THE STUDY OF COASTAL DIKE CONSTRUCTION FOR JAKARTA FLOOD PROTECTION

STUDI KONSTRUKSI TANGGUL PANTAI UNTUK PROTEKSI BANJIR JAKARTA

Hari Suprayogi[1)] Agus Rudyanto[1)] Leo Eliasta[2)] Huda Bachtiar[2)] Midian Wahyu Tukuboya[1)] Lily M. Limantara[3)]

[1)] Directorate General of Water Resources, Jl. Pattimura 20, Jakarta
[2)]Research Center for Water Resources, , Jl. Gilimanuk - Singaraja Km 122, Bali
[3)]University of Brawijaya, Jl. Veteran, Ketawanggede, Lowokwaru, Malang

e-mail: huda.bachtiar@gmail.com

ABSTRACT

National Capital Integrated Coastal Development Program (NCICD) in Jakart has main function for flood protection. According to Bappenas, the Updated-Masterplan NCICD program has three phases; 1) Critical-phase 2) Mid-term phase 3) Optional-phase. The critical-phase sea dike construction is projected to protect Jakarta until 2030. Land subsidence is the main factor that the ciritical-phase of coastal dike must be constructed. Jakarta sinks down around 2-20 cm/ year. Therefore, the existing dike level also becomes lower along the time. Three focus area of sea dike construction under Ministry of Public Works and Housing (PUPR) are Muara Kamal, Kalibaru, and Muara Baru. At the moment, PUPR concentrates in Kalibaru and Muara Baru with the physical construction progress around 48% from the total length 4.,8 km and it will be finished in 2019. The construction of typical coastal dike is spoon-pile with shifting construction to the sea between 50 m-100 m from mainland with the crest level +4.8 m from the Lowest Water Spring. This type is chosen because its efficiency on spatial and preventing social conflicts. In addition, the space between the main land and the spoon pile will be reclaimed to use it for public infrastructure.

Key words: *Critical-phase, land subsidence, coastal dike, Jakarta flood protection*

ABSTRAK

National Capital Integrated Coastal Development Program (NCICD) di Jakarta memiliki tujuan utama untuk melindungi Jakarta dari banjir. berdasarkan hasil studi Bappenas berupa Updated-Masterplan, NCICD memiliki tiga fase; (1) Fase Darurat (2) Fase Mid-term (3) Fase Opsional. Fase Darurat berupa konstruksi tanggul pantai diproyeksikan dapat melindungi banjir sampai tahun 2030. Land subsidence merupakan faktor utama Jakarta mengalami banjir dan jika land subsidence tidak dapat ditangani maka Fase Opsional menjadi fase terkahir. land subsidence jakarta bervariasi 3-18 cm/tahun. oleh karena itu, tanggul pantai eksisting akan menurun jika land subsidence terus terjadi. Fokus area konstruksi tanggul pantai PUPR di Muara Kamal, Kalibaru, dan Muara Baru. Saat ini konstruksi sedang dilaksanakan di Kalibaru dan Muara Baru dengan progres fisik 48% dari total panjang 4,8 km dan ditargetkan selesai pada tahun 2019. lokasi ini merupakan area prioritas karena area tersebut merupakan area pusat permukiman dan pelabuhan perikanan samudera milik nelayan dan dikelola KKP. konstruksi tanggul berupa spoon-pile yang dilengkapi capping-beam. Konstruksi tanggul shifting dari pantai sekitar 50-100 m dengan tinggi tanggul +4,8 m dari LWS. pelaksanaan konstruksi tersebut dilakukan karena terkait aspek ekonomis dan sosial. Selain itu, pergesaran ke arah laut tersebut dilaksanakan untuk menambah daratan baru yang nantinya digunakan untuk ruang publik, seperti taman.

Kata kunci: *Fase darurat, land subsidence, tanggul pantai, perlindungan banjir Jakarta*

INTRODUCTION

Jakarta is the national capital city of Indonesia, where the activity center of economy from regional, national, and international scale is located in this city. Jakarta has population about 9,5 million people. According to Presidential Decree no. 54, 2008 Jakarta is one of the strategical area. Jakarta has coastline about 32 km and geographically has borderline Bekasi City in Eastern Part and in the Western Part has borderline with Tangerang City. Nowadays, more than half of population in Jakarta lives in the coastal area.

The coastal zone area in the Northern Part has potential to be developed. In this area, port, warehouse, and trade center are located in the Northern Part of Jakarta. However, Jakarta in the Northern Part is also vulnerable of flooding from the river side and flooding from the sea side. According to study results Coordinating Ministry of Economy 2014, in 1990 only 12 % or about 1600 Ha land in Northern Jakarta is below sea level, the projection in 2030 almost 90% or 12500 Ha land in Northern Jakarta will be below sea level. In addition, the rate of land subsidence about 2-20 cm/year will cause river can not flow to the sea gravitationally and hence it will lead to flood event from river side.

The current flood defences in the coastal zone of Jakarta do not provide sufficient protection against flood. The coastal zone has subsided in the last decades and it is expected to continue doing so at an average rate of about 7.5 cm per year. It will cause river can not flow to the sea gravitationally and hence it will lead to flood event from river side. At the same time, the crest level of coastal dike will also decrease and it will lead to the flooding from sea side.

