Challenges in coastal flood risk reduction - collaboration between the Netherlands and Japan

NWO-JSPS Joint Seminar

Seminar and field trip report, 12–15 December 2016
Tokyo and Tohoku region, Japan

Tables of contents

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Front cover: Floodgates Control Center of the Koto River Improvement Office, operated by the Tokyo Metropolitan Government. Photograph by D. Paprotny.

1 Background and joint seminar objectives

Both the Netherlands and Japan are threatened by coastal flooding. For the Netherlands, this is a very prominent threat as large parts of the country are below sea level. In Japan, most of the population centers (e.g. Tokyo, Osaka) are located in coastal areas that are threatened by risks of coastal storms, typhoons and tsunamis. In both countries past disasters, such as the 1953 storm surge disaster in the Netherlands, and the 1959 Ise Bay typhoon and the 2011 Tohoku tsunami, have demonstrated the destructive potential of these events. In the future the coastal flood risks are expected to increase due to increased urbanization, economic growth and sea level rise. In recent decades new scientific concepts for assessing and managing risks have been developed, but many questions remain and policy implementation of those new concepts is often lacking.

On 12 December 2016 a seminar was organized in Tokyo, Japan, to exchange information between Dutch and Japanese researchers to improve the methods of reducing coastal risks. After the seminar, field visits were organized to flood protection structures in Tokyo (13 December) and coastal areas affected by the March 2011 tsunami (14–15 December). Some of the seminar's participants, instead of the field visit, carried out a workshop "Challenges in flooding" (13–16 December).

During the seminar the following key questions were addressed:

- How can coastal flood risks be characterized and assessed? What are the state-of-the-art methods for hazard, vulnerability and risk quantification?
- How can integrated concepts for coastal flood risk reduction (e.g. multi-layer safety, multiple lines of defence) be assessed in terms of effectiveness?
- Which strategies and solutions have been chosen in the three regions (the Netherlands, Tohoku region, Tokyo Bay area) and how have these interventions been shaped by past disasters?
- Given future developments, which would be relevant directions and strategies for reducing coastal flood risks in the Netherlands and Japan?

In particular, the seminar aimed to assess a range of possible protection alternatives that could increase the protection levels around Tokyo Bay, including the construction of a storm surge barrier at the entrance of the bay, a smaller barrier between artificial islands in Tokyo city, or the strengthening of coastal defences throughout the bay.

Organization and support

The seminar and field work was organized by the Tokyo Institute of Technology (Tokyo Tech) and Delft University of Technology. The seminar was supported by JSPS (the Japan Society for the Promotion of Science) and NWO (Netherlands Organisation for Scientific Research) and these organizations are gratefully acknowledged for this support.

Structure of this report

The report is organized as follows. Section 2 outlines the seminar and field trip program. Section 3 summarizes the main findings from the seminar, while section 4 describes the most relevant observations from the field visit. Additionally, section 5 reflects on the outcomes of the "Challenges in flooding" workshop. The report concludes with a list of participants.

2 Field trip and seminar program

2.1 General overview

Monday December 12	Joint Seminar *Morning: closed member meeting* *Afternoon: open seminar with two sessions:* *first on engineering and probabilistic methods* *second on planning and management*
Tuesday December 13	Field visit in Tokyo *Tokyo lowlands between Nakagawa and Edogawa rivers* *Flood defences in low-lying and port areas of Tokyo, including levees, floodgates and pumping stations* *Floodgate management centers*
Wednesday December 14	Field visit in Tohoku region, day 1 *Areas damaged by 2011 tsunami and ongoing reconstruction works in Miyagi and Iwate prefectures:* *Sendai* *Ishinomaki* *Onagawa* *Kesennuma* *Minamisanriku* *Rikuzentakata*
Thursday December 15	Field visit in Tohoku region, day 2 *Areas damaged by 2011 tsunami and ongoing reconstruction works in Iwate prefecture:* *Ofunato* *Kamaishi* *Otsuchi* *Yamada*

2.2 Seminar program

Title: Challenges in coastal flood risk reduction - collaboration between the Netherlands and Japan

Member meeting, 12 December 2016, Ookayama Campus of Tokyo Tech		
10:00	Introduction	H. Takagi *Tokyo Tech*
10:10	Natural disasters around the world	T. Shibayama *Waseda University*
10:25	Research at the University of Tokyo	M. Esteban *University of Tokyo*
10:40	Land use, coastal infrastructure and community rebuilding for coastal resilience	K. Iuchi *Tohoku University*
10:55	Future challenges in the coastal zone – modeling & fieldwork	V. Roeber *Tohoku University*
11:10	Coastal disaster research for Asian countries	H. Takagi & his students *Tokyo Tech*
11:40	Coffee break	
12:00	Special lecture: Water disaster management in Tokyo	N. Tsuchiya *Japan Riverfront Research Center*
13:00	Lunch break	

