SY033-801430 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 -

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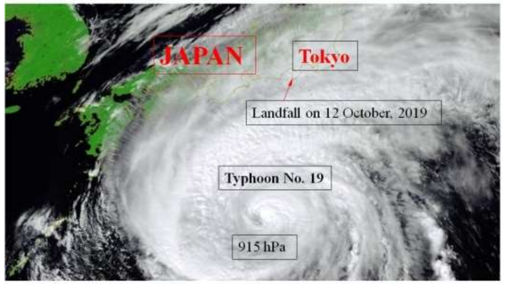
1. Background: Multiple Coastal Water Hazards

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.

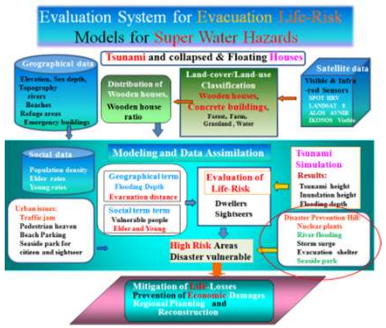


Category 5 **Super Typhoon**

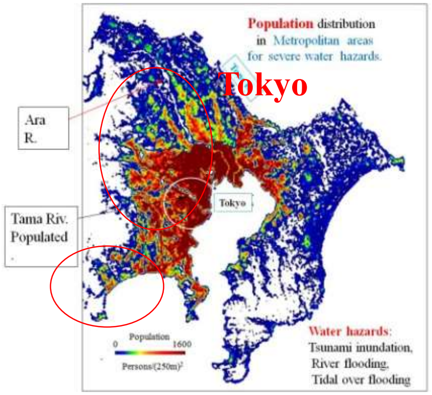
Typhoon Number 19, 2019

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



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.



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,

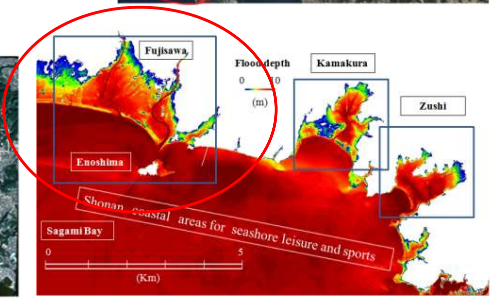
H_{f0} : flooding depth starting from lowest limit to death,

H_{eav} : Eaves height.

Population density

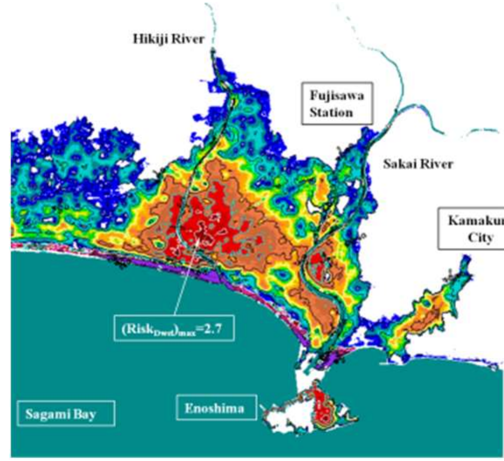
3. Date and System Flow

Elevation of the shonan coastal areas



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)

4. Computed Results

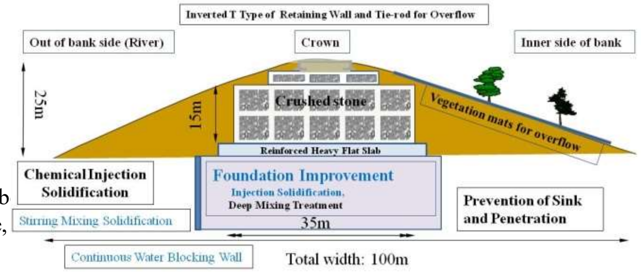


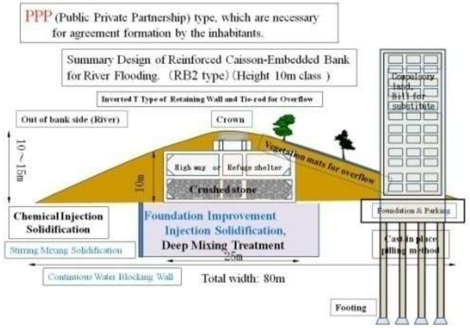
An example of the distribution of human risks in the tsunami inundation into residential areas of Tokyo

5. Caisson-Embedded Banks for River Flood and Tsunami

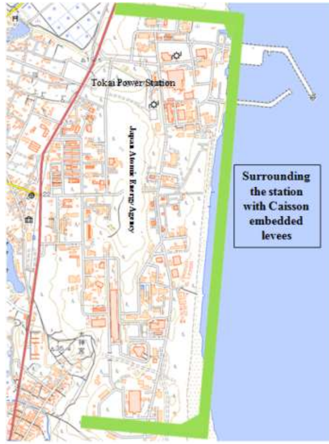
Summary Design of Reinforced Caisson-Embedded Bank for River Flooding (RB2 type) (Height 15m class)

Caisson-Emb Storm Surge,





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.