Three focus area of coastal dike construction under Ministry of Public Works and Housing are Muara Kamal, Kalibaru, and Muara Baru. These are essential due to many people live there. This paper discusses the critical-phase of physical coastal dike construction; parameter for boundary condition, design consideration, and physical progress construction.

LITERATURE REVIEW

Updated-masterplan of NCICD

According to Bappenas (National Planning Agency), the Updated-Masterplan NCICD program has three phases; 1) Critical-phase 2) Mid-term phase 3) Optimum-phase. The Critical-phase of coastal dike is a compulsary phase, where the sea dikes have to be constructed, elevated, and strengthened the existing sea dike. The length of critical coastal dike is about 20,1 km and it should be finished by 2019. The critical coastal dike is constructed by the government (DKI Regional Government and Ministry of Public Works and Housing) and the private company.

The main functional requirement of NCICD is that to provide protection against flooding in the long-term period. The masterplan has to be integrated solution from the upstream to the downstream area; beside engineering aspect, the environmental, regulation, socio-economic conditions are also considered.

Boundary condition

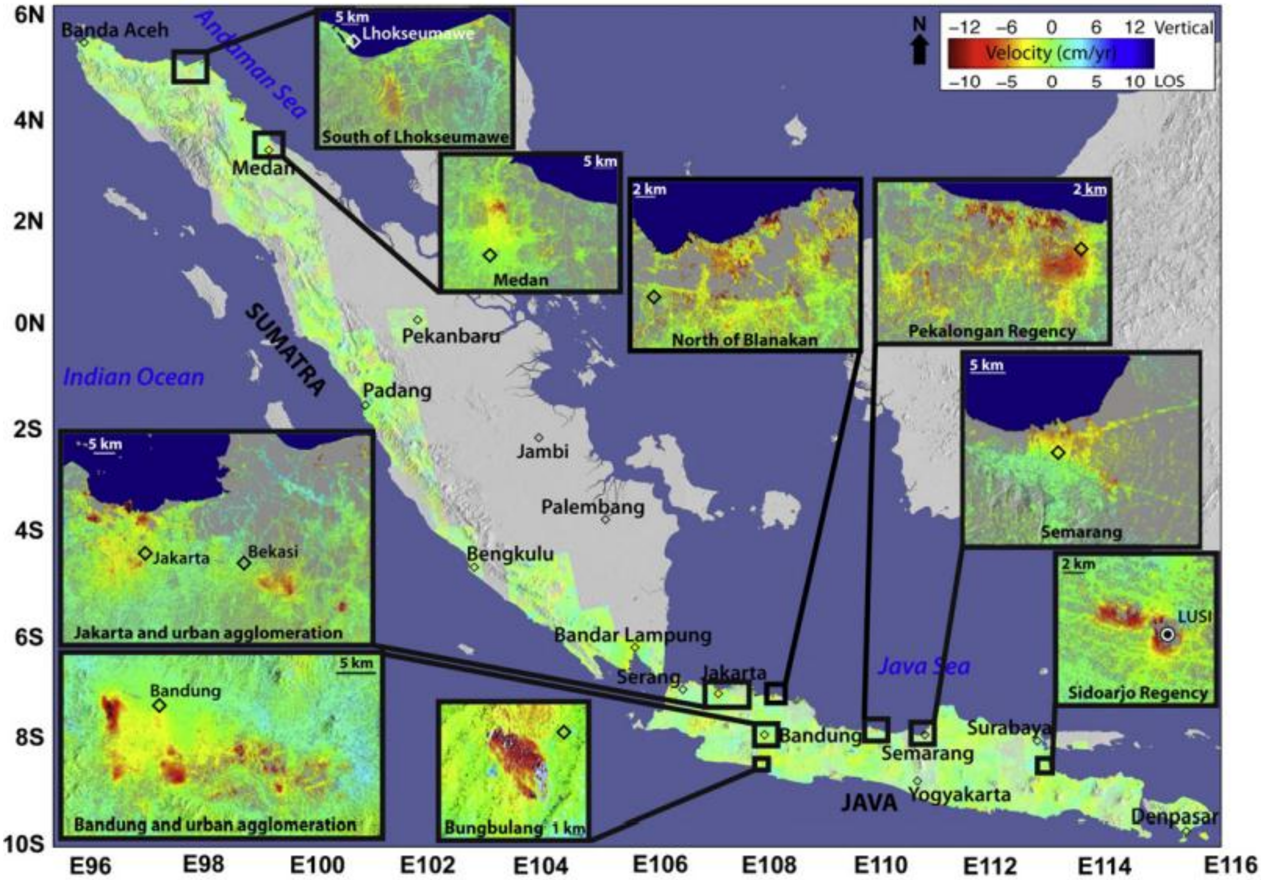
The crest elevation of the dike is based on the boundary condition of the coastal area (SPM, 1984). The dike design is based on the tidal condition in this case we use Highest Water Spring (HWS), Extreme Wave Condition (EWC), Sea Level Rise (SLR), Land Subsidence (LS), Free Board (FB), and Wave Run-up (WR). The crest elevation of the dike is based on the boundary condition of the coastal area [3]. The dike design is based on the tidal condition in this case we use Highest Water Spring (HWS), Extreme Wave Condition (EWC), Sea Level Rise (SLR), Land Subsidence (LS), Free Board (FB), and Wave Run-up (WR). HWS is the tidal analysis results, where we pick the highest value of the tidal during spring tide period. EWC is wave design with the return period 1:10000. Rate of SLR, the dike design is based on the IPCC projection. Rate of land subsidence is

$$Crest\ Elevation = HWS + EWC + SLR + LS + F + WR \quad \ldots\ldots\ldots\ldots\ldots(1)$$