Open seminar, 12 December 2016, Ookayama Campus of Tokyo Tech		
13:45	Introduction	H. Takagi *Tokyo Tech*
13:50	Challenges in Coastal Flood Risk Reduction	R. Stroeks *Dutch Embassy in Japan*
First session on engineering and probabilistic design Chair: Miguel Esteban (University of Tokyo)		
13:55	Global developments in flood risk assessment and applications to tsunami risks in Japan	S. N. Jonkman, N. Okumura *TU Delft*
14:35	Membrane tsunami barrier	B. Hofland, B. Horsten *TU Delft*
15:15	Advances in pan-European flood hazard modelling	D. Paprotny *TU Delft*
15:35	Coffee break	
Second session on planning and management Chair: Jeremy Bricker (TU Delft)		
16:00	Rising waters: the causes, consequences, and policy implications for flooding in the United States	S. Brody *Texas A&M*
16:25	Land use management for flood and tsunami in Japan	M. Banba *University of Hyogo*
16:50	Dutch approach: the value of design in planning and engineering	F. Hooimeijer, Y. Yoshida *TU Delft*
17:30	Closing address	N. Tsuchiya *Japan Riverfront Research Center*

3 Seminar findings

3.1 Flood research in Japan

The first part of the seminar was a closed meeting, dedicated to presentation of research agendas of Waseda, Tokyo and Tokohu universities, as well as the host, Tokyo Institute of Technology. However, half of the total presentation time was granted to the Japan Riverfront Research Center for a special lecture on the water disaster management in Tokyo.

Research interests of aforementioned groups are very diversified, ranging from engineering of hard structures up to analysing risk awareness of people using social-science methods. Therefore, multi-disciplinary research groups and centers have been established. Tsunami hazard has a very high priority on the agenda, but typhoons, hurricanes, coastal erosion, fluvial and urban floods are also investigated. Moreover, the studies are not limited to Japan, but covers a range of countries in Asia and beyond, such as Vietnam, Indonesia, Phillippines, Switzerland and USA. The Japanese groups also have a strong track record in post-disaster field investigations.

During the special lecture, attention was drawn to the low-lying areas around Arakawa river, where the primary flood defence project underway is the construction of ‘super levees’ (Fig. 1). They involve raising a wide strip of land next to a river levee (dike), and redeveloping the urban fabric on it. Super levees solve the flood problem for areas were subsidence caused land to fall below average water level, and require large (10 m high) levees for protection against flood hazard. However, the cost and the need to temporarily relocate the population have slowed down the construction of super levees substantially. Since the idea’s inception in the 1980s only a small part of the Arakawa river vicinity (including Edogawa Ward) has been redeveloped with super levees.

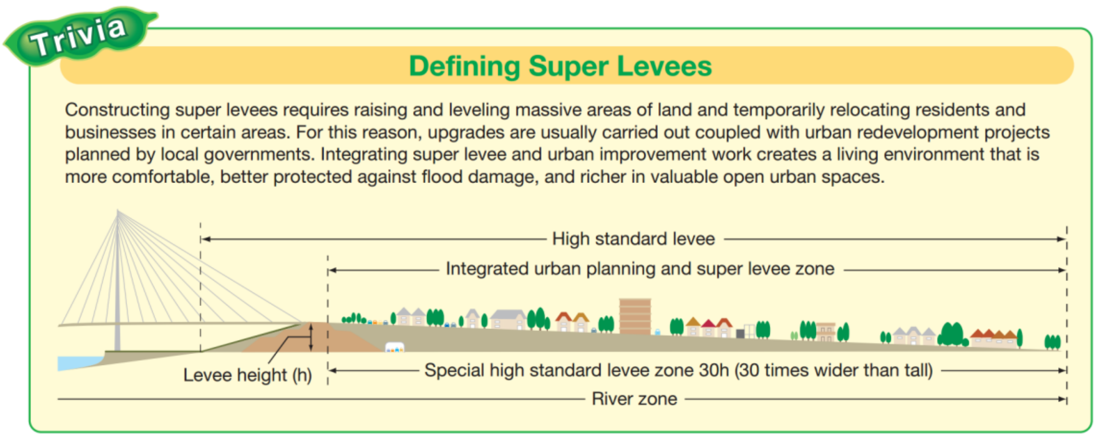

Figure 1. Concept of super levees. Source: “Super Levees Guidebook” by Arakawa-Karyu River Office.

However, researchers are also analysing other solutions to flood problem that are no less invasive, such as relocation. It is very disruptive to communities, but could be an option for post-disaster reconstruction. Not much known is on the long-term effect of relocation. Research by Tohoku University and Tokyo Tech in the Philippines (after 2013 Yolanda typhoon) has shown that permanency of settlement has considerable effects on socio-economic aspects of livelihood. People permanently relocated are able to carry on with their lives in a new environment, while those expecting to move back adapt much worse to their new situation.

Researchers from Tokyo Tech and the University of Tokyo have also studied evacuation, with fieldwork in the Philippines, showing that "horizontal" evacuation carries additional risks during a flood event. Therefore, "vertical" evacuation is investigated as a potential alternative. Meanwhile, scientists from the University of Tokyo noted the problem of awareness of the population about the flood hazard. They conducted extensive surveys in Djakarta (Indonesia) to study that aspect, while Tokyo Tech also analysed the subject in the Mekong delta (Vietnam).

