TSUNAMI
&
JAPAN' s COASTAL TERRITORY

-Architectural strategies for Japan' s precarious coastline

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INTRODUCTION

Japan is a densely populated archipelago, where more than 125 million population live in ca. 378'000 km^2 territory. Approximately, the two-thirds of the territory consists of mountain and only the one-thirds of the territory is flat-lands where most of urban territory and productive activities (industry) concentrate. Furthermore, around 50% of the population and 75% of the capitals are concentrated on the flat-low land (10% of the territory) along the coast where there is a high-risk of flood or tsunami [1]. Therefore, at least 43 % of Japan's 29,751 km coastline is lined with concrete seawalls or other structures designed to protect the inner territories against high waves, typhoons or Tsunamis [2].

Following the devastation caused by the Tohoku Tsunami attack in 2011, the Japanese government proposed a plan to reconstruct the total 400km of massive seawall along the coastline to prevent future disaster. This plan has triggered off a debate among the local community since this massive wall will physically and literally separate their habitation and the ocean. It also implies the possible damage to the ecological system, local fishing industry as well as touristic potential of the small towns.

The problem does not only affect the Tohoku coast since most of the big cities in Japan are located along the coast line and the risk of huge earthquake and tsunami are not limited to some particular region. According to the Japan Meteorological Agency, there is an imminent risk of major quake around Tokai area (Shizuoka, Aichi) as well as Nankai area (Wakayama, Shikoku) [3]. Furthermore, the Japanese government has reported the risk of Tsunami at the Northern coast (along Japanese Ocean) since the arrival time and the magnitude of Tsunami is expected to be larger than the Pacific Ocean side if it is subjected to the earthquake of the same magnitude [4]. Therefore, the issue at hand is nation-wide and future-oriented, rather than the "reconstruction" of the devastated regions. The concept of "*BOUSAI*" (disaster-protection) urban planning is pervasive in all parts of Japan due to such a precarious relationship with the nature. However, the concept of *"BOUSAI"* does not only imply the physical construction of hard-infrastructures, but also the construction of culture, namely the community and its symbolic relationship with nature. One possibility is to construct the wall, but the alternative is to be able to evacuate people when the Tsunami actually arrives. This involves the urban planning, organization of the evacuation and facilities, the information sharing as well as the evacuation training for the inhabitants. The

1. Ministry of Land, Infrastructure, Transport and Tourism Shikoku Area Development Bureau, "the need for embankment", http://www.skr.mlit.go.jp/tokushima/river/event/yoshikouza/n004/text04-10-2.pdf
2. Central Intelligence Agency, The World Fact Book: Japan", https://www.cia.gov/library/publications/the-world-factbook/geos/ja.html
3. Japan Meteorological Agency, "Imminency of Tokai Earthquake", http://www.data.jma.go.jp/svd/eqev/data/tokai/tokai_eq2.html
4. Ministry of Land, Infrastructure, Transport and Tourism, "investigation regarding the large scale earthquake at the Japan Sea", http://www.mlit.go.jp/river/shinngikai_blog/daikibojishinchousa/houkoku/gaiyo.pdf

potential of this alternative, which accepts the limit of infrastructure and maintains the relationship with nature, needs to be further studied and investigated.

In the face of the rapidly changing coastal landscape , the ongoing nation-wide mega-infrastructural projects, and the constant risk of natural hazard, the extensive and large-scale redefinition of threshold condition between the urban territory and the ocean is necessary. On the one hand, a coast line could be considered as a large fortress which could resist to the force of nature and protect the urban territory from the disaster. On the other hand, it could be considered as the interface or threshold which could provide the essential relation between the urban territory and the nature. It could be a recreational space and it could also be a power generating space for the urban territory (wave energy). The reconciliation between these two aspects seem to be inevitable for the long-term developpment of Japan in the coming decades.

This research book is composed of three main chapters. The first chapter, SAIGAI, literally meaning “disaster”, aims at investigating the cultural and historical background of tsunami disaster and landscape concept in Japan. This lays a foundation for the theoretical understanding of the issues pertaining to the tsunami disaster prevention of today. Based on this theoretical reflection of the first chapter, the second chapter, BOUSAI, meaning “disaster prevention”, deals with different types of the practical tsunami prevention strategies. Each of those types will be studied based on their mechanism, practical case studies as well as the analysis of pros and cons in order to understand the potential and the limitation of each option. Following these theoretical and practical understanding, the third chapter intends to define the potential project site based on the risk analysis through mapping. At last, there will be a brief conclusion with synthetic reflection and the vision for the future tsunami prevention.

CHAPTER 1

SAIGAI

JAPAN' S FRAGILE COASTAL TERRITORY

ABSTRACT

Sai-gai is the Japanese translation of "disaster"and the word "sai" in Chinese character is composed of "water" and "fire", implying the association with nature and hazard. This first chapter intends to foster the historical and cultural understanding of the precarious yet constant relationship among nature (tsunami disaster), people (Japanese society) and territory (coastal region).

a. TSUNAMI MYTHOLOGY IN JAPAN

Namazue (illustation of Amur Catfish) / *Kohirano Konmai* (Earthquake brought the equality)

source: Saitama Prefectural Museum collection

This first part intends to explore the cultural background within the Japanese society regarding the tsunami and earthquake disasters, in particular through the myth.

The disaster such as earthquake and tsunami were not merely perceived as a physical phenomena, but instead were linked to their faith as well as the cultural perception of nature.

Myth of Namazue

The origin of *Namazue* dates back to 15th century, but it began to be associated with natural disasters only after the late 18th century. During the Edo era (1603-1868), *Namazu* (giant catfish) was deemed as a river deity associated with floods and storms and it gave a premonition for hazards and warned people of an imminent catastrophes. (fig.1) It also prevented the further disasters by swallowing the water-dragons which, at that time, was believed to be the main culprit of various disasters including earthquakes [1].

In the course of 18th century, *Namazu* gradually began to replace the dragon for its role as a disater-maker. The dragon, with its association with water and rivers, has caused a certain degree of confusion with *Namazu*, yet due to this affinity, the myth was shifted somehow in a natural way. In the 19th century, the myth of *Namazu* propagated around the country, especially after the Great Ansei Earthquake between 1854 and 1855. In this occasion, people began to see the wrongdoings of *Namazu* as a penalty to human greed since it was believed that *Namazu,* by inducing the disasters, forced people to redistribute their wealth. In fact, while the Ansei Great Earthquake had brought about a devastating damages to people and their properties in many cities, it had also brought the opportunities for the people in the lower tier of the society, such as carpenters or people working for wood industry, to make a profit from the reconstruction works. Due to such as an evolution of the myth, *Namazu* became known as *yonaoshi daimyojin*, the "god of world rectification" [2].

The figure on the right page shows *yona-oshi daimyojin* perpetuating a traditional suicide ("seppuku namazu", 1855) (fig.2)- with his sacrifice he provides money, dropping from his belly, for the poor people seen in the background of the image. The scene is supervised by the god Kashima. Some of these anonymous images possess also great magical powers, promising protection from earthquakes and "10.000 years of fortune".

fig.1 Namazue (illustation of Amur Catfish), Takemikazuchi-Kanameishi-shinzu (following 1854 Ansei great earthquakes)
source: Saitama Prectural History Museum

1. Cabinet Office Disaster Management, "1855-ansei-edo earthquake", http://www.bousai.go.jp/kyoiku/kyokun/kyoukunnokeishou/rep/1855-ansei-edoJISHIN/pdf
2. David Bressan, Namazu the Earthshaker, https://blogs.scientificamerican.com/history-of-geology/namazu-the-earthshaker/

fig.2 Seppuku Namazu (1855)

source: Tokyo University Earthquake Research Center, http://www.bousaihaku.com/images/B/B522_5_03.jpg

Legend of Hirokawa-cho

Following the destruction of the Hiromura village by the Tsunami attack in 1854, *Goryo Hamaguchi,* a member of a local merchant family, invested his private fortunes to construct the embankment along the coast line with the aim of preventing future disasters in the region.
Before the actual arrival of Tsunami, he noticed it due to the change of the tide and therefore he decided to put fires on rice sheaves in order to warn people to evacuate to the higher place. (fig.3) Thanks to his warning, hundreds of residents managed to escape from Tsunami before its arrival and saved their lives. His courageous decision and behaviour at that time has been widely appreciated and passed down on to the current generation. It has also formed a basis for the notion of *"Bousai"* which places an emphasis on the prevention of disaster before it causes damages. For the construction of the embankment, Hamaguchi decided to hire and pay wages to local residents during seasons with little farm work and thereby he managed not only to secure the financial difficulties of the residents but also to involve them socially to the *"Bousai"* town-making [1].

The Tsunami Festival is held every year in Hiromura village on November 3rd in gratitude for the significant contribution of Goryo Hamaguchi who used private funds to construct a social and physical protection against Tsunami. (fig.4,5) In the festival, elementary and middle school students take part in ceremonies as well as embankment restoration events, developing and keeping, from generation to generation, a deeper awareness of Tsunamis [2].

In disaster countermeasures, awareness among local residents is even more crucial than the measures taken by the government, so people try to convey this awareness of *"Bousai"* to the next generation through these kinds of events.

fig.3 Tsunami record at Hirokawa-cho following Ansei earthquake
source: Shoemon Yoshida "Record of Ansei", Yougenji-temple archive, http://livedoor.blogimg.jp/dzb16113/imgs/d/1/d1d10a5e-s.jpg

1. *Japan Society of Civil Engineers, "Basic of Bousai, lesson from the town of Hirokawa", http://www.jsce.or.jp/kokusai/civil_engineering/2008/92-3-1.pdf*
2. *Cabinet Office Disaster Management, "Tsunami Bousai Day". http://www.bousai.go.jp/kohou/kouhoubousai/h26/76/special_01.html*

fig.4 Mural painting of Tsunami on the seawall in Hirokawa
source: photo taken by Hiroki Tanigaki
fig.5 Annual Tsunami Festival at Hirokawa (November 5)
source: http://pds.exblog.jp/pds/1/201411/05/20/b0054020_2095224.jpg
fig.6 Inamura's Fire Festival (commemorating the story of Goryo Hamaguchi)
source: http://pds.exblog.jp/pds/1/200710/20/20/a0044420_20164380.jpg

Memorial & Rituals

The occurence of Tsunami is rather sporadic and unpredictable. The time scale of the great catastrophes is likely to be centenary, if not millenary, and it is likely to be a once in a lifetime event if a person actually encounters one. Given the importance of keeping the awareness of Tsunami among people, it was necessary to concretize the memory and the experience of the past Tsunami in a certain form. As a consequence, hundreds of tsunami memorial stones and inscriptions, some more than six centuries old, could be found all around Japan. (fig.7-9) Most of them are built within religious institutions such as temples or shrines since those disasters were associated with the myth as mentioned earlier. These stones memorials and remaining rituals serve as a tacit yet permanent testimony to the past catastrophes that Tsunamis have incurred on this earthquake-prone country. Furthermore, it has played a crucial role in keeping the overall awareness of Tsunamis, as seen in the annual evacuation drills that many communities voluntarily excercise periodically [1].

However, in the contemporary Japanese society, how much of those memories and experiences are actually conveyed and paid attention to? With the confidence in engineering, technology and concrete seawalls, the consciousness of *"Bousai"* could be blurred and therefore it is all the more important now to look back on the old testimony of catastrophes in order to get the physical and cultural sense of Tsunami and disaster prevention. Mr. Yamashita, 87, who survived the recent tsunami at the waters flooded hospital where he was hospitalized, stated that Japan had neglected to teach its tsunami lessons in schools. He further added that the nation had put too much focus in new tsunami walls and other modern concrete barriers, which could eventually be destroyed as it was demonstrated in Tohoku Tsunami 2011.

The old stone inscriptions seem to be a momunent of the bygone era, whose language could be as intricate as archaic. However, following the Tohoku Tsunami in 2011, such an "old" and obsolete image of past Tsunami disasters became suddenly fresh and real, generating new kind of memorials which catches the eyes of contemporary population.

The 'miracle pine' in Rikuzen-Takata (fig.10) that survived the 2011 Tsunami attack in Tohoku region has now become a tourist attraction which stands as a symbol of unrelenting wish for the reconstruction [2]. In fact, it was the only surviving tree among 70,000 in the forest which was wiped out when the tsunami hit Rikuzen-Takata.

1. Martin Fackler. *"Tsunami Warnings, Written in Stone", New York Times, April 20, 2011, http://www.nytimes.com/2011/04/21/world/asia/21stones.html*
2. *Rikuzentakata city, "Miracle Pine Tree", http://www.city.rikuzentakata.iwate.jp/kategorie/fukkou/ipponmatu/ipponmatu.html*

fig.7 Jinsenji temple (Yuasa-cho) monumental inscription
source: photo taken by Hiroki Tanigaki

fig.8 Tokura-Fujihama, Minami-Sanriku-cho, Miyagi, monumental inscription
source: http://www.town.minamisanriku.miyagi.jp/museum/life/article.php?p=420

fig.9 Taisho-bashi bridge, Osaka, Tsunami monumental inscription (1855)
source: http://blog-imgs-42.fc2.com/a/t/a/atamatote/IMG_6387_3.jpg

fig.10 Rikuzen Takada, Iwate, "Miracle Pine Tree" (2013-) as memorial tree
source: http://static.panoramio.com/photos/original/61455779.jpg

Although the pine tree, which also managed to survive major tsunami in 1896 and 1933, died few months after the 2011Tsunami as a result of the environmental changes in the area, the authority has decided to immortalised the tree as a momument by creating giant moulds and artificial brunches and put it back on the spot where it stood before.

On July 25 2012, The Japan Times published an article "*Tsunami-hit structures eyed as memorials*", which discussed the different opinions people have on the preservation of damaged buildings hit by Tsunami.
One option, proposed by a group of researchers, suggests the preservation of the ruined buildings in order to show as permanent reminders of Tsunami destruction, somewhat the reminiscence of the skeletal Atomic Bomb Dome in Hiroshima (fig.11) .

In Miyako, Iwate Prefecture, the owner of the tsunami-engulfed hotel in the coastal city's Taro district hopes that the building will be kept as a monument. (fig.12) As the image illustrates, the six-story hotel was submerged up till the fourth floor and nothing but the bare iron frame remains for the first two storeys.
Before the March 2011 catastrophe, the owner had been told by his elders about past tsunami disasters yet he believes that some tangible proof is indispensable; as he said

"I had no other way than to picture for myself what I heard. We need something that can show the horrors (of tsunami) clearly [1]."

While the ruins could "talk" of the disaster and help keeping the awareness of people, it is also true that some residents see it as a source of pain and anxiety as it reminds them of their frightening experience in very tangible manner.
A 44-year-old woman who lost her home in the Tohoku Tsunami at Minamisanriku-cho said that

"*My heart always aches at the site of it. It's preventing us from moving forward toward reconstruction.*[1]"
This paradoxal attitude regarding the memory of Tsunami seems to portray the reality in which people, willy-nilly need to confront the unsurmountable force of nature.

1. The Japan Times, "Tsunami-hit structures eyed as memorials", July 25, 2012

fig.11 Former administrative building at Minami-Sanriku-cho, preserved as an architectural remains after Tsunami attack in 2011
source: http://www.sendaiphoto.com/blog/img/minamisannriku1.jpg

fig.12 Former Taro Resort Hotel preserved as an architectural remains after Tsunami attack in 2011 (March 14, 2016)
source: Shingo Tagaya; http://iwashun.blog.fc2.com/blog-date-201603.html

b. CONCEPT OF LANDSCAPE & DISASTER IN JAPAN

Suisaiga by Kokei Kojima

The concept of landscape is a cultural construction which reflects the given society's existential and cosmological perception of nature. In a disaster-prone country like Japan, such a concept of landscape is by no means detached from the frequent occurence of natural disasters such as earthquake or tsunami. Therefore, the profound understanding of landscape concept is indispensable for making *bousai* plannings culturally coherent.

This forms a conceptual base regarding the relationship between people and nature in Japanese cultural and historical context through which we can reflect on the contemporary issue of tsunami *bousai* at hand.

Faith & Landscape in Ancient Japan

KAMI, SHINTO & NATURE WORSHIP

As much as 67% of Japanese territory is forest and this is one of the highest worldwide. This seems to have a cultural implication since the ancient concept of nature in Japan was associated with animism and nature worship, which involves a strong belief and reverence in a spiritual life in natural objects, natural phenomena, and even in the universe [1]. This basic faith had been formalized as "*Shinto*", a Japanese ethnic religion. In Shinto, there is no absolute diety but people believe in multitudinous gods known as "*Yaoyorozuno-Kami*". *Kami* are the spirits or phenomena that are worshipped in Shinto and are not distinct from nature, but are of nature itself, which encompasses both positive and negative sides as well as good and evil characteristics. Some of the objects or phenomena considered as kami are natural phenomena like wind and thunder or fertility, natural objects such as mountains, rivers, trees, and rocks, as well as human and ancestral spirits [2]. In this concept, there is no clear line between visible and invisible, old and new, as well as human and nature. On the basis of this particular cosmology, the ancient Japanese people had nurtured a concept that people constitute a part of nature itself.

CONCEPT OF DISASTER IN JAPANESE CULTURE

This spirituality and the relationship with nature were also associated with a particular concept of "disaster". Since natural phenomena were subject of worship and people were in awe of them, they tended to accept the absurdity and gave particular interpretations on it. Some took a fatalistic view with an attitude of resignation in the face of inevitable natural phenomena. Other took it as a form of punishment for their own misbehavior [3]. This, for instance, is the case for the "social-flattening"of *Namazue* discussed earlier. Even after the Kanto Earthquake in 1923, some figure such as Eiichi Shibusawa, the father of Japanese capitalism, took this view by saying that the natural disaster would occur when there is an egoistic and sloppy trend in the society.

These modest attitude toward the disaster equally seems to reflect the Buddhist idea of the three marks of existence (sanbo-in); impermanence, suffer, emptiness [4]. The nature is constantly changing, so sometimes it would give a grace and some other time it may cause a disaster. Torahiko Terada, in his "*concept of nature for Japanese people*" claimed that we just need to enjoy the grace and sustain the disasters, and to live adaptably with nature rather than to resist against it [5].

1. A Dictionary of Religion and Ethics edited by Shailer Mathews, Gerald Birney Smith, p 305
2. Yamakage, Motohisa; Gillespie, Mineko S.; Gillespie, Gerald L.; Komuro, Yoshitsugu; Leeuw, Paul de; Rankin, Aidan (2007). The Essence of Shinto: Japan's Spiritual Heart (1st ed.). Tokyo: Kodansha International.
3. Osamu Hiroi , "Saigai to Nihonjin : kyodai jishin no shakai shinri (Disasters and Japanese people: Social psychology of giant earthquake), Jiji Tsushinsha, 1995.
4. Koren, Leonard. Wabi-Sabi for Artists, Designers, Poets and Philosophers. Berkeley: Stone Bridge Press, 1994.
5. Torahiko Terada, "Concept of Nature for Japanese People", Iwanami Bunko, 1948.

fig. 1 Nature as a subject of worship, Nara
source: photo taken by Hiroki Tanigaki

Landscape Concepts in Japanese Language

The first key to understand the historical and cultural concept of landscape is a language.
In the Japanese language, there are several possible synonyms for European words such as "paysage", "landschaft" or "landscape" including *Fukei*, *Keikan*, *Keshiki*, and *Fudo*. Though they somehow imply the concept related to "landscape", they have different connotation in a subtle way.

FUKEI (風景)

The term *Fukei* was introduced from China in the 8th century through the Buddhism, and represented the Buddhist universe as an perceptible impression of the world [1]. As the Buddhism came to coexist with the Shinto and took root in the Japan, many of Buddist concepts and culture like this still survive in the contemporary society. The word *Fu-kei* is made up of two *kanji, "Fu"* meaning the wind and *"kei"* connoting both light and shadow or the environment made out of those two elements. In this concept, the light and shadow are not considered as two antithetical elements but instead as two sides of the same coin. The beauty of the shade derives from the presence of light and vice versa. Together with "*fu*" (wind), it represented a perception of people, rather than a representation or a description, which emerges from the interaction with the surrounding environment.

KEIKAN (景観)

In the wake of Meiji Restoration, the influence from Europe became predominant and Japan introduced many new ideas, for instance, to the field of natural science. The modern scientific idea of landscape "Landschaft" ("Kulturlandschaft" as man-made environment) was also introduced to Japan at this period. A new Japanese word "*Keikan* "was coined in order to interpret and represent this new concept. In this regard, the connotation of *keikan* is linked to modern and rational concept of landscape that have been introduced from the Western culture [2]. *Keikan* is made up of two words, "*kei*" meaning "state or condition (made out of light and shadow)" and "*kan*" meaning "view". This also corresponds to the Western concept of landscape which is linked to the visual feature of the surrounding.

KESHIKI (景色)

The term *Keshiki* is considred as a concept of landscape originated in Japan. As *Keshiki* was originally expressed with two *kanji* (Chinese characters), meaning "color of *ki*," it seems that the concept embrace the notion of

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1. Hiroumi Ueda, "Landscape Perception in Japan and Germany", in H. Shimizu and A. Murayama (eds.), Basic and Clinical Environmental 15 Approaches in Landscape Planning, Urban and Landscape Perspectives 17, Chap.2, Springer Japan 2014
2. Abe H, Birth of Japanese space – Cosmology, landscape and afterworld [Nihon Kuukan no Tanjyo—Cosmology, Fukei, Takaikan]. Serika Shobo, Tokyo, 1995.
3. Andrew S. Kane , "Landscape discourse and images of nature in Japanese visual culture of the late 19th and earth 20th century", The University of Hawaii, May 2013.
4. Kenichi Sasaki, "Perspectives East and West", http://www.contempaesthetics.org/newvolume/pages/article.php?articleID=670
5. Online Epimology Dictionary, http://yain.jp/i/%E6%99%AF%E8%89%B2

"*ki*", an oriental concept meaning the life-process or flow of energy that sustains living beings [4]. In Heian period (794-1192), the word *Keshiki* meant both the movement of a person's mind and the condition of the nature, but the pronunciation of the former sense changed into "*Kishoku*" in the following Kamakura period, so they became two distinct words [5]. This implies that the concept of *keshiki* originally regarded the inner (mind) and the outer (environment) conditions on an equal footing. This adheres fundamentally to the cosmology of the Shintoism in the sense that there are no clear line separating people and nature. *Keshiki* is a sort of atmosphere rather than a fact or a visual representation which can be perceived through the inner appreciation of the outer world.

FUDO (風土)

Fudo is another important landscape concept in Japanese culture. *Fudo* is composed of two *kanji, "Fu" meaning "wind" and "Do" meaning "soil"*. The word derived also from China and the original meaning was the entelechy or the vital energy of the territory which corresponds to the seasonal cycle of the climate. Tetsuro Watsuji, in his book "*Fudo*: Climate and Culture" in 1935, dealt with an essential relationship between climate and other environmental factors and the nature of human cultures by classifying three types of culture: pastoral, desert, and monsoon . Japanese people, in the unsettled monsoon climate with frequent natural disasters such as flood or drought, could do nothing but accept and tolerate such a convulsion of nature [6]. Due to the variation of such climatic characters, each territory would nurture different cultural and societal system. In this respect, the cultural aspect of human society cannot be dissociated from the physical and climatic characters of the given territoy. The idea of *fudo* is therefore tightly related to the spiritual foundation of people's lives, culture, religion and history which are all rooted in the particulary territory [7]. It is worth noting that this concept of *Fudo* portraits neither natural environment nor human culture in isolation, but instead it indicates the complex and mutual identification between them.

These four different concepts illuminate the cultural and historical reflection on the relationship between human and nature in Japan. Despite the Western influence reflected in the concept of *Keikan*, other three concepts seem to be attuned to eath other; based on anti-anthropocentric cosmology which may derive from the spiritual and religious foundation of Shintoism and Buddhism.

6. Watsuji, Tetsuro. "Watsuji Tetsurō Zenshū (Complete Works of Tetsuro Watsuji)". 20 volumes. Tokyo: Iwanami Shoten, 1961-1963.
7. Keisuke Matsui, "Geography of religion in Japan: Religious Space, Landscape, and Behavior", p17-18, Tokyo, Japan, Springer, 2014

Landscape Concept in Japanese Paintings

On top of the linguistic reflection on the Japanese concept of landscape, a brief study of Japanese visual culture, particularly of landscape painting, could further bring out the essence of human-nature relationship in Japan. As discussed previously, the association between "view" and "landscape" is not of primary importance in Japan, yet we could still elicit one's perception and attitude toward nature through landscape drawings.

SANSUI PAINTING

In Japan, traditional landscape painting is called "*sansui-ga*", literally meaning painting of "*San* (mountains) and *Sui* (waters)". Deriving from China, it is a type of painting which depicts an idealized image primarily composed of mountains, rivers, clouds, rocks and trees [1]. In modern terms, *sansuiga* is distinguished from another type of landscape painting "fūkei-ga", which emphasizes the influence of Western style painting [2]. The landscape painting of *sansuiga* was initially stimulated by Taoist attitudes toward nature, it came to play an important role in Buddhist contexts as well in expressing human thought and philosophical principles. Initially landscape painting served as settings in Buddhist paintings and depicted conceptual or idealized image of nature. When Zen monks brought "*sougenga*" from China in 14th century, Japanese people discovered ink-monochrome painting which represent an ideal of the nature, with human figures in a subservient or non-existent role [1].

Sansuiga had further been developed by some of the distinguished "artist Zen monks" including Shubun (15c). Josetu (1405-96) and Mincho (1352-1431). For Shubun, for instance, the landscape was not depicted from life but from some scenery in his memory or from the abstraction of some precedented works. (fig.2) This type of *Sansuiga* was not intended to illustrate the reality of objective landscape but the emphasis was rather put on the elements (mountain, temple, river etc), its arrangement and the spirit behind them [3]. Sesshu (1420-1506), a pupil of Shubun, is considered as one of the most important *sansuiga* painter in the history as his paintings represented a departure from the original Chinese style and established a Japanese original one. His well-known painting of "Ama-no-Hashidate" (fig.3) is no longer depicting an "idealized" landscape, but interestingly, there is in fact no place from which one can capture the image of Ama-no-Hashidate as depicted. It means that he composed the elements (mountain, shrine, ocean etc) in the territory out of the information he collected on the ground [3]. He depicted the relation among those elements precisely, but the painting actually did not have a subjective (human) perspective. This corresponds to the Japanese cultural cosmology described earlier in which man is not placed at the center of nature but is put within the system of landscape.

1. *JAANUS (Japanese Architecture and Art Net Users System), "Sansuiga", http://www.aisf.or.jp/~jaanus/deta/s/sansuiga.htm*
2. *Andrew S. Kane , "Landscape discourse and images of nature in Japanese visual culture of the late 19th and earth 20th century", The University of Hawaii, May 2013.*
3. *Shubi editorial desk, "special topic: Sesshu and Muromachi ink-wash paintings", Shubi2, edition winter 2012, p32, Shubisha, 2012*

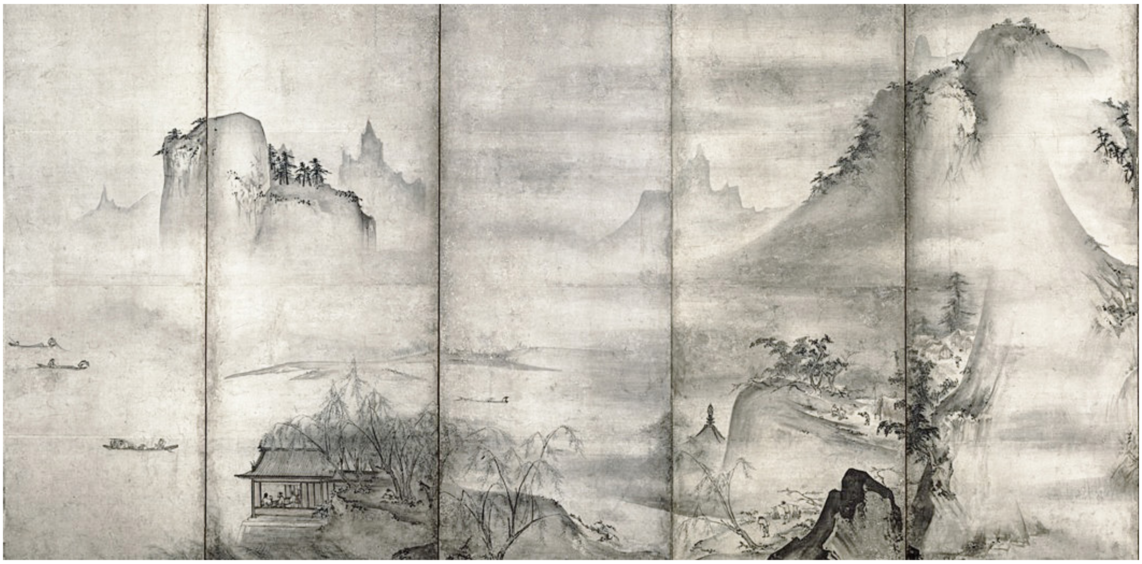


fig.2 Sansui of Four Seasons by Shubun (15c)
source: http://www.tnm.jp/uploads/r_collection/LL_164.jpg

fig.3 Ama-no-Hashidate by Sesshu (1420-1506)
source: https://www.westjr.co.jp/company/info/issue/bsignal/08_vol_118/feature03.html

CONTRAST BETWEEN JAPANESE AND WESTERN PAINTINGS

In the wake of Renaissance, a distinctive world-view rooted in a renewed emphasis and intellectual interest in the human experience began to prevail in Europe. With such a zeitgeist behind, the status of human beings within the hierarchy of the universe had been revalued and the subjective experience of the individual as an observer of his surroundings was granted a new symbolic and artistic significance. By embracing scientific and rational understanding of the world, the artists from the Renaissance began to construct the visual image out of the accurate measurement of space relative to their stand point, in other words, the invention of perspective. As a systematic and objective method to depict one's surrounding as they are presented to their eyes, this technique derives from an an understanding of the outer world as an contraposed object to humanity [1]. Evne after the Renaissance, this concept of nature remained predominant around Europe and this attitude can be observed in some landscape paintings. For instance, the panoramic landscape painting of Ruisdael from 17 century(fig.4), despite its "focus" on nature than human figures, is still linked to a single human perspective which dominates the composition and conveys its subjective experience from a fixed location.

In *sansuiga,* the elements of landscape (moutain and water) were not taken as a background of human actions but as a unique place that enables man to transcend. Landscape concept of *sansui* is characterized by the cultural conception that the cosmic space is filled with "*ki*" which is a vital and spiritual flow of energy [2]. The Japanese landscape term *keshiki* (color of *ki*) is linked to this concept. "*Ki*" is not a visible entity but an invisible force, and therefore a space as *keshiki* was not to be seen but to be felt. This represents the fundamental difference from *keikan* (Western derived concept of landscape) which highlights the importance of human perspective and culturally-constructed framework for perceiving natural scenery. For *sansuiga* paintings, there are actually viewpoints, but they are determined according to the extent of the scenery to be captured. The sense of distance is expressed by the three composition modes called *Koen* (gazing loftily), *Shinen* (casting a deep and exploring look), and Heien (gazing horizontally), and those three different views can be used simultaneously in the same painting [3]. The absence of an absolute viewpoint highlights the particular interpretation of the landscape. The art critic Shuji Takashina observed that this absence of a perspective is due to the absence of the concept in which human confronts the nature [4]. The Sesshu's painting "*Sansui Figure Screen*" (fig.5) is not a visual description of the surroundings but a composition of elements aimed at depicting the impression of "*ki*" in the scene.

1. Denis Cosgrove, "Prospect, perspective and the evolution of the landscape idea", Transactions of the Institute of British Geographers, 10, 45–62, 1985.
2. Kenichi Sasaki, "Perspectives East and West", http://www.contempaesthetics.org/newvolume/pages/article.php?articleID=670
3. Rie Maki, Kana Sekimoto, "The Spatial Composition of Landscape paintings by Sesshu: Analysis of 21 Hanging Scrolls", Yamaguchi University research report, 2010.
4. Shuji Takashina, "Aesthetics of Modern Japanese", Seidosha, Tokyo, 1978.

fig.4 Landscape with a View of Haarlem, Jacob Isaacksz van Ruisdael (1628-1682)
source: https://upload.wikimedia.org/wikipedia/commons/1/13/Salomon_von_Ruisdael_-_River_View_with_Fishermen_-_Walters_37351.jpg

fig.5 Sansui Figure Screen by Sesshu (1420-1506)
source: http://juemon.com/archives/337

Besides the difference in the viewpoint, one critical character of traditional Japanese paintings is the conceptual significance of nature. For instance, the famous ink painting, "*the Pine Trees Screen*" (fig.6) by Hasegawa Tōhaku's (1539-1610), is composed simply of several pine trees, but it incorporates a wide range of nature's invisible yet conceptual implications. The moistness and depth expressed through the fog indicates the particular climate "*fudo*" of the place with the seasonal ambience and the feeling of time [1]. Furthermore, its simplicity of composition, the feeling of spatial depth created by the gradational contrast, the feeling of emptiness (zen) through the abundant use of space seem to communicate the subtle yet profound feeling of nature which mirrors the inner world of the painter. Tōhaku's work reflects a particular understanding of humanity's position relative to nature—human and nature as reciprocal projection of one's profound spirit. This conceptual understanding of nature is associated with the notion of "*keshiki*" which can be perceived through the inner appreciation of the outer world.

With the gradual exposure to European art forms, the influence of Western geometrical perspective began to prevail in Japan at the end of the 18th century. The Japanese *ukiyoe,* which literally means "a painting of the fleeting world", adopted the perspective technique to express the depth of space in the painting. From this point, the traditional Japanese aesthetics and the perception of landscape began to merge with the Western culture, yet it has kept some of the traditional qualities. The famous ukiyo-e artist Hiroshige is not an exceptional case. His master piece "*The Fifty-three Stations of the Tōkaidō*" (1832) depicted a series of local regions along the Tōkaidō in 1832. Some of those paintings, such as the one of Totsuka,(fig.7) were represented in perspective view, capturing people and landscape from a single viewpoint.

It goes without saying that the introduction of this new rational way of seeing the nature has influenced the perceptual and symbolic relationship with nature in modern Japanese culture. The culture is not a closed system, so it is rather natural that it evolves over time through the interaction with different cultural influences. However, it is crucial to be aware of the cultural and historical background and the process of evolution that has formed a basis for the society's identity in relation to the territoty and its particular environment.

1. *Salvastyle, Tohaku Hasegawa Pine Woods, http://www.salvastyle.com/menu_japanese/tohaku.html*

fig.6 Pine Trees Screens by Tohaku Hasegawa (1539-1610)
source: http://www.dnp.co.jp/artscape/artreport/tankyu/image/0806_12.jpg

fig.7 Totsuka in The Fifty-three Stations of the Tōkaidō by Hiroshige Utagawa (1797-1858)
source: https://www.adachi-hanga.com/ukiyo-e/items/hiroshige018/hiroshige018_main.jpg

Reflection: Landscape & Modernity in Japan

In the ancient society, the major cultural influence in Japan primarily derived from China including Buddhism, arts, or writing system, yet Japan has also nurtured its own cultural realm over centuries under "sakoku" (national isolation) policy. In the period following the Meiji Restoration (1868), Japanese society has witnessed the unprecedented transformation and acceleration of modernization, involving the rapid urbanization, industrialization as well as deep political, economical or cultural paradigm shift. Japan has pursued modernization by making its national policy "escaping Asia for Europe", aiming to catch up with European powers. Japan quickly absorbed modern systems, knowledge and culture by following the Western civilization model and adapting it to the Japanese society. In the post-war period, the focus of such an influence shifted rather to the American culture which was accompanied by the rapid economic growth and the change to more consumptive lifestyle.

During this turbulent period, a major shift in the landscape paradigm took place and it altered the cultural perception and the attitude toward nature. From the Meiji Restoration onward, the exposure and the sociocultural inclination to European culture triggered a change in attitudes toward nature, laying the foundations for gradual emergence of current understanding of the word "*shizen*", the meaning of which coincides with the European understanding of nature as "outside" and contraposed to the sphere of human society [1]. With the accelerated development of mega-cities and large urban areas during last century, the traditionally fostered and cherished integration between man and nature is put at stake.

The issue of *bousai* is not irrelevant to this wave of transformation. With the increased technical advancement related to the disaster prevention field, we have an enhanced possibility to anticipate, to communicate, to analyse, or to mitigate damages from the potential natural hazards. However, the overconfidence in our capacity to "control" or "manage" the nature would have significant consequences in altering further our relationship with nature, our living environment as well as our lifestyle. *Bousai* cannot turn its back on the landscape issue since it has a major impact in defining our cultural attitude toward nature.
The landscape is a culturally constructed notion which evolves with history and define intellectually our perceptual relationship with nature.

1. Andrew S. Kane , "Landscape discourse and images of nature in Japanese visual culture of the late 19th and earth 20th century", The University of Hawaii, May 2013.
2. Karatani, Kōjin. Origins of Modern Japanese Literature, p24, Duke University Press ,1993.

As Kojin Karatani, a Japanese philosopher and literary critic, puts,

"*Landscape, as I have already suggested, is not simply what is outside.*
A change in our way of perceiving things was necessary in order for landscape to emerge [2].

In the face of growing attention on the nationwide disaster prevention efforts, the primary objective should not only concern the safety or protection against natural disasters, but also define the culturally coherent landscape vision. In the traditional Japanese landscape concept, man resided within the system of nature which would bring both grace and disaster and people could do nothing but accept what it came out. The contemporary Japanese society, which works in a different economic and cultural logic as before, would need to face the historical culture on the one hand and the reality on the other hand. While the relation with nature remains to be crucial for the population, the need or the enhanced possibility for "protection" pose a dilemma for posing human against the nature.

The questions persist regarding how to reconcile the cultural conception with the contemporary situation and how people could envision the new and culturally coherent relation with nature.

c. TSUNAMI HISTORY IN JAPAN

Story for generations about Earthquake and Tsunami in Osaka

source: Osaka History Museum

Inscriptions on up to 600 years old stone marker located near the coastal city of Kesennuma warn descendants:
"Always be prepared for unexpected tsunamis. Choose life over your possessions and valuables."

"If an earthquake comes, beware of tsunamis."

"High dwellings are the peace and harmony of our descendants, remember the calamity of the great tsunamis. Do not build any homes below this point."

reference: http://historyofgeology.fieldofscience.com/2011/03/historic-tsunamis-in-japan.html

History of Tsunami Catastrophe

The words "Tsu-nami" in Japanese means "wave in the harbour". It stems from the experience of fishermen that only when they returned from the sea into the supposed secure harbour they discovered the terrible destruction that these waves can cause on the shore. Tsunamis are caused by the rapid dislocation of large quantities of water mass by displacement of the seafloor typically triggered by earthquakes or landslides, but also by explosions caused by volcanic eruption or meteoric impacts.

The Pacific Ocean is surrounded by tectonic active borders of the lithospheric plates; nearly 53% of tsunamis worldwide occur here and 82% of them are caused by earthquakes [1].
Recognized Tsunamis sediments in Japan date back nearly for 5.000 years, historic records span for nearly 1.300 years, however the most detailed and precise accounts cover mostly the recent period [1].

The list on the right page summerizes the cause, the location, the magnitude of the earthquake, the height of tsunami as well as the number of casualty for recorded major earthquake [2]. Most of tsunamis were triggered by major earthquakes while few were caused by volcanic activities. Since tsunami tend to hit the ares near the tectonic boundaries, the region such as Tohoku (Sanriku) or Tonankai are hit by tsunami more often than other regions in Japan.

In the following, some of the major tsunami catastrophe from the recent history, namely, Ansei (1854), Meiji Sanriku (1896), Showa Sanriku (1933), and Tohoku (2011), will be reviewed individually to give more detailed account of each disaster.