Land subsidence

Coastal regionas are increasingly exposed to flood damages due to growing population assets, rising sea levels and possibly more frequent and intense storms. Flooding in the context of future storm variability, sea-level rise and shoreline change is one of the most important issues facing coastal populations today. Flooding in Indonesia comes from the upstream due to heavy rainfall or from the sea side due to storms or just high tides due to significant sinking of the land down below the sea level. Chaussard, et al (2012) found the correlation between population growth and land subsidence in coastal areas (see Figure 1). They argued that the subsidence is primarily caused by excessive ground water extraction for industrial, water use, and agricultural use. Accoding to population data density in 2000 consensus, population density in Java Island (about 250 to 999 person/km^2) is higher than Sumatera island (about 25 to 249 person/km^2). Therefore, it indicates that the higher dense of population, the higher rate of land subsidence due to groundwater depletion.

Land subsidence in a local and regional scale becomes much important. Wöppelmann and Marcos (2016) argued that land subsidence are a key element in understanding how sea levels have changed over the past century and how future sea levels may impact coastal areas. Land subsidence analysis have been estimated by subtracting the best estimate global rates of sea level rise from the local trend observed at a tide gauge and looking at their difference (NRC, 1987).



Source: Chaussard, et al., 2012

Figure 1 Land subsidence over Java and Sumatera Area

RESULTS AND DISCUSSION

Field situation and existing coastal dike condition in 2013

Existing protection levels in the coastal zone were determined during two surveys (black lines in Figure 2). The first survey was conducted in March-April 2013 and covered public areas within the area of DKI. The second survey was conducted in September 2013 covered privately owned areas, Tangerang and Bekasi. Figure 3 and Figure 4 shows field situation of Jakarta coastline in Muara Baru and Kalibaru respectively. The existing dike showed that the inland area is below the sea level. Therefore, the critical situation has to be solved by constructing the dike.

