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Contents:

Topics

Above original articles were published in monthly JSCE Magazine during year 2003.

Project Reports of 2004 Outstanding Achievement Award, JSCE

Group I awards

(Presented in recognition of achievements relating to innovative planning or design, or individual technologies such as constructing technologies that made an outstanding contribution to the further advancement of civil engineering technology in relation to specific projects.)

Group II awards

(Presented to milestone projects that made an outstanding contribution to the development of civil engineering technology.)

On Promotion of Civil Engineering Works under Critical Fiscal Conditions
An Interview with the Governor of Mie Prefecture

From Centralization to Decentralization through Information Disclosure

The Clock Can No Longer Be Set Back

Masayasu KITAGAWA
Governor of Mie Prefecture
(Retired Apr. 20, 2003)

Weakening Effectiveness of Public Works Projects - A Turning Point

There are opinions arising that public works projects are growing less effective and that they should be radically cut back. What is your current opinion on the effectiveness of public works projects?

Kitagawa: There is no question that public works projects are indispensable. Nevertheless, we must make them more efficient, more environment-friendly, and we must remember to protect the lives and assets of the local residents as well. Based on the premise that public works projects and social capital provision are essential, I believe we must all contribute our opinions and discuss how to increase the effectiveness of public works projects.

Of course, I feel that the multiplier effect of public works projects have gotten relatively weak, but it is only natural. When our nation was still immature and required much social capital, public works projects were undertaken without limits. Our political administration system was based on such state. The system has remained unchanged over the years and that is the reason why public works projects are growing less popular.

During the stages when our nation's social capital was yet immature, civil engineers and those in the related profession who carried strong visions gave their best efforts to raise social capital to an adequate level. That same effort is now required to create a new theme, discover a new angle or come up with a new method. I believe we have reached such a turning point and because we fail to clearly demonstrate that point, people are starting to get the wrong idea that public works projects are unnecessary. In my view, this is a perfect opportunity for new discussions to spring up. Through new discussions, new ideas will be established, and new directions, new concepts and new technologies will arise.

For instance, Japanese land carries various special conditions such as the frequent earthquakes and typhoons and the short distance between mountains and coasts. These conditions must be taken in consideration when building a house and determining whether it should be designed to last 30 years, 100 years or 200 years. The situation is obviously different from countries where earthquakes and typhoons do not hit. Up until now, we continued to build concrete buildings, one after another with hardly a thought about the environmental loads. Instead, we must first discuss and consider the

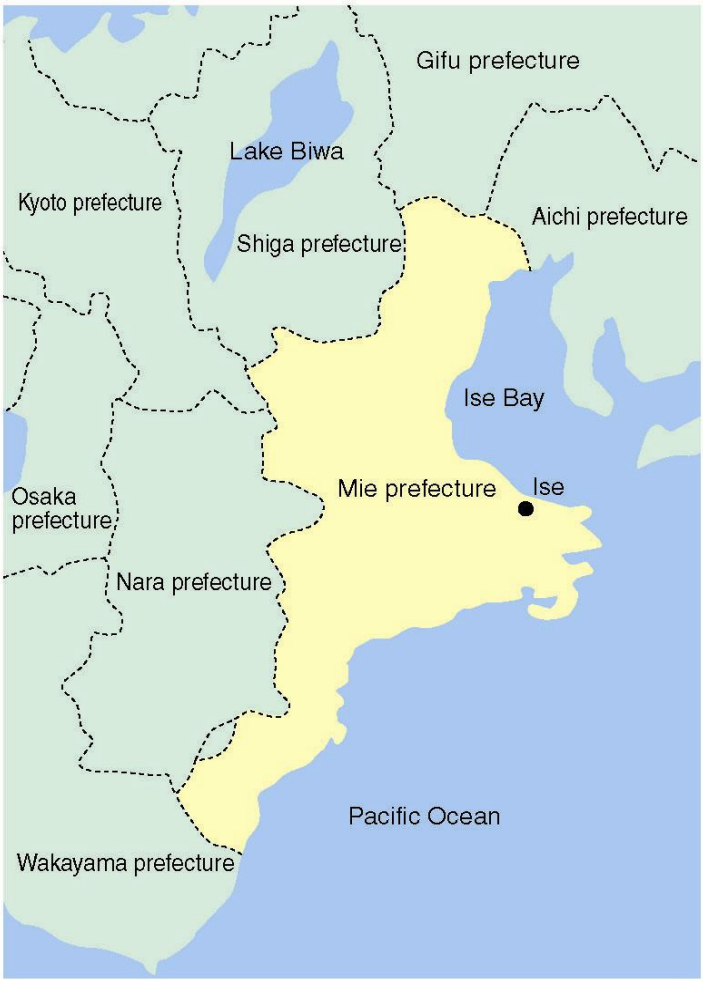

Figure 1: Location of Mie Prefecture

philosophical aspects. People's line of thought will change according to the shifting form of urban development. More consideration will be given to the environment, landscape, and comfort rather than focusing only on efficiency. I think that a new type of social capital provision will start to emerge there.

Do Not Criticize the Critics- Criticize the One in Charge of the Supply Side

Public works may be evaluated based on its cost-effectiveness. Do you feel ill at ease with such evaluation method?

Kitagawa: In the past, there was not even such evaluation. Suppliers gain power when goods are scarce. And thus, arrogant attitude of the administration went unchallenged. The government provided social capital, but everything was strictly confidential, and no information was disclosed. Under such circumstances, the government made irrational demands on local authorities. For example, the government's stance is to make every road a 4-lane road regardless of whether in a city or in the mountains, because that was what the government had decided. Such attitude is what brought about the present criticism against public works. The government must disclose more information, and adopt a modest stance in which evaluation of public works projects are carried out to achieve a fulfilled, abundant society. The ultimate question is how much comfort and how much security can be achieved at how much cost to the beneficiaries.

In the past, the supply side had too much power, resulting in numerous one-way arguments so it is not surprising that criticisms arose. We must not counter-criticize the critics for pointing out the faults. The criticisms will only increase if the supply side does not humbly accept what the others have to say and change their attitudes accordingly. It is a shame that the argument of those who resist the criticism on the supply side is still dominant. From now on, they must self-criticize to change the situation because it is unfortunate that social capital provision, which is indispensable to the society is being criticized today. The suppliers are the ones who are responsible for this but everybody seems to blame the other side.

Up until today, prefectural administration was under centralized power. The fundamentals of my administration reform calls for breaking away from the centralized power and to have the prefecture take initiatives "to achieve excellency."

What technologies and what new concepts are there to create maximum effect with minimum

cost? New technological ideas must be invented to start a new age. As long as the suppliers continue to believe that they are correct and continue to counter-criticize the critics of public works projects, these projects will see its end.

In budgets for public works projects, the share or the allocation was never allowed to change. But now, conditions are changing. For example, such changes as population decrease and the advances in information technology should seriously be taken into consideration.

I use the word "systematic complementarities" to express the nature of the current system in which everything is mutually related and fixed on one another. In a growing society, it is to one's advantage if one becomes an employee of a big company. In order to be employed by a big company, education is the important gauge, which is measured by school grade deviation value. Such system where one was systematically complemented to another was developed during the post-war era. Similarly, budgets are still unable to change the shares once set during the days of scarcity. That is why I believe it is better for everybody to get together to discuss this issue. Should highway construction be frozen based on public highway corporations' internal problem, without even listening to voices of the region concerned? When talking about public works projects, various issues such as medical, welfare, regional and industrial policy issues come into play. That is why I say we need to hold an official discussion. The entire system of public works projects should be carried out that way. Otherwise, it would be unfortunate for the ones in charge. A situation must be created so that they could work toward their ideals and dreams. It is not good to have the people in charge of the projects to feel hesitant or hold a sense of guilt. Whatever it takes, I would like to resolve this as a political issue.

The Greatest Problem: Local Governments were Held Accountable to the Nation, Not to the Taxpayers

The "stock and flow" approach is recently used in evaluating public works projects. What is your opinion regarding the stock effect and flow effect of public works projects?

Kitagawa: I may be going a bit too far to say this from the position of a governor, but the stock is essentially important in administration. The governmental body that ought to head for the stock is able to see only the flow and not the assets, because the accounting regulation is based on cash basis accounting. The constitution too is premised on cash basis accounting when it comes to handling public funds. I believe this to be the administration's ultimate mistake. Therefore, I adopted the corporate accounting system with balance sheets and thus acquired a new viewpoint to think about what assets we should bequeath. I think it is important to first create the stock through urban development and then to create the flow system for how to protect and foster them.

As such, in the long run, I believe we should look at the stock. Information came undisclosed until now, resulting in bid riggings and disingenuous business systems. But from now, it is important that the process be made clear. We should look at which technology is the most suitable, not only which is cheapest. Otherwise, new technology will not develop and we will only get what we pay for. The future calls for consideration toward culture, environment, and barrier-free state. Nevertheless, at the present stage, if such consideration results in 10% higher price, the prefectural assembly will not approve. In order to break free from such situation, accountability must be fulfilled to taxpayers, or the residents in the prefecture. Until now, the local government came mostly unaware of its accountability to the taxpayers. They only had to

fulfill their accountability to the nation. That was the greatest problem. We must consider future social capital provision by keeping in mind the fact that we must shift the target from nation to taxpayers accordingly. Determining what specific operations to take will be our job. I would like to ask professionals from JSCE for their cooperation and guidance.

Local Administration as a Comprehensive Matrix, And Not As A Vertical Division

You are in a position to oversee the entire region of Mie Prefecture, and allocate the budget to public works projects, education, social welfare and others. What do you feel is difficult in allocating the budget?

Kitagawa: The greatest difficulty for me is the fact that the administration functions are vertically divided. On the contrary, a city is created horizontally in a comprehensive manner. A nation will not last, if for example, the Ministry of Land, Infrastructure and Transport allowed no other rules than its own, and the Ministry of Education, Culture, Sports, Science and Technology in the same manner approved only of its own. I think the local governments should be placed in charge of its local affairs. If it failed, I will take the responsibility. I urge the central government to entrust the local governments with the freedom of making a failure. Nagatacho and Kasumigaseki do not understand all that goes on in the local regions. Nevertheless, the central government tries to tell us what to do. If we do not obey, they say they will not provide us the subsidies

It is because the local governments had their eyes set on the central government, and failed to see its resident's needs that the communities themselves started to function abnormally. Our accountability exists not to the nation. Since the Devolution of Power Law, the system has changed. We are trying to turn our eyes to the local community and start taking responsibilities. Of course, the relationship between the nation and the local community should be equal and cooperative, not a conflicting relationship. Nevertheless, at times, I would not hesitate to stand against the nation. I will debate the issue thoroughly. If it cannot be resolved through discussion, I am prepared to appear in court.

To carry out a total regional policy, we should look at things from a comprehensive administrative point of view. Using separate vertical budgets, for example from the Ministry of Land, Infrastructure and Transport, from the Ministry of Agriculture, Forestry and Fisheries, and from Ministry of Education, Culture, Sports, Science and Technology symbolizes an immature, pre-modern nation. That is why I compiled a budget incorporating a horizontal viewpoint for each policy, apart from the vertically set rules. There are 21 items including environment, barrier-free state and culture among others. We should acquire a comprehensive viewpoint, including both hardware and software. The private sector will serve to enhance the public sector, and in turn, the public will serve to enhance the private. Decentralization is important to enable projects to be carried out within a matrix.

The nation should get involved, focusing in essential matters. For example, in deciding how a city should be built, it should not only relate to distribution, but to IT and transmitting the culture as well. If one has to go the central government office 20, 30 or whatever times to secure a budget of 100 million yen, and the governor or the mayor must go and thank the government office again when they do receive it, it will only make our country worse. The country will perish once people start to take pleasure in that system.

Hearing the Governor, the current situation sounds

similar to the period when Japan's old feudal government system was moving toward Meiji Restoration. I heard government officials criticize that the only thing that changed after losing the war was the elimination of military affairs, and all others remain unchanged since the period under the Supreme Council of State. Commodore Perry arrived at the end of the Bakufu period, bringing confusion and leading Japan to its first step toward modern democracy. In the same way, I believe people like the Governor must voice their opinions against the central government even if it triggers a little confusion. I place a great hope in the Governor to promote fundamental systemic revision.

Kitagawa: The government do not understand that what is common practice to them is absurd in the eyes of the private sector. We should be aiming to optimize the whole, as partial optimization may lead to disastrous whole. There is nothing wrong for the road corporation to resolve their own problems but to combine it with the issue of highway construction and to focus only on profits is merely dealing with a part of the problem. Unless we include peace, security, comfort and convenience of national land, or what we call Japan's grand design in our perspective, it may lead to disastrous whole.

What we are about to do is implement this change to bring about total optimization, like the shift from the Tokugawa shogunate system toward modern nation, but without the help of Commodore Perry and GHQ. It will be difficult, but nevertheless, I have no doubts it is possible. What we need is for each body within the society to explicitly criticize itself, and to reflect upon itself, zero-based. We, ourselves, should also look back on the mistakes that the prefectural government made. That is the starting point. In that sense, I believe this is a very good opportunity, and we must not fear to hold true discussions.

Clarify Costs Against Burden, and Hold Residents Responsible

Now that we are facing aging population and a serious decline in birthrate, where do you think the necessity lies for public works projects that accompany the change in social structure? Which area do you think will become the main playing field for future civil engineering works?

Kitagawa: Roads until now were constructed based on the "catch up with the West" concept. It is now definitely easier for the drivers of 10-ton trucks but for the aged and physically-disabled, wouldn't it be far more easier to walk on roads during the Meiji period where there were no cars? Excessive emphasis was placed on functional transport of more quantity in less time, and culture and sensitiveness has been much ignored. That is something we must start changing.

When compiling a budget, it has been the practice to first measure the incoming amount. It is the bureaucrats' job to set limits on the number of projects based on the budget. By measuring the inflow and cutting back on the outflow, the administration will obviously gain more power. On the contrary, the way it should be is to determine the expenses first and then calculate how much budget is required. The consideration for the outflow must come first and if the budget is insufficient, taxes should be discussed. If we do not follow this flow, I think a true regional

development cannot take place.

A regional community is made up of various sectors such as public works projects and social welfare. In order to improve the town, which is the synthetic body of these sectors, we must respect the accountability to the residents. “It requires approximately this much cost. You residents are the sovereign members of this community. What would you like to do?“ That is how a real information provision or information disclosure should be done. This way, benefits against burden are made clear, and the residents can take initiative in good town building.

For example, when constructing a community hall, the residents would say, “The town mayor shall go to the national government to secure the construction budget.” What can be constructed with 100 million yen now becomes 200 million yen. That additional 100 million when added up amounted to 700 trillion for the entire nation. The residents who order the mayor to go secure the budget do not have the slightest intention of become independent. Also, most mayors and governors actually believe securing budgets is their job, and the nation as well have continued to ask local governments to shoulder a heavy burden as part of the economic stimulating measure, so everybody is responsible in raising this 700 trillion yen. From now on, we should say, “We have to build a community hall of 100 million yen. To build a library, it will cost an additional 100 million. Please pay for this additional 100 million through your taxes.” The reason we have no autonomy is because we are not saying this. This centralization of power is what is allowing this situation to continue, where benefits and burden are left in ambiguity. In order to change this, there is no other way than to promote decentralization of power and information disclosure.

Wouldn’t it be necessary to have a mechanism of communication for residents to participate and to understand each other when starting on a new reform?

Kitagawa: Speaking in terms of democratic theory, promoting a two-way communication exchange with the residents will create a state where populism tends to be easily accommodated. The only way to cover for that is to open up. There is no other way but information disclosure. It will not be easy on the administration since it will mean exposing what used to be hidden but opening up means to have the residents, sovereign members of the community, to cooperate with us and for them to be on an equal footing. In other words, they will be sharing the responsibility. They should not mistake democracy for objective democracy or leaving everything in the hands of the administration. The residents will also be held self-responsible. Disclosure of information will be meaningless unless we take the stance and say “I will take the responsibility for you, but you will also be held responsible. I will go secure 100 million yen for the community hall, but you will shoulder the additional 100 million for the library.” That is how clear we should be, and that is where democracy steps in for the first time. The residents will respond, “Considering the cost-effectiveness, we will settle with only 100 million for the community center this time.” Without doing this, the residents will mistake democracy for their right to make continuous demands, and the administration and policy makers will mistake democracy for their duty to continue shaking their lucky mallet to fulfill the demands. It was through this misunderstanding on both sides, that a 700 trillion yen debt was created. Disclose information and hold the residents self-responsible. Otherwise, democracy will not hold. At present we have a typical fools’ politics where they merely supply the people for what they ask. Therefore, with help from professionals

like you, we must study as hard as we can to find the most desirable way to carry out public works projects so that we can indicate some direction. By sharing that information with the residents, can we say, "You are wrong. You say this, but based on this calculation, we should do this over a 30-year period." I feel we must try to make such discussions possible.

In that sense, I am an active promoter of information disclosure, and I'm doing my best so to allow myself to state flatly, "It is your responsibility." However, the Ministry of Agriculture, Forestry and Fisheries, the Ministry of Foreign Affairs, and the Defense Agency are all doing the opposite. They say it creates a problem of risk management. What they are trying to protect is their organization, rather than the interests of the people. The public will not accept it. It is not my personal opinion but that is where the laws such as the Decentralization of Power Law and Freedom of Information Act are leading to. We are already heading toward a decentralized nation and we cannot set the clock back. Unless we start here, the public will not truly support public works projects or social capital provision. It is important to let our voice be heard because it would be truly unfortunate if people start to believe that public works projects are corrupt.

Biggest Issue in Mie Prefecture With its Many Coastlines: The Anti-Earthquake Measure

Are there any examples of distinct undertakings concerning the public works project in Mie Prefecture?

Kitagawa: We are planning a so-called 10-year strategy for roads. We analyzed the cost effectiveness with our own hands and focused on 284 areas out of 755 zones. These will be the only projects that will be carried out over the 10 years. We collect opinions from residents of the prefecture, and gain understandings from local authority councils as we promote this. The Ministry of Land, Infrastructure and Transport asked us to explain how it is possible for a prefecture to have a 10-year strategy when the nation only has a 5-year strategy.

Up until now, there was pride in having 2 roads, one of Ministry of Land, Infrastructure and Transport, and another of the Ministry of Agriculture, Forestry and Fisheries. It was encouraged under the principle, "Ministry's interests without national interest." We used to follow that principle accordingly, but now, we've started to integrate all the public works projects into one by establishing an evaluation system for public works projects and promoting efficiency.

Mie Prefecture used to be 45th out of the 47 prefectures in terms of provision of sewerage systems. We implemented the "jump-up project" which in effect raised the ranking to 42nd. We are courageously promoting the projects under this time of heavy criticism toward public works projects, because such sewerage systems are strongly related to the environment and to the everyday lives of the people. The Ministry of Land, Infrastructure and Transport also understand this and help us out. We provide additional funds. As can be seen from this example, we should not only view public works in terms of economic efficiency, but should understand that it is something that provides a foundation for policies all-around.

The geographic characteristic of Mie Prefecture is its elongated shape stretching from the north to south. Are there any special features as public works regarding this point ?

Kitagawa: In geographical sense, anti-earthquake measures are a big concern and is where we require help from all of you professionals. The coastline of Mie prefecture is 1,083km long, and it is exposed to the threats of Tokai, Tonan and Nankai earthquakes.

Once an earthquake occurs, it would cause a chain effect. It is even possible that two earthquakes occur within a single month at the shortest interval. There has recently been a new law established regarding disaster prevention for earthquakes, but our biggest fear is tsunami. The levees along the coastline were mainly created when the Isewan Typhoon hit. Their competency is declining. Much of the coastlines in Mie Prefecture are deeply indented and the plains are narrow. Measures against tsunamis are the most important in protecting the lives and assets of the people. We must implement a sturdy measure, and that is where I would like to cooperate with JSCE in studying and promoting it.

Concerning environmental conservation and earthquake disaster prevention measures, wouldn't it be difficult to build a consensus among the tax payers on how much they all should contribute?

Kitagawa: We are currently putting together an action plan. We will take care of all that is possible in terms of software, for example, quick evacuation and quick notice. For that, we must determine the evacuation areas and other matters. However, there are limits. Therefore, we must attach priority to matters. I intend to carry out the action plan in the following order: augmenting the levees, constructing roads leading to the evacuation areas, or building anti-seismic facilities.

For the residents of the local community, these are their personal and direct concerns. When an area is designated as an enforcement area, the burden on mayors and the people of the municipal government increase, for they must augment roads, build levees, etc. We were concerned that there may be areas where the people would resist. Nevertheless, they were all in strong favor for promoting the project. What makes it difficult is having people outside those designated areas adopt ideas of cost effectiveness, like people do in Tokyo. I feel we must properly communicate with the people in the surrounding areas regarding this point.

Looking Toward Engineers to Tackle the Issue spontaneously with a Fresh Viewpoint

You had a few opinions about JSCE in your comments, but what are your hopes toward the civil engineers?

Kitagawa: I made some wise remarks up to now, but in the end, unless professional engineers start the reform spontaneously, it will not get any further. It is important that you take on the issue with a fresh viewpoint.

The conditions of the society have already begun to change. For example, the population will no longer increase. Due to the development of IT, the world has only one price for one commodity. There are a billion and several hundred million people in the labor market. Everything is global. Under such circumstances, the professionals should look at the lifecycle to set the most appropriate unit price, and think hard about the "value for money" including the technological aspects, of how much value there is against the cost. Considering the current social situation, we should also do what we could not in the past due to undisclosed information. The sense of powerlessness will disappear in the fields where information is disclosed. I will be very grateful if the professionals from JSCE would work together with us in the fields that we propose.

Governor Kitagawa's commitment to change Japan was palpable through his comments.

Mie Prefectural Office, October 10, 2002

Summary of the CO_2 Issues – Its Mechanism and the International Efforts

Yu NAKAMURA
Secretary General
Japan Center for Climate Change Actions

Rapidly Progressing Global Warming

At the end of the 19th century, it was already discovered in the study of Svante Arrhenius, a Swedish chemist, and others that the increase of carbon dioxide (CO_2) concentration in the air would raise the atmospheric temperature. It was not until 1985, however, at a scientific conference held in Villach, Austria that we were alarmed that global warming was steadily progressing due to human activities and that it might jeopardize human existence unless some measures were taken. Based on the recommendations made at this conference, the IPCC (Intergovernmental Panel on Climate Change) was established in 1988 by the WMO (World Meteorological Organization) and UNEP (United Nations Environment Programme). From the 1990s until now, scientific knowledge on global warming has been reviewed entirely and serious discussions have taken place to address issues on climate change, especially, from the standpoints of mitigation and adaptation.

According to the IPCC's report, the global average surface temperature has increased by 0.6±0.2℃ during the past hundred years. Figure-1 shows the deviation of the Earth's surface temperature for the past 140 years. The temperature, which had been relatively stable until the 19th century, has increased drastically over the 20th century. It is no doubt attributable to the fact that human beings have tremendously increased consumption of fossil fuels, which has caused the mass emission of carbon dioxide into the air, and emitted other man-made greenhouse effect gases (GHGs) like chlorofluorocarbons as well.

Although the mechanism of the temperature rise has been closely studied, not every mechanism is scientifically clarified. Factors of, for example, ozone in the troposphere and aerosol are yet to be examined. However, the temperature rise since the industrial revolution, namely, during the past nearly 200 years can be for the most part explained by the radiative forcing of GHGs, that is, the potential of the increased concentration of such gases which enhances the absorption of ultra-red energy and trap its heat in the air. Table-l indicates the contribution rates of GHGs based on radiative forcing to the temperature rise. Carbon dioxide accounts for 60%, which is the largest of all. This figure does not stand for the rate of CO_2 concentration among GHGs but it means that 60% of the temperature rise is caused by the concentration increase of CO_2.

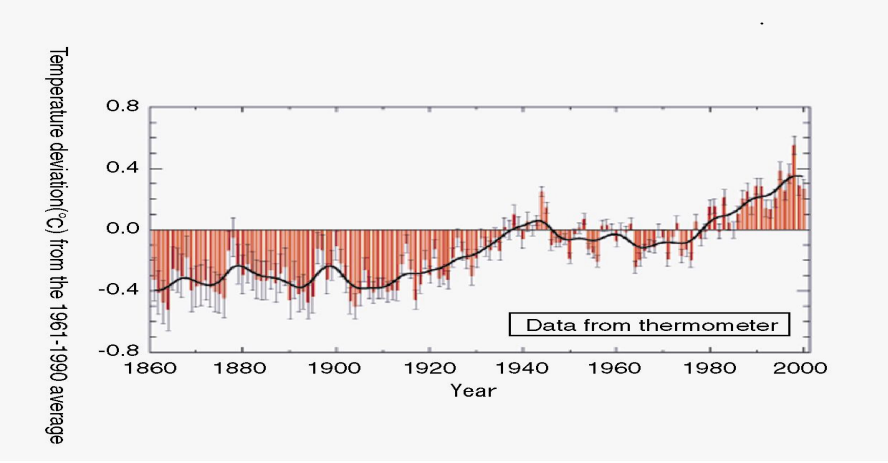

Figure 1: Global temperature change during the past 140 years (from the IPCC Third Assessment Report)

It is difficult for us to perceive an approximately 0.6℃ temperature rise directly on our skin. However, as a result of long-term temperature rise, the effects are surely manifested in the meltdown of glaciers, or in phenomena of climate change like El Nino, floods and so forth. Unless appropriate measures are taken, it is no doubt that the temperature will keep going up for centuries. The biggest problems will be that the direct damage would prevail through disasters caused by climate change, and that the basis of human existence would be largely and irreversibly impaired by the loss of biological diversity.

Table-1: Contribution of greenhouse gases based on radiative forcing to temperature rise (prepared by the author based on the data in the IPCC Third Assessment Report)

Carbon dioxide	60%
Methane	20%
Nitrous oxide	6%
Chlorofluorocarbons	14%
Others	Less than 0.5%

Relationship between CO_2 Concentration and Global Average Surface Temperature

One of the major factors that made it possible for human civilization to come into existence and achieve its prosperity today is that the climate has been mild and stable. The CO_2 concentration in the air has been kept almost constant at 280 ppm for the past thousands of years, and the temperature change has been moderate. However, the CO_2 concentration has been rapidly growing since the industrial revolution, especially since the beginning of the 20th century (Figure-2), and it is still increasing year by year. The correlation between CO_2 concentration and the atmospheric temperature is scientifically clear, but in reality its cause and effect is quite complicated

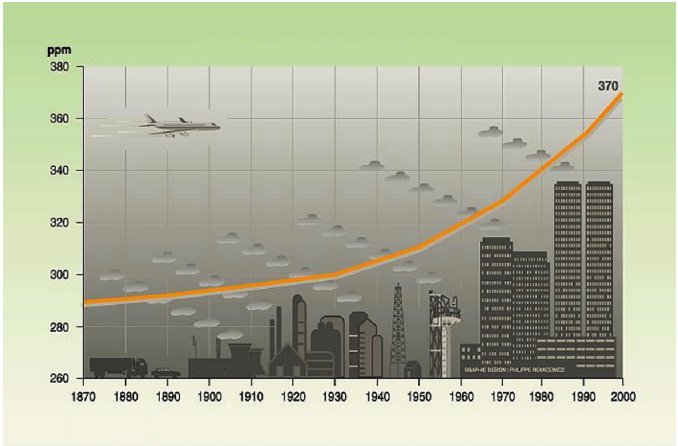

Figure 2: Global atmospheric concentration of CO_2 (Source: UNEP/GRID-Arendal)

because the CO_2 concentration is not only ever-changing but also different depending on the Earth's latitude and because there is a time delay in temperature rise caused by the CO_2 concentration increase. However, it can be said that the correlation is relatively simple in the long-term perspective in such degree that we are able to disregard the time delay of atmospheric warming and the spreading speed of CO_2 in the air.

Looking at the global environment in terms of geological time scale, glacial periods and interglacial periods have been occurring in turn repeatedly at a cycle of about 100,000 years. Figure-3 is a graph indicating the CO_2 concentration and the temperature deviation retroactive to 400,000 years ago. It is very clear that the shapes of the two graphs synchronize and that there is a strong correlation between them. The CO_2 concentration fluctuated between 280 ppm and 180 ppm four times and the temperature deviated from –8℃ to around +2 ℃ synchronically with it. Simplifying this correlation, a 100 ppm or 0.01% change of CO_2 concentration corresponds to a temperature change of approximately 10℃.

Although the global average surface temperature is today kept at around 15℃ due to the greenhouse effect, calculation already shows that if

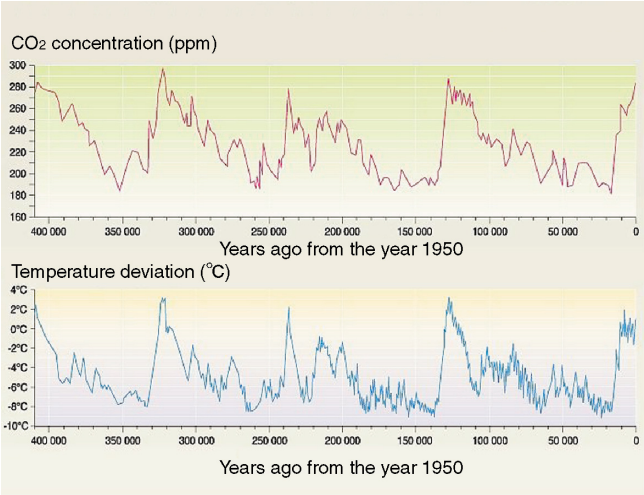

Figure 3: CO2 concentration and temperature deviation in the past 400,000 years (Source: UNEP/GRID-Arendal)

there were no carbon dioxide in the air, the average temperature would fall to -18 ℃. Namely, a greenhouse effect which is produced by a CO_2 concentration at 280 ppm, a level before the industrial revolution, corresponds to a temperature rise of 33℃. In short, 0.01% increase of CO_2 concentration produces approximately 10℃ temperature rise and this proportional relation corresponds to that of the past glacier and interglacial periods.

The above-mentioned correlation is summarized in Table-2. What is notable here is that it indicates that the CO_2 concentration has risen by 0.01% during the past 200 years and the temperature approximately by 0.6 ℃. Even if the CO_2 concentration could be kept at today's level, the temperature might keep on rising for centuries to come, possibly about 10℃ higher than that of today.

The IPCC's Third Assessment Report foresees that the CO_2 concentration at the end of the 21st century will be around 540~970 ppm. The estimated value differs depending on what kind of scenario, for example, such scenario as a high growth type or a sustainable development type, each nation is going to follow. But, in any case it does not suggest that the CO_2 concentration could be stabilized by the end of the 21st century but it would go on growing even in and after the 22nd century. Unless we can stop the CO_2 concentration in the air from rising further in the future, human beings must try to stabilize the CO_2 concentration at least at the level which would not create problems upon our future generations, undertaking aggressive measures for limiting CO_2 emission at the same time. Whatever level we may aim at, however, we have to reduce the CO_2 emission to less than half of the present level, as stated in the next paragraph. This means that we must not only discard the conventional type of economic development but also establish a completely new paradigm for our way of life.

Carbon Cycle

Today, human beings give off approximately 24 billion tons of CO_2 into the air every year by directly burning fossil fuels and tapping biomass resources. It is well known that part of CO_2 in the air is absorbed by trees, but the account has not been balanced. The remarkably rapid progress in the fields of geosciences and oceanography triggered by the global warming issues in recent years has brought a light to the understanding of the unclear portion of its balance, which has been called the "missing carbon."

Trees, i.e. terrestrial vegetation, and the ocean, mainly absorb the emitted CO_2 in the air. Its account balance is generally called the "carbon cycle" if we focus only on carbon element within different carbon compounds. Figure-4 shows the summary of the atmospheric carbon cycle. The upward arrows show the carbon emission into the air and the downward arrow shows the removals of CO_2 from the air. "Factory, vehicles etc." stands for the carbon emission from the burning of fossil fuel, which is totally attributable to human activities. "Field, bare land etc." includes the CO_2 emission and absorption through the surface of fields and bare lands, the

amount of witch is affected by land use change. Forests as well as ocean also emit and absorb a great amount of CO_2.

Although carbon dioxide is released into the air by 6.5 billion tons a year in terms of carbon (C-t/year) mostly caused by human activities, about 1 billion tons is absorbed into trees and 2 billion tons into the ocean, and then the balance, approximately 3.5 billion tons of carbon, remains in the air every year. This remaining carbon produces an increase of CO_2 concentration by about 1.5 ppm every year.

It is necessary to reduce the remaining portion to zero in order to stabilize the CO_2 concentration in the air at a certain level. If an epoch-making technology to sequestrate a large amount of CO_2 were not put into practical use, the CO_2 emission level must be reduced to less than half of the present amount. In reality, however, the fossil fuel consumption is continuously growing for the time being as developing countries are being industrialized, and the net CO_2 release into the air will surely increase.

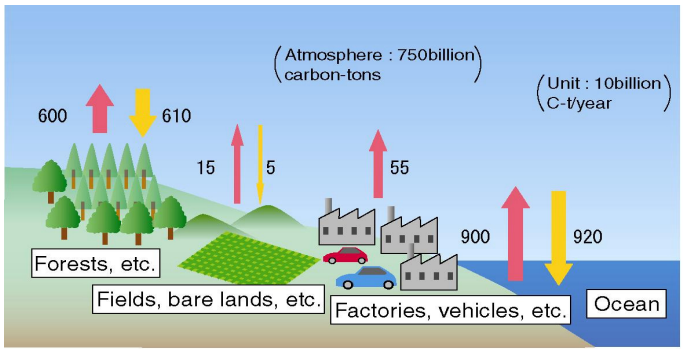

Figure 4: Carbon balance in the air (Prepared by the author based on the data in the UNEP/GRID-Arendal and other documents)

International Efforts and the Kyoto Protocol

IPCC issued the first assessment report in 1990. Based on the report, the Framework Convention on Climate Change was adopted at the United Nations in 1992 and came into force in 1994. The Conference of the Parties (COP) has been held every year since 1995. Detailed methodologies for global warming prevention was discussed at these conferences and the Kyoto Protocol was adopted at the 3rd Conference of the Parties (COP3), which was held in Kyoto in 1997.

A summary of the Kyoto Protocol is shown in Table-3. One of the features is the numerical target of GHGs' reduction level assigned for all developed countries to be achieved during 2008 to 2012, the first commitment period. Targets of –6% for Japan, –7% for the USA and –8% for EU are well known but those numbers were based on, so to speak, the political compromise. When the protocol enters into force, those numerical targets will become legally binding and each party must endeavor all out to clear the targets in the light of international trust. In the case of non-compliance with emission targets at the end of the commitment period, a party must make up the difference in the subsequent period, plus a penalty of 30%. It will also lose its eligibility to participate in the Kyoto mechanisms, which are explained below.

Another feature of the Kyoto Protocol is that the emission reduction that a party has achieved can be transferred to another party as a means of pursuing the objectives. There are three innovative mechanisms named Kyoto Mechanisms: Joint Implementation (JI), Clean Development Mechanism (CDM) and Emission Trading (ET.) The Protocol stipulates that use of these mechanisms should be supplemental to the domestic measures. JI is a mechanism to allow developed countries to use the reduction amounts generated by the project implemented jointly with other developed countries for their targets. CDM is a mechanism to allow developed countries to use the reduction amounts generated by the project done with developing countries for their targets. Through ET, developed countries may acquire the amount reduced by other developed countries. The Kyoto Mechanisms is a

great wisdom of mankind to encourage each party to comply with the Protocol. However, some NPOs criticize them as loopholes because parties can achieve their target not with their own efforts but with other countries efforts.

Details of each mechanism have yet to be agreed upon among parties and are still being discussed at COPs and other meetings of the subsidiary bodies. As for the international transfer of the reduction units under JI and CDM, which are the collaborative projects between nations, it is necessary to make precise certification in a fair manner. For that purpose, various institutions are established and elaborate procedures are specified for registration and certification.

Regarding the emission trading, there is a great deal of concerns on how the market will be developed in the future and how much the price per unit will be. At present, Russia, whose economic activities greatly fell back due to the collapse of the former Soviet Union, has already achieved a reduction amounting to as much as 1 billion tons and is regarded as the biggest seller. Both the United States and Japan were thought to be potential buyers at first, but the United States stayed out of the market since it expressed not to ratify the Protocol.

Japan's Response

In Japan, since 1990 when the Action Plan for Global Warming Prevention was drawn up, all-out efforts to combat global warming has started at municipalities and industry sectors. The government issued the Basic Environment Plan in 1994 and announced detailed measures in the "Guidelines for Measures to Prevent Global Warming" in 1998, a year after the adoption of the Kyoto Protocol. These guidelines were reviewed and amended last year with more detailed plans.

The emission of GHGs in the year 2000 in Japan has increased by 8% from the 1990 level. Rates of CO_2 emission by sectors are shown in Figure-5. Among these, the emission from consumers sectors, both residential and commercial, and the transportation sector showed the remarkable increases of more than 20% during past ten years. This is why the measures for those sectors are focused to a great degree in the guidelines so that Japan could achieve about 14% reduction by 2010 from 2000 level to attain the Protocol target. So, legislative preparations and technological development for energy saving especially in commercial and residential sectors are increasingly spurred. For example, "Top Runner Standards" are applied to home electric appliances not only to accelerate reduction of energy consumption but also to lower the standby power of most electric appliances to less than a watt. At the same time, reformation of the social and economic systems, such as introduction of carbon tax and implementation of the daylight saving time, are under consideration.

In the industry sector, the Japan Federation of Economic Organizations, the Keidanren, called industrial groups for their cooperation and has been taking positive measures such as the drawing up of the Voluntary Action Plans, which are to be reviewed every year. A Keidanren's report, published in October 2002, revealed that the industry sector had achieved a reduction of 3.2% in 2001 from their 1990 emission level. It is notable that the reported amount of reduction achieved by the Japan Federation of Construction Contractors was 30.9%, which is significantly larger than that of other industrial groups. If the Voluntary Action Plan is not carried out in the future, i.e. in the "Business as Usual" case, it is forecasted that it will turn into a growth by approximately 8.4% in 2010. The whole industry sector is aiming at curbing the increase to the level of 0% by 2010.

Future Tasks

Our concern for the time being is drawn to bringing into effect of the Kyoto Protocol. Of the developed 38 nations that set up numerical targets in the protocol, the United States and Australia have expressed their intention not to ratify it, but if Russia ratifies it in the future, the conditions for its entering into force will be fulfilled (a condition to be fulfilled is that the CO_2 emission in 1990 by the developed countries which ratified the protocol should be more than 55% of the total CO_2 emitted by all of the developed countries). And the Protocol will come into effect 90 days after Russia's approval. The reason why Russia has not yet ratified as of February 2004 is reportedly a matter of parliamentary procedures, but the economic aspect cannot be overlooked. In other words, one of the reasons may be that the trend of the emission trading market without the United States cannot be foreseen precisely. If Russia's ratification will not be realized for any reason, the Kyoto Protocol, on which all the concerned nations in the world have been spending a lot of time and exerting their substantial energy, will be for nothing. There still is such a risk but I can only hope that it will not happen.

Even though the Kyoto Protocol comes into effect in the near future, it will only regulate the counter-measures by developed countries during the first commitment period from 2008 to 2012. We cannot expect an effective outcome if we take only stopgap measures in coping with issues of global warming.

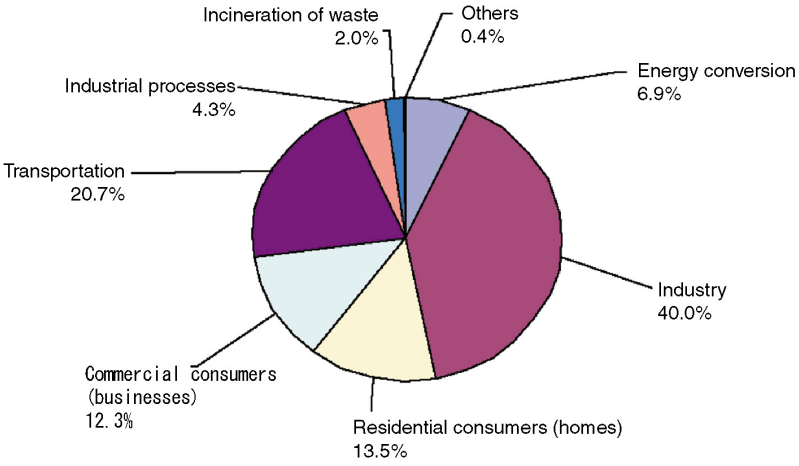

Figure 5: Rates of CO2 emission by sector in Japan in 2000 (Source: Ministry of the Environment)

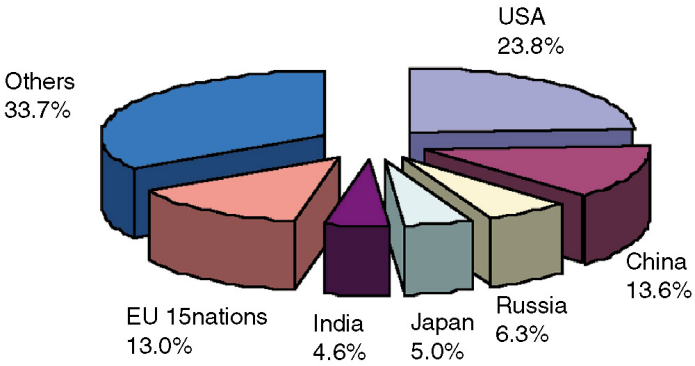

Figure 6: CO2 emission rates by nation in 1997 (Source: Oak Ridge National Laboratory, USA)

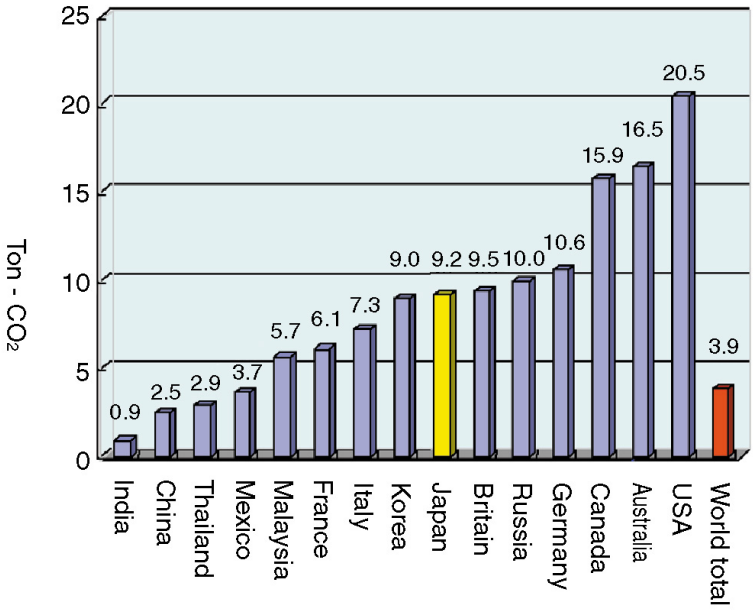

Figure 7: Emission amount per capita in 1997 (Source: Oak Ridge National Laboratory, USA)

Long-term and continuous measures are necessary at least throughout the 21st century. At the same time, it is not too much to say that, in order to solve the problem, it is crucial that developing countries participate in the solution process as real players for combating against global warming as soon as possible. Behind the rejection of the Protocol by the United States, there lies a problem of the developing countries' participation.

Taking a look at the figures of each country's CO_2 emission (Figure-6), the United States, which is at the top of the list, emits approximately 24% of the world's total and the second highest is China with 14%. Gathering from the China's remarkably high economic growth rate in recent years, it is no wonder if China reaches the level as high as the United States in a decade or so. Russia is the 3rd highest (6.3%) and Japan the 4th (5.0%), and India, which is the 5th highest, emits 4.6%. India will, sooner or later, get ahead of Japan. Incidentally, in terms of annual CO_2 emission per capita in 1997, the United States has more than twice as much as Japan, while China is one fourth of Japan and India one tenth (Figure-7).

Apart from big countries like China and India, oil producing countries and small island states are also organizing groups and gaining greater voices in international negotiations. Developed countries are now also forming groups, which partially oppose each other. However, in order to pass down the earth's environment unharmed to future generations of mankind, it is essential to reach a global consensus on this matter beyond the conflict of interests among the groups of developed and developing countries. Under the present circumstances, this seems to be an issue almost impossible to be solved. However, the global warming is steadily in progress. If significant impacts of global warming become apparent and the survival of the mankind faces a crisis, the consensus would be reached more easily. However, when such time comes, it would be too late.

(Note: Various information on global warming and climate change can be viewed at the web site of the Japan Center for Climate Change Actions at http://www.jccca.org.)

Table-2: Correlation between $COB_{2\ B}$concentration and atmospheric temperature change

(Prepared by the author based on the data in the IPCC Third Assessment Report)

Period	**CO_2 concentration change**	**Atmospheric temperature change**
400,000 yrs ago – 200 yrs ago	0.02%⇔0.03%	±10℃
200 yrs ago － present	0.03%→0.04%	+0.6% <Still rising>
Future	0.04%→ ?	?
(Reference)	0.0%⇔0.03%	<Global mean temperature> －18℃⇔＋15℃（±33℃）

Table-3: Summary of the Kyoto Protocol

Target gases: carbon dioxide, methane, nitrous oxide, HFC, PFC, SF6

Target period: 2008-2012

Emission reduction targets: 5.2% for 38 developed countries as a whole (from 1990 levels)

EU: －8% Iceland: ±10%

USA: －7% Australia: +8%

Japan: －6% Norway: +1%

Russia: 0% New Zealand: 0%

Kyoto Mechanisms:

1) Joint implementation (JI)

2) Clean Development Mechanism (CDM)

3) Emission Trading (ET)

Other issues:

1) Emissions and removals from the land use, land use change and forestry sector

2) Financial assistance for developing countries

3) Compliance regime and others

The Demand Forecast: Causes of Accusation, Issues and Prospects

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1. Political Interests and Public Distrust in Demand Forecasting: Interest Factors Hidden in the Black Box

By and large, transport demand forecasts are overshadowed by the intentions and interventions of the parties involved. There is a general apprehensiveness in public that excessively optimistic forecasts are customarily projected to secure the vested interests. This paper attempts to shed light, however, on interests of a different nature, which are evidently involved but largely overlooked in the process.

A case this author experienced last year, as a member of a review panel for a monorail system in operation, illustrates the dynamics of various interests influencing demand forecasts. The system's operation is currently facing financial difficulties, as the number of users fails to reach even half of the expected figures. The demand forecast made in the 1970s assumed an extremely large population along the planned monorail line as well as a large-scale modal shift from bus passengers. With the benefit of hindsight, this resulted in an outrageous demand forecast. Although it is no longer evident whether this result reflects the political interest of the time, it is nevertheless certain that the demand did not attain the forecasted level. However, it is clear that the policy efforts needed, such as the re-designation of residential zoning, development incentives, and the reorganization of bus routes, were insufficient to make the forecasted demand materialize.

It was also my impression that among the committee members and the executive officials, there are those who selectively ignore the lack of policy efforts from the start of the operation up to this day, and place the responsibility solely on the "excessively optimistic demand forecast" (which is influenced by the political interests aiming to realize the monorail project). With careful consideration, it becomes clear that there is an equally strong "political interest" behind such behavior. To reflect certain "political interests" at the planning stage of the project (i.e. passing on responsibilities to the future) and to place the responsibility on the "excessively optimistic demand forecast" of the past (i.e. blaming responsibility exclusively on the past and excusing current officials of all blame) are both politically motivated.

How Does Political Interest Sneak In?