1. David Bressan, "Historic tsunamis in Japan", March 17,2011, http://historyofgeology.fieldofscience.com/2011/03/historic-tsunamis-in-japan.html
2. Japan Meteorological Agency, "list of histrical tsunami", http://www.data.jma.go.jp/svd/eqev/data/higai/higai-1995.html

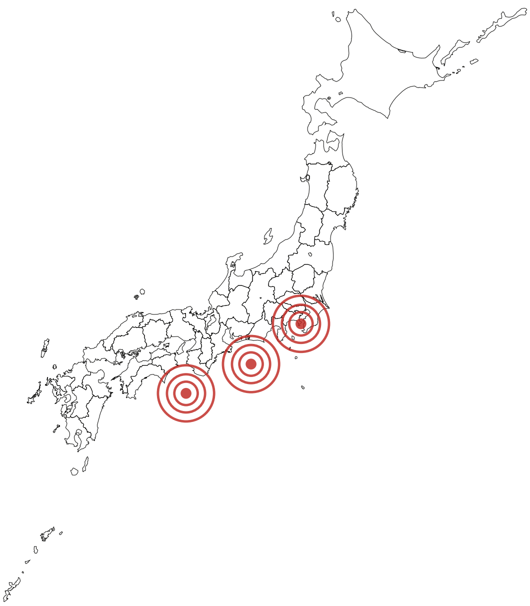
	Cause	Location	Magnitude	Max Tsunami height	Casualties
684	Great Hakuho Earthquake	Kii peninsula, Awaji, Shikoku	8	?	?
869	Jogan Sanriku Earthquake	Sendai, Tagajyo	8.4	3m	1,000
887	Ninna Earthquake	Nankai, Kyoto, Osaka	8.6	?	?
1293	Kamakura Eijin Earthquake	Kamakura	7.1	?	23,000
1361	Shohei Earthquake	Tokushima, Kochi, Kii, Osaka	8.4	3.3-4.6m	660
1498	Nankai Earthquake	Wakayama	8.6	10m	30,000-40,000
1605	Keicho-Nankaido Earthquake	Boso peninsula, Tokyo, Shizuoka, Kochi	7.9	10m	5,000-10,000
1611	Sanriku Earthquake	Iwate, Miyagi, Aomori	8.1	20m	5,000
1707	Hoei Earthquake	Kochi, Tosa, Osaka	8.4	-25.7m	-30,000
1741	Oshima-island volcano activity & Landslide	West-Hokkaido		20m-	1467
1771	Yoeyama Great Earthquake	Okinawa	7.4	40-80m	13,500
1792	Mt. Unzen volcanic activities	Nagasaki, Higo, Ariake		23.4m	15,000
1854	Ansei Great Earthquakes	Tokai, Boso, Chiba, Kyushu	8.4	21.7m	80,000-100,000
1896	Sanriku Earthquake	Iwate, Miyagi, Aomori	8.5	38.2m	27,000
1923	Great Kanto Earthquake	Shonan, Boso, Izu, Atami	8.2	12m	200-300
1933	Sanriku Earthquake	Iwate, Miyagi	8.1	28.7m	3,000
1944	Tonankai Earthquake	Mie, Aichi, Shizuoka	8.1	10m	1,200
1946	Nankaido Earthquake	Kochi, Tokushima, Wakayama, Mie	8.4	6m	1,500
1964	Niigata Earthquake	Niigata, Shimane	7.6	4m	36
1983	Sea of Japan Earthquake	Aomori, Akita	7.7	10m	107
1993	Hokkaido Earthquake	Okushiri, Hokkaido	7.8	31m	197
2011	Tohoku Earthquake	Miyagi, Iwate, Fukushima	9.0	40.5m	18,550

fig.1 History of Major Tsunami in Japan
source: Japan Meteorological Agency

Ansei Earthquake 1854

The Ansei great earthquakes were a series of three major earthquakes that struck Japan during the Ansei era between 1854 and 1860.
The magnitude 8.4 Ansei Tōkai earthquake happend on December 23,1854 and its epicenter was around the Suruga Bay. Even though it gave primarily severe damages in the Tōkai region, some damages were observed as far away as in Edo region. In the areas of current Shizuoka Prefecture from Numazu to Tenryu River, many houses were damaged or destroyed. Following the earthquake, the accompanying Tsunami further caused damages along the entire coast from the Bōsō Peninsula (Chiba prefecture) to Tosa province (Kōchi Prefecture). On the east side of the Izu Peninsula, Shimoda was hit by the tsunami one hour after the earthquake. A series of nine destructive waves hit the city, washing way 840 houses and claiming 122 lives. Diana, the flagship of a visiting Russian admiral, Putyatin, was spun round 42 times on its moorings and was so badly damaged that it sank in a later storm (fig.2). At Suruga Bay, on the west side of the Izu Peninsula, the village of Iruma was destroyed and a 10 m high sand dome was deposited, on which the village was later reconstructed.

The Ansei Nankai quake was an 8.4 magnitude earthquake which hit the Nankai and Shikoku region on December 24, 1854. The casualties from this earthquake went over 10,000 people and the damages were observed from the Tōkai region down to Kyushu. The map on the right page illustrates the inundation in Osaka city. (fig.3) On Shikoku, Tsunami heights reached 7.4 m at Usa, 8.4 m at Ōnogō in the Susaki area, 8.3 m at Kure on the Kōchi coast, 7.5 m in Mugi, 7.5 m in Kamikawaguchi of Kuroshio, 7.2 m at Asakawa on the Tokushima coast, and 5 m at both Hisayoshiura and Kaizuka on the coast of Ehime.



The Ansei Edo quake was a 6.9 magnitude earthquake which struck Edo (Tokyo) on November 11, 1855. A series of hundred and twenty earthquakes were observed in Edo between 1854 and 55. Nevertheless, the earthquake triggered only a minor tsunami.

Reference: Cabinet Office Disaster Management, "1854 Ansei Tokai & Nankai earthquakes", http://www.bousai.go.jp/kyoiku/kyokun/kyoukunnokeishou/rep/1854-ansei-toukai_nankaiJISHIN/index.html
Disaster Prevention System Institute, "Ansei Nankai Earthquake", http://www.bo-sai.co.jp/anseinankai.htm

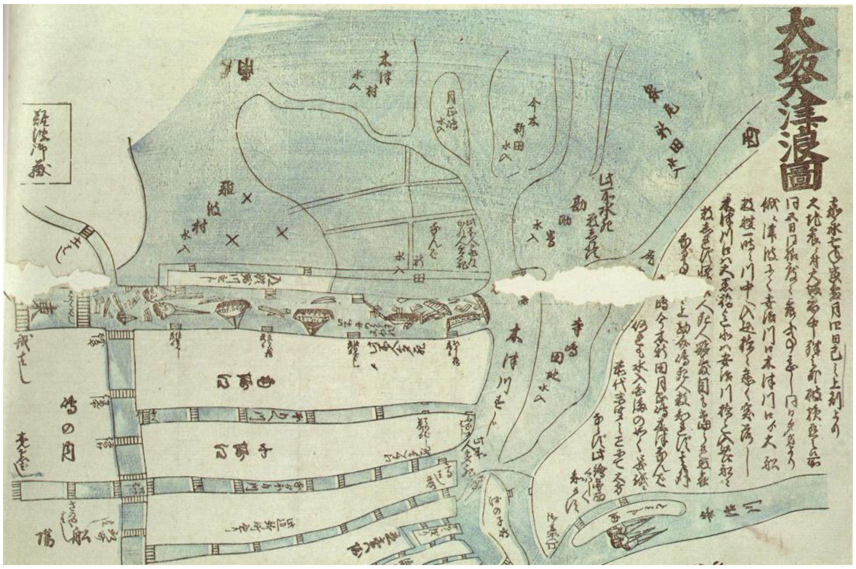


fig.2 Russian frigate Diana hit by Tsunami at Shimoda bay, 1854

source: Russian Central Navy Museum collection, https://nippon.zaidan.info/seikabutsu/2004/00561/contents/0009.htm

fig.3 Osaka Otsunamizu (1854 Ansei great earthquakes)

source: Osaka Museum of History, http://www.mus-his.city.osaka.jp/news/2014/tenjigae/150113.html

Meiji Sanriku Earthquake 1896

The 1896 Sanriku earthquake is considered as one of the most catastrophic seismic disasters in Japanese history. The 8.5 magnitude earthquake occurred on June 15, 1896, and the epicenter was approximately 166 kilometres off the coast of Iwate Prefecture. After the earthquake, two Tsunamis arrived and they destroyed about 9,000 houses and killed at least 22,000 people. The Tsunami reached a height of 38.2 metres; almost equivalent of those generated after the 2011 Tōhoku earthquake.

On the evening of June 15, 1896, communities along the Sanriku coast in northern Japan had a celebration of a Shinto holiday and of the return of soldiers from the First Sino-Japanese War. After a small earthquake, there was little concern because it was so weak and many small tremors had also been felt in the previous few months.

The first Tsunami wave hit the Sanriku coast and the second wave followed only 35minutes after the first one. Damage was particularly severe because the Tsunamis coincided with high tides. The major damages and deaths were observed in Iwate and Miyagi region. (fig.4) Minor casualties were also recorded also from Northern region such as Aomori and Hokkaido.
The power of the tsunami was immense and large numbers of victims were found with broken bodies or missing limbs.

Most of the local fishing boats were offshore when the tsunamis hit the coast and some boasts were washed ashore on the coastal area. (fig.5)

In the deep water the wave was unnoticed and the fishermen discovered the destructed harbour and debris when they came back in the next morning
Tsunami of up to 9 meters were measured as far away as in Hawaii and caused damages to several houses.

Reference: Cabinet Office Disaster Management, "1896 Meiji-Sanriku Earthquake & Tsunami", http://www.bousai.go.jp/kyoiku/kyokun/kyoukunnokeishou/rep/1896-meiji-sanrikuJISHINTSUNAMI/
Cabinet Office Disaster Management, "report of specialist committee regarding the disaster lesson from Meiji-Sanriku Earthquake and Tsunami", http://www.bousai.go.jp/kyoiku/kyokun/kyoukunnokeishou/2/pdf/shiryo2-4.pdf

fig.4 Shizukawa-cho (Miyagi) after Meiji Sanriku Tsunami 1896

source: http://www.sozogaku.com/fkd/mf/MA0000616_01.gif

fig.5 A ship washed up on the ground after Meiji Sanriku Tsunami 1896

source: http://matome.naver.jp/odai/2133615578493531501

Showa Sanriku Earthquake 1933

Only 37 years after the Meiji-Sanriku Earthquake, the magnitude 8.4 earthquake hit again the Sanriku coast of the Tōhoku region on March 2, 1933.

Although the damage caused by the earthquake was not so severe, the associated tsunami, which reached the height of up to 28.7 metres, caused extensive damage, destroyed many houses and recorded numerous casualties.

The tsunami destroyed over 7,000 houses along the northern Japanese coastline, of which over 4,885 were washed away. The image of stranded boat dredged up the tragic memory of the tsunami attack that hit only few decades ago. (fig.6)

The tsunami wave reached till Hawaii islands with a height of 2.9 m, which caused slight damage.
It resulted in the death toll of 1522, 1542 missing people, and 12,053 injured.

One of the heavily damaged place was the town of Taro (now part of Miyako city), where 98% of the houses and 42 % of its population were lost. At Kamaishi in Iwate Prefecture, almost all the settlements were washed away by the tsunami and people were turned adrift. (fig.7)

Despite the experience in Meiji-Sanriku Earthquake in 1896 in the same region, disaster preventive measures were not sufficiently implemented at the coast. However, thanks to higher level of tsunami awareness and fresh memory, human casualties were relatively low compared to the previous one.

Reference: Ministry of Agriculture, Forestry and Fisheries of Japan, Showa-Sanriku-Tsunami, http://www.maff.go.jp/primaff/koho/seika/project/pdf/zirei7.pdf
Cabinet Office Disaster Management, "learning from disaster history: Trench-based earthquake and tsunami", http://www.bousai.go.jp/kyoiku/kyokun/kyoukunnokeishou/pdf/saigaishi_kaikoujishin_tsunami.pdf

fig.6 Devastation at Kamaishi after Showa Sanriku Tsunami 1933
source: http://www.jiji.com/news/handmade/special/feature/v2/photos/20100822earthquake_disaster_of _japan/edj00370.jpg

fig.7 Entire settlement in Kamaishi washed away after Tsunami 1933
source: http://livedoor.blogimg.jp/roku2005/imgs/c/0/c018d1c2.jpg

Tohoku Earthquake 2011

Fresh to our memory, a magnitude 9.0–9.1 undersea megathrust earthquake struck Tohoku region at 14:46 on Friday 11 March 2011. The epicenter of the earthquake was about 70 km east of the Oshika Peninsula and the hypocenter was at the depth of around 29km. In the recorded history, it was the most powerful earthquake in Japan. An upthrust of approximately 6 to 8 meters was recorded along a 180-km-wide seabed at 60 km offshore from the Tohoku coast and it resulted in a major tsunami that caused severe damages along the Tohoku coast.

At Natori city in Miyagi Prefecture, the tsunami of approximately 10 meter high swallowed up the city, claiming 911 lives 13,991 houses being washed away. (fig.8) The tsunami wave reached the maximum 40.5m in Miyako, Iwate Prefecture and reached as far as 10 km inlands in the Sendai region(fig.9).
The death toll rose up to 15,894, 6,152 injured, and 2,562 people missing according to the Japanese National Police Agency report on March 2015. Furthermore, more than 300,000 people are forced to leave their home and live either in temporary housing or relocated their permanent houses.

The tsunami wave propagated and got across the Pacific Ocean, arriving to the entire Pacific coast of North and South America.

The initial estimates indicated that the tsunami would arrivee in 10 to 30 minutes to the first affected areas. For other areas farther north and south of the coastline, it took more than an hour after the earthquake to reach the tsunami. A large tsunami was observed in Sendai, which flooded the airport near the coast and the destructive waves swept away vehicles, planes and buildings as they traveled inland.

Reference: Cabinet Office Disaster Management, "overview of Tohoku Earthquake", October 28, 2011, http://www.bousai.go.jp/kaigirep/chuobou/suishinkaigi/1/pdf/sub5.pdf
Fire and Disaster Management Agency, "report of damage caused by Tohoku Earthquake", October 20, 2016, http://www.fdma.go.jp/bn/higaihou/pdf/jishin/154.pdf

fig.8 Tsunami arrival at Natori city, Miyagi Prefecture, March 11, 2011
source: Mainichi Newspaper Online http://mainichi.jp/graph/select/archive/20110311higashinihondaishinsai/001.html
fig.9 Tsunami arrival at Miyako city, Iwate, March 11, 2011
source: http://www.static.jishin.go.jp/resource/figure/figure001015.jpg

The tsunami even destroyed the massive concrete seawall structure at Taro in Miyako city, putting in question the effect of such defense structure. (fig.10) The shocking image of stranded vessel again evoked the fear of repeated tragedy which periodically hit the region. (fig.11)

The consequence of this catastrophic seismic event was not limited to immediate physical or human damages. As the number of refugees soared, it resulted in shortages of daily essentials including food, water, shelters, and medical products. Some earthquake survivors died in the shelters or during the evacuation.

The economic impact included both immediate problems, such as the suspension with industrial production in factories, and the longer term issue such as the cost of reconstruction which has been estimated at ¥10 trillion ($122 billion).

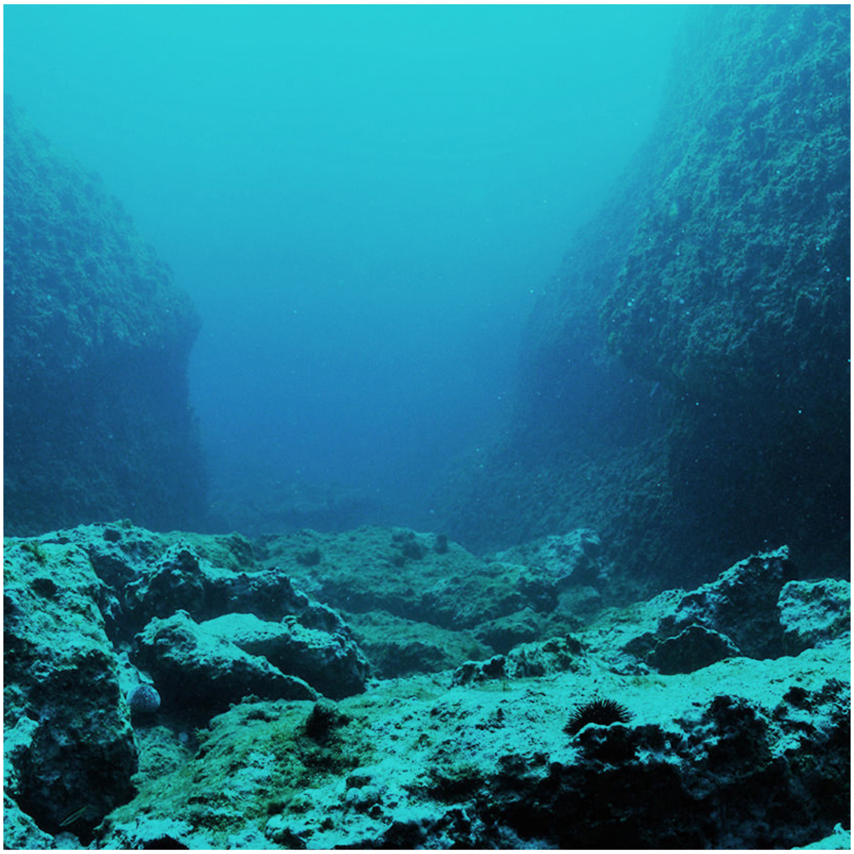
This earthquake and tsunami has triggered further intense debates over the coastal security, notably due to the meltdown accident at the Fukushima-Daiichi Nuclear Power Plant. The severe releases of radioactivity and a long-term health and environmental concerns deprived the local residents of their habitation either temporarily or permenently. The accident brought a ripple of fear and trauma throughout the nation, leading to the temporary suspension of all the nuclear power plants for the inspection purpose. This naturally triggered the debate over the energy secutiry of the nation where the nuclear energy has played a major role in the past decades.

The combination of natural and artificial hazard has resulted in an unprecedented catastrophe where the fragility of the boundary condition between nature and our living territory was revealed and the overconfidence on the technology as a way to control the force of nature was put into question.

fig.10 Seawall structure destroyed by Tsunami, Miyako, Iwate Prefecture
source: Kenji Aoyagi, http://blog.goo.ne.jp/raymiyatake/e/9c4bdab0bad4f4a81fe12309baa65159

fig.11 A huge vessel was wased up on the ground at Kesennuma, Miyagi
source: EPA, http://blogimg.goo.ne.jp/user_image/49/94/2fabb2371f5e689c2a6644a1ec4a09d0.jpg

d. TSUNAMI MECHANISM & TIME SEQUENCE



Oceanic crust at the bottom of the Mediterranean

source: Alamy Stock Photo, https://www.newscientist.com/article/2100988-worlds-oldest-ocean-crust-dates-back-to-ancient-supercontinent/

The word “tsunami” comprises the Japanese words “tsu” (meaning harbour) and “nami” (meaning wave). A tsunami is a series of enormous waves created by an underwater disturbance and the consequent displacement of a water mass usually linked with earthquakes below the ocean.

This part aims to illustrate the mechanism and the time sequence of a tsunami in order to understand the physical and temporal implication of this natural phenomenon.

Tsunami Mechanism

Tsunami differs essentially from the normal tide or large waves. The generatin of Tsunami is triggered by the displacement of the deep seafloor due to earthquakes, landslides or volcanic activities. Tectonic earthquakes are a special kind of earthquake that are linked with the Earth's crustal deformation and with the generation of tsunami. When this type of earthquakes occurs beneath the sea, the deformation of the seabed displaces the water above from its equilibrium position. Enourmous mass of water is consequently displaced and propagates as a Tsunami wave. A tsunami can be triggerd in any tidal condition and even at low tide it can cause an inundation in coastal areas.

More specifically, the basic sequential mechanism of tsunami is illustrated on the right page. (fig.1)
I. Ordinary condition: The oceanic crust sinks underneath the continental crust, generating and accumulating the stress between those crusts.
II. Interplate earthquake & tsunami generation: The thrust faults associated with plate boundaries move abruptly, resulting in water displacement above the seafloor. only the largest of such events (typically related to flexure in the outer trench swell) could cause enough displacement to generate a significant tsunami
III. Propagation of tsunami: The vertically displaced water on top of the hypocenter begin to spread in all the direction. In deep ocean, waves travel at a speed of about 800 km/h and are only a few tens of centimetres high. On the contrary at the shallow shore, waves travel much slower at about 30km/h but the wave height increases.
IV. Escalation of wave height: Due to the velocity difference of the waves according to the depth of the sea, the subsequent fast waves (deep sea) begin to catch up the precedent slow waves (shallow shore), resulting in the augmentation of wave height.
V. Land submerged (pushing wave): tsunami waves go beyond the coast line and travel inside the living territory, washing out cars, trees or houses.
VI. Backrush (pulling wave): The waves stop travelling inward and begin to backrush toward the direction of the sea, washing back destroyed houses or cars.
VII. Subsequent waves: The arrival of the secondary/tertiary wave, repeating the process of V
VIII. Subsequent backrushes: The backrush of the secondary/tertiary wave

reference: North-Eastern Atlantic, Mediterranean and connected seas Tsunami Information Center, http://neamtic.ioc-unesco.org/tsunami-info/the-cause-of-tsunamis

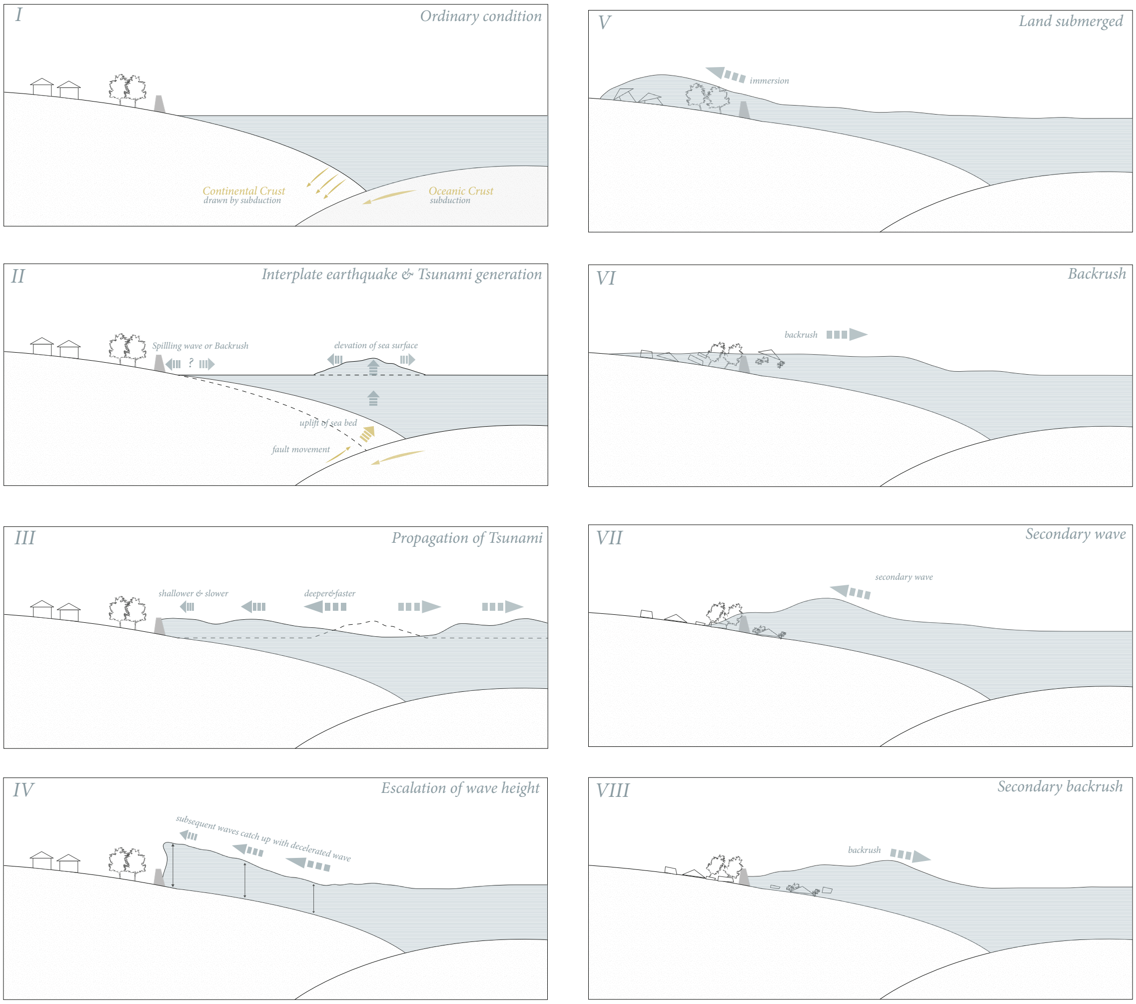


fig. 1 Tsunami mechanism and sequences
reference: http://neamtic.ioc-unesco.org/tsunami-info/the-cause-of-tsunamis

Waves in the ocean are generally generated by wind and they are quantitatively described through their amplitude, namely the height of the wave and wavelength which is the distance from one crest to the next crest. Tsunami has considerably longer wave length and it could even be as long as 200 kilometers, whereas normal ocean waves have a wavelength of about 30 or 40 metres.

In principle, the deeper the sea is, the longer the wavelength becomes. Therefore, a tsunami usually has a longer wavelength and travels faster in the deep ocean than in the shallow shore near the coastline. Contrary to the velocity, tsunami height grows inversely proportional to the sea depth. At the deep sea, with its long wavelength, tsunami passes almost unnoticed since it usually rose only about 30 cm above the original sea surface. Tsunami gets higher as they approach the shore line and one could almost see it as a vertical wall moving with a destructive force.
The formula expressing the velocity of a tsunami can be described as $\sqrt{gh}$ where g is the acceleration of gravity (9,8 m/s2), and h is the depth of the sea expressed in metres.

The figures on the right page (fig.2) illustrate graphically this relation between sea depth, tsunami speed and the wave height. For instance, at the sea depth of 5,000 meters, while the wave height is relatively low, the velocity of tsunami is expected to be as fast as 800km/h, which is almost equivalent to the velocity of an airplane. At the sea depth of 500m, the wave height gets higher than the one of 5,000m case, but the velocity goes down to ca. 250km /h, which is comparable with a high-speed train. At the sea depth of 50m, the tsunami speed further drops to around 80km/h, which is at the level of normal automobile. At the shallow shore with the depth of 10m, the wave height gets very high, whereas the velocity becomes as slow as bicycle.

reference: Japan Meteorological Agency, "Mechanism of Tsunami generation and propagation", http://www.data.jma.go.jp/svd/eqev/data/tsunami/generation.html

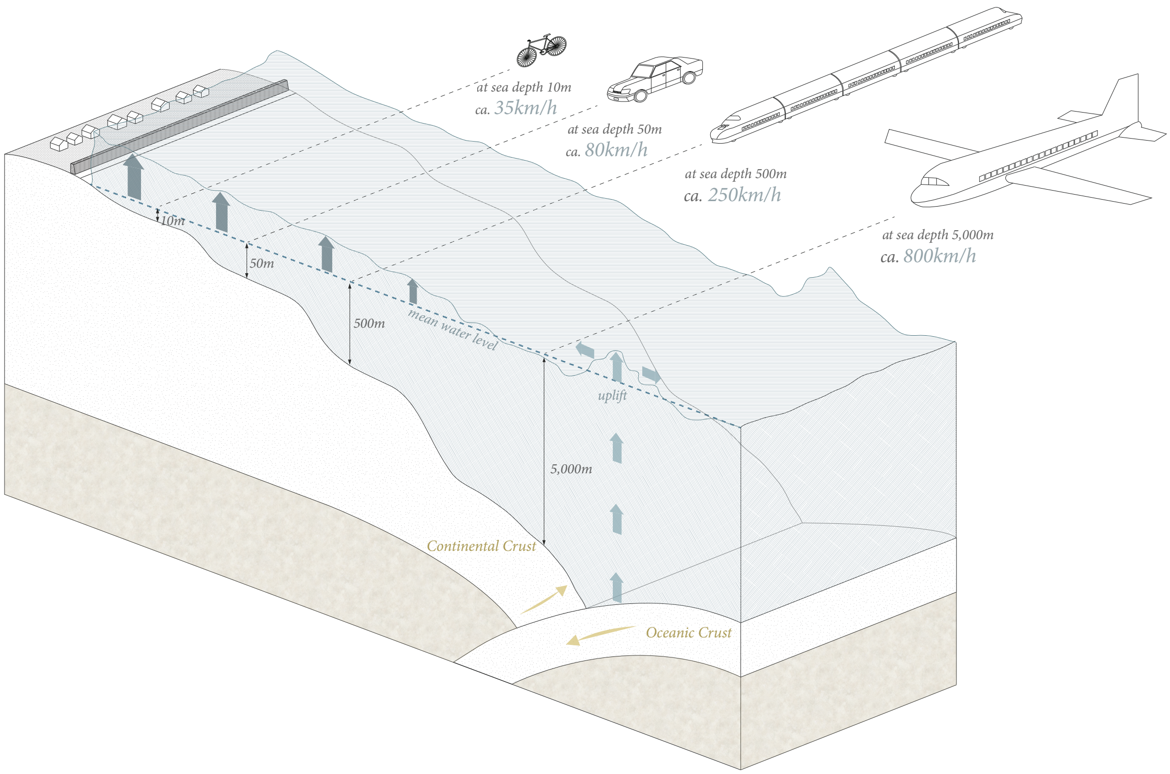


fig.2 Sea Depth & Tsunami Height/Speed

reference: http://www.data.jma.go.jp/svd/eqev/data/tsunami/generation.html

Tsunami Timeline

The figures on the right page show the actual sequences of tsunami observed at the town of Minamisanriku during the Tohoku earthquake and tsunami events in March 2011. (fig.3)

On 9th March, 2 days before the mainTohoku earthquake, there was a minor tremor in the region and a local fisherman has noticed the change of sea levels following the earthquake.
On the same day, 1m of tsunami was indeed observed at the coast.

On 11th March 2011, Magnitude 9 mega-earthquake struck the Tohoku coastal region at 14:46 local time.
In this case, the low tide (backwash) was observed approximately 20minutes after the earthquake at 15:05.
Subsequently, 13 minutes after the backrush, the sea level began to rise at 15:18
Within few minutes, the tsunami wave exceeded the height of seawall and it reached at the level as high as 12 meters above the sea level.

The tsunami washed away most of the building structures in the town, leaving only concrete or steel frames of some structures.

Depending on the various factors, such as the physical location, the topographic feature, the distance from the epicenter, the condition of tide, the magnitude and the arrival time of tsunami vary considerably. Even for two neighboring communities, they may suffer totally different degree of damages. In the current case, the backwash was observed before the arrival of the first tsunami wave, but for other places, leading wave arrived without the backwash. In any case, this sequence of events may happen in very short period of time, so an immediate evacuation is essential when one notices the earthquake and there is a risk of tsunami.

source: Eiki Takahashi, Record of Tsunami at the town of Minamisanriku in the event of Tohoku tsunami, http://recorder311.smt.jp/blog/21887/

1. 15:05, March 11, 2011
after 14:46 M9 earthquake, backrush

4. 15:26, March 11, 2011
Tsunami arrived at 12m above sea level

2. 15:18, March 11, 2011
sea level rise after the backrush

5. 17:11, March 11, 2011
photo from the hill (25m above sea level)

3. 15:25, March 11, 2011
Tsunami went beyond the seawall

6. 7:57, March 25, 2011
11 days after the Tsunami hit

fig.3 Tsunami at Minamisanriku-cho, Miyagi, March 11, 2011
source: http://recorder311.smt.jp/blog/21887/

e. JAPAN'S SEISMIC COASTAL TERRITORY

Tsunami at Natori City, March 11, 2011

source: Kyodo/Reuters https://www.theguardian.com/world/gallery/2011/apr/11/japan-earthquake-tsunami-natori-in-pictures

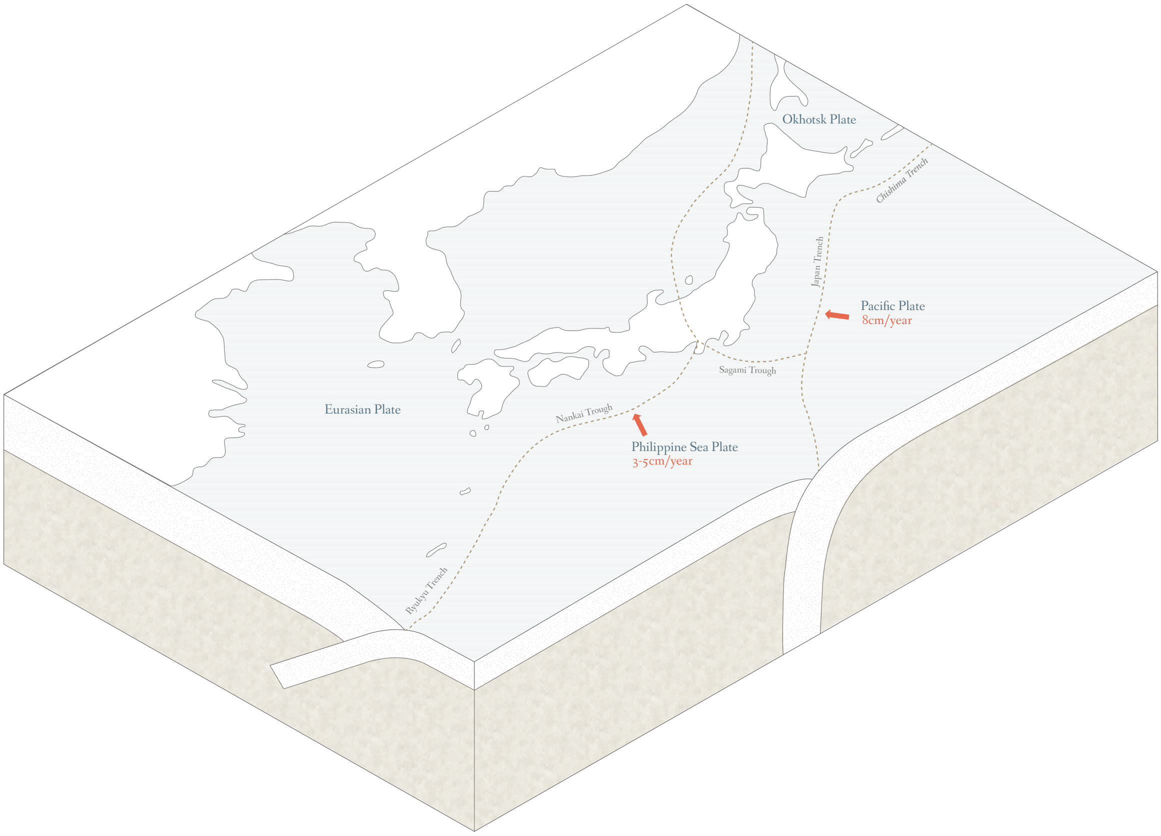
On the basis of the understanding of the history and the mechanism of tsunami disaster in Japan, this section aims to analyse the character of Japanese coastal region from the viewpoint of the territory's physical characters as well as the development of urban settlement.

The interaction of natural and artificial layers would reveal the potential and innate risk of the coastal region about tsunami disaster.

Seismic Plate

fig.1 Tectonic Plates around Japanese archipelago

data source: Natural Earth



Japan archipelago sits atop the junction of four tectonic plates; the Pacific Plate, the Philippine Sea Plate, the Okhotsk Plate, and the Eurasian Plate. The two oceanic plates, the Phillipine Sea Plate (3-5cm/year) and the Pacific Plate (8cm/year), slowly yet constantly sink underneath the continental plates, accumulating the interplate strain which would be released in the form of earthquake. (fig.2)

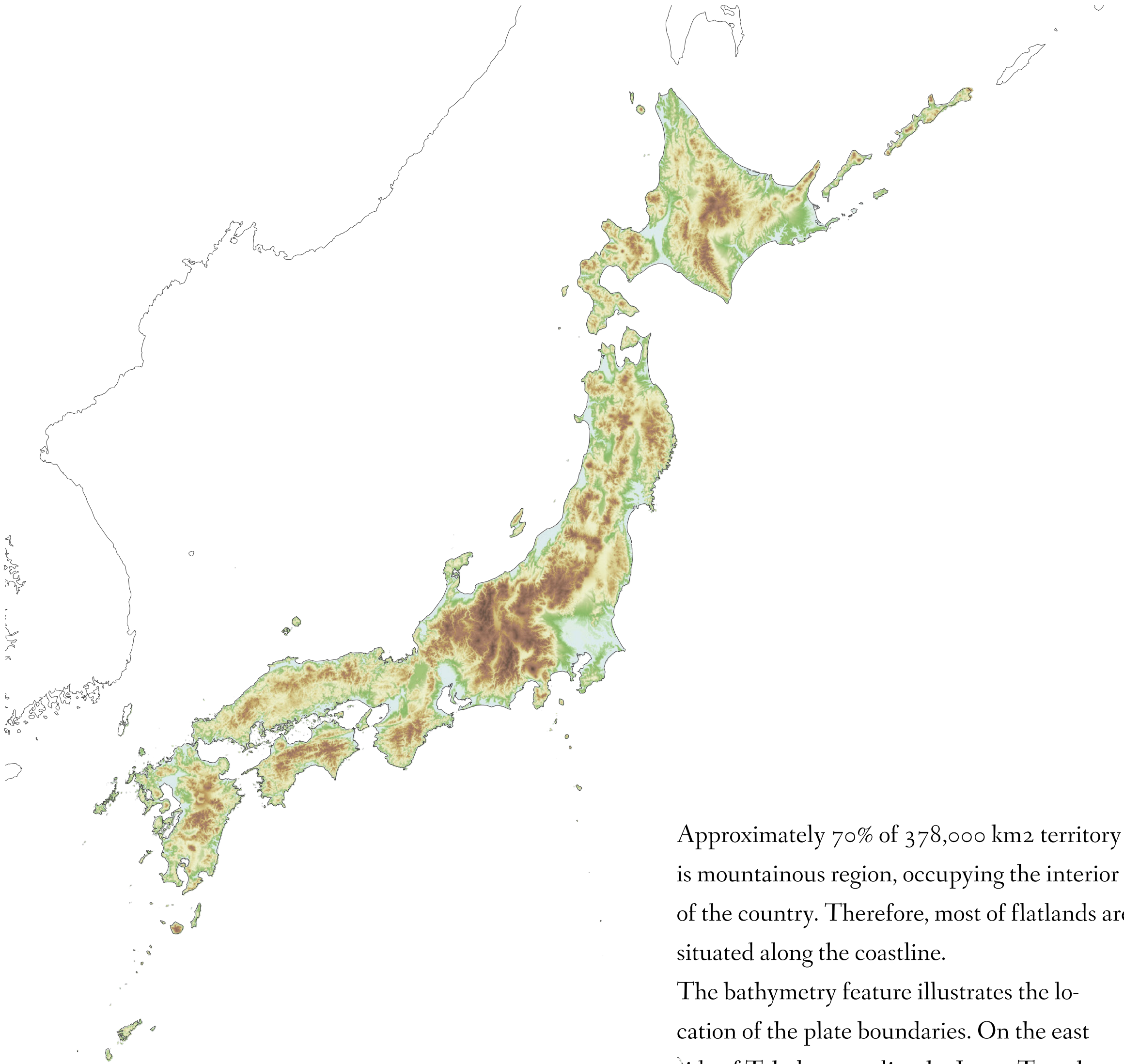
Japan lies along the "Pacific Ring of Fire" , an area in the basin of the Pacific Ocean where a large number of earthquakes and volcanic eruptions occur [1]. On average, as many as 4,800 earthquake of the magnitude larger than 3 occurred between 2001 and 2010 around Japan, accounting for almost one-tenth of all the earthquakes worldwide [2].

fig.2 Axonometric View of Tectonic Plates around Japan

data source: Natural Earth

1. Brett Israel "Japan's Explosive Geology Explained" http://www.livescience.com/30226-japan-tectonics-explosive-geology-ring-of-fire-110314.html
2. Japan Meteorological Agency, "about Earthquake", http://www.jma.go.jp/jma/kishou/know/faq/faq7.html

Topography



Approximately 70% of 378,000 km2 territory is mountainous region, occupying the interior of the country. Therefore, most of flatlands are situated along the coastline.
The bathymetry feature illustrates the location of the plate boundaries. On the east side of Tohoku coast lies the Japan Trench (ca.10,554m depth) and on the south side of the Pacific Coast lies the Nankai Trough (ca. 4,000m depth).

fig.3 Japan Topographical Map
source: Geospatial Information Authority of Japan, http://www.gsi.go.jp/kankyochiri/gm_jpn.html