Extensive modelling work is also carried out, of tsunami and storm surges in order to better understand coastal phenomena. Tohoku University developed its own morpho-hydrodynamic model BOSZ, which similar in purpose to the Dutch XBeach model. Coastal erosion and tsunami breakwaters are other topics pursued by Tokyo Tech with the use of advanced models.

3.2 Application of engineering and probabilistic methods

In the open seminar, a few engineering and probabilistic approaches to floods were presented by researchers from TU Delft. The session was opened by a short address by the senior innovation advisor to the Dutch ambassador to Japan.

The first presentation highlighted how two regions (the Netherlands and the Houston / Galveston Bay area in Texas) deal with coastal hazards. In the Netherlands a comprehensive flood protection system has developed over the last decades. In recent years, the safety standards and management of the system have been revised based on a nationwide risk assessment. Meanwhile, despite the Houston / Galveston Bay area being at significant risk from coastal flooding due to hurricanes, there is no comprehensive risk reduction system in place. Over the last years, plans have been developed (including levees, storm surge barriers and natural features) on how the risks can be reduced. The final part of the presentation provided a brief comparison between the two regions and included a broader discussion of global trends in solutions to reduce coastal risks. Additionally, possibilities of extending the approaches from those two regions to Japan were also shown.

The second presentation was dedicated to a particular engineering solution to protecting the coast from tsunami, dubbed "membrane tsunami barrier". Proof-of-concept model tests on a novel, self-deploying on-shore tsunami barrier were shown. The tsunami barrier consists of a Dyneema® membrane, floater and cables that are stored underground, so that it does not hinder access to the coast. Due to buoyancy the barrier self-deploys when struck by a tsunami (Fig. 2). The tests showed that the tsunami barrier indeed deployed automatically and can completely block a 19 m high (reflected) tsunami. The researchers are currently in the process of further detailing the barrier and have completed initial design focused on Kamakura, south of Tokyo.

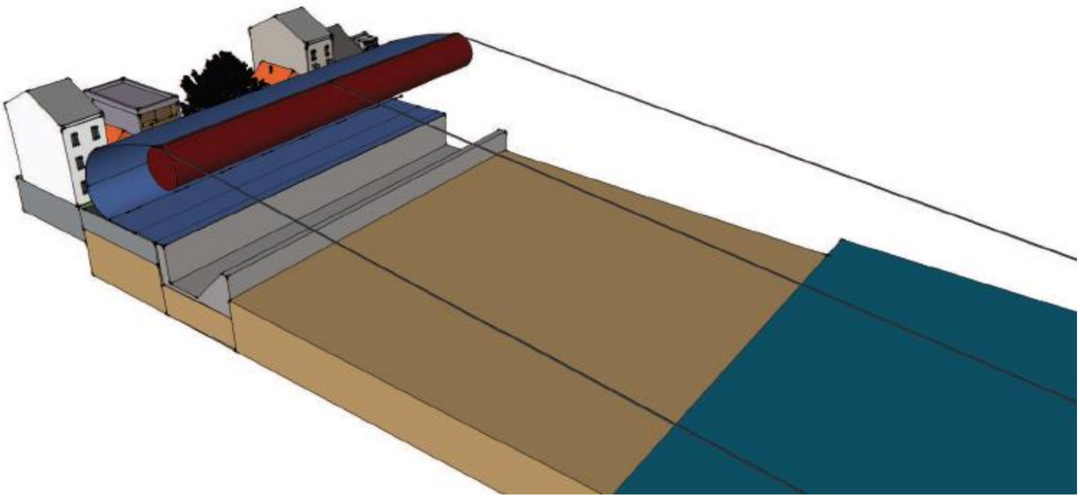

Figure 2. Visualisation of the membrane tsunami barrier, when deployed during an event. Drawing from presentation by Bas Horsten and Bas Hofland.

The final presentation in this session presented results of project “Risk analysis of infrastructure networks in response to extreme weather” (RAIN). It goal was to develop pan-European maps of meteorological and hydrological hazards. That included preparing river and coastal flood hazard maps. Typically, the computational expense of running hydrological models is very large and often limits the extent and depth of such studies. In this presentation, the modelling solutions that have relatively low computational expense were shown, together with their validation. The results showed that using less advanced methods could yield equally good results as more complex approaches. This is mostly achieved by more effective use of established methods, however it included an innovative approach to river discharge estimation through the use of Bayesian Networks. This statistical model is potentially an effective solution for use in data-poor regions.

3.3 Flood management and planning in Japan, the Netherlands and the USA

The final session of the seminar was dedicated to policy, planning and management in three countries.