Why are demand forecasts always linked to such "political interests"? The technical jargon-like methodologies that are used in forecasting demands play a role in this. By seeking to reflect the reality into the model to such an extent that it becomes a craftsman's display of fine-tuning techniques that obscures the structure and assumptions of the model, making it incomprehensible to an outsider. This creates an environment in which "political intention" can easily sneak in. However, there has been much improvement on this point recently due to the result of efforts to increase openness and transparency at the planning stage (Note-1.)

The second reason is that the forecasts of social phenomena are inherently "intentional" in nature. Unlike in weather forecasts and forecasts on other natural phenomena, it is normal that intentions in the form of "expectation," "influence," "determination" or "caution" come into play when forecasting phenomena related to human activities such as the economy, elections, population or disaster damage. Therefore, it is natural to assume that these predictions are somewhat biased. Intentions of an arbitrary character are intrinsic in predictions related to human activities.

Need for a Sound Relationship

On the other hand, from the beginning, planning theory maintains its stance to eliminate all arbitrariness and to take an objective approach free from any specific values as much as possible. However, this stance could result in strange cases of contradiction such as the following example. At a planning committee meeting on an urban railway project which I participated in recently, the margin of error for the demand forecast was announced as only ±5%. However, this would be impossible when even the current year's demand forecast is off the mark. According to the explanation, the error margin was based on a fixed quantity of inputs such as population and on a fixed set of variables for the model. Here, the interest is in the performance of the model, and the final fluctuation of the output is not of concern. However, using the phrase like "the margin of error for the demand forecast is only ±5%" out of its context could be a seed of distrust for forecasts in general as time goes by. The efforts of those involved in demand forecasts to distance themselves from arbitrariness or intentions ironically caused the political intentions to sneak into the demand forecast. Therefore, a more straightforward, clear and sound relationship must be established between "forecasts" and "political interests".

2. What Can Demand Forecasts Offer and to What Extent? Are the Roles and Assumptions Realistic?

In demand forecasts at the planning stage, the human society is considered as a system where certain policy variables (control variables) or data variables (environmental variables) are entered. The outcome would be their impacts on the society. The forecast is the outcome obtained by entering certain variables. In the case of demand forecasts, the outcome is reflected in the traffic volume. By evaluating the outcome of the system from various points and by judging the nature of policy variables, these forecasts are expected to be helpful in decision-making. In "prediction" or "evaluation," this would be essentially based on a foundation of public or corporate values and their patterns of behavior in a democratic society. When we are dealing with society, very strong technical or practical assumptions are unavoidable. For example, people or corporate values and their patterns of behavior are given as fixed; the phenomena are greatly simplified and dealt with as a closed system; and are assumed as being at the equilibrium of various phenomena.

Essential Difficulties

However, in real life, there is no guarantee for such firm assumptions. People's behavior is not always based on careful or rational thinking and people tend to be forgetful. We are not all saints and our values change quite frequently for small reasons. When it comes to politics, going along with the mass opinion or populist tendencies are nothing extraordinary. (As examples, we should look back to the average public opinions and values just twenty years ago, on global and river environment, barrier-free services or food safety and notice the drastic changes since then). We must conclude that forecast and evaluation have great intrinsic difficulties (Note-2.)

Moreover, considering the recent changes in social environment, we can foresee further difficulties in providing accurate forecasts. Firstly, it is likely that unexpected circumstances could arise quite frequently. Secondly, as public values diversify, society's decision-making has become unstable (especially in areas related to regional governance). Thirdly, as there are fewer cases today where independent projects could be effective, there is an increasing need to realize multiple measures in a concentrated and coordinated manner. This increases the opportunities for a decision in one area to influence other related areas. For these reasons, it is neither realistic nor effective to unreasonably expect a "scientific demand forecast" or "scientific evaluation."

Lacking a Sense of Balance

However, even with such intrinsic difficulties, as long as most decisions on infrastructure require considerable social resources such as manpower, goods, money, and time, the forecast is still necessary in order to make estimations. Why? In a few words, because it is much better than a "simple guess." Although it is just a forecast, it still has its worth.

The important thing is for those who are involved in demand forecast or project evaluation to be constantly aware of the difficulties and the limitations in forecasting. More importantly, and it is commonsense to honestly admit and to constantly declare publicly that after all, a demand forecast is just one of the yardsticks. We would be better off guessing, if phrases like the aforementioned "precision of ± 5%" is accepted out of its context like a golden rule. Moreover, as in the example I mentioned in the beginning, this could be misinterpreted as hidden political interests on either side.

Researchers on behavioral analysis or forecast model development would also require a similar engineering sense of balance because both fields encompass many elements for great changes. Therefore, it does not serve any purpose to concentrate only on developing precise models. In many cases, rather than precision, robustness in the face of outside elements of disorder should be pursued.

3. New Approaches: Changing Needs

So far, I have explained that "demand forecast" and "interests" cannot be considered separately, that despite this fact, the relationship between the two tend to be obscure, that difficulties are intrinsic in demand forecasts, and that factors of uncertainty may increase in the future. I would now like to turn to other situations surrounding the demand forecast in attempt to explain them.

The missions of the social infrastructure measures have more or less shifted from the construction and development as seen previously, to place increasing importance on usage. The former approach only focuses on one point (construction) on the axis of time while the latter is focused on the trend extending long after construction.

The sense of purpose has also diversified. Previously, the main usage of forecasts was to "forecast and provide." However, it has been shifting to "forecast and prevent or protect" such as in disaster mitigation or environmental protection.

On the other hand, the demand forecast, which was previously focused on long-term impacts of large-scale projects, has come to encompass wide-ranging objectives, from short-term forecasts for various measures such as "Integrated Urban Transportation Strategies" and social experiments or to forecast possibilities to influence demand with marketing measures.

Based on these circumstances, I would like to give my opinions on the kind of new approaches we

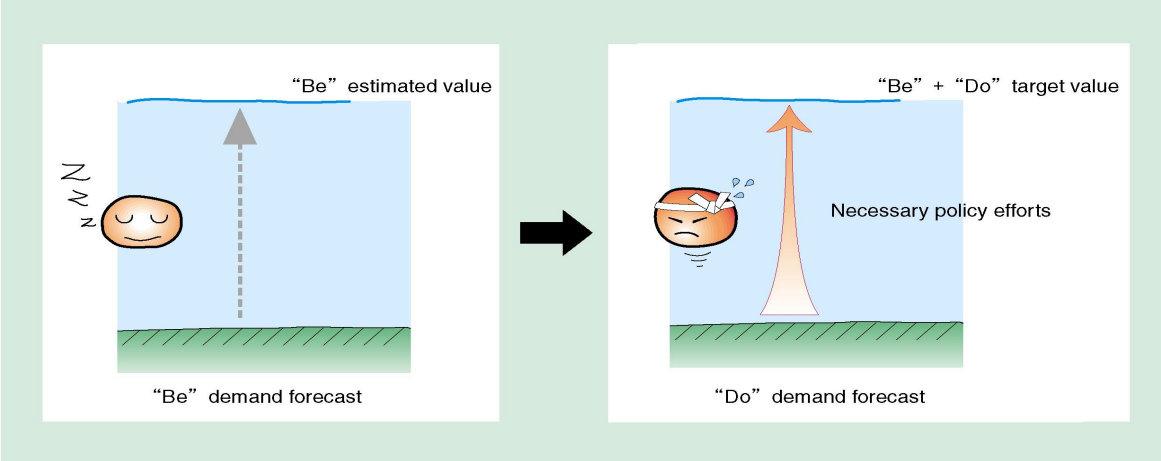

Figure 1: From "Be" Forecast to "Do" Forecast

should incorporate into the demand forecast and how we can transform the paradigm.

From "Be" Forecast to "Do" Forecast

Forecasts and interests cannot be considered separately. Demand forecasts encompass an element of "targeted value" that is overshadowed by political interests to some extent. As this is the case, I believe that the "interests" should be incorporated into the demand forecasts in a more transparent way, clearly defining where the border is between the "be" forecast that would be naturally realized and the "do" forecast, which could be realized only through policy efforts. This forcibly clarifies the type of "policy effort" which is necessary in order to achieve the target, and monitors whether enough "policy efforts" are put in or not, based on the commitment.

With such a process as the premise, it would be difficult to incorporate unreasonable intentions into a demand forecast. A parallel can be found in university entrance examinations. There is nothing against setting a high goal for achievement, but you must make the necessary efforts to achieve it. Setting goals too high is an invitation for failure. Demand forecasts should be based on the balance of reasonable goal setting and steady policy efforts.

Engineering Approach to Forecasts

When designing buildings and other structures, critical conditions are always taken into consideration. The materials are chosen and the structures are designed so as to prevent any problems that would arise under such critical conditions. I believe the same approach should be adopted when forecasting demands. Let us consider the example of river management (despite it being quite a different field.) The flow volume fluctuates according to natural as well as human-induced conditions and in order to assess the safety, it would be natural to estimate a larger flow volume. On the other hand, when considering irrigation and other water usages, a lower flow volume must be estimated. The same is true in transportation demand forecast. It is only natural that the demand forecast value (estimated value) patterns be different depending on the process of forecasts; when considering the safety or the environmental burden, when designing the facilities, when examining the influence of the network on the traffic, and when considering the profitability of the project. This is because the demand patterns differ with each critical condition.

From "Artilleries" to "Guided Missiles"

Under previously mentioned social circumstances, it should be necessary to transform demand forecasts from one-time prediction prior to the project, to a long-term continuous forecast throughout planning, implementation and service

periods of the project. I believe the concept of "demand scenario management" should be introduced.

The demand scenario management is to prepare as many thinkable demand scenarios as possible, and estimate to one's best, the probability of each scenario. From the planning stage of the project, the concerned parties should have reached a consensus on the actions they would take (such as design modification, fare increase, capital increase, deadline delay, or project withdrawal) when certain demand scenario becomes a reality at certain point during the project. The demands should also be repeatedly analyzed as the project makes its progress, and necessary modifications should be made on the scenario, and policy measures must be continuously managed as well (Note-4.)

The current demand forecast is like an "artillery battle", leaving it up to the shot whether it hits the target or not. On the contrary, the concept of demand scenario management is like a "guided missile," which continues to analyze both its own course and the target's course after the shot is fired to track the target with precision.

In order to realize such demand scenario management, it is not sufficient to merely reform the demand forecast. The planning system must be reformed as well and the entire policy process must also be reexamined and transformed. It is not an easy task. However, it is an important issue that we must tackle.

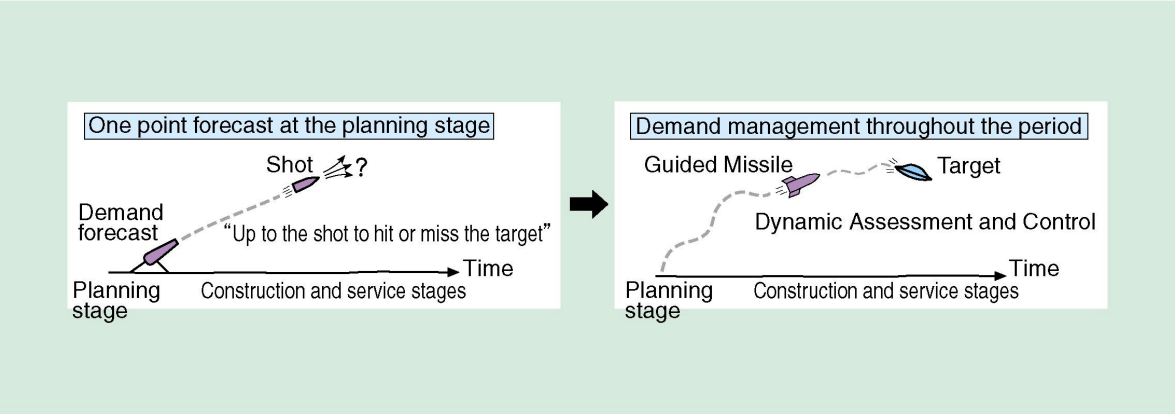

Figure 2: From "Artillery" to "Guided Missile"

Note-1: For example, Traffic Demand Forecast Report (Japanese) published by the Japanese Ministry of Land, Infrastructure and Transport (July 2002) explains in details, past reviews and the contents of the models of the transportation demand estimate.

Nore-2: These three uncertain elements were noted in accordance wit UE (Uncertainty in external factors)、the UV (Uncertainty in Values), and UR (Uncertainty in decision-making in related fields) that J.K. Friend and S.N. Jessop mentioned. In "Great Planning Disasters" (Univ. of California Press, American Ed. 1982), the author, Peter Hall skillfully explains these factors along with the case studies of various projects.

Note-3: A renowned transportation specialist, Prof. Phil Goodwin calls for the transformation from "predict and provide" to "predict and prevent."

Note-4: This concept has certain common aspects with the "Strategic Choice Approach" proposed by J.K. Friend

The Future Transportation Demand Forecast

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Problem Recognition

Recent newspaper reports are filled with lines like "outrageous forecast" or "half the assumption," and it is quite understandable if many readers regard the traffic demand forecast as an irresponsible numbers game. This is a serious problem because the transportation demand forecast is an area within the discipline of infrastructure planning and public doubt is cast on the practice that employs cutting-edge technologies of the discipline. It is no exaggeration to say that this situation may lead to academic crisis. It is certainly very difficult to make precise forecasts reflecting unexpected changes of large extent such as the fluctuations of economy and population before and after the collapse of bubble economy and the reduction of air passengers due to terrorism. However, the recent technology of the transportation demand forecast has achieved a considerably high degree of accuracy compared with the past.

Then, why are the forecasts still widely off the mark? Why do citizens raise objections that they are overestimated or underestimated? Behind these problems lie the limitations of previous project planning procedure, in which excessive responsibility was imposed on the demand forecasts. By attempting to justify the projects through demand forecast results, it is probable that an environment, which harbors elements other than objective engineering technologies, was created.

What is the Bottom Line of the Problem?

I believe that the problem of transportation demand forecast, which is criticized recently has relatively simple structure. The core of the problem is not in the demand forecast itself. Nobody expects the demand forecast to be completely accurate. Rather, citizens are concerned of whether the project is truly necessary, of the increase in financial burden, of the influence on the environment and of other issues related to the content of the project, as well as of the way in which the project was implemented, such as when and who decided the project, and whether the public opinion was reflected upon. All this is quite natural and that is why it is difficult to obtain public consent just by explaining that the demand forecast result is correct and that there are no environmental or financial problems.

More essential discussions on development of infrastructure must take place with the participation at regional and national levels, and involving the public. It is a source of concern that some administrative bodies are still not aware of this need. Serious efforts to address wide-ranging issues concerning demand forecasts, such as reviewing the planning process, encouraging public involvement (PI), and disclosing technological information, are becoming more and more important.

Key to Handling the Problem

Although it is not easy to solve this problem from its root, distributing or dispersing the

aforementioned excessive responsibility in an appropriate way is one way to deal with the demand forecast criticism. First, the analysis using engineering technologies or the demand forecast must be clearly separated from administrative procedures, which determine the scale of transportation demand. Generally speaking, if we can present a demand forecast result within a certain margin, it is easier to ensure objectivity of the practice. Although it goes without saying that the input terms of the model differ depending on the uncertainty of the future, and that the demand forecast values change accordingly, there has been an environment where, from the conventional way of forecasting the demand, in many cases the above-mentioned two points are apt to be confused and shown as one point, and then a social doubt against the mentioned engineering technology is apt to be raised.

If we separate them, the administration has to select and determine the value to be the aim of the plan among the forecast values within a certain margin at its own discretion. Then at this stage the selected value turns from a forecast value to a planned value. The necessity of this sort of separation has been pointed out on a conceptual basis. It is high time we carried it out. Unless it is going to be done, researchers will probably have to set a certain distance from the demand forecast that one administration adopted, since it is impossible to ensure the validity of a one pointed forecast value after admitting its future uncertainty.

Requirements of the Model to be Used for Forecast

So, what are the requirements of the demand forecast model to be used for project planning by the administration? Even in the United States where citizens are highly concerned of the road improvement issues, there are cases where demand only using the Excel spreadsheet. In case of demand forecast review in a certain ordinance-designated city, a group of citizens eventually subtracted some figures from the future OD sheet. Major newspapers reported it as the demand forecast result by the citizens. Here a simple subtraction from the forecast by the administration was regarded as a demand forecast practice.

However, as far as I know, the transportation demand forecasts at the level of individual projects and network planning in our country are being carried forward with utmost caution, entailing enormous amount of work that leads to meticulous space partitioning. But those kinds of sincere efforts are neither understood nor of interest to anyone. From the outset not many people want to know what kind of sophisticated calculations are made in order to forecast the demands and, even if it were disclosed, not many people would be interested. If it is not disclosed, however, it is taken in the opposite way, as if it is being concealed.

I'm going to clarify the requirements for the demand forecast model again. First, it must be open for disclosure including of the main data. If there is another model that is obviously superior at the practical level, it cannot be said that the used model is appropriate as a forecast model. It may not necessarily be the cutting-edge model in the academic sense, but efforts to put new ideas to a practical use, regardless whether there is a precedent or not, are necessary for both sides, the administration and researchers. Also, conducting simple forecasts at relatively less influential projects may have some validity.

The Facts that Have Been Pointed Out

There was a famous case that took place about a transportation demand forecast at the end of the1980s in San Francisco. It is a known fact that this turned out to be the opportunity to bring up a

project to improve the method of transportation demand forecast as a national project in the United States. Later, at the end of the 1990s in Atlanta, a budget measure for a project in which the "transportation planning expected not to aggravate air pollution" became the target of a lawsuit. These are cases that took place in the United States where the political power and the technical power of environmental groups are very strong, but it has been foreseen that the surveillance by the citizens and environmental groups would become severer sooner or later in our country as well.

The bottom line in this context is very clear. Now it is necessary for the administration to disclose all the information on demand forecast and as well continuously make efforts to improve the method. If you don't work hard enough saying "efforts won't make much difference" or "an exact method will not be easily found", you don't understand the bottom line well enough. As a matter of fact, the transportation demand forecast in the San Francisco Bay Area after the famous case was not replaced by a completely innovative model or a forecast method that was brand-new to everyone, as far as the author knows. However, most of the information on the forecast model making has been disclosed since the preparatory stage and the efforts for improvement have been made continuously within the limited budget. It seems that the disclosed information itself did not draw much of the citizens' attention, though.

Japanese Efforts

Researchers, including myself, have been insisting on the necessity of forecast with a margin, disclosure of the information on demand forecast and the necessity of constant efforts for elaborating a model, since it has been obvious that Japan would have a similar problem as that of the USA sooner or later. From around 1997 until the time of the Report No. 18 of the Council for Transport Policy issued in 2000, in a demand forecast model for a large city railroad, an examination in order to predict the route selection behavior on the complicated railway network more accurately has been continuously carried out, and the forecast system using a disaggregate probit model was established in some places. This forecast system was such a thorough and a large-scale system that it might as well be called the world's highest standard, since Tokyo is a large city that has the highest railroad density in the world.

On the other hand, as for the aviation demand forecast, it is based on an advice given by the Japanese Ministry of Public Management, Home Affairs, Posts and Telecommunications on the overestimation about local airports. The examination has been carried out mainly by the Civil Aviation Bureau of the Land, Infrastructure and Transportation Ministry since around 1999 and a new aviation demand forecast system was established and announced to the public in 2002. It was a four-step estimation forecast system, using a disaggregate logit model, in which each of the composite variables such as access, airport route selection, transportation means selection and destination selection are inputted in the top rank, taking into account the capacity restriction of crowded airports like Haneda Airport and also the demand fluctuation depending on the aviation operation frequency.

Although more efforts for improvement are required for the future, it may well be said that an excellent demand forecast system that stands the comparison with any other has already been established at the present practical level, since the re-development of these forecast systems has made for great progress recently.

Efforts for Separation are Under Way

In a certain ordinance-designated city in the metropolitan area, although a subway construction project had been proceeding under a project permit, a new mayor was elected on a campaign pledge to review the project since a huge amount of construction cost was needed, and he got influential people to immediately get to work on the review. It was a unique attempt in which he set up an exploratory subcommittee by the citizens at the same time. Review of the demand forecast at the key persons' subcommittee was meant to examine the validity of the demand forecast conducted by the administration technically from the outside, to ensure the validity of the used demand forecast model, to report the fact that any special problems were not found in the setting conditions of the input data to the model, and in addition, input all the conditions sorted out by the city's ability to control and eventually suggest how to figure out a forecast value with a margin. Following that, the key persons' subcommittee figured out a new forecast value with a margin. Based on the suggestion of the subcommittee, the city proceeded on a review, conducted a balance calculation using one point as a planned value, and announced the result to the public. This way of proceeding in which a forecast result with a margin is shown and the administration adopts it can be evaluated to be quite unique and a methodology which had not been conventionally conducted.

The Administration's Judgment is Becoming More and More Important

In the case of a prefecture that implemented the review/inspection of the airport demand, they clarified their position in a way that was innovative enough to break out of the old shell. The committee on the airport demand review, together with the administration and consultants, established a new model along with the idea of the latest transportation demand forecast model that were indicated by the MLIT Civil Aviation Bureau, scrutinized the way of setting up the input conditions, estimated the future forecast value with a certain margin and announced it to the public. As a reason for producing a certain margin in a result, it cites the number of flights in service and the condition of access that the administration can involve itself in, and the economic growth rate that is beyond control. All of the discussions and documents of the committee were disclosed and the proceeding was observed. So it may well be considered that as much transparency as possible was secured.

The prefecture worked out the demand forecast to be a standard for the airport planning by its own judgment, well within the margin indicated as a result of the demand forecast. This has created a separation of two behaviors, that is, the technical and specialist review of demand forecast, and the selection of the planned value by the administration, and I believe that it is also a new trial which is quite innovative just like the aforementioned example. This project is proceeding with some groups still against it but it is clearly assessable that the prefecture made its own positive judgment on the demand forecast issue in dispute and carried it forward.

Improvement of the Planning Procedure

As seen above, as far as the author knows, some attempts have already been made to divide the demand forecast with a margin and the determination of the planned value. Some points of contention have also been clarified. That is, if the separation goes far, the points of contention will move on to the validity of the plan or the influence assessment and how the administration will deal with them will be questioned. And it will likely be an issue concerning the planning procedure.

At the PI (Public Involvement) Council on the Tokyo Outer Orbital Road, a suggestion has been made by the citizens that " since the forecast value is highly likely to change, whether the administration can promise at this present time to cope with this issue appropriately when it was found that the forecast went wide of the mark rather than discuss the demand forecast value, that is much more important than the discussion on the demand forecast value". Although there are some worries about the project of the Tokyo Outer Orbital Road because of the underestimation of the traffic volume, how far can the responsibility of the administration be expected on the demand forecast value? That is the question to be reconsidered. If the demand is likely to become less, we have to make a suggestion of a new concrete measure of cost reduction and demand creation and try to realize them, and if it is likely to become more, we have to ensure a concrete measure to mitigate the environmental influence. There is no question about the fact that those efforts are more essential.

While overestimation is becoming the issue in question, what if we declare we are going to make what is necessary regardless of the demand from now? It will have no persuasiveness, and does not only look like a new turnaround, but will give a near-sighted and impromptu impression. Let me repeat that what is important is how to get over the present essential problem and indicate a new way to go for the future or steadily step further along on the process for reform. I believe that it is the only way to make it possible to have wide discussions concerning how planning goes on as to whether profitability is really essential in introducing public transportation, or whether the air service using large-scale equipment, that has only one-third of actual service of America and Europe, is really sufficient.

Outside Evaluation of Demand Forecast

Improvement of the planning process is now under way at many levels. In the Prioritized Infrastructure Planning Act, established at the end of March, 2003, PI regulations at the time of planning are stipulated and it is expected that the transparency of the planning will be increased as well as regulations on short-term review of the plan and regulations on coordination with other national integrated plans will be made. Also, as for PI at the time of making a plan for each project, guidelines are being worked out and being revised. It is strongly required that sufficient information will be provided at the PI scenes from now on, especially that very careful and meticulous information will be provided concerning the demand forecast.

Hereupon I would like to mention the third point of view, that is, "evaluation", in addition to the aforementioned two points, the matter of "separation" and the necessity of "improvement". In this case, "evaluation" means that the method of demand forecast and its result are subject to outside evaluation. Especially, in a case where the administration itself implements the demand forecast, it is preferable that the method and the result of the demand forecast should be relegated to an outside organization's inspection. It will be necessary to address this issue making a certain rule, such as setting up a committee for inspection, or asking the experts for a review of the report. At the same time, not only by a third person's neutral evaluation, but also the citizens' evaluation is important. Even a check by a group holding the opposite standpoint may be of some help. It may point out accurately the obtuseness of the documents or mistakes in recording from a different viewpoint from the administration and experts. These are evaluations in a wide sense that are to be achieved by making the information open, which the administration should utilize in a positive way.

Strategy and the Accuracy of Demand Forecast

10 years ago, JSCE Infrastructure Planning Committee held its first one-day seminar inviting researchers in marketing science. In order to reduce 10%, transportation demand forecast from civil engineering perspective would conduct a model analysis for average of 10% reduction. What is needed is a 10% reduction in quantity. Therefore, if we set a particular target of 10% from the beginning and directly approach the travelers in an attempt to make them cancel their trips, the goal may be reached. The same is also true in case of 10% increase. Such marketing analysis has not been sufficiently developed in the field of civil engineering. A strategic approach facing individual markets, rather than forecasting the average value, will become increasingly important in the field of transportation demand forecast. This approach is not a forecast that free of any artificiality, but it is a strategic approach in order to bring the demand closer to the targeted future.

Lastly, we should reconsider whether the idea that the demand forecast must be accurate is appropriate. As a perfectionist, one is forced to declare, "I adopted it because it was accurate." This way of thinking, however, is close to expressing that "It cannot be adopted if it is not accurate enough." If we discuss whether it is accurate or not, it is quite obvious that we will come to the conclusion that complete accuracy is impossible after all. This way of thinking may eventually lead to spreading a way of thinking such as "Let's decide only about today, since the future is uncertain and nobody cannot tell", or "it might be better not to decide about the future since there is no way to predict it." Then, a 50 year-long project, not to mention a 100- year-long national project, will not be planned. If we fail to make efforts to share long-term goals and keep leaving everything to the demand forecast, I'm afraid we will fall into such a situation in the long run. Is it an unfounded fear? What can we do if we fall into such a situation? I believe that a society should be one where many people have empathy and common understanding that "there is something we have to decide now, although the future is uncertain". For that aim, I would like to suggest that we immediately take more serious and earnest actions aiming at solving the problem from its root.

Large Deformation Solid Analysis by Eulerian Method

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The finite element method is the most essential tool in solid analysis. However, the present state is that there still remain numerous problems that are left unsolved in terms of consistency with the actual phenomena in the area of large deformation analysis. Using the Eulerian method described below makes the clarification of complicated phenomena, which have been impossible by means of the general solid analysis code, possible. Thus, the Eulerian method can be expected as a powerful tool for the future of the solid analysis.

Present State of Solids Analysis Method

Because of the dramatic progress in the circumstances surrounding computers in recent years, studies clarifying phenomena of dynamics of all matters using a computational simulation have been a focus of attention together with the theory and the experiment. Among others, the finite element method has become common practice as a method for solid analysis. Moreover, not only in infinitesimal deformation analysis as a linear problem, but also in large deformation analysis as a non-linear problem, application of the finite element method is steadily spreading in the industrial world, with the backing of many high-quality recent publications, and in addition, diffusion of the general-purpose codes.

However, there still are numerous problems unsolved in the non-linear finite element method for large deformation analysis. In this paper, the author attempts to introduce such problems and to describe the Eulerian method, which is expected to solve such problems, as well as to introduce some examples of application of the Eulerian method.

The Problems of Lagrangian Method

In solid analysis, it is a common practice to adopt the Lagrangian method in which finite elements move as the matter deforms as shown in Figure-1. However, there are some problems in this solid analysis by the Lagrangian method as follows:

Firstly, in an analysis of a movement with a large deformation, distortion of finite elements becomes magnified and its accuracy becomes lost. As a result, there is a risk for the analysis to break down. Moreover, the development of cracks and breaks, which the free boundary generates, is hard to be analyzed unless a specific method, such as the dual nodal points method is used.

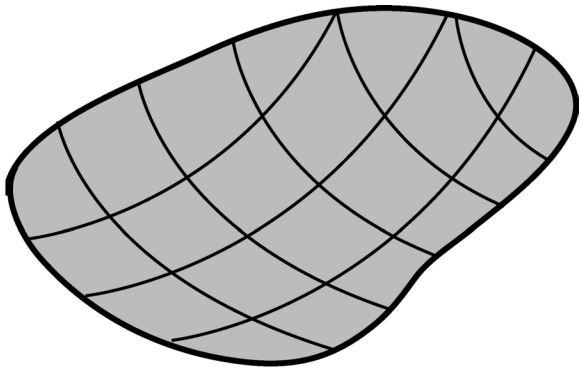

Figure 1: Mesh control by means of the Lagrangian method

Solution by the Eulerian Method

In the Eurlerian method, a computation mesh is fixed in the air (Figure-2), and the matter moves over the mesh. Unlike the Lagrangian method generally used in the solid analysis, the Eulerian method can handle any large deformation because the computation mesh is never distorted in this method. Moreover, creation of a free boundary can be realized without introducing a specific method, and the analysis of breaks and cracks becomes possible.

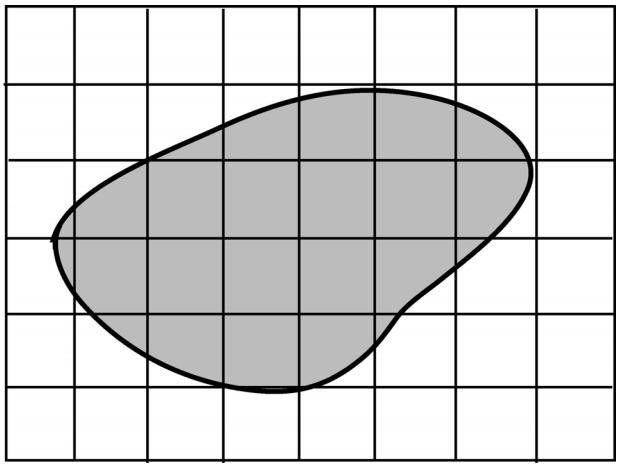

Figure 2: Mesh control by means of the Eulerian method

Comparison between the Lagrangian Method and the Eulerian Method

This section compares the result of analysis of the Lagrangian method and the Eulerian method. In the Lagrangian method, an ordinary code for solid analysis is used. In the Eulerian method, a convection equation will be solved. However, a fluid analysis code cannot be used as it is and it is necessary to convect everything that has path-dependency such as stress and the constitutive equation parameter.

Figure-3 shows the result of the collision analysis by both the Lagrangian method and the Eulerian method. The red area shows the solid materials in each method. In the Lagrangian method,

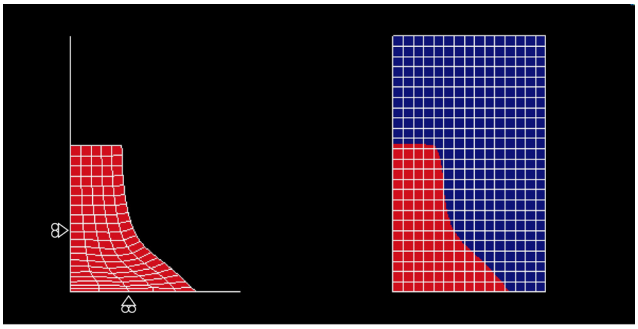

Figure 3: Collinsion analysis be means of Lagrangian method (left) and Eulerian method (right)

the way finite elements move along with the matter deformation may be observed. In the Eulerian method, the way the matter deforms over the fixed finite elements can be recognized. In this way, it is possible to obtain consistent analysis results by both the Lagrangian method and the Eulerian method.

An Example of the Eulerian Method Application to a Large Deformation Solid Analysis

This section presents an example where the Eulerian method was applied to a solid analysis, which has been difficult or impossible by the more common Lagrangian method. Figure-4 shows the results of the pushing process analysis of metal materials. The metal shown in green revealed quite a large deformation. In a large deformation analysis of this kind in the Lagrangian method, the accuracy of the measurement of finite elements is lost and the analysis breaks down. However, since the computation mesh is never distorted in the Eulerian method, any large deformation can be handled, and

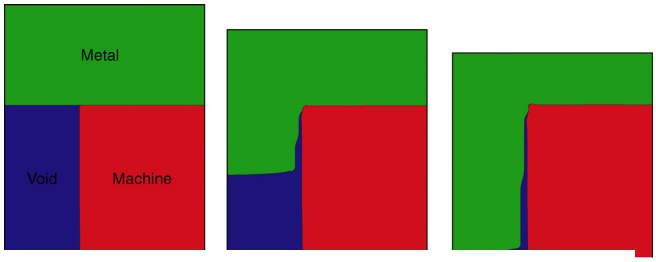

Figure 4: Pushing process analysis

eventually, the pushing process as indicated in Figure-4 becomes possible.

Figure-5 shows the analysis results of a high-speed cutting process. It is reported that countless scissels that are completely cut-off are generated during the high-speed cutting process. These scissels may be the cause of damages to blades and, in some cases, to the whole cutting process machine. Therefore, it is indispensable to understand the detailed process of the generation of these scissels by the high-speed cutting process in order to develop a more advanced cutting process machine. By applying the Eulerian method, it becomes possible to solve the matters of numerical difficulty, such as the handling of large deformation and the cutting-off of scissels.

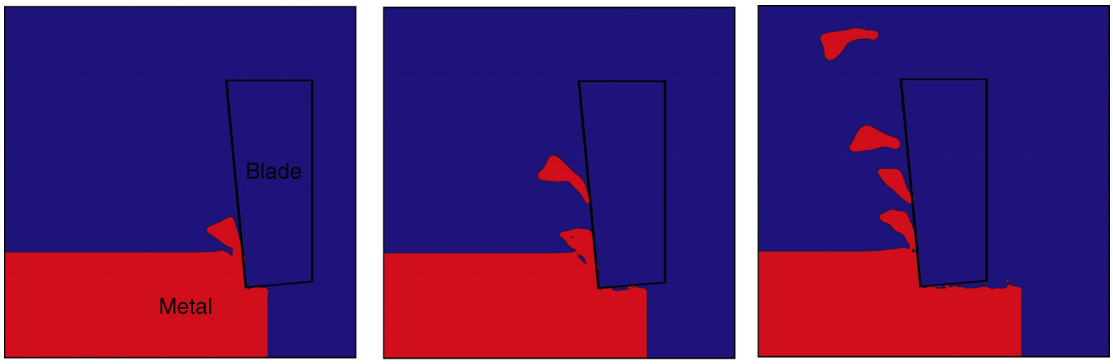

Figure 5: High-speed cutting process analysis

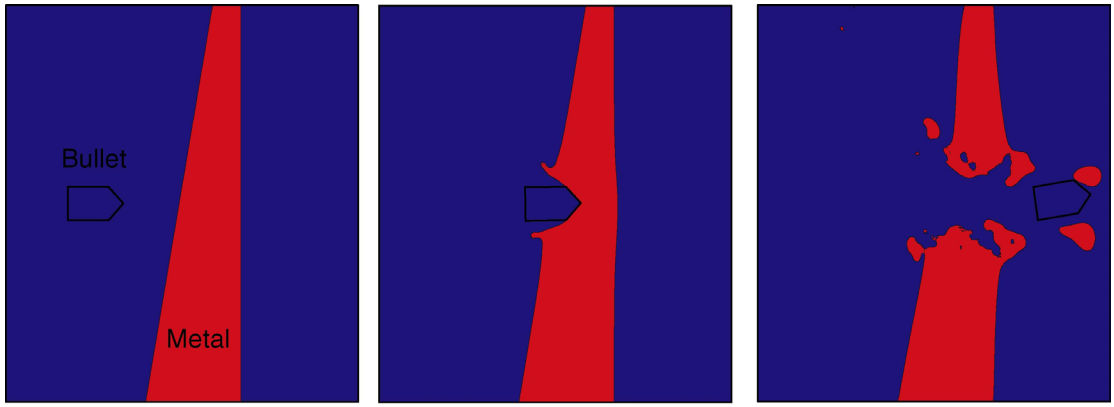

Figure 6: Penetration analysis

Figure-6 shows the penetration analysis of a bullet in a piece of metal. By means of the Eulerian method, it is accurately re-produced how the metal shard spatters after the bullet hits the metal.

Future Development of the Eulerian Method

The Eulerian method enables a more realistic solid analysis, which has been impossible by the Lagrangian method. In other words, solid analysis that has been thought to be impossible until now becomes possible by challenging the prevalent analysis method, such as the Lagrangian method for solid analysis as shown in Figure-1, and the Eulerian method for fluid analysis as shown in Figure-2.

Moreover, the finite element method is disseminated in the field of computational fluid dynamics, where the difference method has been the main stream. Thus, development into linkage with fluid analysis, where the Eulerian method is usually adopted, has been facilitated. In the future, we can expect developments into computational simulation with more large-scale social applications such as ocean bed excavation and complicated dynamics phenomena that are related to phase transformation such as fluid, gas and solids.

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Urban Tunnels
The First Step towards Diversification and Enlargement of Cross-sections: Subway Construction Using a Triple Multi-Face Shield Method

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The Triple Multi-face (MF) Shield Construction Method

The "MF shield construction method" that allows a cross-section of partially overlapping circles to excavate tunnels was developed and employed for a double MF in 1985. The triple MF shield method is an expansion of the double MF, using three revolving cutters to excavate while constructing a triple MF segment with two rows of pillars inside as it moves forward. This method was adopted for the construction of the Osaka Business Park (OBP) station for the first time ever in April of 1995.

Construction of the Osaka Municipal Transportation Subway Line N0.7 OBP Station

This station is west of the OBP district which is between two Class A rivers in the North-South direction and it also crosses under a ϕ 7.1 sewerage tunnel separated by 90cm and IMP building. The station length is 155m and the platform is 135m while the length of the station lies in a space of 107m between vertical shafts. The platform level is roughly 32.5m below surface and was the deepest station (at the time) in the Osaka subway system.

The upper half of the tunnel has an N value over 50 which is a compact sand bed (Os-6) while the bottom half is a clay layer with an N value of 8-25 (Oc-5) and the ground water level is at the GL-20m level and the permeability coefficient is $k=2 \times 10^{-2}$cm/s.

Issues and Measures for the Application of the Triple MF Shield

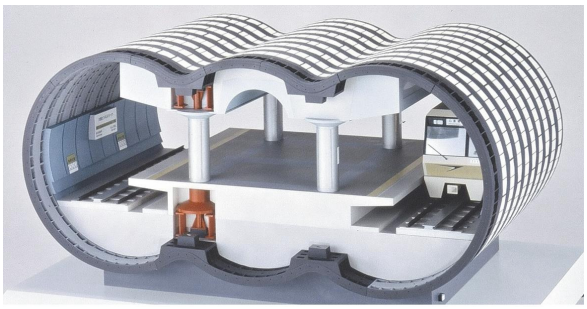

Photo 1: Tunnel lining and structure of the OBP station

Considerations for the Large Flat Section (Design)

For the lining design, setting the external pressure (partial earth pressure, etc.) and the appropriateness of analysis methods is an issue. The former was evaluated through measurements by sensitivity analysis while the latter was given direction with loading tests before evaluation.

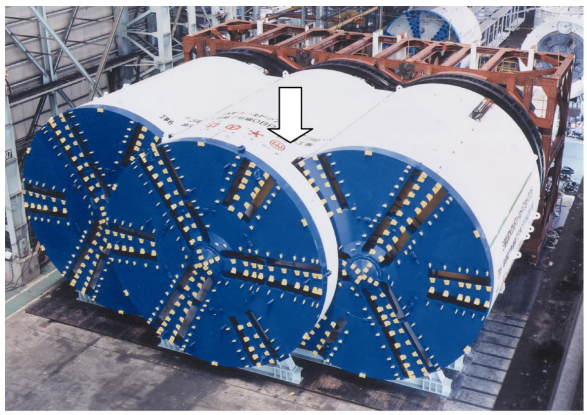

Photo 2: Triple multi-face (MF) shield
Note: arrow indicates gull section

Development from Double MF to Triple MF (Implementation and Project Management)

The concept of the MF shield construction method is easy to understand, but specific guidelines and

applicable results were virtually non-existent. Under circumstances where mistakes were not allowed, investigations through evaluations and component testing were carried out on control of the shield machine's attitude, mud management for the 3 independent chambers (the mud chamber behind the cutters), the management of backfilling the tail void that was 3 to 4 times more than a single shield, and the assembly of triple MF segments among other issues. The issues, measures and implementation results are shown in Table 1.

Photo 3: Shield machine steel shell

Ground Deformation (Environment)

The danger of cutting face collapse was pointed out as a main concern for difficulties in establishing the arch in the sandbar for the “gull wing section” of the tunnel’s upper half. Also, slack around the cutting face was a factor for subsidence during excavation. Based on experience with a single circular shield, the possibility of cutting face collapse was judged to be minor. The ground deformation due to the latter was estimated to be -7mm and responsive measures included preventive grouting for the sewerage tunnel and instrumental monitoring.

Current Reflections

Gull Wing Section

Susceptibility occurrence of face collapse at the "gull wing section" was one of the repeated concerns. Of course, looking from the crossing direction makes it look like the arch will not be formed and fractures might occur but measurements and shield driving management data did not indicate such signs. Instead, the backfilling might have contributed to making the earth pressure higher than the circumference area. As for the stability of the cutting face, the general sense is that there was not a great difference with a single circular shield, earth pressure concentrated in the “gull wing section” of the center pillar due to differences in rigidity causing relief in the circumferential area but may cause 50 to 100kPa of partial earth pressure.

Table 1: Construction and management technology that made the application of the triple multi-face (MF) shield possible

Name	Issues	Measures Implemented	Evaluation of Results
Positioning control of machine	Steering and especially rolling control method: effects pillar orientation and position	Using 2 types of models for testing to analyze rolling characteristics and draft measures	Adjusted the rolling that occurred with copy cutter and diagonal steering
Mud management with 3 independent chambers	Occurrence of pressure variation with the chamber and face or transport of mud from the ground: large possibility of loosening the face	Installation of inter-chamber airways and management of mud transport between chambers to ≒0	Dry sand management was possible with independent chambers
Management control of large backfilling in complex structures	Ensuring the filling of the gull section and management figures: possible occurrence of land subsidence and partial earth pressure	Installing simultaneous injection pipes in both gull sections and proposal of injection pressure distribution forecasting method	Simultaneous backfill grouting was possible with injection forecasting

Table 2: Kajima Corporation's Efforts in Diversifying Shields

Year	1989 － 1993	1998	2003
Overall project "Enlargement, branching, and joining technology of shield tunnels"			
Variable cross-section shield construction method (joint research)			
Triple-link multi-face (MF) shield construction method			
Upright double MF shield construction method (twist)			
Multi Shield (Mother & Son) construction method			
Wagging Cutter Shield construction method			
Multi-Micro Shield Tunnel construction method			
High-strength boltless segment			
Octopus construction method			
Adjustable width (contraction and expansion) construction method			Road tunnel shield system
Branching and bit exchange (screen shield) construction method			

Ensuring the Precision of Shield Production and the Need for Supplementation Technology

The impact of manufacturing precision for the shield machine on positioning control was potentially large. Experimental measurements during the factory test assembly showed that the form was slightly twisted in the middle and on either side. The actual behavior resulted in rolling in the opposite direction of the make of the shield, but was remedied with the over cutting and diagonal pushing (using the lower right and upper left). The machine's form (distortion) was within ±10mm, but considering the fact that rolling still occurred, it is important to be prepared with several tools to actively control the attitude.

Departing from Past Performance unwillingly

The steel shell (Photo 3) of the shield machine that arrived became part of the structural material. Generally, the shield machine serves as a temporary structural material and the rib is removed and reinforced concrete structure is reconstructed. But with a triple MF, it is difficult to remove the rib and central pillars so there was no choice but to fill the steel structure with concrete. However, this structure is more practical than unreasonably converting it into a reinforced concrete structure and results in better quality. Such cases will provide a chance to change thinking and design methods that rely too much on past experiences.

Turning Point

From the perspective of shield technology, the construction of the OBP station using the triple MF shield was a turning point for larger cross-sections and the diversification of shields. Although this is a personal note, it also coincides with the period that "Kajima Corporation" started looking beyond circular tunnels. This construction project not only contributed to individual technological innovations but also changed the corporate culture that admitted diversity.

Long-span Bridges: Technology Spanning the Future

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The Development of Long-span Bridge Technology

In the field of long-span bridges, the Akashi Kaikyo Bridge and the Tatara Bridge of the Honshu-Shikoku bridges are the world's longest suspension bridge and cable-stayed bridges, respectively. In addition to this, many other bridges are listed among the world's long-span bridges, indicating that Japanese long-span bridge technology now ranks high among the world. In addition to bridge span, there are many matters that are noteworthy such as the fact that the bridges with large deepwater foundations are numerous and that the Seto Bridge is the world's first large-scale road and rail bridge.

Long-span bridge technology in Japan originated from studies of Western bridge technology, which was half a century ahead and began with Wakato Bridge and Kanmon Bridge. Technology made rapid advances during the construction of the Honshu-Shikoku bridges that followed. Since the Honshu-Shikoku bridges were built in phases, the technology developed was maintained while new technology was developed to resolve the issues of the next bridge. The lines of long-span bridge technology that developed under these circumstances can be seen in the bridges awarded the Tanaka Award (Division of Outstanding Bridge Design and Construction) by Japan Society of Civil Engineers. These technologies cover a broad area ranging from survey, design, construction, maintenance and management. However, this article will focus on construction technology for the superstructure of long-span suspension bridges and cable-stayed bridges.

Award-winning Bridges and Technological Development

Table-1 and Table-2 show the Honshu-Shikoku bridges that were awarded the Tanaka Award (only suspension and cable-stayed bridges are shown in Photos 1-5) as well as an outline of the technology developed.

Construction Technology of the Suspension Bridge Superstructure

Main Tower

Building the main towers frequently call for the construction method established with the building of Kanmon Bridge where blocks fabricated at a factory with high precision was transported to the site and built with a crane. For the Akashi Kaikyo Bridge, the main tower reached greater heights and was roughly 300m above sea level. Also, to ensure construction efficiency of the increasingly large tower pillar cross-section, factory equipment was upgraded and the capacity of building cranes was enhanced so that the weight of one block increased from 55t for the Innoshima Bridge to 160t for the Akashi Kaikyo Bridge.