Bathymetry

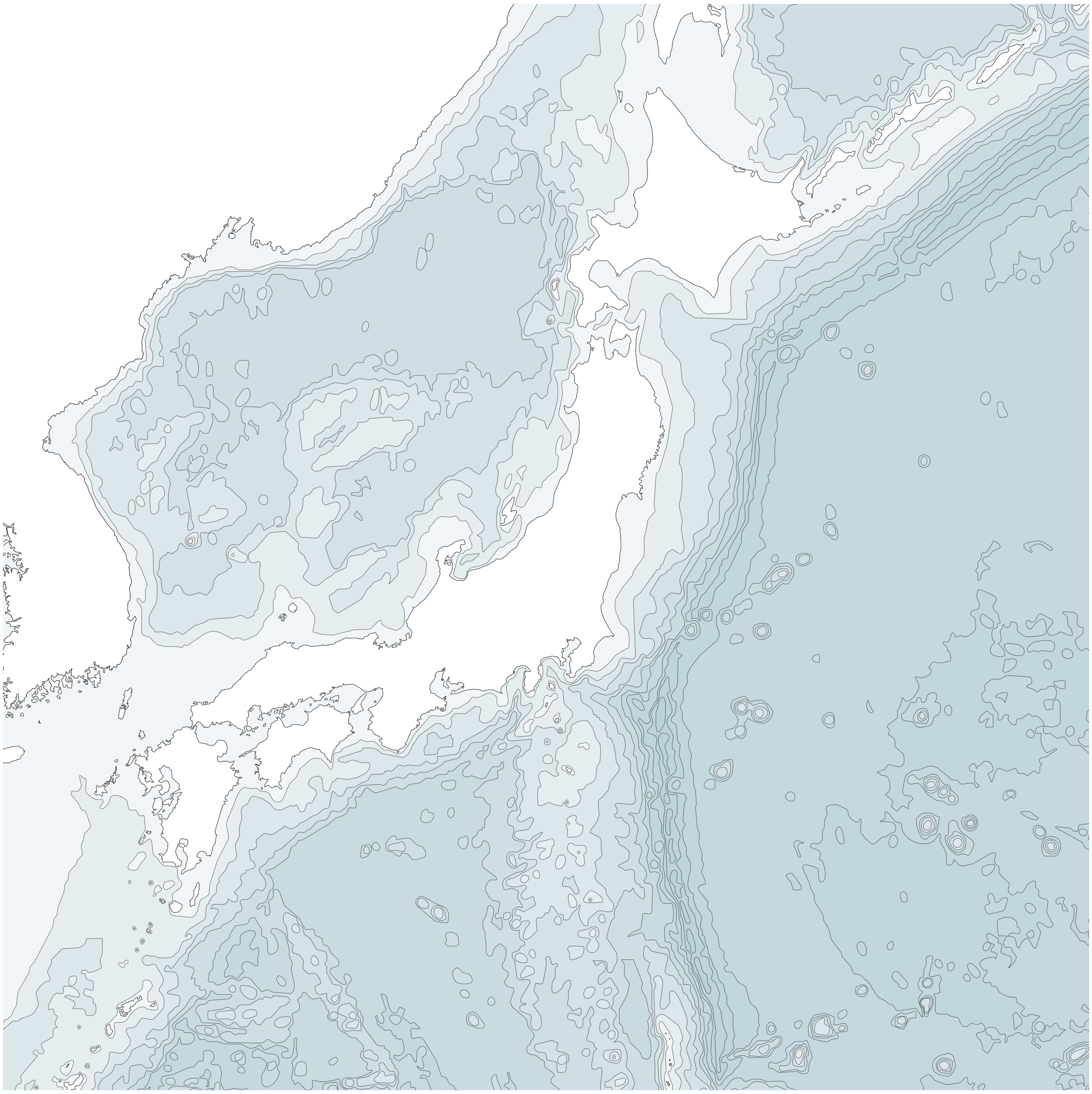
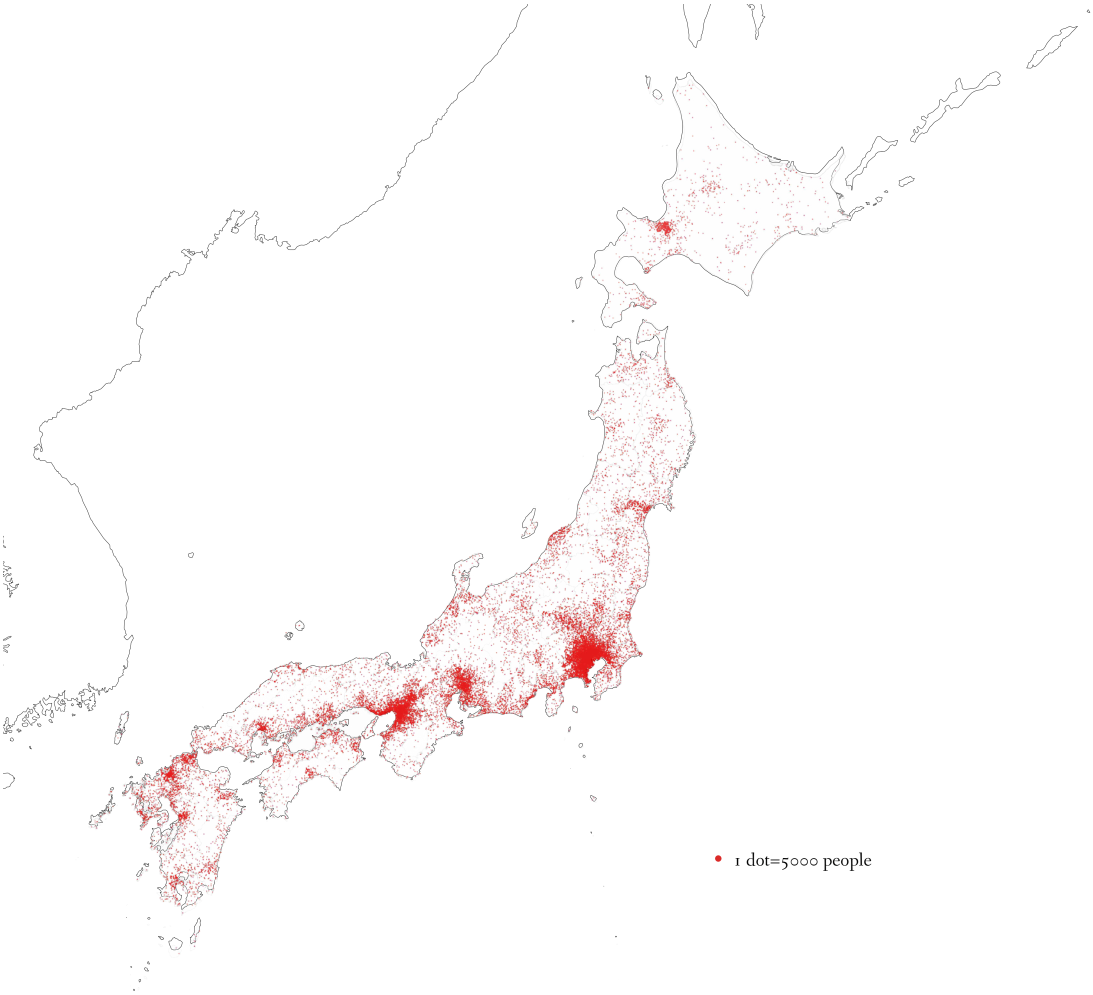


fig.4 Bathymetric Map around Japanese archipelago
source: Natural Earth

Population Distribution



The total population in Japan is approximately 127 million and it is highly concentrated on few metropolitan areas. The Greater Tokyo Area alone has an estimated population of 37.8 million and the Kansai Area has approximately 22.7 million population.

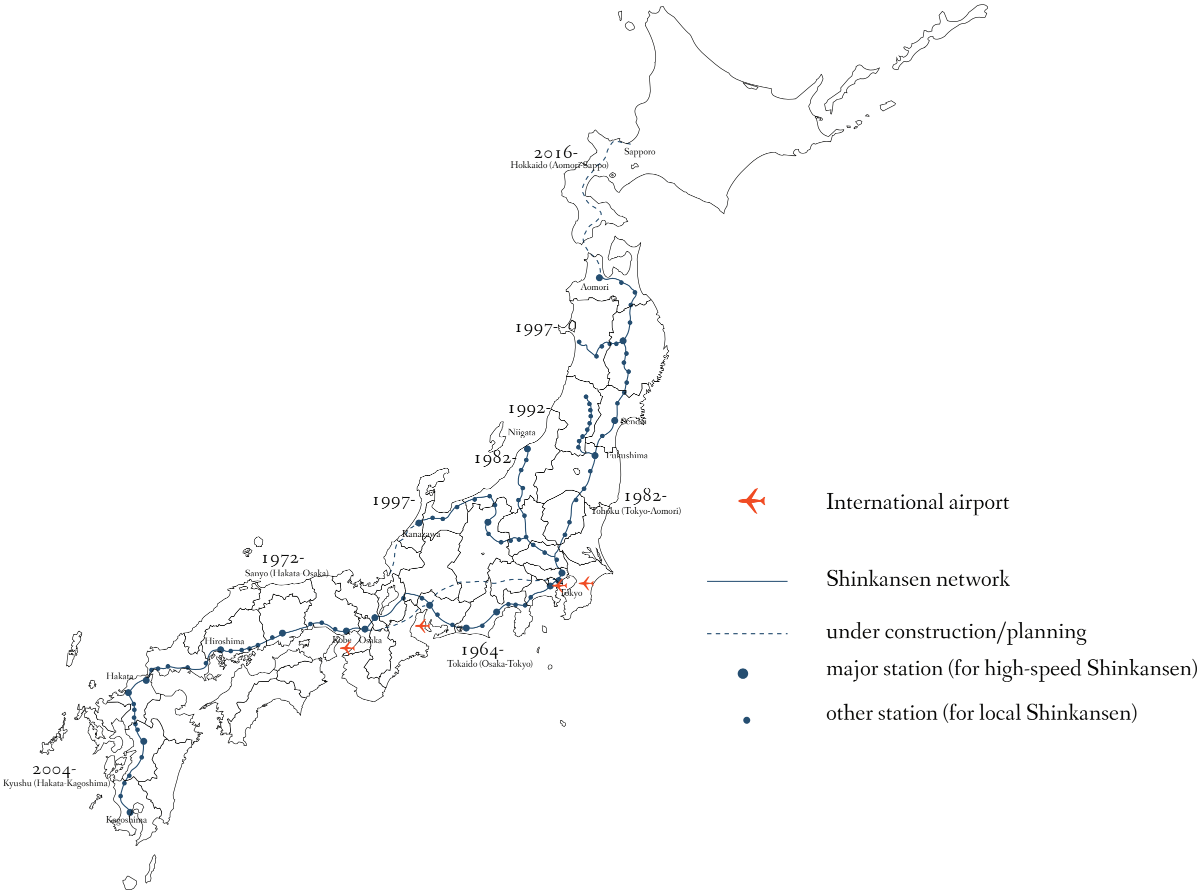
fig.5 Population Distrubution
reference: http://www.osaka-kyoiku.ac.jp/~syamada/map_syamada/shosen/C120509PopulationDotMap_Japan.jpg

Urban Area

Following the topographical feature, the major urban districts sit on lowlands along the coast. Consequently, the cities in Honshu (main island) seem to form a continuous band of urbanized territory, stretching from Hiroshima, Osaka, Nagoya, Yokohama to Tokyo.

fig.6 Urban Area
source: Natural Earth, http://www.naturalearthdata.com/

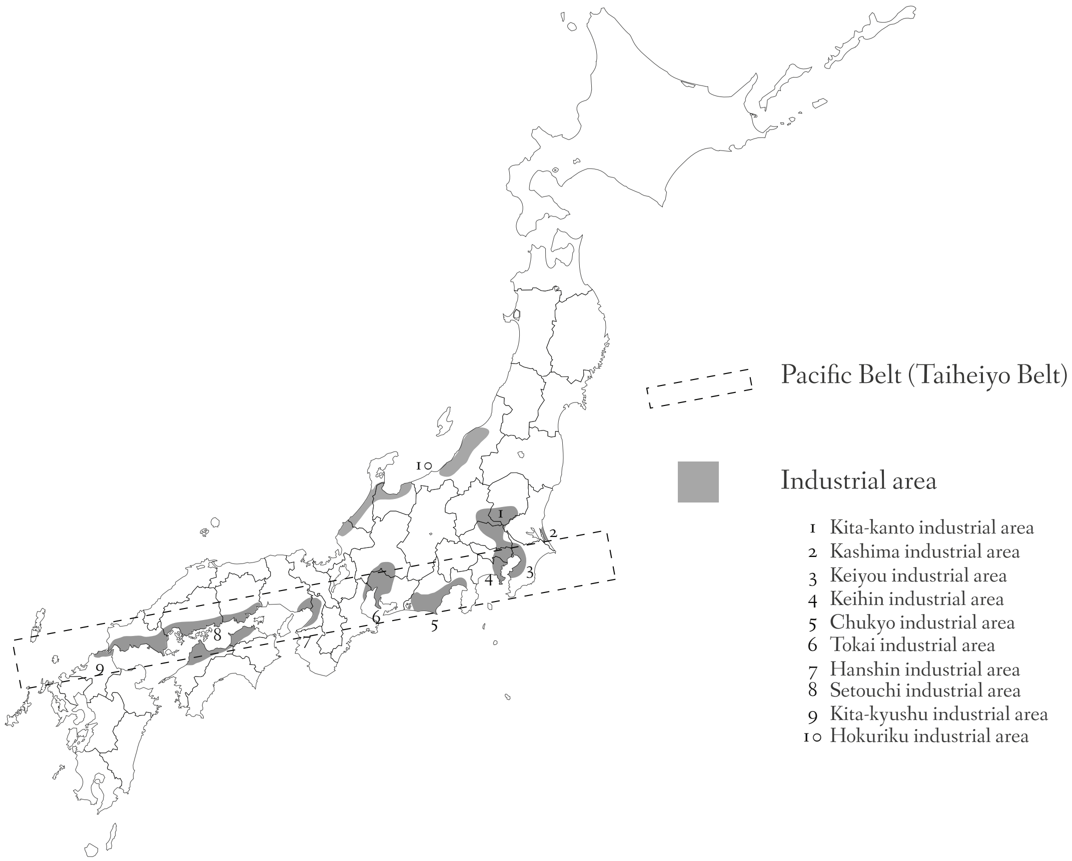
Major Transportation



The development of major transportation followed the logic of the urban development. All four international airports are located in the major coastal urban area;Tokyo, Nagoya and Osaka. The evolution of the Shinkansen fast train line also started in 60's from the same major axis of the country (Tokyo-Osaka) and it continues extending up till now.

fig.7 Main Transportation Network
source: Japan Railways Group, Google Maps

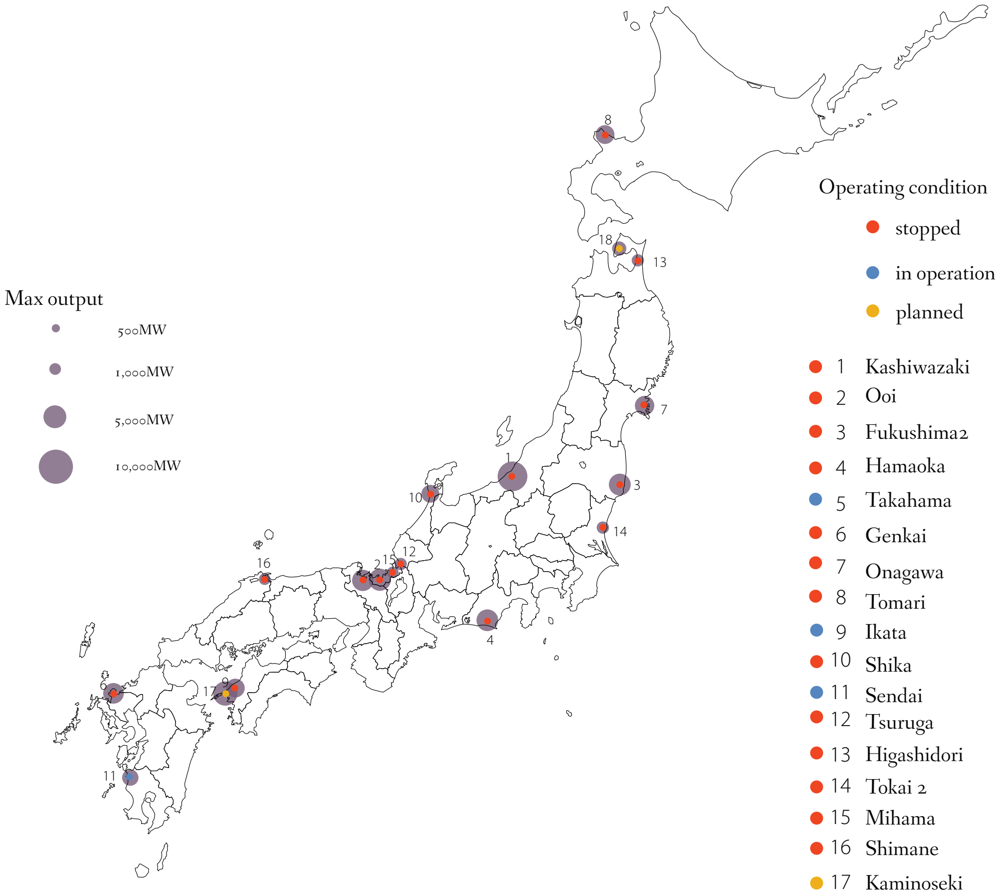
Industrial District



As with the transportation, the majority of cardinal industrial districts have been developed along the Pacific coastal regions from Kyushu to Kanto region and they constitute the band of industrial area called "Pacific Belt".

fig.8 Pacific Belt/Network of Industrial Zones
source: Google Maps

Nuclear Power Plant



(x1000kW)

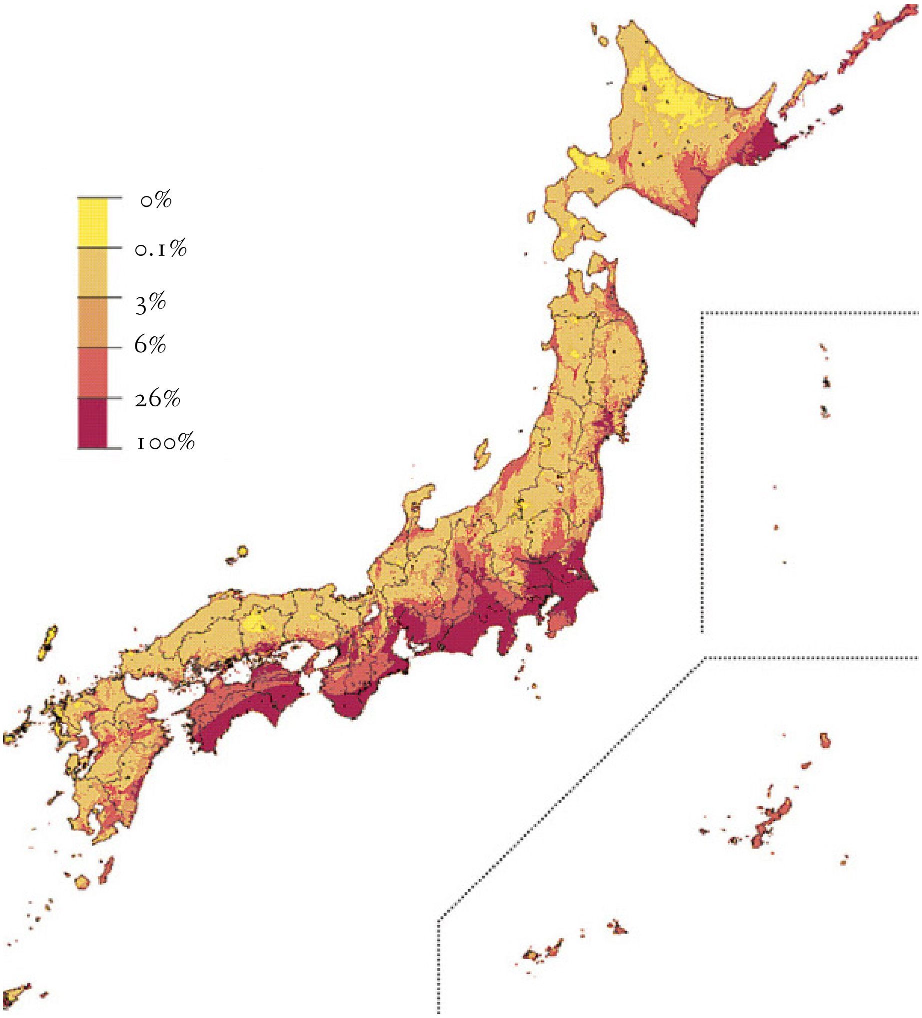
● (stopped)	1	Kashiwazaki	8,210
● (stopped)	2	Ooi	4,710
● (stopped)	3	Fukushima2	4,400
● (stopped)	4	Hamaoka	3,617
● (in operation)	5	Takahama	3,392
● (stopped)	6	Genkai	2,919
● (stopped)	7	Onagawa	2,174
● (stopped)	8	Tomari	2,070
● (in operation)	9	Ikata	2,022
● (stopped)	10	Shika	1,898
● (in operation)	11	Sendai	1,780
● (stopped)	12	Tsuruga	1,160
● (stopped)	13	Higashidori	1,100
● (stopped)	14	Tokai 2	1,100
● (stopped)	15	Mihama	826
● (stopped)	16	Shimane	820
● (planned)	17	Kaminoseki	2,740
● (planned)	18	Ooma	1,383

All of Japanese nuclear power plants are also located at the coastal region due to the necessity of cooling water, but most of them tend to be situated off the central axis of the country.

fig.9 Location of Nuclear Power Plants

source: Federation of Electric Power Companies in Japan

Seismic Risk in Japan 2016-2046



According to the earthquake risk map issued by a governmental institution for earthquake research, the areas of higher risk of major earthquakes lie along the Pacific coast line [1].

fig.10 The probability of earthquake occurence (> seismic intensity 6 lower) between 2016-2046
source: The Headquarter for Earthquake Research Promotion; http://www.jishin.go.jp/

1. the detail of the map will be discussed in the later chapter

Reflection

Through the analysis of these natural and artificial layers, some important observations came out.

The overconcentrated nature of Japanese urban development patterns, especially along the Pacific coast, would indicate the potential high risk in case the mega-tsunami would hit those concentrated regions. The majority of the population, capitals, infrastructures are settled densely along the narrow strip of continuous urban band which are facing the Great Pacific Ocean.

The force of tsunami wave which emerges from the 4,000 meter deep seafloor would defy the imagination of urban population. Japan faces the threat of earthquakes inland and the fear of tsunami from the shore. Wedged between these unavoidable and even innate threats from the nature, Japan has evolved a vast extension of urban territories on the potentially vulnerable coastal regions. Whether one likes it or not, Japanese society is obliged to live with *"Saigai"* (disaster) and to form a resilient urban structure which can withstand or mitigate the forthcoming disasters.

While the society, the urbanization, the industry and the technologies have evolved at an incredibly fast speed during the last century, the nature maintains its own rhythm and cycles when it comes to the disaster. When the cycle hits the contemporary urban territory in Japan, the damage would be unparalleled. The sporadic presence of nuclear power plants along the coastline all over the country can even add the risk to the already serious hazard of the natural force.

Despite the expansion of anthropogenic territories, no human technology is capable of controlling the immense force of earth's activity underneath. With the understanding and the acceptance of these risks, Japanese society would need a set of strategies to protect the territory from tsunamis. The next chapter, "*Bousai*", explores some of the possible countermeasures and strategies against the tsunami disaster.

CHAPTER 2

BOUSAI

COASTAL DEFENSE INFRASTRUCTURE & SPACE

ABSTRACT

Bousai is the Japanese translation of "disaster prevention". Through the introduction of 5 principle *bousai* "structures" (disaster prevention measures) with its types and concrete example both from Japan and abroad, this chapter aims to provide the resources for spatial, technical as well as cultural interpretation and critics of possible *bousai* policies and projects.

a.SEAWALL

Seawall with acrylic window opening , Kesennuma, Sendai
source: http://line.blogimg.jp/mutamasahiro/imgs/e/8/e83c308e.jpg

A seawall is a structure separating land and water areas.

It is designed to prevent coastal erosion and other damage due to wave action and storm surge, such as flooding.

Seawalls are normally very massive structures because they are designed to resist the full force of waves and storm surge.

Seawalls are often used at locations off exposed city fronts, where good protection is required. They are also used along other less inhabited coasts, where combined coast protection and sea defence is urgently needed.

Seawall Definition

Reference: Mangor, Karsten. 2004. "Shoreline Management Guidelines". DHI Water and Environment, 294pg.

Types of Seawall

Sea walls are engineering coastal defense structures which are designed to protect the coast from tides and erosion. Depending on various physical or specific local conditions such as coastal position or available spaces, appropriate forms or types of the seawall structure would be selected [1]. (fig.1)

The most common materials used for seawalls are reinforced concrete, steel, gabions or boulders, which can withstand the massive force of wave energy. Other less common materials include wood, composite materials such as fiberglass or large sandbags [2].
The followings are the three major types of seawall based on their specific characters.

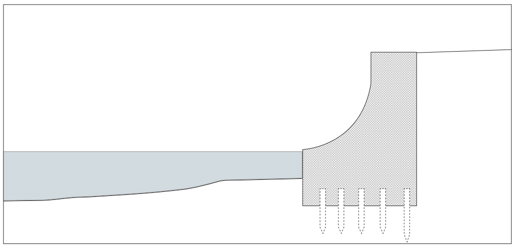
1. Vertical Wall
The vercial wall type, as its name indicates, is designed to protect the shore with vertically standing wall. The major advantage of this type is that it requires less space compared to other types of seawalls. Moreover, it is relatively simple to design and construct this type of wall. On the contrary, due to its verticality, it is less efficient in dissipating wave energy and thusly it is prone to suffer damages in short period. Furthermore, the clapotic waves (vertical movement of waves) can erode the toe of the wall [3]. The curved form could help to mitigate these aspects and provide the enhanced protection for the toe of the wall.

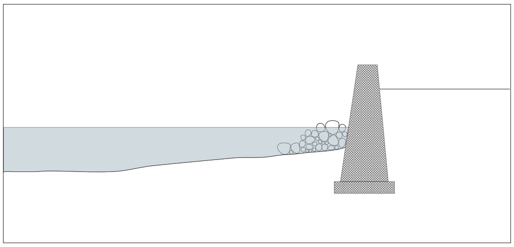
2. Sloping Wall
Sloping or stepped seawalls are designed to dissipate more efficiently the wave energy compared to the vertical wall type. It typicaly requires more spaces (20-40m) and materials to construct this type of wall. However, there are usually flat area on top of the slopes and people could usually access and walk on that space.

3. Mound
This type typically uses heavy chunk of rocks such as granite, limestones or other materials such as concrete blocks to protect shorelines against tides or erosion. This type takes the form of riprap or revetments and is suitable for less demanding setting where lower energy and erosional processes are expected. Due to the porosity between rocks, it can filter through the water after dissipating the wave energy [4]. This option has a great advantage in the cost and the simplicity of design and engineering process.

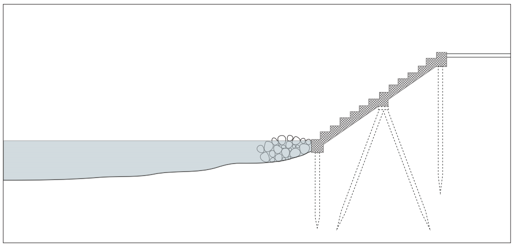
1. GeoResources. (2001) Coastal management. Retrieved online 18 April 2011 from: http://www.georesources.co.uk/coastman.htm
2. Clarke, J R. 1994. Integrated Management of Coastal Zones. Fao Corporate Document Repository, USA.
3. Beer, Tom (1997). Environmental oceanography. Boca Raton: CRC Press. p. 44.
4. Milligan, J & O'riordan, T. (2007) "Governance for Sustainable Coastal Futures" in Coastal Management. Vol. 35, Issue 4, p 499–509.

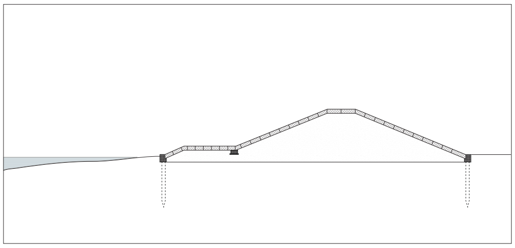
1. Vertical Wall



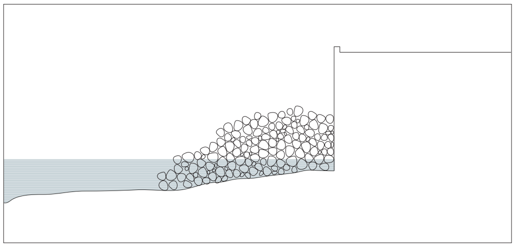


2. Sloping Wall





3. Revetment/Riprap



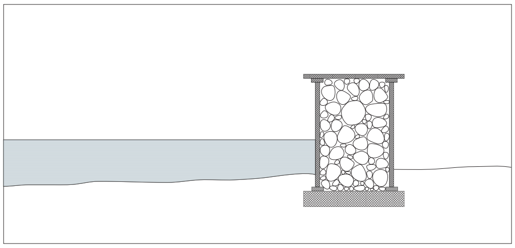


fig. 1 Various types of Seawalls

reference: Pilarczyk, K.W. Design of seawalls and dikes- including overview of revetment (1990)

Example 1: Sendai South Coast

Sendai is the capital city of Miyagi Prefecture, and the largest city in the Tōhoku region, with the population of one million. Sendai south coast stretches approximately 65km from Sendai city to the border with Fukushima, consisting of industrial and commercial core areas of the region. The coastal area including Sendai Airport and most of defense structures have been severely damaged following the earthquake and tsunami on March 11, 2011. The tsunami wave reached as far as 8 kilometers inland from the coastline.

Although the jurisdictionary authority fo the the coasts are normally the Miyagi Prefecture, the nation took over the responsibility for the restoration operations [1]. The new seawall is a sloping wall type (1 : 2 ratio) and the height of the wall is 7.2m. (fig.3)

It became 1m heigher compared to the previous one which is set to take the frequent tsunami and storm surge into consideration. The design of the structure aims at improving the resistance of the wall in order to delay, as long as possible, the destruction of the wall and the eventual overtopping [2]. The operation began on March 2012 and the total of 29km restoration work have been completed on March 2016.
As shown in the image on the right page, the long trapezoidal concrete mass demarcates a clear border between the sea and the land. (fig.2)

1.Situation of Sendai South Coast, http://www.thr.mlit.go.jp/sendai/kasen_kaigan/fukkou/pdf/sendaigaiyou.pdf
2. Restoration of Sendai South Coast, http://www.thr.mlit.go.jp/sendai/kasen_kaigan/fukkou/pdf/honfukkyu.pdf

fig.2 Sendai south coast seawall aerial view (March 2016)
Source: https://i.ytimg.com/vi/3_PucCBvKto/maxresdefault.jpg
fig.3 perspective view of theseawall (May 2016)
Source: Atsumi Kensetsu Corporation, http://atsumi-kensetsu.jp/wp-content/uploads/2016/05/ead0fbeecaafb6c60bb317444ccf732b.jpg

Example 2: Omaezaki Coast

Omaezaki is a city in Shizuoka Prefecture and is located at the tip of Omaezaki Peninsula on Japan's Pacific coast. The city have a population of 32,433 as of September 2015. Omaezaki is considered as a high-risk area for a tsunami attack due to its geographical location as well as the Hamaoka Nuclear Power Plant which is located also along the coastline of the city.

The majority of the city is comprised of gentle hills with some steep cliffs on the peninsula's east coast and this topographical feature, to a certain degree, help protecting its territory from the eventual tsunami. (fig.4)

However, the artificial coastal defense structures are also needed and the coastline, except the beach zones, is armored by curved concrete wall which are designed to withstand and dissipate the harsh wave action. (fig.5)

The combination of natural and artificial layers provide an enhanced defense capability alone the coast.

fig.4 Omaezaki Port aerial view
Source: http://jafevent.jp/area/chubu/shizuoka/

fig.5 Omaezaki Port Seawall
Source: photo taken by Hiroki Tanigaki

Example 3: Hidaka-Gobo Coast

Gobō is a city located in Wakayama Prefecture, western part of Kii Peninsula.
The city has an estimated population of 27,483 as of 2003 .

The coastal cities along Kiisuido Strait including Gobo city are assumed to be in a vulnerable area in the event of Nankai earthquake which could occur in the coming decades.

Therefore, the city intends to ramp up its efforts to facilitate the disaster prevention measure against earthquake and tsunami. For instance, residents in Gobo take part in the regular tsunami drills based on the scenario that the city would be hit by a tsunami 25 minutes after a magnitude-8.6 earthquake [1].

The city employed various types of coastal defense structures depending on the local condition and the geographical character. The image on the right page is a sloped seawall made of gabion, a series of container filled with stones to fortify the coastal defense structure. (fig.7)

1. UPI July 23, 2005 , "20,000 take part in Japan tsunami drills" http://www.upi.com/20000-take-part-in-Japan-tsunami-drills/33591122153357/

fig.6 Hidaka Gobo gabion seawall aerial view(2005)
source: bing maps
fig.7 Perspective view of the gabion seawall (2005)
source: http://www.k-mil.net/products/datasheets/024488D.pdf

Example 4 : Ofunato Port

Ōfunato is a city located in Iwate Prefecture in the Tohoku region and the city had an estimated population of 38,010 as of September 2015.
Historically speaking, the city incurred devastating damages by earthquakes and tsunamis that struck the Sanriku coast.

The 1896 Sanriku earthquake triggered a 25 meter-high tsunami wave which killed approximately 27,000 people in Sanriku region. The magnitude 8.4 Sanriku earthquake in 1933 caused a 28 meter-high tsunami which killed 1522 people.

Ofunato hit the headlines yet again when it was struck by 23.6 meters tsunami in the event of 2011 Tōhoku earthquake. The tsunami arrived approximately 3 kilometers inland and 3,498 houses out of 15,138 houses in the town have been destroyed by tsunami. Iwate Prefecture has been undertaking the restoration and reconstruction of damaged coastal defense infrastructure.

At the Ofunato Port, the height of the new seawall is designed to be 4meters higher (7.5m above sea level) than the one existed before the earthquake [1].

This new seawall, constructed in 2014, is a special type of vertical seawall whose thickness is less than 1 meter [2]. (fig.9)

1. Iwate Prefecture, http://www.pref.iwate.jp/kasensabou/kasen/fukkyuu/tsunami/021174.html
2. Satoru Imakawa, http://imakawa.net/archive/615.html

fig.8 Ofunato aerial view(photo May 11, 2014)
source: http://www.ajiko.co.jp/saigai/touhokufukkou/1000funato.jpg
fig.9 Ofunato Port new Seawall, 7.5m above sea level (2014)
source: http://imakawa.net/wp/wp-content/uploads/IMG_0614.jpg

Example 5 : Hamaoka Nuclear Power Plant

As all the nuclear power plants in Japan are located near the shoreline so as to ensure sufficient cooling water, the issue of coastal defense and security around those facilities are particularly sensitive and delicate concerns for the nation. The appalling accident at Fukushima-Daiichi nuclear power plant necessitated the revision and reconstruction of defensive seawalls for the other nuclear plants in Japan. It is, for instance, the case for the Hamaoka Nuclear Power Plant, which is located in Shizuoka Prefecture. The Hamaoka plant has five units at a single site and the net area is approximately 1.6 km^2 [1].

In May 2011, two months after the Fukushima accident, Prime Minister Naoto Kan at the time requested the shutdown of the Hamaoka plant since it is estimated that the magnitude 8.0 or stronger earthquake will hit the Tokai region within next 30 years with 87% likelihood according to the government estimation [2]. On 9 May 2011, Chubu Electric has decided to comply with this request and the plant operation is under suspension as of now.

The plant has been designed to withstand a magnitude 8.5 earthquake [3]. Previously, sand hills of up to 15 metres provided defence against 8 meter tsunami, but Hamaoka previously did not have concrete seawall.

Therefore, a plan was revealed on 22 July 2011 to build a 22 meter high seawall to protect the facility from tsunami attack. (fig.11)

With this height, the plants could theoretically withstand tsunami waves higher than the waves that hit Fukushima Daiichi Plant and the hight expected for the predicted tsunami in the area. The construction of 1.6km long concrete seawall was completed on December 2015 with the estimated cost of around 1.3 billion dollars [4].

1. *Chubu Electric Power Company, information about the Hamaoka Nuclear Power Plant, http://www.chuden.co.jp/hamaoka-pr/guide/powerplant.html*
2. *The Headquarters for Earthquake Research Promotion, http://www.jishin.go.jp/*
3. *Quake shuts world's largest nuclear plant Nature, vol 448, 392-393,*
4. *Japan Atomic Industrial Forum (JAIF), "Hamaoka operator to build 18m-high embankment", 22 July 2011, http://www.jaif.or.jp/english/news_images/pdf/ENGNEWS01_1311392496P.pdf*

fig.10 Hamaoka Nuclear power plant seawall aerial view

source: Sankei Newspaper; http://www.sankei.com/photo/images/news/160331/sty1603310004-f1.jpg

fig.11 Hamaoka Nuclear power plant seawall (W2m, H22m, L1600m), construction completed December 26, 2015

source: http://blog.goo.ne.jp/raymiyatake/e/9c4bdab0bad4f4a81fe12309baa65159

PROS & CONS of Seawall

The underlying idea behind the seawall structure is to "resist" against the force of nature.
The main advantages of this structure are its defense capacity, durability, the time span of the solution and the possibility of alternative usages. The seawall could be an effective way to mitigate disaster by stopping the wave at the coast and avoiding the inundation to the urban territory. This holds true as long as the magnitude of tsunami does not exceed the designed value of resistance. If constructed robustly, they can exist longer under high energy environments in comparison with other soft engineering method such as sand beach renourishment. Moreover, they can provide a more long-term solution than soft engineering options (i.e. use ecological principle to protect coast) [1]. Moreover, there is a possibility that the seawall construction can integrate some other activities or recreational space.

However, these structures have a set of critical drawbacks. In fact, the construction of high seawalls in the Tohoku reconstruction process has certainly triggered intense debates and nationwide public awareness. The first obvious reason is the immense cost of construction. As much as 700 billion yen was allocated for the reconstruction of seawall at 5 prefectures in Tohoku which were managed by the emergency surtax and the government bond [2]. Some of seawalls, such as the one in the town of Taro in Iwate Prefecture, did actually fail in the event of Tohoku tsunami in 2011, so people began to question the validity of the wall [3]. Another demerit is about the view and landscape relation. They block the view to the ocean and deprive people of their relationship with the landscape. Due to the invisibility of the sea, it may also deter people from noticing the tsunami at early stage of evacuation. Furthermore, the construction of seawall sometimes involves the destruction of sand beach where people used to enjoy the sea bathing. Various environmental problems would also be accompanied by the construction of seawall. By disrupting sediment movement and transport patterns, it may destroy shoreline habitats (wetlands etc) and can also cause erosion [4].

1. Short, A. *Handbook of Beach and Shoreface Morphodynamics.* John Wiley and Sons Ltd. Ch 7. 1999.
2. Asahi Digital, "Swelling budget for seawall construction, 700 billion yen for 5 prefectures in Tohoku", May4, 2014
3. "In Japan, Seawall Offered a False Sense of Security". New York Times. 31 March 2011.
4. Kraus, N & McDougal, "The Effects of Seawalls on the Beach: Part I: An Updated Literature Review in Journal of Coastal Research. Vol. 12, No. 3, 1996.