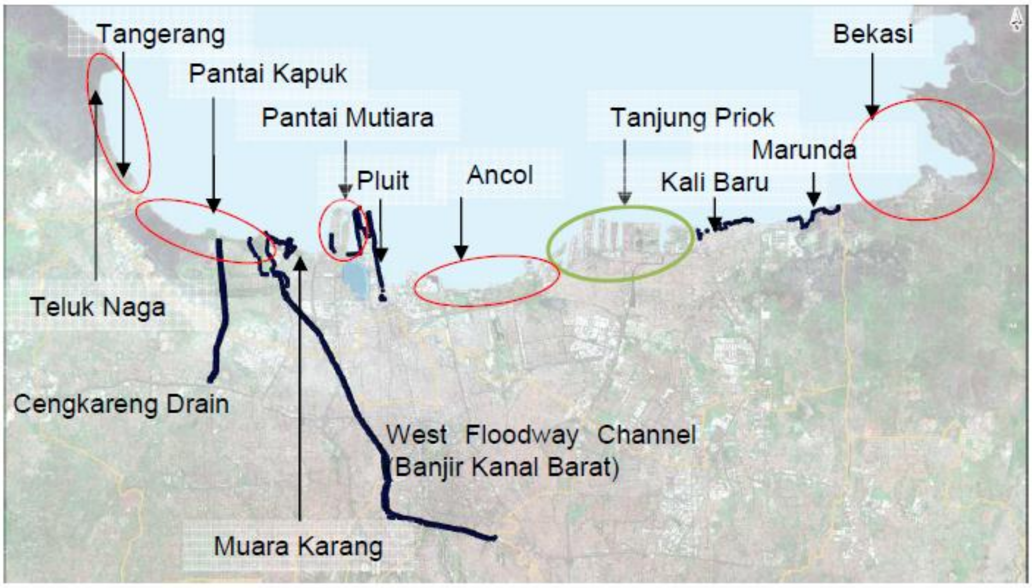


Figure 2 Field survey map location in 2013

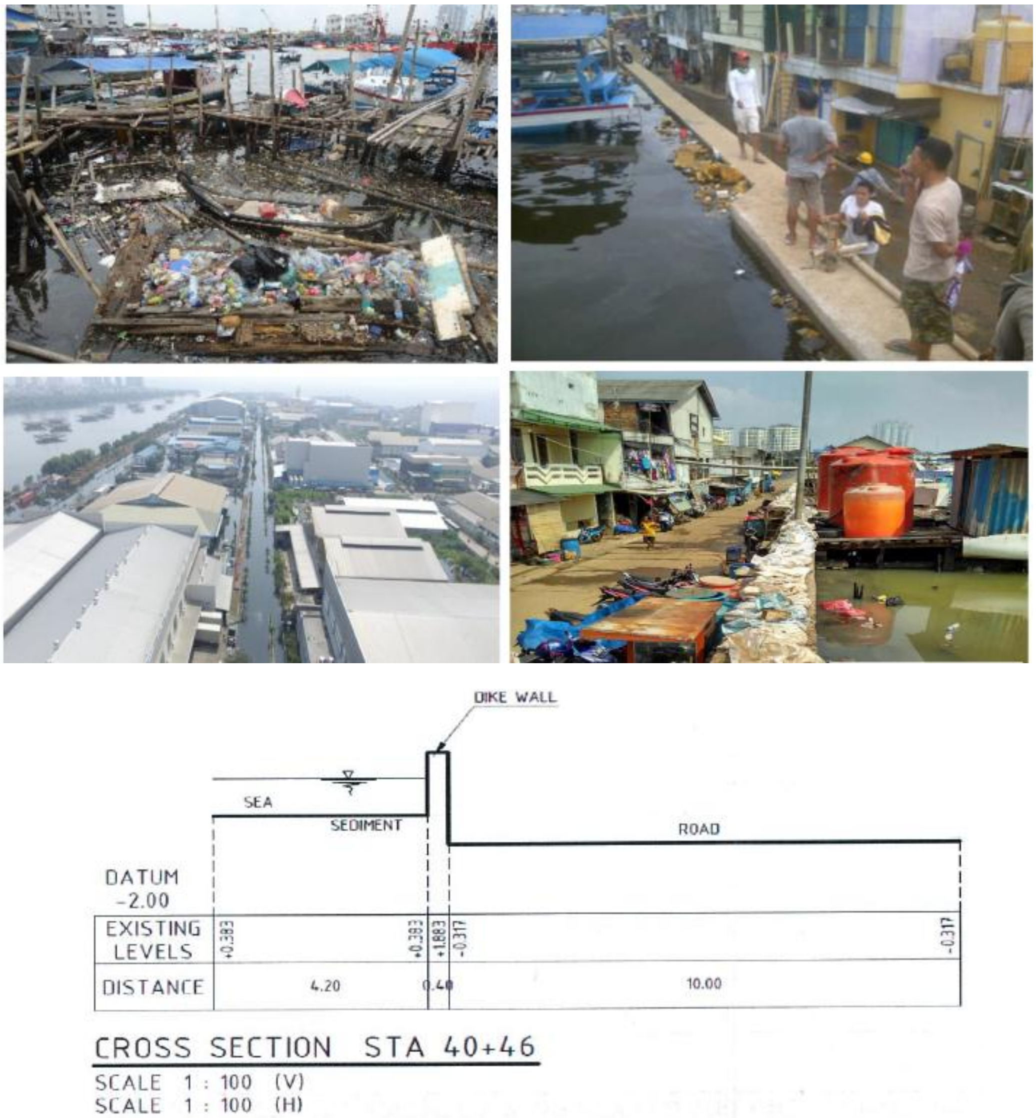


Figure 3 Field situation of dike in Muara Baru (Pluit Area)