Creeping cranes (special machine equipment where tower pillars are constructed by climbing the rails installed on the tower pillars) were used for the building cranes since the main towers of the suspension bridges were generally high but since the building cycle will also include preparation for the cranes to climb and other tasks, the scheduling becomes an issue. For this reason, the Akashi Kaikyo Bridge utilized a tower crane that climbs and

Table 1: Awarded Bridges and Major Technological Development (Suspension Bridges)

Name Year of completion, span	Major Technological Development
Ohnaruto Bridge 1985, 876m	● Establishment of multi-column foundation construction method ● Improvement of cable length measurement systems and construction methods ● Establishment of superior wind-resistant girder construction method
Ohshima Bridge 1988, 560m	● Japan's first box girder suspension bridge ● Direct lifting construction of girder using a barge with one point moorage
Seto Ohashi Bridge 1988, 940, 990, 1100m	● Establishment of design methods for road-rail suspension bridges ● Development of inclination angle adjustment and track expansion devices ● Welding and inspection methods for high-strength steel material ● Establishment of laying-down caisson method ● Underwater blasting method ● Development of pre-packed concrete method ● Cable construction using the new AS method ● Girder construction using crane ship
Akashi Kaikyo Bridge 1998, 1991m	● Flutter analysis using a large-scale wind tunnel tests ● Earthquake resistant design considering dynamic interactions between the foundation and ground ● Development of undisturbed sampling method for soft rock and gravel and improvement of indoor testing methods ● High-strength wire and reduced preheat high-tension steel ● Fluoroplastic paint (long-term rust-resistant paint) ● Grab excavation in strong currents and deep water ● Mooring and sinking system of caisson ● Development of desegregating underwater concrete and high fluidity concrete ● Development of low-heat cement ● Development of scouring prevention for foundations ● Development of scouring prevention for foundations ● Development of underground linked wall construction method for high-depths and great thickness ● Improvement of cable structure and a corrosion prevention system using dry air supply ● Sea crossing of pilot ropes using helicopter
Kurushima Kaikyo Bridge 1999 600, 1020, 1030m	● Improvement of earthquake resistant design methods for the bedrock foundation ● Improvement of laying-down caisson method ● Direct lifting of girder blocks using a self-positioning barge

Table-2: Awarded Bridges and Major Technology Development (Cable-stayed Bridges)

Name (Completion year, span)	Major Technology Development
Hitsuishijima Bridge Iwakurujima Bridge 1988, 420m	● The world's first and longest road-rail cable-stayed bridge ● Elastic earthquake support using disk springs ● Vibration control during tower construction using TMD ● Vibration control during tower construction using TMD ● Anti-bending measures for fixed cable sections
Ikuchi Bridge 1991, 490m	● Composite structure for long-span cable-stayed bridge design method ● Elastic support using rubber bearing ● Construction of large blocks for the main tower using crane ships
Tatara Bridge 1999, 890m	● Development of design methods for the 900m-class cable-stayed bridge ● Confirmation of load-bearing capacity of a 900m-class cable-stayed bridge ● Structural improvement of steel slab and fixed cable sections ● Ensuring wind stability after completion and during construction ● Cable vibration control

descends a post separate from the pillar (Photo 6). This crane has full swiveling capacity and can also self-adjust its height in accordance with the pillar's height. This crane was later used for constructing the towers of the Kurushima Kaikyo Bridge and the Tatara Bridge.

Since the main tower in construction is not steadied by a cable, even relatively low velocity winds can cause vortex-induced oscillation. Since this vibration disrupts tower construction, the usual approach for suspension bridges is to extend a wire from the top of the tower to the tip connected to weight and oil damper on the ground. For the Akashi Kaikyo Bridge, the installation of a Tuned Mass Damper (TMD) was used for the main tower itself (Figure 1).

Cable

The cable of a long span suspension bridge is composed of tens of thousands of 5mm diameter steel wires bundled into a cable. Construction methods include the air spinning construction (AS method) and pre-fabricated strand construction (PS method).

The AS method requires the individual lining of steel wires on site. It was developed roughly 150 years ago and was used in the laying of cables for major suspension bridges in Europe and in the U.S.

On the other hand, in the PS method (Figure 2), a hundred of elemental wires are bundled into a strand in a factory and erection at the site is conducted strand by strand. This method was first adopted for the Newport Bridge in the United States during the 1960s. This method was mainly used for suspension bridges in Japan such as the Kanmon Bridge and many Honshu-Shikoku bridges, building a steady track record. For the Kanmon Bridge, one strand was composed of 91 steel wires but for bridges since the Innoshima Bridge each strand is composed of 127 wires. The Akashi Kaikyo Bridge also adopted the PS method (Photo 7) but the length of the cable strand became approximately 4,100m, or more than twice the previous length. These raised concerns on whether construction on site was possible and whether it ensures quality as a parallel wire cable. Therefore, a full-size strand was test manufactured and

Photo 1: Ohnaruto Bridge

Photo 4: Kurushima Kaikyo Bridge

Photo 2: Seto Ohashi Bridge

Photo 5: Tatara Bridge

Photo 3: Akashi Kaikyo Bridge

Photo 6: Tower construction using a tower crane (Akashi Kaikyo Bridge)

Figure 1: Tower vibration control (TMD)

wound on a reel to confirm that construction was possible.

The first step of the cable erection process begins with the sea crossing of the pilot rope that connects the all spans. This crossing developed from a method where floats are attached to the rope and pulled by a tugboat to a method where the rope is tensed by tugboats and crane ships while pulled from the sky in order to reduce the impact on passing ships. However, since the Akashi straits is an international sea route that carries a heavy volume of ship traffic, which would be disturbed by such a method, a new method was developed (Photo 7), involving the carrying of a light-weight, high-strength synthetic fiber with a large helicopter (Photo 7). This method was also used for the Kurushima Kaikyo Bridge.

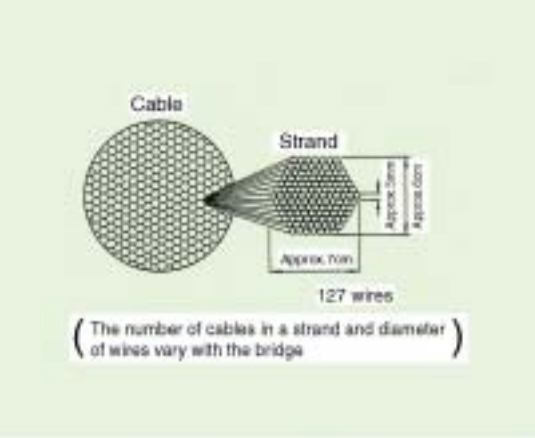

Figure 2: Cable cross-section using the PS method

Stiffening Girders

For stiffening girders, the truss type was adopted for many suspension bridges since it can be constructed without using the sea surface directly below. The construction method involves consecutive rigid coupling hinge construction method with plane blocks which was developed for Kanmon Bridge and used in Innoshima Bridge construction. This method involves the coupling of newly constructed truss plane blocks manufactured at the factory to existing components on the site and then the hanger rope is pulled into the new component and stabilized. This method allows for

Photo 7: Cable strand construction (left), sea crossing of pilot rope (right) (Akashi Kaikyo Bridge)

Photo 8: Large block construction for the stiffening girders (Seto Ohashi Bridge)

greater wind-resistant stability during construction when compared to the all hinge construction methods used in Western suspension bridges.

This construction method usually requires hinges to remedy excessive stress on the diagonal truss bracing and the hanger rope on the end of the erection, but this was improved to a hinge without rigid coupling by adjusting the pulling tension with a multiple joint as used at Ohnaruto Bridge. This method was later used at the Seto Bridge and Akashi Kaikyo Bridge.

Also, when an ocean construction zone close to the main tower can be secured for work ships to be moored, the large-scale block construction method is used where stiffening girders are fabricated as large blocks at the factory and erected at once by large-scale crane ships to shorten construction period and relieve complicated tasks in the initial phases as used for the

Seto Ohashi Bridge and Akashi Kaikyo Bridge (Photo 8).

The Ohshima Bridge is the first Japanese suspension bridge that adopted box type which is economical and easy to maintain for stiffening girders. The construction method used involved lifting from the sea level directly below while a barge loaded with the girder block maintaining moorage at one point on the upstream side of the current to shrink the sea space needed and reduce the effect on ship traffic.

The Kurushima Kaikyo Bridge also used box type as stiffening girders. The Kurushima strait has rapid currents and a bent course that serves as an international waterway so barges cannot moor for long in the waterway where there is heavy ship traffic. Therefore, a self-positioning barge that can keep the same position directly under the construction site without mooring under strong currents was developed (Photo 9). Self-positioning barges were equipped with full-rotation propellers in all four corners and were combined with a survey system that used light waves from the land. The position of the barge is measured and a computer steers it to the designated spot using the automatic position control system. This barge was also used for Akinada Bridge in Hiroshima Prefecture.

The Construction Technology of the Cable-stayed Bridge Superstructure

In Japan, the Onomichi Bridge completed in 1968 with a span exceeding 200m was the pioneer bridge for the full-scale cable stayed bridge and for many of the cable-stayed bridges that followed a rapid increase in span length. Currently, there are over 40 bridges with a span exceeding 200m in Japan. In Japan many noteworthy cable-stayed bridges were constructed including the Hitsuishijima and Iwakurujima Bridges among the Honshu-Shikoku bridges, that became the world's first and longest road and rail cable-stayed bridge and the Ikuchi Bridge was a combination cable-stayed bridge that used steel box girders for the central span and PC box girders for the side span.

The Tatara Bridge completed in 1999 with a center span of 890m became the world's longest cable-stayed bridge by exceeding France's Normandy Bridge (completed in 1995), which has a center span of 856m. The girder construction for the Tatara Bridge required the installation of supports in the sea to facilitate construction and used a construction method based on "balancing construction from the tower combined with overhang construction of the central span." The construction length was 150m from the tower for the balancing construction and 435m for the overhang from the center span (Photo 10 and 11). In adopting this construction method, structural analysis was carried out after and during construction while a 1/70

Photo 9: Girder construction using a self-positioning barge (Kurushima Kaikyo Bridge)

Photo 10: Balancing construction of the girder (Tatara Bridge)

scale full model was used for wind tunnel tests to ensure safety.

Photo 11: Overhang construction of the girder (Tatara Bridge)

Future Developments

Currently in Japan there is a vision for a strait-crossing project. This project aims for a new transport axis that creates a multi-axial land structure. This will require the construction of an extreme long-span bridge surpassing the Akashi Kaikyo Bridge.

Considering the changing social environment surrounding public works, in order to construct such a long-span bridge in the future, it will be necessary to pass on the technology accumulated while developing new technology to make possible a drastic reduction of costs and construction period.

Such technology from a design and manufacturing perspective would include the adoption of new structural forms that have superior wind and earthquake resistance, the implementation of new design methods, relaxing material quality requirements, streamlining of manufacturing, and development of new materials. Also, for site construction technology, this would require the promotion of technology development to include the development of construction methods and machine equipment that can withstand harsh natural conditions, optimization of required construction precision, and streamlining of temporary facilities to reduce site workloads.

Damages from the Eruption on Miyake Island and Measures against Mudflow

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Summary of Report

The "Emergency Volcanic Alert" was released on June 26th 2000. Frequent earthquakes occurred on the Izu Islands from that day on. It later led to a major eruption, and caused unprecedented large-scale and widespread damage. All islanders evacuated in September of the same year and are now entering their 3rd year away from the island, still unable to return. There have been three eruptions since the Showa Era, and the main eruption activities in all three consisted of fissure eruptions. Lava flows and explosions ended in a relatively short period. The latest eruption, however, was somewhat different. Volcanic gas and mudflow damages were the big distinguishing features. This is a summary report on the volcanic activities, the outbreak of the damages, and efforts toward restoration with a focus on sabo projects.

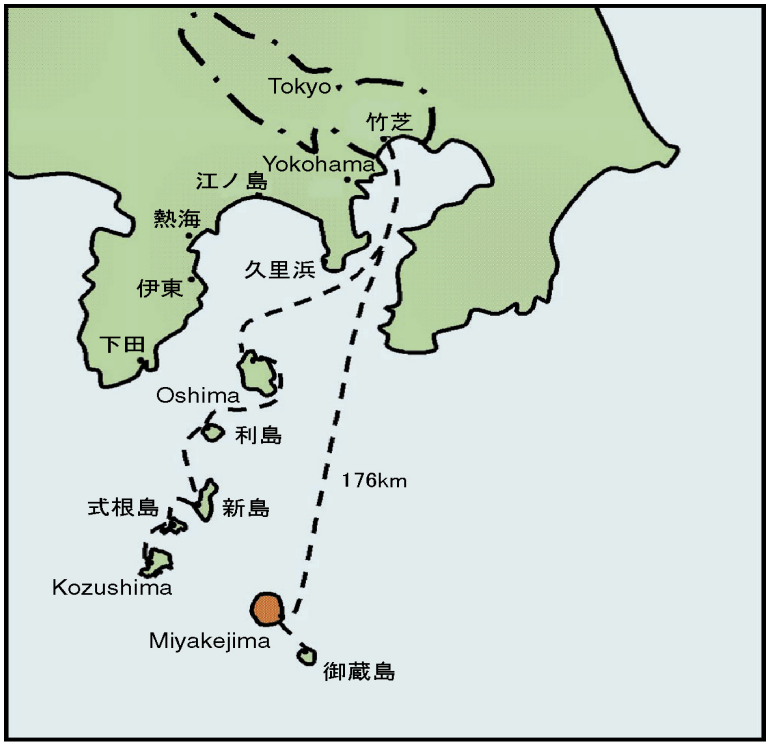

Figure 1: Location of Miyake Island

Brief Overview of Miyake Island

Miyake Island is located 180km south-southwest of Tokyo's city center. It is an oval-shaped island with a diameter of 8km, area of 55km^2, and a circumference of approximately 35km (see Figure 1). The skeleton of the island is estimated to have formed approximately 3,000 years ago. It is connected with the southern belt of the Fuji volcanic zone. Towering over the center of the basaltic volcanic island is Mount Oyama, which is a double composite volcano, composed of a central volcanic cone and an outer rim crater. It is a young volcano, with no coast erosion and very few steep cliffs visible along the coastline of the gently sloping cone-shaped island. Before the evacuation, Miyake Island supported a medium-sized population within the Izu Islands, with a total population of 3,872 and 1,952 households according to a survey conducted by the Miyake Village in January 1999.

Massive Eruption of Volcanic Gas

The 4th volcanic activity since Showa Era started with the earthquake swarm in June 2000. Followed by a short tranquil period, the volcano resumed its activities in July. There was a small-scale eruption, destroying a part of the slope

near the mountaintop and causing the crater to cave in. Later, heavy rain produced large-scale mudflow damage, and an earthquake of lower 6 level on the Japanese earthquake scale generated sediment damage. The volcanic activity reached its peak in August, and a major eruption covered the entire island with volcanic ash. A maximum-scale eruption occurred on the 29th when a unique low-temperature pyroclastic flow occurred in the Kamitsuki area. The islanders began to evacuate the island voluntarily, starting from the elderly and the children. On September 2, the Miyake Village mayor ordered all islanders to evacuate.

The biggest characteristic of this latest volcanic activity is the massive eruption of volcanic gas. It is a key factor that still prevents the return of islanders. Volcanic gases containing such elements as sulfur dioxide has been known to erupt since mid-August and its volume reached tens of thousands of tons per day.

Mudflow Damage

Another characteristic is the mudflow damage. A massive amount of volcanic ash accumulated over Mt. Oyama covering from its peak to foot, preventing rainwater from seeping in. Every big rainfall was accompanied by mudflow, engulfing boulders and large stout trees, causing heavy damage. The entire island was left in paralysis (Photo-1).

Photo-1: Osawa (Damage as of July 26th 2000)

The Tokyo Metropolitan Government Road (TMG Road) received heavy damage in 16 places. Damage due to the mudflow gradually spread, leaving the road impassable over a long time. Fourteen village roads were damaged, and the forest roads were also damaged in over 60 places.

Concerning lifeline facilities, the pump unit of the water system was impaired, and water supply and drainage pipes were damaged in 31 places. Regarding electricity and telephone lines, 30 utility poles either collapsed or were tilted by the mudflow. Electric cables were washed away or disconnected in 67 places.

Houses were seriously damaged as well. Out of approximately 2,000 households on the island, 43 houses were damage. Leaks and termite damages were later also reported.

Measures Against Mudflow – Sabo Projects

Measures against mudflow are the key to post-disaster restoration. Looping around the breast of Mt. Oyama is a forest road known as the "Hachimaki Road." Erosion control projects are implemented above this road, and sabo projects are carried out in regions below. The two projects are carried out by coordination with each other.

In sabo projects, both hardware and software measures were taken in the initial stages of post-disaster restoration. Hardware involves setting up log booms and training dike from large sandbags. Software involves establishing a mudflow control system using equipments such as rain gauges, vibration sensors, etc. Simple measures that can be carried out on the spot, and work that need to be completed prior to the actual construction phase have been given priority.

The actual post-disaster restoration work started immediately after the outbreak of the disaster

in fiscal 2000 in the name of "Disaster-Related Urgent Sabo Project (DUSP)" under guidance of the Ministry of Land, Infrastructure and Transport. Work on 15 sabo dams and flow channels began in 16 mountain streams (where water is not flowing without rainfall) where damages from mudflow generated right after the eruption. Although detailed field investigation of the "F2000 DUSP" began in December 2000, it took 6 months to complete the essential investigation for designing execution due to severe weather conditions. Therefore, the actual post-disaster restoration work began only in July 2001. The completion of the first dam, Kanigasawa Sabo Dam, was in December of that same year (Photo-2). Unmanned machine construction was carried out in areas involving danger due to the accumulated volcanic gas. The remaining 14 sabo dams were completed by the end of fiscal 2001 (Photo- 3).

Photo-2: Kanigasawa Sado Dam (Disaster Related Emergency Sado Project of Fiscal year 2000)

Photo-3: Igayasawa Sado Dam (Disaster Related Emergency Sado Project of Fiscal year 2000)

With the adoption of "Special Emergency Project for Severe Volcanic Disaster (SEPSVD)" of 2001, a five-year plan was implemented to build 51 sabo dams and flow channels in 27 mountain streams, adding 11 more to the above 16. The F2001SEPSVD started on 4 sabo dam projects on 3 mountain streams in January 2002. The F2002SEPSVD is will be starting on 3 sabo dam projects on 5 mountain streams.

With the adoption of F2001DUSP, 9 sabo dam construction projects began on the 9 mountain streams where many mudflow damages were later seen, including Kanasozawa. In fiscal 2002, with the adoption of 2002DUSP in Shiramisawa, Tepposawa and Yukeisawa, a survey of the 2 sabo dams had begun, since the damage was further aggravated by Typhoon No.13.

It is decided that projects will be carried out in 37 streams in total, and a total of 28 sabo dams are to be completed within the fiscal year. All current projects are working toward completion by fiscal 2005 (see Figure 2).

Effect of Sabo Dams against Typhoon No.13

Typhoon No. 13 developed on August 12th 2002 and approached Miyake Island on August 19th. A consecutive rainfall measured 322mm at Ako observation station, marking the maximum rainfall since the eruption. Sediments from Teppozawa and Yukeizawa accumulated on the TMG Road over approximately 300m^3. Approximately 200m of Todo was temporarily closed, and TMG Road and village roads were covered with sediments in Okaborizawa and several other places as well. However, new dams constructed under the F2000DUSP along the 14 mountain streams and existing dams along the 2 mountain streams from which rocks had been

removed, successfully prevented sediments from getting washed out over the roads. It may be concluded that the security level against mudflows increased drastically along the mountain streams where dams were built.

Izu Islands Sediment Disaster Countermeasure Investigation Committee

Such basic concept of the sabo project is based on the proposals and guidance provided by the Izu Islands Sediment Disaster Countermeasure Exploratory Committee (Chaired by Shun Okubo), which was established in fiscal 2001 for professionally investigating the Izu Islands disaster measures against volcanic activities on the Miyake Island and against Kozu Island offshore earthquakes.

As an emergency measure, projects are prioritized based on the status of sediment outflow and subjects for conservation. For each mountain stream, sabo facilities will be developed based on protection rate against mudslide of 50% or above of what would be required under a rainfall of 1 in a 100-year chance. Sabo dam projects and stream conservation projects are jointly implemented to alleviate mudflow damages in a more efficient and effective way, with the help of new methods for setting up training dike using special blocks and large sandbags.

The committee meeting was continually held in fiscal 2002 as well. Being reviewed in the discussions are which geographical regions have potential danger of mudflow, and what is the benchmark level of rain that will generate a mudflow. Enhancement of the mudflow control system is also being explored. In preparing for the islanders' return, official announcement of regions with potential danger of mudflows and other improvement in terms of software are further required.

Present Work Environment

The situation on Miyake Island differs substantially from the work environment on the mainland in the sense that emission of massive amount of volcanic gas is still continuing.

Initial Response

In the initial stages of the restoration work, the future volcanic activities were difficult to predict. After all the islanders evacuated, apart from certain disaster-prevention members, the restoration crew was forced to spend time on the ship during nights and when the mountaintop was not clearly visible to the eye. One month was the limit to continue under such harsh conditions, so the Local Disaster Countermeasures Office was moved to the adjacent island, to Kozu Island. For the remainder of the year, the crew used fishing boats to cross to Miyake Island to carry out their work, but from the following year, they started using small passenger boats. Helicopters from the Self Defense Forces and the Tokyo Metropolitan Government came to help during bad weathers when the sea was rough. The restoration crew faced many difficulties until the clean-house (mentioned later) were established. Investigations and designs necessary for drawing up the sabo works plan and implementing the projects were also conducted under harsh conditions.

Volcanic Gas

The main elements of the volcanic gas observed until today were sulfur dioxide SO_2 and hydrogen sulfide H_2S. Most serious is SO_2, which frequently surpasses the level set out under environmental standards and work standards.

According to a remote observation method called the COSPEC (ultraviolet wave correlation spectrometer), the maximum level of SO_2 immediately after the eruption in autumn 2000 reached over 60,000

tons per day. After entering 2002, the level is 3,000 tons per day when low, and ranges from 20,000 to 30,000 tons per day when high. The spread is quite large, but overall, the amount is declining.

The density of SO_2 is largely dependent on the direction of the wind. Throughout the year, there is relatively more wind blowing from the west, so that the east side of the island near the Miyake Island Airport tends to receive high-density gas.

The SO_2 level set out under the environment standard is 0.04 ppm per day, 0.1 ppm per hour on the average. However, there is another standard, the work standard, which sets the level at 2ppm (maximum gas density recommended under ACGIH). Under this standard, each work group must carry a gas detector that sets off an alarm whenever the gas level exceeds 2ppm, then the crew must then put on their gas masks.

Clean-house

Since there is a limit to how much work the crew can perform by crossing over from Kozu Island, lodgments called "clean-houses" were established on Miyake Island, which allows the crew to stay overnight on the island as well. These houses are designed to ensure safety even under the eruption of volcanic gas (Photo-4).

Photo-4: Clean-House (Ako Desulfurization Lodgment)

The biggest feature of the clean-house is the desulfurization system, which eliminates gas elements when the outside air containing SO_2 enters the building. It was based on the technology used in semi-conductor factories and developed uniquely for dealing with these gases. There is the "dry system" where the gas is eliminated through activated carbon filters covered with oxidizing agent, and the "wet system" where the SO_2 gas is chemically treated by neutralization through sodium hydrate NaOH solution.

As of December 2002, there are a total of 17 such facilities where 650 people could stay overnight.

Future Prospects

The evacuees are entering their 3rd year since they evacuated the island on September 4th 2000. Outlook is still not clear as to when they will be able to return. They continue to have uncertainties and worries over their aging houses left behind under weather and volcanic gas, over their unstable evacuation life, and over their life after their return to the island.

In July 2002, the Central Disaster Prevention Council of the Government declared Miyake Island as Area Concerning Urgent Improvement of Refuges under the Act on Special Measures for Active Volcanoes. This enabled the establishment of clean-houses as escape facility of islanders. The project is scheduled for completion in March 2003.

Also, the "Investigative Meeting Concerning the Volcanic Gas on Miyake Island" was established in September 2002. Its aim is to scientifically determine the safety securing measures that will enable the islanders to return. In other words, it will define the volcanic gas conditions under which the islanders are safe to return. The information needed to make the decision is to be presented within this year.

Post-disaster restoration measures other than those against mudflows are steadily being implemented as well. The Tokyo Metropolitan Government's mission is to increase the security level on the island so that the islanders can return to the island without delay once the volcanic activities settle down. It will continue to put forth its best efforts in promoting the restoration work in the future as well.

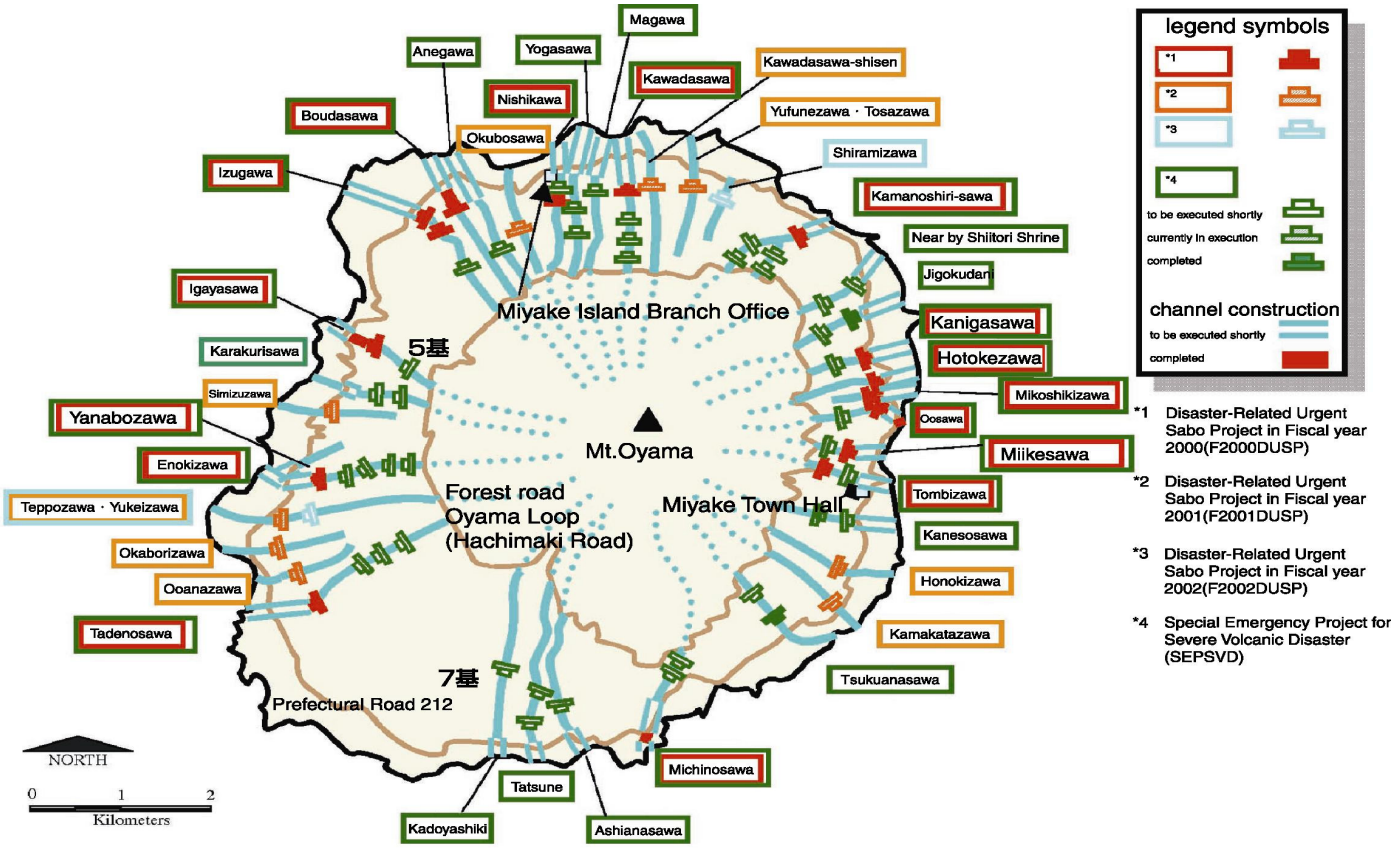

Figure 2: Execution of Sado Works on Miyake Island (As of October 2002)

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Technological Report on Hakkoda Tunnel: Excavating Through the Mines Preventive Measures for Acidic Mine Water from Muck

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26.455 kilometers long Hakkoda Tunnel on the Touhoku Shinkansen line is a long-length mountain tunnel that surpasses Iwate Ichinohe Tunnel, which has been the world's longest mountain tunnel until today. The surrounding area of this tunnel is interspersed with abandoned mines, which affect the rocks around the tunnel route. Rocks containing sulfurized minerals such as the iron pyrite are dispersed in the area. For this reason, the pollution of surrounding environment by acidic mine water from oxidization of sulfurized minerals during mucking came into question. As a solution to this problem, a two-step measure was taken in order to prevent oxidization of muck:

① To separate muck that could possibly produce acidic mine water from ordinary muck.

② To apply industrial waste management technologies to seal off mineralized muck from underground water, rainwater and oxygen.

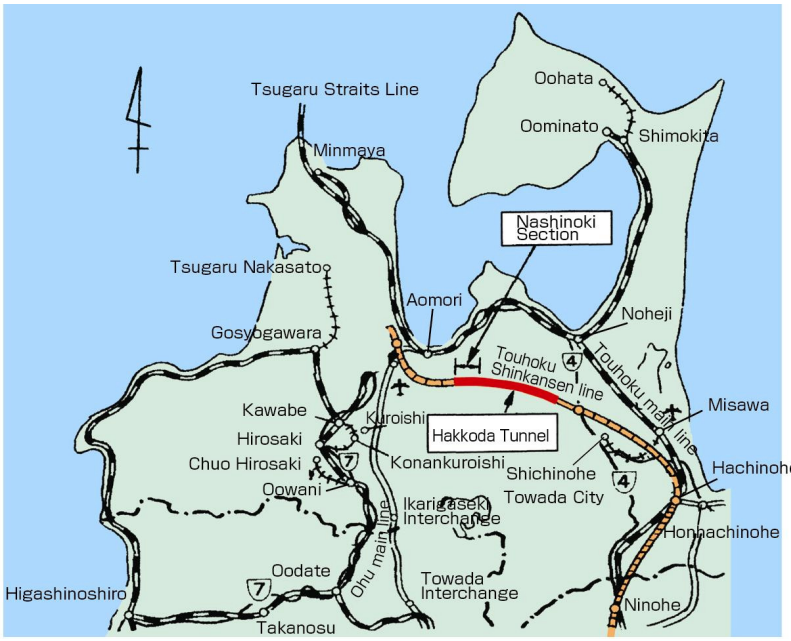

Figure-1: The location of Hakkoda Tunnel

Overview of the Tunnel

Hakkoda Tunnel is in excavation between the TenmabayashimuraIchinowatari section to Aomori-shi Komagome section of the new Hachinohe – ShinAomori zone of Touhoku Shinkansen line. Hakkoda Tunnel cuts practically east to west through the mountainous region on the northern foot of Mt. Hakkoda (figure-1). For the excavation, the tunnel was divided into six sections each approximately 4 to 4.6 km in length. In May 1999, the excavation work in the Nashinoki section, which is closest to ShinAomori started and since then, excavation in each section is underway.

Basic Principles of Mucking

Hakkoda Tunnel is surrounded by interspersed mineralized rocks except for the areas surrounding its two portals. Kamikita mine, which produces black ores, is in the area and numerous small-scale mines are dotted nearby producing copper,

lead and zinc. In mine areas, the effect of acidic poisonous water flowing out from mines abandoned or in use, to the surrounding environment has always been an issue[1]. Similarly, in excavating tunnels in mine areas, acidification of spring water and leachate from muck can be expected and its treatment is a critical task.

In such situations in the past:

① The entire muck was used to build embankment structures, covering the surfaces with impervious sheets or concrete[2].

② The entire muck was transported and entrusted to companies with processing plants[3].

However, for Hakkoda tunnel, new technology had to be developed as there was no space left for embankment and the processing plant with limited capacity could not deal with the large amount of muck.

Prior to the excavation of Hakkoda tunnel, preliminary survey in order to grasp the distribution of mineralized rocks and the geological characteristics of the area was undertaken and the processing method of the mineralized rocks were examined As a result, we came up with two basic principles:

① To separate between muck which could possible produce acidic mine water (hereafter called "control-type muck") and those without such problem (hereafter called "ordinary muck.").

② To apply industrial waste management technologies to seal off mineralized muck from underground water, rainwater and oxygen[4, 5].

I would like to report on the separation and disposal technologies.

Separation

Basic Conditions

Based on the actual tunnel excavation work, we have determined the following three points as the basic condition of testing of muck:

① Muck produced in a day's excavation was separated as a unit as it was impossible to make finer distinction by each heading.

② It is necessary to obtain test results within 24 hours, as when it takes more than a day, it would require muck bins that could contain the accumulated muck.

③ It is necessary to test the soil ahead by horizontal drilling because the nature of the soil could undergo sudden changes in a day's excavation.

Separation Criteria

In order to assess whether the muck is a control-type or an ordinary type, outcome of long-term exposure (more than 10 years) of muck of which the sulfur content is already known at the planning stage of excavation will be taken into consideration. Moreover, layered rocks that appear on the headings of the tunnel will be collected by short-range boring and will be tested for the changing ph level of leachate over time using simplified leaching test. Based on these two results, the muck will be categorized as control-type in following circumstances:

① When a vein or an ore is visible on the headings by naked eyes.

② When the ph level of leachate is under 6, ten minutes (currently one hour) after the simplified leaching test (The extracted mine samples are dried and are ground to less than 10mm. Then, 100g of ground mine sample are placed in a container with 500ml of distilled water. After shaking in an apparatus, it is left at rest. The ph level is measured after 10 minutes, 1 hour, 24 hours, 7 days, 28 days and 56 days.)

③ When the sulfur content of the rock amounts to more than 2wt% based on the result of chemical composition analysis.

Moreover, based on our construction experiences we

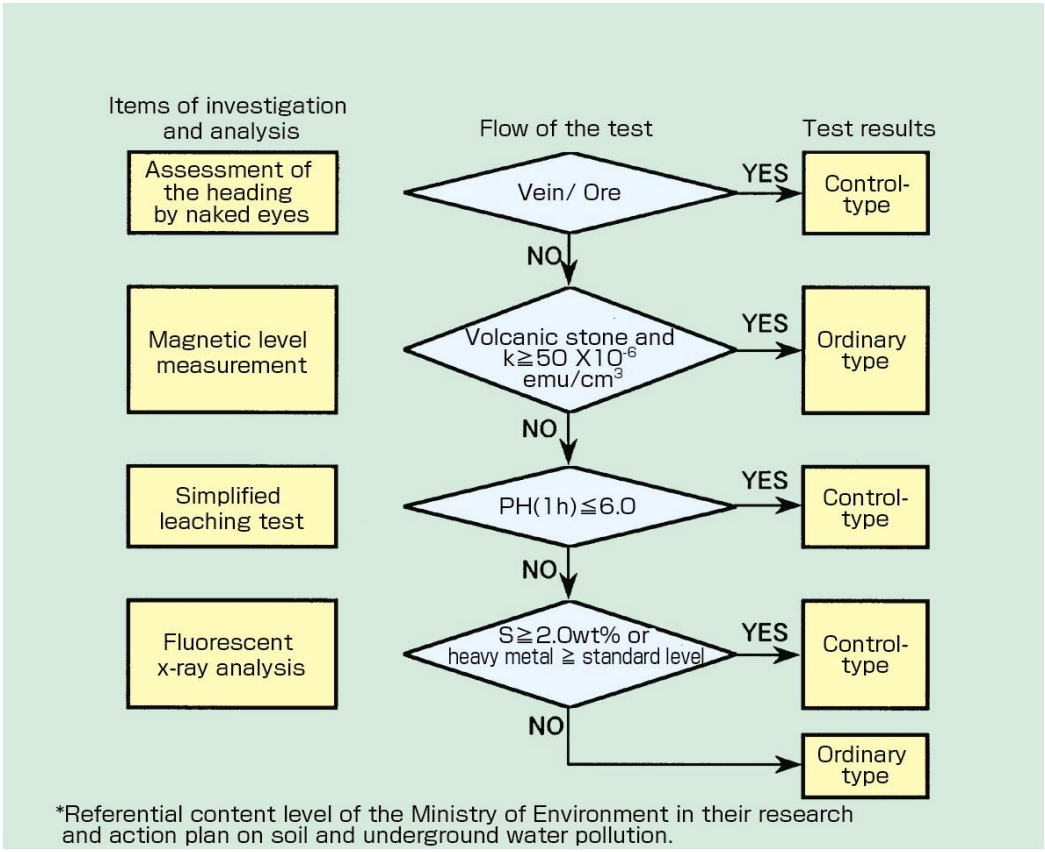

Figure-2: Flow of the control-type muck testing (excluding mudstones)

have added the following criterion:

④ Igneous rocks with magnetic level under $50X10^{-6}$ emu/cm^3 according to the measurement using commercially available apparatus for magnetic level measurement.

Figure 2 demonstrates the flow of the test. Outside of mineralized rocks, occurrence of acidic leachate from mudstones was reported. A separate criterion exists for the mudstones.

These test results can be obtained in 24 hours. Therefore, muck bins, placed at portals are divided into 2 sections so that a day's worth of muck can be stored in them. After the testing of rocks, the muck is transported to the disposal area.

Disposal

In disposing of control-type muck, since a long-term treatment would be necessary once the acidic leachate is generated, it is important to take adequate measures at the excavation stage. That is to apply the treatment method, which would not generate acidic leachate. Various methods could be assumed in order to prevent the generation of acidic leachate from control-type muck, but we have considered the following two methods:

① "Treatment by neutralization" which is to neutralize the acidic leachate with limestone.

② "Control method" in which industrial waste management technologies are applied in order to shut out the muck from underground water, rainwater and oxygen.

For the first method, we considered using crushed limestone or calcium carbonate as neutralizers. However, based on the test results at the tunnel planning stage, we have determined that the first option would require a long period of time before neutralization becomes apparent. The latter option was too expensive and it could not be applied to this project either.

We have decided to apply the second method for this

project as its effectiveness was certain and realistic method in terms of cost exists.

As for the specifications of control-type disposal facility, we have taken into account the examples of existing industrial waste disposal facilities and decided on structures on each section (Figure-3). The base area is made impermeable by placing double liner sheet with long-term durability (made of low-density polyethylene). In order to protect the sheet, crushed stones and mortar are sprayed in between the ground and the sheet and 50 centimeters of gravels are placed on top of the sheet. When the construction is complete, it will be covered by an impervious sheet.

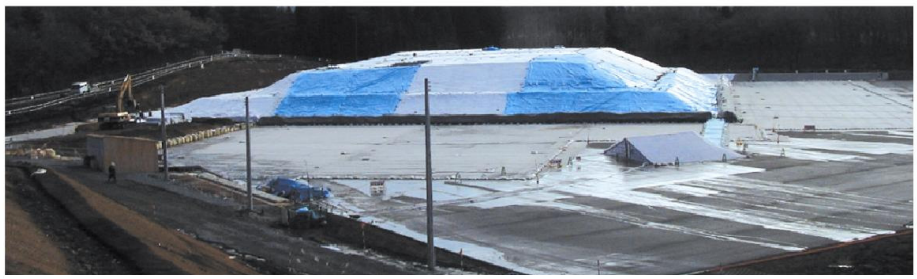

Figure-4: Control-type disposal facility in Nashinoki section

Although damage to the impervious sheets at the base is unlikely during or after the construction, in case when the damage occurs, it would be difficult to excavate and to repair the sheets. Therefore, it would be necessary to create a system that allows the immediate detection and repair of the damages to the impervious sheets.

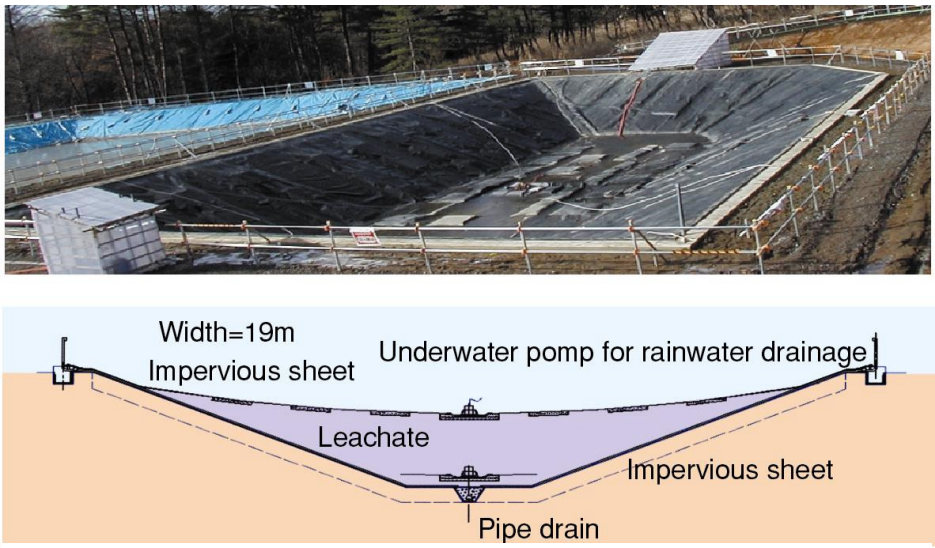

Figure-5: Leachate storage pond in Nashinoki section

Example of Nashinoki Section

The control-type disposal facilities are to be located in each section and their designs are under the process of optimization to fit the conditions of specific sites. Following is the example of the Nashinoki section.

Since the control-type disposal facility in Nashinoki section is located on a gentle slope, it takes the form of a mound in order to reduce the volume of muck (Figure-4). Moreover, since a wide area is available for the leachate storage pond, we have newly developed a bag-shaped storage, which does not require a canopy (Figure-5).

There are two main systems of detecting the breakage of impervious sheets, the physical system and the electrical system. The physical system can be subdivided into:

① Detection by sections of single impervious sheet

② Detection by suction, pressurization and gravity flow of double impervious sheets.

For Nashinoki section, we have applied the latter, suction/double impervious sheet method called "T&OH System" because its past records showed its long-term stability and because it facilitated the reparation of breakages.

Conclusion

We believe that the knowledge on separation

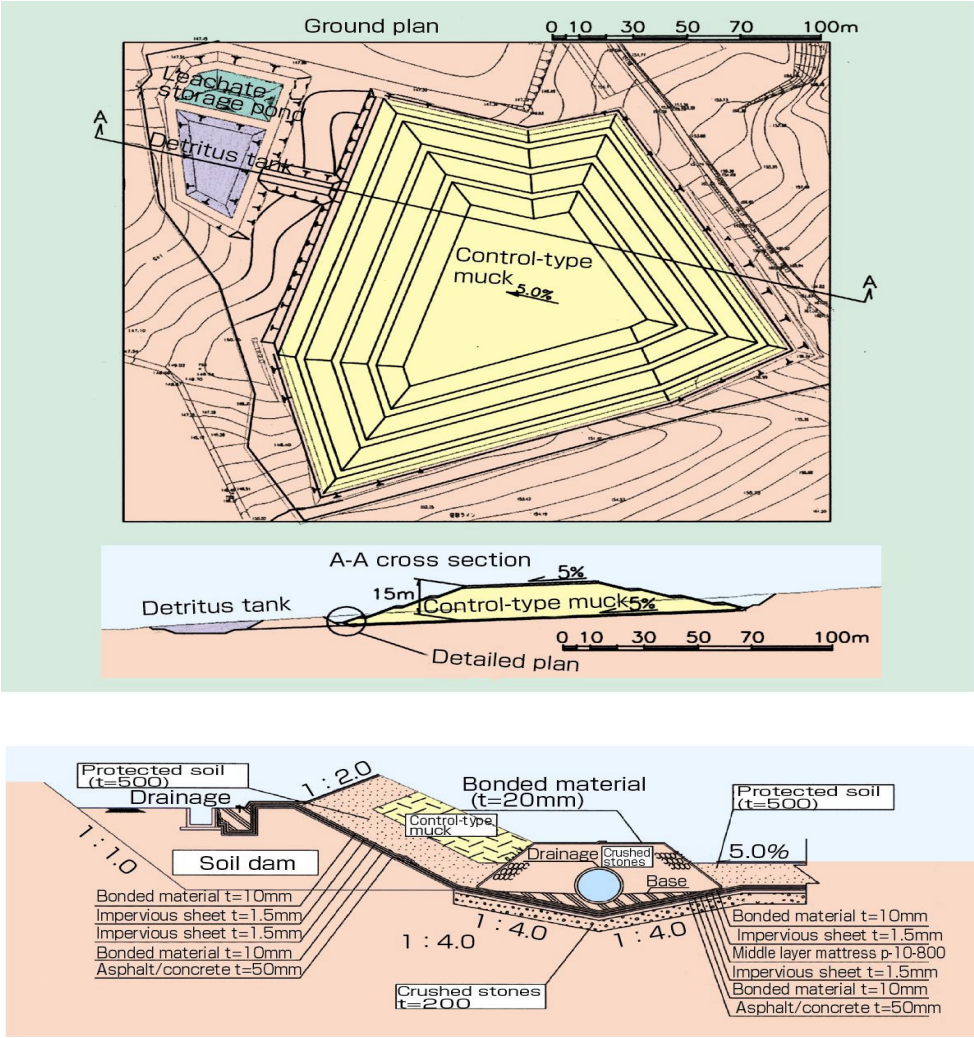

Figure-3: Control-type disposal facility

and disposal of muck producing acid leachate that we have gained through this project could very well be applied to future projects. However, in setting the standard level of the testing criteria, the characteristics of the rocks in each region should be taken into consideration.

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World's Largest Pumped Hydropower Project: Kannagawa Hydroelectric Plant

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Kannagawa Hydroelectric Plant

Kannagawa Hydroelectric Plant is a pumped storage power plant, currently being constructed by Tokyo Electric Power Co., Ltd (TEPCO). It bestrides 2 water systems over 2 prefectures: Tonegawa River of Gunma prefecture and Shinanogawa River of Nagano prefecture. The maximum output will be 2,800MW, one of the largest pumped hydropower projects in the world (Figure 1). The first construction of large-scale pumped storage power plants dates back to the 1970s, high-capacity power plants have been developed one after another, seeking methods to accommodate the peak power demands and pursuing merit of scale. TEPCO, in the old days, constructed hydroelectric plants Yagisawa, Azumi, Midono, Shintakasegawa, Tanbara, Imaichi, Shiobara, and Kazunogawa. Kannagawa power plant is the 9th pumped storage power plant.

Figure 1: Location of Kannagawa power plant
①Nagano Pref. ②Minamiaikigawa River
③Minamiaiki-mura ④Underground power plant
⑤Upper reservoir ⑥Ueno-mura
⑦Gunma Pref. ⑧Lower reservoir
⑨Kannagawa River ⑩Saitama Pref.
⑪Yamanashi Pref.

The deregulation of the electricity market began in 2000 in the wholesale market, and rationalization of electric supply facilities were carried out. Upon construction of power plants, efforts are exerted to further develop the technologies that have been accumulated until this day, as well as to significantly decrease the construction costs by embracing various state-of-the-art technologies.

In addition, large-scale construction projects will always give way to issues of co-existence with the natural environment and the locality. In the case of Kannagawa power plant also, efforts are made toward co-existence with the local community, and to minimize the effect on the natural environment as much as possible. It is especially distinguishing in the fact that the construction site has been opened up to mass media to actively disclose information in order to achieve co-existence with the locality.

The Kannagawa project can be viewed as a project integrating all the technologies employed in large-scale pumped hydropower projects over the last 30 years. This report will introduce the present status of the Kannagawa Plant construction project, focusing on the new technologies that are especially of interest.

Present Status of Construction Project

This project includes construction of the upper dam in the Minami-Aikigawa of the

Shinanogawa river system located in eastern Nagano Prefecture, and the lower dam in the Kannagawa of the Tonegawa river system located in southwestern Gunma Prefecture, and then connecting the two dams with a 6 km-long water tunnel. Power will be generated with effective head of 653m, and maximum water consumption of 510 m^3/s. Construction began in May 1997, and the #1 plant at 470MW is scheduled to start operation in 2005.

The upper dam is a zoned fill dam with impervious core, with banks 136 m high and 444 m long, and with a volume of 7.2 million m^3. The embankment of the dam began in October 1999, and approximately 90% is completed as of today. The lower dam is a concrete gravity dam of 120 m in height, 350 m in length, and a volume of 720,000 m^3. The concrete placing was completed in December 2001, and the curtain grouting is currently under way.

