technologies, so these were interdisciplinary talks like those at the Global Center of Excellence (GCOE) of the University of Tokyo. I talked about metal technology, landscape design, and other subjects. This seemed to be information that the students in Thailand would not normally encounter. They told me that they found the lectures very interesting and informative, and this gave me a renewed appreciation of the achievements of Japan. By introducing my own country's technologies in another country, I was able to view them from an outside perspective with a bird's-eye view, and this has changed my outlook on many aspects of Japanese technologies. In Europe, the relationship would be equal because their technologies are on the same level as ours; however, I think that it is meaningful to build stronger collaboration and to communicate and teach about Japanese technologies and culture in developing countries in regions such as Asia.

Kawabata: The Port and Airport Research Institute often holds the seminars in developing countries, especially ASEAN countries. We had also been involved in activities developing a framework for the approach to achieve strategic maintenance of port structures subjected to harsh marine environments. The ASEAN and Japan have jointly developed the guidelines for strategic maintenance of port facilities. Regarding the journals, we submit articles to international journals when the subjects are basic research. But in case of practical research, we usually present our work in domestic journals, because some types of structures are unique to Japan.

Usui: I have been involved in several projects overseas. Most countries do not perform calculations of cracking risk with the kinds of analyses that are used in Japan. In the specifications on mass concrete for a certain project, for example, there were rules stating that the maximum temperature of concrete had to be controlled below a certain level, and the internal and

external temperature differential had to be controlled to within a certain number of degrees. I had the impression that Japan is much more advanced in predictions of cracking in mass concrete. However, I think the reason that these kinds of Japanese technologies are not widely used overseas is that it would be difficult to apply these technologies, as Japanese standards are not used in projects in other countries; and even when these technologies are explained to customers, they tend not to accept them. One problem is that we do not have any connection with people overseas. It's important to have connections with local university professors and local engineers who are trusted by the ordering parties. There is currently only a limited amount of study abroad, and I think that is a negative. Considering the future, it is important to send human resources abroad for the sake of expertise and building connections. The technologies that we have are reliable, and if we build connections with people overseas when promoting awareness of our technologies in other countries, I think that we will have a lot more influence.

Takahashi: *I spent a year studying abroad, and I had exactly the same impression. I realized that it's important to send many young people abroad to build human relationships, instead of just going on and on about the excellence of Japanese technologies. We do invite people from other countries to come to Japan, but conversely, it's also important for many of us to go abroad. China is already doing that, and there is very large number of Chinese students who are studying abroad. If some percentage of those Chinese people remain abroad and become employed there, that means China has connections with those countries. If Japan doesn't start doing the same thing, I think it will be difficult to expand our activities overseas.*

Asamoto: *I spent a year in France, and I think it's better to go overseas when you're young. If you want to go abroad but you only wait for some opportunity to come up, you'll probably end up not going. I think it's best to tell others in advance about your desire to go overseas and start preparing early by planning about three years ahead. You should also carefully choose a destination that will give a great experience for you. I didn't study abroad in university, but worked at a private company in France because I have not worked at any private companies even in Japan. I was glad to be able to build connections with foreign people who were working in the practical field. Also, instead of letting those connections end after you come back to Japan, I think it's important to continue the exchange and keep in contact with people in that country by email and the like.*

Takahashi: *In our discussion today, you have shared various dreams that you have, and I hope that you will all keep on pursuing your dreams. You have also mentioned various areas where collaboration is important, and I hope that the mutual exchange among the participants here will continue after today as you continue to develop your ideas. Thank you for your participation.*