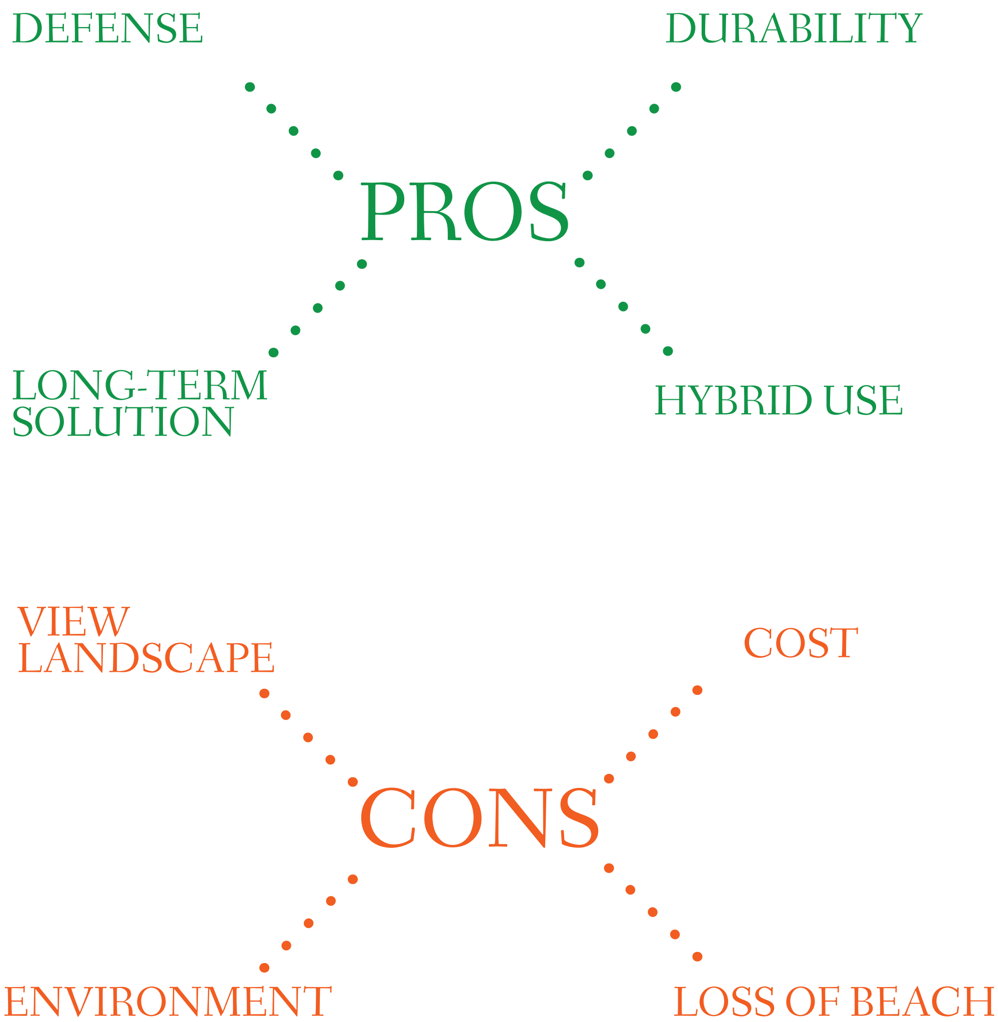


fig.12 Pros and Cons of seawall as a coastal defense structure

b. BREAKWATER

Breakwater at Goto, Nagasaki, changing color of inshore/offshore
source: Mayumi Goto, https://twitter.com/72_goto/status/710304892137529345

A breakwater is a barrier built out into the sea to protect a coast or harbour from the force of waves.

Like the case in seawall, this structure is primarily intended for the protection of coastal territories from the disastrous effects of wave and tidal forces.

The salient difference compared to a seawall is that a breakwater is typically built directly into the water.

By alleviating the intensity of wave action offshore, it could reduce the coastal erosion and secure harbor safety.

System of Breakwater

In general terms, a breakwater refers to a structure in a harbor which is designed to mitigate the coastal erosion and to break the force of wave action to provide safe harborage for vessels [1]. Unlike a natural harbor which is protected by its topographic features such as headlands or reefs, an artificial harbor needs a breakwater to ensure the safe and calm berthing. While a seawall structure is constructed onshore along the shoreline, a breakwater is built inshore shallow waters. Typically, one end of a breakwater is attached to the shore but it could also be detached up to few hundred meters from the shoreline.

Besides the ordinary roles mentioned above, a breakwater can also play an important role in the context of disaster mitigation, especially associated with tsunami. For instance, it was recognized that the breakwater inshore in Kamaishi port in Iwate Prefecture, which was constructed as the deepest harbor breakwater in the world (63m), did actually alleviate the tsunami disaster on March11, 2011.

The figure on the right page illustrates the simulation result conducted by the Ministry of Land, Infrastructure, Transport and Tourism regarding the effect of breakwater to reduce tsunami effect. (fig.1) According to this simulation, the tsunami height would have been 13.7m if there were no breakwater, whereas it was actually 8.1m thanks to the mitigation effect of the breakwater. Furthermore, the time the tsunami wave needed from the observation point at 20km offshore to the overtopping of seawall at the coastline was 34 minutes in the actual case with the breakwater, while it would have been 28 minutes if there were no breakater [2]. The 6 minutes of difference could be critical for people to gain extra time for the eventual evacuation. Although the degree of this effect may vary depending on the particular site conditions, the effect of a breakwater, as one layer of disaster prevention, should be further studied and taken into consideration.

1. Breakwaters, coastal structures and coastlines: proceedings of the international conference organized by the Institution of Civil Engineers and held in London, UK on 26-28 September 2001

2. Ministry of Land, Infrastructure, Transport and Tourism, "Disaster mitigation effect of breakwater at Kamaishi Port" http://www.mlit.go.jp/hakusyo/mlit/h22/hakusho/h23/html/k1112ce0.html

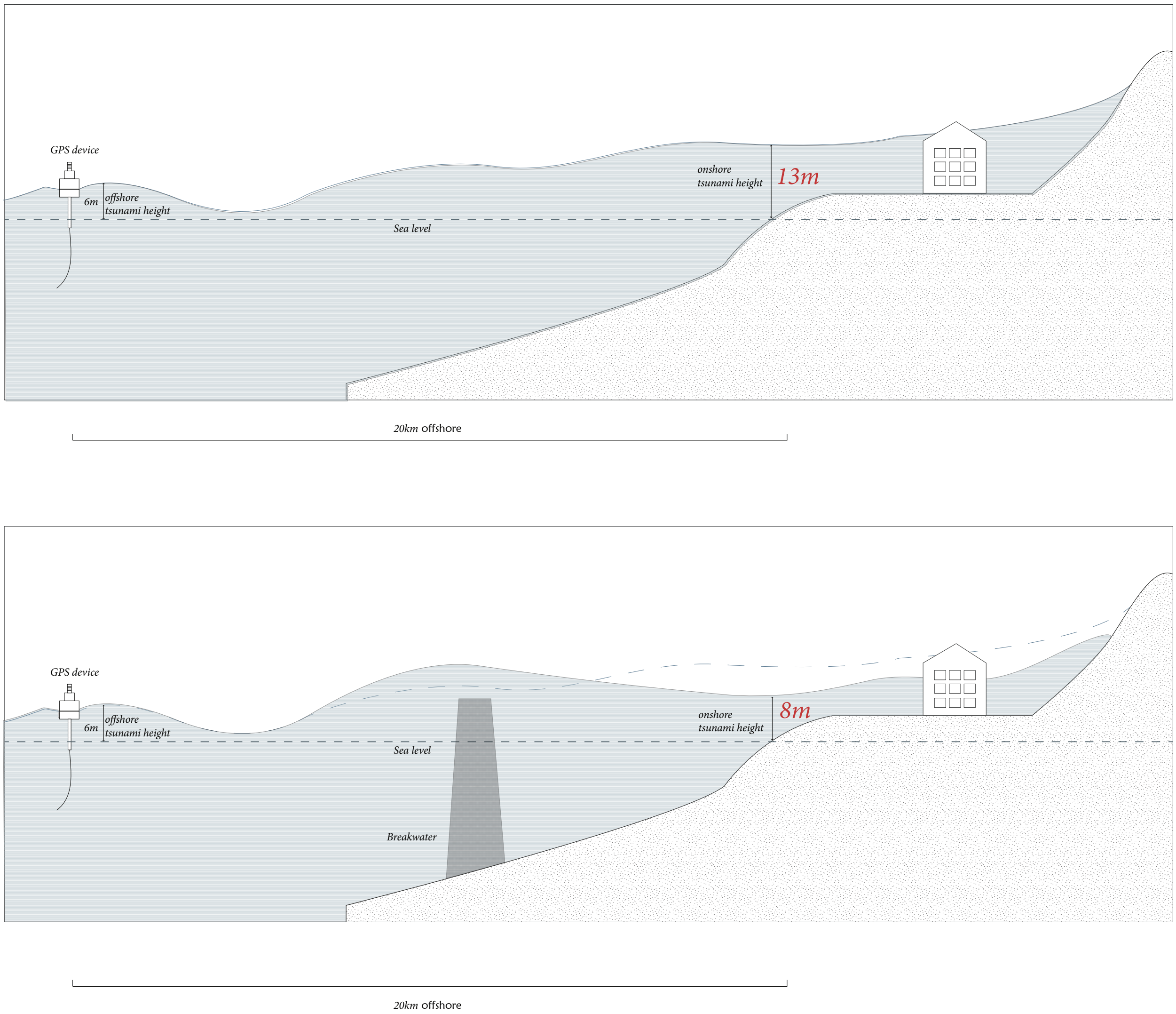


fig.1 Tsunami mitigation effect of breakwater

reference: Ministry of Land, Infrastructure, Transport and Tourism , http://www.mlit.go.jp/hakusyo/mlit/h22/hakusho/h23/html/k1112ce0.html

Types of Breakwater: Permanent Breakwater

In principle, a breakwater structure absorbs the wave action in similar fashion as a seawall, either by resisting with the mass (e.g., typically with caissons), or by dissipating with the slope or with the interlocking blocks (e.g., with concrete or rock armor units). The followings are 4 major types of permanent breakwater structures. (fig.2)

1. Caisson Type

A caisson is a large watertight chamber typically made of concrete. A caisson breakwater uses the mass of the caisson and the infills to resist the overturning forces of the waves. The sides of the caisson are usually vertical and vessels can be berthed on the inner side of the breakwater. The caisson is placed either on a rubble foundation (which could be sloped to dissipate the wave energy) or other type of thin bedding layer [1]. Regarding the construction, they are relatively more expensive to construct in shallow water, whereas they can offer a significant saving over revetment type in deeper water due to the saving of the materials [2].

2. Stacking Concrete Block Type

This type uses a series of concrete mass blocks which are then vertially stacked one upon another. As is the case in the caisson type, this is also based on the principle of mass to resist the wave energy and it usually has vertical sides to allow vessels to anchor in the harbor.

3. Wave Dissipating Block Type

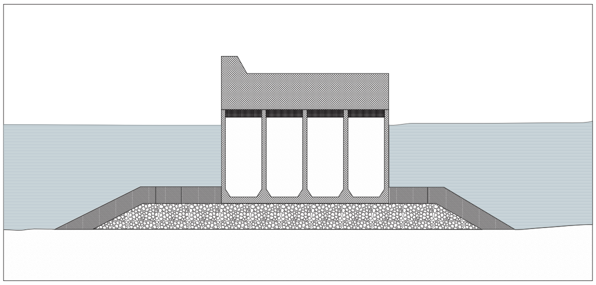
There are many different forms of wave-dissipating blocks which are designed to dissipate the force of incoming waves. The significant difference from the previous two types is that it allows water to flow through rather than resist it by the porosity between the interlocking block elements. In Japan, the word "tetrapod" is often recognized as a generic name for wave-dissipating blocks regardless of their shapes. It is estimated that almost 50 percent of Japan's 35,000 kilometer coastline has been covered by Tetrapods and other forms of concrete blocks [3].

4. Combination Type

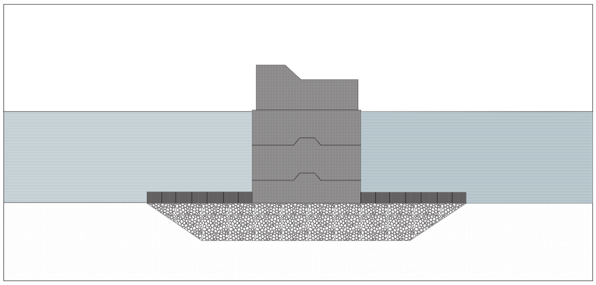
Keeping the basic principle (resist/dissipate) in mind, there could be many more variations of breakwater by combining two or more elements mentioned above. For instance, the wave dissipating block could be used in combination with the caisson to further enhance the performance of the breakwater.

1. Burcharth, HF 2003, *Breakwaters with Vertical and Inclined Concrete Walls: Report of Working Group 28 of the Maritime Navigation Commission. PIANC General Secretariat, Brussels.*
2. *Nagi M. Abdelhamid, Design of Breakwater, http://www.unimasr.net/ums/upload/files/2013/Mar/UniMasr.com_d62d82175df7542f23f6483f962c2538.pdf*
3. *Stephen Hesse, "Loving and Loathing Japan's Concrete Coasts, Where Tetrapods Reign", The Japan Times on July 22, 2007.*

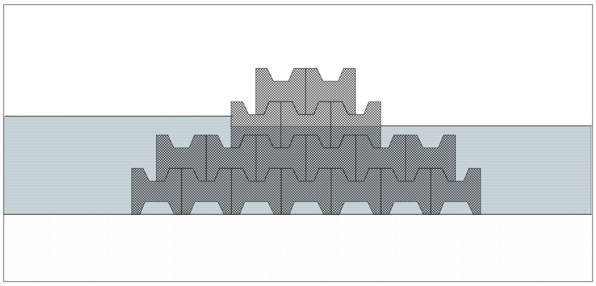
1. Caisson Type



2. Stacking Concrete Block Type



3. Wave Dissipating Block Type



4. CompositeType

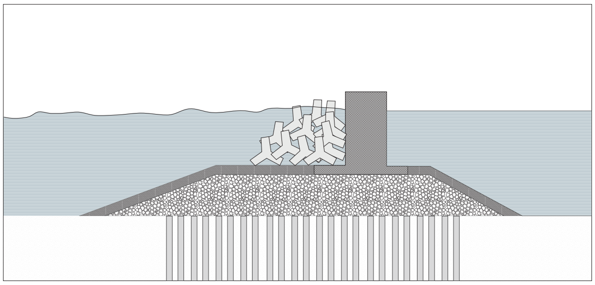


fig.2 Types of permanent breakwater structure

references: Burcharth, HF 2003, Breakwaters with Vertical and Inclined Concrete Walls
http://astamuse.com/ja/drawing/JP/971/65/727/A/000013.png

Types of Breakwater:Movable Breakwater

Besides the permanent breakwater types mentioned above, there are also some exceptional types which can be put in operation only when tsunami actually arrives. Despite the fact that those types are not yet widely in use, it is worth mentioning the upcoming technoligies and its potential in the disaster prevention. The following are two different types of such leading-edge movable types of breakwater.

1. Vertical Telescopic Type (fig.3)

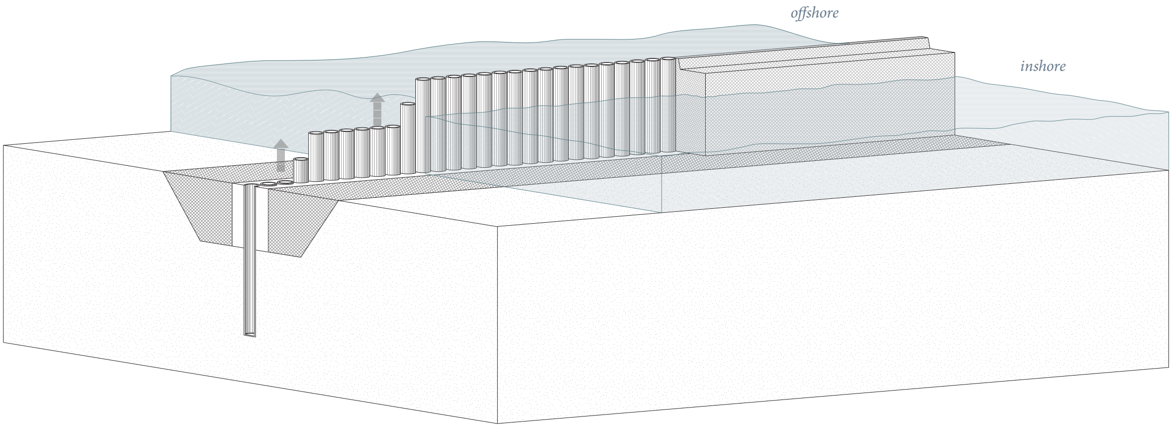
The basic idea behind this type is that a breakwater can be "activated" and raised only in the event of tsunami or storm surge. The vertical telescopic breakwater (VTB), as its name indicates, works as a telescopic structure and it is comprised of lower and upper steel piles. The upper pile is operable and can be raised or lowered into the lower pile. The upper piles are aligned so as to provide a wave barrier. Since the diameter is slightly larger for the lower piles, small gaps of few centimeters remain for hte upper piles. The lower piles, which are installed in the seafloor, are linked to air pipes from an air supplying facility on land. Air supply is provided to the inside of the upper piles and the upper piles begin to move upward when the internal air pressure in the piles surpasses the weight of the piles. To lower the piles back, it is necessary to vent the air from the upper piles from the exhaust valve installed at the top of the piles [1].

2. Flap Gate Type (fig.4)

The flap gate breakwater is another new type structure for coastal disaster reduction. In common with the vertical telescopic type, it lies on a seafloor under normal conditions but lifts up with buoyancy when a tsunami or storm surge actually occurs. It is made up of a series of doors along the seafloor which are rotated and lifted up to form a continuous wave barrier. It serves for two purposes; as a breakwater for tsunami or flood disaster mitigation by controlling water level change and as a breakwater designed to ensure the calmness of the berthing. The flap gate operates by a hydraulic cylinder positioned underneath the gates [2].

These two movable types of breakwater could be an interesting alternatives for the tsunami disaster prevention where there is a dispute concerning the visibility of the ocean. Unlike the permanent vertical wall, it does not interrupt the view under normal condition and the physical continuity from the land to the ocean can be maintained.

1. Mitsubishi Heavy Industries Technical Review Vol. 49 No. 4 ,December 2012, http://www.mhi.co.jp/technology/review/pdf/e494/e494044.pdf
2. Hitachi Zosen Corporation, "Movable Flap Gate-Type Breakwater", https://www.hitachizosen.co.jp/english/technology/hitz-tech/infrastructure03.html



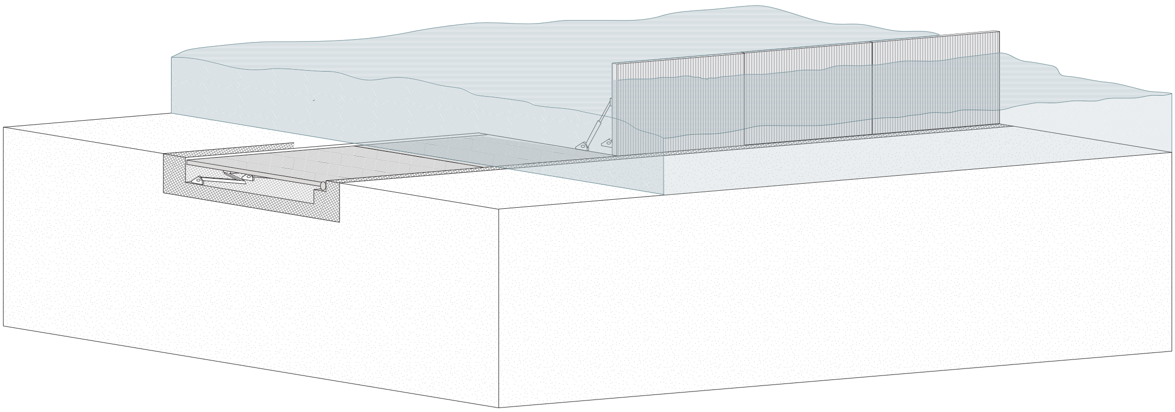


fig.3 Vertical Teloscopic Breakwater
references: http://www.mhi.co.jp/technology/review/pdf/e494/e494044.pdf

fig.4 Flap Gate Breakwater
references: https://www.hitachizosen.co.jp/english/technology/hitz-tech/infrastructure03.html

Example 1 : Ofunato Port

As already mentioned previously, the city of Ofunato has suffered three major earthquake and tsunami attack in modern times; Sanriku earthquake in 1896, 1933, as well as Tohoku earthquake in 2011. These consecutive disasters have generated the strong awareness of disaster prevention in community and social level and the restoration and the improvement of the relevant infrastructures became an urgent agenda for the reconstruction process. The city tries to combine different strategies to protect the port and the city area.

The breakwater at Ofunato port was destroyed by the tsunami in 2011 and the reconstruction work began in August 2012 with the initiative of the Ministry of Land, Infrastructure, Transport and Tourism. The plan was to install 23 immense concrte caisson (length=20.0m, width=21.6m, height=17m, weight 3,500 tons), which is roughly equivalent to 6-storey building [1]. (fig.6) The total of 244 m (north part) and 291m (south part) breakwater is under construction and the total construction cost is estimated to be around 29 billion yen (ca. € 236 million) [2].

The image on the right page is the caissons before sinking them in water and we could recognize the massiveness of these boxes. The 23 caissons are already installed on the seabed at Ofunato port in October 2016 and the top 2 meters of these caissons are visible above the ocean surface. The entire construction is expected to be finished until March 2017.

1. Iwate Prefecture, https://www.pref.iwate.jp/dbps_data/_material_/_files/000/000/011/101/News_from_Iwates_Reconstruction_Vol41.pdf
2. Mainichi Newspaper, October 19, 2016, http://mainichi.jp/articles/20161019/k00/00e/040/172000c

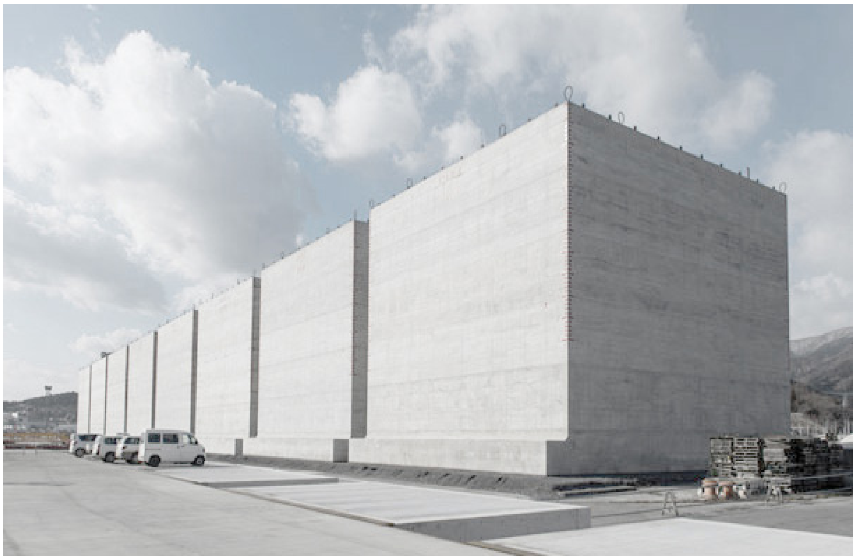


fig.5 Ofunato aerial view(May 6, 2016)
source: http://oofunato-fukkoucm.jp/

fig.6 Huge caissons for the new seawall at Ohunato Port
source: http://images-dot.com/S2000/upload/2015062300195_6.jpg

Example 2 : Town of Onagawa

Onagawa is a town located on the Sanriku Coast in Miyagi Prefecture and have an estimated population of 6,993 as of June 2014. The Onagawa Nuclear Power Plant is located on the southern part of Onagawa Bay. In the event of Tohoku earthquake and tsunami in 2011, Onagawa was one of the most severely damaged town in the region. The height of the tsunami reached as high as 15 meters and the wave travelled as far as 1 kilometer inland. Furthermore, almost half of its designated evacuation sites were flooded by the tsunami wave, and even 6 of reinforced concrete buildings of up to 4-storey were overturned. As a consequence, it culminated in 827 casualties and the loss of 70 % of the buildings in the town [1].

The local authority embarked on the reconstruction of the town both from urbanistic and infrastructural view points. One of those projects was the reconstruction of the destroyed breakwater structure at the Onagawa Bay. It is composed of 365.5 meter south breakwater and 387.7 meter north breakwater. (fig.8) By thickening the foundation and joining the caissons, they were designed to be able to resist the force of tsunami equivalent to the one which hit the town in 2011 [2]. The breakwaters were built 36 meter underneath the water and the top 5 meter is visible on above the water surface.
The total cost of the reconstruction is approximately 8.1 billion yen (ca. € 65.7) [3].

According to seismologists, the geographical character of Onagawa Bay, with its deep inlets and the ria shoreline may have contributed to multiply the destructivity of tsunami forces [4]. Apart from the reconstruction operation, the town faces the long-term disaster mitigation plans which incorporates not only the infrastructure but also the evacuation strategies as well as disaster warning systems.

1. Kingston, Jeff (13 March 2016). *"Onagawa is on the rebound from devastation". Japan Times, http://www.japantimes.co.jp/opinion/2016/02/13/commentary/onagawa-rebound-devastation/#.WG-za_nhBdh*
2. *The Town of Onagawa, "Advances in the earthquake disaster reconstruction work in Onagaw", 2016, http://www.town.onagawa.miyagi.jp/ayumi28.html*
3. *Kahokushimpo, "the completion of the breakwater at Onagawa", March 26, 2016, http://www.kahoku.co.jp/tohokunews/201603/20160326_11042.html*
4. *Satake, Kenji (2005). Tsunamis: Case Studies and Recent Developments. Advances in Natural and Technological Hazards Research (Book 23). Springer. p. 99.*

fig.7 Breakwater at Onagawa-cho aerial view
source: Miyagi Prefecture http://www.pref.miyagi.jp/uploaded/image/80874.jpg
fig.8 Breakwater at Onagawa-cho, Miyagi
source: http://userdisk.webry.biglobe.ne.jp/000/393/36/N000/000/073/142827297369859173178_1DSC_1066.jpg

Example 3 : Kitakyushu Port

The Kitakyushu port is located in the Kitakyushu city, at the northern tip of Kyushu island. The port is one of the largest in the region and considered as one of the three largest passenger ports in Japan together with Tokyo and Kobe port. (fig.9) The development of the port began at the end of 19th centuryas a special export port for the goods such as coal, flour, and rice.

After the end of World War II, most of war vessels previously possessed by Imperial Japanese Navy were either dismantled or taken over by the Allies as wartime reparation, some of the vessel's body were reused as breakwater structure in 1948. (fig.10)

In the case of Kitakyushu port, around 400 meter out of 770 meter breakwater was made by sinking and stabilizing with rocks and concrete on three navy ships; Suzutsuki, Fuyutsuki and Yanagi. Two of these destroyers, Fuyutsuki and Suzutsuki, were part of the suicidal sortie operation against American forces on Okinawa island. Despite the failure of those operations, they managed to survive until the end of the war and therefore their hull was employed for the breakwater at the Kitakyushu port [1].

The breakwater is selected by the Japan Society of Civil Engineers among 2,800 modern civil engineering heritages [2]. As the vessels deteriorated, some restoration work have been carried out so as to keep not only the function as a breakwater but also as a memorial structure to which people can visit.

This exceptional type of breakwater is created on the one hand as a pragmatic solution to protect the harbor but on the other hand as a product of the particular history.

1. Global Security .org, "IJN Akitsuki Class Destroyers", http://www.globalsecurity.org/military/world/japan/akitsuki-dd.htm
2. Japan Society of Civil Engineers http://www.jsce.or.jp/committee/hsce/2800/list_whole%20(2800)/40_fukuoka.htm

fig.9 Wakamatsu port aerial view
source: Bing Map
fig.10 Wakamatsu port, navy ship (destroyer) breakwater
source: http://kancolle-news.com/wp-content/uploads/images/livedoor.blogimg.jp/lovelive2015-kantai/imgs/e/0/e0a93839.jpg

Example 4 : Wakayama Shimotsu Port

Wakayama Shimotsu port straddles Wakayama, Kainan and Arita city and is managed by the Wakayama Prefecture. Due to the physical characteristics of the area with the deep inlet from the Kii Channel, this district has suffered some damages by earthquakes and tsunamis, notably by the Nankai Earthquake in 1946 and Chile's earthquake in 1960. (fig.11) Given the risk of great earthquake in Nankai or Tonankai area, which is expected to happen with high probability in the coming decades, there is a concern that the height of tsunami would surpass the existing breakwater. In that scenario, the large urban areas including residential, administrative, and commercial areas will be flooded by tsunami, so it is urgent to take measures to prevent the possible tsunami disaster [1].

The three companies, Obayashi Corporation, TOA Corporation and Mitsubishi Heavy Industries Bridge & Steel Structures Engineering Co., were involved in the design and the construction of Vertical Telescopic Breakwater (VTB), a movable vertical piling breakwater, in the harbor at Shimotsu Port. (fig.12) Under normal conditions, the breakwater would be hidden under water, but in the event of tsunami, it would rise from the sea bottom and prevent or mitigate the impact of tsunami to the harbor and coastal areas. As the breakwater system remains in the seafloor at ordinary times, this breakwater system has minimal impact on tidal currents and ambient scenery.

The construction of 230 meter breakwater (upper piles; ø =2.8 m, l=28m, lower piles; ø =3.0 m, l=29m) began in October 2012, and the initial cost estimate was about 25 billion yen (ca. € 203 million). However, following the new damage prediction of the possible Nankai Earthquake published by the Cabinet Office in August 2012, the further analysis of the technical feasibility was carried out and it turned out that the system may not work if the lower piles would be deformed by the force of the earthquake [2]. Therefore, this project was aborted in February 2015.

1. *Obayashi Corporation, "Obayashi, TOA and MBE to Begin Construction of Vertical Telescopic Breakwater at Shimotsu Harbor, Wakayama", August 29, 2012, http://www.obayashi.co.jp/english/news/others/2012082925.html*
2. *The Nihon Keizai Shinbun, "world's first VTB may not work in the event of great earthquake", June 25, 2014, http://www.nikkei.com/article/DGXNASFK2402I_U4A620C1000000/*

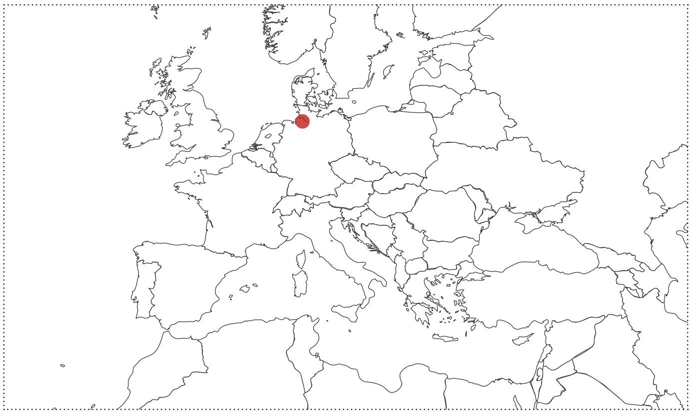
fig.11 Wakayama Shimotsu Port aerial view
source: Ministry of Land, Infrastructure, Transport and Tourism, http://www.pa.kkr.mlit.go.jp/general/img-photo/wakayama-photo02.jpg
fig.12 Wakayama Shimotsu Port, Vertical Telescopic Breakwater project (2015)
source: http://blogs.c.yimg.jp/res/blog-dd-70/kai_yamamoto/folder/1499608/87/63683887/img_0

Example 5: Maeslantkering, Hoek van Holland

It would be interesting to take a look at some of european examples of breakwater structure. The Maeslantkering (Maeslant barrier) is one of the largest storm surge barriers located at Hoek van Holland, the west coast of the Netherlands. It is an enormous movable gate structure which horizontally pivots and closes automatically when the sea level rises in the event of flood or storm surge. (fig.13) Since the waterway (Nieuwe Maas – the Scheur – Nieuwe Waterweg) where the storm barrier was planned was the main route to the port of Rotterdam, the world's largest port at the time, it was not possible to construct a barrier like the Dutch Oosterscheldekering and the Thames Barrier which blocks the sea route. Therefore, the plan to build two large floating gates on both dikes of the waterway were selected.

The flood barrier is made up of two enormous retaining doors, which remain in dry docks under normal condition. When a storm surge is predicted, water is let into the docks to make the doors float. When the doors have reached the closed position they will be filled with water and sink to the sill which is constructed on the bottom of the river. When the storm is passed, the water inside the doors will be pumped out to make the doors float again and they return to the docks [1].

The construction of the barrier commenced in 1991. The first phase was the construction of dry docks on both sides of the banks and the sill on the bottom of the river. Then, the two colossal steel gates (h=22m, l=210m) were built to which steel trusses (h=20m, l=237m) were welded. For the joint, the large ball shaped form (ø=10m) was employed so that the gates can move freely under the influences of water, wind and waves. During the closing or opening process, this ball shaped joint gives the gate the opportunity to move freely under the influences of water, wind and waves. The construction of the barrier cost 450 million euro and it was completed in 1997 after 6 years of construction work [2].



1. Structurae, Maeslant Barrier, https://structurae.net/structures/maeslant-barrier
2. Seacity Research Net, Maeslantkering Barrier, http://www.seacityresearchnet.com/archives/1104

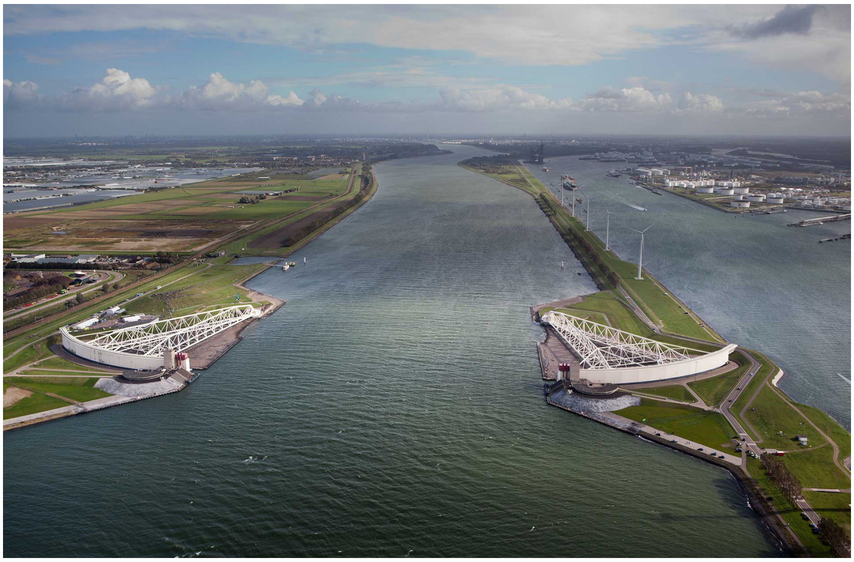


fig.13 Maeslantkering (450 million EUR storm surge barrier), Hoek van Holland (1997-)
source: https://greennewz.files.wordpress.com/2014/09/maeskanterling-barrier-gates.jpg

fig.14 The scale of Maeslantkering compared with people
source: http://www.beleefdedeltaroute.nl/files/poi/9/Fotoviewer/thumbs/thumb_900x600_maeslant%20vergelijking%20eiffeltoren.JPG

Example 6 : MOSE Project, Venice

Another important reference from the European context is the case of Venice where the city is facing a serious threat due to the frequent high tide and the sinking of land. In particular, the Great Flood of 1966, which resulted in the massive loss of life and properties, triggered the debate over the long term strategies for the problem and the necessity to protect Venice from the future floods. As a countermeasure against such a constant and imminent risk of flood and storm surge in Venice, a defense system called MOSE (Modulo Sperimentale Elettromeccanico) has been designed to separate the Venetian Lagoon from the Adriatic Sea and to protect the city from recurring flood of up to 3 meters [1]. (fig.15) The system is composed of 78 mobile hollow gates (each module; width=20m, length=20-30m, thickness=5m, weight=300tons) embedded in the seabed at the three inlets to Venice's lagoon [2]. (fig.16)

The construction work on the project began in 2003 after much delay and the work is being carried out in parallel at the Lido, Malamocco and Chioggia inlets. The MOSE project is estimated to cost €5.496 billion, increased €1.3 billion from the initial cost estimate[3]. Besides the huge initial investment, the operational cost, which is expected to be about 9 million euro, would not be negligible [4]. It will be fully operational in 2018, two years of delay from the original plan.

The MOSE project has faced resistances from various interest groups. First of all, there is a debate over the cost-effectiveness of this enormous investment. It is based on the fact that there are no agreed estimates of the cost of flooding and the savings the gates could ensure. The MOSE project is said to be much more expensive than those for alternative systems employed by the Netherlands and England to resolve similar problems. There are also severe criticism over the environmental concerns, as the construction of the barrier could cause the pollution, the deterioration of the habitat and eventually the disturbance of delicate ecosystem of the lagoon.

1. Mose Project official site, https://www.mosevenezia.eu/?lang=en
2. Atos, "hollow gates embedded in the seabed at the three inlets to Venice's lagoon.", http://www.atos.com/dam/jcr:ff4ada29-a161-4dd5-81ee-20bbb4840d75/AS94.pdf
3. Portanova, Maria, "Mose, in dieci anni 1,3 miliardi di costi in più. E allarmi inascoltati" . Il Fatto Quotidiano, June 6, 2015
4. The Economist"Flood barriers Saving Venice " September25, 2003 ,http://www.economist.com/node/2084767

fig. 15 Venice Mose Project aerial view
source: https://upload.wikimedia.org/wikipedia/commons/b/b8/MOSE_Project_Venice_from_the_air.jpg

fig. 16 Venice Mose Project close-up view
source: http://jto.s3.amazonaws.com/wp-content/uploads/2013/10/wn20131014a9a.jpg

PROS & CONS of Breakwater

Like a seawall, a breakwater is a hard coastal defense infrastructure and its primary objective is to mitigate the wave action and to provide safe harbourage. It can absorb the force of wave and can protect fragile shores over a longer period of time. When a tsunami enters inside harbor, a breakwater can mitigate the height of the tsunami and can delay the seawall overtopping of the wave [1]. The great advantage over a seawall structure is that a breakwater does not block the view to the ocean. The majority of the structure is hidden underwater and there is also a distant from the coastline so people can still maintain the visibility of the ocean. Furthermore, some new type of breakwater such as Vertical Telescopic Breakwater System (ref. example 4) can be totally submerged underwater. The fact that a breakwater is constructed in the water rather than on the ground even gives people the chance to have a closer contact with the ocean if the structure is accessible to public. In this regard, like in the case of a seawall, there is a possibility that a breakwater structure can be used for recreational activities. Finally, there is an ecological advantage of breakwater structure. It can provide a reef habitat which gives a range of environment for fish eggs, larvae, fauna or flora. This idea to use offshore structure for ecological benefit has been widely developed in Japan [3]. Furthermore, breakwaters do not block the local current, so the wildlife in the area still have access to their habitat.

However on the other hand, there are equally some drawbacks for breakwater structures.
Above all, as with the case of seawall structure, the construction of breakwater requires massive financial investment. For instance, the breakwater at the Kamaishi port in Iwate prefecture costed approximately 120 billion yen (ca. € 984 million) [2], but it was severely damaged by the 2011 Great Tohoku Earthquake and tsunami only 2 years after the completion of the 30 years construction work. Despite the modern construction technque and the high cost of the construction, it was provem that breakwaters are subject to damage if faced with a large tsunami and the cost-effectiveness solely in terms of tsunami prevention is in doubt. Even though the primary purpose of the breakwater is to enable the calm and safe harbor, this calm water may encourage the accretion of sediment. This trapping of sediment can induce adverse effects leeward of the breakwaters, causing beach sediment starvation and the increased erosion [4]. Finally, the critical issue related to the breakwater structure is the scour, which is the removal of granular seabed by hydrodynamic forces in the vicinity of a coastal structures due to the acceleration and deceleration of the current around there [5]. Excessive scour may lead to the instability and eventually the failure of the structure.