Four generator motors with the largest single output in Japan, as well as two transformers, will be placed in the underground power plant. A large cavern of 216 m long, 33 m wide, 52 m high, and with cross sectional area of 1400 m^2, and 220,000m^3 excavated earth will be constructed approximately 500m deep in the ground. The excavation of the top heading started in October 1998, and excavation of the cavern was completed in October 2000. Electric equipments such as the power generators and pump turbines are currently being installed. The inclined shaft of the penstock is 961 m long and has a vertical head of 714 m, an inclination of 48 degrees and a diameter of 6.6 m. Excavation by full face TBM was completed in April 2001, and is now undergoing installation of steel penstock. Construction of tailrace tunnel is near completion, and the headrace tunnel is currently being lined with concrete. By February 2003, 80% of the entire civil engineering work was finished, and entered the last stage of the construction project, in anticipation of the #1 plant starting its operation in 2005 (Figure 2).

An Approach Toward the State-of-the-Art Technology

This project has taken up many challenges toward new state-of-the-art technology in both the underground structures such as the steel penstock and the underground power plant, and in the dam itself.

Steel penstock - Long inclined shaft excavation and the introduction of high tensile strength steel lining

The full face TBM was used in the excavation of the inclined shaft in the steel penstock. The convention method of excavating the inclined pipeline had two stages. First, the pilot tunnel in the small cross section is excavated from below using the climber method. Second, rationalization is done from above to the predefined cross section, by using the blasting method. TEPCO applied the TBM method for the first time for the pilot tunnel in the excavation of the inclined shaft of the penstock at Shiobara power plant. In the Kazunogawa power plant, it applied the TBM method to both the pilot tunnel and to the reaming excavations for improved safety and rationalization of construction through mechanization of excavation. Based on these experiences, the full-face TBM excavation was adopted in this project to seek further rationalization of the excavation of the inclined shaft. This was the first full-face TBM excavation in Japan of an inclined shaft with bore diameter of 6.6m. Many new technologies were introduced, including a development of a TBM with high torque converter, the invert-liner method that serves as a safety catcher for the TBM machine weighing 600t at a steep incline of 48 degrees, and the drilling and logging system using the rock bolt drifter for drilling as the forward sounding technology. Excavations of inclined shafts by TBM began in November 1999, and was completed in April 2001 and

reached the upper space (Photo 1). The average speed of TBM excavation progress was 71m/month, and excavation was completed on schedule.

Photo 1: TBM reaching the inclined shaft

Also, regarding the steel penstock, use of harder steel has been sought to cope with the increasing size and head in pumped storage power plant. In 1975, HT-80 (high-tension steel with tensile strength of 80 kgf/mm^2 class) was applied to the Ohira power plant of Kyushu Electric Power Co. and more than 20 years have passed since then. As the pumped storage power plant further increase in size and the greater the head becomes, the louder the call to decrease the construction cost through use of high-strength steel products. With such background, the Kannagawa power plant became the first to employ the HT-100 (high-tension steel with tensile strength of 100 kgf/mm^2 class) in Japan. This succeeded to lower the mass of steel and the construction cost by approximately 10%. The newly developed HT-100 steel plate and welding joint have passed various tests that confirmed that they satisfied the target performance level. Specifications for both have also been established. For the HT-100 steel products, Japan Hydraulic Gate and Penstock Association has formulated the "Technological guidelines for the application of high tension steel (HT-100) to hydraulic structures" and it has been adopted as the engineering standard in the "Commentaries on the engineering standards for power-generating hydroelectric facilities" by Ministry of Economy, Trade and Industry in March 2000 after passing the deliberations of the Japan Electro technical Standards & Codes Committee

Observational Design and Construction System in Cavern Excavation of Underground Power Plants

The construction of large-scale underground power plants began from mid 1960s. For TEPCO, the Kannagawa power plant is its 6th since the construction of Shintakasegawa power plant, which began its construction in 1971. The Kannagawa power plant is located at 500m depths underground in the sedimentary rock of Chichibu on the south belt of the Paleozoic-Mesozoic layer. Since the cavern excavation would take place under high rock pressure, an observational design and construction system was applied to rationalize the support design as well as to actively improve the cavern stability. It was assumed that there may be concentrated stress areas where the in-site stress would reach over 25 MPa maximum in the arch shoulders on the side of the tailrace tunnel and around the corners of the cavern on the penstock side because the lateral pressure ratio inside the cross-sectional surface of the cavern is great due to the fact that the maximum principal stress axis are rotated from the longitudinal axis of the cavern.

A construction method was employed in which the spreading of loosened zones is minimized due to early support measures such as allocating many PS anchors in this concentrated stress area, and smoothing the excavation of the wall surface as much as possible (Photo 2). Curvatures are put on the corner areas of the cavern of the power plant, and a smooth finish is applied on the wall surface (Photo 3).

Because of the rational support on the base rock through this selective allocation of PS anchors, and because of the 3-dimentional-configuration effect by the rock bed acting as struts, the development of

Photo 2: Underground power plant undergoing excavation

the loose areas is suppressed. Further, by applying the AE measurement and stress measurement fully in measurement control, the Observational design and construction / construction system has been compiled, which successively measures the dynamic behavior of the cavern during excavation while optimizing the support.

Photo 3: Underground power plant after excavation

New Technologies and Methods for Dam Construction

The zoning for the upper dam gives sufficient consideration to the quality features and to the volume of borrow pit. For core materials that naturally have high moisture content, statistical methods is used to study the optimal condition of multi-layer stockpile and excavation, and they are rationalized by combining them with weathered rock inside the reservoir, which has low moisture content and was planned to be disposed of. As a result of a test for multi-layer stockpile and mixing, it was confirmed that the expected particle size and moisture content was achieved. It led to a significant cost reduction with ensured quality, as well as attaining noticeable results in terms of overall environment conservation through effective utilization of low-quality rocks (Photo 4).

For the construction of the concrete in the lower dam, the RCD method was adopted to save labor and to promote efficiency, as were the case with Sabigawa dam and Kazunogawa dam. For Kazunogawa dam, the unit cementitious material content (C+F: cement and fly ash) was 110kg/m^3, and the lift of each concrete layer was increased from 75cm to 1m to boost the concrete placing per hour. For the Kannagawa power plant, the RCD concrete unit cementitious material content of 100kg/m^3 is being tested for further rationalization, which will

Photo 4: Upper dam construction status (taken from downstream)

become the least amount used in Japan. Regarding the composition for the dam concrete, a test placing was carried out in the construction yard. Based on the confirmation of specifications for composition and construction as well as a study on reduction of unit cementitious material, by setting the number of compaction by the vibration roller from 12 to 16, it was confirmed that both the construction status and core quality had satisfied the requirements and the placing of the dam body concrete was successfully completed (Photo 5)

Photo 5: Lower dam construction status (taken from upstream)

Conservation of the Natural Environment and Co-existence with the Local Community

The construction site, with the underground power plant located directly below the Osutakayama Mountain as its center, spreads across Gunma and Nagano prefectures and is surrounded by abundant nature and attractive scenery. Therefore, the local community has a keen interest in the environment conservation measures that accompany this construction project. Under such circumstances, the project was executed to achieve co-existence with the natural environment, a big challenge. In November 1999, the project became the first large-scale construction project to obtain the EMS International Standard "ISO 14001" in Japan, and with that, it attracted attention to its continuous efforts to reduce the environmental loads throughout the entire construction zone.

For example, in terms of prevention of river water pollution and conservation of water quality, as well as efficient utilization of by-products of the construction project, the quality of the water discharged from the project area will be strictly controlled, and the trees that have been cut down will be chipped into small pieces and used by the local farmers as fertilizers or manure, and the mud cake generated from processing of muddy water will be utilized as the foundation materials for tree-planting. This power plant is aiming for a disclosed power plant construction, communicating information to the local community and welcoming numerous observers.

In November 2001, His Imperial Highness the Crown Prince who attended the opening ceremony of the 16th Cultural Festival of "Gunma 2001" visited this construction site for the underground power plant as part of his tour to acknowledge the conditions of local districts, and took a look at its vast underground powerhouse cavern (Photo 6).

Photo 6: His Imperial Highness the Crown Prince visiting the construction site

Toward Creation of New Wisdom

The Kannagawa Project can be viewed as a compilation of all the technologies developed over the past 30 years, ever since the construction of large-scale pumped hydropower projects first began.

With its completion approaching, we should think not only about technology transfer, but also about the creation and development of new wisdom based on the technologies accumulated to this day. That involves each technology in hardware terms as well as the creation and systemization of "technology management," which includes all kinds of technology in software terms as well. Also, it means advancing into a broader area from electricity/civil engineering to creating new social infrastructure, and also the shift from domestic to overseas.

A long time has passed since people began talking about the globalization of construction industry, and about bolstering international competitiveness to vitalize the Japanese economy. We must consider how to further expand the high technological skills that has been developed and accumulated domestically. We must set forth a specific and comprehensive vision.

For example, in Southeast Asia and other surrounding countries, there is a strong demand toward development of electric power resources by IPP. We must clarify under what kind of vision we should further direct our accumulated technological skills as collective strength of our entire nation; what kind of technology management would be required to make effective use of our prominent technology overseas under widely differing conditions. From such perspective, we need to continue to take on new challenges with great confidence in the future as well.

Lastly, I would like to extend my gratitude to the people in Underground Construction Group at Civil and Construction Technology Center, Construction Department, TEPCO and to the people at the Kannagawa Hydropower construction site for their kind and generous cooperation.

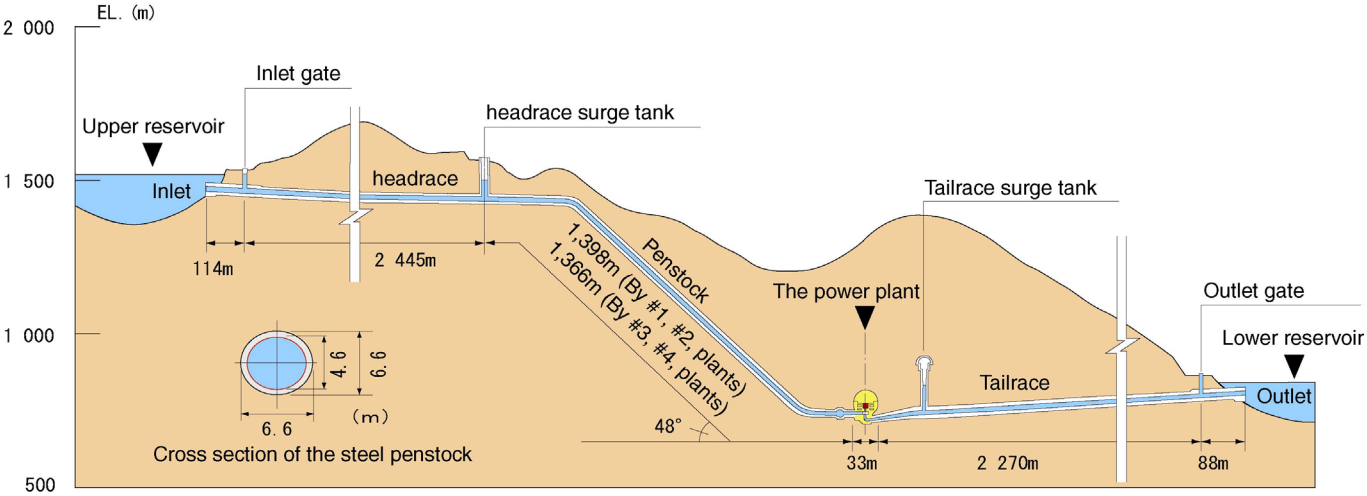

Figure 2: Vertical sectional plan of water tunnels in Kannagawa power plant

Technological Report: Repair Technology for Tilted Structures by Grouting

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Grouting method is generally used for the improvement of fissured grounds or grounds lacking in strength when they are excavated. In recent years, the repair method for the buildings and other structures which had tilted were developed by employing the grouting method. This method is named "Jacking of Grout Method (JOG Method) " and has been used in repairs of over 100 cases from tilted buildings to monuments and culverts after the Kobe Earthquake and the Taiwan Ji-Ji Earthquake. This report introduces the basic principle of this new technology and some examples of its application.

Principle of Jacking and the Work Procedure

When the grouts such as the cement milk are injected into the ground, they infiltrate the permeable ground without disturbing the soil skeleton (the seepage injection). However, in the ground whose permeability is low, they split the structure of the soil particles as it expands, causing the ground to bulge (split injection).

Although ground bulge due to grouting should be controlled to be as small as possible not to affect the ground surface or surrounding structures, tilted buildings and other structures can be repaired by effective use of the ground bulge due to grouting. The method, introduced in this report, can control the ground bulge accurately through appropriate selection of the grouting material and schedule according to the ground properties and the size and structure of the foundation with the base of the knowledge that had been cultivated in the usual grouting construction. Figure-1 indicates the working procedures and defines the overview of this method.

1) Bore through the foundation of the structure. Insert a double tube consisting of an outer pipe with the internal diameter of 27.2~34mm and an inner pipe with the internal diameter of 15mm, so that their tips are placed just at the bottom of the foundation. The double tube is employed when using grouts whose gel time is extremely short, in order to prevent premature solidification. In this case, two types of grouts are injected separately and are mixed and solidified at the outlet of the tube.

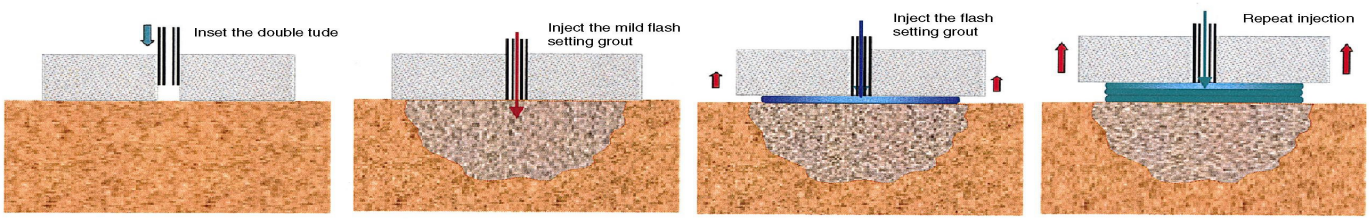

Figure 1: Construction Procedure of JOG Method

2) Inject the mild flash setting grout, whose gel time is scores of seconds, through the double tube. Although the grout will infiltrate in the hemispherical zone in the ground, the zone will be gradually expanded by the repetitive work of the seepage injection in the permeable ground or of the split injection in case of the ground with lower permeability. This zone will play a role of the reactions for jacking after it has been solidified.

3) Inject the flash setting grout whose gel time is within a few seconds. Because the previous grouting has created a solidified zone of low permeability, the newly injected grout cannot infiltrate this zone and then it splits the clearance between the foundation and the ground surface as a wedge effect. Thus, it becomes a thin layer and expands as it raises the foundation.

4) Lift the foundation gradually by repeating the procedure indicated in 3). Because the area to which the grout can be injected through one hole is limited, the multiple injection system has been developed in the JOG method. In this system, the plural holes are bored at the designed points on the foundations of structures and they are linked with the injection pipe on which the branching valves are placed. The grouting is carried out by the interval injection method in which the grout is injected through each hole intermittently in a short time and in turn. The order of the hole to be injected in each cycle and time of the injection at each hole are controlled according to grouting schedule determined from the ground properties and other conditions. The foundations of structures are lifted gradually, keeping their balance by this interval injection method.

It is possible to select the grouting manner by varying the cycle time defined by the time interval of injection for each hole in the interval injection. For example, in building a reaction zone with a mild flash setting grout, when the cycle time is shorter than the gel time, the grouting takes place in a yet-to-be solidified zone. This will minimize the risk of ground bulge but will increase the risk of grout overflowing the previously set zone. On the other hand, when the cycle time is longer than the gel time, the following grout is repeatedly injected into the zone where the grout at the previous step has already been solidifying, and thus the risk of grout overflow will be minimized but that of ground bulge will increase. Based on the understanding of these interrelationships, the grout time for each injection pipe could be adjusted in a unit of 1/ 10 second and the sum of the injection time for all the holes in a cycle could be set as the cycle time.

In grouting works, the behavior of the structure is measured with precision using displacement sensor and tilt sensor. In order to control the grouting in multiple pipes based on these data, the grouting control system was built by combining the automatic switch valves and a central processing computer system.

Characteristics of the Method and its Applicable Condition

In the method, which had been employed so far to repair tilted structures, the ground was excavated around and beneath the foundations of structure to build a reaction zone at the bottom of the foundation and then the foundation was jacked upward by using the reaction from this zone. The clearance created by the jack was finally grouted. This method requires numerous steps, extending the work period and augmenting the cost. On the other hand, the grouting method suffices to place the injection pipes in the foundation and to jack it up by injecting the grout through them. As this method does not require excavating around and beneath the structure, it enables to restore the structure in question with almost no influence on adjoining structures. Moreover, as the method does not place partial pressure in the foundation, the security of the work is ensured. The

method has numerous other merits such as the absence of vibration and noise, and the short work period of approximately 1~2 weeks in general.

This method is suitable in cases of spread foundation with sufficient rigidity and strength. Contrarily, it is not suitable when the structure is supported by a pile foundation, especially by point bearing piles, as grouting at the pile points is not feasible.

This method may not result in successful repair when there are damages of the buckling on important parts of the structure such as its columns or its walls, or when sufficient rigidity and strength of the foundation cannot be guaranteed because additional damage may be induced even by the grout jacking method.

In cases when the supporting ground consists of sand, gravel or other types of soil of low compressibility, there is almost no problem. However, working on insufficiently consolidated clay and other types of ground with high compressibility often require careful consideration because there is a possibility of delayed ground subsidence after the completion of the work, which would diminish the preciseness of the final result of the construction.

Examples of Construction Works

Repair of a Box Culvert

Photo-1 shows the box culvert prior to the repair work. It was presumed that the box culvert was tilted due to subsidence of the supporting ground after the construction was completed. When the repair work was considered, the embankment had already been loaded over the boxes and the subsidence had settled. At that stage, the subsidence of 116mm was measured at the maximum. Each of the five reinforced concrete boxes, which were linked to comprise the culvert, was tilted. The soil, which supports the mat foundation of the culvert, was made of alternating strata of silty clay and sandy silt.

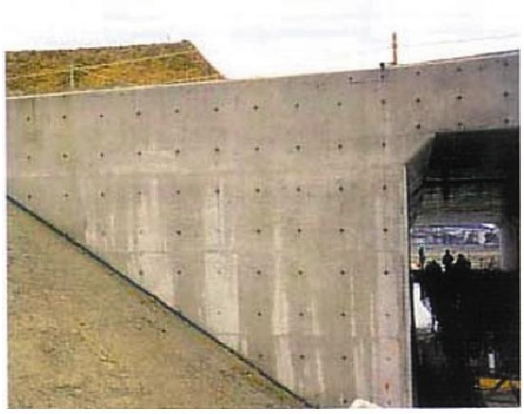

Photo 1: Box culvert prior to the repair

Photo 2: Box culvert after the repair

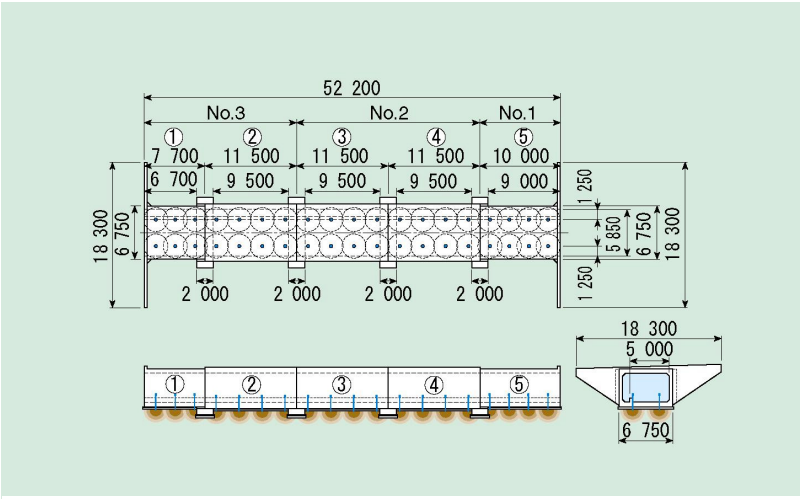

Figure 2: Plan for the repair of the position of the box culvert

As Figure-2 shows, the box culvert was repaired by grouting at 45 spots of the culvert foundation and by jacking one box at a time. All five culverts were finally restored to their designed position.

Restoration of a Tilted Apartment Building

Many buildings were damaged during the Kobe Earthquake, which occurred in 1995. Photo-3 shows one such example. This apartment building in the coastal area was tilted to a great degree due to the ground liquefaction and the violent shaking. This structure was concrete reinforced and was supported on a sandy ground by a mat foundation with continuous footings. The total weight of the structure was approximately 1100t, its surface area was approximately 113.40m^2, and a maximum subsidence measured was 410mm. The grouting method, which could minimize the vibration and the noise and could be undertaken safely, was applied in the repair works of this structure because an investigation after the disaster revealed that the rigidity and the strength of the structure itself was maintained, and from consideration to the fact that the floors above the second are still inhabited.

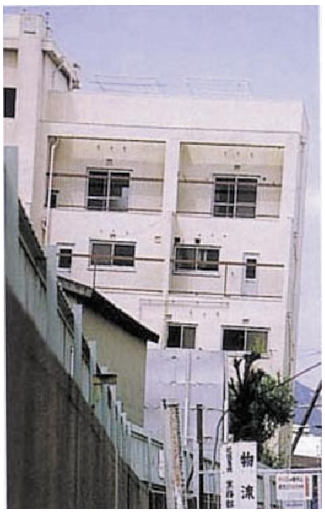

Photo 3: Tilted apartment building

Photo 4: Restored apartment building

In repair works, 19 holes were drilled from the first floor through the foundation, and the injection pipes were subsequently placed in these holes. The grouting was controlled by precise measurement using laser level at the four corners of the building and its center. The building has finally been restored to its original state in 19 days as shown in Photo-4.

Restoration of a Tilted Clock Tower

Photo-5 shows the clock tower at Citizen's Square in Port Island, Kobe. Port Island is an artificial island built from land reclamation. During the Kobe Earthquake, liquefaction occurred at various sites on this island. This clock tower was also tilted due to liquefaction. Luckily, no fissure was observed on the exterior wall of the tower and there was no damage to the structure. However, due to the tilt, the tower swayed in the south-north direction as the bell rang. The tower was concrete reinforced and was 20m in height and 250t in weight. It was supported on a sandy ground by a single footing of 42.25m^2. During the earthquake, the maximum subsidence of 112mm was observed and the tower was tilted by 2 degrees, displacing the top part of the tower by 650mm at maximum.

Photo 5: Clock tower tilted due to an earthquake

Photo 6: Restored clock tower

As Figure-3 demonstrates, the injection pipes were placed at the four corners of the footing. By grouting control based on measurement, the tower was restored to its original position in six days as shown in Photo-6.

Future Developments

So far, the JOG method has been applied mainly to repair the structures that are tilted due to earthquakes and other incidents. However, by placing the injection pipe at the time of construction of the structure that are prone to subsidence or tilting, it

becomes possible to readjust the position or the level of the structure anytime such needs arise. Moreover, this method possesses various other possible usages.

The JOG Method was developed in eastern Osaka area where “the development of a satellite through the collaboration of some small and medium-sized enterprises “drew public attention last year. The authors wish to introduce this method to our readers, in hopes that this may encourage the revitalization of technological development in the private sector.

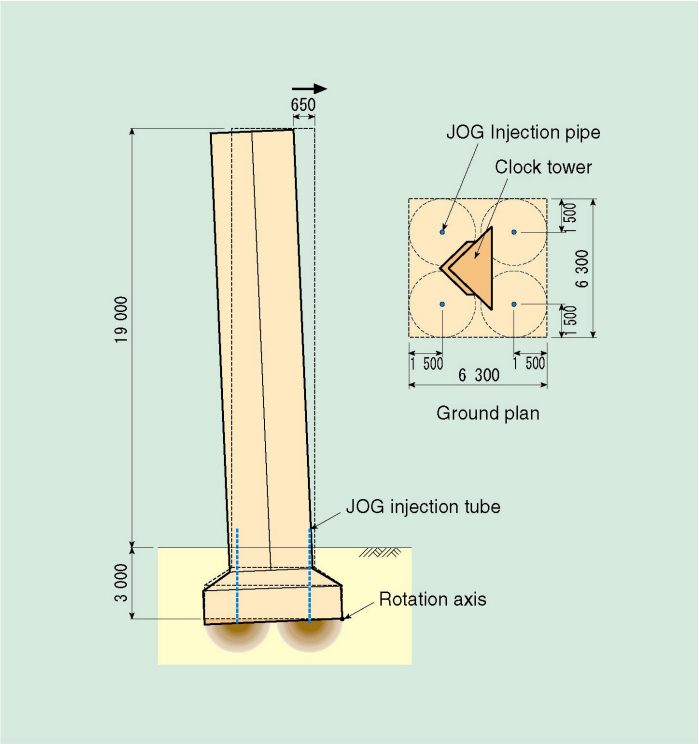

Figure 3: Tilt of the clock tower and the overview of the repair work

The San Roque Hydropower Plant: The First Overseas Hydropower IPP Project by Japanese Power Company

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Office of Civil Engineering and Architecture
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Operation starts at San Roque Hydropower Plant

The San Roque Hydropower Plant (Photo-1) in the Philippines is the first overseas hydropower plant project in which a Japanese utility company participated. The project, in which Kansai Electric Power Company (KEPCO) was involved, commenced its operation after having successfully passed the commissioning tests for all units by the National Power Corporation in the Philippines (NPC) on May 1, 2003. The Plant is now running successfully at its dependable capacity of 85 MW during daytime peak demand period.

Photo 1: Panoramic view of the San Roque Hydropower Plant

Project Background

The San Roque Hydropower Plant is a part of the San Roque Multipurpose Project planned by the government of the Philippines. The plant is located in Pangasinan Province, in the northern part of Luzon Island in the Philippines.

The San Roque Multi-Purpose Project was

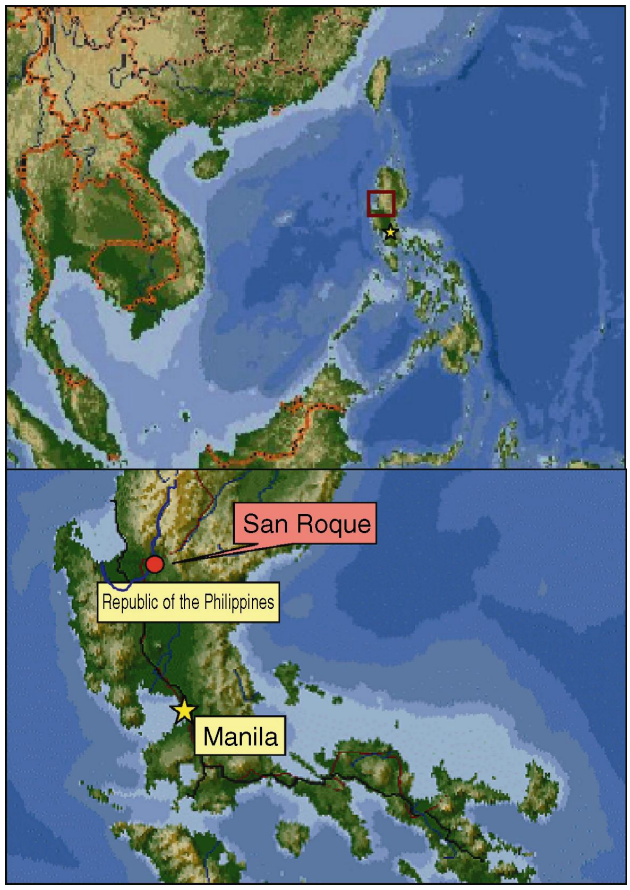

Figure 1: Project location

to construct a 200 meter-high, 1.2 kilometer-long embankment dam on the Agno River with a reservoir whose surface area measures approx. 12.8 square kilometers extending from the Pangasinan Province into the Benguet Province. The purposes of the project include irrigation, flood control, water quality improvement and power generation. It is considered as the largest presidential flagship project in the Philippines, originally conceived under the Marcos administration at the end of the 1970s and its preliminary investigation was undertaken in mid-80s using the ODA fund. However, it soon halted due to political and economical changes during the last days of the Marcos administration. The succeeding Aquino administration promoted the policies to approve the participation by the private sector in the infrastructure

development projects in order to solve the problem of electricity shortage and the lack of funding. Since the electricity shortage fell into a serious crisis at the beginning of the 1990s, the Ramos administration, which succeeded the Aquino administration, enacted a law to promote a drastic deregulation policy in order to encourage more participation by the private sector. Under such circumstances, the importance of the San Roque Multi-Purpose Project was acknowledged anew. It was decided that the project would be resumed with a new concept of introducing private capital in the power sector.

The international bidding for this project was announced in July 1996. In response, all but one elected not to submit the proposal; it is the development team of Sithe Energies, Marubeni and Italian-Thai. The San Roque Power Corporation (SPRC) was launched as the project company. After that, Italian-Thai Corporation withdrew from the project because of the Asian currency crisis in 1997. KPIC Singapore Pte. Ltd., a 100% sub-subsidiary of the KEPCO replaced its position as an investor in October 1998.

A power purchase agreement (PPA) was concluded with NPC in October 1997and became effective in February 1998. In March 1998, an engineering procurement and construction (EPC) contract was concluded with an American contractor, which started the construction work. Thus, this epic multi-purpose project with the total project costs amounting to about 1 billion US Dollars was launched.

KEPCO dispatched several engineers to the project site to take care of various kinds of assignments such as the construction management, administration, negotiation with the stakeholders and supervising commissioning tests.

Photo 2: Civil engineers from KEPCO at the dam site

Project Overview

This project is a so-called BOT (Build-Operate-Transfer) Project, in which the project company, SRPC builds a 200 meter-high rockfill dam and a 345 MW hydropower plant (115MW X 3 units), operates and maintains it for 25 years before the transfer to NPC. However, the difference between this project and a regular BOT project is that the non-power components such as the dam, the spillways, the grouting and drainage galleries and the lower level outlet was transferred to NPC at the time of the completion of construction. After the transfer of the non-power components, NPC takes the responsibility for maintenance, operation and safety as well as for the operation of the reservoir. Under the direction of NPC, SRPC carries out the daily inspection and maintenance including the operation of the spillway gates. Details of the project are shown in Table-l.

The San Roque Hydropower Plant is expected to meet the peak energy demand. The plant supplies the peak energy for eight hours, everyday throughout the year at its dependable capacity of 85 MW. Whenever surplus water is available, the plant can either generate extra electricity (beyond 85 MW) or generate off peak power, or realize the combination of the two operations. Based on the historical inflow data of the Agno River, the average annual energy

Table-l: Details of the project

Location	Pangasinan & Benguet Provinces Luzon Island, the Philippines
River	The Agno River
Reservoir basin	1,250 km^2
Average water inflow	About 84 m^3
Rated output	345 MW (115 MW X 3 units)
Maximum water consumption	260 m^3 /sec
Effective head	180 m
Annual power generation	About 1 billion kWh
Type of dam	Embankment Dam (Rockfill, Central core)
Height	200 m
Embankment length	1,130 m
Embankment volume	About 40 million m^3
Impoundment capacity	990 million m^3 (Effective impoundment capacity 530 million m^3 Surcharge capacity 140 million m^3)
Designed flood discharge	12,800 m^3 /sec
Spillway gates	Radial gates (6 sets)
Power Tunnel	Length 1,200 m, internal diameter 8.5 m (Concrete and steel lining: Photo-3)
Low level outlet	Length 1,300 m, internal diameter 5.5 m

generation is approximately 1,000 (GWh), which can contribute to the needs for domestic electricity in the Philippines and to the reduction of fuel consumption for thermal power plants.

Project Promotion

The San Roque multipurpose project has the four purposes; irrigation, power generation, flood control and water quality improvement. The construction of non-power components including the dam was to be implemented using government fund. As for power generation, it was to be implemented through BOT scheme using private funds. Thus, by making the dam multi-purpose and by the government and the private sector sharing the responsibility, the former can develop large-scale public infrastructure at a lower cost, while the latter can reduce the construction cost. In this project, NPC pays their contribution to SRPC for the non-power components and SRPC takes the responsibility for construction of all structures including non-power components. Also, the non-power components were to be transferred to NPC at the time of the completion and operated by NPC.

In order for the private sector to promote such large-scale project, risk sharing for the private sector was undertaken by means of the PPA, which made the hydrological risk reduction possible with the guarantee of the Government of the Philippines.

On the other hand, SRPC concluded an EPC contract with the United Engineers International, Inc. (UEI) for design and material procurement, and with Raytheon Ebasco Overseas Ltd. (REOL) for the execution of construction work. This contract is on a full turn and lump sum basis, that is, with the fixed construction cost and schedule, the EPC contractor undertakes the whole construction from design, procurement to construction work. Single company undertakes the responsibility for the whole construction, by which optimization of construction methodology and the reduction of the construction cost can be made. For example, there are merits as follows; the dam zoning and embankment process can be optimized to meet the actual conditions of the site. Workers and machines can be mobilized according to

the progress of the construction. Schedule adjustment for each structure can easily be made. Also by making it a lump-sum contract, SRPC was trying to avoid or reduce the risk pertaining to the construction.

Photo 3: A power generation channel (concrete-line area)

Construction Work Process

This project made its progress smoothly and on schedule since the construction began on March 1998. It was completed for the most part, except for small-scale miscellaneous works, on February 14, 2003, and on May 1, it passed the commissioning tests for all units by NPC. The actual process of the construction work is shown in Table-2.

Table-2: Actual process of the construction work

1998.3	Construction start
1999.4	Power Plant excavation start
1999.5	Power tunnel excavation start
1999.7	Diversion tunnels completion
1999.11	Dam embankment start
2000.10	Steel liner penstock installment start
2001.11	Turbine / Generator installment start
2002.5	Dam embankment completion
2002.8	Reservoir impoundment start
2003.2	Construction completion
2003.5	All units passed commissioning tests

As for the dam embankment result, the monthly record of the largest embankment volume at about 500,000 m^2/month for the core and about 2,000,000 m^2/month for the rock shell were made making full use of two belt conveyors and heavy equipment at peak periods (Photo-4). The number of engineers and workers who were involved in the construction amounted to about 4,500 during peak construction period. Among them, there were about 100 workers from overseas, mainly from the U.S. The remaining 98% were hired locally. Since large-scale hydropower plants such as the Angat, the Ambuklao and the Binga hydropower plants have been already constructed in the Philippines, many of the local workers already possessed a considerable experience with the construction work.

Regarding the quality management in this project, in order to carry out a design and construction based on the international standard, a third-party organization carried out a rigorous inspection. Especially, on non-power components such as the dam, which was to be transferred to NPC at the time of completion, an independent engineer appointed by NPC vetted the safety of the equipment. As for SRPC, it entrusted an EPC contractor to carry out a quality guarantee program based on the EPC contract. For example, in REOL, they divided the organization of the construction site into three sections; engineering, construction and quality control, which assess the other two sections' work independently at every stage of the construction. In addition, SRPC and EPC contractor had established the consulting committee, which is composed of three experienced engineers who vest the construction progress and the quality of the management by visiting the site every three months, and also made a continuous assessment of the UEI's design for the purpose of securing its quality. Moreover, in addition to these quality guarantee programs by the contractors, as an owner's engineer, Harza Engineering Company International, LLC (became Montgomery Watson Harza Global Inc., by merger in 2001) made assessments of all the processes from design to construction works.

Photo 4: Dam embankment work (From the left bank of the dam)

Operation and Maintenance (O&M)

The San Roque Hydropower Plant is being operated successfully by about 40 O&M trained staffs under the instruction of NPC (Photo-5). In order to provide high quality O&M, SRPC concluded an O&M assistance contract with Sithe Hong Kong Power Service Co. (SHKPS). This Sithe subsidiary provide the staff training, O&M manual instruction and draw up O&M annual planning and annual budgets for SRPC. KEPCO in cooperation with SHKPS send staffs to SRPC in order to provide O&M staff, the direct training of O&M technology on hydropower plants accumulated in Japan.

Development of Overseas Hydropower Projects

The San Roque Multi-Purpose Project was advanced with high expectations as the presidential flagship project of the Philippines on a BOT basis partly using private capital under the cooperation between the Philippine government and NPC. On May 1, 2003, it successfully passed the commissioning tests for all units by NPC, and started the 25-year-operation. It is highly expected that the project benefits such as irrigation, flood control, water quality improvement and power generation, will contribute considerably to the economic growth of the Philippines.

This project was very successful in starting the operation by reducing the cost burden by each stakeholders of the project by sharing the risk appropriately according to the PPA and EPC contracts, by carrying out careful preservation of the natural environment and the social environment based on the Environmental Compliance Certificate issued by the Philippine Government. We highly expect that this kind of overseas hydropower generation project will be further promoted in co-existence with nature and society all over the world.

Photo 5: Semi subterranean power plant (From the rear: No.2 machine and No.3 machine)

Glossary of terms:

1. IPP (Independent Power Producer): An IPP project is a project where an independent power producer (IPP) who is the owner of a power generation facility sells the power to other electricity producers, distributors and directly to consumers in order collect their project cost through the income. Some developing countries are encouraging IPPs to participate in the electricity market in order to make the full use of private vitality in electrical projects that require colossal amount of fund.
2. PPA (Power Purchase Agreement): A power

purchase agreement concluded between a power supplier and a power purchaser (off taker) in which purchase unit cost of electricity and the rules of supplying electricity are stipulated.

3. EPC (Engineering, Procurement & Construction) Contract: A form of a construction contract agreement, in which a contractor takes the responsibility for all the process from the design, procurement to construction. It is also known as the "turn key project," to signify that when the plant is transferred from the contractor to the orderer, a mere turn of the key suffices to start the operation. In order to avoid the currency risk of the construction cost, a fixed amount (lump-sum) is usually adopted.
4. BOT (Build-Operate-Transfer): A form of private sector activation in which the private contractor undertakes the construction and management of a project and transfers the ownership to a public sector, such as the government, after a certain period of the facility operation.

Design and Construction of Offshore Discharge Shaft for Lungmen Nuclear Power Plant No.4 in Taiwan

- The World's First Underwater Construction of the discharge shaft with use of steel pipe sheet piles -

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Civil Engineering Design Division
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At the easternmost tip of the island of Taiwan, where it is closest to Japan, the cape of San Diao Jiao is located at 30 km east of Taipei. This was where the Spaniards who occupied the northern part of Taiwan during the first half of the 17th century first landed. Struck by its scenic beauty, they named this place after Santiago, the holy site of Christianity. On the northern side of the cape, Yen Liao Beach stretches its white sandy beach for 3 km. In summertime, the road along this coast becomes congested with vacationers from Taipei area.

Figure-1: The Location of Lungmen Nuclear Power Plant

Today, the Lungmen Nuclear Power Plant No.4 Project, one of the big projects in Taiwan is under way near this Yen Liao Beach. The Lungmen Nuclear Power Plant No.4 Project was put forth in order to cope with the future electricity deficit in Taiwan. The Taiwan Power Company (TPC) is building two units of advanced boiling water reactor (ABWR) with the energy output of 1350MW each in Gong Liao Xiang in Taipei County in the northeastern part of Taiwan.

In this project, we proposed the new type of an underwater shaft with use of steel pipe sheet piles (underwater SPSP shaft) as the alternative plan of the discharge shaft for the warm wastewater from the power plant. In this report the process of the design and construction of the proposed underwater SPSP shaft is presented.

Offshore Discharge Shaft Construction Bidding and the Design Change

Construction Overview and the Original Plan for the Discharge Shaft

Kajima Corporation has been involved in the construction of two lines of the tunnel and the outlet to discharge the cooling water from the nuclear

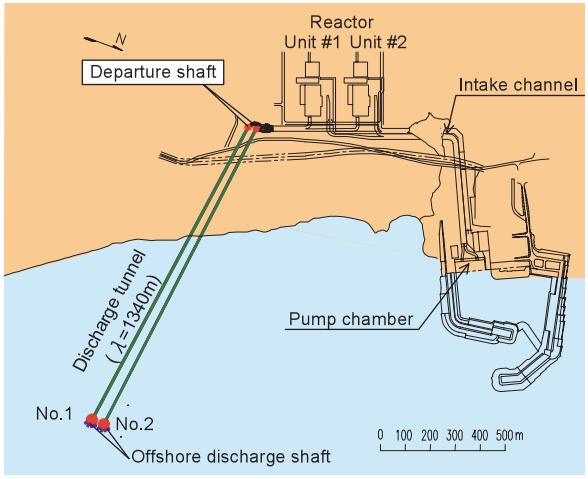

Figure-2: The Lungmen Nuclear Power Plant Plan No.4

Table-1: Project Overview

Project Name	Lungmen Nuclear Power Plant No.4 Circulation Cooling-water Discharge Tunnel Project
Owner	Taiwan Power Company
Consultant	Sinotech Engineering Consultants, Ltd.
Contractors	RSEA Engineering Corp., Kajima Corp, Daiho Corp.
Location	Gong Liao Xiang, Taipei County, Taiwan R.O.C
Construction Period	April 2001 ~ January 2005
Work Content	Land departure shaft ϕ 20m X H53m@ 2 units Land junction culvert □—4.25m X 4.2m X 90m Discharge tunnel ϕ 8.3m X L1333.3m ϕ 8.3m X L1336.7m (Excavated outer diameter 8.3m, inside diameter at completion 6.7m) Offshore discharge shaft ϕ 20m X H26.3m@ 2units Multi-nozzle Discharge Head 463 t @ 2 units Protection block 30 t @ 1500 pieces

power plant to a location at approximately 700m offshore. The system consists of three structures: the onshore departure shaft for a shield machine, the discharge tunnel by the shield tunneling method and the offshore shaft which also serves as an arrival shaft of the shield machine. (Figure 2, Table-1)

The offshore shaft was to be installed in an open sea facing the Pacific Ocean at the depth of 11m. The area is a breaker zone with the wave height of 10.5m and the wave period of 16 seconds. The construction was possible during the six months period from April to September and the period of continuous tranquility was only three months from April to June. The original plan was 1) to construct an concrete caisson in this harsh sea area, 2) to sink the caisson down to 48 m depth undersea by the pneumatic caisson method, 3) to install a S-shape outlet pipe in the caisson, and 4) to install two straight outlet pipes of approx. 55m each, supported by the pile foundation. (Figure 3)

TPC project invited international competitive bidding for this project and the contractor was selected based on the cost and the technical capacity. Yet, since all the bidders were companies with past accomplishments, it is not an exaggeration to say that the price was the key determinant. After close examinations of construction methods in order to win the fierce international bidding, we came to a conclusion that it was extremely difficult and practically impossible to build a shaft by sinking a pneumatic caisson in the breaker zone facing the open sea and hit directly by typhoons and monsoons. However, since it was mandatory to submit the bid based on the original plan and the submission of an alternative plan was not allowed, we devised and submitted our second best plan to the bid, which was to construct a steel working platform around the caisson which could be rapidly built and to secure the safety of the caisson in the time of rough weathers like typhoons and monsoons. The winner of the bid in April 2001 was the joint venture of three companies, RSEA Engineering Corporation from Taiwan and Kajima Corporation and Daiho Corporation from Japan.

Examination of the Underwater SPSP Shaft

Before tendering the bid, we examined fully any possible alternatives while studying the original

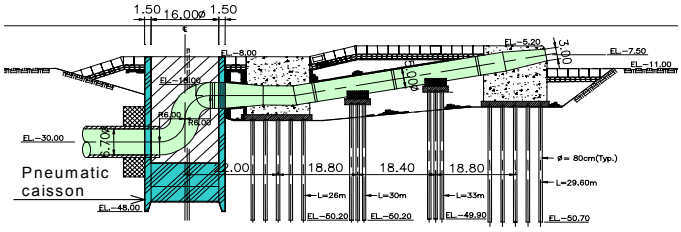

Figure 3: The original plan of the offshore shaft based on the pneumatic caisson method

plan. In Taiwan, where there had been no previous cases of approval of a large-scale design change after the construction start, the chances that the alternative plan would be adopted was uncertain. However, since the period of continuous tranquility was limited to the three months from April to June at the sea area where the shafts were to be built, the difficulty of executing the original plan (pneumatic caisson method), which would take place mostly on site, was becoming clear. Therefore, we regarded the success of an alternative plan to be the most important point in deciding whether we participate in the bidding or not. After thoroughly clarifying the problems in the construction, step-by-step we solidified the possible components of the alternative construction plan. Consequently, we delineated an alternative for the underwater SPSP shaft with the following basic principles.

(1) Adopt the undersea construction method in order to escape the effects of huge wave forces caused by typhoons or monsoons.

(2) Place steel pipe sheet piles into the ocean bed so that they would form a circular earth-retaining wall, in order to excavate 26m below the ocean bed. Earth-retaining support should be a circular beam waling that is made on shore and secure the construction safety in the succeeding construction process.

(3) In order to minimize the construction in the sea site, the shaft structure should be underwater steel reinforced concrete structure. Steel frames and J-shaped pipes are made into a module and are transported to the sea site by ship and installed at once.

(4) Taking the quality of the structure and the impact on the ocean environment into account, anti-washout concrete (HYDROCRETE) will be cast continuously.

With the judgment that this alternative was advantageous for the client, TPC and for the consultant who was to manage the construction as well as for the contractors, and that there would be no bottlenecks to obtaining the approval except for the prerequisite at the time of tendering, we decided to submit our bid.

Submission and Approval of the Alternative Plan

In the contract for this project, field change requests (FCR) were allowed on the condition that the cost does not exceed the original plan. However, design changes that would be approved as FCR were not large-scale ones such as the change of the shaft structure we were proposing and therefore the possibility of such approval was uncertain. Although the consultant who designed the original plan admitted the difficulty in executing the original plan, we were requested to demonstrate the same or higher level of strength, stability and long-term durability of the underwater SPSP shaft compared to the original pneumatic caisson plan. In response to these requests, we made further examinations and demonstrated clearly the risk of the original plan and the advantages of the alternative plan. In this way, we were able to obtain an approval of unprecedented underwater SPSP shaft as an FCR from the TPC and the consultant.

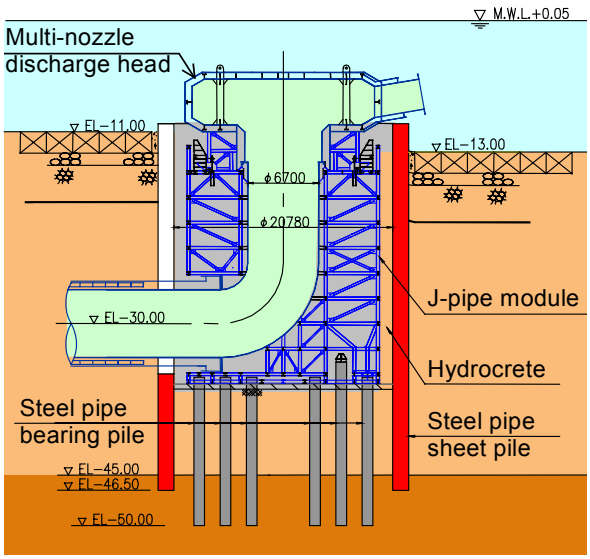

Figure-4: Underwater steel pipe sheet pile shaft

Structure of the Underwater SPSP Shaft

In the plan for the construction of the underwater SPSP shaft, steel pipe sheet piles (ϕ 1,500) were placed in a circle on the ocean-bed at 11 m depth. Then, the interior soil was excavated to the depth of 37 meters from the sea level. After driving steel pipe bearing piles on the excavated bed, a J-shaped discharge pipe that was made into a large module (J-pipe module) was installed by a large floating crane. Then, the HYDROCRETE was placed inside the shaft and the discharge shaft was built. Subsequently, a multi-nozzle discharge head was installed on the J-pipe and the surrounding reinforcement concrete was placed. The steel pipe sheet piles where the shield machine would arrive were removed and finally, the protective blocks for scour prevention were paved around the shaft.

