An interdisciplinary approach to urban reconstruction after the 2011 Tsunami

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Publication date
2018

Document Version
Final published version

Published in
TU Delft DeltaLinks

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Students of hydraulic engineering, geotechnical engineering, transport infrastructure, urban drainage engineering and urbanism studied the recovery of the city of Yuriage using the *goal integration* method. Much can be learned from the bold approach of the Japanese to disaster reconstruction and fighting shrinkage in regional spatial planning. By **Fransje Hooimeijer, Jeremy Bricker** and **Kanako Iuchi**.

Introduction

Located on Pacific Ring of fire, the Tohoku region of Japan is one of the most prone location to earthquakes and tsunamis, and for decades has been struggling with shrinking and aging population, together with declining economy for the last several decades. Nonetheless, Tohoku is renowned for the most productive coastal fishing waters in Japan, and is thus home to a large number of fishermen and their families, who are the people most vulnerable to tsunami. Due to the high hazard in the area and the vulnerability of the population, various measures such as seawalls, coastal forests (a forrest in fron of the coastline to reduce the impact of a tsunami wave), breakwaters, and water gates have been constructed along this coast to reduce loss of life and property during tsunamis. The 2011 tsunami served as a proving ground to show pros and cons on previous measures, as well as giving landscape architects and urban planners a clean slate (in many locales) to guide the region's reconstruction, necessitating the inclusion of hydraulics, geotechnics, urban drainage, structural, and transportation engineers in the planning process as cities, lifelines, and transportation arteries are rebuilt and relocated. Thus the reconstruction serves as a living laboratory to understand how in the project the differerent diciplines of planning, design and engineering come together and answer the question: What lessons learned from the 2011 Japan Tsunami reconstruction process can be applied to increase the resilience of Dutch cities?

The Delta Infrastructure and Mobility Initiative (DIMI) of TU Delft initiated this project to have a multi-disciplinary team work in an interdisciplinary fashion by testing if lessons for resilient reconstruction from Tohoku could be applied to the Netherlands in the case of an unexpectedly severe storm surge event here causes similar obliteration of a city. The study was organized with the aim for interdisciplinary and international cooperation. The interdisciplinary goal within the Delft University of Technology, is not only about the connection between Civil Engineering

and Architecture but also to establish cooperation among the fields of hydraulic engineering, urban water management, transportation planning, and geotechnical engineering to create integrated learning from the tsunami reconstruction. The international cooperation is about maintaining knowledge exchange and developing ties between researchers at TU Delft and in Japan (Tohoku University, Tokyo Institute of Technology, Waseda University, and the University of Tokyo) in the fields of flood risk management, delta planning and design.
The goal of this paper is to elaborate on the multidisciplinary research approach that was undertaken in the workshop in Tohoku University in Japan and to derive lessons for this application in education and research projects.

Method

The study was done by two groups of MSc students: an interdisciplinary group and a group of thesis students. Both groups consists of students of 5 departments: hydraulic engineering, Geo-Sciences and Engineering, transport infrastructure and logistics (TIL), Urban Drainage Engineering, and Urbanism. The KNAW (Royal Netherlands Academy of Arts and Sciences) labels the method of taking the same case as “goal-integration”. By having experts from different disciplines study the same case, listening to each other’s progress on a voluntary basis during the research process, the cooperation lies in aiming for the same goal: a new future for the case. The approach of goal integration probably has the largest degree of liberty for the researchers involved, and a comparatively smaller chance of resulting in interdisciplinary, rather than multidisciplinary, findings. The definition of a multidisciplinary project is where each expert contributes their own discipline-specific part to the project, while an interdisciplinary project goes a step further by having each expert understand the methods of the other disciplines and contribute to a more coherent and valued overall project. This shared case is interdisciplinary, also to allow for a more experimental approach within the boundaries of the case. Two additional methods are the charrette and integrated design. The method of charrette may refer to any collaborative session in which a group of people drafts a solution to a problem (Lennertz and Lutzenhiser, 2014). The structure of these sessions may vary, but there are always multiple sessions in which the group is divided into sub-groups to enhance dialogue to integrate the aptitudes and interests of a diverse group of people. The goal is to create an innovative atmosphere in which the diversity of the group is used to collaborate to a shared vision for the future.
The other method of integrated design is part of the charrette. In contrary to what Voorendt (2017) proposes, that of five design-stages (analysis, synthesis, simulation, evaluation and

decision) only the first (analysis, to identify requirements that will results in a synthesis) can be done in a multidisciplinary way, in the workshop the final frame was put into a sketchy design proposal.