1. *Ministry of Land, Infrastructure, Transport and Tourism, "Disaster mitigation effect of breakwater at Kamaishi Port" http://www.mlit.go.jp/hakusyo/mlit/h22/hakusho/h23/html/k1112ce0.html*
2. *Nikkei Shinbun, " the effect of Kamaishi Breakwater", March 31, 2011, http://www.nikkei.com/article/DGXNASFK3100F_R30C11A3000000/*
3. *Coastal defences: processes, problems and solutions by Peter W. French, Routledge, London, 2001, p162.*
4. *Breakwaters, coastal structures and coastlines: proceedings of the international conference organized by the Institution of Civil Engineers and held in London, UK on 26-28 September 2001*
5. *Steven A. Hughes, "Design of Maritime Structure: Scour and Scour Proteciton", http://www.oas.org/cdcm_train/courses/course4/chap_8.pdf*

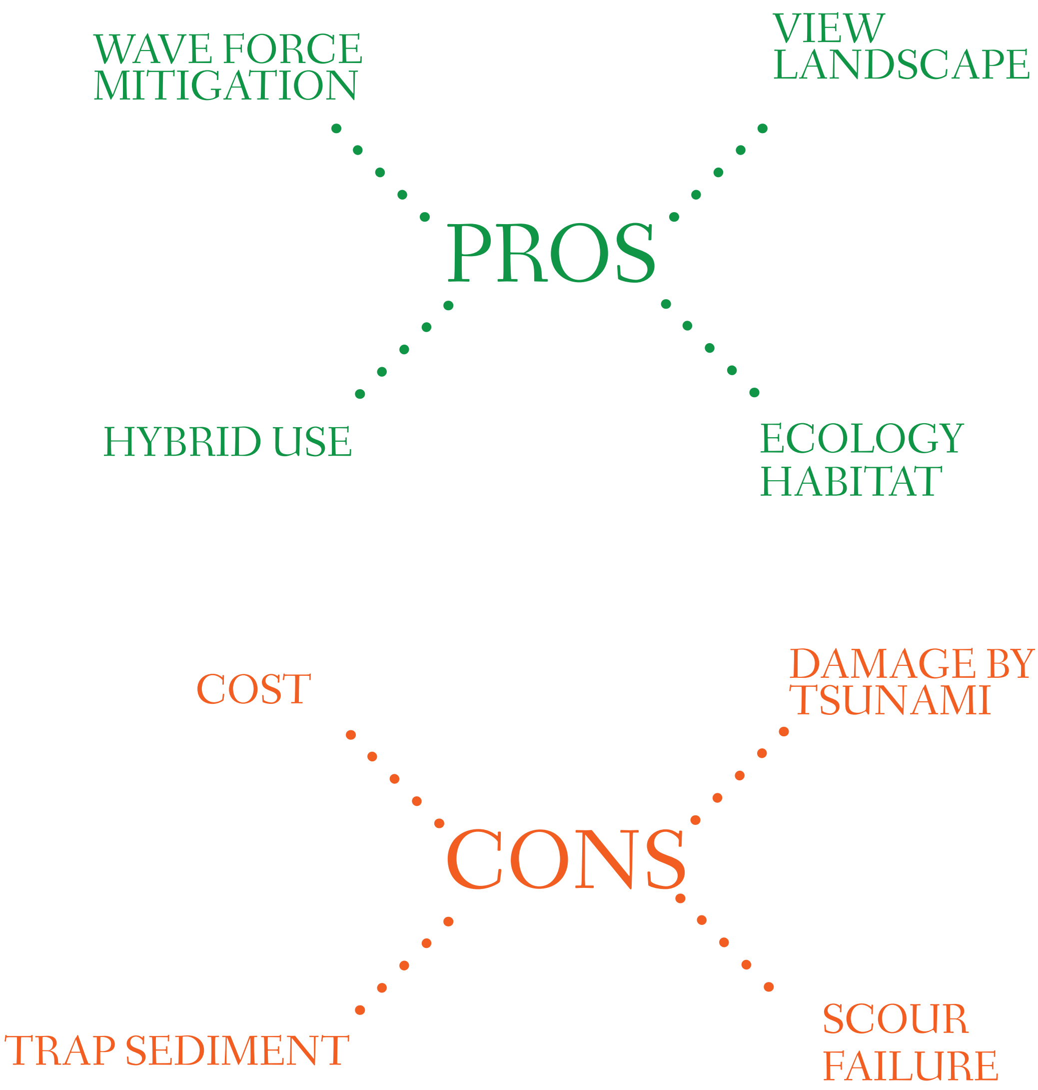


fig.17 Pros and Cons of breakwater structure as a coastal defense

c. EVACUATION STRUCTURE

Tsunami Evacuation Sign
source: http://ecosign.moriko.org/swfu/d/tsunamihinan_r.png

Emergency evacuation is the immediate and urgent movement of people away from the threat or actual occurrence of a hazard.

A evacuation structures provides a space of refuge for communities in which evacuation out of the inundation zone is not feasible in a short time.

Types: Evacuation Tower

One approach for the tsunami disaster prevention is to "resist" against the force of the wave, with some sort of infrastructures, as is the case with a seawall or a breakwater. However, it is also crucial to take a look at some alternative or supplementary approaches, which put more emphasis on people. As it was the case for the Tohoku tsunami, the magnitude and the destructiveness of the tsunami cannot be foreseeable in advance, and the tsunami waves did actually destroy and surpass many of coastal defensive structures. In that scenario, people need to evacuate in short order to the upland or designated evacuation facilities.

A so-called tsunami evacuation tower is such a public facility for people living nearby to evacuate from tsunami attack. (fig.1) Depending the the topographical character of the place and the proximity of epicenter, the first wave of tsunami could arrive even within 10 minutes. In this regard, tsunami evacuation towers are effective solution for the neighborhood scale, especially for the places where the land is flat and the evacuation to the higher ground in a short amount of time is not feasible. Many of them were newly built after the 2011 Tohoku earthquake and tsunami [1].

The evacuation tower is a simple structure which is composed of the upper evacuation space, storage space, and the stairs or ramps which lead to the evacuation space as illustrated on the image on the right. Other facilities normally included in the tower are emergency lighting, heating device, battery for the electricity, communication equipment, lightning rod, emergency foods, drinks or medicinal products [2].

The structures can take a variety of forms, from simple steel structure to more elaborated design structures that could serve for public purposes when not in use as shelters [3]. The structure and the form of evacuation towers vary and they are typically constructed in steel frame or reinforced concrete structure. An appropriate fireproof treatment should be applied if the structure is in steel. The evacuation space should be at least 2-4 meter higher than the maximum expected inundation height of the area. The space needed for the evacuation space is in principle, 2 people per square meter [2]. The expected durability of the tower is 50years [4].

1. http://thebbb.net/japan-pedia/204-tsunami-evacuation-tower.html
2. Ministry of Land, Infrastructure, Transport and Tourism, "Design guideline for the port evacuation facilities", http://www.mlit.go.jp/common/001004732.pdf
3. Michael MacRae, ASME.org, Tsunami Forces Debate over Vertical Evacuation, April 2011, https://www.asme.org/engineering-topics/articles/manufacturing-processing/tsunami-forces-debate-over-vertical-evacuation
4. Ministry of Land, Infrastructure, Transport and Tourism, "references for the design guideline for the port evacuation facilities", http://www.mlit.go.jp/common/001004733.pdf

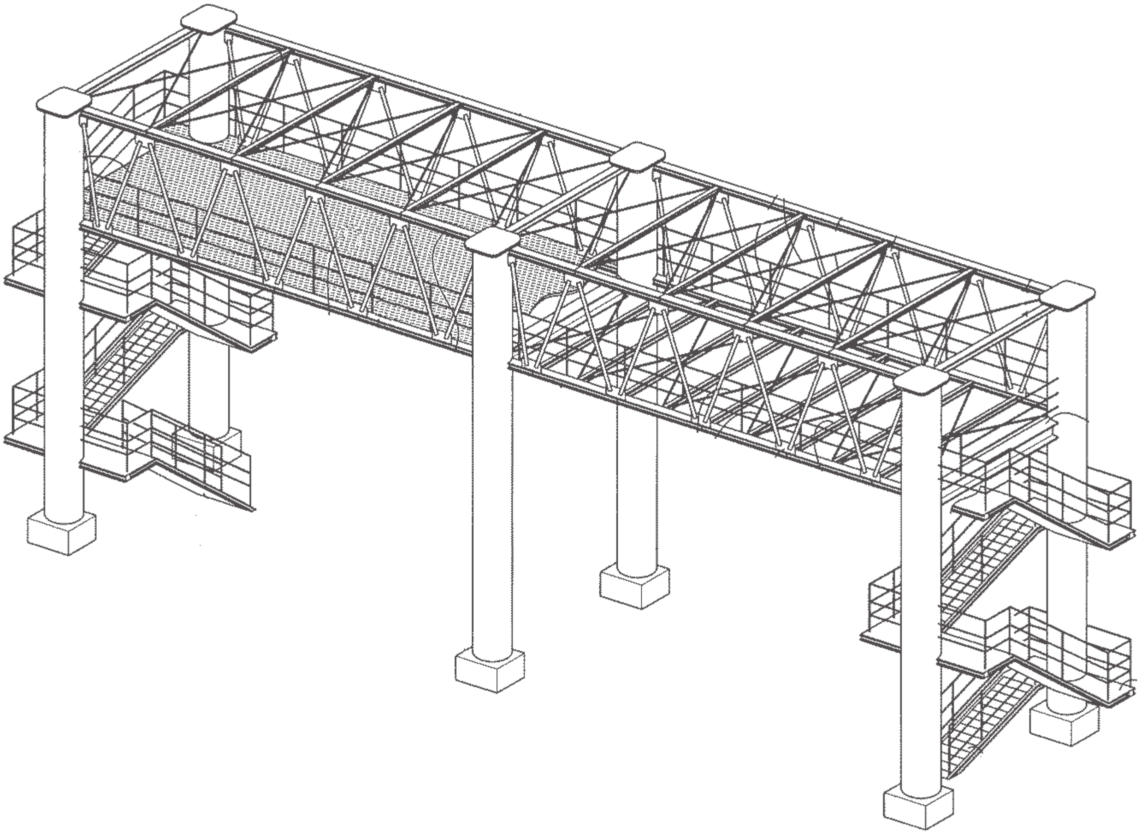


fig.1 Evacuation Tower Scheme

source: Daisuke Honma, Nihon-sharyo-seizo Corporation, http://astamuse.com/ja/published/JP/No/2015001131

Types: Underground Shelter

Another facility related to the tsunami evacuation is the underground evacuation shelter. (fig.2) Even though there are only few built cases for this kind of shelter as of now, it could be a valuable alternative for the region whose topography makes it difficult for elderly citizen to evacuate on their own to the higher place. Since this type of shelter is unprecedented and new, some practical as well as technical ideas are being studied.

One possible type of the underground shelter is called a horizontal cave structure [1]. As the figure on the right illustrates, a horizontal as well as a vertical box are inserted to the steep topography, allowing people to gain time to evacuate further to the higher place with a safe condition. Their underground location allows for the incoming wave to pass overhead without striking them. The entrance of the shelter should be protected and blocked by a resistant structure or debris to avoid the floating object to hit the shelter itself.

The possible technical challenge is to create a tight seal while people may still be trying to get inside the shelter. An additional problem would be to ensure a sufficient oxygen supply in case the shelter should be submerged for a long time [2].

1. Kochi Prefecture, http://www.pref.kochi.lg.jp/kenmin_voice/2012052500245/
2. Clouds Architecture Office, "TSUNAMI EVACUATION SHELTER", http://www.cloudsao.com/TSUNAMI-EVACUATION-SHELTER

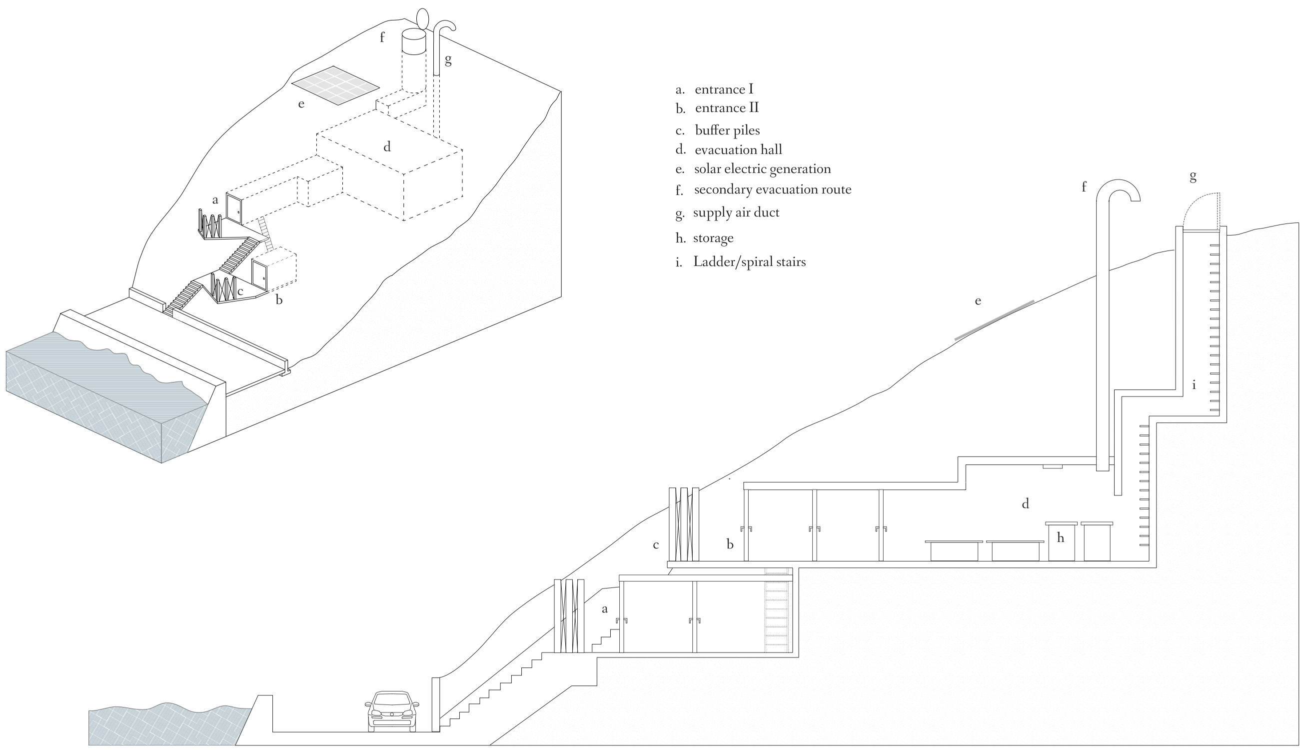


fig.2 Underground Evacuation Shelter Scheme

source: Fujiwara Industry Co. , http://www.fj-i.co.jp/sinhp/bousai/k_tika.htm

Example 1 : Evacuation Tower in Iwata City

Iwata city is located at the western part of Shizuoka Prefecture and has an estimated population of 164,680 as of September 2015. The city faces the Pacific Ocean on the south and it is predicted that the maximum 12 meter high tsunami could hit the city in the event of Tokai earthquake [1].

A tsunami evacuation tower called "Nagisano-Koryukan" was constructed in May 2016 in order to provide the emergency evacuation space for people nearby. (fig.3) The tower has a composite structure of steel frame and steel pipes with concrete infill and the evacuation space is elevated 12 meter above the ground, supported by 4 steel pipes. The total floor area is 317 sqm and the evacuation space has a capacity to accommodate up to 330 persons in case of tsunami emergency. (fig.4) The tower is equipped with emergency equipments such as blankets, emergency foods and drinks, as well as toilets [2].

This facility is accompanied by some touristic programs, restaurants or shops and visitors can learn about basic information regarding the disaster prevention at the tower.

1. https://www.landerblue.co.jp/blog/wp-content/uploads/2016/01/TKY201208290774.jpg
2. Nagisano Koryukan, "tsunami evacuation tower", http://iwata-nagisa.com/tsunami-evacuation-tower/

fig.3 Nagisano-Koryukan Evacuation Tower, Iwata City, Shizuoka Prefecture (12m above sea level)

source: http://soraeki.blog84.fc2.com/blog-entry-1119.html

fig.4 Nagisano-Koryukan Evacuation Tower interior view, Iwata City, Shizuoka Prefecture

source: http://hamamatsusayaka.hamazo.tv/e6985879.html
source: http://iwata-nagisa.com/tsunami-evacuation-tower/

Example 2 : Evacuation Tower in Kumano City

Kumano is a city located at the southern part of Kii Peninsula in Mie Prefecture and faces the Kumano Sea. The city has a population of 17,727 as of August 2015. The geographical location of Kumano is close to the potential epicenters of Nankai or Tonankai earthquake and the tsunami wave may arrive briefly after the earthquake. Therefore, the evacuation strategies would play a significant role in reducing the human sufferings.

In Arima district in the Kumano city, two evacuation towers were built in April 2016 to tackle this issue. The height of the tower is 8.5m (the estimated tsunami height is 4m) and they have the capacity to accommodate 300 persons respectively [1]. The structure is cylindrical concrete structure and the stair is attached to the perimeter of the cylinder. (fig.5)

The construction of the tower was once suspended by the city, but it was recommenced in response to the strong requests from the local residents [2]. The total cost of the construction for 2 towers were approximately 93 million yen (ca. € 754,000) [3].

1. Kumano city, "tsunami evacuation plan", February 25, 2015, http://www.city.kumano.mie.jp/bousai/tunami/tsunamihinankeikaku-27%20.pdf

2. Mainichi Newspaper, "tsunami evacuation tower completed at Kumano", April 6, 2016, http://mainichi.jp/articles/20160406/ddl/k24/040/328000c

3. Yasuhisa Minami, "the inspection of tsunami evacuation tower at Kumano city and the town of Kihoku", http://nanchan521.exblog.jp/25161476/

fig.5 Evacuation Tower in Kumano City, Mie Prefecture (20m above sea level)
source: http://nanchan521.exblog.jp/25161476/

fig.6 Evacuation Tower in perspective
source: Masanori Fujine, http://fujine-masanori.sblo.jp/article/176560485.html

Example 3 : Evacuation Tower in Konan City

Kōnan is a city located in the east part of Kōchi Prefecture in the Shikoku Island. The estimated population of the city is 32,785 as of October 2016. According to the estimate published by the Cabinet Office, they city may suffer the tsunami of up to 15 meter in the event of the great Nankai Earthquake which could occur in the foreseeable future [1]. The city is undertaking a series of measures to mitigate the damages which will be caused by the eventual tsunami arrival.
The construction of evacuation towers is a part of the city's important initiatives to prepare against the tsunami disaster. The city plans to build total 21 of tsunami evacuation towers.

One of those tower was completed in November 2015 in Yasu district in Konan city, where there is no tall building. The concrete brutal structure, which appears to be a parking structure, has an evacuation place at 14.8meter above the sea level. (fig.7) The structure is made in reinforced concrete and the stairs and slopes are made in steel.

Under ordinary conditions, the evacuation tower is locked, and it is accessible only in case of emergency. The tower incorporates the storage space and the space for temporary toilets so that the place can be utilized as a refuge facilities after the initial evacuation [3]. According to the city, the rest of the towers, which will be constructed, will have similar or the same specs and the usage as the ones already constructed [3].

1. Konan city tsunami hazard map, May 2, 2013, http://www.city.kochi-konan.lg.jp/download/?t=LD&id=613&fid=8015
2. Futaba Bousai Shinbun, "tsunami evacuation tower at Yasu district", http://futaba-bousai.cocolog-nifty.com/blog/2015/10/post-7097.html
3. Konan city, "Bousai Tokushu, the completion of the first tsunami evacuation tower", November 2014, http://www.city.kochi-konan.lg.jp/download/?t=KH&id=215&fid=16298

fig.7 Evacuation Tower in Konan City, Kochi Prefecture (14.8m above sea level)
source: http://futaba-bousai.cocolog-nifty.com/blog/2015/10/post-7097.html

fig.8 Evacuation Tower in perspective
source: http://www.tmf-earth.com/casestudy/evacuationtower/

Example 4 : Underground Shelter in Muroto City

Muroto is a city located at the east-south part of the Kochi Prefecture, within which there is a Muroto Cape projecting toward the Pacific Ocean. The city has an estimated population of 13,203 as of October 2016 and suffers from the excessive decline and aging of population, with 45.3 % of the population being older than 65 years old as of April 2015 [1]. The expected tsunami height for the possible Nankai earthquake is more than 15 meter and the worse part is that the tsunami wave could arrive within 5 minutes to the coastline as it is located at the tip of the island [2]. Consequently, the city needs to deal with the disaster prevention measures in such a way as to take these twofold risk, with the aged population and the fast tsunami arrival speed, into consideration.

In this context, the Japan's first underground tsunami shelter was constructed in August 2016 at the Tsuro district in Muroto city, where more than half of its 234 population are older than 65 years old [3]. The cliff was hollowed out by the horizontal cave (height= 3.5m, width= 3m, depth=33m) and the vertical cave (height= 23.9m, ø=2.5m), forming the L-shape evacuation shelter underground. (fig.9) The horizontal cave is protected by double water stop doors and a spiral stair (fig.10) is installed in the vertical cave, from which people can evacuate to the upper part of the cliff. It is also equipped with emergency battery, ventilation and lighting facilities as well as storage space [4].

The construction of the shelter began in December 2014 and was completed in August 2016. The total cost for this project was about 350 million yen (ca. € 2.84 million) [3]. It is expected that this facility will help facilitate the difficult emergency evacuation among the aged individuals.

1. *Muroto City, " General Plan for the Development", http://www.city.muroto.kochi.jp/hp/k0103/sinkoukeikaku.pdf*
2. *Kochi Prefecture, Tsunami Hazard Map Muroto City, http://www.pref.kochi.lg.jp/soshiki/010201/files/2012121000171/2012121000171_www_pref_kochi_lg_jp_uploaded_attachment_84021.pdf*
3. *Tatsuya Sato, Asahi Shinbun Digital, "Japan's first tsunami shelter, hole in the cliff", August 25, 2016, "http://www.asahi.com/articles/ASJ8S63YLJ8SPLPB00D.html*
4. *Hiroshi Tanigawa, Nikkei Shinbun, March 22, 2013, http://www.nikkei.com/article/DGXNASFK2102D_R20C13A3000000/*

fig.9 First Underground shelter in Japan: Sakihama-cho, Muroto City, Kochi Prefecture (August 2016)
source: The Kochi Shimbun, https://www.kochinews.co.jp/article/44884
fig.10 Spiral Stair in the underground shelter
source: The Kochi Shimbun, https://www.kochinews.co.jp/article/44884

PROS & CONS of Evacuation Structure

In contrast to coastal defense structures, the primary objective of the evacuation structure is not to "resist" or "mitigate" the tsunami action but to "escape" from it. In the aftermath of the Tohoku quake, there has been an increasing awareness about the importance of evacuation and the number of tsunami evacuation facilities increased from 1,790 in 2010 to roughly 10,000 by the end of 2013 nationwide[1]. The advantages of such evacuation structure such as a tower or a shelter are multifold. First of all, they can provide a speedy and immediate solution for the imminent risk of tsunami. Considering the timespan of seawall, breakwater or landscape project, this strategy can respond much faster to the risk of tsunami. Furthermore, the scale of investment is relatively smaller compared to those large scale projects. Another advantage is that they can be used as evacuation shelter after the emergency evacuation. The facilities are normally equipped with emergency food, drink or other daily essentials, so people could spend some time after the occurence of earthquake or tsunami. Moreover, the evacuation structure can be used for different purposes such as local events or festivals [2].

While nobody doubts the necessity and the importance of evacuation itself, some warn about the potential drawbacks of such evacuation structures. Some expert doubts if vertical evacuation on a large scale would still be effective even facing a giant earthquake and tsunami that could happen in Japan [3]. According to the simulation conducted by prof. Katada at the Gunma University, there is a possibility that the damage would even be increased due to the presence of evacuation tower in some scenarios since people would try to evacuate downward if there is an evacuation tower nearby. However if the height of tsunami exceeds the estimated height or if the structure cannot withstand the tsunami force, those evacuated people would get caught in tsunami [4].
Another difficult issue is the management of the facilities. As seen the case of Konan city above, some structures are constantly closed and inaccessible unless there is an actual disaster. In that case, it is doubtful if people can really evacuate efficiently in short time in an urgent situation. Even if a tower is open, the issue of management persists regarding the safety of the facility. For instance, a primary school pupil fell down from 7 meter high tsunami evacuation tower in Shizuoka which are open and accessible to anyone [5]. An unoccupied tall structure with no specific purpose than emergency evacuation without management system may trigger other unexpected use or consequences. At last, the difficulty of the evacuation itself should be noted. In particular, for people with reduced mobility such as elderly people, the evacuation to the tower could be demanding without assistance. For the region where the tsunami could arrive within 5 to 10 minutes after the earthquake, it would be very difficult to evacuate those people.

1. Nikkei Asian Review, "Japan revamps plans, buildings for mega-disasters", March 14, 2015, http://asia.nikkei.com/Politics-Economy/Policy-Politics/Japan-revamps-plans-buildings-for-mega-disasters
2. Tadashi Okamoto, "Tsunami tower and the change of bousai awareness among people", January 22, 2016, http://www.huffingtonpost.jp/tadashi-okamoto/tsunami_b_9035882.html
3. Michael MacRae , April 2011, https://www.asme.org/engineering-topics/articles/manufacturing-processing/tsunami-forces-debate-over-vertical-evacuation
4. Sankei News, "the installation of tsunami tower may increase the damage according to the simulation by Gunma University", June 28, 2014, http://www.sankei.com/affairs/news/140628/afr1406280001-n1.html
5. Shizuoka Shinbun, "a pupil fell down from the tsunami tower, severely wounded"http://www.at-s.com/news/article/social/shizuoka/287800.html

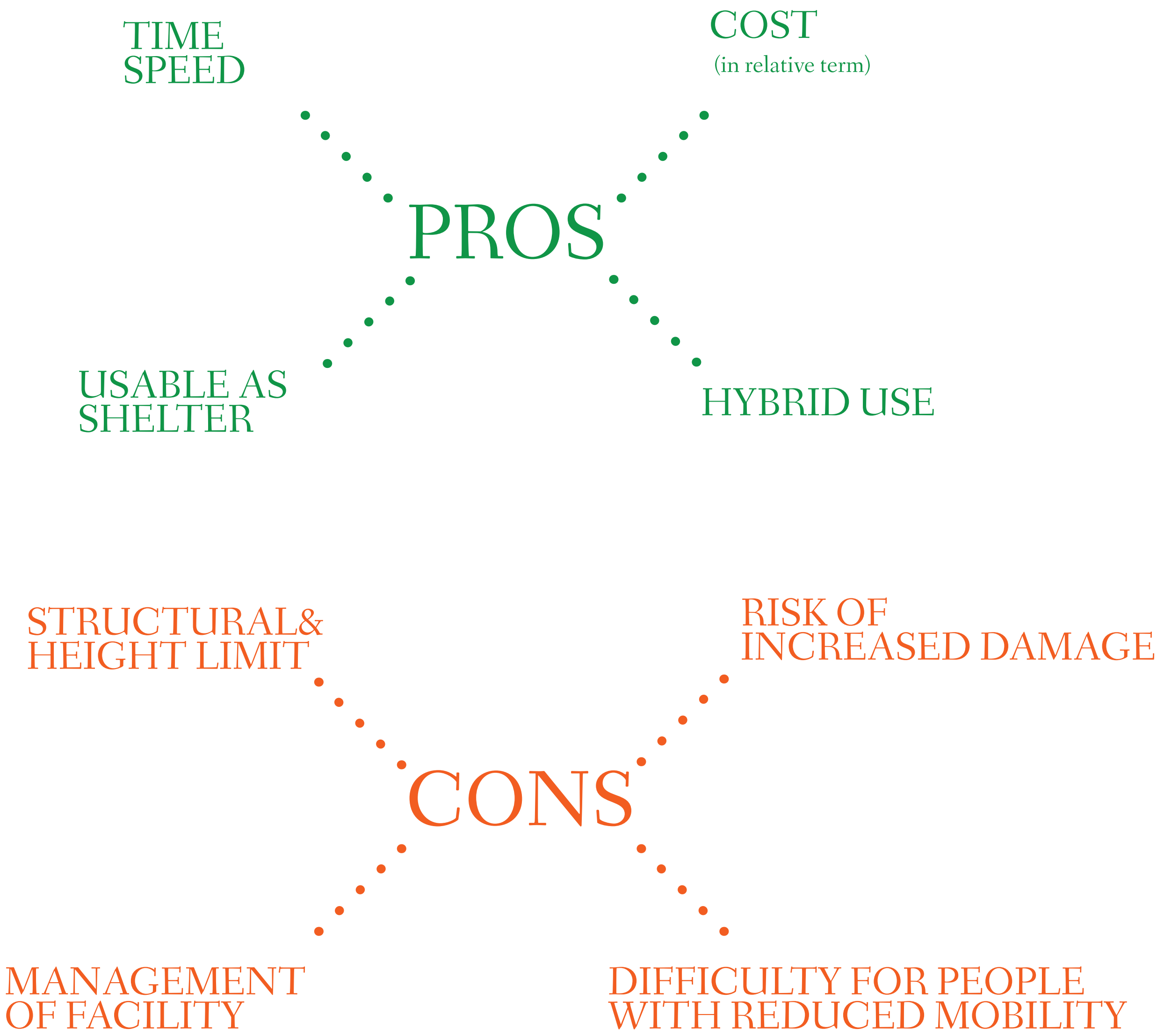


fig.11 Pros and Cons of evacuation structure

d. LANDSCAPE STRUCTURE

Tide barrier Forest, Hatozu beach, Kamae-cho, Oita Prefecture

source: http://blog-imgs-61.fc2.com/t/a/k/takosyasin/027357s.jpg

A landscape structure is a man-made yet territorial response to the territorial threats imposed by natural disasters.

Unlike other structures, it is an organic structure which lives and grows in the territory, and therefore needs to be maintained by the society.

Landscape structure must respond not only to the physical dimensions of disaster but also to the territorial system as a whole.

Concept: Chinjyu-no-Mori (Sacred Shrine Forest)

Up to this point, the tsunami was treated broadly as a natural "threat" since its scale and power seems to be absurdly immense in contradistinction with any defense structures that people can design and produce. The landscape structure would offer an alternative viewpoints in this regard, since the underlying concept is not to overcome the threat but rather to create a territorial system, in which the tsunami and a sort of disaster defensive landscape would act as an integrated whole. The landscape structure is not used here as a synonym for the landscape concept which accounts for our spiritual perception of the nature, but rather used here as a territorial strategy which needs to be designed and fostered in the long run. Nevertheless, the landscape structure and the landscape concept are not separable since the former makes sense only with the appreciation of the latter.

In the territory of Japan, where the nature, people and Kami (gods) are all believed to be a part of the integral whole, forests have played a cardinal role in the formation of cultural landscape in spiritual, religious as well as physical viewpoints [1]. In each village or town, our ancestors set a shrine, which was believed to protect the villagers. Those Shinto shrines were surrounded by forests known as "*chinju-no-mori*" [1]. (fig.1) Since those forests have been deemed as sacred and thusly protected over centuries, they tend to keep the original vegetation rooted in the place. They provide the habitat for animals and plants, bring minerals to the fields and the river, and they also protect the area from the natural disaster. In the past, these sacred forests played a major role in the disaster mitigation. In the event of Tohoku Great Earthquake in 2011, the deeply rooted trees helped mitigating the tsunami force. In the Great Kanto Earthquake in 1923 and the Great Hanshin Earthquake in 1995, they helped to avert the outspread of fire in the city thanks to indigenous evergreen broadleaf trees which contain abandunt moisture [2].

In reference to those sacred forests and their role in Japanese territory, the project called "Chinjyu-no-Mori Project" was launched in July 2012 with the aim of reviving locally rooted forests and habitats which at the same time can enhance the disaster defence capacity of the place. (fig.2) The fundamental philosophy behind this project is the coexistence with the nature rather than resisting it [3]. The project is led by a group of experts from various profession, including a former Prime Minister, religious scholars, physicist, painter as well as architects (Tadao Ando, Shigeru Ban). With the participation of more than 43,000 local residents, 376,650 trees have already been planted as of December 2016.

1. Keisuke Matsui, "Geography of religion in Japan: Religious Space, Landscape, and Behavior", p19-37, Tokyo, Japan, Springer, 2014
2. Kunio IWATSUKI, "Harmonious co-existence between nature and mankind: An ideal lifestyle for sustainability carried out in the traditional Japanese spirit", Humans and Nature 19: p1–18 ,2008
3. Chinjyunomori project, http://morinoproject.com/about

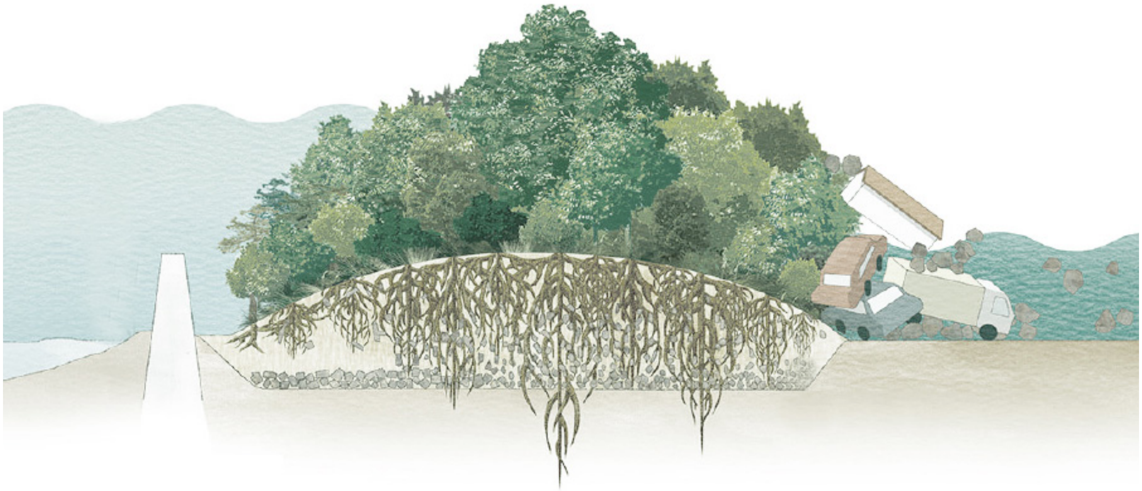


fig.1 Chinjyunomori (the grove of the shrine) at Otsuchi-cho after Tohoku Earthquake
source: Mitsuru Sawaki, http://morinoproject.com/about

fig.2 Chinjyunomori project concept
source: Chinjyunomori project; http://morinoproject.com/about

Example 1 : Iwanuma Coast

Iwanuma city is located 20km south of Sendai city in the northern part of Miyagi Prefecture. The estimated population as of October 2016 is 44,817. The coastal area of the city suffered a devastating damage by the tsunami triggered by the Tohoku earthquake in March 2011. The height of the tsunami wave reached 10 meters and 180 people have lost their lives. However, at that time, some residents of Iwanuma city in the coastal area managed to survive by getting up to artificial hills near the coast. In order to build on their own experience to keep these lessons alive and to reduce the human damage in the future, the city embarked on a plan to make the hill called "The Hill of Millennial Hope" along the coastal area in Iwanuma [1].

The project involves the creation of totall 15 hills in the area and people can evacuate on those hills when another great tsunami will hit the coast in the future. It also involves the creation of garden paths which connect the hills and the planting of evergreen broad-leaf trees on the slopes, which will eventually become a green sea wall to reduce the tsunami force. To fill the hill, the recycled debris generated by the earthquake was used, and this helped reduce the waste-treatment costs as well as the CO_2 emmission by the transportation [2].

The first planting event took place on June 9 in 2013 and 4,000 people participated in planting the total 30,000 trees of 17 different species. As of December 2016, 4 of such planting events have been organized and the total 29,000 people planted 250,000 trees on 73,000 sqm surfaces [3]. (fig.4)

The idea of landscape structure is to create the defensive as well as environmental system which grow and live with people and the experience in Iwanuma coast is a visionary landscape experiment whose aim is to protect from and to live with the nature.

1. Iwanuma city, "about the Millennial Hills" http://www.city.iwanuma.miyagi.jp/kakuka/040300/sennnennkibounooka.html
2. Asia Low-Carbon Cities Platform, "Disaster-reconstruction Project Harmonious with Nature and the Creation of the Hill of 1000 year hope", http://lowcarbon-asia.org/english/city/knowledge/knowledge_10/index.html
3. Chinjyu no Mori Project, http://morinoproject.com/activities#sec03

fig.3 Planting event at "Hill of the Millenial Hope", Iwanuma Coast, June 9, 2013
source: http://www.m-omoide.jp/photo/f/20130718174146521081.jpg

fig.4 Planting event at "Hill of the Millenial Hope", Iwanuma Coast, June 9, 2013
source: Morino Bochotei Association; http://morinobouchoutei.com/?p=1838

Example 2 : Onagawa-cho

As already mentioned in the breakwater section, Onagawa in Miyagi Prefecture was one of the most severely damaged town in the region in Tohoku tsunami in 2011 and the extensive reconstruction plan is in progress. Despite the importance of hard infrastructure like a breakwater project, in this part, the focus is on the territorial strategy of the city.

Following the catastrophic experience, the city is planning to reform the territorial settlement pattern as shown in the figure on the right page. The principal idea behind this plan is to displace the residential area in the higher elevation by filling the earth and the lower deserted area will be slated and elevated around 5 meters in order to be used for commercial space [1]. There is a stone momument from the 1933 tsunami and this demarcates the boundary between safe and dangerous area and from now on no residential housing can be built below this point. Instead of building the tall seawall, the entire town would be elevated 5-15 meters by mounds [2]. (fig.5)

In tune with the accelerating depopulation trend of the city, the new plan will take "compact community" as a concept. By concentrating services and public facilities, the city will be able to maintain its vitality [3].

It is noteworthy to observe that the reconstruction process, which involves the territorial transformation, reflects also the social change of the city. In other words, the "bousai" planning constitutes the essential part of their life style and it is closely intertwined with the given territory and the society which lives with it.

1. Jeff Kingston, "Onagawa is on the rebound from devastation", The Japan Times, February 13, 2016, http://www.japantimes.co.jp/opinion/2016/02/13/commentary/onagawa-rebound-devastation/#.WDhgBfnhBdg
2. Yoshihide Abe, "Rebuilding the Tsunami-Stricken Onagawa Town ", http://www.etic.or.jp/recoveryleaders/en/wp-content/uploads/Rebuilding-Onagawa.pdf
3. Suda Yoshiaki, "Rebuilding Onagawa, An Interview with Suda Yoshiaki, Mayor of the Tsunami-Devastated Town", June 29, 2015, http://www.nippon.com/en/in-depth/a04305/

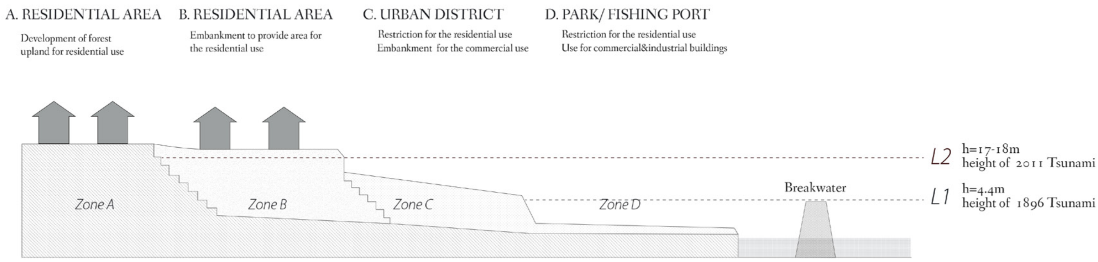


fig.5 Onagawa-cho new town planning idea (2012)
source: Onagawa-cho new town planning information session document

fig.6 Onagawa-cho (Miyagi Prefecture) new town planning vision image
source: http://www.town.onagawa.miyagi.jp/hukkou/image/20150227_onagawa_wan.jpg

Example 3 : Rikuzen Takada

Rikuzentakata city is located at southeast part of Iwate Prefecture and it has the estimated population of 19,472 as of October 2016. As is widely known, the city suffered catastrophic damages by the giant earthquake and tsunami which washed out the city center including the city office and as much as 70% of houses were subjected to severe damage and more than 1,500 people lost their lives [1].

The reconstruction and redevelopment initiatives are currently under way. The new development of the city, which involves the embankment and the leveling to achieve higher elevation of the ground of up to 12meter, will significantly alter the original landscape of the territory. The cost of this land transformation is estimated to be around 110 billion yen (ca. € 892 million) [2]. Thusly, there is a rising concerns among people about how high the planned elevated ground will be, and how their lives will change in the new residence [3].

Besides the elevation of the ground level, the city is also building 1.8 km long seawalls, one 3 meters and another 12.5 meter high, as part of disaster mitigation infrastructure for the future tsunami [4]. At the seafront, the city is planning to create a130 ha disaster prevention memorial park which aims at reinforcing the disaster defensive capacity of the area, reviving the historical and natural habitat, revitalizing the city, and passing down the tsunami experience to the next generations [5]. (fig.7-8)

The landscape in this case was used as a tool to protect the territory, but at the same time it will grow as a system of the place itself. Naturally, there is a discussion both for and against such a mega project for the sake of reconstruction, yet the discussion it evokes is worthy of further reflection.

1. Rikuzen Takata City, "damage situation in Rikuzen Takata", http://www.city.rikuzentakata.iwate.jp/shinsai/oshirase/hazard1.pdf
2. Wedge, May 2015, "over-engineering reconstruction, 110 billion yen for raising 12m at Rikuzen Takata", http://ironna.jp/article/1323
3. Panasonic Corporation, "Challenges in Tohoku Reconstruction", http://panasonic.net/es/solution-works/rikuzentakata/
4. Shusuke Murai, "Some Tohoku disaster areas on fast track to rebuilding while others stuck in slow lane", The Japan Times, March 9, 2015
5. Iwate Prefecture, "General planning of Takata Matsubara reconstruction memorial park", August 5, 2015, https://www.pref.iwate.jp/dbps_data/_material_/_files/000/000/038/224/siryou2.pdf

fig.7 Rikuzen Takada Post Tsunami Reconstruction Memorial Park Plan
source: Iwate Prefecture, https://www.pref.iwate.jp/dbps_data/_material_/_files/000/000/038/224/siryou2.pdf

fig.8 Rikuzen Takada Post Disaster Reconstruction Image (March 2013-December 2016)
source: Kajima Corporation, http://www.kajima.co.jp/tech/c_great_east_japan_earthquake/deconstruction/deconstruction02/

Example 5 : Constitución, Chile

Despite the variation of the concept, the presence of landscape is ubiquitous in any territory or culture. Thus, it would be interesting to refer also to the foreign experience and see how they integrate the landscape in the disaster preventive measures.