Since this method does not need large-scale temporary structures above the sea and the most of the construction work is performed under the water using working ships, there is little danger of collapse by huge waves caused by typhoons or monsoons and there is little effect on the environment. On the other hand, as the construction work had to be completed only by working ships, the work at the offshore site facing the open sea was a battle with severe marine conditions.

Construction of Underwater SPSP Shaft

Placing the Steel Pipe Sheet Piles on the Ocean Bed

On April 2002, the driving work of the steel pipe sheet piles began as the first step in the offshore shaft construction work. Since there was no factory in Taiwan that had an experience in manufacturing steel pipe sheet piles, we ordered a Taiwanese factory to make a full-scale model of steel pipe sheet piles and placed an order after confirming that they were able to secure sufficient manufacturing accuracy and quality. In placing the steel pipe sheet piles, the introductory frame was installed at the broadside of the self-elevating platform (SEP) and the piles were driven using a hydraulic vibro hammer. In order to secure the accuracy in steel pipe sheet piles placement, the control for the accuracy of the location of the SEP and the introductory frame was important and we were able to succeed in closing the circular SPSP shaft without problems. (Photo-1)

Excavating Inside the SPSP Shaft

After installing the circular steel waling at the top of the already placed steel pipe sheet piles, the inside of the shaft was excavated down to 37m underwater. In order to prevent the contamination of the surrounding sea area, a silt protector was employed.

Driving Bearing Piles Using Long Follower

Thirty steel bearing piles (ϕ 1,000) was driven at the bottom of the excavated shaft. Since the piles had to be placed at a considerable depth, 43m-long follower was employed. And the flying pile driving method took place using the introductory

Photo-1: Steel pipe sheet pile driving work by a vibro hammer

Photo-2: Driving work of bearing piles with use of 43m follower

frame placed at the broadside of the SEP as a guide. PDA (Pile Driving Analysis) was performed using test piles for confirming the bearing capability. Although the process using long follower was very challenging, sufficient accuracy in driving was successfully secured. (Photo-2)

Underwater Installment of the J-pipe Module

The J-pipe module is a large steel frame module of 534t/unit consisting of a J-shaped water discharge pipe and steel frame structure, which upholds it. This J-pipe module was manufactured in Taiwan and transported to the site by a floating crane with 1,600t hanging power. Because of the domestic transportation within Taiwan by the ship of Japanese nationality, an approval for shipping from the Transportation Department was required. After long negotiations, the approval was finally granted and thus, we were able to transport it by sea on May 5th, 2003, and installed it in the shaft. (Photo-3)

Casting HYDROCRETE

Since there was no previous experience of anti-washout concrete placement in Taiwan, the underwater casting tests were carried out at the site. Having demonstrated that sufficient quality could be obtained, the approval for usage of the HYDROCRETE was granted. For the concrete placement, the HYDROCRETE, which was mixed in a plant on land, was shipped with agitating truck on barges to the site. The amount of concrete needed was about 17,000 m^3 for the two shafts. The placement of 1,000 m^3/day was achieved as well as the completion of placement work in approximately two weeks.

Photo-3: J-pipe installation work by a 1,600t hanging power floating crane

Installment of the Multi-Nozzle Discharge Head

The multi-nozzle discharge head was a steel cylinder-shape structure of 17.3m diameter equipped with 4 units of ϕ 3.0m outlet nozzle, with the total steel weight of about 460t/unit. It was the largest multi-nozzle discharge head in the world. The discharge head was manufactured in Taiwan, transported by a floating crane and installed on June 2003. (Photo-4) After the installment of the discharge head, the surrounding reinforcement concrete was placed up to the top of the shaft.

Thus the construction work of the underwater SPSP shaft, which had been started in April 2002, was completed in July 2003. At present, the shield tunnel construction work is now under way to reach the shaft.

Photo-4: Installation of the multi-nozzle discharge

Overseas Report

Seawater Purification System Utilizing the Tidal Range Fluctuation: A Unique Engineering Challenge at the Jakarta Fishing Port

Sadao ORISHIMO

Pacific Consultants International

The Outline of the Jakarta Fishing Port

Indonesia is the world's third largest maritime nation after the USA and Australia, possessing 5.41 million km^2, i.e. 200 nautical miles of Exclusive Economic Zone (EEZ). In 2000, it became the world's 6^{th} nation in fisheries sector, producing approximately 4.93 million tons of fish. Of the total fish production, 4.14 million tons or approximately 84% depends on the marine fisheries. However, due to the insufficiency of the fisheries infrastructure development and modernization of the fishing boats, a sustainable marine fish resources management system has not yet been established. Under such circumstances, in 1999, President Abdurrahman Wahid reorganized the Directorate General of Fisheries that had been under the Ministry of Agriculture into the Ministry of Marine Affairs and Fisheries in order to place emphasis on the sustainable development of the marine fishery resources.

In 1973 the Government of the Republic of Indonesia requested the Japanese Government to conduct a feasibility study for the development of a fishing port/market in Jakarta to upgrade its fishing industry. The Overseas Technical Cooperation Agency (OTCA: presently Japan International Cooperation Agency (JICA)) responded and conducted a feasibility study for the construction of a new Jakarta Fishing Port/Market. That is when the history of the Jakarta Fishing Port (JFP) (Photo-1) began. JFP was completed in 1984 with yen-loans from Japanese

Photo 1: Jakarta Fishing Port

Overseas Economic Cooperation Fund (OECF: the predecessor of the present Japan Bank for International Cooperation) and started its service as the largest fishing port in Indonesia. The author has been involved in this project since 1978 and is still working as the chief consultant. In Phase I: Port Facilities Construction works, locally traditional bamboo piles and bamboo mats were used to build the foundation of 4,000 m long coastal revetment and breakwater in order to cope with the soft seabed condition (JSCE Journal; March 1986.)

The original plan for JFP was to integrate small-scale fish landing places around Jakarta and to make JFP the fishery center in the Java Sea. However, trawl fishing in the Java Sea was completely banned in the beginning of 1980, and the fishing ground was expanded as far off as the Madura Island, the Natuna

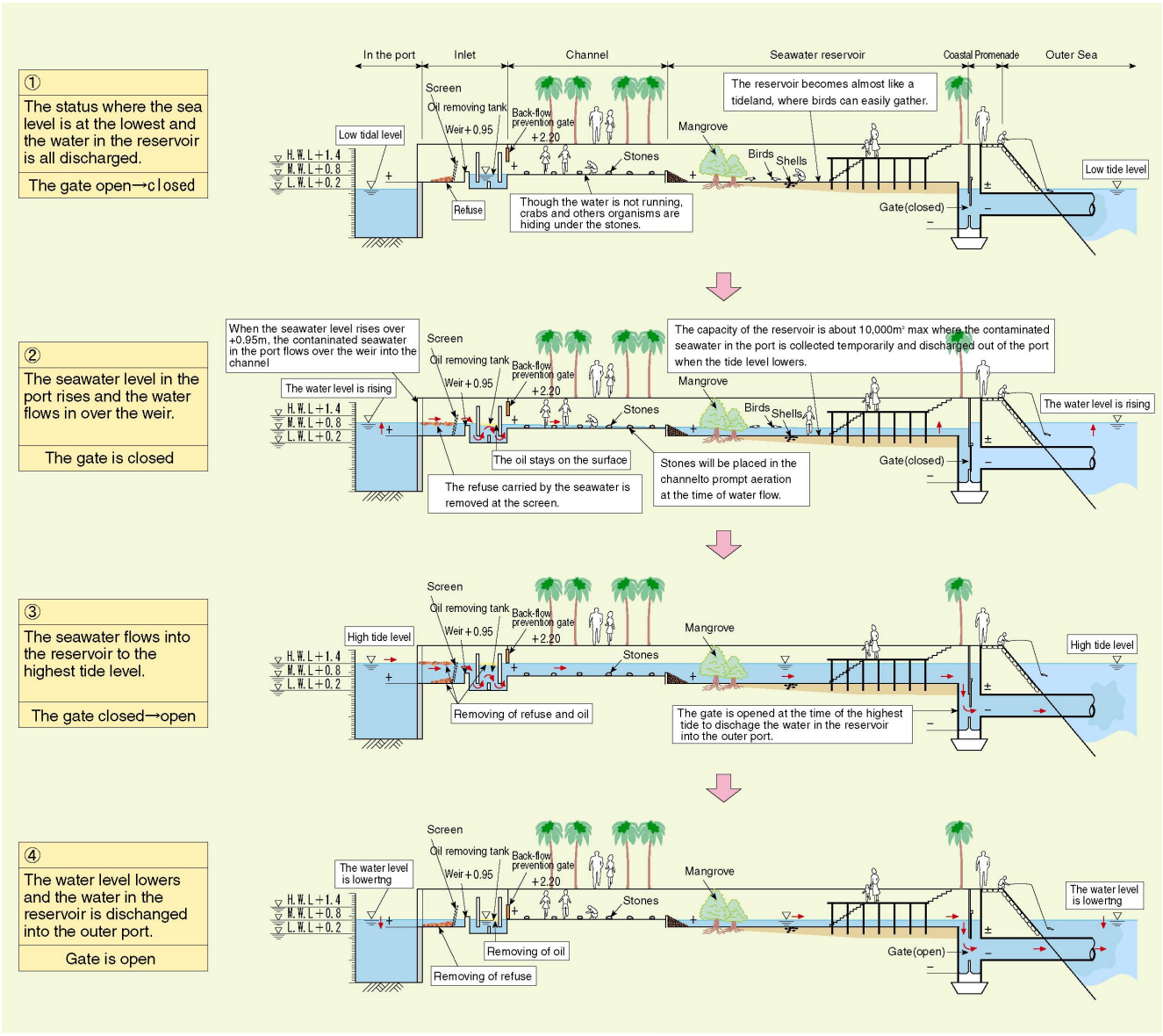

Figure 1: The outline of the Seawater Purification System

Sea area and the Indian Ocean off Sumatra.

During the latter half of 1980, in addition to its function as the supply base for marine products to Jakarta citizens, JFP became known as the base for fresh tuna landing from the Indian Ocean and the daily airfreight exportation for the sashimi market. This business became very active partly because of the strong yen and the increasing number of airline flights to Japan from Jakarta. At present, about 20% of the fresh tuna airlifted to Japan from overseas is from Indonesia. Fishery products transported from various places nationwide are traded during nighttime at the Jakarta Fish Wholesale Market located inside JFP complex where more than 10,000 people in the fishery business related work carry out their transactions. More than 80 companies engaged in fish processing activities have been operating their factories in JFP covering about 30ha of land area of JFP with more than 10,000 employees. JFP is now the processing center of shrimp and fish, contributing to the export of fishery products in Indonesia as well as local market. At present, the JFP has grown to be a fishing town where almost 30,000 people are working everyday from early morning to midnight. The value of fish transaction amounts to approximately 100 million yen on-site every day.

The JFP provides three functions: A fishing port, a fish distribution center and fish-processing center. Moreover, in the Phase IV project, a "1,500 meter-long coastal promenade along the east coast" and a "unique mangrove revetment on the west coast" have been constructed, providing beach recreation spots for citizens who enjoy fishing and strolling along the waterfront. The JFP has been specially noted by the Japanese government for the following reasons: 1) It is one of the typical and pioneer Japanese ODA projects based on the "technical cooperation by JICA" and the "JBIC's yen loan"; 2) The redevelopment projects considering the environment are continuously implemented, and 3) It is well popularized in the district and used by the local fishermen and citizens. With the above reasons, together with the fact that it is well placed in the city of Jakarta, the JFP has been attracting to private investors and a lot of visitors from both within the nation and abroad coming to JFP.

The Present State of the Sea Area of the Fishing Port

As the JFP was constructed in the Jakarta Bay, with a shoal extending for a considerable distance from the shore (the seabed grade of 1 in 300), the port is surrounded by the breakwaters (occupying about 40 ha, of sea area having average water depth of about 5 m) is exclusive. The tidal range fluctuation is usually only about 60 cm and the natural exchange of the seawater in the port cannot be expected much. Moreover, around 300 ships are using the quaywall for mooring frequently with more than 3,000 fishermen are living on board the ships. Since wastewater from the fishing vessels are disposed directly in the basin including waste oil by leakage coming from the vessels, the pollution of the water in the port basin is becoming worse and worse. During the Phase IV engineering stage, it was decided by the author and his colleagues to construct a device for seawater exchange / purification system in order to overcome the water pollution in the port basin that will be applicable in relation to tidal fluctuation, site condition and environmental aspects point of view.

Engineering Conception of the Seawater Purification System in the Port Basin

The seawater purification system was required to meet the following criteria and conditions:

(1) To accelerate the exchange of about 2 million m^3 seawater in the port.
(2) To be able to remove floating garbage and waste oil during seawater exchange process.
(3) Easy operation and less maintenance cost.
(4) To clean the polluted seawater as much as possible before discharging outside the port basin.
(5) To enlighten and educate the citizens about the seawater pollution issue.
(6) To beautify the environment as part of the fishing port complex

It is a common idea in Japan to discharge the seawater using a large pump and floating garbage by a refuse collecting ship. However, in a developing country like Indonesia, and in a fishing port, which generate small profit, the possibilities of using machine type system will be difficult and expensive to operate and maintain. For several years, the author has been searching for a device that would fulfill the criteria and conditions as mentioned above.

While taking a bath at home, the author observed the grimes being washed away as the hot water in the bathtub overflowed. Observing this phenomenon, the author came to a revelation that it might be possible to recreate this phenomenon using the daily rise and fall of the tide. Having arrived at this idea, the author has assembled the prerequisites that must be met to realize this idea as follows:

(1) A system that naturally overflows the seawater.
(2) In order for the seawater to overflow, the place must be a lower place than the sea surface.

(3) A reservoir that is large enough to temporarily collect the overflowed water from the port.

(4) To be able to maintain the condition of temporary emptiness of the reservoir.

In order to meet the above conditions, the author and his colleagues have decided to construct as large a reservoir as possible. The conceptual plan of the water purification system of the port was created as shown in Fig.1. The outline of the system is as follows:

(1) Construct a reservoir, which is large enough (approx.10, 000 m^2), and make its basin as low as possible. (Photo-2) in order to make the capacity as large as possible (max. 10,000 m^3 at the time of spring tide, average 4,000 m^3).

(2) Install a gate to discharge the reservoir water out of the port, so as not to let the outer seawater in by opening/closing the gate. To install a screen in front of the gate to prevent the refuse from the reservoir from flowing out of the port.

(3) Install a device to take in the seawater in the port ("inlet" hereunder) at the innermost area of the port. (Fig.2, Photo-3)

(4) Construct a weir in the inlet in order for the seawater in the port to overflow into the empty reservoir when the tidal level rises over the weir height. (Fig.-3)

(5) Install a screen in the inlet in order to prevent the floating refuse/garbage in the port from flowing into the reservoir. (Photo-4)

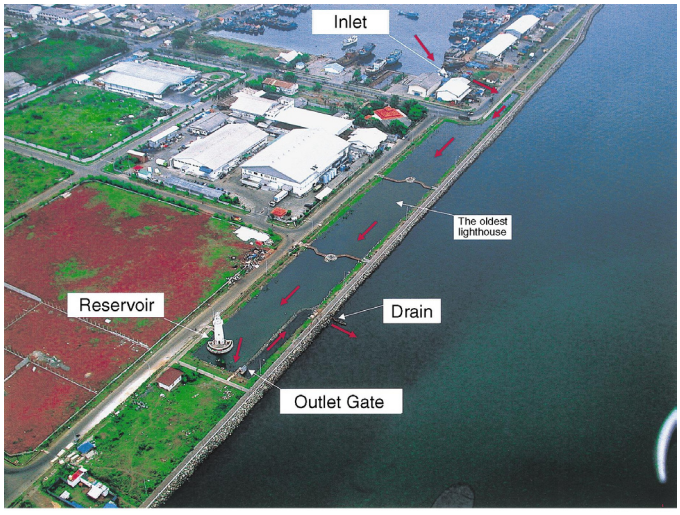

Photo 2: Port Seawater Exchange Reservoir

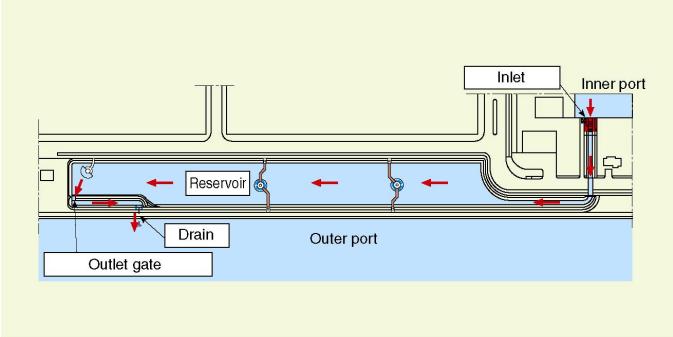

Figure 2: The outline of the water purification system

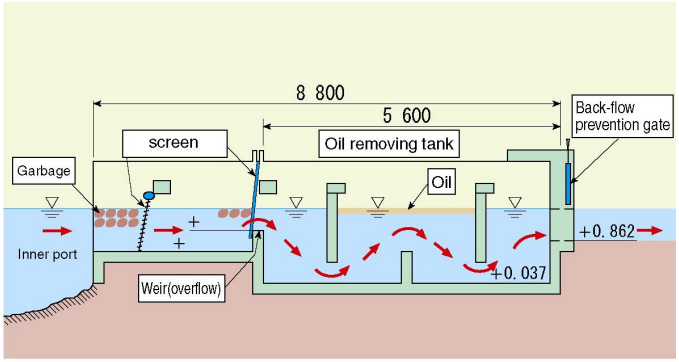

Figure 3: Sectional plan of the inlet

(6) Since the oil easily floats on the inlet water, an oil-removing tank should be installed to prevent the oil from flowing into the reservoir.

(7) Install a gate at the inlet in order to prevent the seawater that had flowed into the reservoir from going back to the port during ebb tides.

(8) Create a channel made of natural stones extending from the inlet to the reservoir to prompt aeration at the time of the seawater inflow and create an environment in which sea habitats such as fishes, crabs and others organisms can thrive. (Photo-5)

(9) Plant mangroves in the reservoir to create a seawater purification system by zooplankton and phytoplankton mechanism of mangrove characteristics. (Photo-6)

(10) Create a tideland in the reservoir in order to prompt purification functions by shells.

(11) Plant enough vegetation around the channel and the reservoir to create a beautiful

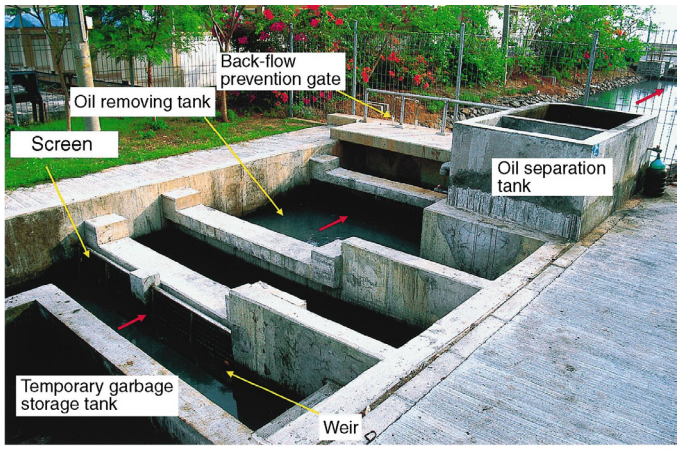

Photo 3: Inlet

landscape (Photo-6). Also, build wooden bridges and terraces as resting spots for people.

Conclusion

The construction works have been completed and the testing of the seawater purification system has been carried out. As a result, the following points have been found out.

(1) The seawater in the port is overflowed over the weir at the flux time as had been expected. Although the inflow amount differs depending on the tidal level of the day, the maximum is 10,000 m^3/day and the average is 4,000 m^3/day. Since the water amount in the port is approx. 2 million m^3, about 0.2% of the water in the port is discharged every day.

(2) It was confirmed that the floating refuse such as plastic bottles, plastic bags and wooden pieces could be completely removed when the seawater in the port flowed over the weir and through the screen. This has proved that the inlet had a better refuse collection function than had been expected. If the refuse caught at the screen fails to be removed, the screen promptly gets blocked up with the refuse and the seawater's overflowing power at the weir deteriorates. It is important that the people in charge continuously remove the refuse at the time of the seawater overflow.

(3) The oil and other matters floating in the port flows into the inlet, as are clearly recognized in Photo-l. The oil floats in the oil-removing tank and can be easily disposed of.

(4) The seawater from which the refuse and oil were removed is more transparent than expected.

(5) The revetments of the channel and the reservoir made of natural stones are environments where algae grow easily and fish and other organisms can breed, providing a good fishing spot. Also, they create a pleasant space in a fishing port, abundant in greenery.

(6) Mangroves are in midst of their growth.

(7) The oldest lighthouse in Indonesia was maintained in the reservoir, which provides a landscape that is in harmony with the historical heritage.

Thus this "seawater purification system" has proved to fully function as designed. However, since the timely opening/closing of the gate according to the tidal level and removing of the refuse and the oil have to be executed by man, whether this system will perform according to the designed functions continuously totally depends on the operator's will and passion.

At the time this article was written, as part of the industrial wastewater was still flowing into the reservoir, the degree of purity of the seawater in the port was not measured quantitatively. It is our future


Photo 4: The refuse is removed at the screen

Photo 6: Mangroves

Photo 5: Channel from the inlet to the reservoir

goal to measure the water quality periodically (levels of COD, nitrogen, phosphate, etc.) and assess the effects of the system quantitatively.

Lastly, in introducing this system, I would like to express my sincere gratitude to Mr. Sadayuki Oka, Fisheries Agency (JICA Fishery Expert at that time), who gave me precious advices; to Mr. Nobuo Hazeyama, Chief Representative of JBIC Jakarta at that time; to Mr. Hideki Wakabayashi at the Japanese Embassy; and to Mr. Toshiro Matsushima at Rinkai Corporation, who has been involved in this construction project.

Following is the URL of the Jakarta Fishing Port for further information: http://www. jakartafishport.com

Preliminary Report on the Damages caused by Off-shore Tokachi Earthquake (Sept. 26, 2003)

Joint Off-shore Tokachi Earthquake Investigation Team
Of Japan Society of Civil Engineers &
The Japanese Geotechnical Society

Overview of the Emergency Investigation

On September 26, 2003 at around 4:50am local time, an earthquake of Mj= 8.0 with its epicenter off the Tokachi shore in Hokkaido occurred, causing damages to rivers, ports, harbors, waterworks, roads and bridges in Tokachi, Kushiro, Iburi and Hidaka regions. This earthquake also triggered tsunami, which was observed over a long period of time. The Earthquake Engineering Committee [1] of the Japan Society of Civil Engineers entered immediately into examination on dispatching an on-site investigation team. Upon consultation with the JSCE Emergency Disaster Countermeasures Division, the dispatching of the investigation team was decided. The investigation took place on October 4 and 5, 2003 jointly with the members of the Disaster Coordination Council of the Japanese Geotechnical Society. The member list of the Joint Investigation Team by JSCE and JGS is shown in Table-1.

Compared to previous incidences of earthquakes that occurred in eastern Hokkaido such as the Off-shore Kushiro and the Off-shore Toho Earthquakes, the Off-shore Tokachi- Earthquake has the following characteristics:

1) Its seismic coefficients were widely distributed to almost the entire region of Hokkaido.
2) Hydraulic bore caused by tsunami was observed in Tokachi River for a long period of time.
3) Secondary disaster involving the oil tanks of Tomakomai Oil Refinery, Idemitsu Kosan Co., Ltd.

This is a preliminary report on the characteristics of the earthquake motion as well as an overview of the damages caused by this earthquake.

Characteristics of Earthquake and the Earthquake Motion

At around 4:50 am on September 26, 2003, an earthquake of Mj 8.0 took place, with its hypocenter at the depth of 42km located off Hokkaido's Tokachi shore. This earthquake, which was named "2003 Off-shore Tokachi Earthquake", is a reverse fault earthquake that occurred at the boundary of Pacific Plate and the land plate, at approximately the same location as the 1952 Off-shore Tokachi Earthquake (Mj 8.2).

According to the long-term evaluation that the governmental Earthquake Research Committee published in March 2004, the probability that Mj8 level earthquake occurs within the 10 year period from January 2003 was 10~20% and the same probability for a period of 30 years was 60%. Moreover, according to the "Probabilistic Earthquake Forecast Map for Northern Japan (test version)" that was published from the same source

[1] Chairman: Professor Yozo Goto, Director of Kawasaki Laboratory, EDM Research Center, National Research Institute for Earth and Disaster Prevention

at around the same time, the regions that experienced strong shaking during this earthquake has comparatively higher probability of experiencing another earthquake of over Mj5 or Mj6 within the next 30 years.

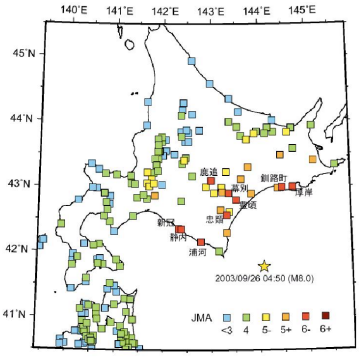

Figure 1: Distribution of seismic coefficients by JMA

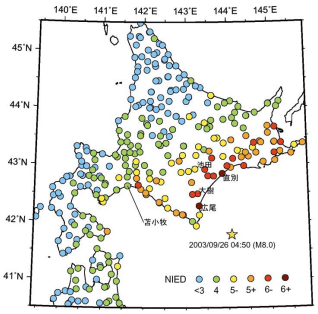

Figure 2: Distribution of seismic coefficients based on K-NET and KiK-net records

Figure-1 shows the distribution of seismic coefficients, published by the Japanese Meteorological Agency. According to this, the strongest seismic coefficient was 6 lower. Regions that experienced strong shaking encompassed wide-ranging areas centering the Tokachi office, as well as the Kushiro and the Hidaka offices of the Hokkaido prefectural government.

This earthquake was observed and recorded by numerous organizations other than the Japanese Meteorological Agency, such as the National Research Institute for Earth and Disaster Prevention (K-NET and the KiK-net) and the Hokkaido Regional Development Bureau. Figure-2 is the distribution of seismic coefficients based on the records of K-NET and KiK-net. Among observation records that were disclosed, some indicate results that could be an equivalent of magnitude 6 higher on the seismic intensity scale. The maximum acceleration and the maximum velocity that were recorded seemed to be consistent with past attenuation relationship on average. However, it is characteristic that discrepancies were seen in areas within relatively short distance from one another.

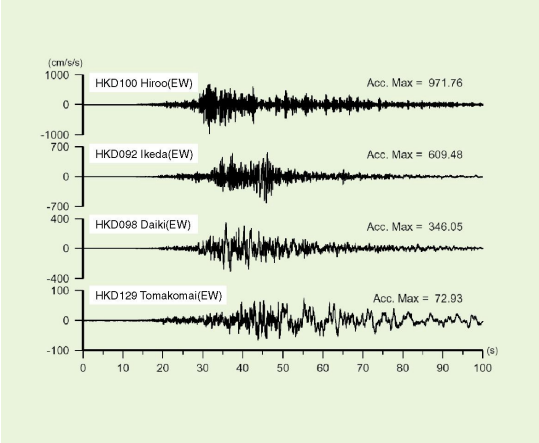

Figure 3: Acceleration waveforms observed on K-NET

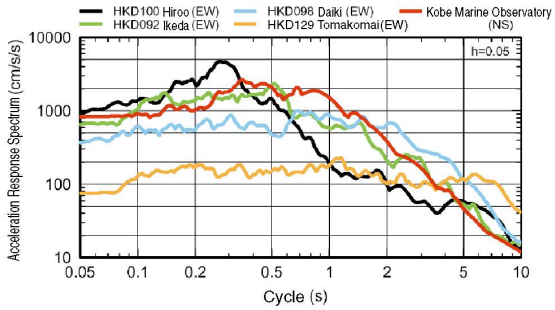

Figure 4: Acceleration Response Spectrum observed on K-NET

Figure-3 shows the acceleration waveform and acceleration response spectrum of K-NETs in Hiroo, Ikeda, Daiki, and Tomakomai. The characteristic in common among these waveforms is the relatively long duration of earthquake motion due to the large scale of the earthquake. On the

other hand, the shapes of response spectra are all different according to their locations. However, there are many spectra that have shown a large response before 1~2 second cycle, except the spectrum for Hiroo, in which a large response was observed at the cycle of 0.3 second. Moreover, in Tomakomai, there was a large response after the cycle of 5 seconds, indicating the possibility that such characteristic of this earthquake motion had an effect on the sloshing of the crude oil tanks. From now on, detailed verification using strong motion simulation including deep ground structure and basin effect will be necessary on top of non-linear response of surface layer.

In Cyokubetsu, where the strongest earthquake motion was recorded among the K-NET records, the slanting of the small structure, housing the seismograph was reported. Therefore, it would be necessary to interpret the records while taking into consideration the state of the seismograph. In K-NET Uraga, the maximum acceleration and the maximum velocity were observed during the aftershock that occurred around 6:08am of the same day.

Since records from the 1993 Off-shore Kushiro Earthquake are available from some of the same observation locations for this earthquake, it is expected that these records would be used for comparative studies of the characteristics of the two earthquakes and the relations to their damages.

Topography and the Estimation of Seismic Coefficient Distribution

Since seismic coefficients of 5 higher or 6 lower were recorded in various regions during this earthquake, it is presumed that topography and geographical features influenced these results and that its seismic coefficient distribution was complex. In order to infer the distribution of seismic coefficients, we have investigated the size and the direction of oval openings that occurred on the bases of utility poles in various regions. In the southwestern Tokachi Plain, which lies between Hidaka mountain range and Toyokoro hills, extend the old alluvial fan and the sediment terrace, encircled by the Tokachi River. The openings on utility poles were largest in the alluvial plain along the Tokachi River, the Shiranuka Hill in east of the alluvial fan, by the rivers (Urahoro River, Rekifune River) flowing in the hilly land of the old alluvial fan, lowlands (such as Cyokubetsu) by the shore, and the edges of the hilly land (3-level terrace from Churui to Daiki and the plateau in the south of Tokachi Port among others) (Figure-5). Overall majority was the case in which the poles were pushed from south to east, i.e., the openings were observed from north to west side of the poles. This tendency was most evident in eastern Obihiro where 81% or 22 out of the entire 27 poles that were studied fit the case (at the time of investigation in 9/27). In the region between Churui and Daiki where 3 floors of terrace lead to the Rekifune River, openings were recognized on the poles by the edges of the terrace and in the alluvial lowland. By the edge of the terrace in southern Hiroo, some houses have tilted due to the sliding of the slope. Some artificial embankments were observed in this area. Although there are fewer cases along the Tokachi River, in which any one direction of shaking is eminent than the others, many show the traces of being pushed toward southeast or east. On the other hand, on the vast plateau where Obihiro Airport is located, practically no opening was found within the limit of our investigation. Following are the descriptions of the situations in various regions.

Hiroo

In the hilly land (steep slope area) in the south of Tokachi Port where the damages from tsunami was prominent, houses tilted due to the sliding of the slopes and cracks along the back of the houses were observed (Figure-6). This area is designated as the dangerous area of steep slope failure by the government.

In the flatland at the bottom of the terrace, no opening was found on the poles within the limit of our investigation.

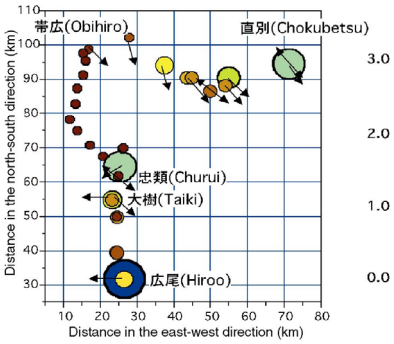

Figure 5: Sizes (radius, color) and principal direction of the openings found on the bases on utility poles (Total up to 9/29)

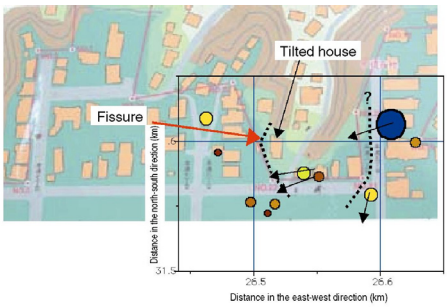

Figure 6: Damages houses and openings on utility poles in the hilly land in the south of Tokachi Port

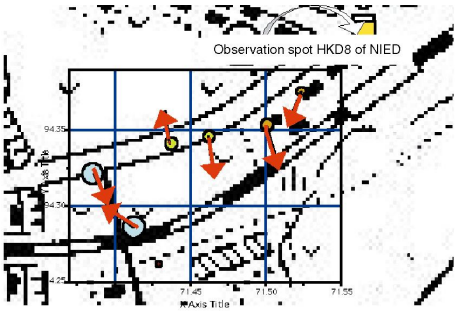

Figure 7: Movement of utility poles near Cyokubetsu Station

Urahoro River Bridge on JR Nemuro Line

This bridge is a simple support concrete bridge with 4 spans (1 span=30m) and 4 main girders. A symmetrical shear fissure which may be due to the shaking in the direction perpendicular to the bridge axis (direction of the river flow) appeared on the tallest bridge pier at the river center (circular section, height=9.5m). A 5mm opening was observed in the S45E direction at the foot of an iron pole of the adjoining water-level observation facility. The form of this damage was consistent with that of the bridge pier.

Photo 1: Urahoro River Bridge pier

Cyokubetsu

Cyokubetsu is located near where the Super Express Marimo train derailed. Along the national road 38 in Cyokubetsu, the principal axis of the oval openings found on the bases of the utility poles were in the direction of south-southeast to north-northwest for the most part (Figure-7), which is practically perpendicular to the railroad. This site also houses the K-net observation spot (HKD 086) of the National Research Institute for Earth and Disaster Prevention.

<u>Tsunami</u>

Tsunami reached Tokachi, Kushiro, and Uraga among other regions 20 minutes after the earthquake occurrence and has also reached the regions between the Pacific and the Sanriku shores of Hokkaido. This tsunami has caused inundation of the port facilities at Tokachi Port and has caused damages to the fishing industry.

After the occurrence of the earthquake, various organizations entered the site to measure the height of the tsunami and to investigate the damages.

Figure-8 shows the heights of the flood marks in Hokkaido (preliminary figure) assembled by a member of the team (Dr. Tanioka). Further details are available at: http://www.hel.ce.akita-u.ac.jp/tsunami/tokachi2003/

As can be observed from the diagram, the flood marks in Hokkaido were approximately 1~4m (Approximately 1m according to the tidal record. The flood marks in Honshu were mostly under 1m. Statistically, tsunami that occurred is of an average scale for M8-class earthquakes and there are no flood marks of disproportionate size. This is considered because the relatively monotonous ocean floor topography of Tokachi and Hidaka regions did not allow the tsunami energy to concentrate in one place.

Photo 2: Tsunami watermark at Tokachi Fishing Port

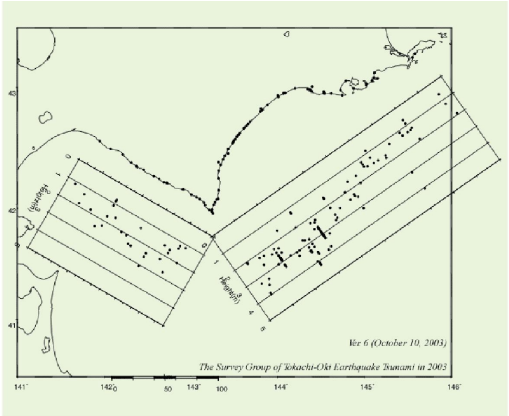

Figure 8: Height of Tsunami watermarks (preliminary figures)

The characteristic of this tsunami is its long duration. In the eastern and central regions along the Pacific coast of Hokkaido, tsunami warning lasted for about 4 hours and it was only after 13 hours since the occurrence of the earthquake that the overall tsunami advisory was lifted. The actual tsunami, including the smaller scale ones, lasted for even a longer period of time. There were regions where the first wave was the largest and other regions where the largest wave was observed few hours after the first wave. This is considered due to the occurrence of edge waves and the recurring multiple reflections. Under such circumstances, the possibility of a large-scale tsunami remained even long after the earthquake occurrence, requiring a long period of vigilance.

The tsunami caused 11kms of reverse flow on Tokachi River. The image of tsunami flowing upstream as undulating hydraulic bore was videotaped by the national self-defense force and was broadcasted on TV. However, this image might not have captured the largest wave; even greater wave might have occurred. Although previous tsunami damage forecasts would have predicted that tsunami flowing upstream and passing above the embankment might result in expansion of flooded area, the strong shaking of this earthquake greatly damaged the embankments of Tokachi River. Therefore, even though the waves did not reach the crest height, if the waves had reached the damaged areas of the embankment, an even greater damage might have occurred. An examination for the cases of such compound disasters would also be necessary.

Considering the scale of this earthquake, it could be said that the damage from tsunami was surprisingly small. This owes to the fact that the

earthquake occurred around 5am when many of the fishing boats had already left the port and to the high evacuation rate of the citizens, which in turn was influenced by the strong shaking, communication activities by the local authorities, and the lessons from the past earthquake and tsunami experiences. However, there were problems as seen in the case of a local authority that did not issue an evacuation advisory even though the tsunami warning had been issued. Had there been many residents who did not evacuate because of the lack of warning, it would indeed be a serious problem. In eastern and central regions on the Pacific coast of Hokkaido, the initial tsunami warning was switched to less urgent tsunami advisory later. This may have been interpreted as having been through the peak period. However, this type of tsunami carries the potential of producing the largest wave many hours after the occurrence of the earthquake. Moreover, there was also a possibility to reach the highest water level after the switch to tsunami advisory, when the long-lasting tsunami period overlaps with the high tide. This demonstrates the importance of examining the way to communicate the warnings and advisories.

Damages to the Ground, the Embankments and the Reclaimed Lands

Damages to the ground and to the embankment / reclaimed lands were seen in a vast area from Kushiro to Sapporo. Among which, especially the downstream Tokachi River suffered many damages. The damages were mostly in areas where structures were built on top of artificially constructed embankments or reclaimed lands, and ground liquefaction or landslide, which are damages on naturally accreted grounds were rare. Following are the description of damages in five categories:

Excavated and refilled ground

Photo-3 shows a risen sewage manhole in Onbetsu City. Numerous manholes as long as 1.5m floated above the ground surface not only in Onbetsu City, but also in Toyokoro and Kushiro Cities as well.

Photo 3: Risen manhole in Onbetsu City

Photo 4: Differential settlement of houses in Kiyoda-ward, Sapporo City

Photo 5: Damages to the embankment near the mouth of Tokachi River

Although it cannot be observed from the ground surface, it is presumed that the sewage pipes had also risen. Such disasters were also seen during the 1993 Off-shore Kushiro and the Off-shore

Southwest Hokkaido Earthquakes as well as in Kushiro City during the 1994 Hokkaido Off-shore Toho Earthquake. The cause of the floating will soon be investigated but according to the results of investigations after the three previous earthquakes, the main cause was the liquefaction of the area refilled by sand after the original marly ground was excavated to place the sewage pipe. It is likely that the cause was the same again this time and that we have not learned from the past experiences of disaster. However, it is hoped that the measures will be taken from now on. Although the floating of the manholes were not prominent, sinking of the refilled areas on top the sewage pipes were seen in Mukawa City and Uraga City as well.

Other cases of liquefaction of sand that refilled the excavated ground were seen in Toyokoro City where two houses had undergone differential settlement. Since the original grounds under these houses were weak, they were excavated for about 3m and refilled by sandy soil, but this apparently produced a counter effect.

Low embankments on top of weak soil

Damages on 1~2m embankments on weak soils were observed in a residential area of Otsu, and at a gas station in Toyokoro-minami in Toyokoro City. In the previous case, sliding of the embankment and the sand boil was observed, causing the differential settlement of the house above it. In the latter case, sliding occurred in a vast area, causing the tilt of the underground tank and the ground fissures. In these cases, it is presumed that the lower parts of the embankments that sunk into the weak soil were liquefied.

Plateau and the graded hilly lands

In the graded area in Kiyoda-ward, Sapporo City, several houses have undergone differential settlement (Photo-4). It is presumed that the sand boil took place around the houses and contributed to the liquefaction of the graded embankment. In this area, there is a history of similar damage on the embankment after the 1968 Off-shore Tokachi Earthquake.

In Kyouwa, Tanno City located north of Kitami City, a large area of an farm land with a gentle slope of 2 degrees have flown out. This area, which was previously a marshy rice paddy, was reclaimed and turned into a farmland. As sand boil was observed here, it is suspected that the volcanic sandy ash soil that was used in embankment liquefied and caused flow damage. However, further investigation would be necessary to clarify the mechanism.

Coastal reclaimed land

In coastal reclaimed land from Tomakomai to Nemuro, liquefaction was observed in many ports and harbors. In Kushiro Port, sand boil was observed in many locations. However, although the rear ground subsidence occurred, there were no great damage to the quays. One factor behind this may be the development of liquefaction countermeasures of quays by measures such as the soil improvement.

River embankment

River embankments in various location suffered damages like crack and sliding. At 3.4km from the mouth of Tokachi River, the embankment slid toward the inner land and collapsed (Photo-5). As sand boils were observed at the toe of the outer slope of the embankment, it is suspected that the liquefaction might be the cause of the damages. All though the cause of the damage will be investigated, two scenarios are possible; one is the liquefaction of the ground itself and the other is the consolidation settlement and the liquefaction of the embankment that was built on top of the weak soil.

Damages to the Highway Bridges

Numerous cases of damage to the bridges were seen in Tokachi region. Here, damages to the Chiyoda Ohashi Bridge at midstream Tokachi River, the Tokachi-Kakou Bridge at downstream Tokachi River, the Rekifune Bridge near the Tokachi Port in Hiroo Town where large earthquake motion was observed, will be reported.

Tokachi-Kakou Bridge

Tokachi-Kakou Bridge, completed in 1988, is a concrete bridge spanning the mouth of Tokachi River near Otsu. It is 928m long and the main bridge is a 3-span, continuous girder bridge measuring 100m, 165m and 100m and made by Dywidag system. As for the side bridges, on the right side, there is a 3-span, continuous concrete box girder bridge measuring 189.9m (3 x 63.3m), and on the left side, there is a same type of box girder bridge measuring 183.9m (3 x 61.3m). The damage was concentrated in the side bridges, especially in the left continuous girder bridge, of which the abutment shifted the maximum of 80cm toward the direction of upstream, causing great damage in the supporting area. Photo-6 is the image of the bridge taken from the right bank. On the left side of this photo, by the left bank, you may observe the distortion of the wheel guard toward upstream. The distortion was also verifiable from the white lines on the road surface. The emergency repair works consisting of stabilization of the superstructure and prevention of the bridge from falling as an aftershock countermeasure were completed by October 7th 2003, when it reopened to the traffic. Thereafter, a full-scale repair work is under way. According to the maximum acceleration response spectrum (gal) (h=0.05) by waveform observation obtained near the bridge (Otsu Port, Cyokubetsu), a value higher than the standard specified by 2002 Specifications for Highway Bridges Level 2 (type II) was observed at Cyokubetsu EW element (natural period around 0.35sec and 0.6sec) and at Otsu Port NS element (around 0.4sec). Moreover, the characteristic of high peaks around natural period 1.6sec was seen.

Photo 6: Torsion of the bridge axis toward the left bank (Tokachi Kakou Bridge)

Photo 7: Steel Sheet adhesion reinforcement on the Chiyoda Ohashi

Photo 8: Rekifune Bridge; Loosened anchor bolt

Chiyoda Ohashi

Chiyoda Ohashi is a bridge spanning the

midstream Tokachi River. It is 706m long and the main bridge is a 5-span simple steel truss bridge (5 x 60.5m). On its either side, there is s 5-span post-tensioned PC simple T-beam Bridge (2 x 5 @ 39.3m). It was completed in 1954, thus it is over 50 year old.

The earthquake struck when the plan was under way to reinforce it and span it. As it was damaged during this process, an immediate and full-scale repair will be needed. The damages occurred in the supporting area of the main bridge as well as on the pier of the side bridges. The damage to the bridge piers is a typical damage by torsion. An emergency repair work by steel sheet adhesion reinforcement was undertaken (Photo-7).

Rekifune Bridge

This is a bridge located near Hiroo Town (Tokachi Port) on the National Road 336. It is a 553.6m long continuous 15-span simple concrete girder bridge (15 x 36m) completed in 1972. The damage is concentrated in the supporting area. According to the result of the maximum acceleration response spectrum by waveform observation in Hiroo, both NS and EW elements are nearly 3G around 0.3sec (h=0.05). Photo-8 shows the damage on the supporting foundation and the fall off of the anchor-bolt.

As for the background to these bridge damages, the stratum structure of the afflicted region by the Tokachi shore is characterized by its thick sediment layer. Therefore, it may be inferred that the influence of this weak, liquefying layer to the seismic response was considerable.