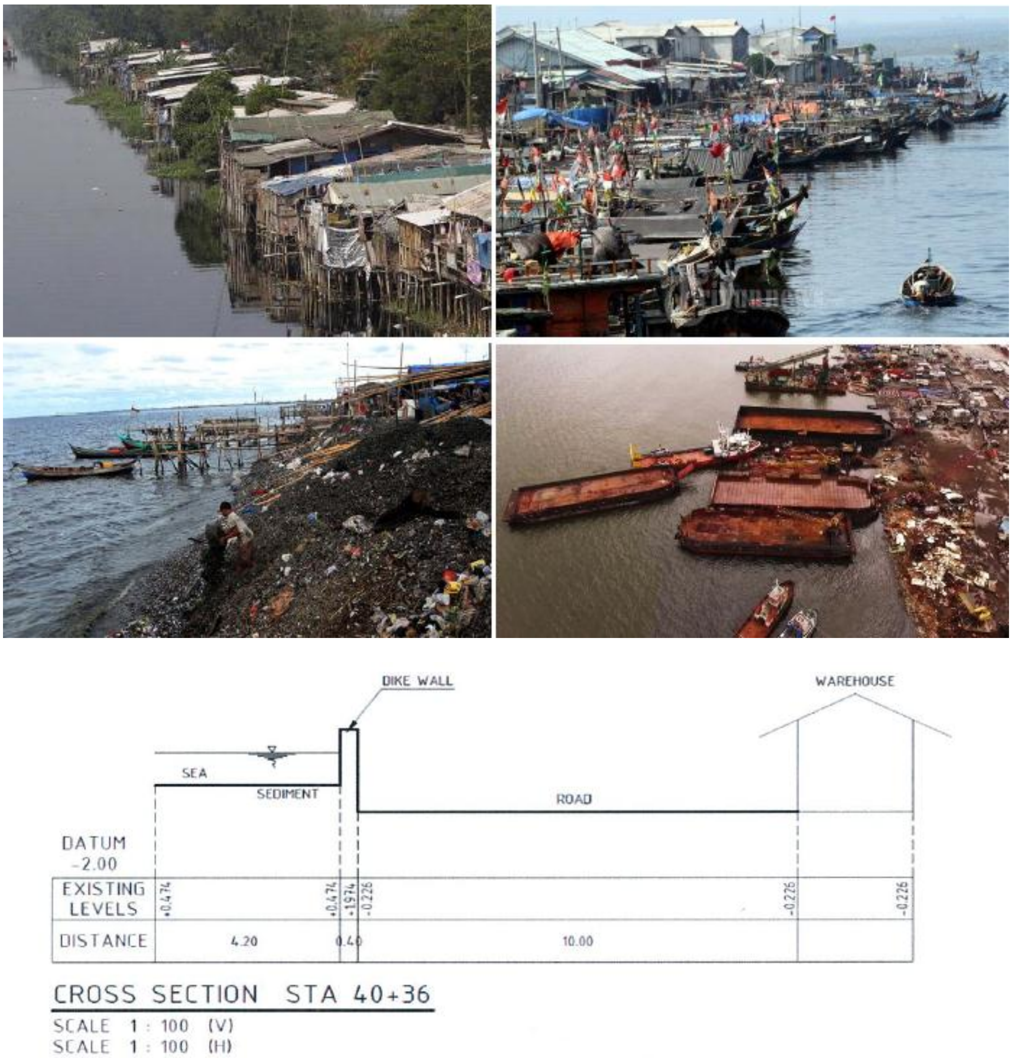


Figure 4 Field situation in Kalibaru

Table 1 Average height of coastal protections (from west to east)

section	average height	type of protection	remarks
Teluk Naga (Survey II)	1.0 m +LWS	Mangrove	Fish ponds
Tangerang (Survey II)	1.4 m +LWS	Mangrove	Fish ponds
Pantai Indah Kapuk (Survey II)	1.1 m +LWS	Mangrove	Mangrove reserve, dike further inland
Pantai Indah Kapuk (Survey I)	3.7 - 4.0 m +LWS	Dike	High end housing
Muara Karang	1.4 - 1.7 m +LWS	Seawall	Housing
Muara Karang (Survey I)	3.0 m +LWS	Seawall	PLTU
Pantai Mutiara (Survey II)	1.2 m +LWS	Seawall	High end housing
Pluit (Survey I)	1.6 - 1.9 m +LWS	Seawall	Fishing port
Ancol (Survey II)	1.5 m +LWS	Waterfront/Beach	Recreational area
Tanjung Priok	no data	no data	no data
Kali Baru (Survey I)	2.5 m +LWS	Seadike/land reclamation	Land reclamation from crab-materials
Marunda (Survey II)	2.7 m +LWS	Quay walls	Port area, PLTU
Bekasi (Survey II)	0.7 m +LWS	Mangrove	Fish ponds

The survey covered approximately 16 km coastline and 45 km of river embankments. The following areas were surveyed in the coastal areas:

- Pantai Mutiara
- Pluit (here in after Muara Baru)
- Kali Baru
- Marunda

At some locations (Teluk Naga, Tangerang, Pantai Indah Kapuk, Bekasi) the actual coastal protection is located further inland. At these locations the approximate topographical level at the coastline is provided in Table 1. The current design water level is approximately 1.7 m +LWS2012. Crest levels should be higher to accommodate for wave run-up. Crest levels are close to the current design water level at most locations. This means that acombination of high water and strong waves may lead to overtopping and inundation of the areas.

To the east (Bekasi) and west (Tangerang and Kapuk) large mangrove areas and fishponds are present. These rely on a frequent inundation of seawater. A coastal flood defence might be found further inland. However, topographical elevations may be high enough so inundation will not occur further inland at present.

At Muara Karang, Pantai Mutiara, Pluit and Ancol existing protection levels are dangerously low. At present they are already below the design water level. During combined high water and storm surge, wind/wave setup or seasonal water level increase, the protections may overflowand inundate the populated hinterland. At Pantai Indah Kapuk the coastal protection level is above the current design water level. Here the risk of overtopping is small. Also the new port area of Marunda is constructed well above current (still water) the current design water level and overtopping is not likely on the short-term. The protection level at Kali Baru is approximately 2.5 m +LWS2012. It is above the current design water level. However, this land reclamation is developed using coarse material. The permeability of the material is high and therefore the construction may not be able to protect the (low-laying) hinterland from inundation.

Crest elevation

The crest elevation is based on the boundary condition of the coastal area. The critical-phase coastal dike is projected to protect the inland until 2030. The parameter and the value for the dike height calculation is showed in the Table 2 below. For the wave calculation, the wave model with 10,000 year return period yields significant wave height 2.27 m around location and at the shore around 1,75 m. The SLR projection from IPCC (2013) is about 8 mm per year and until 2030 it will predict linierly around 0.12 m. The land subsidence around location is about 100 mm per year and projection until 2030 linierly is 1,4 m.

