New Countermeasures for Coastal Levees as Stable and Safe Structures against Unexpected Sizes of Tsunami, Storm Surges, and River Flooding - To Cope with Emerging Disasters by Historical Earthquakes and Super Low Pressures around Coastal Mega Cities for Human Habitats in Hazardous Era -

Daijiro Kaneko[1]

[1]Remote Sensing Environmental Monitor

November 22, 2022

Abstract

The author provides stable and safe designs of coastal and river banks using a new structural concept which stably keeps frame structure inside of the embankments, and therefore protects the backside of lowland areas, where more than ten millions of people live and social investment facilities are distributed. The projects can proceed under the framework of Public Private Partnership (PPP). This new proposal simplifies the design of multi water hazards from the probabilistic collapse risks to deterministic planning for human lives and accumulated social public facilities around coastal mega cities such as Tokyo and Nagoya in Japan. Those Metropolitan citizens experienced historical Kanto earthquake in 1923 and largest Tone-River flooding in 1947. On the other hand, heaviest storm surge in Japan by Typhoon Isewan in 1959 around Nagoya City in the Ise Bay facing Pacific Ocean. These regions distribute in flat low elevation areas for conveniences of foreign trade with port facilities, industries, and traffic infrastructures including hub airports. Mean while, those coastal districts and citizens sometimes remains in legendary collapse risks, such as gigantic fires or pandemic infection diseases nowadays along with the catastrophic destructions by M8 to M9 earthquakes, inundation and river flooding against social frameworks to keep human cultural livelihoods in the hazardous era of this modern earth of Gaia.

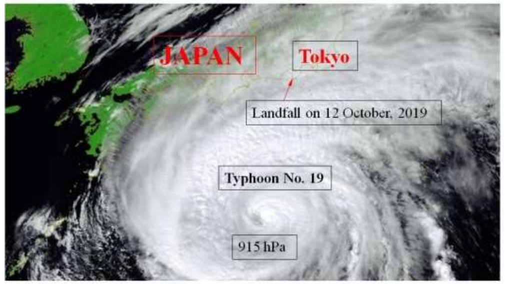
SY15E-0589 NEW DESIGNS FOR COASTAL LEVEES AS STABLE AND SAFE STRUCTURES AGAINST UN EXPECTED SIZES OF TSUNAMI, STORM SURGES, AND RIVER FLOODING - EMERGING DISASTERS BY HISTORICAL M9 EARTHQUAKES AND SUPER TYPHOONS AROUND COASTAL MEGA CITIES FOR HUMAN HABITATS IN MODERN ERA -

Daijiro KANEKO[1] [1] *Remote Sensing Environmental Monitor, Inc. Kanazawaku, Yokohama, JAPAN*

1. Background: Multiple Coastal Water Hazards

1. **Super typhoons** grows by climate change through much evacuation from sea, thereby risks of s river flooding, storm surge and heavy water hazards have emerged recently.
2. Ministry of construction, Land, Infrastructure, Transport and Tourism discuss the countermeasures in thee important bays of **Tokyo**, Ise-wan and Osaka for **water hazards** in low lands of **coastal Mega Cities**.
3. The Author proposes **no-collapse embankments** and improves to cut water **penetration** by stirring mixing solidification of levee foundation.
4. The proposed caisson-embedded banks are applicable to **river flooding, storm surge**, and **tsunami** inundation to urbanized coastal areas including **atomic power generation** plants

Typhoon No. 19 caused widespread damage across Japan.

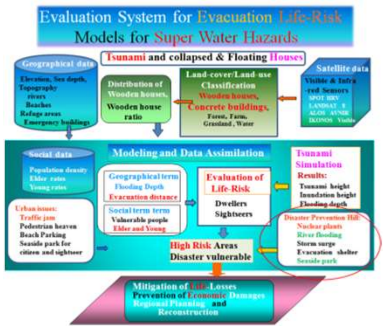


Category 5 **Super Typhoon**

Typhoon Number 19, 2019

Typhoon Hagibis near peak intensity while approaching the Northern Mariana Islands, early on 7 October

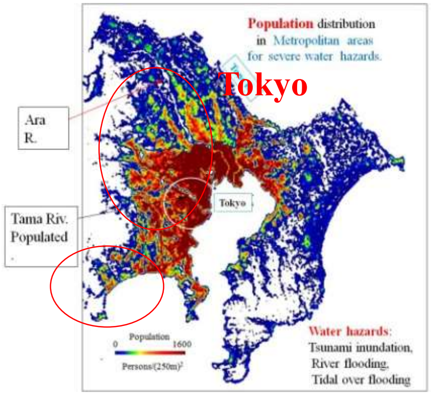
10-minute sustained: 195 km/h (120 mph)
1-minute sustained: 260 km/h (160 mph)
915 hPa (mbar); 27.02 inHg