Chile, as with Japan, is widely known to be an earthquake and tsunami-prone country. In the recent case, a magnitude 8.8 eathquake hit the country on February 27, 2010 whose epicenter was only 3 km off the coast of Pelluhue commune in the Maule Region. Within 30 minutes after the earthquake, a series of tsunami waves hit coastal towns, among which Constitución suffered the hardest damage [1]. The master plan for reconstruction of the city was entrusted to the architectural office Elemental and they were given 100 days to do all the designs, from tsunami mitigation strategy for housing, public buildings as well as energy and economic reactivation[2]. The architect listened to the diverse opinion from the citizen about their dissatisfaction and the dream for the city and some of the common idea among them was to deal with the historical shortage of public space and to have a democratic access to the river. Considering these feedbacks and the limitation of infrastructure to resist wave energy, the architect proposed a threefold strategy; 1. alert/evacuation plan 2. a forest as coastal barrier and public space 3. low cost housing [3] . The landscape here was used as a defensive measure as well as a space for people. (fig.9)

As the architect Alejandro Aravena puts;

"So, we thought that against geographical threats we had to offer geographical answers. Instead of resisting the waves' energy, our strategy was to dissipate it by introducing fri-ction. Instead of heavy infrastructure we proposed a forest to mitigate tsunamis.[2]"

Alejandro Aravena

1. NBC News, March 1, 2010, "Chile Earthquake, What the earthquake didn't take...the sea took.", http://www.nbcnews.com/id/35644365/ns/world_news-chile_earthquake/#.WHJP5fnhBdg
2. Elemental, Constitución plan for sustainable reconstruction, http://www.elementalchile.cl/en/projects/pres-constitucion/
3. Hallie Busta, "Post-Tsunami Sustainable Reconstruction Plan of Constitución", January 13, 2016, http://www.architectmagazine.com/project-gallery/post-tsunami-sustainable-reconstruction-plan-of-constitucion_o

fig.9 Constitución Aerial View with Forest Barrier

source: http://www.elementalchile.cl/en/projects/pres-constitucion/

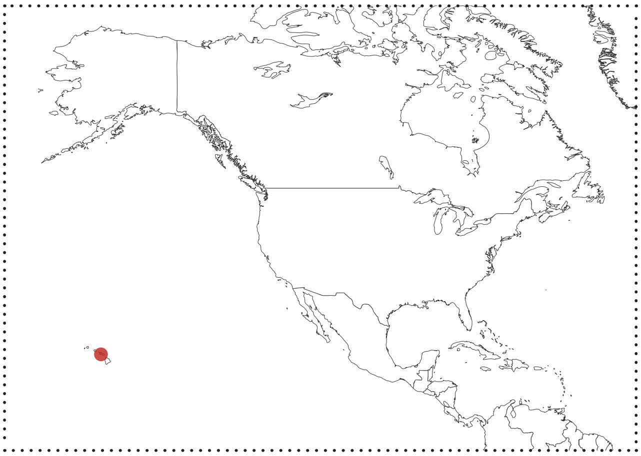
Example 6 : Hilo Bay, Hawaii

Hilo is a largest settlement in Hawaii and has a population of 40,759 as of the year 2000. Due to the active volcanic activities on the archipelago and its geographical location in the middle of the Pacific Ocean, Hawaii is under constant risk of great earthquake and tsunami.

In the event of Valdivia earthquake from Chile in 1960, Hilo was hit by a tsunami and suffered an extensive damages [1]. The reconstruction of the downtown was based on the Hilo Downtown Development Plan in 1974. In the plan, the safe areas were identified based on the experience from 1946 and 1960 tsunami. Buildings built below 6meter evelation had to be able to withstand the force of major tsunami. Parking structures were also designed to block the water from travelling further inlands [2]. (fig.11)
By means of territorial strategy (not building in tsunami risky areas) and the creation of open spaces, the area has enhanced its disaster prevention capacity. The US National Tsunami Hazard Mitigation Program's publication "Designing for Tsunamis" highlights the importance of understanding site conditions and four basic site planning techniques for the new development [3].

1. Avoid building on tsunami risk areas
2. Slow down tsunami waves by forests, ditches, slopes, or berms
3. Steering water (porous dike, walls etc) to reduce the impact of tsunami
4. Blocking waves by walls, hardened terraces, berms and parking structures

What this strategies implies is the design of the whole system, in which the landscape, the decision of land use, and the construction of hard infrastructure should work together to achieve the effective disaster mitigation.



1. George Pararas-Carayannis, "Chile earthquake and tsunami of 22 MAY 1960", http://www.drgeorgepc.com/Tsunami1960.html
2. LArch 474 Project Design Studio, Department of Landscape Architecture, University of Washington ,"Tsunami Mitigation and Prevention", http://courses.washington.edu/larescue/precedents/prevention.htm
3. National Tsunami Hazard Mitigation Program, "Designing for Tsunamis–Seven Principles for Planning and Designing for Tsunami Hazards", March 2001, http://nthmp-history.pmel.noaa.gov/Designing_for_Tsunamis.pdf

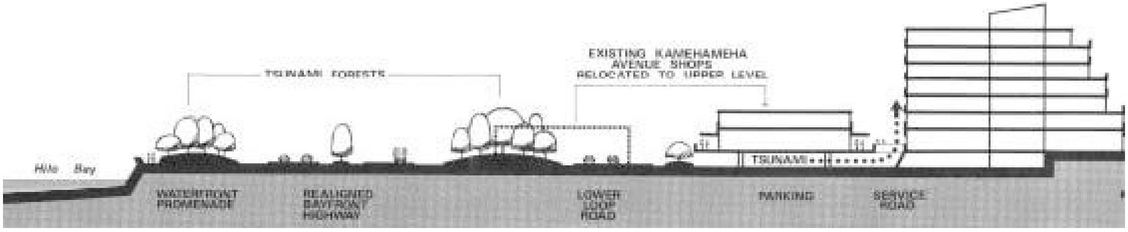


fig.10 Hilo Bayin Hawaii Reconstruction Plan after 1960 Tsunami
source: University of Washington, Tsunami Mitigation and Prevention, http://courses.washington.edu/larescue/precedents/prevention.htm

fig.11 Hilo Bay Aerial View with Forest Barrier
source: https://www.lovebigisland.com/wp-content/uploads/2011/01/Hilo-Hawaii-1038x576.jpg

PROS & CONS of Landscape Structure

In the wake of local reactions against the massive concrete seawall construction in Tohoku region, the landscape structure, which aims to profit the force of nature, come under the spotlight. However, the idea of using the nature for the purpose of disaster mitigation is not unprecedented all over Japan. Some of the scenic pine groves such as the one in Tsuruga in Fukui Prefecture or the one at the Suruga Bay in Shizuoka Prefecture have long played a role in the disaster mitigation of the coastal region [1]. The disaster prevention forest can mitigate and dissipate the force of tsunami and they can also prevent the floating object such vessels from intruding to the city area [2]. This effect has been proven in the event of Tohoku tsunami in 2011 [3]. In the long run, the advantage of this structure is that it grows as a living organism and therefore require only few maintenance after the first few years. Furthermore, the space around the landscape structure can be used as recreational space as were the cases with Iwanuma city, Rikuzen-Takada (memorial parks), or the Constitución in Chile. In the context of Japan, the symbolic meaning of forest and its worship give the cultural as well as aesthetical meaning to this landscape approach. This comes in line with the idea of "symbiosis", meaning "living togher", with the nature, which has long been the subject of worship in the country.

One of the disadvantage would be the time it requires to be effective as a disaster-prevention forest. After the planting of the trees, it will takes almost 20 years to grow to the forest [3]. Moreover, unlike engineering objects, the effect of the landscape structures in disaster prevention cannot be measured nor designed in a precise manner due to the natural variation of tree size, roots and their strength. Therefore, it would be equally difficult to predict the degree of risk and damages to the city area [4]. Unlike a seawall, the disaster-prevention forests are not designed to "block" the wave, so they can be effective only in mitigating the force of tsunami to a certain degree. While they were effective in the tsunami mitigation, it is also true that a vast area of such forests were severely damaged or lost as the Tohoku tsunami hit. Another possible risk is that a large amount of fragmented trees cut by a tsunami wave could become dangerous floatign objects themselves. Finally further critical issue derives from the difficulty of environmental coordination for the particular species of tree. The tree type used for the coastal defense purpose needs to have the resistance to salt water and for that reason the Black Pine (*kuromatsu*) became prevalent for the coastal forest in Japan. However, for this species, there is a risk of the pine wilt disease, a type of contagious disease caused by nematode infestation which could kill the trees [3]. Since they are the living structures, it also involves the complex management of the ecological environment.

1. Shizuoka Prefecture, "the general plan of management for Miho-no-Matsubara", March 2015, http://www.city.shizuoka.jp/000701631.pdf
2. Tsunami Digital Library, "the consideration regarding the effect of disaster prevention forest at Chile Earthquake and tsunami", http://tsunami-dl.jp/document/093
3. Forestry Agency Tohoku Forestry Management Bureau, "regeneration of coastal disaster prevention forests, reconvery from the Tohoku Great Earthquake, http://www.rinya.maff.go.jp/tohoku/koho/saigaijoho/pdf/bousairin_pamphlet.pdf
4. Chinju-no-mori project, http://morinoproject.com/about
5. Nobuo Shudo, "the effect and the limitation of the disaster-prevetion forest against Tsunami", the collection of papers for the 32th coastal engineering conference, 1985, p 465-p469.

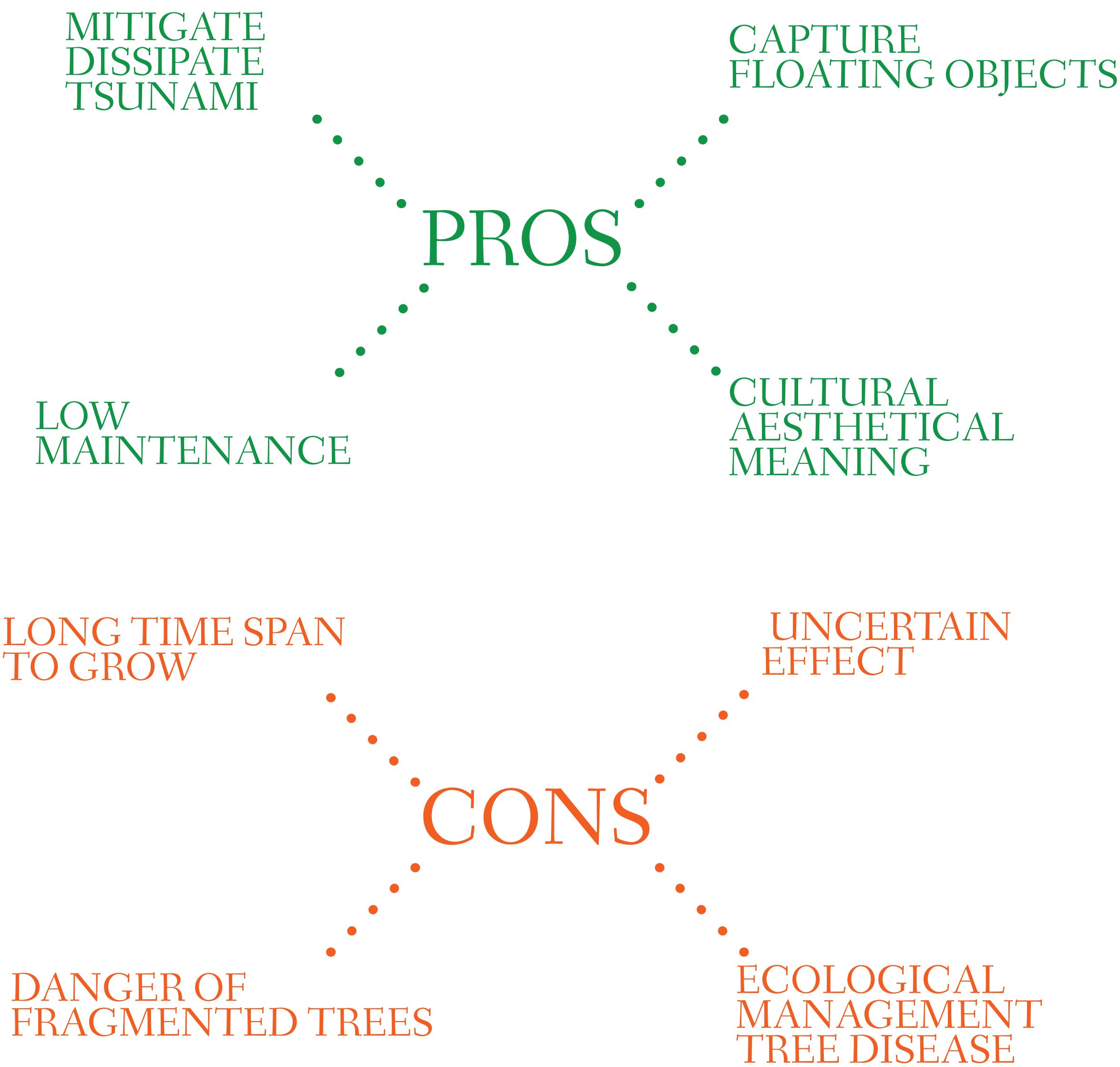


fig.12 Pros and Cons of landscape structure

e.HYBRID STRUCTURE

Fire Festival on the breakwater at Nakaki Port, Minami-Izu-Cho, Shizuoka Prefecture

source: http://mitte-x-img.phj.jp/minamiizu-kankou/photo/middle/%E4%B8%AD%E6%9C%A8%E7%81%AB%E7%A5%AD%E3%82%8A%20(2).jpg

A hybrid is something that has been produced from two different types, especially to get better characteristics.

A hybrid structure in *Bousai* indicates that the structure serves not merely for the defense against natural disasters but serves also for different purposes, giving the pragmatic engineering structures some added values.

Types: Disaster Prevention & Energy Production

Needless to say, the primary purpose of the coastal defense infrastructures such as a seawall or a breakwater is to protect people from the destructive force of tsunami and to prevent the coastal erosion. However, this does not exclude the possibility that they can be used for other purposes. Given the fact that the occurrence of mega-tsunami like the one in Tohoku 2011 is sporadic and rare and the investment for such structures is in general extremely costly, it would be reasonable to seek different potential utilities for those structure. The idea of hybrid structure thusly is to harness the potential of tsunami defensive structure and render it useful for other purposes.

One of the potential hybrid with the coastal defense structure would be an energy production.
Since a costal defense structure is constantly in contact with wave and tides, there is a potential to capture the kinetic motion of the ebbing and surging of ocean tides or the force of waves energy to produce electricity [1].
Various types of devices are being developed to convert those energy into electrical energy. For instance, a device called oscillating water columm(fig.1), which has a chamber with the bottom end open to the sea and the top end vented to an air turbine, can convert the wave energy and this can be integrated to the breakwater structure.
For the tidal energy, although it is not yet prevalent especially for the large scale production , it has potential for future electricity generation. For instance, a new technology called "tidal lagoon", which has circular retaining wall embedded with turbines that can capture the potential tidal energy, is now being developed. The world's first tidal lagoon project in Swansea Bay, which is a 'U' shaped breakwater containing a row of hydro turbines, is in progress and they are aiming to start the construction in 2018 [2].

In the modern time, the energy production in Japan, especially the nuclear and thermal energy, has been spatially linked to the coastal areas due to the necessity of large amount of cooling water. The energy concerns, due to the nuclear accident at Fukushima Daiichi Power Plant in 2011, call for the reconsideration of new sustainable energy policy in the long run. At least, the diversification of energy prodution sources would be indispensable for the energy security of the country and the hybrid of disaster prevention and energy generation could be an attractive option for the future development of the coastal regions.

1.Towards Sustainability, "Marine Renewable Energy", http://www.towards-sustainability.co.uk/issues/energy/wave.html
2. Tidal Lagoon Power, "An iconic, world-first infrastructure project in South West Wales", http://www.tidallagoonpower.com/projects/swansea-bay/

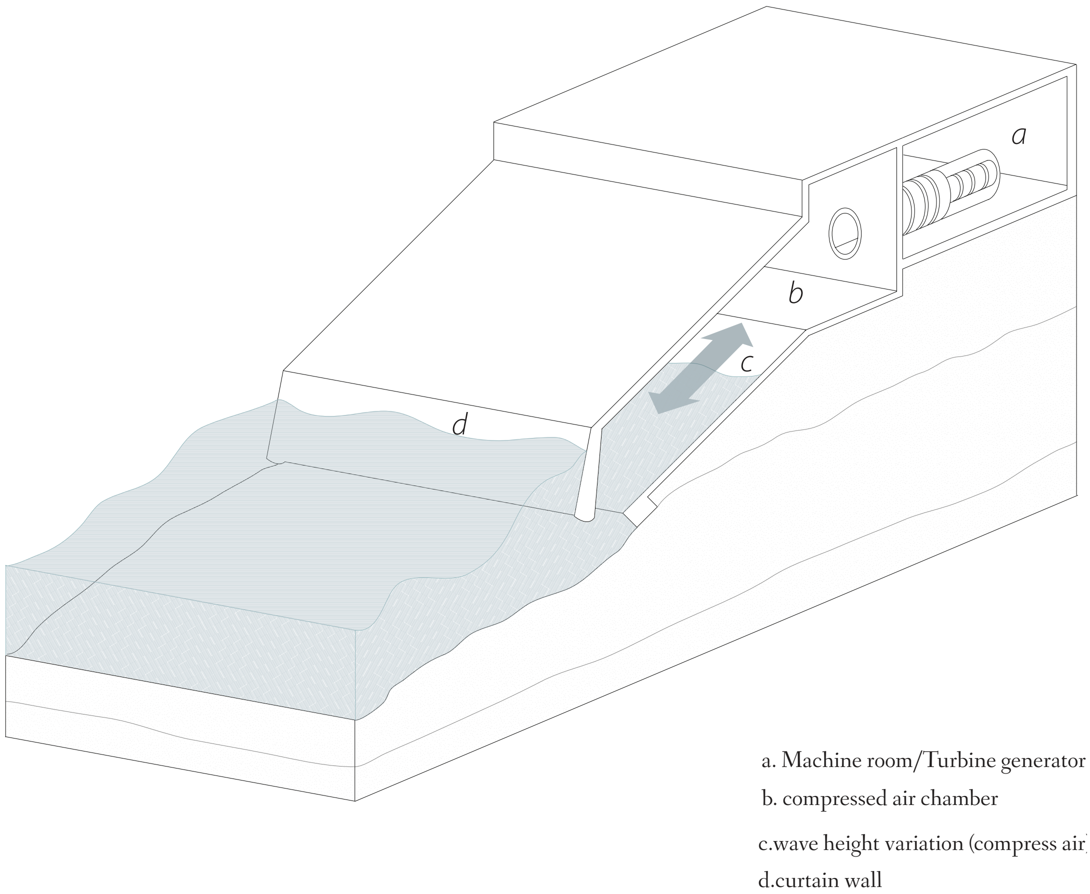


fig.1 Oscillating Water Column wave energy generation system
reference http://s.hswstatic.com/gif/wave-energy-2.jpg:

Types: Disaster Prevention & Recreation Space

The Second possible type of hybrid structure is the combination between coastal defense structure and recreation space. (fig.2) In addition to the pragmatic aspects of the coastal structures, it is also crucial to keep in mind that they have a significant spatial implication and potentials for the coastal areas. As they spatially occupy the boundary or intermediate area between land and sea, they play an important role in providing people the opportunity to be in touch with the sea.

This aspect is equally important from the point of view of the disaster prevetion. When people lose their physical relationship with the ocean, the awarenss of the threat of tsunami or storm surges would be diminished or at least would become less intuitive. In fact, one of the intense debates over the pros and cos of seawall construction is that the massive wall may give a false sense of security because people cannot sense and detect the abnormal condition of the sea surface when they have no visibility on it [1].

Therefore, this hybrid structure proposes to reestablish the open and closer relationship between citizen and ocean. This involves a spatial design of coastal areas as well as an assignment of appropriate functions to such spaces. The space around coastal defensive structure has a great advantage and potential due to its immediacy to the sea, which can provide the feeling of openness and the direct link with nature that the urban people would look after for their recreation. In line with the ongoing restructuring of coastal defense system in Japan, spatial and recreational system of coastal areas should be equally taken into consideration.

1. Chiba Nippo, "Don't forget to expect the unexpected: Seawall construction and evacuation planning", April 11, 2016, http://www.chibanippo.co.jp/serial/316654

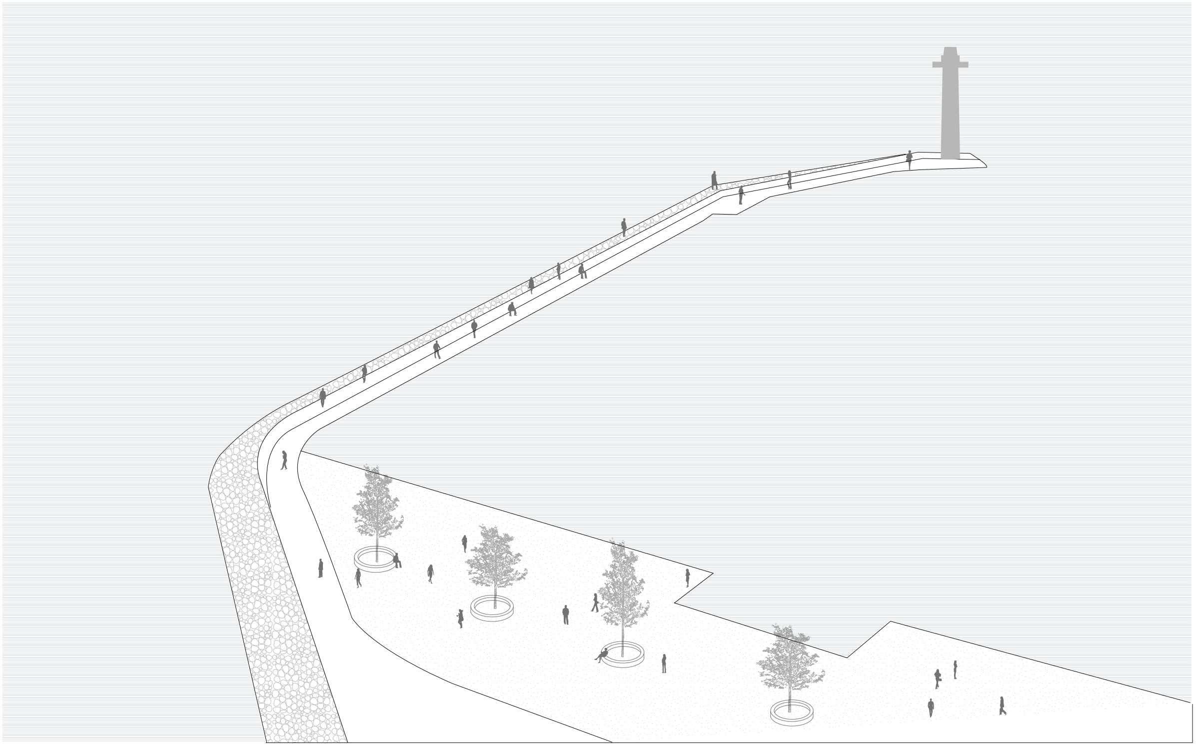


Fig.2 Coastal Defense Structure as Recreation Space

Example 1 : Sakata Port Wave Energy Farm

Sakata port is situated on the Sea of Japan coast of Yamagata Prefecture. The port incorporates different types of energy production facilities, including thermal power plant (1977-), offshore wind power plant (2004-) , solar energy (2013-), and the feasibility study and experiments of wave energy farm had been carried out between 1987 and 1999. The experimental wave energy production facility is a composite breakwater with a special caisson with the oscillating water column which can absorb wave energy and convert it into the air pressure. The air power can then activate a turbine-generator in the machine room on the caisson . (fig.3-4)

The second phase of experiment, which involves several private companies, research institutions as well as universities, began in April 2015 with the aim of achieving the power generation cost below 40 yen/kW in order to be comercially viable [1]. At this experiment, they were testing the air chamber which can be added to the existing breakwater structure, and if this system will be put in practice, it is expected to reduce the construction and installation cost of wave energy farm [2].

The use of the breakwater as a wave power converter will effectively curtail the cost of power generation. This breakwater at the same time aims to ameliorate the wave resisting capacity and the performance as a breakwater by absorbing the wave energy through the power generating system [3]. This reciprocal advantage between the defensive and energy producing facility gives a positive sign that the hybrid structure would be beneficial and realistic option when the cost performance of this energy production system will be further reduced through the technical improvement.

1. *Asia Biomass Office, "demonstration experiment of wave energy began at Sakata port", June 2015, https://www.asiabiomass.jp/topics/1506_01.html*
2. *New Energy and Industrial Technology Development Organization (NEDO), "the feasibility test began at the Sakata port in Yamagata Prefecture", April 17, 2015, http://www.nedo.go.jp/news/press/AA5_100378.html*
3. *Shigeo Takahashi, Hiroaki Nakada et. al. "Wave Power Conversion by a Prototype Wave Power Extracting Caisson in Sakata Port", https://icce-ojs-tamu.tdl.org/icce/index.php/icce/article/view/4941/4621*

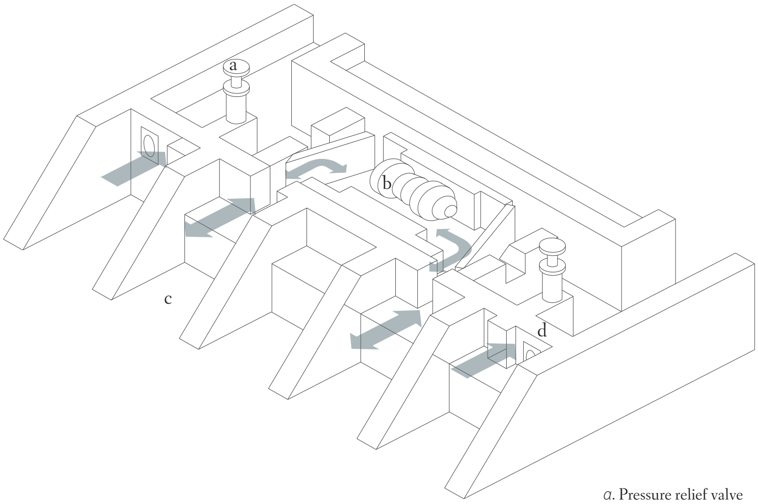


fig.3 Verification test of a caisson type breakwater wave energy farm at Sakata Port (1987-)
reference: http://2nd.geocities.jp/kadolikes96jp/photo/sinrigan3_640.jpg

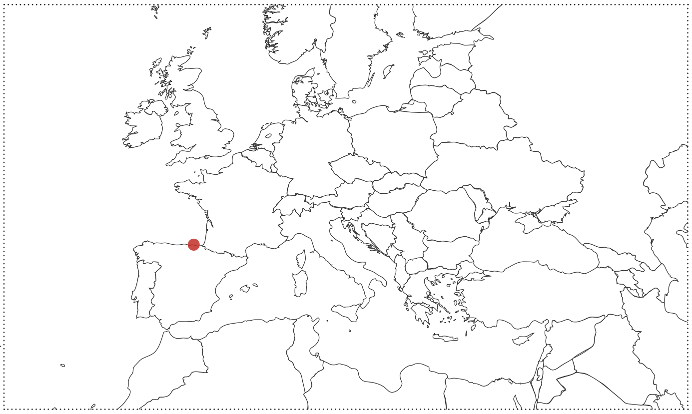
fig.4 Caisson breakwater wave energy diagram
source: Japan Science Foundation Publication, Japan's Energy Development 1997, http://www.rist.or.jp/atomica/data/dat_detail.php?Title_No=01-05-01-08

Example 2 : Mutriku Breakwater Wave Plant

Another case for the energy-coastal defense hybrid structure comes from the town of Mutriku located in northern Spain. The area is frequently hit by the Biscay storm, which have damaged the piers, and it has caused major instability in the harbor. As a consequence, there have been a number of accidents at the entrance of the harbor and therefore new coastal defense strategy was called for.

The local government layed out many different alternative configurations for the harbor to tackle the issue. The new 440 meter long breakwater was then commissioned in 2006 as a new defensive facility for the port. (fig.5) With the design completed for a breakwater, the government contacted Basque Energy Agency (EVE) to examine the possibility to make use of the structure to integrate some form of wave-based power-generating system without interfering with the breakwater's primary function [1]. The hybrid concept enabled the breakwater to be used to protect the harbor and to generate power simultaneously. During the feasibility study, it was found that the Oscillating Water Column technology could be incorporated into the design of the breakwater while respecting the design and the functionality of the breakwater. The plant, which has a capacity of 300 kW(enough to power 250 households) from 16 turbo-generator sets, is the Europe's first multi-turbine breakwater wave power station and was completed in July 2011. (fig.6) It is also the first commercial wave plant in operation connected to the grid in Europe [2]. The one hundred meter long energy plant incorporates 16 air chambers and when a wave hit it creates the air pressure in the chamber to drive the turbines.
The investment for the plant was €2.3 million [3].

According to the Basque Government's Energy Strategy, the renewable energy will become increasingly prominent for the town, with the aim that 19% of electrical energy consumed in the Basque country will be of renewable source by the year 2030 [3]. In this regard, the town's physical and environmental issues were addressed by the single hybrid structure.



1. Y. Torre-Enciso, I. Ortubia, et. al. "Mutriku Wave Power Plant: from the thinking out to the reality", Proceedings of the 8th European Wave and Tidal Energy Conference, Uppsala, Sweden, 2009
2. Lauren Freyer, "Spain Expands Renewables With Wave-Powered Electricity Plant", November 26, 2012, http://www.npr.org/sections/alltechconsidered/2012/11/26/165911832/spain-hopes-for-economic-boost-with-wave-powered-electricity-plant
3. Basque Energy Agency (EVE), "The wave energy plant in Mutriku ", July 18, 2016, http://www.eve.eus/Noticias/La-planta-de-las-olas-de-Mutriku-alcanza-un-hito-d.aspx?lang=en-GB

fig.5 Mutriku Breakwater Wave Plant : europe's first operational breakwater wave energy plant (2011)
source: http://www.es.travelbasquecountry.com/what-to-do/harnessing-the-power-of-the-sea.aspx#.WAIwAOCLRdg
fig.6 Mutriku Breakwater Wave Plant : 100 m long, 16 turbines/16 air chambers
source: http://www.es.travelbasquecountry.com/what-to-do/harnessing-the-power-of-the-sea.aspx#.WAIwAOCLRdg

Example 3 : Wakkanai Breakwater

Wakkanai is a city located at the northern part of Hokkaido and known as the northernmost city in Japan. The city faces both the Sea of Japan and the Sea of Okhotsk and it is exposed to the ocean's strong wind and waves in all seasons. The North Breakwater (Kitabouhatei-dome) was designed by Makoto Tsuchiya, who was 26 years old at the time, and was built in 1936 with the aim of protecting ship passengers from the violent wind and waves. (fig.7) Thanks to the arched breakwater, passengers heading to the Sakhalin route were able to board the ferry, located in the adjacent harbor, without having to go outside [1].

The breakwater is a reinforced concrete structure with the particular semi-arch which was designed to emphasize the resisting form against the force of wave. The 427 meter long semi-arch is supported by 70 columns (column spacing of 6 meter) and the height of the arch is 13.6 meter [2]. (fig.8) The monumental scale, the row of massive columns and the succession of arches seem to evoke the image of ancient Roman architecture, which at least did not exist in the region. In 1945, due to the Soviet invasion, the ferry route connecting Wakkanai and Sakhalin was closed and the breakwater structure began to be used as a storage for coal or other goods. The structure got weathered and deteriorated with the passage of time. As the structure was already deemed as a symbol of the city, citizens were ardently encouraging the restoration. The breakwater structure was restored truthfully to the original design in 1980 [3].

Up to the present date, the North Breakwater, which overlooks the Soya Gulf, has been appreciated as a symbol of the northern wharf and it is designated as a Hokkaido Heritage since 2001 and as a civil engineering heritage since 2003. The reason for the selection was the structure's role and influence in the economic activity as well as in the cultural formation of the city [3]. In fact, this monumental structure attracts the tourists to the city and some of the city events are also held there.

1. Wakkanai City, "Kita Bouhatei Dome", http://www.city.wakkanai.hokkaido.jp/kyoiku/supotsushogaigakushu/bunkarekishi/bunkakenz020.html
2. The Japan Civil engineering Consultants Association, "Kita Bouhatei Dome", http://www.jcca.or.jp/dobokuisan/japan/hokkaido/bohatei.html
3. Japan Society of Civil Engineers, "Interpretation regarding Kitabouhatei at Wakkanai Port", http://committees.jsce.or.jp/heritage/node/253

fig.7 Wakkanai Port North Breakwater in context
source: Eiichi Ishikawa, http://control.yukihotaru.com/dome4.jpg

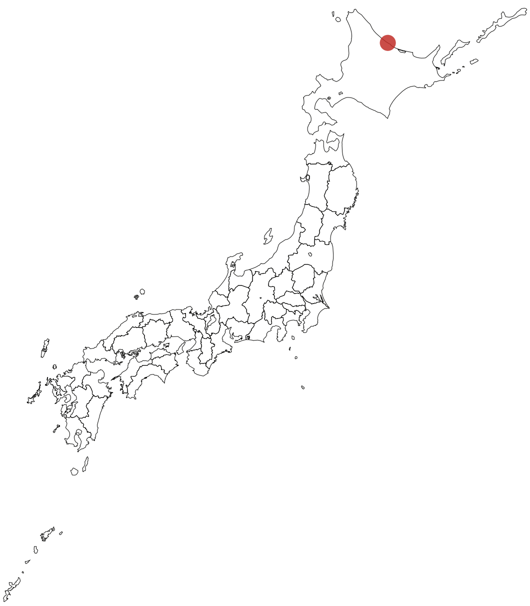
fig.8 Wakkanai Port North Breakwater as prefectural heritage/tourist spot (1936-)
source: https://cdn.kaumo.jp/element/7460787a-5072-4040-ba75-3bd67723d61c.jpg

Example 4 : Monbetsu Okhotsk Breakwater

Monbetsu is a city located in Okhotsk Subprefecture in Hokkaido and faces the Sea of Okhotsk. Not so distant from the previous Wakkanai breakwater, there is another interesting case of recreation-coastal defense hybrid structure at the Monbetsu port.) The port is protected by a series of breakwaters of different length and orientation. The Third Breakwater of the Monbetsu port is called "clione promenade" which names after the Okhotsk region's famous marine life "sea angel". The promenade is 515meter long and was open in 1996 [1].
Literally, this breakwater serves as a promenade which leads to the Sea Ice Observation Tower called "Okhotsk Tower". (fig.9) In a way, this coastal structure was designed and has been used as a recreational space on the water. The upper promenade is supported by a row of massive pillars and the locals also use this lower colonnaded space for different purpose such as market. (fig.10)

The attached Okhotsk Tower is the world's first underwater drift ice observatory(height=38.5m, depth=7.5m undersea) [2]. Its undersea windows are the largest of this kind in Japan. The 7.5m deep undersea world allows visitors to observe a variety of marine creatures, including some rare fish and cliones in the Sea of Okhotsk. Furthermore, the tower has other different facilities including kiosk, film hall, a 360-degree observation lounge, as well as an outdoor balcony cafe [3].

This whole complex of coastal structure, its space and facilities suggests the potential of hybrid recreational or commercial space on the water. In this way, people can maintain the closer relationship with the ocean and this can also help keep people's awareness of its threats.



1. Monbetsu Tourism Information, http://inspot.jp/mombetsu/spots/115
2. Monbetsu Tourist Assocciation, "Okhotsk Tower" http://mombetsu.net/areaguide/40.html
3. Hokkaido Official Tourism Website, "Okhotsk Tower", https://en.visit-hokkaido2.jp/travelPlanner/details.php?code=6203010000108

fig.9 Monbetsu Okhotsk Tower as research observatory/tourist viewing platform (1996-)
source: http://livedoor.blogimg.jp/shipponao/imgs/6/7/67213548.jpg

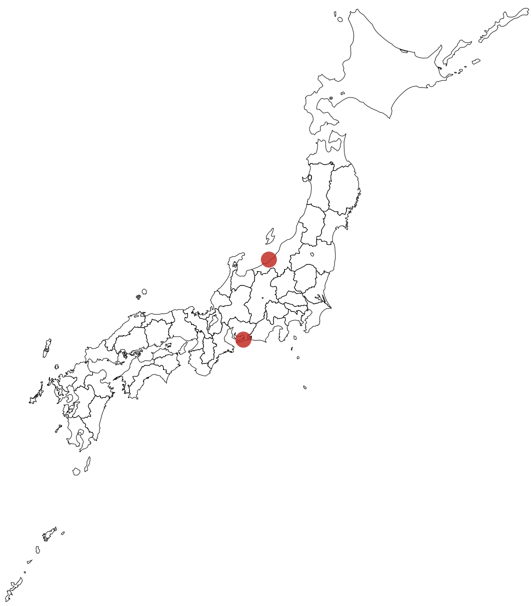
fig.10 Monbetsu Breakwater in Hokkaido as promanade/market
Source: http://img.huat.jp/object/nakaya/nakaya_496_1.jpg

Example 5 : Araimachi & Joetsu City

In Japan, many breakwaters are kept inaccessible for people to reduce the risk of overtopping waves. However, a recent important trend is to make breakwater accessible to public [1]. One possible way to use breakwaters as a public space is to create a promenade as with the case with Monbetsu Clione Promenade that was mentioned previously.

Another possible and more common use of the breakwater is for fishing. Indeed, this function generally does not require a particular design to be added to the original breakwater structure, so people just go fishing if the breakwater is accessible even if it is not designated for that purpose. For other places, they are equipped with handrails and are specifically open as commercial fishing park where people can also rent the equipment. For instance, Wakayama Marina City, which is an artificial island incorporating various function such as market, hot spring, and hotels, also incorporates the fishing facilities and promenade as a part of breakwater structure [2]. Another example is from Naoetsu port in Joetsu city on the side of the Sea of Japan, where the previously inaccessible breakwater was open on a trial basis as a fishing pot in October 2015. This opening was promoted by the Japan Sportfishing Foundation as a part of its "Open Breakwater Project" [3]. (fig.12)

Apart from these examples, the similar kind of fishing spots can be found all over Japan and this hybrid utilization of leisure and coastal defense facility has become a popular scenary in the coastal areas.



1. The Institution of Civil Engineer, Coastal Structures and Breakwaters: Proceedings of the Conference Organized by the Institution of Civil Engineers Held in London, England, November 6-8, 1st ed Edition ,1991
2. Wakayama Marina City, http://www.marinacity.com/
3. Yoshinori Morimoto, "trial opening of the breakwater at the Niigata Prefecture as a fishing spot", http://s.webry.info/sp/60813806.at.webry.info/201510/article_2.html

fig.11 Fishing at Breakwater in Araimachi, Shizuoka
source: photo taken by Hiroki Tanigaki

fig.12 Naoetsu port, Joetsu city, Niigata Prefecture
source: http://s.webry.info/sp/60813806.at.webry.info/201510/article_2.html

e.BOUSAI SOCIETY

Difference of desired wall height between the authority & the residents, Nonoshima Island

Source: http://userdisk.webry.biglobe.ne.jp/024/459/80/N000/000/004/147070063082994968177_DSC_0526.JPG

For effective disaster management, national Government, local governments and wide range of relevant partners work out disaster management plans and carry them out appropriately.

The effective Bousai involves both the hard infrastructures and soft societal management structures which need to work together. It could be achieved through the laborious discussions, concessions and reconciliation among the various interested parties.

There is a need for citizens as well as public administrators to be educated in disaster resilience issues for better prevention, mitigation, preparedness and recovery from such events.

Societal Reaction to Tsunami & Bosai

The Great Tohoku Earthquake and Tsunami in 2011 marked a turning point in drawing the wide public attention to the issue of “Bousai” planning. The actual visual image of the arriving tsunami waves, the houses being washed up, or the evacuating people had been spread out through various type of media and it has heightened the awareness of tsunami disaster from the level of dim fairy tale to the realistic threat to their own community. In fact, the news coverage of tsunami related issue is not limted to the Tohoku area, but is extended to the rest of Japan. Since the tsunami and related *Bousai* planning are intricately intertwined with whole gamut of social, economic or political issues at hand in Japan, the topic related to the future earthquake, the reconstruction of the affected area, the new plan or project for the future disaster preventive measures hit the headlines in almost daily basis.