Acknowledgement

This emergency joint investigation took place between October 4 and 5, 2003 and was joined by 32 participants including those who have responded to public advertisement. On the first day of the investigation (Oct.4), the entire team assembled at Obihiro Airport and after a briefing on the damage overview, they were assigned into one of the four groups for structures, rivers, ports, and lifelines, before the investigation began. During the investigation, our team was greatly aided by the Development and Construction Department of the Hokkaido Development Bureau of the Ministry of Land, Infrastructure and Transport and by the Civil Engineering Research Institute of Hokkaido in obtaining special passes, in preparing conference rooms, in providing explanations on site and in various other ways. We are also greatly indebted to the related personnel of the Obihiro District Public Works Management Office, of Toyokoro-cho Municipal Office, and of the Zukosha Corporation for their help in preparing related documents and for their help on-site. Lastly, on behalf of the investigation team, we would like to thank those who have taken the time to prepare the mid-term reports on their areas of investigations

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Table-1: Member List of the JSCE / JGS Joint Investigation Team

Team Leader	Koichi SATO	Graduate School of the Hokkaido University
Sub-leaders	Kazuo KONAGAI	Institute of Industrial Science, University of Tokyo
	Seiichi MIURA	Graduate School of the Hokkaido University
Secretary-general	Toshiyuki OSHIMA	Kitami Institute of Technology

Secretaries		Masakatsu MIYAJIMA	Kanazawa University
		Takao HASHIMOTO	Chiyoda Engineering Consultants Co., Ltd.
Earthquake / Earthquake Motion		Shunichi KATAOKA	Hirosaki University
		Kazuo KONAGAI	Institute of Industrial Science, University of Tokyo
		Yutaka ISHIKAWA	Shimizu Corporation
		Riki HONDA	Disaster Prevention Research Institute, Kyoto University
Earthquake Disaster		Seiichi MIURA	Graduate School of the Hokkaido University
		Susumu YASUDA	Tokyo Denki University
		Hiroyoshi KIKU	Kanto Gakuin University
		Satoshi YAMASHITA	Kitami Institute of Technology
Tsunami		Fumihiko IMAMURA	Graduate School of the Tohoku University
		Koji FUJIMA	National Defense Academy in Japan
		Tomoyuki TAKAHASHI	Akita University
		Yuichiro TANIOKA	Graduate School of the Hokkaido University
Damages to Civil Engineering Structures	Bridges / Roads	Koichi SATO	Graduate School of the Hokkaido University
		Toshiyuki OSHIMA	Kitami Institute of Technology
		Toshiro HAYASHIKAWA	Graduate School of the Hokkaido University
		Kenji IKEDA	Civil Engineering Research Institute of Hokkaido
		Hisashi KONNO	Civil Engineering Research Institute of Hokkaido
		Kazunori WATANABE	Civil Engineering Research Institute of Hokkaido
		Kenji KOUSA	Kyushu Institute of Technology
	Rivers	Satoshi NISHIMOTO	Civil Engineering Research Institute of Hokkaido
	Ports / Airports	Takahiro SUGANO	Port and Airport Research Institute
		Masaki MARUMOTO	Tokyo Soil Research Co., Ltd.
		Yoichi TAJI	Institute of Technology, Shimizu Corporation
	Residential areas	Takao HASHIMOTO	Chiyoda Engineering Consultants Co., Ltd.
Lifelines	Waterworks	Masakatsu MIYAJIMA	Kanazawa University
	Waterworks / Fuel Tanks	Susumu YASUDA	Tokyo Denki University
	Communication	Kiyoshi KAWASAKI	Hokkaido Branch of the NTT InfraNet
Industrial Facilities: Tanks		Yozo GOTO	EDM Research Center of National Research Institute for Earth and Disaster Prevention
Emergency Response		Fumihiko IMAMURA	Graduate School of the Tohoku University
		Tomoyuki TAKAHASHI	Akita University
		Yuichiro TANIOKA	Graduate School of the Hokkaido University

Yasuzuka News – Using Snow and Solar Energy for Town Planning

Yoshiomi ITO
Chief Snowman
Yukidaruma Foundation, Niigata Prefecture

Yasuzuka, the Snow Town

Yasuzuka-machi, which is located on the border between Niigata Prefecture and Nagano Prefecture, is a typical town surrounded by gently rolling mountains. In summer it is hot and humid, while in winter it has a mild climate with heavy snowfall. The humidity is endemic to the Hokuriku District. It is one of the areas with Japan's heaviest snowfall amounting to 2 meters in depth on the plain area and 4-5 meters in depth on the mountainous area. In 1971, the region was designated as the "Special Heavy Snowfall Area". The residents have to shovel snow in front of their houses every day as a routine and have to fight with snow day after day. Although they are compelled to live with snow for almost half a year, they are very energetic. Winter events are enjoyed every year, and, especially, "The Snow Festival", which is held in the middle of February, is a magnificent event during which 500,000 candles are lit all over the town and snow statues are made by vigorous town people.

Snow is a Gift from the Sky

It was not until 1985 when we heard voices from the visitors from large cities to Yasuzuka, expressing their adoration of snow that we realized that urban residents associate snow with image of the "winter wonderland" and that it is something they enjoy touching. Then it occurred to us that we could deliver snow to places where it is rare. When we started to sell snow along with fresh edible mountain plants in 1986, naming it "A touch of snow; Echigo Spring Journey" we received more demands than the

Figure-1: Location of Yasuzuka-machi

town office was able to handle. This developed into the first attempt in Japan to merchandise snow called "Snow Home Delivery", thus the snow utilization in our town started. In the following year 1987, we held a "Farewell Korakuen Snow Festival" at the Korakuen Baseball Stadium that was going to be dismantled for the construction of the Tokyo Dome. We brought in 450 lorry loads of snow, approximately 5000 tons, from Yasuzuka. Approximately 40% of Yasuzuka citizens came to Tokyo in order to participate in this event and it was a great success. These projects were reported through the media and the name of "Yasuzuka-machi" became known nationwide. The inhabitants' notion about snow began to change. To the adults in the snow country who had been brought up with snow and who are too familiar with the burden of snow, it is something simply troublesome. But when they saw the city children playing happily with the snow, they realized that snow indeed is a gift from the sky. In December 1987, we drew up "The Snow Country Culture Village

Basic Plan". This plan was aimed at reconsidering the life style in snow country in regards to food, clothing, shelter and play and to create a town resembling a park utilizing our fortune, that is, snow, greenery and the people. As an organization to materialize and implement the plan, the "Yukidaruma (Snowman) Foundation" was established in 1990. At the same time, the snowman was chosen as the town's logo. In addition, the "Cupid Valley Ski Resort" opened in the Sugawa area and number of visitors to Yasuzuka-machi rapidly increased. Thus, the residents began to recognize the snow as their fortune and a fine resource, indispensable for town planning.

Utilization of Snow

In addition to this situation and with increasing concern about environmental issues, we tried to work out ways to use snow as clean cooling energy. Snow can be used as a cooling energy resource if it is stored until the summer. It is a perfect natural air conditioner. In 1992, a "snow house" was built as a facility for storage of agricultural products in the Taruda area. This natural refrigerator keeps the inside temperature at 0~3℃ (humidity 90± 5 %) all year round without the use of electricity. Subsequently, Yukidaruma Regional Product Exhibition / Market (Bussan-kan), which uses the melting water from the snow house for summertime air-conditioning was opened in 1995. The effect of this air-conditioning system using snow melting water" was greater than we had expected. We obtained responses of evaluation like "I didn't get tired even though I was exposed to cool air for a long time". The cost of electricity, required to send the melt water to the pump, is very low. Also handmade soba noodles always taste in season because the soba grains and wild yams, which are the ingredients for soba noodles, are refrigerated in the "snow house", and thus the delicate flavors of the harvest are kept without being spoiled. The snow house is actively used for storing the organic rice grown with minimum pesticides on the stepped rice paddies and also for the low temperature maturation of locally brewed sake. It makes the sake take on a soft, elegant and fruity flavor. The reputation is enhanced because of the image of having been stored in the snow.

In 1990, the "Yukinomachi Mirai-kan (The Snow town Future House)," which is a public facility having both the function as the stronghold of the "Yukidaruma Foundation" and also that of a place for interaction where public can visit, was newly constructed. The introduction of "snow air-conditioning" was a natural outgrowth of our belief that we can work in a comfortable circumstance because we have snow and that snow gathers the people. The two systems, which were adopted, were the All-air Type Snow air-conditioning system and the "Using cold-water Type Snow air-conditioning system" which had been used at the "Yukidaruma Bussan-kan (Snowman Commercial Museum)".

In the All-air Type Snow air-conditioning system, we drill a hole in the snow and cool the air by letting the air pass through the hole. Since the surface of the snow absorbs the dirt, it also serves as an air-filter. Since dew condensation generates by passing the air through the hole, it also has a dehumidifying effect and makes the air-conditioned

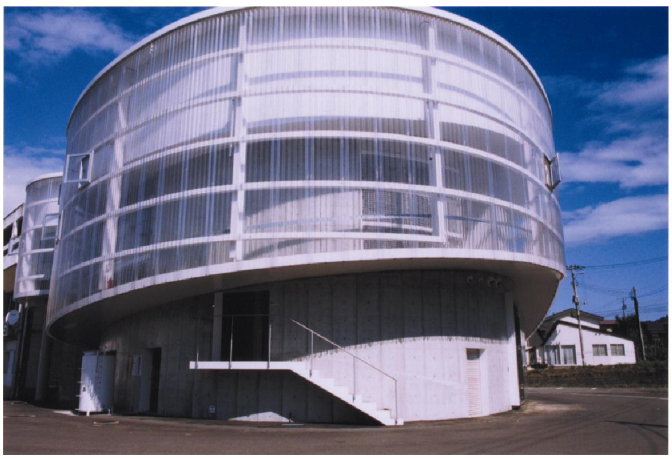

Photo-1: "Yukinomachi Mirai-kan (Snowtown Future House)" where the snow air-conditioning was introduced.

place comfortable. In addition, the rainwater fallen on the Yukinomachi Mirai-kan and the snow melt water after being used for cooling the air are gathered in the middle water pit (secondary pit) and reused for the toilet flush water. In introducing the snow air-conditioning, the construction costs are almost twice as high as the ordinary electricity air-conditioning, but the electricity cost comes to less than one-fourth.

In January 2002, the snow air-conditioning system was installed in the lunch room and the kitchen of the town-run Yasuzuka Elementary School to let the children learn and realize how splendid snow is and how nice it is to live in snow country. The children who had been unable to taste lunch well or unable to eat all their food because of the summer heat have become able to eat and enjoy lunchtime.

Gift from the Sun

In 2000, a complex facility "Yasuragi-so" and a hot spring facility "Honobono-so" were established and the "snow melt water circulating air-conditioning system" was adopted for the both facilities. In order to air-condition both facilities, we built a large snow house, which can store approximately 800 ton (1,200m^3) of snow. Moreover, by installing a "solar energy collector" on the sidewall of the snow house, the temperature of the heat storage tank reaches up to 60℃ in summer and nearly 30℃ on a sunny day in winter and serves greatly for hot water supply and heating the hotspring of both facilities.

The Bright Future of Snow Country

Yasuzuka-machi has been actively working on town planning sticking to the idea of snow as "a gift from Heaven". That is because when we seek economical and cultural plenitude in snow country, we feel snow is very close to us and we believe that the rich nature, nurtured by snow, nurtures the people and the culture. We accept the gift from Heaven with both arms extended and we will use it in the town planning that is unique to Yasuzuka.

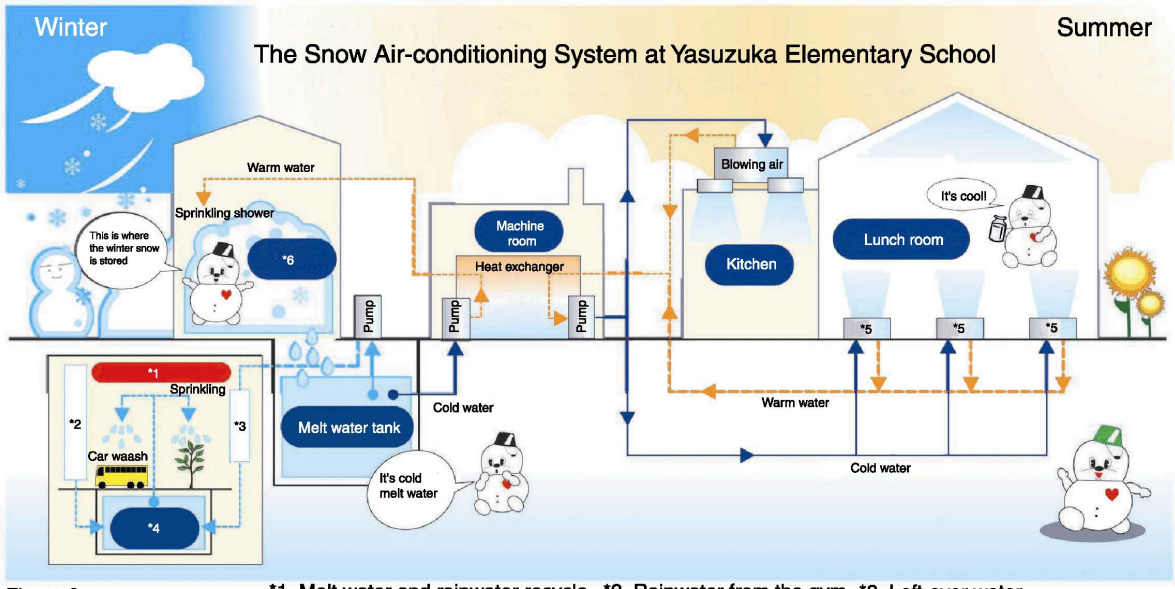

Figure-2

*1 Melt water and rainwater recycle *2 Rainwater from the gym *3 Left-over water
*4 Miscellaneous water tank *5 Blowing air *6 Snow Storage tank
Project Name:The 2001 rich and comfortable snow country planning promotion project.

The Concrete Lohse Girder Group designed by NAKAJIMA Takeshi
A young civil engineer's achievements in Nagano

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When I first studied about the structures of bridges, I found it very interesting, the classification based on the position of the road in relation to the principle bridge structure: that is, to call a bridge that has a road on the top of the bridge a "deck bridge" and the one that has a road on the bottom of the bridge a "through bridge". Among the through arch bridges, I learned that the bridge with thick arches is called a "tied arch bridge", one with thick girders, a "Langer bridge", and one with arches and girders of the same thickness, a "Lohse bridge". Professor ITO Manabu, who taught me, said that those were the names used in Japan, and in English all of them are called "tied arch bridges". This is one of the examples where the imported technologies from Germany were developed and settled with German names in Japan.

In 2002, a group of the five concrete Lohse girder bridges designed by NAKAJIMA Takeshi was selected as a civil engineering heritage recommended by JSCE in Nagano Prefecture. I was a bit surprised by this news. First, they are "concrete" Lohse girders, while ordinary Lohse and Langer types are made of steel. And, this is a "group". Moreover, an individual designer's name, Nakajima Takeshi, is crowned on the title. There are not so many cases where civil engineering structures are grouped by the structure form, location and the designer. Although there are examples of the stone arch bridge group in Kyushu or the group of bridges on the Sumida River by TANAKA Yutaka, this case is far more unique. It is Professor KONISHI Junichi and his colleagues who

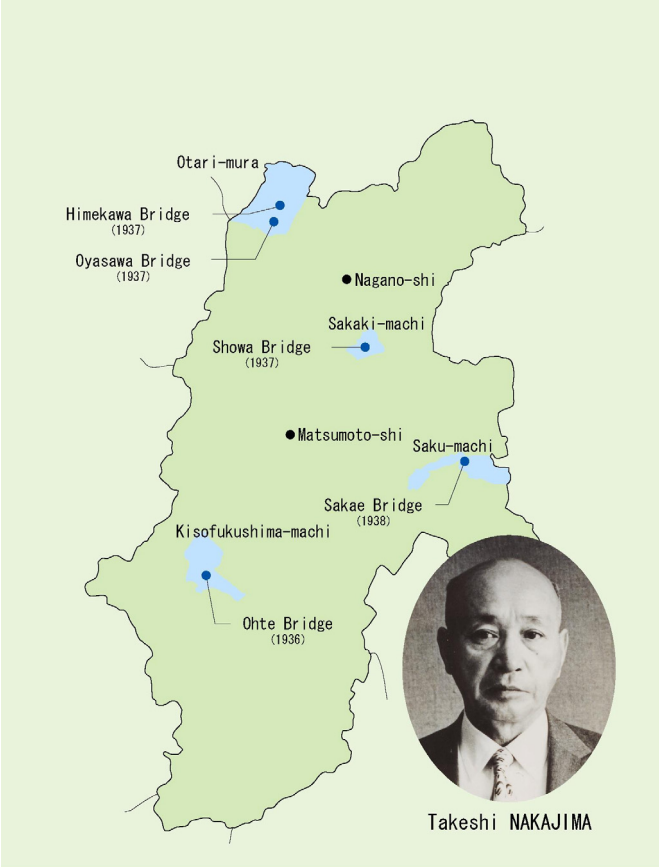

Figure-1: Locations of the concrete Lohse girder bridges by NAKAJIMA Takeshi in Nagano Prefecture

cast a spotlight on the bridges of various sizes geographically dispersed in Nagano Prefecture as "a group of Lohse girders designed by NAKAJIMA Takeshi in Nagano Prefecture".[1] Without this discovery, these bridges might have been left to decay or disappear without any attention paid. The group is composed of the Ohte Bridge in Kiso Fukushima-machi (1936), the Oyasawa Bridge and the Himekawa Bridge in Otari-mura (both in 1938), the Showa Bridge in Sakaki-machi (1937) and the Sakae Bridge in Saku-machi (1938). After an one-day examination of the route to visit these five bridges (and attractive hot spring inns) by railway and automobile, on an early winter day, I went on a trip to Nagano with my son as an inexperienced assistant.

NAKAJIMA Takeshi

The designer NAKAJIMA Takeshi (1906-1980), born in Sapporo, graduated from the Civil Engineering Department of Hokkaido Imperial University. After his career in the local governments of Ibaragi and Gifu prefectures, he was transferred to Nagano Prefecture as a road engineer in 1933. During the short period of three and a half years, before being transferred to Niigata, he designed and built six concrete Lohse girder bridges, which are said to be the earliest in the world. They were the above-mentioned five bridges and the Sakai Bridge (1939, Tobu-machi), which was removed in 1972. Nakajima wrote papers on the structure analysis of the Langer girder, the Lohse girder and the Vierendee girder when he worked in Gifu. At the time of his transfer to Nagano, a previous improvement plan of bridges, which were to be built in steel, turned out to be inexecutable due to the deficiency in steel stock. So he attempts to alter them to concrete Lohse girders instead. For that purpose, he developed a calculation method for "varied Lohse girders" with the fixed connections of the arch and the girder.[2] The connections of a Lohse girder are considered to be hinged supports, but in the case of a concrete structure, they are actually fixed. He arranged the complicated calculating methods to be very simple and also he tried to put it into practical use by figuring out secondary stress and some points to be noted in implementation. Dr. TANAKA Yutaka was an executive advisor for Nagano Prefecture at that time. He strongly supported Nakajima's idea and encouraged him to put it into practice.[3] In 1936, the Ohte Bridge, the first concrete Lohse girder bridge, was completed. Nakajima expressed his impression saying "I could not help feeling afraid when the support was removed, and I really felt the 35m-span so long". He created the same type of bridge one after another. The result was written up in his paper[4], which later became his dissertation at Hokkaido University.

Thus, the design and the construction method of a concrete girder as a standard type were established by Nakajima. Even after his being transferred, about 30 concrete Lohse girder bridges were built in the 1950s and 1960s in Nagano Prefecture. There are three bridges of the same type respectively in Okayama Prefecture and Yamaguchi Prefecture, Nagano Prefecture has an outstanding number of that type of bridges. That is clearly because of the influence of the young engineer.

Afterwards, Nakajima worked in Niigata and Kobe as the engineer for the Ministry of Internal Affairs. After the World War II, he worked as the department manager, the bureau manager at the Construction Bureau of Kinki, Chubu and Kanto Districts of the Ministry of Construction. He then held posts as Director of the Metropolitan Expressway Public Corporation, Vice President of Yokogawa Construction Co., Ltd. and President of Chizaki Road Co., Ltd.

The Bridges

The Ohte Bridge and the Oyasawa Bridge are one-clear-span bridges, the Sakae Bridge has

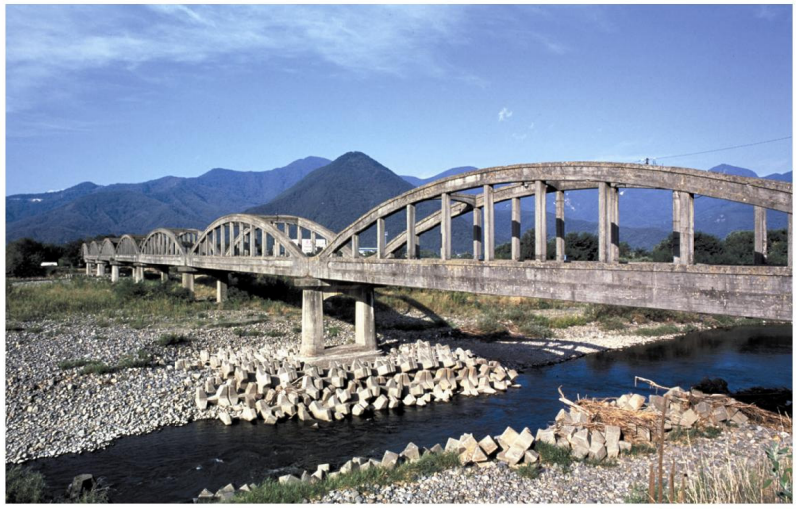

Photo-1: Showa Bridge (1937, Length 361.4m)

concrete girders on both sides of the Lohse girders. The Himekawa Bridge has three arches and the Showa Bridge has nine arches. The Himekawa Bridge and the Oyasawa Bridge in Otari-mura are both Pony type, which has no lateral bracings. As for the locations, the Ohte Bridge is located on the road leading to the Town Office, and the Sakae Bride is located in the heart of the town on the road leading to the station. The Oyasawa Bridge crosses over a steep valley alongside the railroad, the Himekawa Bridge casts its reflection on the affluent water of the dam, and the Showa Bridge rhythmically crosses over the grand Chikuma River. Each of the five bridges gives different impressions to the viewers. The degrees of the damages and repairs are not the same. However, all of them have the glamour of smooth curves, those are the catenaries of arches, the shade of hollows on the arch members, the curves on the lateral bracings, the convex parabolas produced at the connections of spans, and the curves at the end of chords that serve as handrails. All of the bridges have a human scale width of less than 6 meters and they still remain alive slowly and quietly without bearing the main road traffic. I am concerned about the progressive damage to the Oyasawa Bridge, which seems to be progressing to a critical condition. Nakajima's papers are filled with a keen sense of mission as an engineer as to how efficiently, economically, rationally and steadily bridges should be built. As a result, a concrete Lohse girder bridge was decided on as a standard design. However, it has never been applied automatically, but with some suitable arrangements respecting locations and scales. As a result, each bridge has its own characteristic expression and is harmonized with the surrounding

Photo-2: Ohte Bridge (1936, Length 34.3m)

Photo-3: Himekawa Bridge (1937, Length 92.3m)

Photo-4: Oyasawa Bridge (1937, Length 28.8m)

Photo-5: Sakae Bridge (1938, Length 86.6m)

scenery. This trip, tracing the earnest achievements by the young engineer was truly pleasant and refreshing. It also gave me a chance to reconsider what civil engineering work should be.

-All photos were provided by KONISHI Junichi

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Grass Root Efforts in Disaster Prevention in Hirogawa-cho, Wakayama Pref.

Heroic Acts of HAMAGUCHI Goryou during the 1854 Nankai Earthquake

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Discovery through a Book

Last year, I happened to read "Lighthouse in a Storm: A Moving Tale for Three Generations"(Meisei Publications: 2001) and I was greatly moved by the hero who saved the villagers from tsunami during the Ansei Nankai earthquake in 1854. This hero, HAMAGUCHI Gohei is better known as HAMAGUCHI Goryou. He lit stacks of rice straws that were piled up by the roadside to signal a safe refuge for the villagers who were adrift in tsunami in the dark. His swift action is indeed the true meaning of local disaster prevention.

On November 2nd 2002, as part of the events commemorating the 150th anniversary of the foundation of Taikyu High School, the bronze statue of HAMAGUCHI Goryou was unveiled during the ceremony that took place at the Taikyu Prefectural High School in Yuasa-cho, Wakayama Prefecture. This High School was formally called Taikyusya and was founded in 1852 by a group including HAMAGUCHI Goryou as a practice hall for both scholarship and the martial arts. On the following day, the neighboring town of Hirokawa-cho Oaza Hiro where Goryou was born celebrated the 100th Tsunami Festival. I would like to report on both of these events, which I participated. Moreover, I would like to introduce the achievement of HAMAGUCHI Goryou and the undertaking for disaster prevention in Hirokawa-cho.

Photo-1: Practice hall where scholarship and the martial arts were taught.

HAMAGUCHI Goryou

HAMAGUCHI Goryou (1820-1885) was born in Hiro-mura in Arida-cho, Kiinokuni (current Hirogawa-cho in Wakayama Prefecture) and was first named as Hichita. In 1831, at the age of twelve, he was adopted as the heir by the Hamaguchi family. He was renamed Gita and he headed for Shimousanokuni (current Chiba Prefecture). There, he worked in the Yamasa soy sauce brewing enterprise. At the age of fifteen, as the sign of coming of age, he was renamed as Gitaro**.** He continued to work in the family business while pursuing both scholarship and the martial arts. When he was 20, he married Matsu, who is the daughter of IKENAGA Umataro from the neighboring Yuasa-cho. Returning to Choshi where his family business is located, Goryou met his lifetime teacher, Ryousai Miyake who taught him about current affairs in the West.

On 1851, Goryou returned to his hometown from Edo and founded "Hiro-mura Syugidan." The

following year, he co-founded with HAMAGUCHI Toukou and IWASAKI Meigaku, the center for both scholarship and the martial arts (later called Taikyusya) in Hirogawa-mura Ta-machi. In 1853, at the age of 34, he was again renamed as Giheie and succeeded as the head of the family.

Three years after his return to his hometown, on December 24th, 1854, during the Nankai earthquake of magnitude 8.4, Goryou saved the villagers who were adrift in tsunami. As I will explain later in more details, this has developed into a story called "Inamura no Hi*." After the tsunami disaster in Hiro village, Goryou devoted his energy in the rescue effort of the villagers for a whole year. And in 1855, he formed a group "Ura-gumi" for which he assembled young men from farming and fishing families and trained them in order to strengthen the national defense. In 1880, the 61-year old Goryou took office as the first chairman of Wakayama prefectural assembly. In 1884, he went to the United States and in the following year, he passed away at Saint Vincent Hospital in New York. He was 66 years old.

The Unveiling Ceremony of the Bronze Statue

On Saturday, November 2nd from 11 o'clock, as the first of the 150th anniversary events of the founding of Wakayama Prefectural Taikyu High School, the unveiling ceremony of the bronze statue of HAMAGUCHI Goryou took place. Among the invitees were twelve guests from the sister schools, Cambridge High School in the U.S., Keri Keri High School in New Zealand, and Kouga High School in China. HAMAGUCHI Goryou, who was one of the founding members of the Practice hall from which Taikyu High School originates, befriended SAKUMA Souzan and KATSU Kaisyu who had profound knowledge in Western affairs. Goryou himself had a strong interest in the Western countries and believed deeply in the exchange with foreign High Schools.

1852, at the end of the Edo era was when Goryou, with HAMAGUCHI Toukou and IWASAKI Meigaku founded the Practice hall in Hirogawa-mura Ta-machi (current Hirogawa-cho, located in the south of Yuasa-cho). This year marks the 150th year in the history of Taikyu High School. Today, Taikyusya is reconstructed in Hirogawa-cho, near the gate of Taikyu Junior High School (Photo-1).

The gigantesque bronze statue of 3.05 meter in height, which appeared underneath the veil, gave me the impression of someone majestic and stern and at the same time, the facial expression seemed to provide warmth and hope to people (Photo-2). Amidst the congratulatory addresses by the guests, HAMAGUCHI Michio, who is the current president of Yamasa soy sauce company, who resides in Choshi in Chiba Prefecture and who is the great great grandson of Goryou commented, "Hardly anyone at that time was respected as much as Goryou."

Photo-2: Bronze statue of HAMAGUCHI Goryou

The Legend of Goryou

In the first year of Ansei, during the Ansei Nankai earthquake, the great tsunami swooped upon the Kii Peninsula. As I explained earlier, Goryou saved the habitants of coastal Hirogawa-mura in Kiinokuni by guiding them to a safe refuge with burning rice stacks. It is estimated that the height of

* Fire lit on stacks of dried rice straws.

the wave at the time of tsunami was 8 meters. 36 people lost their lives in Hiro-mura by this tsunami, 125 homes were carried away by the wave and 10 homes were completely destroyed.

This story appeared in the tenth volume of the fifth grade Japanese language arts textbook (former Ministry of Education) for the old system elementary schools. It was written by NAKAI Tsunezou and was titled “Inamura no Hi”. It became a famous story nation-wide and it must have been passed on as a moving story. Photo-3 shows the first page of this textbook. The copies of this work are displayed on the standing signboard in the grounds of Taikyu Junior High School and on the signboard in the Inamura no Hi Place in front of the Hirogawa-cho city hall. 32 hours prior to this earthquake, the Ansei Tokai earthquake devastated a wide area between Kantou region in the northeast and the Kinki region in the south (magnitude 8.4.) At this time, Goryou advised the villagers to take refuge in elevated ground to escape from the tsunami.

Goryou’s wit saved the villagers from tsunami, which is a natural disaster that occurs particularly in the coastal regions at the time of great earthquake. I find his swift and wise decision truly moving and would like to applaud for this. Since I also work on projects to prevent local residents from getting involved in natural disasters, there are so much that I could learn from Goryou’s smart action despite the lapse of almost 2centuries between us.

Photo-3: "Inamura no Hi" which appeared in the elementary school Japanese language arts textbook (author: NAKAI Tsunezou)

Hiro Village Embankment

A year after he experienced the great tsunami of 1854, Goryou consulted HAMAGUCHI Kiemon and started the construction of the great embankment at Hirogawa-mura. This “Hiro-mura embankment” was completed in 1858 and was designated by the government as the historical site. It is 2 meters wide at the top, 5 meters high and 600 meters long. Today, the embankment is reinforced by a concrete frame but it still maintains the original form (photo-4). Goryou invested his personal fortune and completed this embankment with the effort of 56,736 man-days. One could imagine from this that Goryou poured into the disaster an extraordinary zeal so that the villagers would never be involved again in the tsunami disaster that they have experienced the preceding year. This embankment is composed of a forest of pine trees, which serve as windbreak, as well as sumac from which villagers extract wax, which is one source of their income.

Photo-4: Hiro-mura embankment, which Goryou constructed with his personal fortune.

Tsunami Festival

Tsunami Festival took place on Monday November 3rd from 9 am, in Hirogawa-cho Oaza Hiro. This year marked the 100th anniversary of this event.

The celebration took place in the landfill site in the inlet at the end of Kii aqueduct. (Photo-5)

This land of Hiro was hit by great tsunamis in 1707 and in 1854. The latter was induced by the Ansei Nankai earthquake, which I have explained earlier. Ordinarily, Hiro village, which is located in the lowland by an inlet, would have been devastated but the villagers were saved by Goryo's wise action.

The celebration of Tsunami Festival started in a solemn atmosphere with 182 participants including Taikyu Elementary and Junior High School students, related organization and guests. Firstly, SASAKI Kouhei the priest of Hiro Hachiman shrine, which is located on the elevated ground where Goryou led the villagers to escape the disaster of tsunami during Ansei Toukai earthquake, gave a speech in which he consoled the spirits of the victims of tsunami and wished a prosperous future for Hiro.

Every guest's speech expressed their gratitude for Goryou's deed in saving the villagers. the mayor of Hirogawa-cho, ISHIHARA Hisao touched on the history of Tsunami Festival and explained that this festival has passed on the villagers' gratitude for the construction of the embankment. Moreover, he expressed his awe for the natural phenomenon of tsunami and alarmed the attendees of the current danger of tsunami by future Nankai earthquakes. In conclusion, a memorial tree was planted in front of the monument. It was an oak tree, which is a symbol of the town.

Photo-5: Tsunami Festival at Hirogawa-cho Oaza Hiro

Countermeasures for Tsunami at Hirogawa-cho

Along Gobo-Yuasa line, the prefectural road 23, which runs nearby the ceremonial site of the Tsunami Festival, a concrete seawall is built to prevent high tides. On this seawall, are murals of tsunamis and the Inamura no Hi (Photo-6). As you enter the residential area from this road, you can see a gate (Akamon) that is build as a tsunami countermeasure at the Hiro-mura embankment (Photo-7).

Photo-6: Murals of tsunami and "Inamura no Hi" on the concrete seawall

As I observe these structures that are built as tsunami and high tides countermeasures, I realize that Hirogawa-cho has learned from their bitter experience of the past tsunamis as well as Goryou's legacy. It is a town with a strong awareness for disaster prevention and it taught me the very starting point of disaster prevention.

Conclusion

These days, my activity is focused on the disaster prevention effort at the local level. In promoting local disaster prevention, I think to pass on the legacy of a person like HAMAGUCHI Goryou who has made a great contribution in disaster prevention and reduction would provide an occasion for the residents to think about natural disasters. In writing this article, I referred to "Burning rice stack: the foot print of HAMAGUCHI Goryou, a man who

fought the tidal bore" which is published in 1998 by Hirogawa-cho, Wakayama Prefecture and also to "Tale of HAMAGUCHI Goryou" published in 1934 by the Organizing Committee of the 50th Anniversary Festival Commemorating the Death of HAMAGUCHI Goryou.

Acknowledgement

In participating both events, Mr. YABUZOE Yasuhiro, the principal of Taikyu High School and other teachers, as well as the staffs of Hirogawa-cho town hall have been very helpful to me. Also, Mr. SHIMIZU Isao who is the director of Hirogawa-cho central public hall (former principal of Taikyu Junior High School) guided me to places related to Goryou. I would like to express my sincere gratitude for these people.

Photo-7: The gate (Akamon) for tsunami disater prevention in Hirogawa-cho, Oaza Hiro.

NHK New Year's Eve Grand Song Festival
Live Broadcasting from Kuroyon Power Plant

Masaki MATSUMOTO
General Manager
Office of Civil Engineering and Architecture
The Kansai Electric Power Co. Inc.
(General Manager, Hokuriku District Office-as of July 31, 2003)

Photo-1: Overview of Kurobe dam at wintertime.

"Star on Earth" by Miyuki Nakajima

During last New Year's Eve Grand Song Festival, which is broadcasted annually by NHK (Japan Broadcasting Corporation), "Star on Earth" by Miyuki Nakajima was broadcast live from *Kurobe Gawa No.4 Power Plant (Kuroyon)*. This song is the theme song of a popular NHK program "Project X: Challengers." As it was also the first time that Ms. Nakajima, a widely popular singer who writes her own songs appears on this program, the event drew a great deal of attention from the public, marking the highest viewing rating in the history of the program (54,9% in Kansai area according to Video Research).

According to the NHK website, "Project X" is a documentary series "featuring obscure pioneers who played a major role in the country's epoch-making projects after World War II." Since it was launched in April 2000, it has inspired courage and moved viewers throughout Japan. Ms. Nakajima was requested to write its theme song, "Star on Earth" by the production team. Singing about the "lights of obscure pioneers" this song seems to cheer today's Japanese businessmen and its popularity has become a social phenomenon. In a construction site in metropolitan Tokyo, this song is played every morning at the meeting to raise the spirits of the workers. In fact, some KEPCO power plants also play this song at the start of the work.

Kuroyon Construction and "Project X"

The reason why Kuroyon was selected as the live broadcasting site for the Song Festival was of course because "Project X" featured the struggle of workers in the Kuroyon Construction Project. NHK listed Mt. Fuji and Seikan Tunnel among others as possible sites for live broadcasting. However, after discussing with Ms. Nakajima who was greatly moved by the struggle for Kuroyon construction, they decided on Kuroyon as the site.

Kuroyon Plan was to construct a dome-type arch dam in the valley at a height of 1268 meters above sea level in the upstream of Kurobe River, which flows between Tateyama and UshiroTateyama mountain ranges. The dam was to be 186 meters high

with the length on top of the dam at 495 meters. Its total capacity was to be 200 million cubic meters and its available capacity was to be 150 million cubic meters. Moreover, it was to lead water to the underground power plant in the downstream and produce electricity of maximum 258 MW by using 545.5 meters effective head.

Greatest obstacle in realizing this plan was to transport construction materials that weigh up to 600 thousand tons to a truly unexplored region with precipitous cliffs hindering the way. The main transportation artery was the 5.4km "Kanden Tunnel (known at that time as Omachi Tunnel)" which runs east and west from Omachi in Nagano Prefecture to the region right below the Northern Japanese Alps at a height of 1500 meters above sea level. As the early completion of this tunnel was the key to the success of Kuroyon Construction, the plan was to start excavating from both Omachi side and the dam side.

With the help of latest excavator, excavation from Omachi side made a good progress in the beginning but it encountered a fractured zone at 1691 meters from the portal. There, ground water of 4 degrees Celsius gushed out from the soft ground at a maximum of 660 liters per second, at hydraulic pressure of 42 kg/cm^2, an incredible force. The team made a breakthrough with technological study and indomitable effort but it took seven months to excavate 80 meters of this fractured zone.

On the other hand, counter excavation effort from the side of dam site faced the difficulties of transporting the materials to the site. All necessary materials must be transported over the Tateyama mountain range of over 3000 meters in height. Material transportation through precipitous cliffs was undertaken by manpower with almost 400 workers involved during busiest periods. During winter times, they took advantage of deep snow to descend the steep slopes of Tateyama by sleighs and bulldozers, which was obviously a very risky operation.

As soon as "Kanden Tunnel" was completed with great difficulties, transportation of heavy machines to the dam site started and construction works for the dam and for the power plant made a rapid progress. And in June 1963, after 7 years, efforts of 10 million man-days, and 51.3 billion yen, Kuroyon Construction was finally completed.

There is even a novel titled "Kurobe no Taiyo (Sun of Kurobe)"[1] which centers around the excavation work of Kanden Tunnel. This was made into a film with the same title starring Yujiro Ishihara and Toshiro Mifune, both prominent stars of Japanese films. "Project X: Challenging Kuroyon Dam during Severe Winters" which was broadcasted in June 2000 focused on material transportation over Tateyama and the struggle of the wintering team at the dam site.

Photo-2: Fractured zone at the heading of the Kanden Tunnel. (1957)

Live Broadcasting Site for New Year's Eve Song Festival

After the program, I received many inquiries about the location of the live broadcasting site. Every time, I answer that it is a track tunnel near Kuroyon power plant but I wonder if they are correctly understood. So I would like to use this opportunity to

[1] By Seiji Kimoto, published by Shinano Mainichi Newspaper

describe the site in more details.

It might be obvious to the readers of *Civil Engineering* that it is a common practice to build hydraulic power plants way downstream of the dam in order to maximize the effective head. Kuroyon power plant was built in the area called Higashidani, 10km north from the dam along the Kurobe River.

All facilities from the power plant to the substation and the switching station were constructed underground. This almost globally unprecedented decision took into consideration the fact that the surrounding area is designated as Chubu Mountain Range National Park requiring special care for the protection of the natural environment. Also, it is not uncommon that the lowest temperature in the wintertime in this region drops to 20 degrees Celsius below zero. The facilities were constructed underground in order to prevent damages from avalanche and accumulation of up to 3-4 meters.

To excavate an enormous cavity, which could contain numerous structures 200 meters below ground on a steep mountain area was not an ordinary feat. Excavated rocks amounted to 500 thousand cubic meters. With unexpectedly poor geological condition, this work was as difficult as the excavation work for Kanden Tunnel and the dam construction.

The live broadcasting took place in one of the tunnels that were excavated as a path from downstream to Higashidani excavation site. It is commonly known as "Jyoubu-kidou" or an upper track. Prior to the Kuroyon construction, there was a track connecting the 5.6km between Keyakidaira and Senninndani. This was extended for another 0.9km to Higashidani construction site and has become known as Jyoubu-kidou. The completion of this main

Figure-2: General map around Kurobe River.

connection route facilitated the transportation of materials from downstream and the transportation of excavated rocks and workers. Even today, 76.2cm wide trains run on this Jyoubu-kidou daily and it is used as the transportation route connecting the power plant with the downstream areas.

The stage for the live broadcasting was located in this track tunnel, at a point approximately 100m downstream from the entrance at the power plant. It is a narrow space, 3.3 meters wide, and its height does not even reach 3 meters. The surrounding walls are not lined with concrete. Although they seemed impressive through the TV screen, aided by the lighting effects, in reality, there are nothing more than irregularities that the exposed ruggedness of the rock surfaces create.

Backstage of the New Year's Eve Song Festival

According to the staff of our company at the site, NHK was well prepared for a live broadcasting

under severe circumstances. They sent technical team to investigate the site many times before selecting the right spot for live broadcasting. Notably, prior to the selection, a technical staff checked the acoustics inside the track tunnel by walking slowly in the tunnel while clapping hands to listen to the echo.

The "switching center" which serves as the base for the live broadcasting was placed on the second floor of Kuroyon power plant. From there, the airwaves were relayed to NHK headquarters in Tokyo by satellite, via an outside broadcast van, parked at Ogisawa trolleybus station which is operated by KEPCO.

KEPCO gave a full support so that the live broadcasting of this national program would succeed. Over 60 man-days of our staff were involved in the preparation more than a month before the actual telecast. On December 28th, three days before the telecast, about twenty of our staff entered the site to help transport the equipments and to secure the power supply and communication circuit.

According to our staff at the site, on December 30th, Ms. Nakajima visited the track tunnel, which was to be her stage. Then she returned to the sleeping quarter before coming back to the Kuroyon power plant on the 31st, under the powdery snow. She had many rehearsals before the actual telecast at 11 pm.

During the telecast, Ms. Nakajima wore a wine red evening dress. She powerfully sang the "Star on Earth" as she advanced slowly in the track tunnel in 2℃ below zero temperature. I was extremely moved by this, which I assume many of the readers were watching also.

It seems that Ms. Nakajima is a very friendly person off stage. She spent the rest of the New Year's Eve with staffs in one of the facilities of t

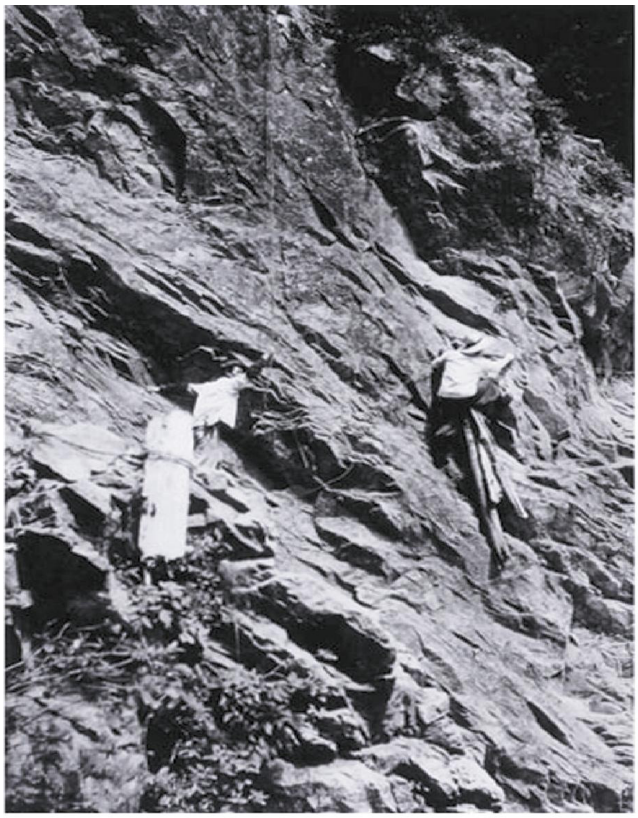

Photo-3: Transportation of materials on precipitous cliff by manpower. (1956)

Photo-4: Excavation site for the Kuroyon power plant. (1959)

the power plant. They served traditional New Year's dishes for celebration such as the Toshikoshi noodle and Osechi. At the dawn of the New Year, Ms. Nakajima toured the facilities of the power plant, guided by our staff and left Kurobe, early in the morning.

Kuroyon Construction and Civil Engineering in Japan

Photo-5: Live broadcasting site for the New Years Eve Grand Song Festival.

Kuroyon Construction was a project of an unprecedented scale in the history of civil engineering in Japan. Not only has it played an important role in fulfilling the societal mission of stable provision of electricity, but it has also assembled technological expertise and wisdom from around the world in the areas of construction planning, design and building. Moreover, it has given many new directions to the civil engineering construction in Japan and in the world.

Construction of dome-type arch dam was the fruit of world-class research. During construction, numerous Japanese as well as world records, for example tunnel excavation speed and per month rate of concrete pouring were renewed by adopting new methods using latest heavy machineries.

However, we should not forget that behind this achievement lie the sacrifices of 171 workers who died during this project. The last scene of "Project X" in which Mr. Sei Nakamura, formerly of Hazama Corporation visited the dam site was truly memorable. Mr. Nakamura, who served as the project manager of the Kurobe dam, vowed to the monument titled "Dedicated to the noble sacrifices" and as he traced the engraved names of those who had died for this project, he murmured that we owe so much to these people.

Today, civil engineering in Japan is experiencing extreme hardship in midst of continuing economic stagnation. It is also true that there are severe criticisms toward the existing systems related to large-scale civil engineering works. Nonetheless, we, civil engineers must face each and every one of the current and future "Project Xs" as "challengers," remembering the hard work and the achievements of our predecessors.

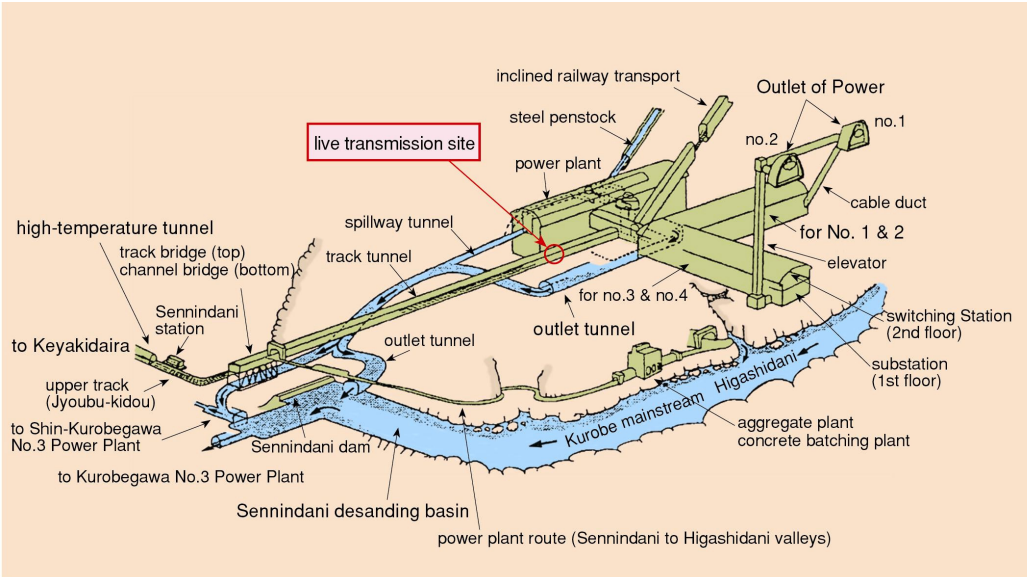

Figure-1: Plan of underground construction around Kuroyon power plant.

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“Disaster Reduction and Human Renovation Institution” in Memory of the Great Hanshin-Awaji Earthquake

Miho YOSHIMURA
Institute of Industrial Science
The University of Tokyo

Preface

In the next 50 years, large-scale earthquakes off the Miyagi Prefecture shore, in Tokai Sea, in Tounan Sea, and in Nankai Sea are regarded as imminent. This article, which is the second of the Virtual Civil Engineering Museum series, is going to introduce the “Disaster Reduction and Human Renovation Institution,” established in memory of the Great Hanshin-Awaji Earthquake, which occurred in January 17, 1995. This institution aims to transmit the experience gained by the earthquake from Kobe to the entire Japan, and eventually to the world.

Background and the Summary

On April 27, 2002, seven years after the occurrence of the Great Hanshin-Awaji Earthquake which hit the southern part of Hyogo prefecture, Disaster Reduction and Human Renovation Institution was opened at the HAT Kobe in Chuo-ku, Kobe City. Its name was chosen among 7,612 submissions from the public. Consequently, the chosen name implies the resolution to pass on the experiences and lessons from the earthquake to future generations, to convey the “importance of a life and the joy of coexistence,” to pass on the importance of “disaster reduction” to future generations and support disaster reduction activities.

The glass cube, which attracts people’s attention among the structures of the HAT Kobe building complex, is the Disaster Reduction and Human Renovation Institution. The building, which looks like a solid crystal, symbolizes Kobe that continues to grow and discloses information on disaster prevention unreservedly.

Photo-1: The Center (Left: Phase Ⅰ, Right: Phase Ⅱ)

Conveying the Experience of the Great Hanshin Awaji Earthquake

The visitors first stop by at the “1.17 Theater” on the 4th floor of the Disaster Reduction Museum to understand what actually happened at 5:46 am on January 17, 1995, when the Great Hansin-Awaji Earthquake actually hit the area. The film, using computer graphics and special effects, tells the horrendous story of that moment, showing how houses and office buildings collapsed, how the Kobe line of the Hanshin Express Highway collapsed and how fires broke out. When you come out of the theater, stunned at the shocking images, what you see there is the destroyed and burning cityscape shortly after the earthquake hit, which was reproduced as a diorama. Leaning concrete condominiums and wooden houses are re-created in full-size and you can virtually experience what you have just seen in the theater.