3. Date and System Flow

Elevation of the shonan coastal areas

1. The models for citizens and sightseers includes social and geographical data such as population density, wooden-house ratio, evacuation distance, and tsunami flooding depth to evaluate the distribution of life risk characteristics in the area.
2. Among the population of 174,050 people in Kamakura city, the risk of tsunami evacuation life was high from the southern part of Kamakura Station to Zaimokuza block, and the population was about 15,310 people.
3. There are about 26,000 people per day and about 100,000 sight sightseers on Saturdays and Sundays. On weekdays the population per mesh will increase by half of the 2,000 inhabitants.



Population density

2. Life-Risk Modeling

$$R_{iskD} = \left[\left\{\left(\frac{D_{dp}}{D_{p0}}\right)\cdot\left(1+\frac{AG_r}{AG_m}\right)\right\}\cdot\frac{WH_r}{WH_0}\right]\cdot\left\{\left(\frac{D_{ist}}{D_0}\right)^2\cdot\frac{H_{fl}-H_{el}-H_{f0}}{H_{eav}}\right\} \quad (1)$$

where, R_{iskD} : **Evacuation life-risk** for **dwellers** caused by Tsunami flooding

D_{dp} : **population density** on the case of dwellers,

D_{p0} : population density settled for standard dense dwellers,

AG_r : aging rate,

WH_r : **wooden house ratio**,

WH_0: average ratio of wooden houses,

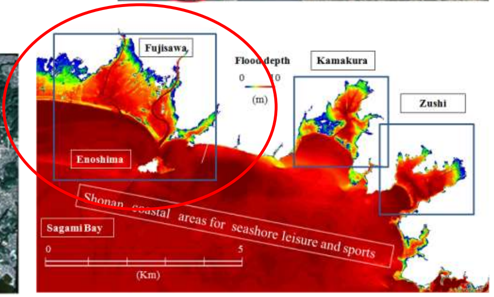
D_{ist} : **refuge distance** to safe and wide specified-parks and hills,

D_0 : standard distance of maximum limit for safe evacuation,

H_{fl} : **height of tsunami flooding**, H_{el} : elevation, H_{fl}-H_{el}: flood depth,

H_{f0} : flooding depth starting from lowest limit to death,

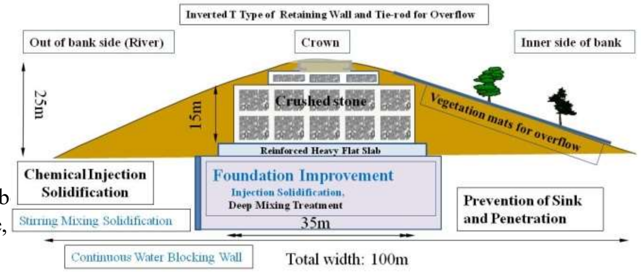
H_{eav} : Eaves height.



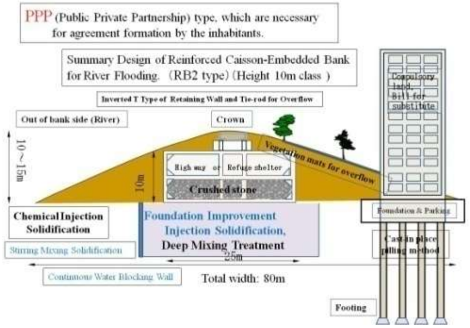
Flooding by Super typhoon No. 19 in 2019 on next day around the Iruma branch river, which flows into Arakawa main river. An photo by his dangerous activity similar to a photographer in war areas, but meaningful academically. (from YouTubeyoutube.com)

5. Caisson-Embedded Banks for River Flood and Tsunami

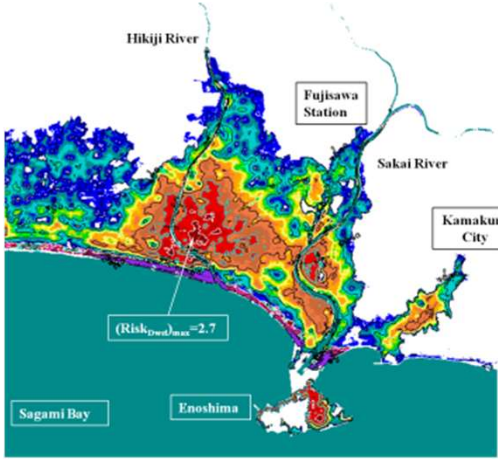
Summary Design of Reinforced Caisson-Embedded Bank for River Flooding (RB2 type) (Height 15m class)



