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Analysis of Land Subsidence (Land Subsidence) Affects Against Water Puddle In Semarang City

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Abstract- Land subsidence is a natural phenomenon that occurs in the young soil layer (alluvial). The incident is bad for the construction that is above it, it is also exacerbated by the entry of seawater that enters due to the soil surface that has been declining so that the ground elevation is below sea level elevation.Semarang city is one of the cities located in the north of Java island that the condition of the land in the city is alluvial soil. Semarang's coastal topography is flat in the range of 0-2% with most of its area almost equal to sea level and even in some places below it. The results of technical geological investigation in North Semarang city showed that the subsurface layers up to 25 m depth consisted of heavier soil types 1.7-1.84 t / m3, silt with 0.200 - 0.448, & clay. The predictions of subsidence using the 1D Terzaghi approach with the T90 obtained the smallest decay of 19.6 cm over 8,624 years and the greatest collapse 127.7 cm for 29.634 years, while using the smallest 216 cm subsidence Geostudio program for 8,624 years and the greatest descendant of 135.9 cm for 29.634 years.

Keywords**:** Land Degradation, Digital Elevation Model, Rob's puddle

1. Preliminary

Semarang city of located in the north of Java Island which is directly adjacent to the Java Sea. The city with a population of 1595,267 people (BPS Kota Semarang, 2015) with an area of 373.70 km^2 is located between $6^0$55'22 "LS - 7^0 7'13" LS and 110^0 16'21 "BT - $110^0$30'36" BT. Alluvial plains of beaches and rivers are the areas contained in the city of Semarang. This layer is the alluvium deposits of beaches, rivers and lakes. Coastal sedimentation lithology consists of clay, silt and sand and a mixture of which some reach a thickness of 50 m or more. Pebbles, gravel, sand and silt with a thick 1 - 3 m is the sediment of rivers and lakes. The lumps are andesite, clay and a little sandstone River and lake deposits consist of.

Soedarsono (2007) Land Subsidence and its effect on residential environment on Aluvial plains in some of Semarang City. Terzagghi ID ground subsidence was 0.084m for 4.64 years (smallest) and 1.07m for 29.63 years (largest), where as with Plaxis that is 0.17m for 6.58 years (smallest) and 1.037m for 27.23 years and Due to frequent inundated residential environment there is damage to infrastructure and the incidence of disease. While the results of research Gentur (2016) rob flood area in north semarang subdistrict in 2014 due to sea level rise 823.545 ha. Tanjung Mas urban village is the most widespread affected by rob flood with wide reach 337.06 ha with the percentage of

flood area 92.496%. The purpose of this research is to know the magnitude and duration (time) of land subsidence that occurred in Semarang city which causes the increase of number of puddles and Know the effect of subsidence (land subsidence) to the width of puddle of rob happened. The decline of this land becomes a serious problem because the location that is experiencing the problem is the access of economics of Semarang city, therefore made the formulation of the problem as follows:

1. How much land subsidence occurs due to the natural burden that occurs in East Semarang Subdistrict, Pedurungan District and Gayamsari District?
2. How long is the land subsidence occurring as a result of its own load naturally?
3. How wide is the puddle of rob caused by the land subsidence in the coastal area City of Semarang?

2. Research Methods

Referring to the objectives to be in can, and estimate the data obtained which will be used to perform calculations and evaluations in the field

The analysis was conducted in a soil mechanics laboratory which was a further analysis of field investigations. These data are used to calculate the quantity and duration of land decline located in research location yaiut North Semarang subdistrict, Pedurungan district and Gayamsari district. The result can be in laboratory in the amount of γ, c, Cc, Cv, and e0. The analysis is done by modeling to obtain the quantity and length of the land decline. The soil samples were secondary data performed by advanced analysis obtained from three sample points representing the research area where each point was done geological instigation with a depth of 20 - 25 m.

Analysis of the data conducted to obtain the results of the decline and water puddles that occur due to the decline is done in two ways, the first way the results of laboratory analysis using land count calculation approach. Land subsidence calculation is done with two approaches that is attachment 1D Terzaghi, while the second approach by using Geostudio Software. The analysts' results from both approaches are the amount of land subsidence and the duration of land subsidence with the variation of soil characteristic loads at the three locations. The second way after getting the result of land decline and duration is to combine the two maps with the analysis of sea water elevation with the software GIS. supporting data to obtain the inundation result in the contour city of semarang map, the highest water elevation (Highest High Water Lavel) combined with the resulting land subsidence map.