Analyses and synthesis workshop

The workshop in which the charrette and integrated design was performed was held at Tohoku University and at understanding where within a scope of interdisciplinary possibilities it can be positioned. In order to foster multidisciplinary collaboration, the DIMI group chose to focus on the neighbourhood of Yuriage, in the City of Natori, just south of Sendai (Figure 1). Before 2011, Yuriage was protected from the sea by a coastal dike and a coastal forest, itself planted after the Keicho Tsunami of 1611 wreaked havoc on the area. Yuriage hosts a fishing harbor protected by a breakwater. Inland across a bay is an island which housed most of the population. Inland across the Teizan canal from this island is the mainland, which housed more population as well as vast expanses of rice fields. The 2011 tsunami overtopped the coastal dike and destroyed the coastal forest. The tsunami inundated the neighbourhood, completely destroyed the residential area on the island, and partially destroyed the residential area on the mainland. Rice fields were put out of commission for 2-3 years due to salt damage, but agricultural production has since resumed. Infrastructure in the fishing harbour was wrecked, but the port was quickly restored to aid in reconstruction operations and restoration of commerce. Figure 3 details the reconstruction plan, implementation of which was well under way when the DIMI group visited in November 2017.

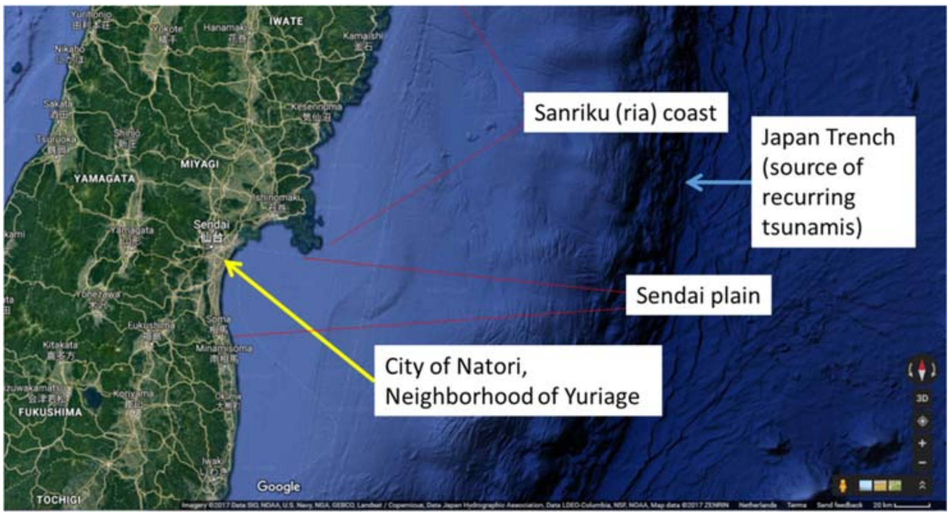

Figure 1. Map of Tohoku (northeast Japan).

Figure 2. Yurage before (left) and after (right) the 2011 Tsunami.

After the site visit and the explanation by the officials of Natori Municipality the workshop started with the charrette. The first round in the charrette was each discipline defining their scope of solutions and decided where Yuriage is positioned within these boundaries. These disciplinary scopes (the range of options from the disciplinary specific perspective) were merged into a shared framework through multiple rounds in which the scopes were put together and adjusted towards eacht other. The final framework showed the linkages between the disciplinary scopes which enabled the students to analyse the relation between the disciplinary decisions to explain and assess the case from an interdisciplinary viewpoint. The last round was testing the framework by projecting new sets of choices for each discipline, which lead to an integrated design.

The disciplinary scopes were developed by the students after visiting the site and receiving an explanation by the officials of Natori office about the disaster and the reconstruction process.

The urbanism students defined their scope between endpoints of innovative urban renewal and conventional urban recovery. The latter is bringing back what was lost but with measures to be safe from tsunami, while the former is using the recovery to innovate and implement new technologies like renewable energy and green/blue structures.

The scope of the TIL students was defined between endpoints of multi-modal to mono-modal mobility infrastructures.