Table 2 Crest elevation

Parameter	Value (meter)
Highest Water Spring	1,19
Extreme Wave Elevation	1,59
Sea Level Rise	0,12
Land Subsidence in Muara baru and Kalibaru	1,40
Free Board	0,50
Dike Height	**+4,80 LWS**

Coastal dike design

The dike design at Kali Baru and Muarabaru use vertical dike at the sea side and slope dike at the land side (see Figure 5). The vertical dike at the sea side is choosed because it will reduce the space, whereas at the land side the dike has slope due to public area development later on. The dike is made from series of spun pile made from concrete with the strength K500. Between the concrete pile there is steel pile and joint the series of the concrete pile. It is constructed to provide additional strength among the series of pile form the dike and avoid seepage. The capping beam also to unite the concrete pile series and to splash the wave impact. Toe protection and armor are located in front of the dike. This is to reduce the wave impact and to avoid local scouring due to return flow of the undertow current. Geotextile is used as the matress below the armour. In order to minimize the seepage as well, the pile is constructed with the depth around -20 m from LWS. In addition, inside the dike is filled by clay and covered by sand and grass.

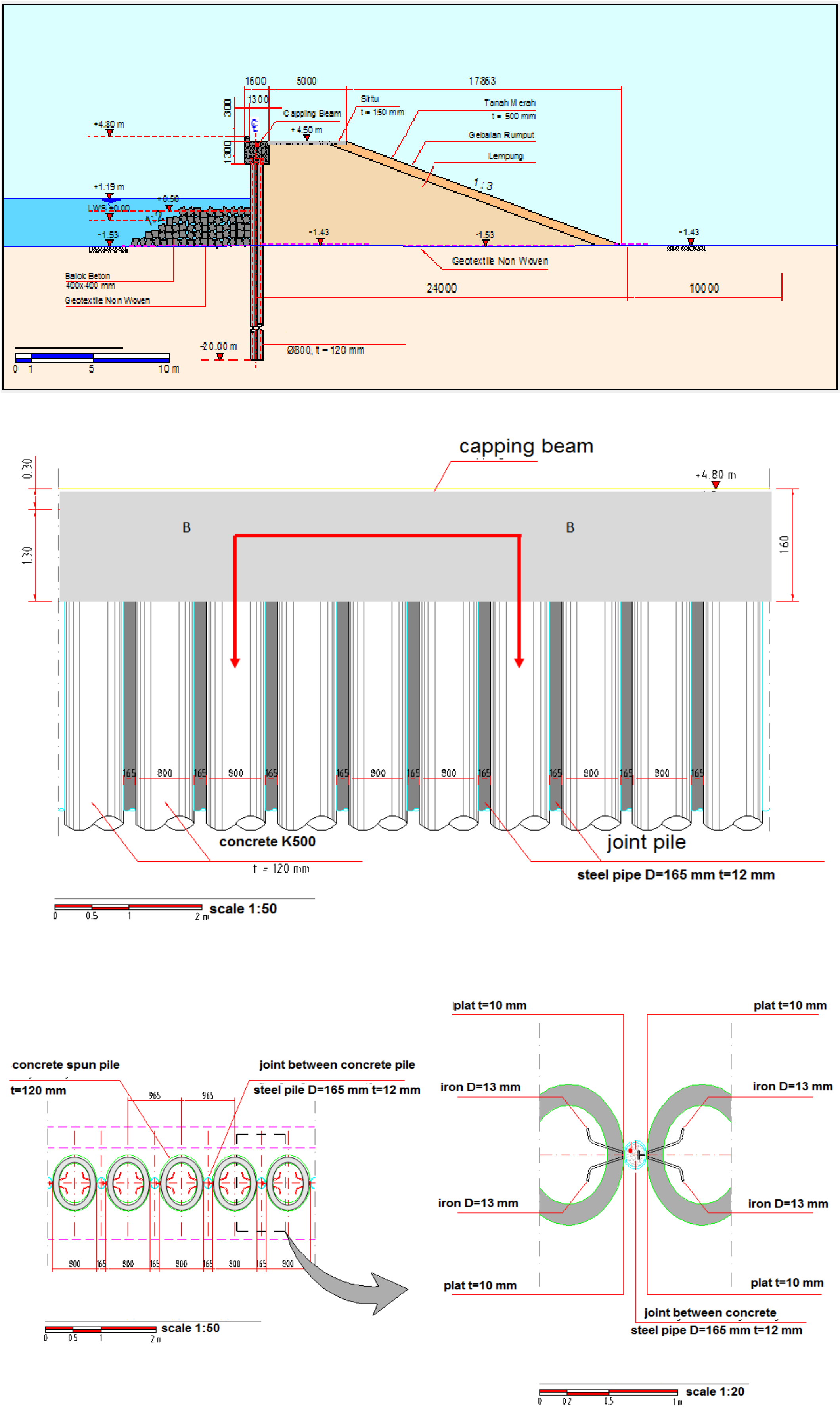


Figure 5 Critical-phase of coastal dike design for Kali baru and Muara Baru

Physical construction

At the moment, PUPR concentrates the physical construction of coastal dike at Kalibaru and Muara Baru. Figure 6 shows dike construction at Muara Baru and the green line is under PUPR responsibility and red line shows the construction progress. The construction shift to the sea side around 80-200 m from the current coastline due to the relocation issue. The physical construction dike is started by piling the concrete one by one until the depth -20 m from LWS. The distance between the concrete pile is around 165 mm.