The first presentation from Texas A&M University outlined the growing problem of flooding in the United States, particularly in coastal regions. Results were reported from observational research on the major drivers of flooding, the economic consequences for local communities, and specific mitigation techniques that can reduce losses over the long run. Examples were presented at the regional and local levels to form a better understanding of how decision makers can implement programs that better protect residents from the adverse impacts of storm events. A significant part of the speech was dedicated to the Galveston Bay area, where it was explicitly shown how land use changes (mainly urban sprawl) influence flood risk. Mitigation measures presented involved e.g. elevating structures, protecting coastal dunes and open spaces as well as constructing single- or multipurpose barriers.

Figure 3. Elevated house under construction in Texas coastal zone. Photo from presentation by Samuel Brody.

Following this, Prof. Banba from the Hyogo Prefectural University spoke about land use planning for the purpose of disaster risk reduction. She presented Japanese examples of integrated land use management and disaster risk reduction planning. Finally, she discussed challenges met in the implementation of these projects and the lessons learned, which can be applied outside Japan as well.

The final speech was carried out jointly by practitioners from The Netherlands and Japan, giving a different, urbanist-architectural vision of flood protection. The Netherlands is well known for its intense relation with water: it brings both prosperity and disaster, but is also the reason for Holland's culture of urbanism. It was indicated by the speakers that this link is not made often. They filled this gap by showing the relation between planning, design and engineering in the Netherlands and how is this to be understood, as well as how to potentially implement it elsewhere. In the second part of the lecture the prize-winning project for Nihonbashi River in Tokyo was shown. There, landscape design and hydraulic engineering are joined in a high quality proposal for improvement of the position of the river in the city.

3.4 Future work and cooperation

The seminar has highlighted important aspects of researching tsunami hazard, protecting coastal communities using technical solutions and increasing awareness and resilience of citizens that are of importance for both the Netherlands and Japan, as well as other coastal regions. More detailed topics for cooperation were identified as follows, in two broad groups:

- Coastal risk assessment and risk reduction design:
    - Planning and rebuilding for sustainability and risk reduction, including integration of civil engineering and urban design and planning;
    - "multiple layered safety", i.e. integration of, and synergies between, protective measures such as dikes and seawalls, landfills, shelters and evacuation. This includes synergistic interventions such as super levees and urban redevelopment;

  - Design cases for integrating flood defences and reinforcements in urban environments;
  - Risk awareness and citizens response, and disaster management.
- Coastal hazard modelling and design criteria:
  - Tsunami wave characterization as a function of bathymetry, bay shape and onshore measures and their characteristics, e.g. walls and landfill, including modelling and experiments;
  - Development of design criteria: probabilistic analysis of return periods of tsunamis and surges, in relationship with level I and II design criteria, with special focus on designing for resilience;
  - Innovative tsunami protection methods, e.g. the tsunami catcher;
  - Loss of life due to tsunamis and the relationship with tsunami parameters and warning characteristics;
  - Risk assessment of defence systems in the Netherlands and Tokyo.

A number of follow-up activities have also been identified and discussed:

- Joint publications on tsunami risk assessment;
- Joint MSc graduation and multidisciplinary student projects;
- Exhibitions in the Netherlands and Japan from Dutch landscape architects;
- Staff exchange;
- Developing joint research proposals, especially focused on international network building and multidisciplinary projects, especially in the field of planning, engineering and designing for coastal resilience;
- Liasion through the Duch embassy to explore possibilities for cooperation.

4 Summary of field visit findings

The field trip consisted of two parts: Tokyo flood protection tour (13 December) and visit to coastal areas affected by the March 2011 tsunami in Tohoku region (14–15 December). Below, the main findings are discussed.

4.1 Flood protection in Tokyo

The field visits on Dec 13 were led by Dr. Nobuyuki Tsuchiya, the Director of the Japan Riverfront Research Center. In the past, Dr. Tsuchiya worked for the Tokyo Metropolitan Government, and was in charge of the Edogawa Ward restoration project, which aims to make the ward both safer (via dike widening into super levees as much as practical) and more livable (via preservation of cultural resources and encouragement of pedestrian and bicycle-centric lifestyles). The tour began at the Shin River, which runs east-west between the Ara River and the Edo River. During the Edo period, the Shin River was dug as a canal to transport salt from salt fields on its east side to the feudal capital on its west side. After modernization of transportation with railroads, this canal was no longer needed, so to reduce its flood risk to Edogawa Ward, the Shin River was closed off to outside waters via a gate on the east (Edo River side) and a dike with a pump station (Fig. 4) on the west (Ara River side). During storms, the gate is closed to prevent high Edo River levels (from storm surge and/or upstream rainfall runoff) from entering, and the pump station is activated to evacuate interior rainfall to the Ara River. The levee on the Ara River had been gradually heightened as the interior of Edogawa Ward subsided, but the levee's proximity to a public road and private residences has prevented its being widened into a super levee.