Caisson-Emb Storm Surge,



4. Computed Results



An example of the distribution of human risks in the tsunami inundation into residential areas of Tokyo

Storm Surge and River Flood in Zero-meter Low-Land Areas

6. Conclusions

1. This study has proposed disaster prevention measures to protect **human lives, private properties and social capitals**.
2. The author has showed the risks and the practical applications of **new levees** as effective countermeasures.
3. The new **caisson embedded embankments** can prevent **multiple water hazards** such as river floods, storm surges in representative industrial bays for trade and political or administrative significances such as **Tokyo, Osaka and Ise** bays.
4. This embankments can equip in the caissons with evacuation centers, high standard roads, and also the levees are used as a **green park** for citizens, drivers, and tourists throughout the year.
5. The new embankments can be applied to protect **nuclear power generation plants** from the tsunami inundation.

SY15E-0589:

New Designs for Coastal Levees as Stable and Safe Structures Against Unexpected-Sizes of Tsunami, Storm Surges, and River Flooding

ABSTRACT

Super typhoons are becoming more frequent and powerful under the effects of climate warming on sea surface temperature, increasing the risks of tidal surges and river flooding. In 2019, typhoons caused large-scale flooding damage throughout East Japan. The Ministry of Land, Infrastructure, Transport, and Tourism has examined the risks of high tide and flood for three major gulfs: Tokyo Bay, Ise Bay, and Osaka Bay. These areas are below zero elevation level, resulting in extreme flood disasters. The government has considered refuge measures, but the evacuation of the population from flooded areas is an extreme undertaking, causing refuge difficulties, and is known to be a limit for countermeasures. This study proposes improved embankment structures to control river flooding in well-known basins of the Arakawa River and the Tone River. The author intends to restrain the flow using dikes of concrete-caisson inside the embankment and prevent extensive flood damage in the metropolitan downstream areas. These dikes do not collapse under extreme flood velocity and overflow. Small lakes equipped with effective water storage flood ponds with low overflow dikes will assist in managing the floodwaters.

This study provides safe and sound designs for nuclear power generation (NPG) plants by applying coastal tsunami levees with the structural concept of keeping a united fabric and protecting NPG without collapsing the levees during an unexpected tsunami.

1. Introduction

The Ministry of Land, Infrastructure, Transport, and Tourism investigated high-tide countermeasures by studying three areas below sea level: Tokyo Bay, Ise Bay, and Osaka Bay. This study aimed to overcome the impacts of super typhoons that have continuously become more substantial due to climate warming. The accompanying risks of high tide, in conjunction with river flooding, are increasing remarkably. In the example of the typical super typhoon No. 19 in 2019, the heavy rain brought large-scale damage throughout East Japan, resulting in the realized fear of river basins flooding. The population that took refuge from the flooding was considerable. In addition, there was extreme difficulty in understanding the policies for adequate refuge against the storm surges.

This study first examines the field of tsunami inundation and then extends to river flooding by examining the phenomena of water penetration under embankments.

The study intends to contain the broad flood-damaged area to the eastern side of the lowland areas by applying a new type of levee: flood-adjustment reservoirs. These levees ensure that the reinforced embankments do not collapse because of overflows and storm surges.

Even in these disadvantageous areas, the defense of water hazards is possible as the stable reinforced dikes will not collapse at high tide or during flooding and tsunami inundation in coastal mega cities.

On the other hand, it is necessary to obtain residents' agreement for the public construction of the embankments by changing their private land for the public benefit. A typical example is mansion construction, as the objective is to benefit each other. This policy is called Public–Private Partnership. In this policy, the infrastructure should be for the co-benefit of public and private objectives in highly populated areas with expensive land values. Usually, these areas are difficult to purchase for public sectors in mega cities.

This study suggests a plan for the entire river basin for river improvement in the capital by adopting the anti-flood reservoir function and an adjustment pond; the rise of a riverbank and intermittent embankment to overflow in conjunction with the new concept of cross-sections.

This study proposes a management plan of the river basin to improve the capital by adopting the functions of flood control basins and the rise of the riverbanks in midstream areas so they will not overflow the top of the bank. The central part of the management proposal is the non-collapse embankment to prevent overflow into important industrial or highly populated areas.

Super typhoons and flood disasters cause loss of life and marked loss of economic and social investments in infrastructure in the highly populated capital of Tokyo. The current methods used to protect the urbanized areas are problematic, even the large-scale refuge plan, due to the economic damage to society and the loss of human lives.