Figure 7 shows physical dike construction in Muara Baru around Nizam Zachman Port. The pile is shiped by boat and one by one the pile is drilled to the ground until -20 m depth reached. The design of the dike also will acommodate the port design. The length of the dike in the inner site is longer than in the East side. The dike design is the same along the coastal area using vertical dike design at the sea side and the slope dike at the land side.

Figure 6 Dike construction area and their process in Muara Baru

Figure 7 shows the physical dike construction progress until July 2017. The pile is already constructed then the joint steel pile will fill up between the concrete pile and it will be tied by the ring at the same time. Everyday we are able to pile 6 to 8 pilar of concrete pile, depend on the field situation as well. Until july 2017, the physical dike construction progress in Muarabaru is about 1.2 km from 1.8 km the total length of the dike. It is both located in the western and eastern part. In particular area, if the soil is hard less than -20 m then the concrete pile will be excavated continuously until the depth reached. After the series pile are constructed then the cap beam is installed and the armour unit infront the dike will be deployed.

According to Presidential direction, the physical dike construction has to consider social, environment, economical, and regulation aspects. There are social issue at the site, where the fisherman can not park their boat. During the dike construction they are facilitated by temporary port. In addition Nizam Zachman port, which is belong to Ministry of Marine and Fisheries, has development program for integrated port development. Therefore, all the development design must be integrated with their program. For example, if the reclamation area behind the dike is already reclaimed by the sand then the land will be used by the minisitry for fiherman facility or another processing industry for fish packaging. However, the regulation to legalize the program, especially in spatial planning, has to be discussed with regional government DKI, PUPR, and Ministry of Marine and Fisheries. Figure 8 shows spatial planning to utilize the space behind the dike, where some areas are used for relocation, fish industry, and public space. The follow up meeting will be discussed for the approval spatial planing.