The tour continued on the south shore of Edogawa Ward, which faces Tokyo Bay. This section is composed of relatively new landfill, built of dredge spoils to restore the shoreline from the dump it had become in the 1960's to 1970's. The levee here takes the form of a super levee, with a width of hundreds of meters, and with various structures and uses on its crest and slopes. The foreshore is an artificial sand beach. Just offshore are two artificial intertidal habitats, one for recreational shelling, and the other reserved for wildlife only (shorebirds and shellfish). The sand beach began being used for watersports this year, as the water quality recently improved enough to allow this. This improved water quality is the result of wastewater treatment and upstream nutrient control measures.

In the afternoon, the tour took us to the Tokyo storm surge gate control center (Fig. 5), where the opening and closing of all the surge barriers around the bay are monitored and operated. Closing occurs when specified water levels are reached. The communication system connecting the gates has redundancies so that the system can be controlled even if some components are compromised. Furthermore, the system is a closed-circuit intranet, and cannot be accessed from the outside, so as to prevent hacking. Each gate is tested regularly to ensure proper operation. In the event of a power outage, the system and gates can run off their own generators and fuel stock. Gates can even be closed manually, by releasing the lift gates to fall closed via their own weight. Though gates can close manually, they cannot be opened without power. We toured one example of such a lift gate at the Kamejima River (Fig. 6). We then visited the Tatsumi pump station (Fig. 7) and gate complex, which was under construction in order to install pumps of larger capacity.

In the evening, the group visited the Tokyo Port storm surge management center (Fig. 8), which is responsible for the storm surge barriers within the Port's jurisdiction. Finally, we visited a gate in a levee inside Koto ward (Fig. 9). This levee is in place to prevent storm surge from moving from the industrial area along the coast, to the residential area further inland. The gate is normally open to allow traffic to pass, but is closed during threatening events.

The Dec 13 field visit highlighted the similarities between the Netherlands and Tokyo's Edo/Koto wards. These wards compose the historic delta of the Tone river, and are composed mostly of peat soils. To reduce riverine flood risk, the Tone river (Japan's largest river) was diverted away from Tokyo Bay and directly into the Pacific Ocean during the feudal era over 200 years ago, but the subsidence of these wards from the onset of industrialization until the prohibition of groundwater pumping in the 1970s has caused these wards to grow more vulnerable to pluvial, fluvial, and coastal flooding. The remainder of Tokyo is at a higher elevation due to the presence of silt soils deposited by ashfall from Mt. Fuji's historical eruptions, but any ashfall that had been deposited in Edo/Koto wards was long ago scoured away by the Tone River, leaving only peat from the delta wetlands that composed these wards before settlement. Like the Netherlands, this region of Japan has been fighting flooding for hundreds of years, but human activities have also exacerbated this hazard (e.g. groundwater extraction has led to subsidence). Also like the Netherlands, these wards are home to a bicycle-friendly lifestyle where residents try to live in close contact with the water, both canals and Tokyo Bay. Fig. 10 shows the super levee in Kasai Rinkai Park, on the seaward side of which a beach and habitat wetland were constructed (Fig. 11). Long-term improvements in wastewater treatment and upstream control of agricultural nutrient (phosphorous) runoff into Tokyo Bay has led to a recent (2016) lifting of the decades-long ban on water-contact recreation in upper Tokyo Bay.

Figure 4. Pump station for evacuating interior drainage from the Shin River to the Ara River.

Figure 5. Tokyo storm surge gate control center.

Figure 6. Kamejima storm surge gate.

Figure 7. Tatsumi pump station.

Figure 8. Tokyo Port high tide management center.

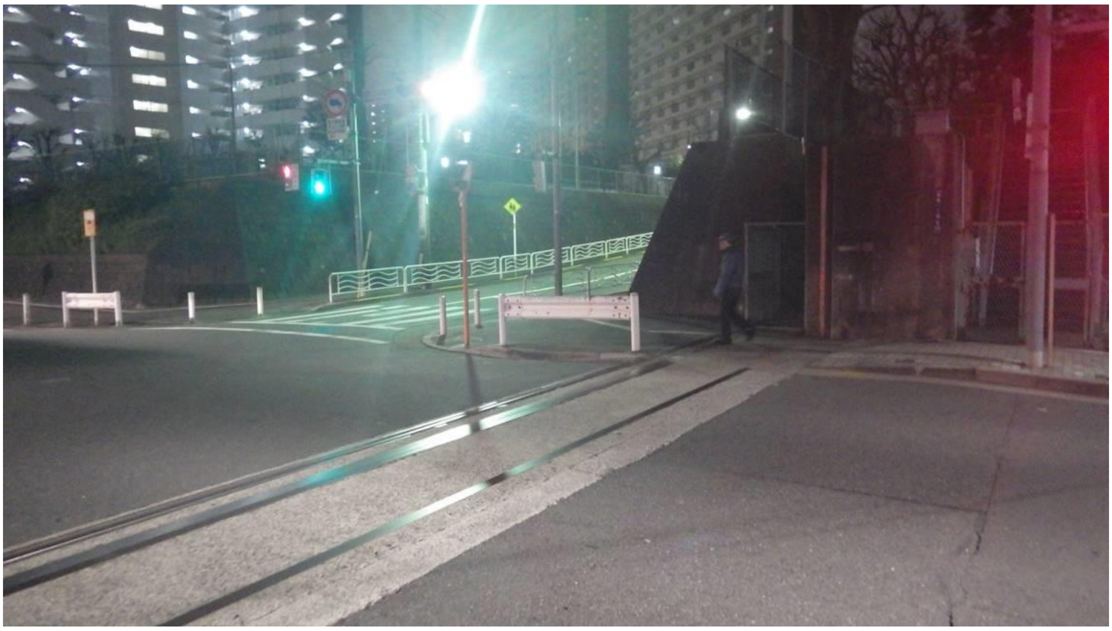
Figure 9. A gate in the coastal levee.