The scope of water management was defined between living with water and protection from water. In between were aquaponics, nature based treatment, harvesting & reuse, visible water & green, extra flood storage and access to the sea. The endpoint of protection from water was defined as retreat from the coast.

The hydraulic engineers defined a scope from ‘hard measures’ to ‘soft measures’.

The scope of geo engineering defined steps between engineered to nature-based solutions, going from retaining wall, anchors, shotcrete (or sprayed concrete), geotextile, drainage to earthwork and bio based solutions.
In five rounds the scopes of the five disciplines were synchronized ending up in two groups (mix of thesis and project students) of which in each group there is a disciplinary representative and delivered their final interdisciplinary framework. These were then tested by posing the WHAT IF? question which meant that one discipline was made dominant in making their preferred intervention and the effect of this choice was then analysed on the other disciplinary choices. This method of rethinking the possibilities and the relation between the preferred interventions as a group resulted in the integrated design: vision and strategy proposal for the site.

The students worked in two groups. Group A designed a framework (see figure 3) in which the red dots indicate where according to the group Yuriage is now, and the grey hatched dots indicate where they would like to position their proposal based on resilience and sustainability. The geo-engineering students did not have specific preference for an intervention.

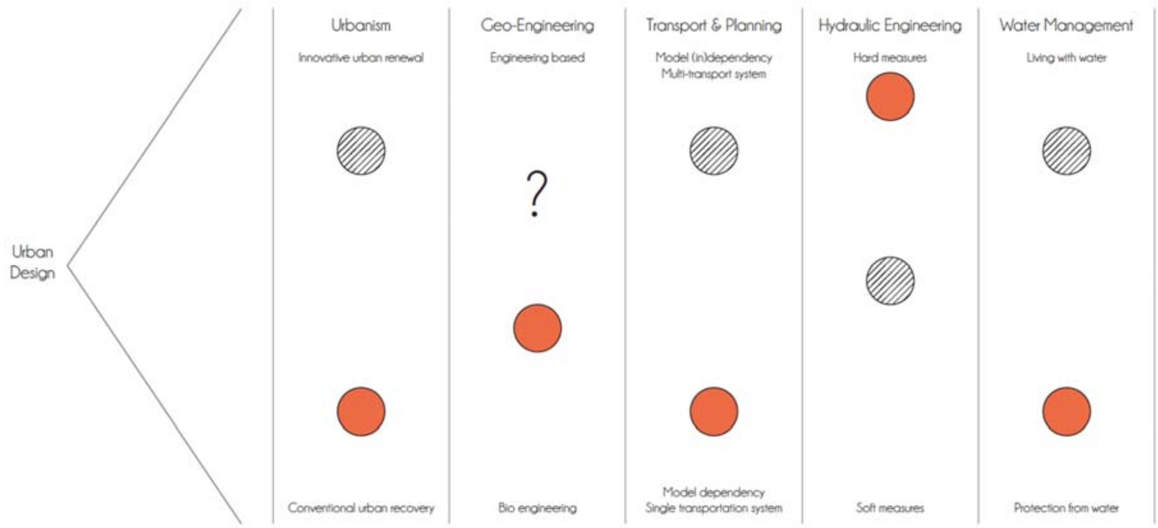

Figure 3: The framework of group A in which the red dots indicate Yuriage today and the grey hatched dots where they would like to take the town in their proposal. The geo-engineering student did not have specific preference for an intervention.

At the beginning of the workshop the group put down five design criteria for Yuriage:

- Level 1 tsunami protection along the whole coast;
- Level 2 tsunami protection for residential areas;
- Connection to the sea;
- Nature integrated in design;
- Multi-purpose space design;

Another aspect they took into account was the fishing harbor which should be situated next to the industrial area where fish are processed. With these criteria in mind, the group members individually created an urban design from their disciplinary perspective. Then they took the best aspects from these various designs and created one comprehensive masterplan.

Figure 4: Plan for Yuriage by group A.