It seems like that the Japanese society as a whole pushes itself forward by sharing these awareness and a sense of threat against natural disaster. The reactions come from various actors, sectors and fields and the accumulation of the experience, knowledge, expertises related to the disaster and the disaster prevention enables the society to evolve to more resilient community against the future possible tsunami. From the civilian sector, more than 1.5 million people in total have participated in some form of disaster relief volunteer activities from all over Japan since the Tohoku Earthquake in 2011 [1]. From the industrial sector, for instance, some particular disaster mitigation related products such as the GPS wave gauge for the early Tsunami detection and a disaster information communications systems have been developped and improved to make a safer society by means of social-infrastructure improvements [2]. The national and local governments are working more on the infrastructural projects and the long-term territorial planning in a large scale.

Apart from each “structures” (seawall, breakwater, evacuation, landscape, hybrid) mentioned earlier, the critical driving force of “*bousai*” lies in a shared societal awareness and reaction against the catastrophe. This forms the basis of *bousai* culture in which citizens share, develop, and transmit their wisdom among each other and to the next generation.

1. Zenshakyo disaster relief and volunteering information, “number of disaster relief volunteers”, https://www.saigaivc.com/
2. Hitachi Zosen, “GPS wave gauge for the early tsunami detection”, http://www.hitachizosen.co.jp/csr/hitz/life04.html

三陸新報 2013年(平成25年)10月8日 火曜日

湾口防波堤で高さ低く

内湾防潮堤 背後の浸水リスクは拡大

県がシミュレーション

湾口防波堤が検討されている神明崎ー柏崎

防潮堤 地域差じわり

被災地 振興と安全、両立探る

宮城「巨大すぎ」住民反発

岩手 低く抑えて着々

三陸新報 2013年(平成25年)7月18日 木曜日

「顔」の内湾に配慮

気仙沼市 県へ防潮堤引き下げ要請

港町は無堤化も

内湾防潮堤のイメージ図（県案）

2013年(平成25年)4月30日 火曜日 朝日新聞

防潮堤 再建開始3割

被災3県 用地取得が難航

高さ4倍計画 住民「海見えず怖い」

検証の末「同じ高さで」 大槌・赤浜地区

港町一部防潮堤造らず

村井知事が譲歩案

気仙沼湾 エースポート前バック可能

無堤化が認められた港町地区だが、臨港道路と堤防の交差など課題は多い

浮上防波堤 建設断念

和歌山で国着手 浮かない可能性

2015.2.19

fig.1 Newspaper coverages of tsunami *bousai* issue

Kesennuma, Miyagi Prefecture explains to the residents the height of newly planned seawall
source: Sanriku-Shinpo October 8, 2013

Kesennuma city made a request to the Miyagi prefecture to lower the height of plannned seawall
source: Sanriku-Shinpo July 18, 2013

a concession plan by the prefectural governor : renunciation to build up seawalls at some port cities
source: Sanriku Shinpo, October 4, 2013

Regional differences upon the construction of the seawalls/residents in Miyagi oppose to the massive wall
source: Nikkei Newspaper, January 7, 2014

Seawall construction reconstruction 30%, difficulty for site acquisition
source: Asahi Newspaper, April 30, 2013

Relinquishment of the construction of "floating seawall" in Wakayama
source: Yomiuri Newspaper, February 19, 2015

Social Trauma of Nuclear Energy & Bosai

As previously mentioned, the issue of tsunami disaster prevention and the nation's energy policy, in particular for the nuclear energy, cannot be discussed in isolation. The citizen living in the proximity of nuclear power plants face the irreconcilable dilemma between the wish for the safe living environment and the constant fear of possible nuclear accident.

Japan has long been one of the world's most committed promoters of civilian nuclear energy. Until 80's, Japan's nuclear industry did not encounter major accident as the 1979 Three Mile Island accident (USA) or the 1986 Chernobyl disaster. However, in the 90's several nuclear related accidents and cover-ups were revealed in Japan including the Mihama steam explosion (1991), cover-ups after accidents at the Monju reactor (1995), and the Tokaimura nuclear accident (1999) [1]. As a consequence, the public gradually began to sober up from the myth of nuclear power's infallible energy supply and the safety of nuclear industry has come under greater public scrutiny [2]. The partial meltdown accident at the Fukushima Daiichi Nuclear Power Plant has further accelerated the mistrust, fear, and the outrage over the nuclear energy policy in Japan, leading to nationwide opposition campaign. (fig.2-5)

Following the accident, all of the nuclear plants had been either closed or their operations suspended for safety inspections. An energy white paper, issued by Resources and Energy Agency and approved by the Japanese Cabinet in October 2011, declared that public confidence in safety of nuclear power was greatly eroded by the Fukushima accident and a new energy policy which relies less on nuclear power is called for [3]. However, the actual policy of the authority and the energy companies seems to be going against this current. At the moment, 42 reactors are operable and able to restart of which 24 reactors are in the process of restart approvals. The Sendai Plant (August/October 2015), Ikata Plant (August 2016), and Takahama (February 2016) have already restarted their operation for some reactors [4].

The tsunami disaster has actually changed the social attitude. Faced with unmeasurable and unpredictable threats of nature, the overconfidence in the technology seems to be absurd. Thousands of people participate in the anti-nuclear assemblies all over Japan. Organizers and participants said that such demonstrations hint at a fundamental change in the country where relatively few have been eager to join political protests since the 60s [5]. The social trauma of tsunami disaster has demystified the public and has given the opportunity to reacknowledge the risk of both natural and artificial disasters and to reflect on the future *Bousai* of the coastal territory.

1. *Research Organization for Information Science and Technology (RIST) , List of nuclear power plant accident in the history", http://www.rist.or.jp/atomica/data/dat_detail.php?Title_No=02-07-02-01*
2. *"Japan cancels nuclear plant". BBC News. February 22, 2000, http://news.bbc.co.uk/2/hi/asia-pacific/652169.stm*
3. *Agency for Natural Resources and Energy , "Energy White Paper", October 2011, http://www.enecho.meti.go.jp/about/whitepaper/2011pdf/whitepaper2011pdf_gaiyou.pdf*
4. *World Nuclear Association, "Nuclear Power in Japan", December 28, 2016, http://www.world-nuclear.org/information-library/country-profiles/countries-g-n/japan-nuclear-power.aspx*
5. *Mure Dickie, "Japanese anti-nuclear demonstrations grow", July 17, 2012 ,Washington Post.*

fig.2 Antinuke assembly at Meiji park in Tokyo, September 19, 2011
Source: http://mphoto.sblo.jp/article/48036201.html

fig.3 Protest against the resumption of Sendai Nuclear Power Plant, Kagoshima Prefecture, October 15, 2015
Source: http://mphoto.sblo.jp/article/48036201.html

fig.4 Demonstration against the reopening of Hamaoka Nuclear Power Plants, Sunpu Castle Park, Shizuoka City, November 22, 2014
Source: http://www.s-kenpyo.jp/topics/141126-131558.html

fig.5 Protest against the resumption of Ikata Nuclear Power Plant, Ehime PrefectureNovember 1, 2015
Source: http://mutekaturyu.blog.fc2.com/blog-entry-1828.html

Finance of Bosai

Any *bousai* planning and project is not free from the financial constraints. Especially, if it involves the construction of mega-structure such as seawall or breakwater, the scale of the expenses would be immense. The Japanese government has allocated a substantial budget to the reconstruction projects for Tohoku area after the 2011 Tohoku Earthquake. The first 5 years after the earthquake (2011-2016) was designated as an intensive reconstruction period and the total 25.5 trillion yen (ca. € 203.5 billion) has been spent mainly for public works such as the debris removal, the construction of seawalls, the restoration of infrastructures [1]. In order to finance this immense budget, the government needed to issue the restoration bonds and impose special restoration surtax [2]. Moreover, the restoration budget until 2020 is expected to reach 32 trillion yen in total and that is almost twice as much as the reconstruction costs for the Hanshin Earthquake 1995. The worst thing is the revelation by the Board of Audit of Japan that as much as 1.4 trillion yen of the assigned budget had been misappropriated for unrelated projects [3]. The problem was that the restoration budget was at first distributed to local communities or public-interest corporations and thus the transparency of money flow was not ensured.

There is also a rising concern about the tsunami prevention measures and budget outside Tohoku area. As for the investment for the future disaster prevention and mitigation, 1 trillion yen (ca. € 8.1 billion) is allocated nationwide from the above mentioned restoration budget [2]. Furthermore, local communities set their own budget in an attempt to reinforce their own tsunami prevention capacity. The table on the right page shows the annual and long-term tsunami-related budget allocation of the prefectures which would be affected by the Nankai, Tonankai or Tokai Great Earthquake in a foreseeable future. (fig.6) It can be observed that for the majority of the prefectures, the tsunami budgets have increased in 2014 in comparison with 2011, implying the rising concern over tsunami after the 2011 Tohoku earthquake. The amount of budget vary significantly depending on the prefecture. This could be due to the different financial strength, population size, as well as the degree of risk of each place. The investment for the mega infrastructural project would be infeasible for the local municipality with low financial strength without the aid from national budget. Even the national budget is barely managed by the special surtax measures at the expense of the public's burden. Therefore, it is crucial for each municipality to scrutinize and sift through the most effective and needed disaster preventive measures.

1. *Sankei News, "reconstruction budget, from the public projects to life regeneration", March 10, 2016, http://www.sankei.com/economy/news/160310/ecn1603100023-n1.html*
2. *Ministry of Finance, "restoration related budget", November 2012, https://www.mof.go.jp/about_mof/councils/fiscal_system_council/sub-of_fiscal_system/proceedings/material/zaiseia241101/06.pdf*
3. *Business Journal, "Why was 1.4 trillion yen restoration budget was misappropriated for irrelevant projects?", http://biz-journal.jp/2013/12/post_3638.html*

1 billion yen ≈ 8.754 € ≈9.5 million CHF

		2011 (yen)	2014 (yen)	long-term (yen)
KANTO	Tokyo	7.5 billion	15 billion	150 billion (10 years)
	Chiba	7 billion	4.9 billion	pending
	Kanagawa	1.9 billion	1.6 billion	pending
TOKAI	Shizuoka	1.1 billion	7.6 billion	220 billion (10 years)
	Aichi	3.7 billion	3.7 billion	pending
	Mie	3.2 billion	4.0 billion	pending
KANSAI	Wakayama	0.08 billion	0.4 billion	pending
	Osaka	no data	13.7 billion	210 billion (10 years)
	Hyogo	1 billion	4.9 billion	30 billion (6 years)
SHIKOKU	Tokushima	0.5 billion	5.0 billion	pending
	Kagawa	no	1.3 billion	pending
	Ehime	0.6 billion	1.0 billion	pending
	Kochi	1.1 billion	4.2 billion	100 billion (20 years)
KYUSHU	Miyazaki	no	0.25 billion	pending
	Oita	no	0.12 billion	pending
	Kagoshima	5.4 billion	4.2 billion	pending

fig.6 Tsunami prevention budget for each Prefecture

source: Asahi Digital, "swelling budget for tsunami disaster prevention, May 4, 2014, http://kiziosaka.seesaa.net/article/396298827.html

Politics of Bosai: Example from a Seawall Project

Bousai is a system and a decision making process which inevitably touches on the politics.
Some disaster prevention projects may require the immense amount of investments and some other project may drastically change the living environment of the surrounding area. As it deals with the safety of citizens and the long-term development of a given community, it involves a process of thorough debates and concessions in order to achieve a consensus.

The reconstruction of tsunami-stricken area in Tohoku region has triggered some of the fierce debate. In particular, local residents and local authority came in conflict with each other regarding the reconstruction of tall seawall. For example, the residents of Nonoshima island in Miyagi Prefecture, which was hit by tsunami and lost 31 houses, did not want a high seawall proposed by the local authority which would interrupt the view to the ocean. As a bulwark against future tsunami, the Miyagi prefectural government proposed to build 3.3 meter high seawall at the fishing port. However, Nonoshima's residents claimed that the wall should not be higher than 2.3 meters [1]. In March 2015, some islanders set up two mock walls made of plywood in order to compare the actual impact of the wall for both scenario, one at 3,3 meters and another at 2,3 meters. The head of the local residents' association Mr. Suzuki insisted that 1 meter of difference makes a huge difference to the seascape [2]. The local government organized some information sessions regarding their plans and they have also exchanged their opinions through a series of meetings. (fig.7-8) The city first proposed to elevate some of the houses near the port by 1.7 meters so that the residents can keep the view to the ocean even with 3.3 meters wall. However, the locals showed reluctance to accept this alternative and the exchange of opinions continued. As a result, the authority finally proposed another alternative to lower the height of the seawall down to 2.1 meters based on the new simulation result. The residents then accepted this alternative plan. One of the residents said that the fundamental of island life is a dialogue with the ocean and the high seawall will break the ordinary life of the island [3].

This is one of the many cases of such political concessions regarding the seawall construction and some are still ongoing. Depending on many different factors including lifestyle, value, culture, budget, or the degree of risk in a community, the final concensus could take a different form. However, the importance is the process of decision making which involves the local residents and reflects their actual needs.

1. *Shiogama City Office, "Mayor's message", May 2015, https://www.city.shiogama.miyagi.jp/seisaku/shise/shicho/kaiken/2015/h2705.html*
2. *Asahi Shinbun, "Residents of tsunami-hit island call for lower seawall to preserve ocean views", May 5, 2015.*
3. *"no high seawall, the islanders request was accepted to lower the height of seawall", http://sakura3411.at.webry.info/201608/article_3.html*

fig.7 Explanatory meeting for the residents of Nonoshima Island regarding the seawall construction plan, August 2016
Source: http://s.webry.info/sp/sakura3411.at.webry.info/201608/article_3.html

fig.8 Citizen group "Protect Gamou" made an overture to review the plan of the seawall construction, Sendai, February 2015
Source: http://s.webry.info/sp/sakura3411.at.webry.info/201502/article_2.html

Reflection& Critics over 5 Structures

The 5 tsunami protection structures mentioned so far, as a premise, are not supposed to compete but instead to supplement each other. In other words, the crux of the issue lies not in the selection of the best disaster prevention measure among them, but in the understanding of the best possible combination among them.

The issue at hand is very delicate since the choice of *bousai* measure touches on the survival of thousands of citizens and billions of huge investment which come from their taxes. The national and local authorities tend to take the safe side, trying to "protect" the territory by means of mega-infrastructural projects. For locals may resist if the proposed plan would cause negative impacts on their life and lifestyle.

Whether someone likes it or not, the fragile coastal regions need to be protected by some form of infrastructure (seawall or breakwater), and in fact at least 43 percent of Japan's 29,751 km coastline is already armored with concrete seawalls or other types defense structures [1]. But the important is to know in which way and in which degrees we need such defense structures. As seen in the example of Nonoshima island, 1 meter difference of the height of seawall may drastically affect their life condition. Furthermore, the immense construction cost as well as potential ecological damage to the coastal region should also be taken into consideration. The goal therfore would be to find the best concession which take the particular local conditions such as topography, financial issues, people's lifestyle, as well as the degree of tsunami risk into consideration.

The *bousai* needs to be understood as a process in which a community fosters its own robust system of disaster prevention. Therefore, any top-down mega-infrastructural projects, even if they can be effective in "protecting" the territory, would not suffice if they cannot be integrated to the lifestyle and the culture of locals.
The *Chinju-no-Mori* project (ref: landscape structure case 1), which involves tree planting events, may hint at a positive sign where citizen themselves become the active actors and participate in the process of *bousai* effort in the community. At present, some management of coastal forests already exists, yet it is mainly managed by the national and local forestry sector and its focus is on the even-aged artificial forests. Because coastal forests in Japan are considered as regional resource and cultural landscape, it is desirable that they are maintained by local residents and local government [2]. Besides the maintenance problems such as biological disease of the trees, further studies and experiences are needed for this landscape structure to be reliable and effective in mitigating the tsunami force.

1. *New York Times. "Japan's Seawalls Didn't Provide Security from tsunami" , http://www.thestar.com/news/world/article/953485--japan-s-seawalls-didn-t-provide-security-from-tsunami*
2. *Fujihara, Ohnishi, et.al, "Conservation and Management of the Coastal Pine Forest as a Cultural Landscape", in "Landscape Ecology in Asian Cultures" edited by Sun-Kee Hong Jianguo Wu et.al, chap. 17, Springer, 2011.*

The involvement of citizens in the *bousai* planning is indispensable for the effective disaster mitigation. In particular, the appropriate evacuation strategy will play a significant role in mitigating the damage when the hard infrastructures on the coast fail to retain the tsunami wave. The evacuation planning, training, the development and the management of the relevant facilities such as evacuation towers or shelters all require the active involvement of the local communities. A major tsunami would not hit so frequently, but the communities would need to establish a long-term *bousai* system which is integrated into their living so that they can react immediately and flexibly to the eventual disaster.

The participation of local citizens in the tsunami *bousai* planning is closely linked to their lifestyle and the way they occupy the coastal space. A coastal space separated by massive concrete seawalls will not allow people to occupy and make use of it. The wall may serve as an effective tsunami protection or mitigation facilities, but not provide a space which involves people or their activities. In this regard, the potential of more varied use of coastal space should be further explored in addition to some of the possible cases such as recreational space or energy production mentioned in the "hybrid structure" section. By allowing the access and the contact with the ocean, people can not only enjoy the extended public space along the coast line but also can maintain the awareness of *bousai* in their direct relationship with the nature.

From the landscape point of view, the critical task is to bring all these structures (strategies) into a wider natural context in a culturally coherent way. For this purpose, the profound understanding of local specific characters (natural/artificial), its *fudo*, its cultural value, as well as its symbolic importance is essential. By incorporating sensibly these 5 structures, the layers of tsunami prevention systems could be established to mitigate in stages the magnitude of the disaster. This certainly involves the "design" of the territory and the societal system which adapted to a specific local condition.

CHAPTER 3

Project Definition

ABSTRACT

On the basis of the theoretical understandings of the previous two chapters, this final chapter is intended to serve as a preliminary study which leads to an architectural project. In concrete terms, it deals with the definition of the site based on the risk analysis and the deeper study of the selected potential site.

a.SITE SELECTION

As a preliminary step for an architectural project, this section aims to identify the potential sites which are facing the imminent risk and need urgent countermeasures against tsunami disaster.

The risk areas will be identified based on the seismic cycles and risk, the extent of expected damage for the forthcoming mega-earthquake as well as the location of nuclear power plants, which might affect extensive area surrounding the plant.

Seismic Risk in Japan 2016-2046

The risk of earthquake and tsunami is omnipresent around the costal region in the country. As a seismic activity, particularly for the interplate earthquake, generally recurs on a certain cyclical basis, it is possible to predict the probability of occurrence of the next earthquake. Based on this, it would turn out that some regions are more risky than others, and therefore they require the urgent actions to prepare for the forthcoming disaster.

Now in Japan, the particular attention is paid to the coastal areas along the Pacific Ocean, which spread through a wide area from Kyushu, Shikoku, Kansai, Tokai, as well as Kanto area. The Japanese Government's Headquarter for Earthquake Research Promotion, issued the map of earthquake estimation which indicates the probability of major earthquake occurence (> seismic intensity 6 lower) in the next 30 years (2016-2046) [1]. (fig.1) This clearly indicates that the areas of higher risk lie along the Pacific coast on the south and the rest of the region have relatively lower risk. Among the areas of highest risk are Shizuoka city (68%) and Kochi city (73%) [2].

Since it is an estimation of the probability, it does not exclude the possibility that some major earthquakes would happen in the other regions. However, it should be noted that the mentioned risky areas are particularly significant since it involves a band of densely populated urban territories especially in Kanto, Tokai and Kansai area. The Tohoku area, except for some large city as Sendai in the Miyagi Prefecture, is generally characterized as rural areas with relatively less degree of urbanization and population, yet the earthquake and tsunami inflicted tremendous damage both to human and properties. If the earthquake and tsunami of an equivalent scale would occur in those urbanized territories, it is not hard to imagine that the extent of damage would be unparalleled.

1. *The Headquarter for Earthquake Research Promotion, "the map of earthquake estimation the edition 2016", http://www.jishin.go.jp/evaluation/seismic_hazard_map/shm_report/shm_report_2016/*
2. *Nikkei Shinbun, "probability of major earthquake is higher along the Pacific coast, the prediction map of the edition 2016", http://www.nikkei.com/article/DGXLASGG09H2W_Z00C16A6000000/*

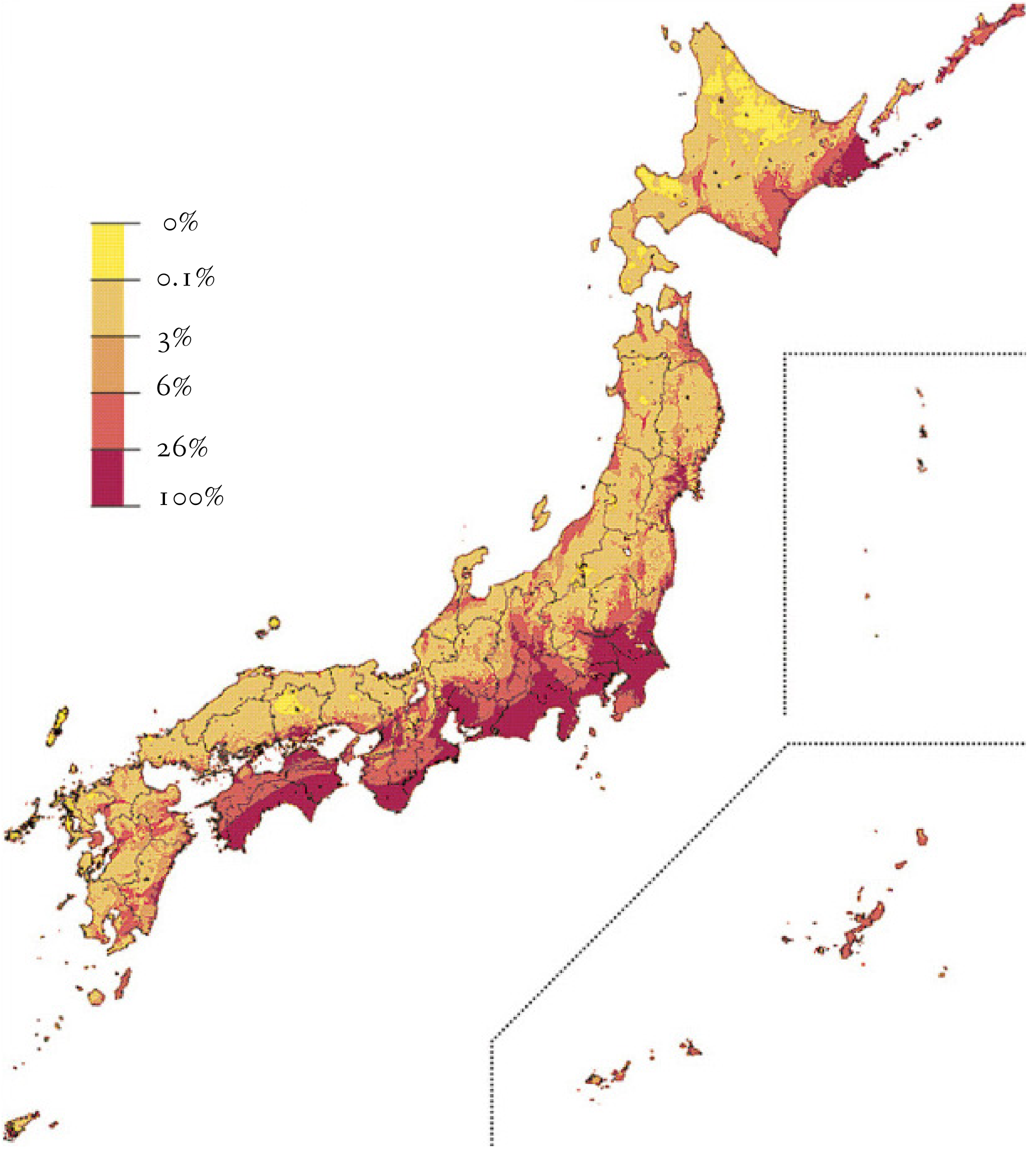


fig.1 The probability of earthquake occurence (> seismic intensity 6 lower) between 2016-2046

source: The Headquarter for Earthquake Research Promotion; http://www.jishin.go.jp/

Seismic Cycle along the Pacific Coast

Given the observation from the earthquake prediction map mentioned above, the focus is now on the areas along the Pacific coast to identify further the more vulnerable area. The reason behind the high probability of major earthquake occurence in that region is due to the tectonic activity in the Nankai Trough which stretches approximately 900km from the Pacific coastline. Historically, this area has been hit by a series of giant earthquakes and tsunami as illustrated on the figure. (fig.2)

The M7.9 Keicho Earthquake in 1605 hit the areas ranging almost the whole span of the Pacific coast, resulting in more than 5,000 death toll [1]. After almost a century, another major eathquake of M8.6 and the accompanying tsunami struck the area in the event of Hoei Earthquake in 1707, which again caused the death toll of approximately 5,000 [2]. The next major tremor was the well-known Great Ansei Earthquake in 1854, which occurred after the longer interval of 147 years. From then onwards, the major earthquakes began to occur partially within the stretch of the Pacific coast, namely the Tonankai Earthquake in 1944 and the Nankai Earthquake in 1946. They were the only two major tsunami disasters experienced in the Pacific coastal area since the last century. The source of the tsunami wave stretched approximately 250km along the Nankai Trough and the tsunami of more than 5 meters high were recorded in the region such as Mie, Wakayama, or Kochi Prefecture [3].

As of the end of the year 2016, no major earthquake and tsunami occurred at the Nankai and the Tonankai region since almost 70 years. The worse case is the Tokai region around the Shizuoka Prefecture, which has already the long interval of 162 years after the 1854 Ansei Earthquake. According to the crust survey, it was confirmed that the interplate strain energy has been steadily accumulated in the area. Therefore, Japan Meteorological Agency warns that there is an imminent risk of Tokai Earthquake and it can be triggered at any moment [4].

1. Tsuchiya Y., Shutō N. Tsunami: progress in prediction, disaster prevention, and warning. Advances in natural and technological hazards research. 4. Springer. pp. 199–207, 1995
2. Tsuji, Y., Namegaya Y. "The 1707 Hoei Earthquake, as an Example of a combined Gigantic Tokai-Nankai Earthquake", 2007
3. Tokutaro Hatori, "Tsunami Behaviors in the Seto Inland Sea and Bungo Channel Caused by the Nankaido Earthquakes in 1707, 1854 and 1946", Jishin Vol. 41 No. 2 P 215-221, 1988
4. Japan Meteorological Agency, "Imminence of Tokai Earthquake", http://www.data.jma.go.jp/svd/eqev/data/tokai/tokai_eq2.html

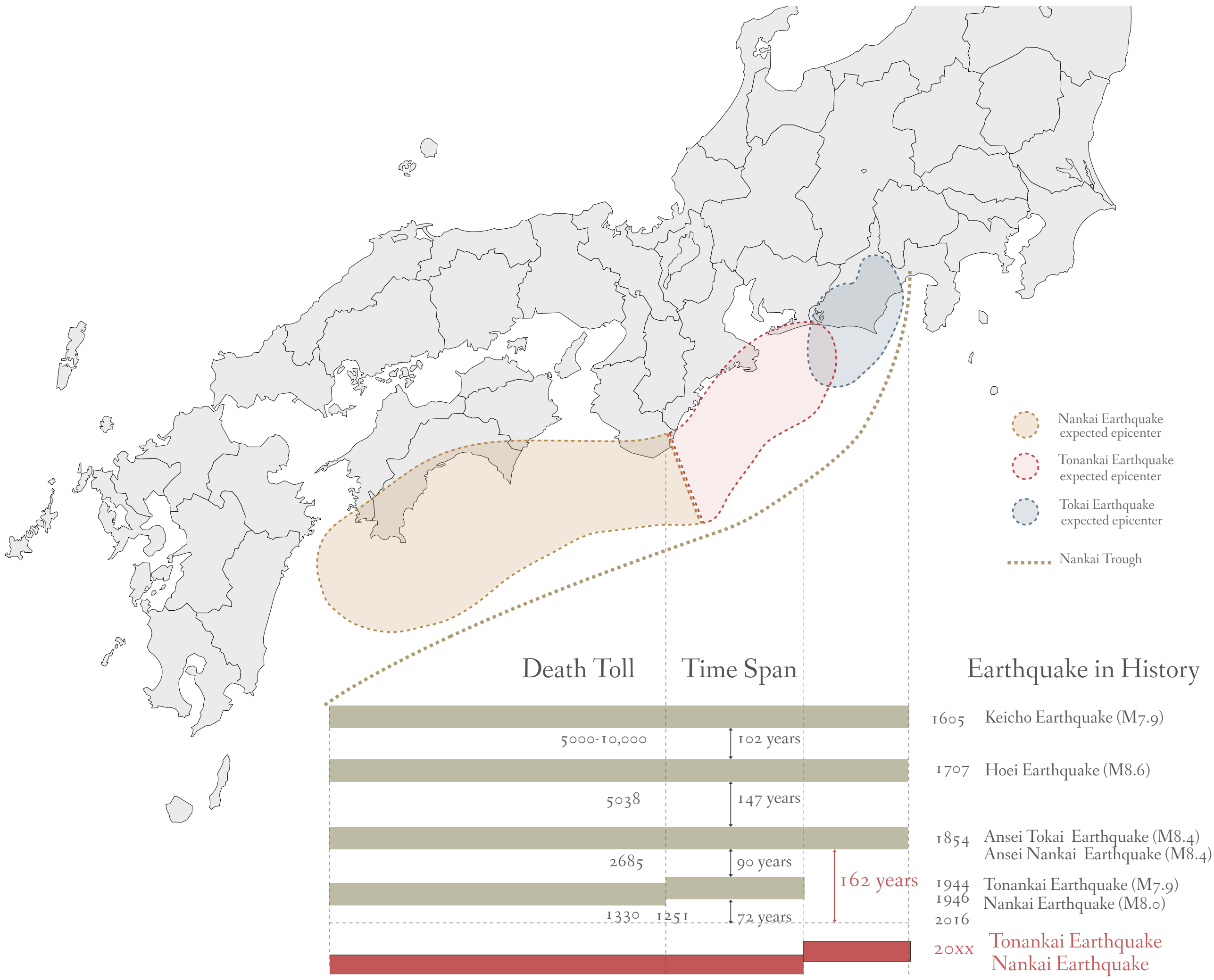


fig.2 Death toll & Expected Tsunami height caused by Tonankai Earthquake

source: The Headquarter for Earthquake Research Promotion; http://www.jishin.go.jp/

Damage Prediction of The Nankai Trough Earthquake

The Japanese Government's Cabinet Office has released the damage prediction of the possible mega-earthquake which would be triggered by the Nankai Trough. (fig.3) The estimate was issued in 2012 and the damage prediction assumes the maximum predictable class of earthquake and tsunami around the region [1]. The prediction of death toll varies, depending on several factors including the location of epicenter, the wind speed, the time of occurence, or the rate of early evacuation, from 32,000 in the least case and to 320,000 in the worst case scenario. This worst case would occur when the damage is large in Tokai area and if it happens during a night in the winter time with the strong wind. If the tsunami destroys coastal defense facilities and watergates, the death toll would rise further 23,000 according to the Cabinet Office [2].

If we look at the regional variation, the Shizuoka Prefecture alone counts more than 100,000 death and it is the highest among all the other regions. This can be explained by the fact that the Shizuoka Prefecture is situated close to the possible location of the epicenter and at the same time is more populated than the region such as Kochi or Wakayama which are also situated in the proximity of potential epicenter. Furthermore, the expected maximum height of the tsunami is particularly high in Kochi and Shizuoka, which may even exceed 30 meters high. Even the average height of tsunami waves of these regions are expected to be higher than 15meters. Due to the proximity to the potential wave source, it is expected that tsunami wave can arrive even within few minutes minutes after the earthquake for the place such as Shizuoka city (13m tsunami within 4 minutes), Iwata city (12m tsunami within 5 minutes), Shimoda city (33m tsunami within 13minutes) and so on [3].

This prediction result further revealed the vulnerability of the Tokai area around the Shizuoka Prefecture. The actual damage would certainly vary from the estimate due to the various factors mentioned earier and other factors which are not taken into consideration in the study. Nonetheless, it is in any case significant for those risky regions to take special heed of this probable worst case scenario and to make the best possible preparation for the forthcoming disaster.

1. *Japanese Government Cabinet Office, "about the damage prediction of the Nankai Trough mega-earthquake", March 18, 2013, http://www.bousai.go.jp/jishin/nankai/nankaitrough_info.html*
2. *Nikkei Shinbun, "maximum death toll of The Nankai Trough Earthquake would be 320,000", August 29, 2012, http://www.nikkei.com/article/DGXNASDG25031_V20C12A8M13300/*
3. *Asahi Digital, "Damage prediction of the Nankai Trough Earthquake", September 28, 2015, http://www.asahi.com/special/nankai_trough/*

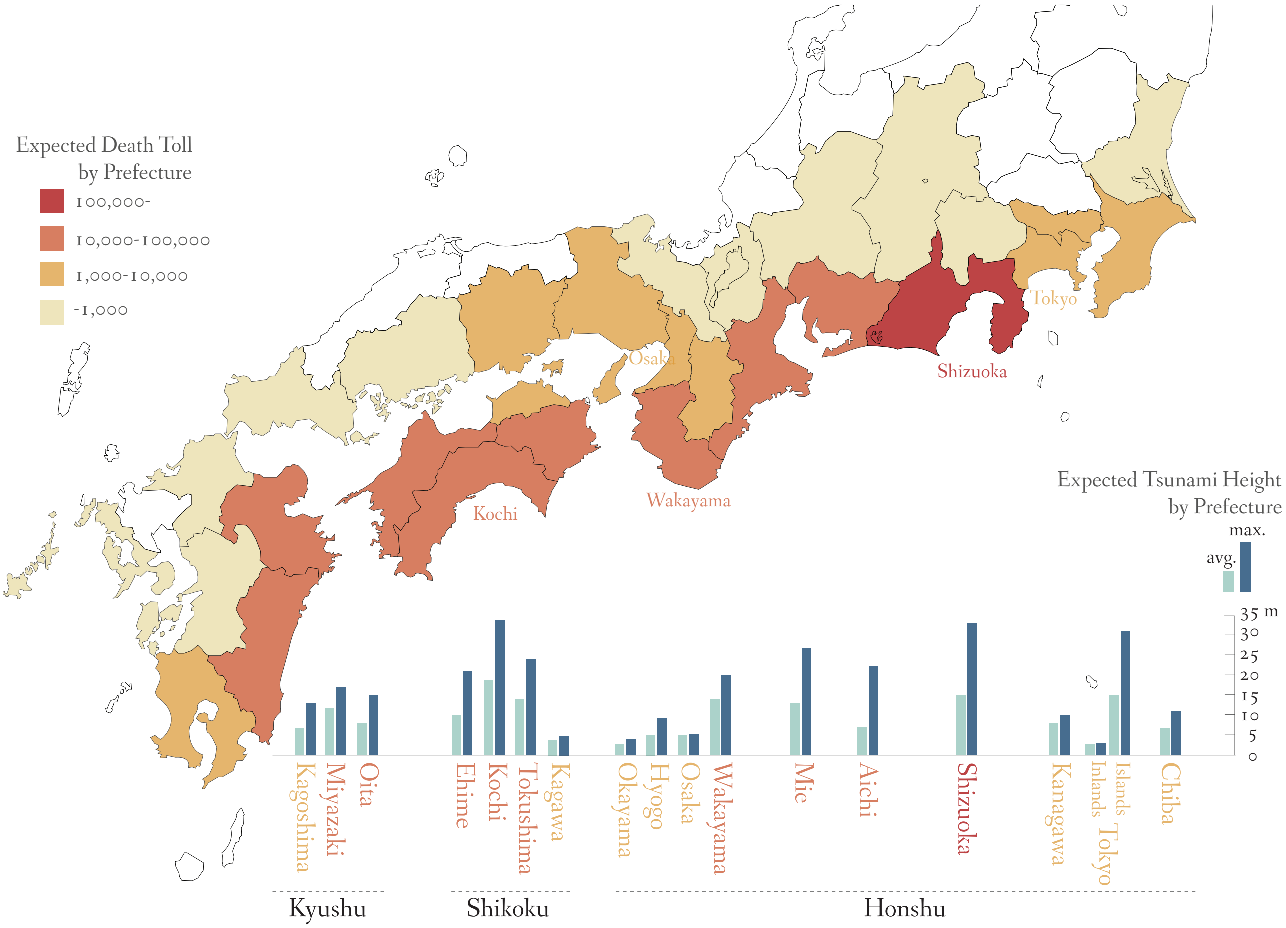


fig.3 Death toll & Expected Tsunami height caused by Tonankai Earthquake

source: Japanese Government Cabinet Office, http://www.bousai.go.jp/jishin/nankai/nankaitrough_info.html

Nuclear Power Plant on the Pacific Coast

Another substantive concern in this high-risk earthquake coastal area is the presence of nuclear power plant. As described earlier, all of the nuclear plants had been either closed or suspended for the sake of safety inspections after the Fukushima accident in 2011, and now 3 out of all 17 nuclear power plant in the country have partially restarted the operation. In the Pacific coastal region of high earthquake and tsunami risk, there is only 1 nuclear power plant, which is the Hamaoka Nuclear Power Plant situated at the Omaezaki city in Shizuoka Prefecture.

In principle, there are specific location requirements for the construction of a nuclear power plant facilities. According to the Agency for Natural Resources and Energy, there are some important conditions for the selection of the site. Firstly, it has to be located in the proximity to the sea due to the need of cooling water and the port through which nuclear fuels can be transported. Secondly, it requires the vast spaces and this eventually limits the option to rural areas where the land price are not excessively high. Surely, this also mitigates the risk of human damages in the event of an eventual nuclear accident. Thirdly, as an earthquake countermeasure, a nuclear facilities should be located on a solid bedrock which is fairly distant from the active faults [1].

After all, all of the nuclear power plants are located in the coastal rural zone because of those location requirements, but the risk of tsunami is somehow neglected or in other words unavoidable. As it is a type of power generation system which is destined to be located at the coastal zone (there is no large river which can satisfy the condition in Japan), the area surrounding the power plants are constantly facing the risk of natural and artificial catastrophe. The Hamaoka Nuclear Plant is now armored by the 22 meters high seawall constructed newly at the end of 2015. There is a gap between the simulation based on the calculation and the actual force of tsunami. As it was the case for Fukushima or other coastal region in Tohoku, there is no absolute safety in the face of unpredictable force of nature. In the worst case scenario, the extent of damage from the nuclear accident at Hamaoka would extend not only Shizuoka but also the entire Tokai region.

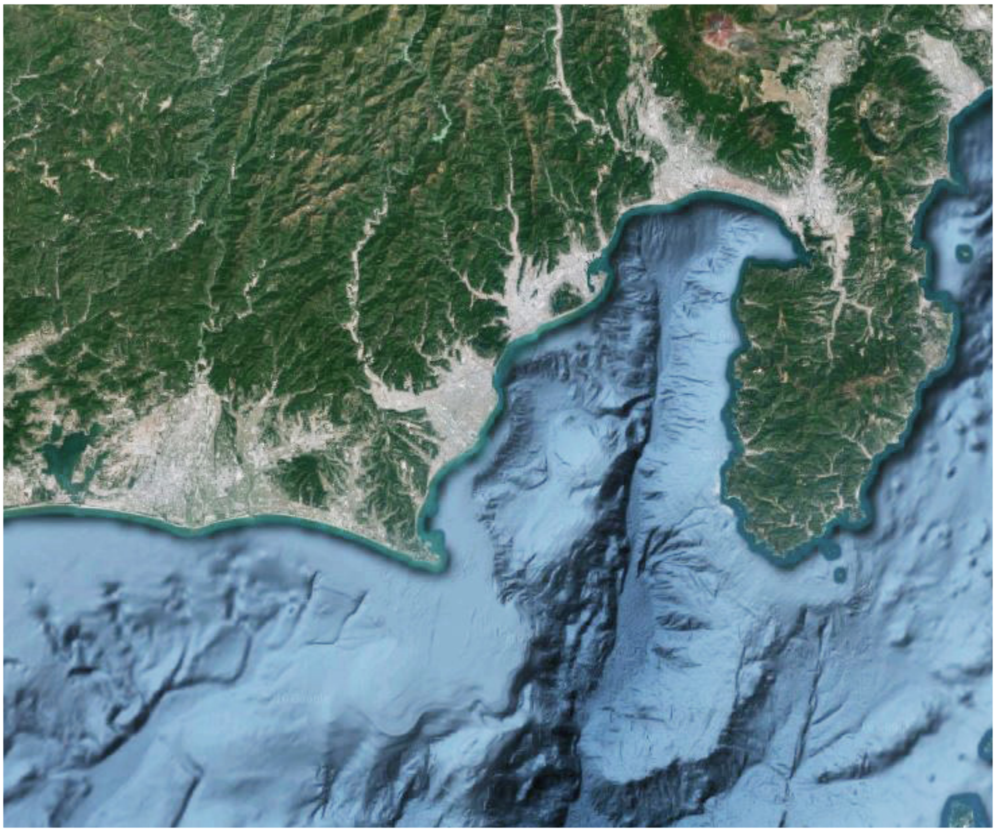
1. Agency for Natural Resources and Energy, "the location of electric generation plants in Japan", http://www.enecho.meti.go.jp/category/others/tyousakouhou/kyouikuhukyu/fukukyouzai/sk/ws-7.html

fig.4 Location and number of units of Nuclear Power Plants
source: Federation of Electric Power Companies of Japan

Vulnerability: Shizuoka Coastal Area

Even though the fact remains that all the areas in the Pacific coastal region are under imminent threat of huge earthquake and tsunami, it came out that some region are potentially more exposed to the risk compared to the others. In particular, the areas around Shizuoka Prefecture is risky and vulnerable area given the trend of seismic cycle, the proximity to the potential epicenter, the population, the expected death toll and tsunami height, and the presence of the Hamaoka Nuclear Power Plant.