Figure 10. Super Levee in Kasai Rinkai Park.

Figure 11. Constructed sandy beach and wetlands off super levee in Kasai Rinkai Park.

4.2 Post-tsunami reconstruction in Tohoku

On Wednesday and Thursday (13–14 Dec) the Tohoku area was visited, specifically Miyagi and Iwate prefectures. Here all coastal towns were hit by the 2011 tsunami. At the moment a large rebuilding project worth an est. ¥20 trillion (€200 billion) is ongoing and nearing completion. Dr. Kanako Iuchi (Tohuku U.) and Dr. Jeremy Bricker (TUD), who are very knowledgeable about the area and the tsunami reconstruction provided much information.

The works at most coastal towns consist of earth works where first the subsidence of the entire coastline during the earthquake (or roughly 0.7 to 1 m) is augmented. Furthermore the levels are increased more by very extensive earthworks, increasing the ground levels up to 10 m or more. Next to that zoning is applied, such that no residential buildings can be made on the lower levels where a level 2 tsunami (return period in the order of 1000 years) can still reach. Most towns also built a large wall or dike close to the shore. This will be overtopped during the higher tsunamis, but is intended to decrease the tsunami flooding. In some towns a breakwater is made with the same function. Communal housing projects are also made for people who lost their homes. It was clear that each local community has chosen for a combination of these different solutions.

Many social problems arise due to the disaster. For some areas it remains the question whether the population will return to the towns. The population in the area was already declining, and many people have settled in other places.

It was noticed that the risk reduction strategy (i.e. combination of breakwaters, dikes, landfill and other measures) differed by location. Choices for the strategy have been made based on local preferences. For example, the town of Onagawa has adopted a planning concept with different zones designated for specific uses. In all cases, evacuation and zoned relocation were a part of the strategy to cope with tsunamis.

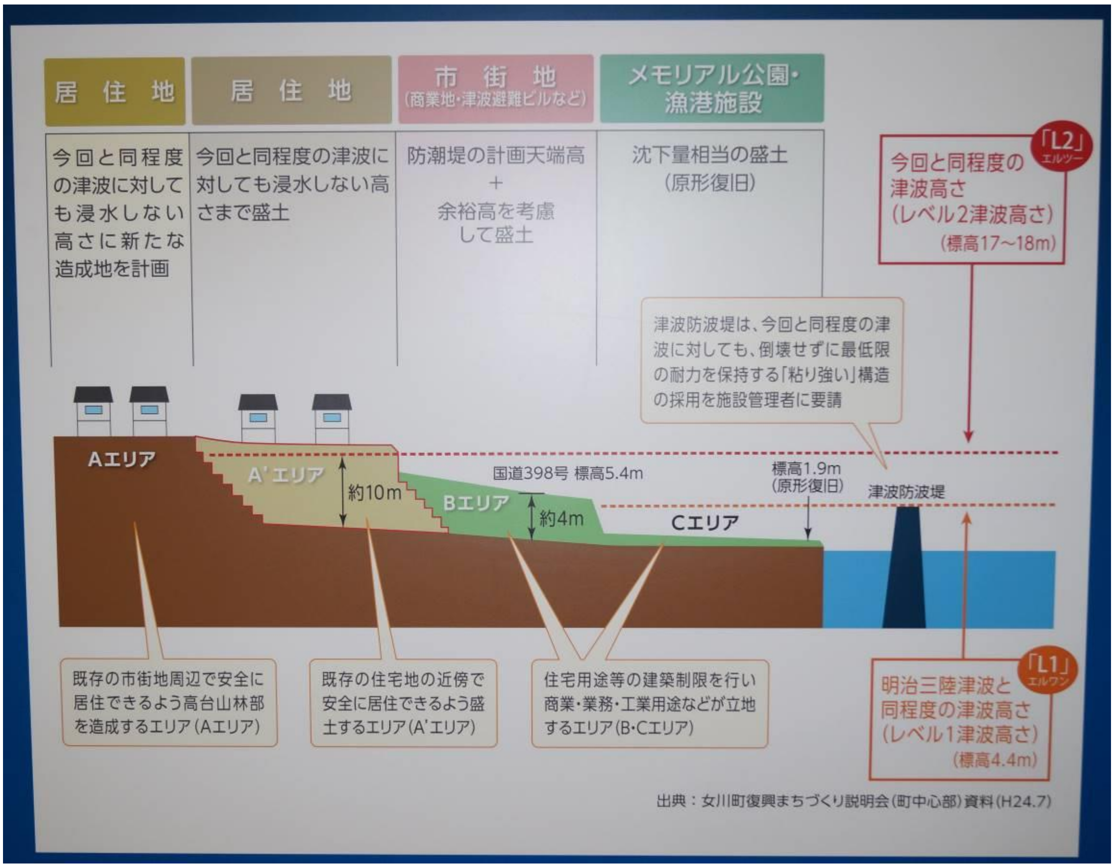

Figure 12. Post-tsunami planning concept of Onagawa: parks, commercial, and industrial functions are allowed in the green zone, residential developments on the higher grounds (yellow and brown).