Figure 7 Physical dike construction progress in Muara Baru

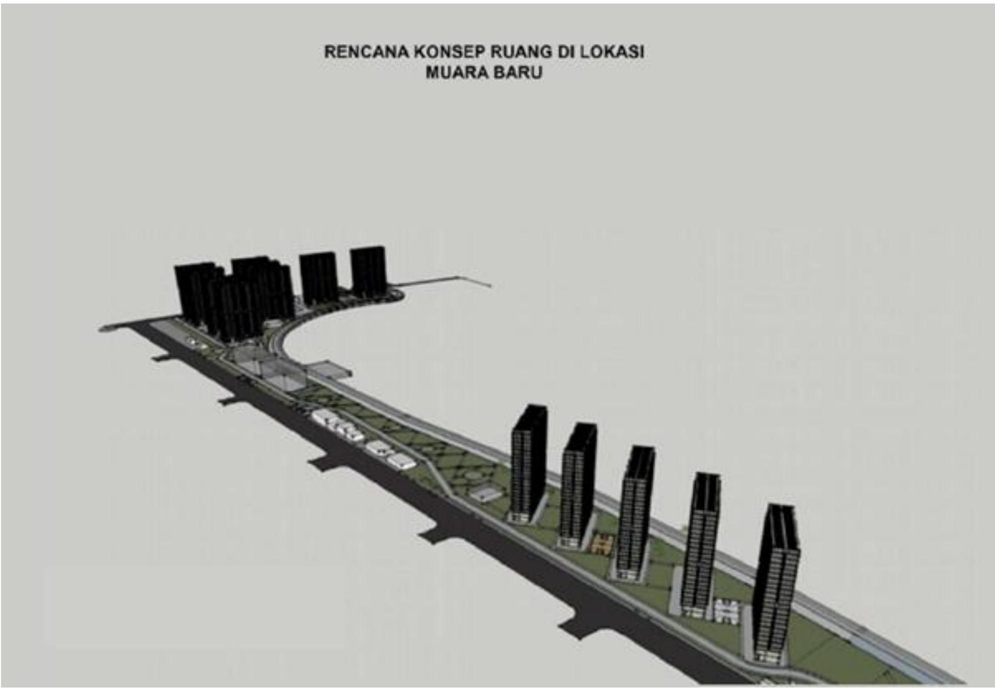


Figure 8 Spatial planning after dike constructed

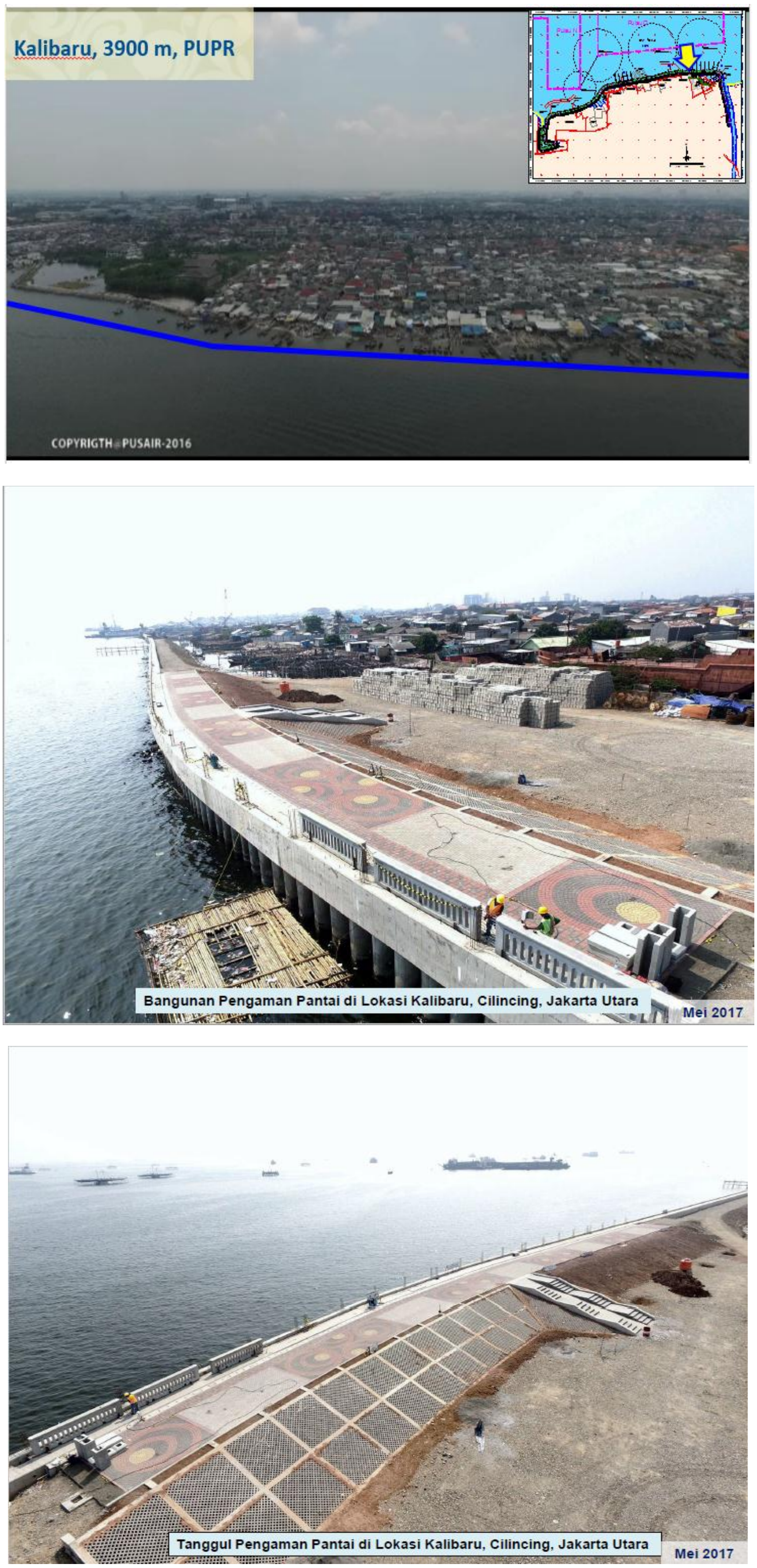


Figure 9 Dike Construction Progress in Kalibaru

Figure 10 Mock-up Dike Construction Integrated with Green Area in Kalibaru

Figure 9 shows the physical dike construction progress at Kalibaru. The dike design and their construction process are nearly the same with Muara Baru since the typical dike design is also the same, where there is concrete pile series and steel pile inbetween the concrete with the same dimension. The total length of dike in Kalibaru is 4.1 km, until july 2017 the progress constructon is 1.3 km. In Kalibaru behind the dike will be used for public area, for example the jogging track with the sea and apartement building as the landscape around the area, inspection road, and park. In addition, there will be prototype green facility, such as garden, around 100 m length in the certain area (see Figure 10).

Social and environmental aspects are still the big challenges at the field. We put an extra efforts to convince people about the urgency of the program. Sometimes social conflict is occurred at the field, where people think that the dike construction is directly related with reclamation program. Therefore, before physical construction of the dike socialitation stage of the program is compulsary process to make people understands about the critical-phase program and to have one perspective about NCICD program. In addition, the regulation and the procedural process.

CONCLUSIONS

Critical-phase of NCICD program is a no regret policy, where the program has to be conducted in a current situation. Critical-phase of sea dike construction is one of the program. PUPR concentrates in Muara Baru and Kalibaru for the critical dike construction at the moment with the physical construction progress around 48% from the total length 4,8 km and it will be finish in the beginning of 2019. The critical-phase of sea dike is projected enable the flood defense from sea side until 2030.

The two areas selection because these are essential and many people live there. The shifting of the dike construction to the sea side is to avoid relocation issue. The sea dike design has vertical profile at the sea side and slope at the land side. According to the field experiments, the unit armours are placed to reduce wave impact and local scouring.

The additional space behind the dike, where the reclamation is conducted, will be used for public space or residential area. However, the decision for utilisation of the space has not decided yet and wait for the agreement of another ministry.

ACKNOWLEDGE

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