Next, the visitors stop by the “Great

Earthquake Hall," where a documentary film recounts how disaster recovery and reconstruction were carried out in the devastated areas from a victim's point of view. The film consists of moving images that were actually used for reporting the quake-stricken town of Kobe, earthquake victims sheltered at school gyms and classrooms, funerals of the victims, hurriedly constructed temporary houses. The film gives us a renewed recognition of the seriousness of the damage Kobe suffered from the earthquake.

Going down to the 3rd floor, visitors find "Learning the Reconstruction Process from the Disaster," an area devoted to information retrieval and instruction about the Great Earthquake based on the actual materials and data. There, visitors can go around five tables and learn about the people's lifestyle and how the city was at that time. In the area, "For Learning about the Messages from the Earthquake", belongings that were donated by the earthquake victims (500 photographs, 260 notes and 70 items of actual materials) are exhibited. If you borrow a "barcode navigation system (B-Navi)," you can check out more detailed comments and experiences, and when you leave, you can print out all the information you need to take home. On the 2nd floor, there is the "Information Container" that conveys the latest information with regard to disasters and disaster management, and the archive that collects and stores referential data.

Photo-2: Disaster situation recreated in a diorama

Photo-3: The Great Earthquake Hall

Volunteers who Support the Institution

140 citizens support the operation of the institution as volunteers in charge of exhibitions, language assistance and storytelling. Among them, storytellers add reality to the exhibited items. At present, approximately 20 storytellers are actively participating and I was able to interview two of them. Mr. Saburo TANIGAWA is originally from the civil engineering field. At the time of the earthquake, he was working for the Ashiya City Hall and he contributed greatly in coping with the disaster and reconstructing the city afterwards. Having retired, he felt that there was something he had left undone, so here at DRI he tells his experiences of that time to visitors. Mr. Tetsuo SENDA expresses his experience and memory of the earthquake in the form of *tanka*[1]. Some of them are introduced here, in the column below. The images of people who are striving to survive under harsh conditions move our hearts all the more through these simple verses with 5,7,5,7,7 syllables.

[1] Japanese poem in five lines and thirty-one syllables

Photo-4: The Learning Corner on reconstruction from the disaster

Institution as a Regional Base for Disaster Reduction Education

One third of the groups who visit the institution are elementary, junior high and high school students. Many of them come from afar during the integrated studies period or for school excursions. A large number of exhibitions are intended for children, in order to direct their attention towards safe and secure town planning from an important early stage as schooling. Last summer, the Institution held a disaster prevention workshop for children to provide a topic for their independent research project during summer vacation. The participants experienced making a disaster map of the town and experimented on liquefaction using plastic bottles with the staffs and students from the Environmental Disaster Prevention Course at Maiko High School, Hyogo Prefecture.

Photo-5: Left: Making a disaster map, Right: Liquidation experiment using plastic bottles

Human Resources Development

One of the important functions of the Institution is cultivation and development of human resources. It holds trainings courses specializing in disaster countermeasures for staffs in charge of disaster countermeasures in the national/local government bodies in order to improve their capacity to respond to disasters based on the experience and lessons from the earthquake. It also makes an effort to foster full-time researchers as experts who can give integrated and practical advice to the disaster countermeasure offices at a time of a large-scale disaster. Dr. Yuka KARATANI, one of the full-time researchers, recounted the following:

"Our goal is to help reduce the damages from disasters both in Japan and abroad by continuously conveying the lessons we learned from the Great Hanshin-Awaji Earthquake through various functions of this institution. I was moved so much when an earthquake victim who visited the Institution said to me, 'these exhibitions may be just "things" to you, but us, the victims, they are valuable objects full of memories.' As I continue the research on disaster reduction, I hope to see from the victims' eye level and listen to the visitors' voice."

Photo-6: Full-time researchers (Dr. Karatani second from right in the back row)

On April 26, 2003, the "Human Renovation Museum" was newly opened to honor the preciousness of life and the joy of coexistence. I believe the Disaster Reduction and Human Renovation Institution is the fruit of people's wish to pass down the experiences of

the earthquake and I hope you would also listen to the message from Kobe.

Facility Information

Location: 1-5-2, Wakihama Kaigan-dori, Chuo-ku, Kobe

Telephone: 078-262-5050

Please consult the following website for more information about the center (hours, entrance fees):

http://www.dri.ne.jp/html/english/index.html

The Earthquake in *tanka* (by Mr. Tetsuo SENDA, *translation: Emiko SERINO*)

(1) On a wall of a collapsed house, there is a note saying that a child still lies underneath.

(2) Kindly, someone gave a little water left for drinking saying it was to wash an injured person.

(3) The big round moon rose again over the town that was crushed and lowered.

(4) A truck came and stopped at a new house bringing another family back home.

(5) Six years have passed and a window reflects the bright lights of Kobe that I love.

Sekisho-Kan, Wisdom and Technologies of the Bridge Engineers from the Late Edo to Early Showa

Tomomi HORIGUCHI
Japan Railway Construction Public Corporation

It is said that approximately 90% of all arched stone bridges (spectacle-shaped bridges) in Japan are located in Kyushu. Among them, most are located in Kumamoto Prefecture, amounting to more than 300 in number. In 1994, Sekisho-kan was established in Toyo-mura, Kumamoto Prefecture to disseminate the bridge-building technology using the indigenous material and to communicate how the regional governing body responded to the people's demand and realized them. In this museum, the spectacle-shaped bridge technologies, the civil engineering work system and the effects of these bridges are presented in a way that everyone can easily understand.

Photo 1: Sekisho-kan: Building made of indigenous welded tuff is suited to pass down the stonemasonry to the future generations.

The Origin of Sekisho-kan

In about 10 minutes by car from Yusa Station on the JR Kagoshima Line, you will soon find a modern structure made of stone bricks, in the abundant greenery of Southern Aso. This building is Sekisho-kan or the "stone engineering museum," where the ideas and the technologies of Taneyama stonemasonry, which originated in Toyo-mura (former Taneyama-mura), are passed on.

Since wooden girder bridges were often washed away during floods and required to be rebuilt again and again, people longed for bridges that could resist floods. The sense of mission of the Soshoya (equivalent to the mayor), and the local stonemasonry united here in Toyo-mura at the end of the Edo Era to give birth to numerous spectacle-shaped bridges in Kyusyu and throughout the country.

Wooden bridges had been replaced by iron bridges such as railroad bridges and today, most bridges are made of concrete. However, with a belief that the stone bridge culture represents the man's wisdom to create the environment, Sekisho-kan was established with the purpose of passing down the wisdom and technology of the Taneyama stonemasons to the future generations, by appealing to the four senses.

Photo 2: Full-sized wooden arch support

Disseminating the Technology

The first thing that will catch your sight as you enter the museum is the wooden full-sized arched

support that is a reproduction of what used to be in the old days. You will no doubt be moved by the geometric beauty created by civil engineering that fought nature and used the power of nature, and by the greatness of the technology that realized it. How stone was processed without machinery is reproduced in a large diorama, and you can see how people worked in the old days. There is also a device, which allows you to experience and understand how huge stones were transported at a time when there were only limited ways of transportation. By actually moving 20~50kg stones using a lever, a wheel set, a pulley or a roller, which are familiar to us through elementary school science course, you can perceive that it is in fact possible to build a bridge using huge stones.

What the author found most interesting among the exhibitions that one can touch and feel was a corner where we can make our own spectacle-shaped bridge. Though it is just about a 40 cm radius arch, I piled up blocks resembling stones on a plastic support that could be lowered or elevated electrically. When I placed the keystone, I felt the entire block tightening and I was thrilled when I pushed the button to lower the support. The moment when I saw the arch standing by itself after the support was lowered was when I felt the joy of creating.

Photo 3: Children absorbed in making a model spectacle-shaped bridge

System of Civil Engineering Works

A "Fantaview" or a 3D animation reproduces the stonemasons' work method in the old days, shows how the spectacle-shaped bridges were created out of people's necessity, and demonstrates the processes of their construction. The film lasts only 2 to3 minutes, with easy-to-understand 3-D images and simply worded narration. You will no doubt be drawn to the fast-paced development of spectacle-shaped bridge construction images and feel as if you were actually at the construction site.

Photo 4: Diorama reproduces the stonemasons' work

Photo 5: 3-D animation; Fantaview

The Man behind Sekisho-kan

Communication has an important place at Sekisho-kan. The director, Mr. Naotaka Uezuka tries to communicate directly with individual visitors as well as with groups with reservations, as much as the time allows. Mr. Uezuka is a great fan of spectacle-shaped bridges as he has been close to them since his childhood. It is his hope to increase the number of spectacle-shaped bridge fans by communicating with the visitors and talking about the bridges in their hometowns, for instance.

Photo 6: The director explains the principle of arch building using a model.

"The Soshoya and the stonemasons made the people's wish for these bridges come true. Not only did the bridges connect the banks, but they also brought upon benefits in the industry, the economy, the culture and the communication of their regions. I would like to let people know that these bridges enriched not only the people's lives in those days but that they have also raised our living standards today." His explanation made me fully understand what great effects spectacle-shaped bridges have brought upon us.

Conclusion

Sekisho-kan teaches us about the wider effects of the bridge construction works as well as the stonemasonry. It shows us that on top of skillful masons, various factors such as politics, economy, technology, and material are necessary for the stone bridge construction. It also demonstrates how bridges have greatly improved the people's living standards. In reviewing the future infrastructure development, it might be worthwhile to visit Sekisho-kan to consider how civil engineering works have been realized in the past.

Facility information

Location: 98-2, Oaza Kita, Higashi Toyo-mura, Yatsushiro-gun, Kumamoto

Tel: 0965-65-2700

http://www.toyo.hinokuni-net.jp/sekisyoukan/INDEX.HTM (Japanese only)

Open: 9:00 ~ 16:30 (Door closes at 16:00)

Closed: Monday (Tuesday in case Monday is a holiday)

Admission Fees:

Adults: ¥300,

College or High School student: ¥200,

Others: ¥100.

Construction of subway extension of Kyoto city

—Huge Rectangular Shield Tunnel—

Takeshi Tamura Kyoto University
Mamoru Furukawa Kyoto Municipal Office
Tsutomu Nakao Kajima Corporation

Subway of Kyoto City

Kyoto, the former and historical capital of Japan for over 1,000 years, began in 1981 to operate the Karasuma Line which runs 13.7km from south to north as the first subway line. This line was followed in 1997 by the Tozai Line which runs 12.7km from west to east-south as shown in Figure 1. The subway system of Kyoto City was further required to serve for the traffic network combining together with other rail lines. As a part of such an important project, 2.4km of extension from the east-south end of the Tozai Line was proposed by Kyoto City and this plan was approved by the Japanese Government to be implemented.

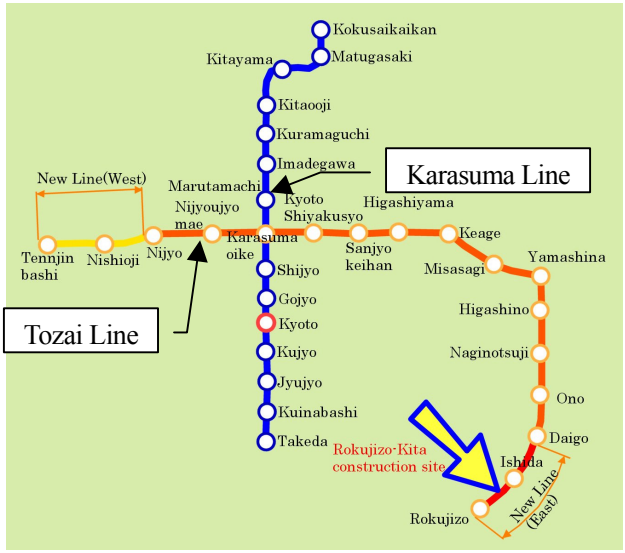


Fig.1:Subway map of Kyoto City

Two new stations along the extended line, Rokujizo and Ishida Stations, were to be built by the cut-and-cover method while the rail tracks between the stations were to be built by the shield tunnel method. The construction of the extended line, which is one of typical urban engineering works, was initiated in 1999. Particularly the construction works near Rokujizo Terminal faced to a lot of difficult issues from the technical point of view. A key to solve these issues was how to construct efficiently the crossover part where the trains transfer from the south-bound line to the north-bound line. This report summarizes the design and construction processes of the crossover section near Rokujizo Terminal.

Huge Rectangular Shield Tunnel

The Technical Committee of the Kyoto Municipal Traffic Bureau continued to discuss carefully about the construction method for 57m long crossover section just next to Rokujizo Station and finally decided that it should be built by a rectangular shield tunnel without the center pillars and that 703m long running (non-crossover) part up to Ishida Station by a rectangular shield tunnel with the center pillars as illustrated in Figure 2. The reasons why the shield tunnel was adopted even for 57m long crossover section are

1) the road above the subway has a quite heavy traffic as a bypass of Route 1,

2) it has advantages in cost and construction period if the environmental impact was considered.

The circular shape is, of course, the most popular for the shield tunnel and its design method is well established through many experiences. A rectangular shape of shield tunnel was, however, employed to make both of the track level and the ground coverage appropriate. Indeed the total height of the rectangular tunnel was reduced into almost 2/3 of that in the case of the circular one. The outer horizontal length of the tunnel section is 9,900mm while the outer height is 6,500mm.

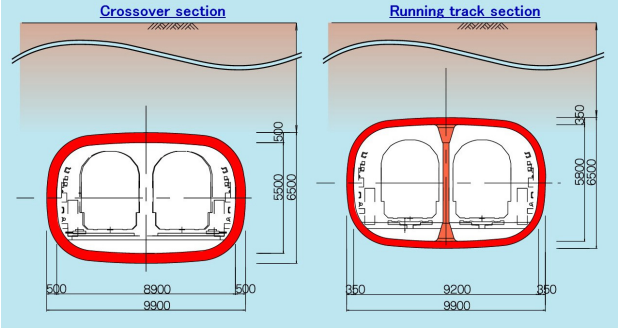


Fig.2: Two different cross sections

This huge rectangular crossover section without the center pillars was surely a worldwide new trial in the history of the shield tunnel. One of the most difficult problems in the design of the tunnel segments at this section was how to confirm the mechanical function of the rectangular shield tunnel which has no center pillar.

Rectangular Shield Tunnels in Japan

The non-circular shield tunnel excavated by the closed type machine is rather new. Figure 3 shows the chronological development of the non-circular shield tunnel in Japan. In the early stage, the 12m^2 cross section of vertically-long elliptical shape was constructed. In the following 10 years, the triply-enlarged cross section of non-circular shield tunnel with 1.6 of flatness ratio (long radius/short radius) became in practical use. The shield segments were mainly made of steel or were the composite structure of steel shell and cast concrete. But no reinforce concrete (RC) segment has been adopted for the case of the rectangular shield tunnel which has no center pillars. The segment thickness of the steel or composite structure can be, in general, smaller than that of RC segment. There are actually some cases where the ratio of the thickness of segment to the longest diameter is around 5%.

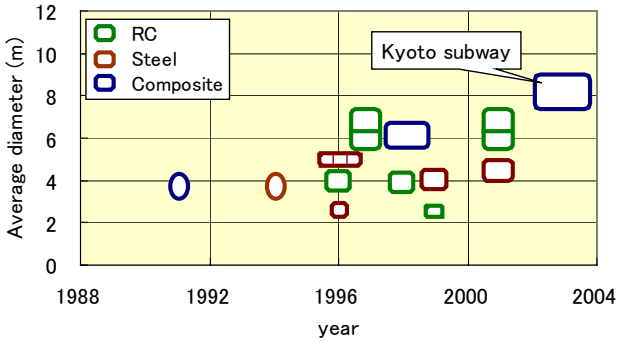


Fig.3: Development of non-circular shield tunnel in Japan

Through a lot of investigation, the composite type of segments with 500mm of thickness was considered to be the most appropriate for the crossover section. On the other hand, the segments of the running section which has the center pillars are made of the ductile cast iron (DC). The top and bottom segments connected by the center pillars are of the corrugate type DC which is highly rigid while other segments are of DC with 4 beam-stiffeners. The thickness of the DC segments was designed to be 350mm. No secondary lining was made for both of crossover and running sections.

The expected rigidity and bearing capacity for the composite and the DC segments were confirmed through the segment-piece test and the assembled-segments test for both types of sections. Photo 1 shows the assembled-segments test of the composite type. As the test results,

1) the so-called “spring-beam model” is applicable to the rectangular section when the structural analysis is done.

2) the sufficient bearing capacity is assured for both types.

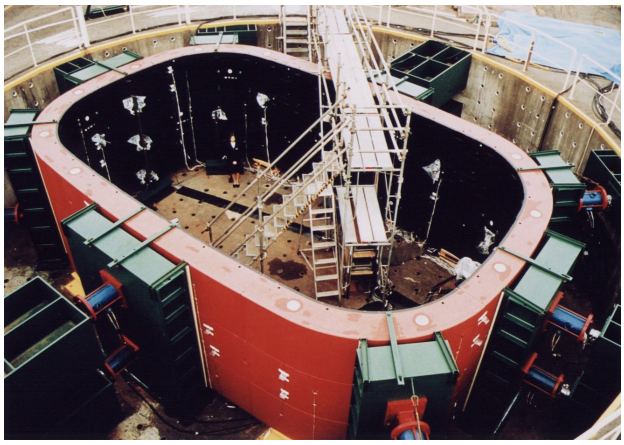


Photo 1: Assembled-segments test on composite segment rings

Photo 2: Connecting part of two different sections

Some amount of vertical deformation discontinuity cannot be avoided at the connecting part of the crossover portion and the non-crossover (running) portion since both types of segments have the different structural properties. To smoothen such discontinuity, 5 rings of transit interval was placed by using the composite segments with the adjusting center pillars. Photo 2 shows the connecting part of two different sections.

Shield Machine

The geological strata from the surface at the construction area are the alluvium, the upper diluvium (terrace deposit) and the lower diluvium (Osaka Group) in order. The shield tunnel was constructed from the south end passing through the upper diluvium to the lower diluvium. The ground coverage is around 12m while the ground water level is located 2-5m below the surface. Most typical shield machine for the rectangular tunnel is of the high density slurry type. Several excavation methods such as "the multi-axes type", "the swinging type", "the over-cutter type", "the eccentric cutter type", "the eccentric multi-axes type" and "the cylindrical drum type" are practically applied. But experiences of long excavation of the non-circular tunnel for the sandy ground were quite few compared with the circular section since the problems of the reliability of excavation mechanism and the abrasion of bit cutters were still unresolved. Finally the Wagging Cutter Shied method was adopted for this tunnel which excavates the ground mainly by wagging a pair of cutter heads within a limited angle and has a special over-cutting system to excavate the corners of the rectangular section. Photo 3 shows the front view of the shield machine.

Photo 3: Wagging Cutter Shied Machine

The erector which controls 6 axes works to assemble the segments. Three shape retainers shown in Photo 4 are equipped with to reduce the initial deformation of the shield tunnel where no center pillar is installed.

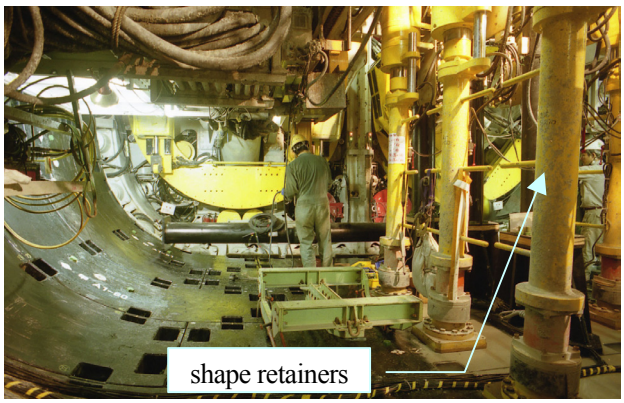


Photo 4: Shape retainers

Construction Achievement

The shield machine launched from Rokujizo Station in February, 2002. The initial advancement per

day was 1.72m at the crossover section and 3.15m at the running section. The average advancement per day at the steady state was improved up to around 6m. The following findings were remarked.

1) The vertical earth pressure at the crossover section was reduced down to the half of the predicted value after removing the shape retainers as shown in Fig.4.

2) On the other hand, the magnitude of the deformation was close to the predicted value. This is considered to be due to the displacement gap between the adjacent segments which was ignored in the analysis.

3) The earth pressure and the member forces of the DC segments were almost close to the predicted ones.

4) The mechanical conditions of the composite segments and the DC segments were stable with the high safety factors.

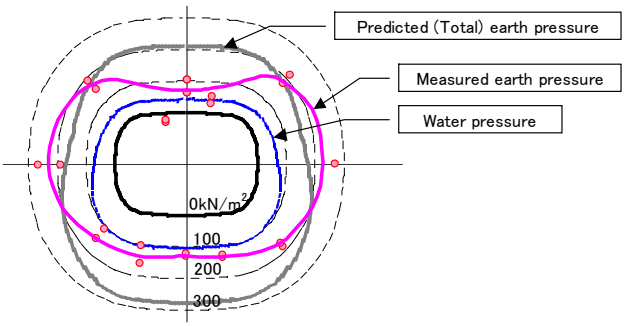


Fig.4: Earth pressure at the crossover section (after removing the shape retainers)

New Challenge

What was the most important point of this construction project is whether the technology established through the circular shield tunnel is applicable to the huge non-circular shield tunnel. The lateral earth pressure of the circular tunnel is believed to increase surely by the vertical deformation at the excavation process which makes the tunnel structure more stable from the mechanical point of view. But such a fundamental mechanism of tunneling has not been verified for the huge rectangular tunnel. In other words, the prediction of the earth pressure applied to the huge rectangular shield tunnel was quite an interesting and challenging subject. A lot of discussion and experiments by engineers from the beginning of the project for several years led to a new breakthrough for the shield tunneling technology. Based upon the careful procedure as well as the detailed observation on site, the construction was completed very safely and successfully as shown in Photo 5. The deformation and the stress states of the tunnel to date are kept to stay within the predicted range.

Photo 5: Completed crossover section (March, 2004)

Construction of a road tunnel by urban NATM in build-up area

－Hanshin Expressway Kobe Yamate Line Kobe Nagata tunnel－

1. Introduction

Hanshin Expressway Kobe Yamate Line is an urban highway planned in western area of Kobe City.

The highway is planned to construct through hill and urban area, and NATM tunnel was selected in 40% of total length of 9.5 km. Most of the tunnels are running below build-up area.

To construct a tunnel in urban area, construction in severe condition is required, restriction on alignment or site area, measures to protect on-ground and under ground structures, or topographical and geological conditions etc.

Severe conditions in this project are such as the measures to control ground settlement at unconsolidated ground with small overburden(Kobe Nagata tunnel), the proximity construction about 10m right above a subway tunnel (Myoho-ji tunnel), the adoption of the glasses section by joining two tunnels to solve the problems from the land usage along the route (Shirakawa tunnel), etc.

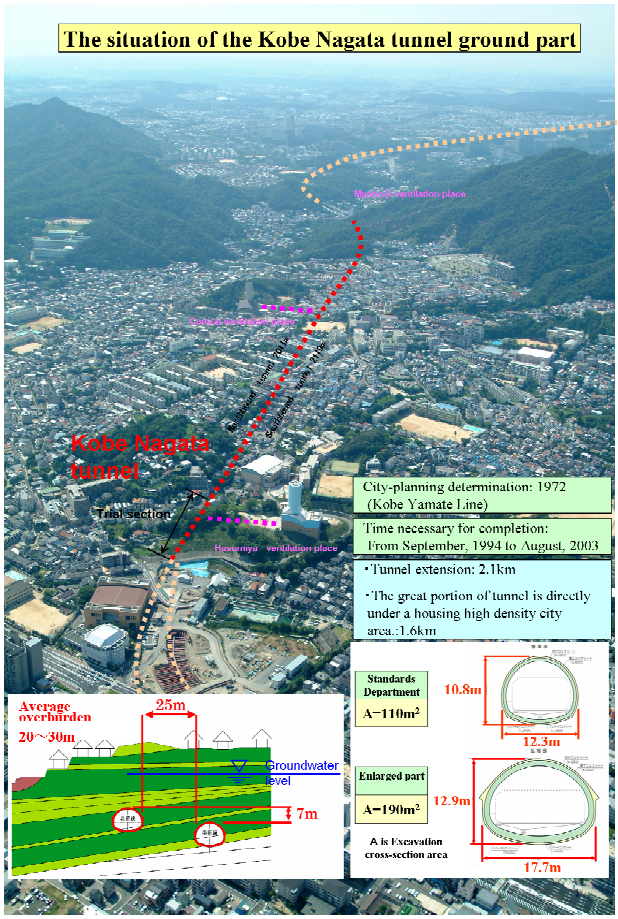
This paper describes the technical achievement in urban NATM through the construction of the Kobe Nagata tunnel.

2. Outline of Kobe Nagata Tunnel

The Kobe Nagata tunnel is twin road tunnel with two lanes each and 2.1km in length.

Standard excavation cross section is about 110 ㎡. However, it is about 190 ㎡ at the largest section where the tunnel is enlarged to connect with ramp and it is equivalent to three lanes.

This tunnel was constructed under typical urban tunnel condition, 20 to 30m of average overburden in topography condition, unconsolidated ground consists of soils with high ground water and



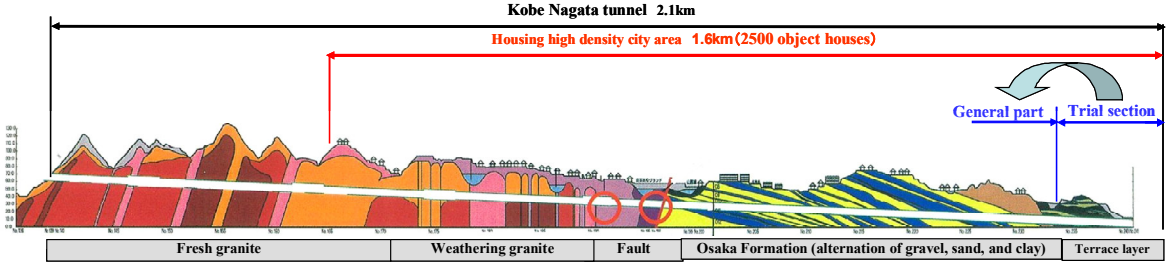


Fig.1 : aerial-view, excavation cross section, longitudinal section and cross section

fractured rock in geology condition, and directly below the build-up urban area in environmental condition.

(Fig.1: aerial-view, excavation cross section, longitudinal section and cross section)

3. Selection of the Tunneling Method

Under such conditions, TBM with shield is commonly used for construction. However, NATM was selected for this project, considering suitability for enlargement of tunnel section, environmental impact of balk excavation for shaft construction and project cost.

Problems during construction, such as ground water, ground deformation, surface settlement etc., were solved with full use of auxiliary methods, which is improving remarkably in recent years.

4. Measures to Technical Problems

4-1 Selection of rational auxiliary methods

Various auxiliary methods, such as long presupport, tunnel face reinforcement, and footing reinforcement are needed to construct urban tunnels with NATM. Therefore, about 170m from the pithead was regarded as the "trial section", and trial application of construction methods or materials was performed. Through the trial, affectability and applicability over the face stability or settlement control were checked.

Based on those trial results, flow chart to select the auxiliary method was established to satisfy the control criteria of above ground structures and underground utilities. With this flow chart, the most suitable auxiliary method for concerned topographic and geological conditions was selected by analyzing the soil condition at tunnel face and real time monitoring result.

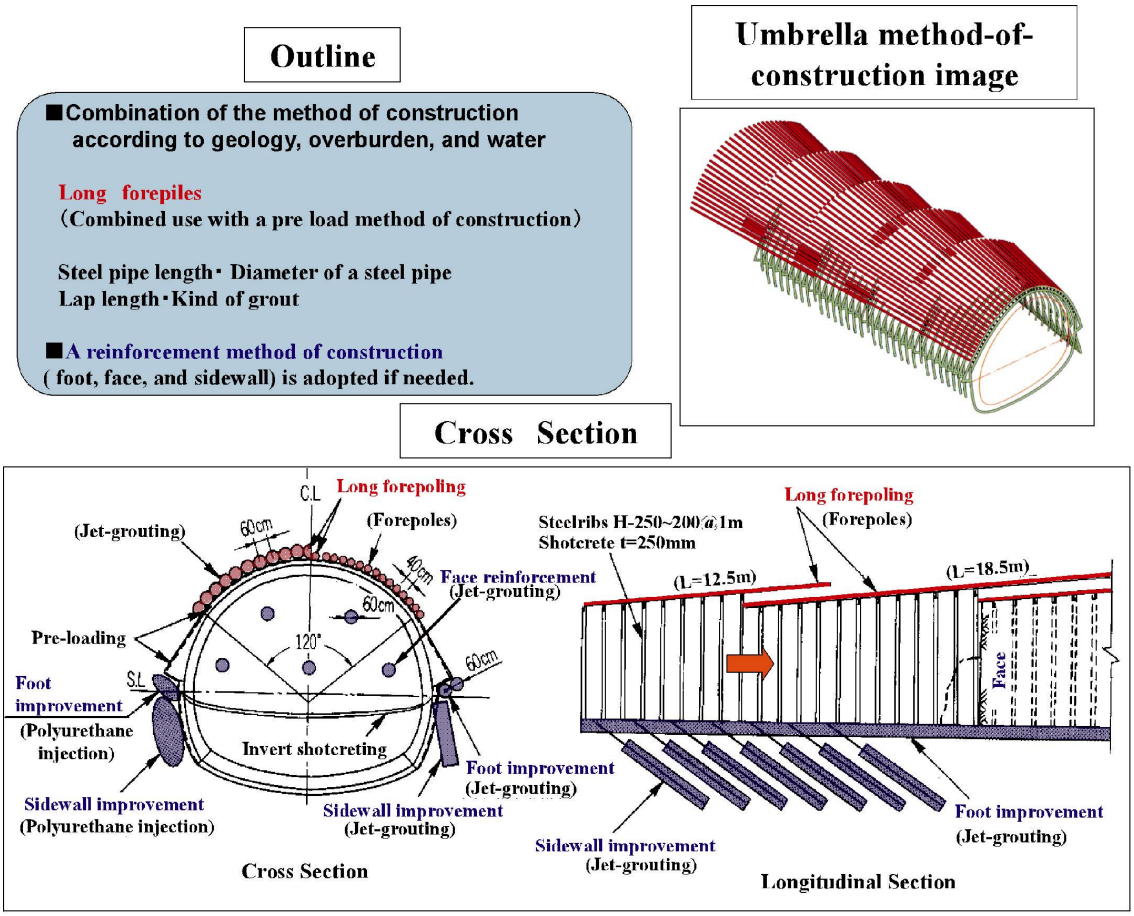


Fig.2 : auxiliary methods

4-2 Utilization of the latest construction methods

In addition to the conventional auxiliary methods, longer and larger steel pipes were used for presupport and high-pressure injection formula method was fully adopted to footing reinforcement and tunnel face reinforcement.

Moreover, the pipe roof construction by slurry type pipe jacking method which can control earth pressure at excavation face and the low grouting pressure and low grout volume type chemical injection method to control the ground movement during stabilization, were adopted and they were put in practical use.

Furthermore, for hard rock excavation near private houses, a hard rock excavator was newly developed and introduced to avoid the blasting and reduce construction noise and vibration.

(Fig.2 : auxiliary methods)

4-3 Handling of groundwater

In order to reduce groundwater level efficiently in advance of tunnel excavation, advanced boring for drainage was carried out in the tunnel, together with deep well from the ground level. The efficiency of the drain was improved by adopting high permeability drain pipe and the compulsive drainage

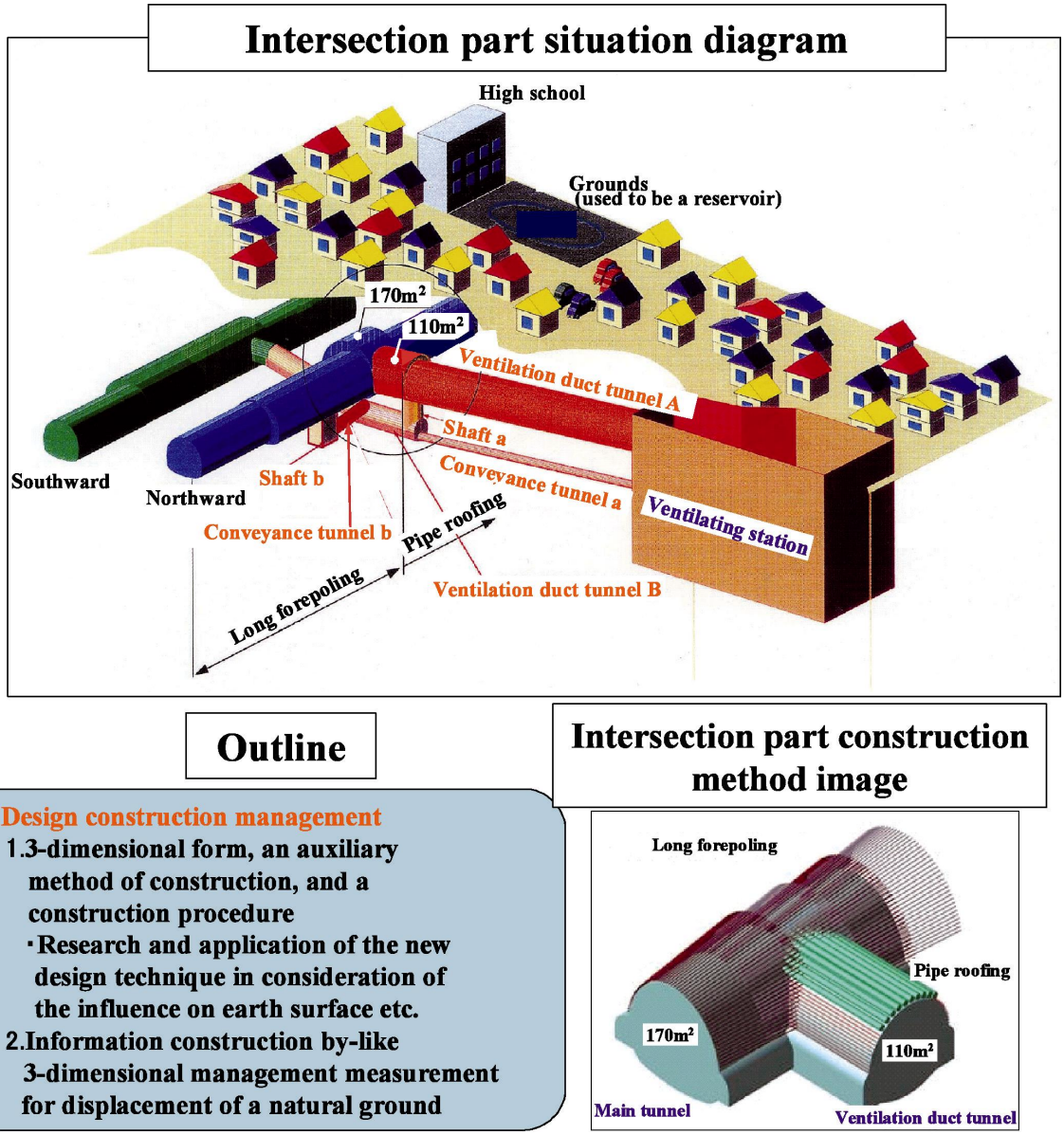


Fig.3: central ventilation place

using the vacuum pump, and excavation process was quite smooth without any troubles with ground water.

Advancing drift was adopted to check the geology and reinforce the ground, where many small faults exist or near the fractured zone and it was also utilized for drainage.

Moreover at the soil section, tunnel was constructed as waterproofed type tunnel structure (all circumferential waterproofing) to mitigates the groundwater drawdown after completion.

4-4 Intersection and connection with a duct tunnel

In the location where the large ventilation duct tunnel, equivalent to two lanes crosses and connects to main tunnel, the supporting pattern and the excavation procedure were examined based on the monitoring results which were obtained during construction and 3-dimensional FEM analysis. By performing the monitoring and adoption of the suitable auxiliary methods such as presupport, stability of a circumferential ground and the surface settlement were well controlled.

(Fig.3: central ventilation place)

5. Conclusion

As described, the Kobe Nagata tunnel was constructed under very severe topography and geology condition and restrictions particular in urban area. And it was completed safely with introducing various pioneering technology and rational NATM construction.

In Japan, there are few instances of NATM construction below build up urban area with such difficult conditions and large scale.

Each problem was settled by making full use of various elemental techniques (auxiliary method etc.) and applicable range of NATM in urban area was remarkably expanded.

About these elemental techniques, efficiency of newly introduced techniques or improved existing techniques was checked by analysis and monitoring, and those techniques are expected to be spread over the future projects.

Furthermore, environmental consideration was made during construction, such as maintenance of the neighboring park by use of surplus excavated soil.

Finally, after opening of this highway the effect of new road network such as dispersion of traffic is observed and this project is considered to be contributing to the community.

The Construction Technology that Executes a Large-scale Underground Station right under the Terminal Station (Minatomirai Line and Tokyu Toyoko Line Yokohama Underground Station)

Torajiro FUJIWARA, Takuya YAMADA, Toshihiko NIIBORI

Tokyo Construction Office, East Japan Railway Company

Construction Work Outline

"Minatomirai Line" is the newly established line based on city planning of the Yokohama-City "Minatomirai 21 Project". Yokohama Minatomirai Railway Co. Inc. of the 3rd sector method becomes an entrepreneur and connects Yokohama station ～ Motomachi-Chukagai station (about 4.1km) in underground. Also the Tokyu Toyoko Line that connects Shibuya～ Sakuragicho and Minatomirai Line run through each other. East Japan Railway Co. Inc. in this project, committed from the entrepreneur, and constructed the underground station right under the Yokohama station.

As the knot point where Tokyu Toyoko Line and Minatomirai Line run through each other, the large terminal station, Yokohama where about 2,300,000 people use everyday were selected. JR Keihin-Tohoku Line, Tokaido Line, Yokosuka line, Tokyu Toyoko Line, Keihin Electric Express Railway Line, Sagami Railway Line, and Yokohama Municipal Subway Line get into current Yokohama station by bank/elevated railroad/underground. Moreover, it has geographical condition that is enclosed north and south direction to the first class river, Aratama and Katabira, and also enclosed the east and west to the station buildings.

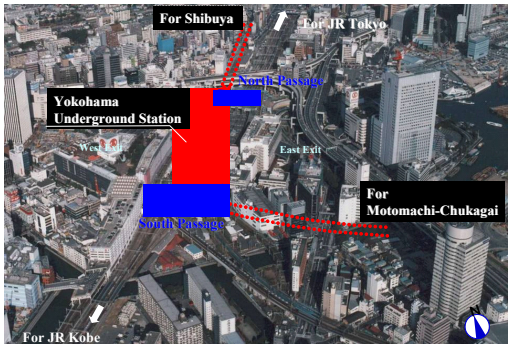


Photo 1: Around Yokohama Station

Therefore, the knot point where Minatomirai Line and Tokyu Toyoko Line run through each other, was selected about 25m right under JR Yokosuka Line and Tokyu Toyoko Line, and had been decided to construct the underground stations of 4～5 of layer box of the extension of 420m including crossing department 25m width .

We report mainly about the item that overcame it to the subjects by the numerous restriction conditions of the nature of soil condition, work space, work time etc., in building a large-scale underground station nearby the operation line, big city terminal station department in this manuscript.

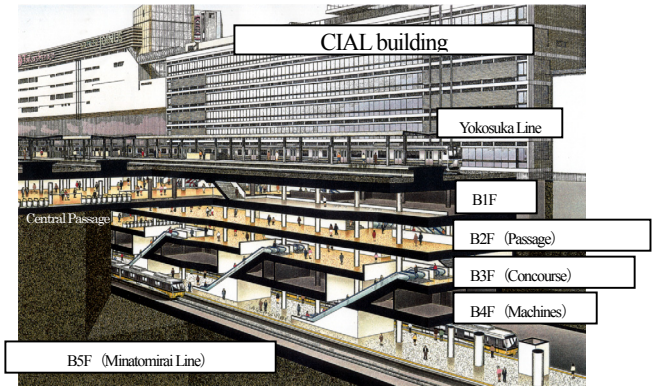


Fig.1: Completed image of Yokohama Stn.

General Condition around Yokohama Underground Station

ⅰ) The Nature Of Soil And Groundwater

The Yokohama station center as for the nature of soil situation of the present Yokohama station periphery, the depth, stratification situation etc. of the support foundation is changing largely as the boundary. The fine foundation that has 50 or more N value (Kazusa layer) exists at the northern part of Yokohama station, -15m under G.L. (Ground Level) .But the viscosity soil layer that has or less N value exists at the southern part of Yokohama station, from G.L. to

more than 40 m under. The Yokohama underground station became to be constructed in such a complicated foundation condition and needed many examinations on the design/execution.

Also, groundwater measure such as preventing the underground station structure body coming up, were a big subject. because the underground water level is high and also confined ground-water exists at the whole underground station construction place.

ⅱ) The Structure Outline of the Underground Station

Minatomirai Line Yokohama underground station is the extension of about 420 m, and in details 24 m of vertical shaft, 209 m of the main body of the station, and 185 m of the JR line crossing part. The main body of the station(*Fig.2*) is located right under the Yokosuka Line and Tokyu Toyoko Line of JR Yokohama station and are the structure of 5 layers (ground 1 layer, underground 4 layers)2 spans and become unit structure with JR elevated railroad. General part was constructed as S+RC structure due to time necessary for the construction shortening, and a part as SRC structure, from the adjustability with architecture specification, because of the idea that Tokyu Hotel Chain constructs a hotel in the underground station upper part in the future. The construction was executed with the inverted construction method. The JR line crossing part is the open cut tunnel where ties the shield tunnel at Motomachi side, and the main body of the station. Its structure is the RC rigid-frame box that changes among 3 layers 1 span from 4 layers 2 spans (*Fig.3*). We constructed the box under the elevated railroad that receives the JR Lines, because it is going across right under 8 JR Lines obliquely. Furthermore, the elevated railroad of the JR Lines direct top of the tunnel was made to be the structure that was separated with superstructure, without receiving by the tunnel from the consideration on earthquake resistance, but supported with the underground continuation wall constructed at the side of open cut tunnel. The construction was executed with the forwarded construction method.

ⅲ) The Conditions on Construction

Yokohama station is large terminal station whose passengers are 2.3 million a day. And it is managed by the tight schedule for railway transportation and even the freight train travels. Although this underground station was constructed with the open cut construction method, the slow down of the train was not permitted in this case. Also, usually the underground station crosses to a right angle in the existing railroad track to fix the influence range to the existing line minimum, but the Yokohama underground station has existing station building with underground structure in both sides of the existing railroad track, needed to construct the underground station in parallel in the existing railroad track. Therefore, the construction extension of the temporary construction beam, that receives the train load temporary became to (total of 283 leagues) about 2.4km in

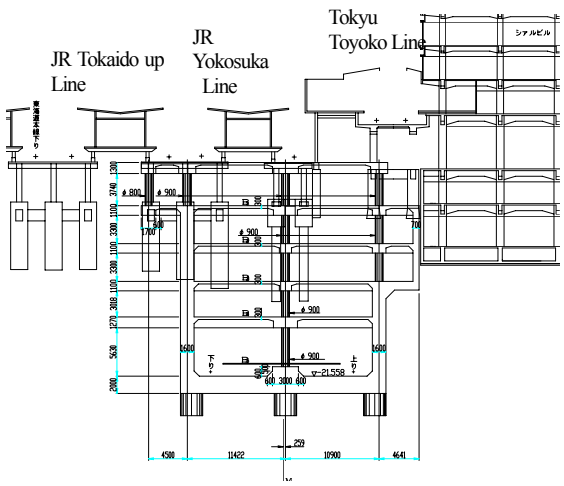


Fig.2: Cross Section of Station

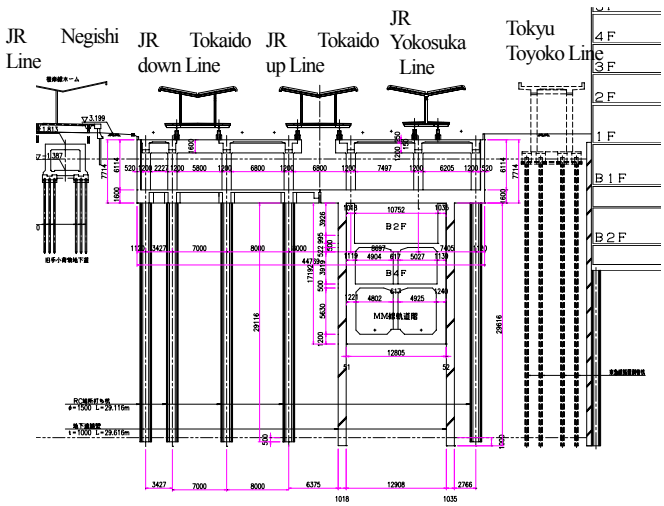


Fig.3: Cross Section of Station(crossing part)

all. Besides, we needed to execute in the short work time, between time to stop feeder line(about 2 hours and 20 minutes in shortest) and time to interrupt on the track(about 3 hours in shortest) , about. 4 hours average.

Overcoming of Each Condition by Technical Development and Construction Method Examination

Among the general condition and the conditions on construction expressed with the preceding clause, piling up examination to accomplish this project into the process, we carried out the improvement and development of the technology for subject overcoming.

Development of the Steel Pipe Pile Pressing by Screw Turn

The temporary pile of the construction beam is as long as 30m because the support layer is deep with a fragile foundation. However, the pile became a jointed pile with 17 connection places because clearance of the place to construct is restricted to 2.5m by the electric wire. We adopted the steel pipe joint by screw that shows it in *Fig.4* to execute this pile in about a few hour limited work time. The shortening in the execution quantity increase, execution time in a night were enabled by this development. About 3 years and about 50% of process shortening ,connection time needs it 20 minutes when we adopt the case of the steel pipe joint by screw, while connection time needs it 90 minutes in the case of the welding joint of to every 1 place and about 5～6 years of process.

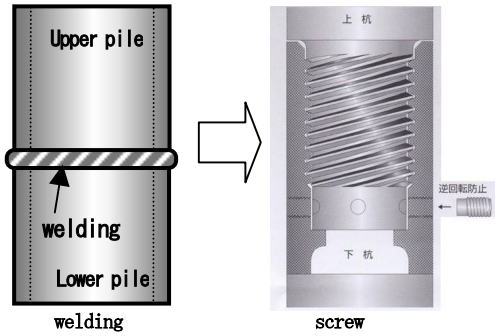


Fig.4: Steel Pipe Joint by Screw

Development of the Steel Pipe and RC Beam Joining Method

The short period and advanced execution accuracy were demanded to the connection part of the steel pipe pile head, when we needed to execute the side beam of the temporary elevated railroad. A chain of joining by conventional welding in 3 hours of the nighttime are impossible and there was a problem in the execution accuracy of the joining by screw in connection direction. We developed the construction method that we put connection part over the steel pipe pile like cap, filled up by acrylic resin system glue and join with the steel pipe pile, and filled up concrete inside that intends the unification. It reduced the work quantity and digging quantity at the time of execution, shortened the work time that usually need 2 nights to 1 night, and materialized a substantial cost-down.