On Wednesday 14 Dec the group visited the following coastal towns.

- Ishinomaki
- Onagawa
- Minamisanriku
- Kessenuma
- Rikuzentataka

Ishinomaki was thought by many inhabitants to be protected from large tsunami attack due to its geographical location just behind a large outcrop/peninsula. Therefore the evacuation percentage here was relatively low in 2011, and there were many casualties.

Figure 13. Old (left) and new (right) seawall in Ishinomaki.

Figure 14. Extensive earth displacement works in Onagawa

Figure 15. Information centre in Minamisanriku.

Figure 16. Tsunami gates and large coastal embankment in Rikuzentakata..

In the town of Rikuzentakata an especially high (12.5 m) flood wall has been erected. In the picture above it is shown in the background. The group climbed this wall in the twilight. This wall cannot be expected to stop an extreme (Level 2) tsunami, and is mainly intended to slow it down. In a sketch in the information centre it was seen to be combined with a large tsunami forest and offshore breakwaters.

On Thursday 15-12 the group visited the following coastal towns.

- Ofunato,
- Kamaishi,
- Otsuchi.
- Yamada

Figure 17. Large (ca. 6 m high) walls and gate in Ofunato.

Figure 18. Kamaishi Bay, with the Kamaishi tsunami breakwater visible at the bay mouth.

The deepest breakwater in the world in the bay entrance at Kamaishi is made to slow down tsunami attack. The caissons that were displaced by the 2011 tsunami have been moved back or replaced, heightened, and friction between caissons and rubble berm has been increased.

Figure 19. Heightened land in Otsuchi with new roads, and some first redevelopments. The layout of the area is comparable to the pre-tsunami situation. In the middle there is one lot that is not raised because the owners are not participating.

5 "Challenges in flooding" student workshop

As noted in the introduction, both the Netherlands and Japan are threatened by coastal flooding and also need to take into account pluvial and fluvial flooding in urban engineering. The hazard is exacerbated by land subsidence and soil sealing due to urbanization, which means that measures to prevent pluvial flooding need to be taken into account. In recent decades, new scientific concepts for assessing and managing risks have been developed, but many questions remain and policy implementation of new concepts is often lacking. In addition, the link between the larger and smaller scale especially concerning vital subsurface infrastructure due to lack of interdisciplinary cooperation among hydraulic engineering, urban design and urban water management, has not been fully exploited.

In light of the above, the aim of the student workshop, which was held in parallel but separately from the field trips described in section 4 above, was to give specific attention to approaches to reduce these risks by means of a combination of multiple structural and non-structural measures through an interdisciplinary approach. The workshop was focused on Tokyo's Edogawa Ward: a large densely populated area threatened by typhoons, earthquakes, pluvial and fluvial flooding. As of 1 May 2015, the ward had an estimated population of 682,418 and a population density of 13,680 persons per km². The total area is 49.90 km². Currently, flood defences (flood walls) are in place, yet at a relatively low level of protection (for a flood of probability around 1/100 per year) and with limited possibilities to adapt the defences to changing conditions.

The workshop was preceded by a visit to the Edogawa area on 11 Dec, which was similar to the one undertaken on 13 Dec by those seminar participants who visited the Tohoku area instead of joining the workshop. Workshop participants joined the seminar on 12 Dec and proceeded to work intensely during 13–15 Dec at Tokyo University, with final presentations held on 16 Dec. The mentors of the workshop were Fransje Hooimeijer (TU Delft), Yuka Yoshida (Yoshida Landscape), Jeremy Bricker (TU Delft) and Akihiko Ono (SfG Landscape Architects).

The integration of information and ideas was done using a charrette system. First the workshop started with a common understanding of the problem and context of the case. The first round of the charrette is the disciplinary focus, in which the students in their comfort zone can elaborate on their knowledge of the proposed problem and their first ideas how to tackle these, which measures could be appropriate. The two groups both set the conditions for further elaboration: the hydraulic engineers set the larger conditions from the hydraulic setting, the urban designers looked into the spatial quality of the site and formulated spatial strategic interventions that could help to improve this. In the second round pairs of hydraulic engineers and urban designers were made to confront the two perspectives and create a main vision. This resulted in the presentation of 4 groups with their specific interpretation of the issues and solutions. After the presentations the main perspectives were discussed and brought back to two main statements: one group pro-super levee (Group 1) and one group anti-super levee (Group 2). These two groups developed their plan for the Edogawa Ward. In a midterm presentation the students could take notice of the similarities and difference between the groups to make new decisions in the follow up of their proposal.