The main structure in their masterplan are the under-construction coastal and river levees, which function as Level 1 tsunami protection (dashed lines). Behind the coastal levee, a coastal forest, dissipates energy from a larger tsunami in a natural way. Protection from the Level 2 tsunami is enacted by elevation of the residential area by four meters on earthfill. Therefore, even if the Level 2 protection does not stop all the water, the residential area will not flood by more than 2 meters. Despite the two lines of protection, there still is a connection between the village and the sea. This connection is created by a green walkway from the village of Yuriage towards the sea. This way the residents can walk towards the beach without having to go through the industrial area. The multi-purpose space use is not visible on the map, but is in the details of the project. These ideas have to improve the atmosphere, livability and safety of the village. An example is the elevated platform from which you have a view over the sea, but which can be used for vertical evacuation too during tsunamis.

The second group B set out the same framework as group A in which the pink dot is where Yuriage is now and the desired level for Yuriage is the dotted circle in pink (see figure 5)

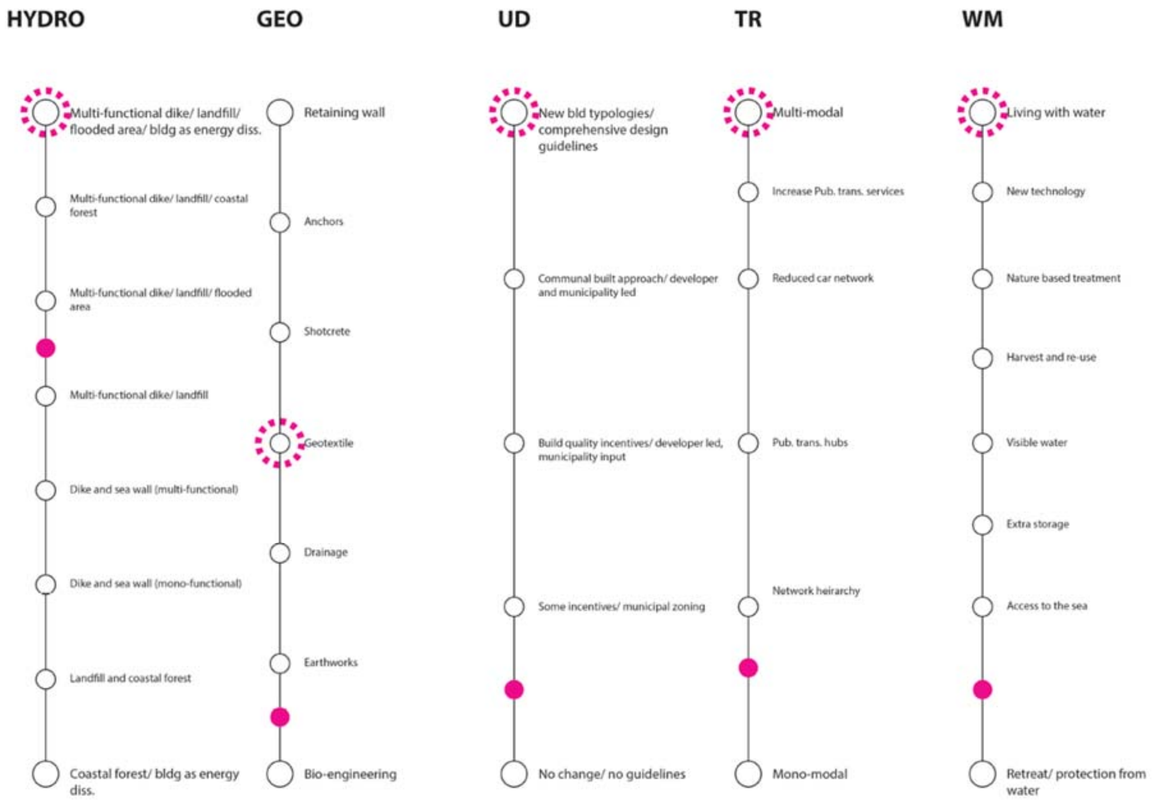

Figure 5: Group B worked out the disciplinary scopes and defined for each discipline where Yuriage is (the pink dot) and where they would like to take it in their proposal (the pink dotted circle).

They focused their design approach on using natural dunes with the dikes inside at the part near the shore. In this way, they achieve balance amongst the five disciplines as both the required safety level is met (important for hydraulics) but also there is space left on the top of the dunes for multiple functions (important for urbanism). One of the functions of the dunes system is the function of a coastal forest, which is a traditional Japanese tsunami protection technique that is integrated into the design. Also based on the water management point of view that required access to and view of the sea, their design constitutes a gradual nature based transition between the urban environment and the sea.