2. Study areas

The disaster prevention countermeasure study areas are those below sea level, including the downtown center of East Tokyo. However, the assumed flood level areas are the basin of the Tone River and the downstream location of the Ara River.

Therefore, the bank body structures around the junction of each objective river and small supporting rivers allow them to be robust against flooding and include the adjustment of water storage functions.

The simulated flood pattern arrives from the east, downstream to the capital; the damaged areas in the south end of Tokyo Bay are the focus areas, designed to prevent severe flooding of the urbanized areas. Therefore, this study includes each prefecture of Tokyo, Kanagawa, Chiba, and Saitama.

In the map of the population density distribution of these metropolitan areas, the author showed three prefectures of population density distributions around Tokyo Bay.

The elevated risk at the time of the disaster of the metropolitan area is specified clearly through the primary disaster factor expressed by the population density distribution shown in Figure 1.

On the other hand, one of the water hazards of tsunami inundation, the primary tsunami breakwater, was maintained in the Kamaishi Port in northern Japan. However, the caissons collapsed under the pressure of tsunami waves (estimated to be 13.7 m in height) caused by the East Japan Pacific offshore earthquake.

3. Characteristics and consideration factors for the levee structures not to collapse

(1) Collapse phenomena

These collapse phenomena are repeated due to the manageable condition of running over the soil bank and digging to the dike foundations.

1) Recently, the bank soil components have been the most common weak point for the collapse of the levees. The cross-sectional river levees repeatedly collapsed despite many large concrete structures distributed around urbanized city areas.

2) Restraint of water permeate and a chemical solution for solidification as follows:

A steel sheet pile for a core wall is effective as a method of chemical injection solidification for foundation improvement. The author makes a pillar-shaped core wall connection of deep cement mixture (the chemical stirring solidification) in the bank outside and inside of the levee body. The purpose for the chemical solidification of the dike is to stop the permeation in the foundation in the case of a sandy soil foundation.

3) Even if the soil mound structures are washed out and are lost by flooding over the top of the bank, the concrete caissons are kept stable, and the caissons maintain the fundamental structures

against flooding. The author emphasizes that this structure comprises characteristics to maintain the function as the stable levee with a horizontally long width.

(2) Matters necessary for social consideration

1) The bank must be resilient against the flood to prevent destructive damage to human life, social capital, and private property, and the levee possesses these characteristics so that the bank evades such damages.

Even if heavy rains are likely, as in years with large water discharge, the new levee has the added benefit of its ability to restrain a great disaster.

2) The author proposes robust embankments, assuming the super typhoons connected to climate warming will continue to impact the country's industry and the economy in the critical harbors of Tokyo Bay, Ise Bay, and Osaka Bay, known as the high-tide invasion zone. These areas are typically industrial-accumulated zones in Japan.

4. Strengthened levee and countermeasure against water penetration in the bank foundation

As the river water level rises over a long time, conventional chemical solution infusion while solidifying the broken stone foundation is practical. However, solidification may not be uniform by the chemical solution infusion solidification process to the foundation of the levees. Therefore, the author supports the prevention of wall penetration using a chemical solution stirring mixture

A multipurpose dike embedded with caisson structures protects human lives, private properties, and social capitals. It is a large disaster prevention structure with strengthened hardware for the most disastrous floods and functionalizes the bank body as a comprehensive refuge shelter while protecting embedded roads.

5. Conclusion

This study proposed disaster prevention measures to protect human lives, private properties, and social capitals from improved hardware that differs from the current refuge situation at the time of the flooding emergency. While the former planning places priorities for river improvements against water disasters caused by super typhoons, the frequent possibility of storm surge disasters around the metropolitan areas shows the risks and the practical applications of new levees as effective countermeasures.

The new levees are necessary in coastal areas due to river flooding and high storm surges. The three representative industrial areas for trade, political, and administrative significance are Tokyo Bay, Osaka Bay, and Ise Bay. In those urbanized areas, there can be a compound disaster by river flooding and storm surge in addition to the water hazard of tsunami inundation (although this occurs at low frequency).

1) The new embankment is oblong and stable to withstand earthquakes. It is also durable against other wave powers, including tsunamis, and this is its most crucial design condition.

2) The synthetic arrangements and updated hardware demonstrate improved outcomes for urbanized areas and promote safe mega cities for comfortable human habitation. Citizens can keep social capitals and private properties safe due to reinforced caissons embedded in the levees. They are strengthened against the awful scales of natural water hazards such as river flooding, storm surges, and tsunami inundation.