For this workshop, three hydraulic engineers worked together to develop design boundary conditions and provide design tools on the macro scale. Initially, hydraulic threats to Edogawa were qualitatively analyzed. Then, mitigation measures such as upstream hydraulic structures and storm surge barriers were socialized as enabling features. During the design process (13–15 Dec), only one hydraulic engineering student remained in the workshop to give hydraulic engineering insights and made sure the visions from other disciplines stay within the lines of engineering practice. More attention was given to the anti-super levee group (Group 2) as they needed to falsify a thoroughly studied super levee plan and provide an alternative. Additionally, suggestions that were provided during the design process are, for example, streamline designs to minimize turbulence, sheet pile installations for seismic retrofit, broad idea of dike dimensions, and optimization of urban drainage system.

Group 1 (pro-super levee) had the super levee plan as their initial condition. At the end, Group 2 (anti-super levee) established a plan to adapt with the super levee with several key points: 1) the super levee should not be constructed on the whole perimeter of Edogawa but only on selected reaches, 2) an implementation of the Dutch *dijkhuis* (dike-home) concept, 3) urban farming opportunity for the residents to sustain the local economy and occupy the slope simultaneously, and 4) linking the super levee with multiple evacuation routes and safety bubbles within the area. Group 2 chose to work with water, instead of forcing the water out of Edogawa. A flood plain on the west of Edogawa was designed to allow water to occupy a larger space and decrease the pressure on the dike. This idea, however, must be integrated with macro solutions stated before, involving other districts to protect Edogawa from coastal floods. Therefore, the relationship between wards and compensation mechanisms must be justified in the future.

The duration of the workshop was the only limitation for the participants to develop interdisciplinary designs. Moving on, more details should be prepared for the designs before the showcase in March 2017.

Figure 20. Design for a new dike profile that also can retain water. Group b: Jiabiao Lin (Bill), Manami Hasegawa, Daiki Mabuchi and Shaswati Chowdhury.

Figure 21. Re-design of the dike at the junction of the highways into an urban farming park. Group a: Maayan Daniel, Ayano Yamaguchi, Supriya Krishnan and Richard Crichton.

6 List of participants

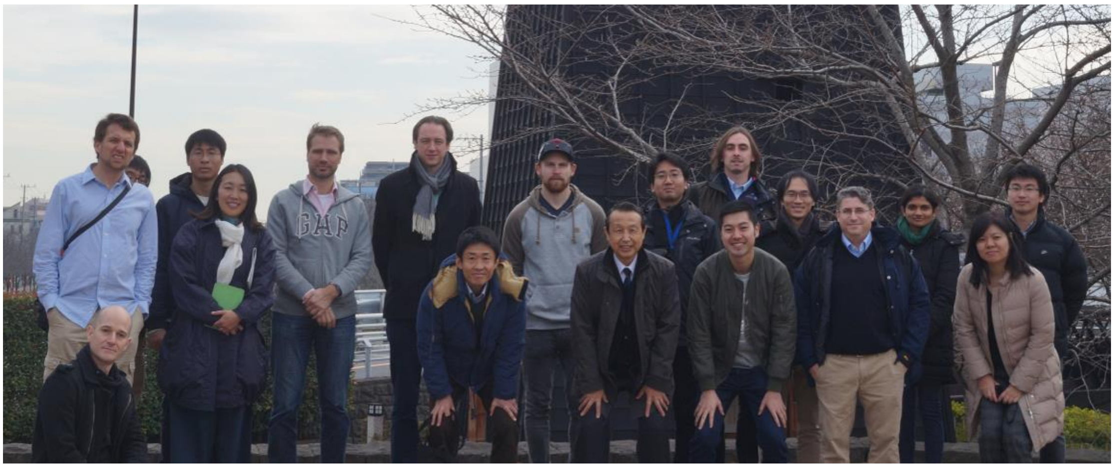

Figure 22. Participants of the joint seminar during field visit to Tokyo's flood defences..

Dutch seminar participants

Name	Affiliation
Bas Jonkman	TU Delft
Jeremy Bricker	TU Delft
Fransje Hooimeijer	TU Delft
Bas Hofland	TU Delft
Dominik Paprotny	TU Delft
Bas Horsten	TU Delft
Non Okumura	TU Delft
Supriya Krishnan	TU Delft
Bill Jiabiao Lin	TU Delft
Maayan Daniel	TU Delft
Johannes Simanjuntak	TU Delft
Samuel Brody	Texas A&M University
Yuka Yoshida	Yoshida Landscape Architecture

Japanese seminar participants

Hiroshi Takagi	Tokyo Institute of Technology
Le Tuan Anh	Tokyo Institute of Technology
Daisuke Fujii	Tokyo Institute of Technology
Jerome Silla	Tokyo Institute of Technology
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