On the basis of these observations, the next section will further study the historical, geographical as well as infra-structural aspects of Shizuoka coastal region which are related to the tsunami disaster prevention.



Shizuoka Coastal Region Aerial View

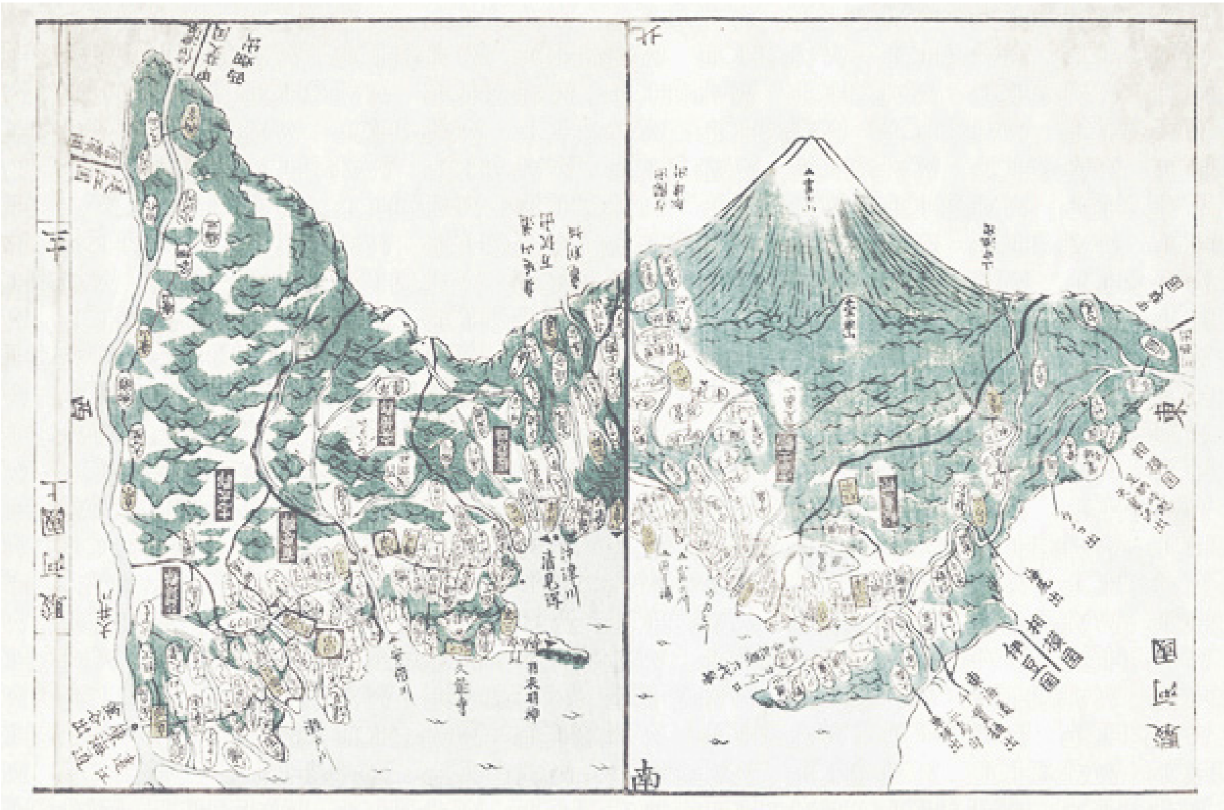
source: google earth

b.SITE READING

Following the site selection based on the risk analysis, this section intends to build the deeper understanding about the complex cultural and physical system of the selected site by means of mapping.

This involves the understanding of the culture element of the site such as the historical settlement or the landscape as well as the physical character of the site such as topography, infrastructure, and disaster prevention facilities including coastal defense structure and evacuation facilities.

Old Settlement: Suruga Province



Until the beginning of Meiji period (1871), Japanese territory was divided into 68 provinces and Suruga province corresponded to the today's central part of Shizuoka Prefecture. Suruga had 12 *Shukuba* (post station) where travelers could rest on their journey along the Tokaido. The map from feudal Edo period in 1837 depicts the Mt. Fuji in vertical elevation and other natural elements including rivers and forests were also expressed in an exaggerated manner. It can be observed that the settlement stretched and concentrated along the Pacific coastline and the rivers as with today. This map seems to illustrate not merely the political division of each family but also the implied perception of the natural environment which surround them.

fig.1 Map of Suruga Province 1837 (current Shizuoka)

source: Toukei Ichikawa, "kokugun zenzu" 1837, the image taken from http://www.mapshop.co.jp/products/detail.php?product_id=24994

This map derives almost from the same age (1838) and records in more precise way the settlement pattern at the Suruga Province. Mountains, rivers, and roads are depicted and the colored ellipses are all villages and the different color represents different districts ("*gun*") which govern those villages. At that time, there was no actual "urban" settlement and it was rather an aggregation of small villages which formed the settlement pattern.
At the *Miho no Matsubara* (pine grove), now a scenic area on the Miho Peninsula in Shimizu Ward of Shizuoka City, was once entirely covered by pine trees and they are depicted on this map.

fig.2 Map of Suruga Province 1838 (current Shizuoka)
source: National Archives of Japan, https://www.digital.archives.go.jp/DAS/pickup/view/detail/detailArchives/0303000000_4/0000000273/00

Cultural Landscape of Suruga: Hiroshige

Hiroshige's famous 36 *views of Mt. Fuji* depicted the symbolic landscape of Mt. Fuji which has been worshiped since ancient time in Japan. It is not a realistic description of the mountain, but is rather an abstract presence of the sacred mountain in the landscape in varying seasons and weather conditions.
The paintings on the right page are both from the Sugura Province around the Shimizu ward of the current Shizuoka city.

The left image, entitled "*The Pine Forest of Miho in Suruga Province*" (1853), (fig.2) depicts a sequence of landscape elemetns from the pine grove, the bay, the humps to the Mt. Fuji. This pine grove, known as "Miho-no-Matsubara" is up to date widely known as a seashore with beautiful sand and beautiful pine trees from which people can enjoy a scenic view of Mt. Fuji and the Izu Peninsula across Suruga Bay. Due to its beauty and the cultural and historical relationship with Mt. Fuji, it is designated as a scenic natural site in Japan [1], and also was added to the UNESCO world heritage list as a part of the Fujisan Cultural Site [2]. On top of the cultural importance, the pine grove has an important role as a coastal disaster prevention forest and it has to be preserved, fostered and passed down for the next generations [3].

The right image is called *"The Sea off Satta in Suruga Province"* and painted in 1858. (fig.2) The composition of the painting emphasizes the contrast between the raging wave in the foreground and gentle and beautiful Fuji landscape in the background. The wave looks wild and rough, yet the sky looks light and calm. There is a ship in the distance which looks feeble in contrast with the energy of the wave. This combination and contraposition between stillness and motion, between a ship (artificial) and a wave (nature) seem to imply the abstract interpretation of the landscape, which constantly changes over time and the precarious yet harmonized relation between people and nature.

The symbolic importance of the three important landscape elements; the Mt. Fuji, the Suruga Bay as well as the Miho-no-Matsubara (pine grove); represents the particular "*fudo*" and the cultural significance of the area.

1. The National Important Cultural Property Database, http://kunishitei.bunka.go.jp/bsys/maindetails.asp

2. UNESCO, http://whc.unesco.org/en/list/1418/multiple=1&unique_number=1883

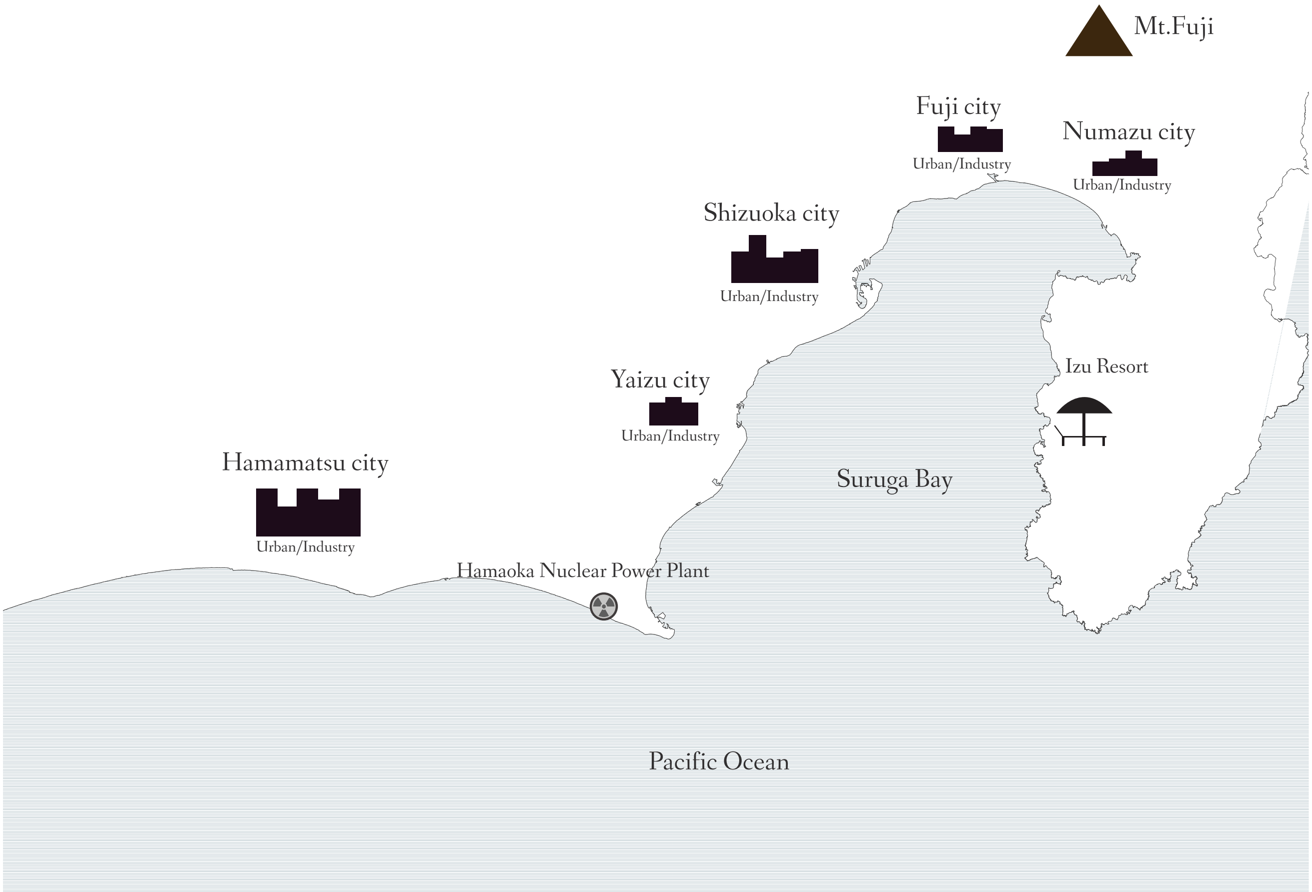
3. City of Shizuoka, "General Planning of Management for Miho-no-Matsubara", May 22, 2015, http://www.city.shizuoka.jp/701_000010.html

Thirty-six Views of Mount Fuji, Hiroshige Utagawa

fig. 3 (left): The Pine Forest of Miho in Suruga Province (1853)
source: https://ukiyo-e.org/

fig.4 (right): The Sea off Satta in Suruga Province (1858)
source: http://www.hokusaionline.co.uk/images/hiroshige/hiroshige1.jpg

Schematic

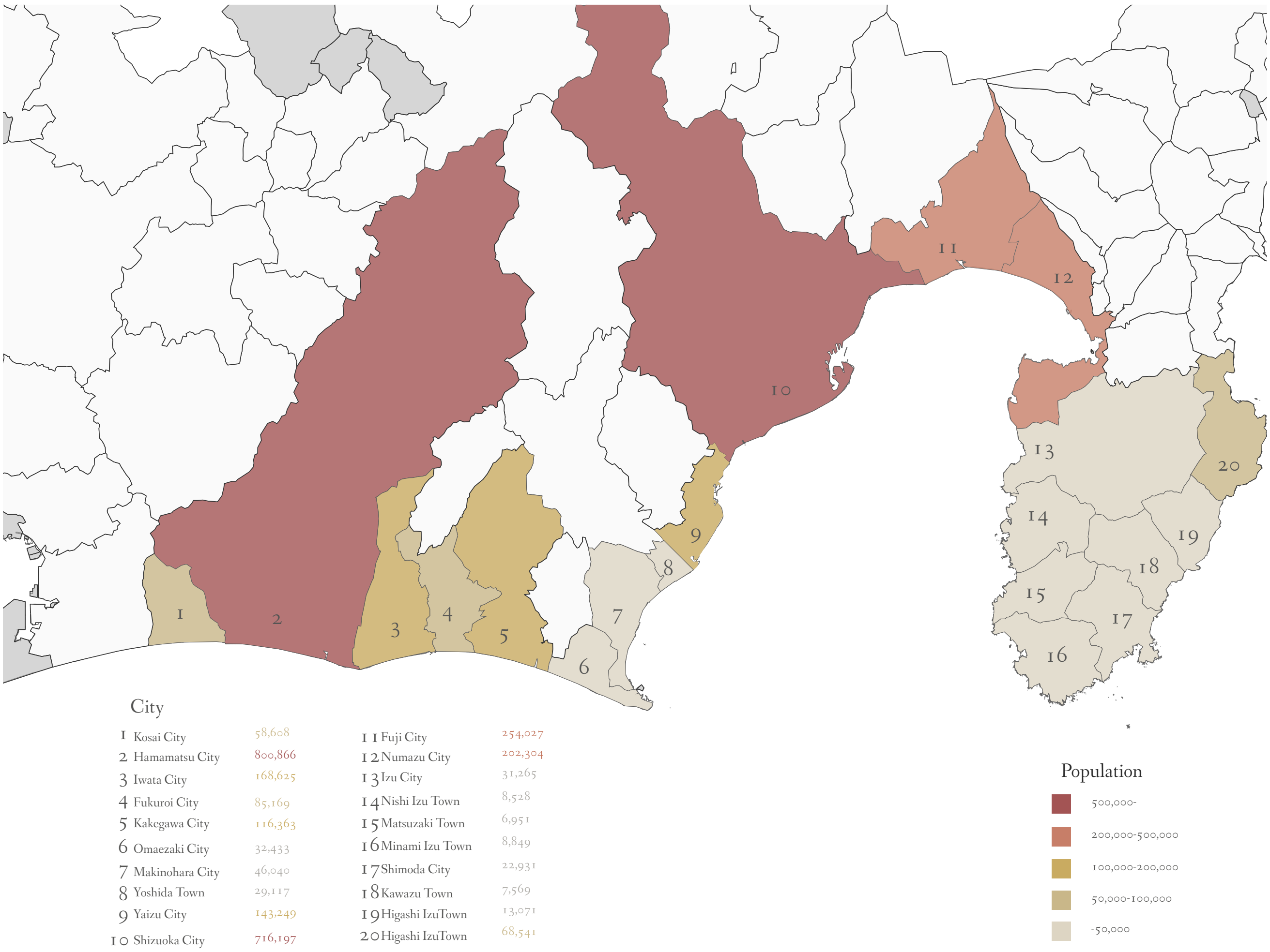


As an introduction, this schematic map aims to gives the rough and general layout of the Shizuoka coastal region. The major cities are Hamamatsu, Yaiszu, Shizuoka, Fuji, and Namazu and they are spreading along the Pacific coast. Those cities constitute the Tokai Industrial District and the major urban infrastructures have developed along with these areas. The west part, on the contrary, did not follow the same logic and developed as Onsen resort. The Hamaoka Nuclear Power Plant is located at the south tip of the Omaezaki cape and the famous Mt. Fuji is situated at the northeast of Fuji city.

fig.5 Schematic layout of Shizuoka

Data source: Google Maps

Population



Shizuoka Prefecture is composed of 23 different local municipalities and has the total estimated population of 3,686,945 as of October 2016. Among the most populated cities include Shizuoka city (716,197) , Hamamatsu city (800,866) , Fuji city (254,027) and Numazu city (202,304), all of them facing to the Pacific Ocean and being part of the Tokai Industrial District. The area of in the west part of the prefecture on the Izu Peninsula are less populated and primarily known as an *onsen* hot spring area which attracts tourists from Kanto region.

fig.6 Population by municipality

Data source: Shizuoka Prefecture

Hydrography

Following the topography, there are many rivers running from the mountain to the Pacific ocean. As urban settlements are located along rivers and there is a risk of tsunami run-up, the location of rivers have a significant implication for the disaster prevention. The major river in the region include Tenryu river between Hamamatsu and Iwata city, Oigawa between Yaizu city and the town of Yoshida, Abe river in Shizuoka city, Fuji river in Fuji city, and Kano river in Numazu city.

fig.8 River & Lake System in Shizuoka

Data source: Natural Earth, Ministry of Land, Infrastructure, Transport and Tourism

Topography & Low Land Flood Zone

Shizuoka has a rich variety of topographical characters. The major cities including Shizuoka or Hamamatsu are spreading around the low land along the coast or the river. The east side of the Suruga Bay has more rich topography without low land and this explains the reason why there is no dense urban settlement there. The Mt. Ashitaka (1,188m) and the Mt. Fuji (3,776m) are situated northeast of the Sugura Bay and surrounded by low land urban areas including Fuji city, Fujinomiya city, Numau city, Susono city and Gotenba city. The coastal urban areas are all located in the lower elevation and thusly are exposed to tsunami risks.

fig.9 Topographic contour & Low land flood zone

Data source: Natural Earth, Ministry of Land, Infrastructure, Transport and Tourism

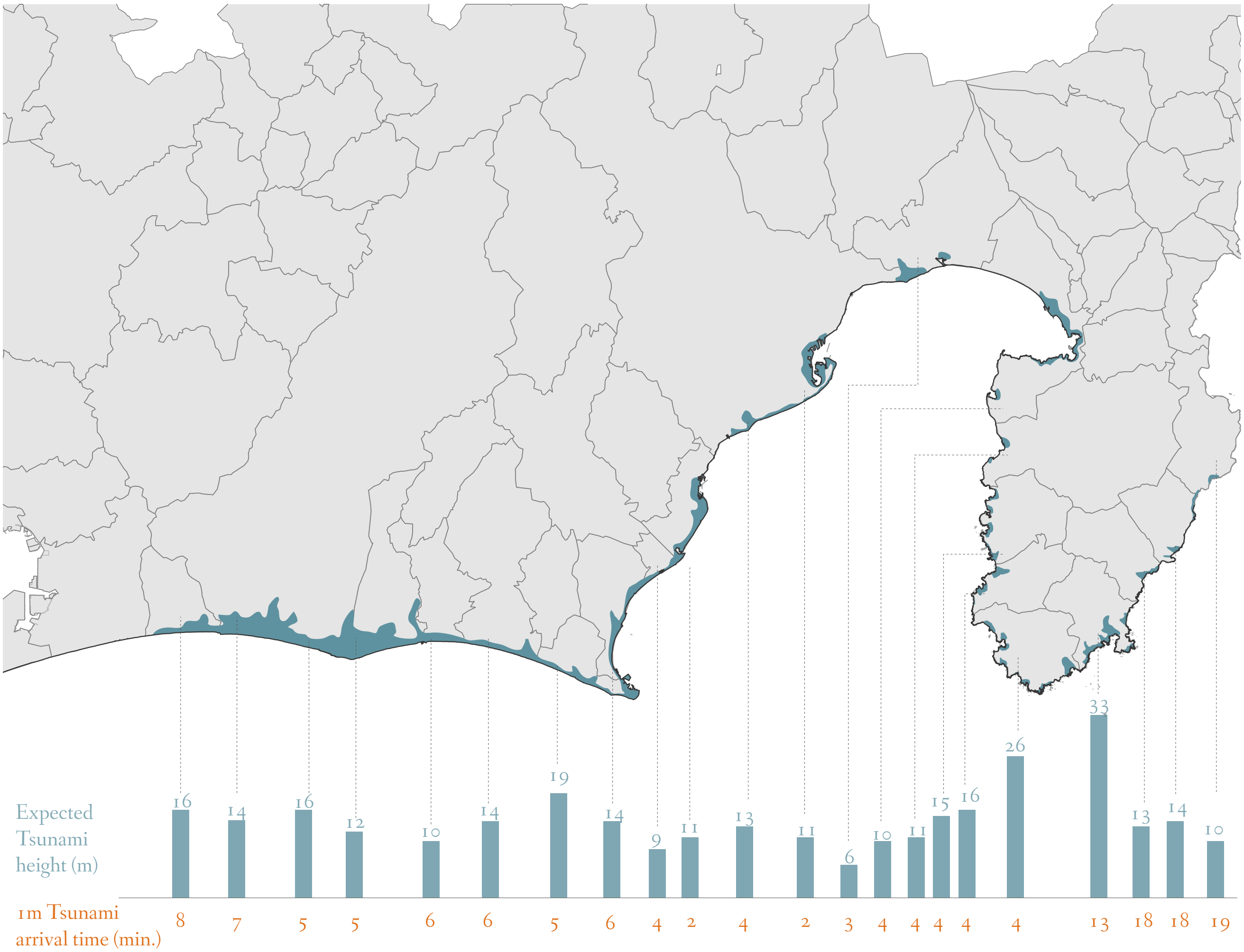
Urban Area/Infrastructure

The urban area as well as the urban infrastructure such as roads and railways are by and large following the shoreline, connecting major cities like Hamamatsu, Shizuoka, Fuji or Numazu, and forming the continuous band of urban settlements. The east part of Shizuoka Prefecture, around Izu Peninsula, is not urbanized and works as a sparsely populated resort area. Another exception is the area around Omaezaki cape where the Hamaoka Nuclear Power Plant is located. The area is also less populated, not served by railways, and has a suburban character.

fig. 10 River & Lake System in Shizuoka

Data source: Natural Earth, Ministry of Land, Infrastructure, Transport and Tourism

Tsunami Height & Arrival Time

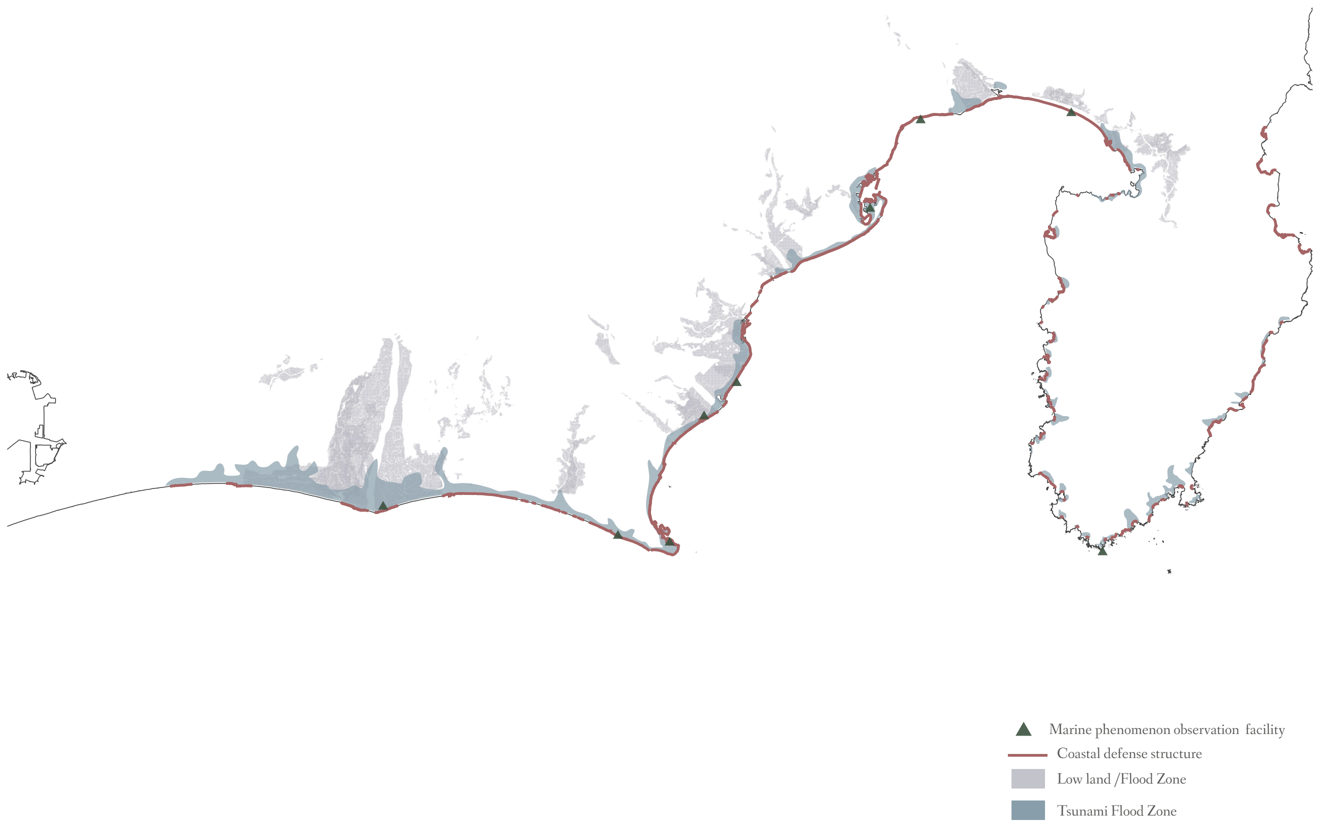


The variation of the expected tsunami height and its arrival time reflects the complex topographic feature of the region. The highest tsunami is expected to hit the tip of the Izu Peninsula, in particular the area around Shimoda city (33m) and the town of Minami Izu (26m). The height of the tsunami is relatively lower for the area around the inner bay including Shizuoka, Yaizu, Fuji and Numazu city, but instead the tsunami arrival time is expected to be very short after the occurrence of earthquake. For the coastal area along the Enshu rough sea including Hamamatsu city, the expected tsunami is relatively higher than the inner bay areas and the tsunami arrival time is also short.

fig.11 Tsunami expected height & Arrival Time

Data source: Asahi Digital, http://www.asahi.com/special/bousai/TKY201208290776.html

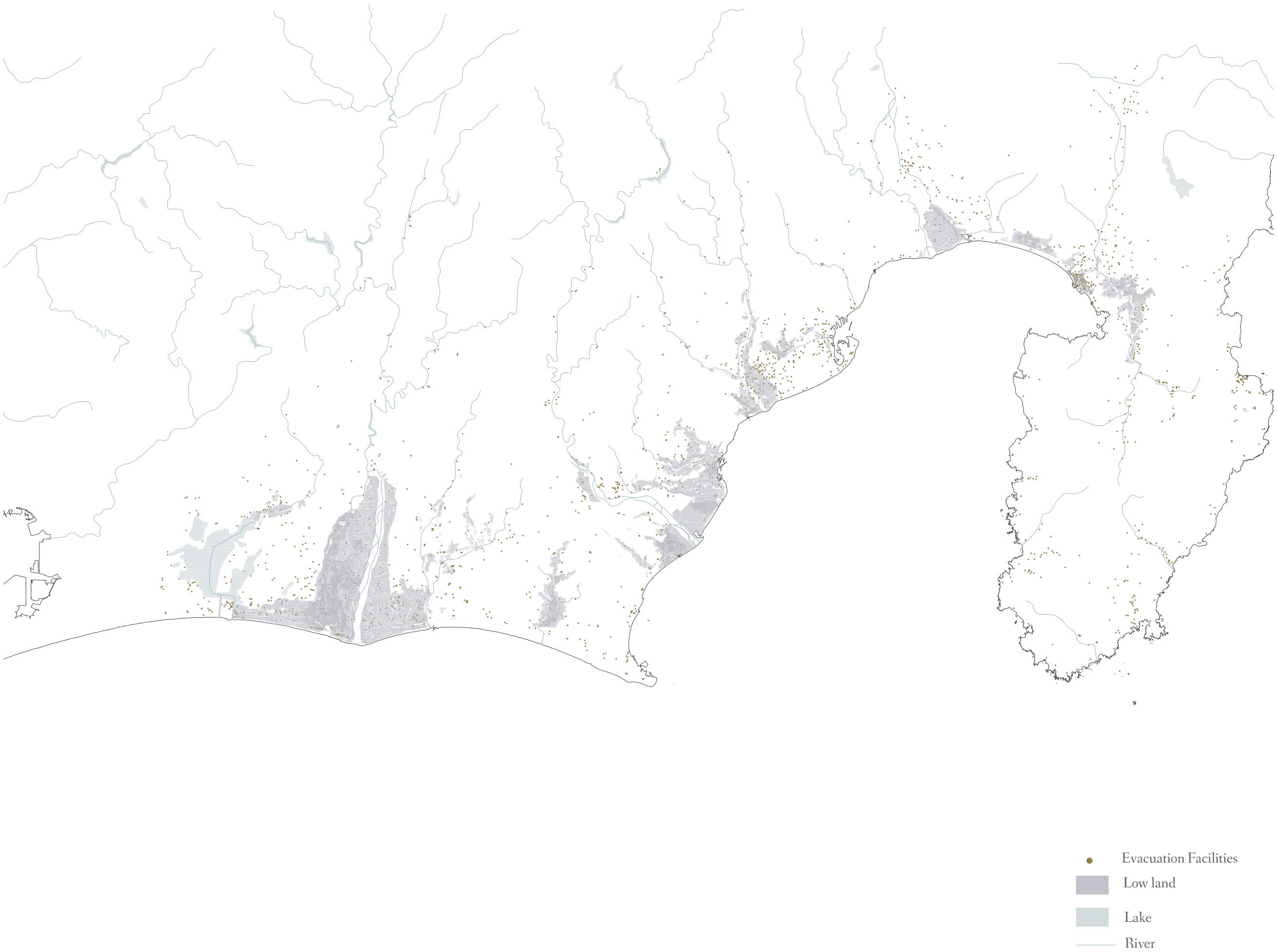
Coastal Defense Infrastructure & Facilities



The most of the coastline is protected by some form of coastal defense structure shown in the red line, but there is a variation in the height of the wall. For instance, one of the tallest seawall in Japan (17m) is stretching 20km along the coast from Fuji to Numazu city while other region have the wall hight of only 3 meter. The area less protected by such structure is on the west of the prefecture around Hamamatsu city and Tenryu river. This area is also designated as tsunami flood zone and there is a low-lying land along the Tenryu river which could be flooded if the tsunami wave runs upstream.

fig.12 Coastal Defense Structure & Tide Observation Facilities
Data source: Natural Earth, Ministry of Land, Infrastructure, Transport and Tourism

Evacuation Facilities



A number of evacuation facilities spread across the region and its location generally corresponds to the urban settlements. Therefore, evacuation structures tend to be located either near the coast line or along the rivers. While the facilities are rather concentrated in a small area in Shizuoka city, they are more dispersely situated for other cities. This could be explained by the fact that the low land in Shizuoka city is densely populated while the other low land such as the area along the Tenryu river in Hamamatsu is less populated.

fig.13 Evacuation Facilities, Low land, and Hydrography
Data source: Natural Earth, Ministry of Land, Infrastructure, Transport and Tourism

Synthesis of Site Reading

By superimposing the layers, it reveals that the Shizuoka coastal territory works in a complex system of natural and artificial elements including the topographic character, the presence of coastal defense structures and the settlement patterns. Each distinct region has its own set of conditions to deal with and the *bousai* plans therefore need to be locally specific in order to mitigate the local risk. By reading the map, it comes out that each region is exposed to different kind of risks due to their local specific conditions.

For instance, the region between Hamamatsu and Iwata city is more exposed to the sea and less protected by the coastal defense structure though there is an expansion of low-lying land along the Tenryu River. Another critical area would be Shizuoka city where the population density is high and the city lies on flat lowland. Another problematic site would be the coastal area from Fuji to Numazu city, where the urban territory is separated from the ocean by 17 meter high seawall which continues 20 kilometers along the coastline. The east part around Shimoda city on the Izu Peninsula is also considered risky area where the highest tsunami is expected to hit due to its geographical location and the topographical feature. The risk of the Hamaoka Nuclear Power Plant around the Omaezaki cape should also not to be underestimated.

On top of these physical risk analysis, the invisible factors such as the financial issues , the political engagement as well as the culture of locals would also play a significant role in the formation of robust tsunami resistant community. After all, the disaster risk should be considered in parallel with the desire of each community. In any case, there would be no absolute protection nor safety measure to protect the territory facing tsunami and it eventually boils down to the question of political decision; how much money are they willing to invest for the protection and to which degree should those territories be protected and what kind of relationship do people want to keep with the nature? On the one hand, the choice of no physical barrier would actually wreck an tremendous damage to people and to the city, but on the other hand, the overprotection by means of physical barrier would break the continuity of the urban and the natural territory as well as the essential relationship between people and the sea which has been maintained since ancient time. With the understanding of this dilemma of *bosai* strategy, it is crucial to have both pragmatic and visionary idea upon the future territory where the *bousai* is well integrated into the life of citizen and its symbolic relationship with nature.

fig.14 Analytical Map Synthesis
Data source: Natural Earth, Ministry of Land, Infrastructure, Transport and Tourism

Conclusion: Synthetic Reflection and Vision

In the first chapter *SAIGAI,* some of the important cultural and historical topics concerning tsunami disaster in Japan were discussed with the aim of providing a theoretical foundation through which the practical and contemporary disaster prevention issues can be referred. Through the study of cultural concepts regarding landscape and disaster, it was revealed that ancient Japanese community lived under a particular cosmology in which human society was not identified in isolation from the nature's broader system. The absence of anthropocentric perspective in relation to nature derived from the faith particularly related to Shintoism and Buddhism and blurred the clear boundary between inside and outside world. The landscape was not to be measured nor to be seen, but to be perceived through the inner spiritual eye. The occurence of natural disasters was believed to be an unavoidable fate or some sort of punishment due to human's misbehaviors. Japanese society has always developed with the awareness of constant risk of natural hazards, and those risks have certainly played an important role in forming the cultural sensitivity toward nature.

In the light of radically changing society and living environment since the Meiji Restoration at the end of 19th century, such a traditional conception of anti-anthropocentric cosmology seems to be fading under the strong influence from the Western culture. With the technological innovation and the accompanying societal paradigm shift, Japan has developed into a major economic power. The belief in the development and the confidence in the technology seem to be pushing the country even further. The scattered presence of numerous nuclear power plants nationwide implies either the overconfidence in the technology or the aweless attitude toward natural threats.

In the aftermath of Tohoku Earthquake and tsunami in 2011, Japanese society has reacknowledged the major risk of tsunami and each local community is now strengthening its effort to create a robust bousai system in preparation for the forthcoming disasters. The second chapter, BOUSAI dealt thusly with such practical tsunami disaster prevention measures with its types, case studies and the pros and cons. Through these studies, some practical issues such as finance or politics as well as spatial implication of each measures were laid out. The infrastructural approach exemplified by seawall and breakwater seems to reflect the modern mentality to "measure" and to "resist" the force of tsunami. The landscape structure, on the other hand, make use of the territory to mitigate the effect of tsunami. This also involves the participation of citizen in planting tree and creating "living seawall". The evacuation structure deals more with people, providing towers or shelter for the eventual evacuation in case tsunami wave exceeds the coastal defense structures. Besides those single measures, the hybrid structure, which incorporates other utilities on top of the disaster prevention purpose, was discussed in order to shed light on the potential of those structures to be integrated more into the community. As discussed earlier, there is no single measure which can resolve the complex issue of tsunami disaster prevention and those measures need to supplement each other to achieve an effective disaster prevention. Since the *bousai* issues touch on the lifestyle of people, it inevitably involves the politics and it needs to reflect the particular local condition.

In the third chapter, a potential project site was identified based on the risk analysis through mapping. Due to the imminent risk of the Nankai Trough Earthquake, the coastal region facing the Pacific Ocean are subject to greater risk in the coming decades. Especially, the area around Shizuoka Prefecture turned out to be particularly vulnerable due to its geographical location, relatively high density of population, the magnitude of estimated tsunami height and the presence of the nuclear power plant. The area was further analyzed based on the mapping and it identified some of the risky areas. Each area has its unique set of conditions and exposed to different kind of risks.
To propose a possible solution for tsunami mitigation, we would need to have the vision, the planning and the design of the actual system. Further detailed studies of the site would be carried out as a feasibility study at the beginning of the project phase.

Throughout these three chapters, the issue of tsunami disaster mitigation was discussed through the theoretical, practical as well as territorial perspectives. They were not intended to draw a linear discourse of the issue, but instead to capture the complexity of tsunami *bousai* from various angles. The dilemma of *bousai* is closely intertwined with the dilemma of cultural issue, life style, and the underlying phylosophy between ancient and contemporary Japanese society. In fact, Japanese society is now revaluing the importance of *bousai* after Tohoku earthquake and it does not only concern the safety but also their life in general. Therefore, in a sense, the reflection on the *bousai* in the community could become a crucial stepping-stone for the re-conceptualization of cultural landscape and the essential relationship between man and nature.

The Japanese Architect Toyo Ito, in his book *"Ano hi kara no Kenchiku* (*Architecture after that day*)*",* argues that the problem of the tsunami disaster prevention lies in the idea to simply "separate" things; between interior and exterior, inside and outside, dangerous and safe zone etc. The modernistic rationality and clarity are beneficial for the technological development but it neglected the role of ambiguty. As the richness of traditional Japanese architecture lies in this ambuity of the space without the clear demarcation between functions or interior and exterior space, he argues that the same principle could be applied to the tsunami defense [1]. His view seems to correspond to the cultural perception and relationship with nature, which regards the inside and outside in an integrated manner.

With reference to the traditional landscape concept in Japan, it would not be simple to say which way of tsunam prevention measures are culturally coherent since the culture itself has evolved. While people would love to keep their contact with nature, the fear of physical and financial damage would necessitate the construction of seawall. However, it is still crucial to look back on the origin and to reacknowledge that human culture does not confront nature but to merge with it.

There is no simple solution for the contemporary dilemma, but we would need to develop a long-term *bousai* strategy which serves not only to "protect" but also to "foster" the system of resilient coastal living space.
I would like to conclude with the synthetic visions based on the reflections above.

Toyo Ito, "Ano hi kara no Kenchiku", p37, Shueisha, 2012

1_INTEGRATED SYSTEM OF HABITAT/RESPECT *FUDO*

The tsunami *bousai* has to be an integral part of "*Fudo*", which is a cultural and physical climate rooted in the territory. Nature and human do not exist as a contraposition but as an integrated whole and therefore the landscape vision needs to incorporate mountain, city, and ocean on a equal footing.

2_CONTINUITY THAN SEPARATION

The creation of clear boundary in the territory would not only risk the loss of contact with nature but also break the ecological flow and to cloud people's awareness toward tsunami. Therefore, the tsunami defense system should be designed without sacrificing the spatial continuity of the territory. Practically it aims to rely less on unreasonably high seawall structure.

3_REQUALIFICATION OF EXISTING COASTAL SPACE

Another vital task would be to render the space around the existing coastal structures more accessible or profitable for local citizens. The pragmatic purpose of "protection" should not sacrifice the territorial integrity and potential of varied actiities (hybrid structure) should be further explored. For instance, the existing seawall or breakwater structure could incorporate activity or function which would invite people or benefit them.

4_ MULTIPLE LAYERS OF BOUSAI STRATEGIES

No single tsunami disaster prevention measure can suffice to provide the safety.
Therefore, we would need to design the well-functioning "layers" or "gradation" of disaster mitigation measures, which does not work in isolation but to function as a system.

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