Development of the Machinery Caisson

We needed to construct the underground station core column (φ2.6m, L=about30.0m) under narrow work condition that was right under the existing operation line and the clearance was restricted as long as about 5m. So we have come to construct the caisson but there are problems of bad working condition and decrease of skilled workers and there was the possibility that the construction will not be executed smoothly and safety. Thereupon, we developed the execution machine to dig and install linear plate automatically and were materialized smooth mechanization execution of caisson type pile works under a narrow condition.

Development of the Joining Method of Steel Pipe and RC Pile

The steel pipe column was adopted as core column, the main column of the underground station, to shorten the time necessary for the construction. RC beam was adopted as the beam to tie the column from a viewpoint of economic efficiency. Because the place where the steel

pipe and RC join exist about 400, so the simple joining and execution method was requested. It made the unit structure that concludes the diaphragm, connection part plate of the steel pipe column, and the plate that welded the reinforcing rod for the machinery joint, with the bolt. Executed by precast, reduced work site, contributed to time necessary for the construction shortening. We executed the small model experiment to this joining method, checked and confirmed the efficacy by the three dimensions FEM analysis constituted as adhesion deterioration style model.

Development of the Constituted Element Continuation Wall

It was scheduled not able to construct widening part by open cut construction method by the viewpoint of the structure stable if the construction of the station under B2F hasn't done, digging outside part of the continuation wall (we call widening part) west side of station and executing box construction. However, it was requested as it makes the time to open of early for 2 months from the entrepreneur. The time necessary for the construction became needed to be shortened due to this. Therefore, we executed the square steel pipe called JES (Jointed Element Structure) vertically, concomitantly using with human power digging. Concrete was filled up within JES. Without waiting for the construction of under B2F of the station part from this case, the execution of the main wall, also be the temporary sheathing, is possible (*Photo 2*).

The application range reaches the wide area of about 500m^2 where it shows in *Fig.5*. Usually, we used JES toward length this time, although it uses it to the railroad track under crossing construction work toward the side, and shortened for 3 months from the process at the beginning.

To the End

The Tokyu Toyoko Line turns underground on January 31, 2004 and the Yokohama underground station becomes a use start and on February 1, 2004 Minatomirai Line in practice. Because of the large-scale terminal station there were the severe restriction on train operation and passenger flow. Also, it was special nature of soil condition right under the station. Piled up various examination and time necessary for the construction was shortened for 2 months than the first plan (March, 2004). Second terms of the underground stations associated with the removal construction work of a Tokyu Toyoko Line elevated railroad began after the opening of the Minatomirai Line. We hope that this manuscript becomes the reference of the future construction works and same kind of underground station construction works. We thank for all the people who were concerned, in this project last.

Photo 2: Constructing JES toward Length

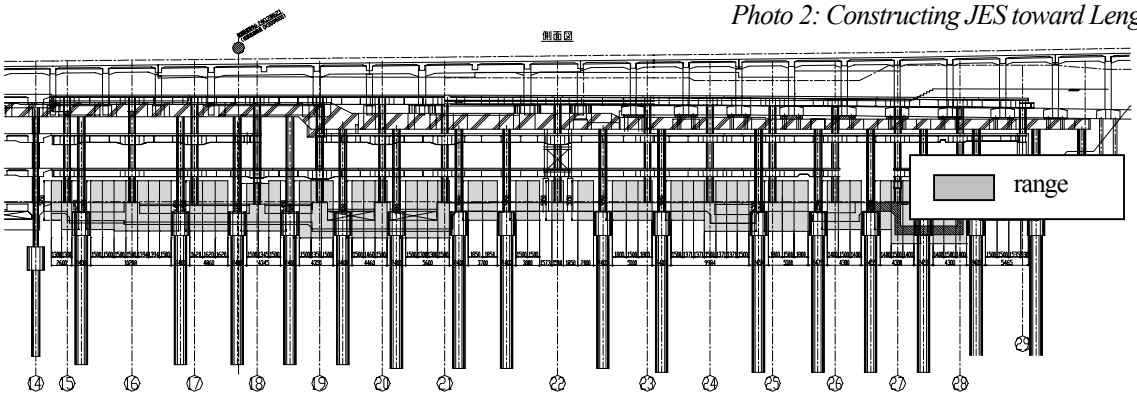


Fig.5: Place to Apply JES toward Length

On construction of the new Shinagawa Station for the Tokaido Shinkansen

Yoshihiro YAMAMOTO
Central Japan Railway Company

1. Introduction

Since the operation of the Tokaido Shinkansen was started in 1964, millions of people have used the Tokaido Shinkansen as the artery connecting three metropolitan areas, Tokyo, Nagoya and Osaka. The quantity of transportation has also increased in proportion to the growth of the Japanese economy. We have invested in the increase of the transportation capacity corresponding to the demand. However, the transportation capacity is about to reach the upper limit of the present infrastructure. As a result the Central Japan Railway Company, have planned the new Shinagawa Station to bolster the transportation capacity of the Tokaido Shinkansen as drastic measures against that.

Shinagawa Station will offer the following benefits. Not only will the transportation capacity of the Tokaido Shinkansen be strengthened, but the accessibility for passengers will also be improved. The station shortens the total travel time for the passengers living in the southwest part of Tokyo by maximum approximately 30 minutes. In addition the station adds flexibility to the timetable and a quick recovery to scheduled times should an emergency or natural disaster. This station will be really effective from those points of views.

2. Outline of the Construction

The quantity of transportation has kept increasing in proportion to the growth of the Japanese economy, and it became much larger than predicted when Japan National Railway was split and placed under private management. Based on the investigation result of the "Advisory Council to Consider the Transport Capacity of the Tokaido Shinkansen" (Ministry of Transport), which was established in Oct. 1990, the report of "Council for Transport Policy" stated the necessity to strengthen transportation capacity of the Tokaido Shinkansen on Jun. 1992.

A basic agreement was reached on the establishment of the new Shinagawa Station for the Tokaido Shinkansen, involving the Japanese National Railways Settlement Corporation, JR East, JR Freight and JR Central on Jul. 1992.

A redevelopment plan of Shinagawa Station East area and a plan of East-West passageway of Shinagawa Station has been made. As a result of the coordination among the persons concerned and considering with the importance and urgency of strengthening transportation capacity of the Tokaido Shinkansen, the Shinagawa Station east area city plan was revised in Apr. 1995, taking into consideration the plan for the new Shinagawa Station for the Tokaido Shinkansen. Thereafter in Mar. 1996 we attained the

Photo.1 An appearance of the Shinagawa Station of the Tokaido Shinkansen

approval of the Minister of Transport, which Railways Enterprise Law requires for the construction of the Shinagawa Station of the Tokaido Shinkansen. Land contracts were entered into with the Japanese National Railways Settlement Corporation, JR East and JR Freight in the same year. The construction was started in May. 1997 and the Shinagawa Station was opened on 1st Oct. 2003 after three re-routings. (Photo. 1)

3. A plan of Track Layout

A maximum of 15 trains (11 to 12 commercial trains and 3 to 4 out-of-service trains) are operated hourly at the neighboring Tokyo terminal (Fig. 1), so the upper limits of commercial trains in the neighboring Tokyo terminal is 11 to 12 per hour. The transportation capacity at point of turnout for the Ooi rolling stock depot and westward is approximately per 15 hour. To operate more commercial trains in this situation a new station needed to be constructed with storage tracks westward of the point of turnout and fully utilize the transportation capacity. It will be possible to fully utilize and bolster transportation capacity with a maximum 4 turn-back trains hourly. To realize such an operation the Shinagawa Station was planed to have 2 island platforms, 4 tracks where trains can stop and 3 storage tracks at the north end. (Fig. 2)

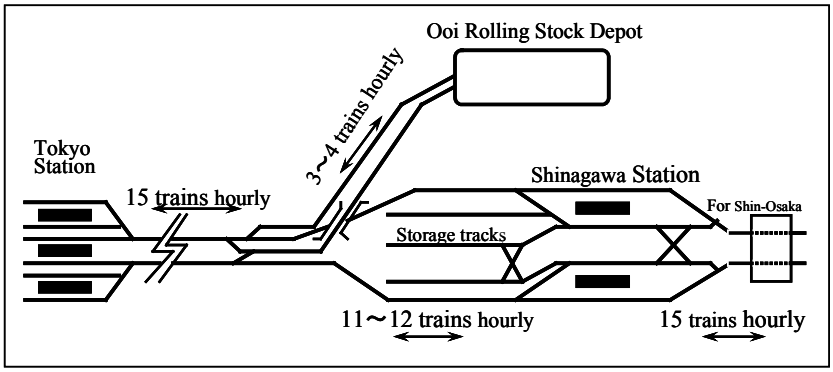


Fig.1 The number of trains in the neighboring Tokyo terminal

There are city road plans east side of the works field and conventional lines of JR East west side of the works field. This required us to construct a new Shinagawa Station in a narrow area. In addition there are viaducts for Ooi Rolling Stock Depot and Yatsuyama Tunnel at both ends, which are very difficult to be moved, so the Shinagawa Station with 2 island platforms and 3 storage tracks needed to be constructed within 1.8 km area between them. Therefore we were able to construct this station which had required functions within a narrow area with the re-routings from the viaduct level to the ground level.

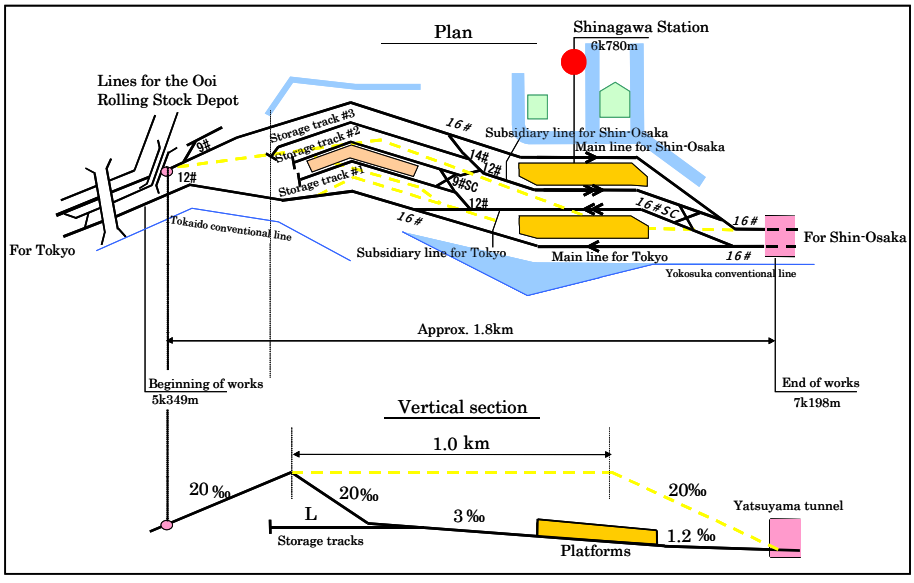


Fig.2 Sketches of track layout

4. Process of Construction

The planned construction scheduled site of Shinagawa Station for the Tokaido Shinkansen was a very narrow area as mentioned above. So by cooperation of the neighboring landowners etc., we borrowed the land in part and advanced the construction.

First, a main line for Shin-Osaka was re-routed in Sep. 1999

to the newly acquired land. Then a temporary line for Tokyo was re-routed west to main line which was re-routed in the previous year. After being re-routed the former viaducts started to be demolished. After that a main line for Tokyo was re-routed in the place of the former viaduct. After this re-routing a temporary line for Tokyo was withdrawn and subsidiary tracks, platforms, passenger equipment and 3 storage tracks were constructed between both main lines. (Fig. 3)

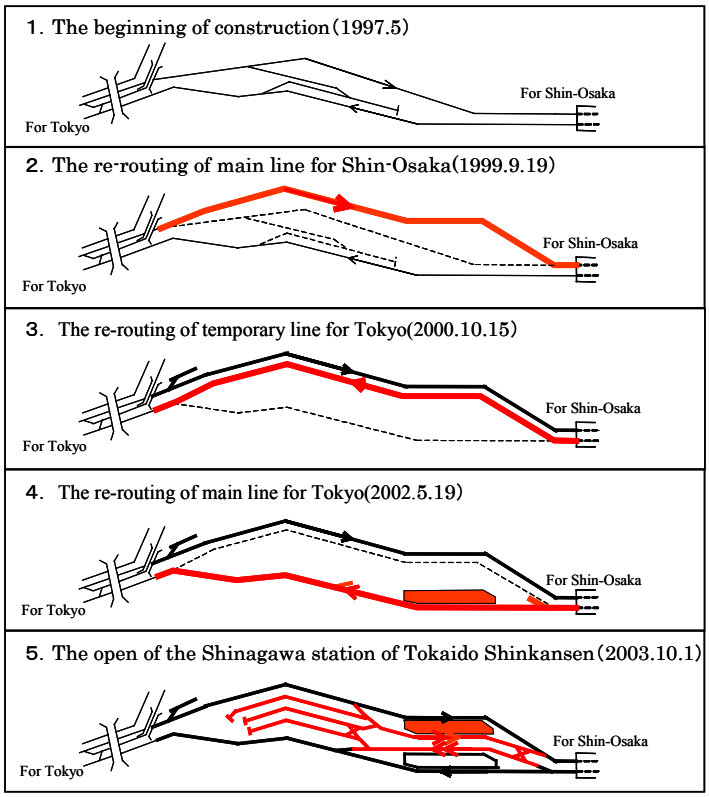


Fig.3 Process of construction

The difficult construction to re-route within a maximum 2.1m track descent and in a maximum 4.4 horizontal track movement simultaneously meant a 155m extension needed to be added. (Fig. 4,5)

Considering with the social mission of the Tokaido Shinkansen, presuppositions of the selected construction methods were as follows;

・No stoppages of the service to commercial trains

・Temporary speed restriction kept to a minimum except on the actual days of re-routings (70km/h)

・Re-routings should be completed within maintenance hours during the night(6 hours)

In addition, soil stabilization and a reinforced roadbed should be completed under the rail tracks in advance due to the soft roadbed at the construction site. The drastic retrenchment of digging the roadbed on the actual days of re-routings was required. Because of these reasons, the method of construction using temporary steel girders and the re-routings during night maintenance hours by utilizing large-sized cranes, large-sized construction machines and large-sized track maintenance machines was adopted. (Photo. 2,3)

These re-routings required extreme precision and strict time schedule controls. The degree of difficulty of these re-routings was extremely high. In Shinkansen history there wan no similar way or re-routings so we had built a life size model close to the re-routings field, which had electric poles, electric cables, retaining wall and so on. We found out the problems of re-routings through using the test re-routing model and solved these problems in advance. In addition we rehearsed these re-routings a week before the work was scheduled and reconfirmed various concerns. Thus we took all possible measures to ensure the success of these re-routings.

These re-routings had to be completed within 6 hours and it was very important to inform all the workers of their roles in the re-routings and to raise the morale of the workers to complete the works. So we held a lecture class using a computer graphics and gave practice experiences to more than 800 workers. In this way these re-routings were accomplished.

5. Epilogue

The construction of Shinagawa Station for the Tokaido Shinkansen was an extremely difficult project, which was completed within very strict geographical, social,

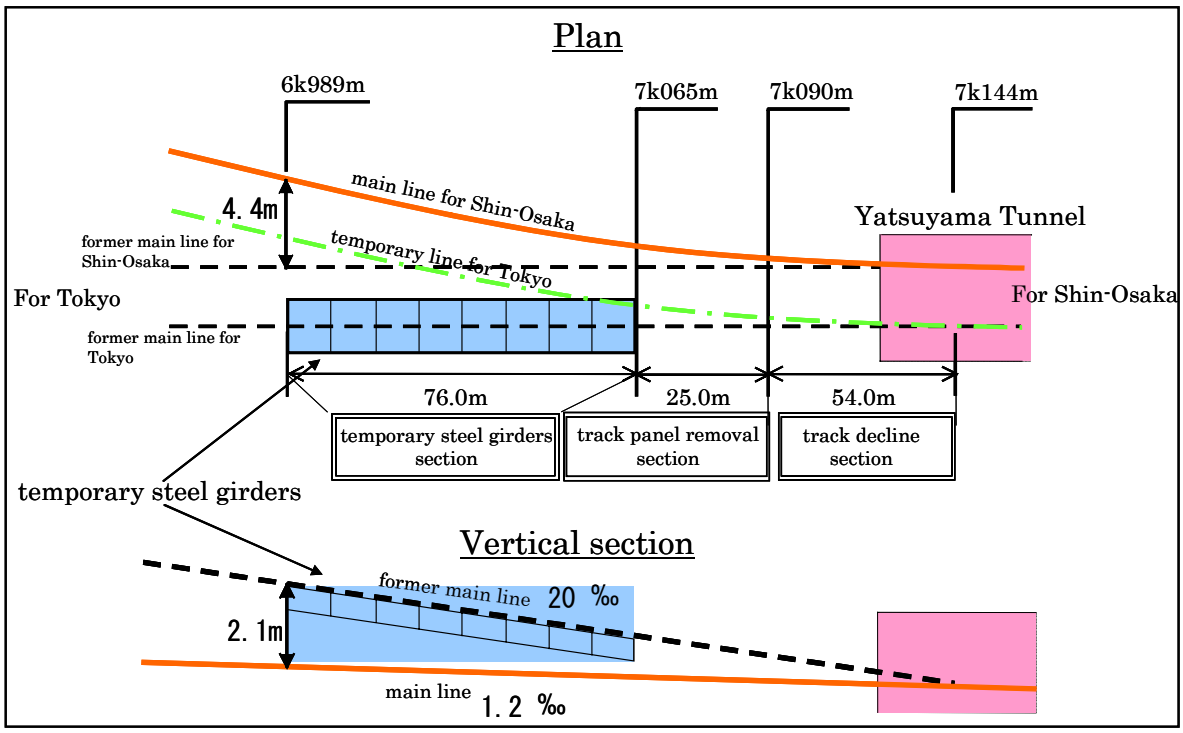


Fig.4 The method of construction using temporary steel girders

technical and bureaucratic parameters. In addition the construction had to be completed within the normal operations of the Tokaido Shinkansen. This was a magnificence project which took 6 and a half years with most attention to safety and prevention of accidents.

Photo2. Re-routings (withdrawal of temporary steel girders)

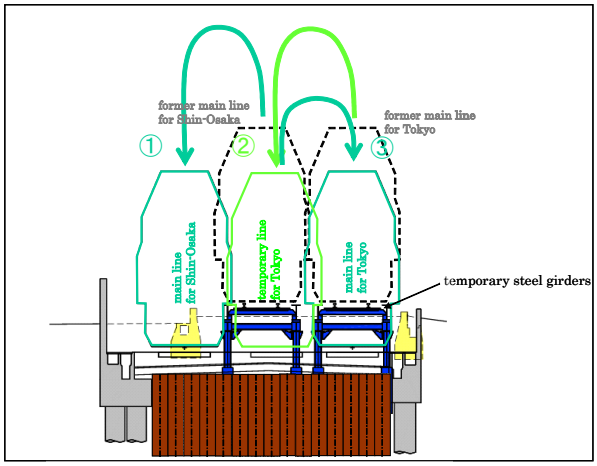


Fig.5 Process of re-routings

Photo3. Re-routings (utilization of a large-sized track maintenance machine)

Construction of Tamagawa-Joryu Storm Sewer by applying cutting-edge technology and in cooperation with the community

The first project of using regional sewerage system to construct storm sewer main in Japan

Tokyo Metropolitan Government, Regional Sewerage Bureau

1. Project overview

In the region measuring approximately 1,200 hectares in the western part of Tokyo that includes the cities of Oume, Hamura and Fussa, the concentration of population has brought about rapid urbanization, increasing the impervious area. This has increased rainwater runoff, leading to frequent flood damage.

The aim of this project was to achieve a swift resolution of the problem of flood damage. It represents Japan's first use of large-scale regional sewerage system to construct stormwater drainage facilities.

2. Achievements of the project

The main issue in implementing this project was how to eliminate flood damage by constructing stormwater drainage facilities in the quickest and most economical manner. Under these circumstances, the achievements of the project are the following:

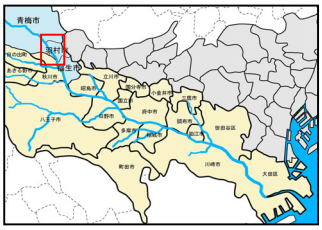
(1) Establishment of new system for the construction of stormwater drainage facilities

Each city and town is responsible for constructing stormwater drainage facilities. For this reason, each city conducted studies independently to construct stormwater drainage facilities using the public sewerage system. However, there were no small and medium-sized rivers in which to discharge the water; moreover, the construction of these facilities had been stymied due to restrictions such as the inability to discharge the water into the Tama River upstream of the Hamura Intake Weir, which serves as the intake for the water system used by Tokyo's 12 million inhabitants.

For this reason, the Tokyo Metropolitan Government called on relevant agencies of the national government and succeeded in creating a new system for the construction of stormwater drainage facilities using regional sewerage systems. As a result, this project was implemented, marking the first time in Japan that storm sewer main had been constructed using a regional sewerage system.

Storm sewers main after completion

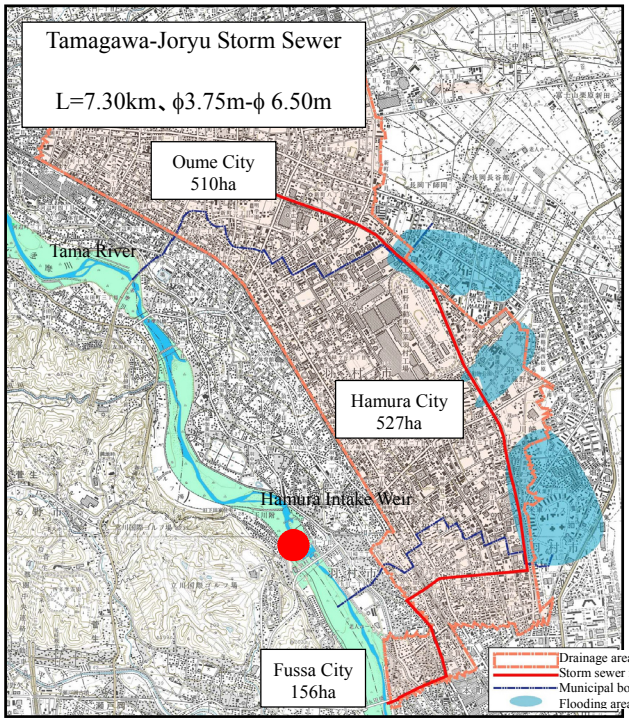
(outlet into Tama River)



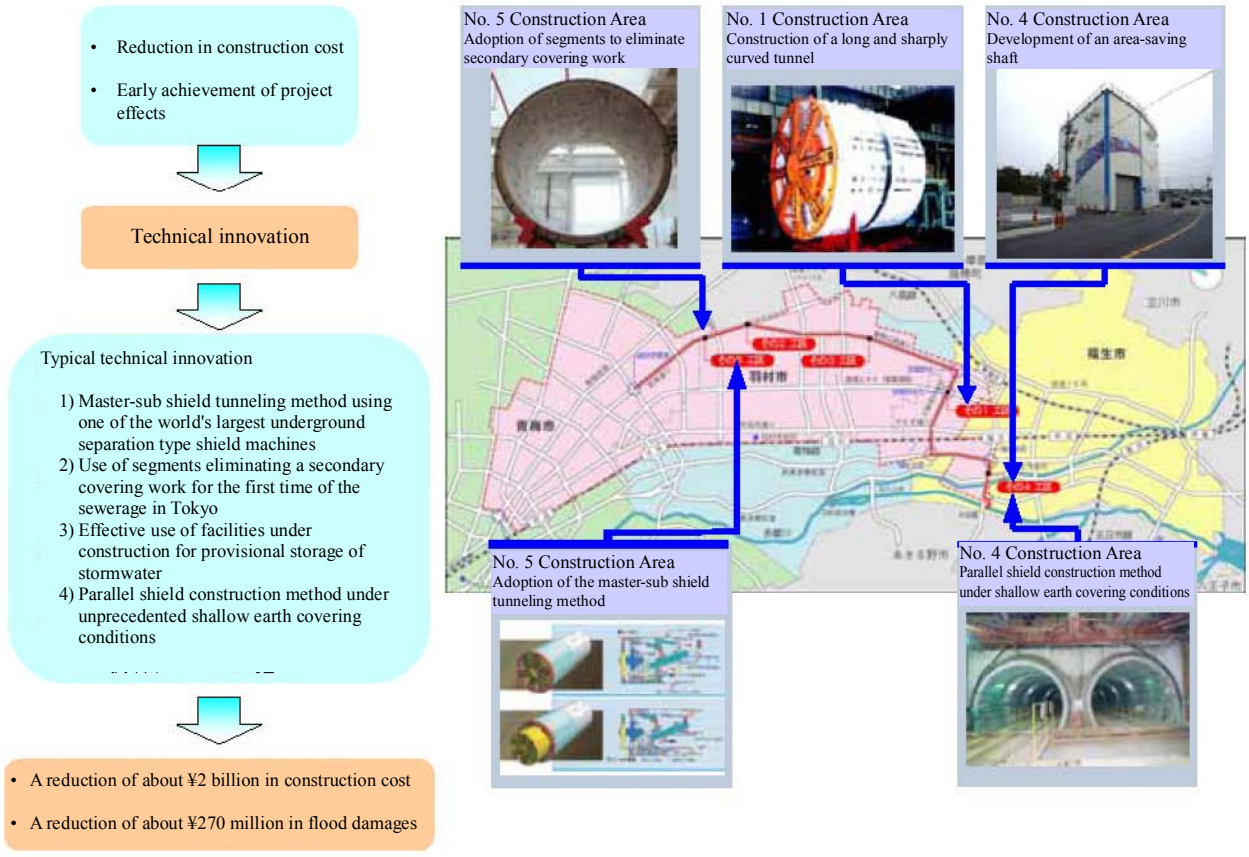
River basin

Flood damage

Project overview



(2) Technical innovation



1) Master-sub shield tunneling method (using one of the world's largest underground separation type shield machines)

No.5 Construction Area extends for a total length of 1,740 meters. As there is a public storm sewer connected in the middle, the inner diameter changes from ϕ3750 mm to ϕ5250 mm. In addition, it was difficult to secure land for shafts. For these reasons, the master-sub shield tunneling method was used.

Use of the master-sub shield tunneling method for a project of the same scale as the conventional underground separation method faced problems in ensuring the smooth advance and operation of the sub-unit. For this project, the problem was overcome by modifying and augmenting the machine body and the reaction support structure.

The master-sub shield tunneling machine used for this project was one of the world's largest concentric and coaxial underground separation types machines. The use of this machine enabled the cost to be reduced by approximately ¥640 million, and it also enabled the construction period to be reduced by approximately seven months.

Master-sub shield machine

2) Use of segments to eliminate secondary covering work

For this project, segments that enable the secondary covering work to be eliminated were used for the first time on sewer pipes. These comprised segments with keyed joints and segments with through bolts. The use of these segments enabled cost reductions of approximately ¥250 million as compared to conventional work costs. Their use also enabled the work time to be shortened by approximately 10 months.

This achievement was verified and a "Design Handbook for Eliminating Secondary Covering Work" was prepared. These criteria have been reflected in the sewer projects conducted by the Tokyo Metropolitan

Government, and they are widely used for sewerage projects throughout Japan.

Use of segments with through bolts

Use of segments with keyed joints

Segments (enabling secondary covering work to be omitted)

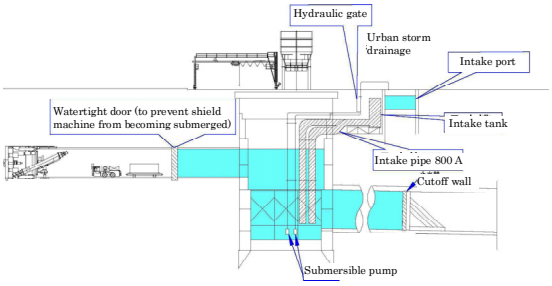
3) Effective use of facilities under construction

In order to respond as quickly as possible to the needs of Tokyo residents who suffer from flooding damage, facilities that had been only partially completed were used. Beginning in 2001, the provisional storage of stormwater flowing into the pipe during torrential rainstorms was conducted six times. For the provisional storage process, a shield machine watertight door was developed in order to prevent the shield machine being used for excavation from becoming submerged. These provisional storage activities enabled 380 incidents of below-floor flooding damage to be prevented, reducing damage costs by approximately ¥270 million.

Date	Maximum rainfall*	Provisional retention (m^3)	Notes
July 10, 2002	30 mm/hr	9,100 m^3	Typhoon No. 6
August 2, 2002	54 mm/hr	12,000 m^3	Torrential rain
August 19, 2002	45 mm/hr	34,500 m^3	Typhoon No. 13
September 7, 2002	23 mm/hr	4,100 m^3	Torrential rain
October 1, 2002	44 mm/hr	35,800 m^3	Typhoon No. 21
August 8, 2003	44 mm/hr	17,800 m^3	Typhoon No. 10
Total		113,300 m^3	

* Values measured at site

Results of Provisional Stormwater Storage



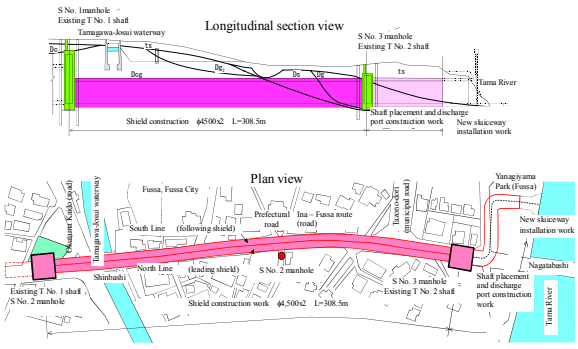
Overview of Provisional Storage Facility

Interior of storage pipe

Shield machine anti-submergence door

4) Parallel shield construction method under shallow earth covering conditions

In No.4 Construction Area, it was not possible to construct a tunnel with an inner diameter of ϕ6500 mm due to restrictions related to undercrossing the Tamagawa-Josui waterway and the height of the riverbed of the Tama River, the discharge destination. For these reasons, it was decided to conduct parallel construction of tunnels with an inner diameter of ϕ4500 mm, by means of U-turn construction using a single shield machine. Due to restrictions on road width, the tunnels were in close proximity to one another, with an interval of only 1.0 meter between them. Moreover, for a section of approximately 100 meters out of the total length, the construction took place under shallow earth covering conditions of 2.5 meters at the lowest. Despite these severe work conditions, foundation improvement and careful construction management enabled the work to be completed successfully without affecting the surrounding area.



Completed view (arrival section)

Parallel Shield Construction Method (under shallow earth covering conditions)

(3) Resident participation in the project

1) Inspection visit to the tunnel site by local residents in wheelchairs

Site visits were arranged for residents of care facilities for the physically impaired. This enabled persons who would not normally be able to do so to view the site.

2) After-school classes for local elementary and junior high school students

Elementary school students drew "wall art" on the walls of the tunnel system as messages for the 21st century. This was the first time in Japan that "wall art" was created on the inside of sewer pipes under construction.

3) PR activities (special events)

An event titled "Welcome! Fureai Tunnel Matsuri (festival)" using the interior of the tunnel was held at the site of the tunnel shaft. The event was co-sponsored by the local town council.

Visit to the site by local residents in wheelchairs

2000 millennium: painting pictures on the tunnel wall

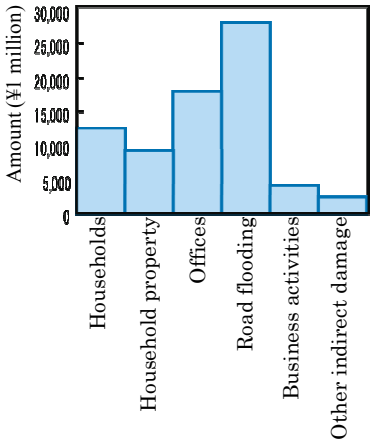
"Fureai Tunnel" festival

Citizen involvement

3. Summary

(1) Project achievements

Simulations were conducted in order to calculate the effect of this project. The results indicated that considerable reductions in home damage, road flooding and the like can be anticipated, leading to a savings of approximately ¥74 billion. The cost-benefit ratio is expected to be approximately 1.5 times.



Expected project achievements

(2) Future prospects

The system implemented in this project for constructing large-scale rainwater drainage facilities using regional sewerage systems is being used at the Kurome River and Ochiai River Basin in Tokyo, the Katsura River Basin in Kyoto and other places throughout Japan. It is one of the most important policies for stormwater control in Japan.

TOKYO PORT OI CONTAINER TERMINAL REDEVELOPMENT PROJECT

Author Name Toshio Oda (Director Terminal Construction Divion)
Affiliation Tokyo Port Terminal Corporation

1. Rebirth of Oi Container Terminal

The Port of Tokyo plays an important role of logistical base in supporting the lives and industrial activities of the 40 million people in the Tokyo metropolitan region centered by the nation's capital of Tokyo. It also has another face of a leading international trade port, ranking the first place among Japan's ports in its handling of containers for five consecutive years since 1998. It is Oi Container Terminal that plays a core role handling 60% of the containers through the Port of Tokyo.

The international marine transportation system for containers, however, has greatly changed as a result of the Post-Panamax vessels brought into full-scale services and the Asian countries which have grown to be a base to produce and export industrial products to the world. Under these circumstances, Oi Container Terminal had to work out fundamental moves toward updating of the terminal as a whole, including solutions to already-obvious issues such as the short storing capacity of containers, the aged terminal facilities and the inadequate traffic arrangements for waiting vehicles on the road.

Photo-1 Panoramic View of Oi Container Terminal

To this end, the Oi Container Terminal Redevelopment Project (hereinafter referred to as "Redevelopment Project") is aimed at revitalization of the container terminal to make the port more international and well suited to the needs expected in the 21st century. The project was embarked in 1996 and to be completed on schedule in December 2003, spending a lapse of eight years and an approximate cost of 80 billion yen.

2. Outline of Redevelopment Project

2.1 Response to Large-sized Container Vessels

In the Oi Redevelopment Project, we recomposed the existing eight berths into seven berths.

Furthermore, the water depth was increased from -13m to -15m which enables the anchorage of container vessels having a capacity of 5,000TEU to 8,000TEU (60,000DWT to 100,000DWT) and lengthy container vessels of 300m long.

In the redevelopment project, on the other hand, we have employed large-sized high-efficiency container cranes with a rail span of 30m for 18 rows. This has made it possible for the terminal to receive large-sized container vessels of 8000TEU exceeding a width of 45m.

As a result, the container unloading capacity has been risen up to 30 to 40 containers per hour with the new cranes.

2.2 Expansion of Terminal Capacity (Response to Increase of Cargo Throughput)

In order to enhance the storing capacity of container yard, we have expanded the terminal area to 13.5ha (increased by 24% approximately) per berth by means of newly developing a pier 35m wide in the front area

of the existing pier and recomposing eight berths to seven. In addition, we have changed the cargo handling system in the yard by unifying the machinery to the high-efficiency transfer crane. With the realization of multi-stack storing and with the enhancement of handling capacity in the terminal with the expansion of area, it has resulted in an increase of storing capacity by about 22% from 49,000TEU to 60,000TEU.

We have increased the number of reefer connection outlets so many as 1.4 times from 1, 990 to 2,720 plugs.

Furthermore, we have upgraded the efficiency of terminal operations to cope with the increased throughputs and to improve services to shippers, introducing the state-of-the-art gate system which maximizes the automatic checking of container vehicles.

2.3 Solution to Congestion with Waiting Vehicles (Response to Traffic Controversy)

In order to solve this traffic issue, considering an expected increase of cargo volume in the future, we have secured a waiting space for 60 vehicles per terminal in front of the IN-gate inside the yard. At the same time, we have increased the number of gates (IN and OUT) from 11 lanes to 14 lanes per terminal to meet the enhanced terminal capacity, in order to save the waiting time of incoming vehicles and to quicken the treatment of container trucks.

Along with the above, we designated the landside road to be controlled for the exclusive passage of the vehicles concerned. We also implemented a safe and effective solution to the traffic issue, making priority lanes for the container vehicles on the lead track to each terminal, which are classified by the type of containers such as loaded or empty containers.

2.4 Preparation for Large-scale Earthquake (Safety Measures)

We constructed New Berth No. 4, 5 and 6 as reinforced anti-earthquake quays, so that we may secure the international logistic function, retain the lives and economic activities of the people in the Tokyo metropolitan region even at the time of earthquake and accomplish an early restoration after earthquake disasters.

The reinforced anti-earthquake quays were designed and constructed as facilities to withstand an inland tremor of intra-plate type like the Great Hanshin-Awaji Earthquake (M7.2) as well as a plate boundary earthquake like the Great Kanto Earthquake (M7.9). In addition, as we have adopted for container cranes on the quay the seismic isolation unit which is capable to prevent derailing or falling by an earthquake, you will be able to resume cargo handling with the cranes even immediately after an earthquake attack. Other facilities were also designed to withstand a plate boundary earthquake like the Great Kanto Earthquake (M7.9). Thus, we are now thoroughly prepared for earthquakes.

Subject	Measure	After Redevelopment	Before Redevelopment
1. Response to Trend of Large-sized Container Vessels	Expansion of berth (Quay Extension)	330m x 5B 350m x 2B (2,350m)	250m x 2B 300m x 6B (2,300m)
	Larger water depth alongside the quay	−15m	− 13m
	Use of large-sized cranes for upgraded performance	7 cranes for 18 rows (new) 5 cranes for 17 rows (new) 6 cranes for 16 rows (Existing 4 + modified 2)	14 cranes for 16 rows 1crane for 14 rows 3 cranes for 13 rows
2. Enhancement of Terminal Capacity (Response to increase of cargo volume)	Expansion of terminal area (Total area)	135,000 sq.m per berth (Total area: 946,000 sq.m)	109,000 sq.m per berth (Total area: 875,000 sq.m)
	Improvement of the cargo handling system in the yard	Transfer crane system for all terminals	Transfer crane system Straddle carrier system
	Enhancement of container storing capacity (all	60,000TEU	49,000TEU
	Increase of reefer plugs (all terminals)	2,720 plugs	1,990 plugs
	Increase of gate lanes (1 terminal, 2 berths on	14	11
3. Solution to Issue of Congestion with Waiting Vehicles (Response to the traffic problems)	Increase of the space for waiting vehicles in the yard	60 vehicles x 3 terminals 50 vehicles x 1 terminal	———
	Landside road for exclusive use, etc.	380 to 450 vehicles	———

Table-1 Comparison of Functions Upgraded by Oi Container Terminal Redevelopment Project

3. Features of Redevelopment Project

In the development project, we minimized new constructions to reduce the total cost of the project, with our effective use of as many existing stocks as possible. Since Oi Container Terminal is the main terminal in the Port of Tokyo, we cannot cease the ongoing cargo handling operations of the terminal even though we are redeveloping the terminal. For this reason, we have proceeded with the project by shifting the berths in sequence alternately, so that the three shipping companies operating the terminal could handle cargos in use of two berths, namely, a total of six berths at all times.

It was our great concern how much we could shorten the term of construction in order to minimize influences on the cargo handling operations because the construction sites were located close to the common berth.

3.1 Countermeasures for Deterioration of Existing Wharves by Seawater

In the redevelopment project, we intended at first to make effective use of the existing piers as container storing areas, but those piers were found deteriorated obviously by seawater with peels or drop-offs in the upper structure of concrete which had been built about 25 years ago. We, therefore, implemented a large-scaled renovation work of the deteriorated area along with the construction for redevelopment. The repairing work is based on "Deterionration Survey and Repairing Manual of Oi Terminal Piers(Draft)". ＊

Photo-2 Pier deterioration situation

According to the result of the visible research, we first select the cross-sectional renovation method for the seriously deteriorated area with peels and drop-offs of concrete. In the next step, for the area where no visible deterioration is seen, we measure an ionic concentration of chlorides. According to the result of measurement, we estimate the dispersion of chloride ion. The standard value for judgment is determined at 1.88kg per cubic meter based on the position of the reinforcing steel when the supply of chloride ion is shut off. In case the value is the same as the standard one or less, we adopt the surface coating method, while we adopt the electric corrosion preventive method in case the value exceeds the standard level.

＊An operation manual edited basing on the survey and the results of repairing works which Oi Terminal has so far implemented.

3.2 Anti-earthquake Reinforcement of Wharf, Yard and Crane

(1)Construction of Reinforced Anti-earthquake Quay

□ PC Beam and Slant Pile Wharf

For the newly built piers we employed PC beams and slant piles to save the construction cost and time. The foundation pile used in this method with a combination of straight and slant piles controls a displacement generated by an earthquake. The structure, therefore, has excellentearthquake-resistant properties despite the small number of pile. In addition, the prefabricated PC beams employed for the upper floor slab requires no on-site concrete work, saving the construction cost and time. At the same time we could make lighter the weight of upper floor.

□ Jacket Type Wharf

Since the neighboring New Berth No. 4 and No.6 have already been put into service, New Berth No. 5 employs the Jacket Type Wharf system in consideration of difficulty in applying the above-mentioned PC Beam and Slant Pile Wharf system and also of workability on the site.

The Jacket Type Wharf has a structure in which a

prefabricated steel truss is fixed onto the bottom of sea with steel piles and it excels in earthquake-resistance. Therefore, fewer processing and welding works are required on the site. In addition, one block is so large-sized of 50m x 35m that we can save much time for construction on the site.

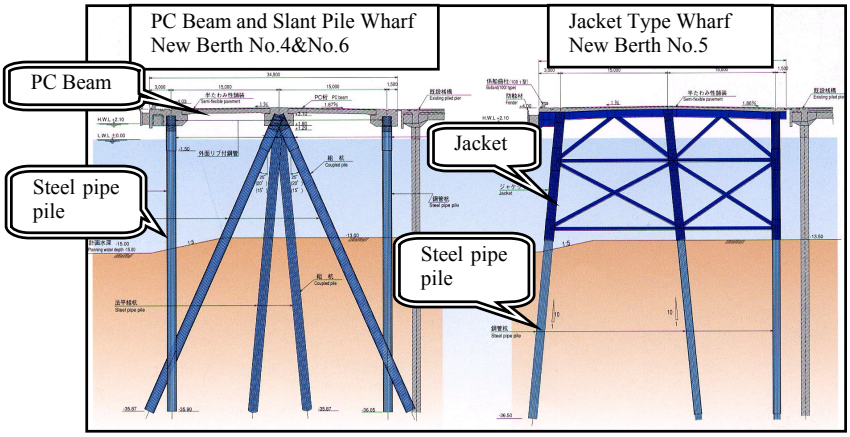


Fig.-1 Cross-sectional View of Reinforced Anti-earthquake Wharf

4. Effect of Redevelopment Project

4.1 Increasing Throughput of Containers

The Port of Tokyo as a whole has attained a steady growth, while Oi Container Terminal remained at a flat pace for the first four years after the start of redevelopment, but from the fifth year it kept growing at a pace of 7% annually on the average.

When it comes to the annual throughput per berth, the terminal handled about 280 thousand TEU in 2002, which was a growth of 30 to 50% comparing with the past throughputs of 190 to 220 thousand TEU per berth before the start of the redevelopment project.

The growth was brought by the extension of quay length per berth up to 330m to 350m, the increased water depth to -15m enabling to load 5,000TEU to 8,000TEU (60 thousand DWT to 100 thousand DWT) and the realization of anchorage of a large-sized vessel 300m long, all of which were the effects of the redevelopment project.

4.2 Contemporary Trend of Large-sized Container Vessels

The largest vessel anchored in Oi Container Terminal was 4,743TEU in 1995 before the redevelopment project but 6,690TEU in 2002 when a vessel of 300m long class can anchor in the terminal. It follows that the redevelopment project could cope timely and smoothly with the trend of enlarged container vessels.

5. Aiming For Further Development of the Port of Tokyo

In order to keep playing an important role as the logistical base to support the economic and industrial activities as well as the lives of people in the Metropolitan region, maintaining and expanding the major shipping services on a global basis, the Port of Tokyo has to take positive actions to maintain healthily the terminal function of the port.

In the management to maintain facilities on the other hand, we foresee negative factors such as the progressive aging of the facilities, the increasing cost for maintenance and the degraded services to users. To solve these issues we have to convert the conventional maintenance-oriented management just following the occurrence of imperfections into a systematic and preventive management. Furthermore, in order to reduce the port-related costs and to shorten lead time, more enhanced services to users are required, such as collaborated cargo-handling operations or environmental arrangements compatible with the logistic IT system.

With all that we have mentioned above, we are making our utmost efforts to strengthen the international competitiveness of the Port of Tokyo, and will keep striving to upgrade it to be a more easy-to-use port for users.

[Summary]

Preserving the Natural Environment and Overcoming Technological Challenges in the Redevelopment of Hydraulic Power Plants (Expansion of the Okutadami / Ootori Plants) -Towards the Coexistence with the (Breeding Activity of) Golden Eagles-

Electric Power Development Co., Ltd.

The goal of the project for the expansion of Okutadami and Ootori Power Plants was to increase the peak power generation through the effective use of the storage capacity of Okutadami Dam. This dam was constructed around the 1950s and it boasts the greatest water storage capacity in Japan.

The scale of this project was an increase of 200MW at Okutadami and an increase of 87MW at Ootori, which amounted to the total of approximately 290MW increase. It is the greatest redevelopment project for hydraulic power plants, excluding pumped-storage power plants in Japan.

Because the project took place in a region with abundant nature, designated as a quasi-national park and with the habitat of golden eagles at a close proximity, one of the biggest challenges of this project was to undertake the redevelopment project while preserving the natural environment (notably protecting the golden eagles). Another challenge of this project was to undertake the expansion work without suspending the power generation through the existing facilities, that is to continue operation of the existing large-scale power plant during the expansion work."

As for the preservation of the natural environment, appropriate measures such as the limiting of the construction period were taken in consideration of the life of the golden eagles and in order to achieve a temporal and spatial balance between their existence and the construction work. Moreover, through the building and the operation of environmental management system, the preservation of the natural environment was assured, and as a result, during the 4-years construction period, two cases of successful breeding of the golden eagles were observed.

This project was successfully completed under the strict limitations accompanying the two conditions of natural environment preservation and continuous operation of the existing plant by aggressively introducing new technologies and new construction methods. These new technologies / new methods are exemplified by 1) cofferdam closure method for high water pressure, 2) boring of the dam body, and 3) expansion of the existing underground power plant.

Photo 1 Cofferdam

Photo 2 Boring of the Dam Body

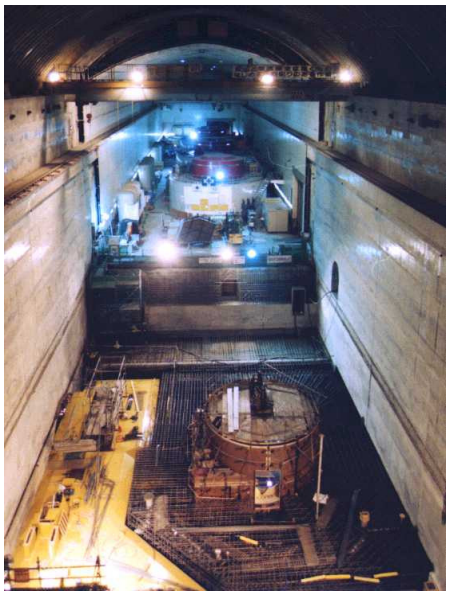


Photo 3 Expansion of the Existing Underground Power Plant

As this was the first project in Japan to have achieved the coexistence with the breeding of golden eagles, it would be the forerunner of the future development projects in coexistence with the natural environment. Moreover, the new technologies and new construction methods that were introduced by this project would contribute to the effective use of existing stocks.