Figure 6: Plan for Yuriage by group B.

Evaluation of the methods used

The goal of the workshop was to have a multi-disciplinary team work in an interdisciplinary fashion. The definition of interdisciplinary from the INTREPID Cost Action (INTREPID is 27 member countries network dedicated to stimulating effective interdisciplinary research for urban issues, sponsored by Horizon 2020) is “a synthesis of knowledge, in which understandings change in response to the perspective of others”, and a concept “that occupies the broadest position on the spectrum”. The methods used in the workshop respond to the necessity of a common understanding of the context of a case, the fact that understanding first needs discussion, and the role of a concept in a multidisciplinary group. The charrette brought the common understanding and discussion whilst the integrated design is appropriate for reaching a concept and synthesis of knowledge.

Both groups reflected on the process and the content of their proposals.

Group A concludes that during the workshop in Japan they found out afterwards that they should have defined some crucial aspects before starting the design. These aspects include the problem statement (is it aimed at protecting the village from tsunamis or earthquakes?), the formulation of disciplinary ‘extremes’ (some extremes were very specific, where other were still very broad, some were about desired outcomes and ranked, some were extremely different) and the scale that they worked on (the different disciplines are used to working on different scales). Furthermore, the method used for the ‘what-if-situation’ did not work. Although this was quite stressing to the process at that moment, it offered a lot of insight that they learned from. In addition to that, they also had a hard time deciding to what extent their personal opinion should play a role. Some of the disciplines are not used to including this, while others do it all the time. For example, hydraulic and geotechnical engineers tend to cost-optimal design solutions to a well-defined problem with clear boundary conditions, while water managers and urban and transport planners are trained to assign values to a range of solutions based on more parameters than just financial cost (i.e., habitat value, societal value, aesthetic value). Allover, the process was slow and difficult, but there were important learning moments that were utilized later in the project.

Group A concludes about the applied methods:

> In transdisciplinary working the different scales of disciplines is important to acknowledge and fit;

> The formulation of the scopes should be done on the same bases and restricted: extremes, maximum and minimum interventions, personal or conceptual preferences.

> Formulation of a common problem statement (tsunami / earthquake) helps the process;

> The inclusion of opinion is very different between the disciplines.

Group B struggled with the method of disciplinary scoping like group A and also failed in bringing it together because they tried to find the perfect balance for each discipline. This was because the scopes were differently understood for each discipline and difficult to fit together. For example, the urbanists focussed on process while all other disciplines had physical interventions in their scope. It is also the question of how the fitting is done, should it fit or is it looking for overlap? For the group it was unclear when to make the transition between qualitative and quantitative design also because the level of the disciplinary propositions differed, Geo, Hydro and WM provided solutions while Urbanism and TIL where communicating on a vison level. These miscommunications occurred more often because of different terminology. In the end the misunderstanding of qualitative statements was corrected by quantitative evaluation in which the map turned out to play an important role in finding spatial compatibility. When they used the map as discussion tool each discipline started to understand each other because the scale of thinking became clear. They concluded that focussing on goals and quality may be more effective than negotiating the scope.

The general conclusions considering methods used are:

- A common case is necessary due to contextual aspects that are affecting all disciplines;
- Charrette is a way of sharing, building a body of knowledge in which group members also get well acquainted, when there is a group understanding of each individual discipline and perspective then the charrette function is not necessary;
- Integrated design can also be used at the beginning to form group coherence and to make goals more clear, this counters with what Voorendt stated.
- Repeating the method is profitable in creating interdisciplinary working, improving the method with repetition.

Conclusions

International and interdisciplinary exchange is quite fruitful in order to open up to new ideas and learn from experiences. The project in Yuriage is an example to the Netherlands because of the cultural boldness of the Japanese approach towards disaster reconstruction, the strategy for distribution of people in safety zones and strategy of fighting shrinkage as part of the larger spatial planning scheme. The mapping of cultural life and stakeholder analyses of the needs for people to recover and build a new life are aspects that are very well imbedded in the Japanese social systems.

The method of analysing Yuriage with use of charrette worked quite well, however, finding a common goal as a group and from that what the disciplinary scopes should enhance would improve the method. Placing integrated design earlier in the process could be a solution to this.

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