3. Literature Review

Land subsidence is a natural phenomenon due to the consolidation of soil due to the maturation of the young soil layer in Semarang below (Suhelmi, 2012). Soil consolidation process can take place more quickly because pore water is pushed out by increasing vertical loads due to decrease of ground water level (Soedarsono, 2012). Based on Whittaker and Reddish, 1989 in Metasari 2010, the general factors causing land subsidence (land subsidence) include:

1) Natural subsidence decline caused by geological processes such as geological cycles, sedimentation of the basin and so on.
2) Decrease of soil due to groundwater extraction (groundwater extraction)
3) Due to massive groundwater retrieval that exceeds its capability, there will be a decrease in the amount of ground water in aquifer layer.
4) Decrease due to building load (settlement)

The problems that are often faced by big cities that are close to the waters (the sea) is the problem of water puddles due to the tide from the sea (Rob). One of the big cities in Indonesia, especially in Java Island with a high level of disaster threat is Semarang City. Rob floods that occurred in the city of Semarang is one big threat for residents in the city. According to Bakti (2010) tidal flood or better known as rob is a problem that often occurs in areas that have sloping beaches and elevation of the ground that is not much higher than the highest tides.

- Calculation analysis
  - Load calculation (search $\Delta\sigma$) every layers
    Thick loading (h)
    Loading (γ)
    $\Delta\sigma = \gamma$ x h..... 3.14
    Depth 0 m - 0,65 m
    $\gamma = 1{,}84\ t/m^3$; $\gamma_w = 0\ t/m^3$ (MAT = 1,5 m) ;
    $\gamma' = \gamma - \gamma_w = 1{,}84 - 0 = 1{,}84\ t/m^3$
    $\Delta\sigma = 1{,}84.(0 - 0{,}65) = 1{,}1973\ t/m^2$
  - Effective Calculation stress Starts (search σ') every layers
    Depth 0 m - 1m = (1 - 0) $\gamma'/2$ 3.15
    Depth 2,5 m – 3 m = $(2{,}5 - 3).\frac{\gamma'}{2} = 0{,}5\ .\frac{0{,}64}{2} = 0{,}161\ t/m^2$
  - Calculation of the Final effective Stress
    $\sigma 1$ = $\sigma' + \Delta\sigma$ 3.16
    Depth 2,5 m – 3 m $\sigma_1 = \sigma' + \Delta\sigma$ = 0,161 + 2,755 = 2,916 t/m²
  - The calculation looks for a decrease in the soil of each layer

$$\Delta S = \Delta h \cdot \frac{Cc}{1 + e_o} \log \cdot \frac{\sigma 1}{\sigma} \cdot 90\% \qquad 3.17$$

    Where :

ΔS	: Great Subsidence	e_o	: Pore Number
Δh	: The Observesion Soil Layer	$\sigma 1$	: The Final Effective Stress
Cc	: Index Of The Crop	σ'	: Effective Strees Begins

    Depth 2,5 m – 3 m $\Delta S = 0{,}5.\frac{0{,}332}{1+1{,}328} log.\frac{2{,}916}{0{,}161}.90\% = 0{,}081$ m
  - Calcultions are looking for Land subsidence

$$t = \frac{Tv \cdot H^2}{Cv} \qquad \text{..... 3.18}$$

    Where:
    t = Long Decline
    Tv = *Time Factor*
    H = The Observesion Soil Layer
    Cv = coefficient of consolidation

$$t_{10} = \frac{0{,}008.(2300)^2}{8{,}54.10^{-3}} = 495503{,}531 \text{ detik} = 0{,}1571 \text{ years}$$

4. Research Result and Discussion

A. Prediction of Magnitude and Length of Land Decrease on Alluvial Land

This analysis aims to test the loading, soil mechanical properties tested great effect on the amount and duration of decline that occurs in alluvial plains. The magnitude and duration of land subsidence can be described as follows:

a. The big prediction and the duration of soil loss due to the load, physical and mechanical properties of soil on alluvial land use the 1D consolidation theory of terzaghi.

The large predictions and the length of soil decline in the area studied refers to the 1D consolidation theory approach developed by Das (1998) and Weslay (1997). Physical and ground counts used to calculate are γ (specific gravity), γ '(dry matter weight), σ' (effective stress) Cc (perspect index), Cv (coefficient of consolidation) and eo (pore number). This study uses three areas used in this analysis. This study uses data into 20 -25m soil in the form of drilling and laboratory analysis of soil mechanics.

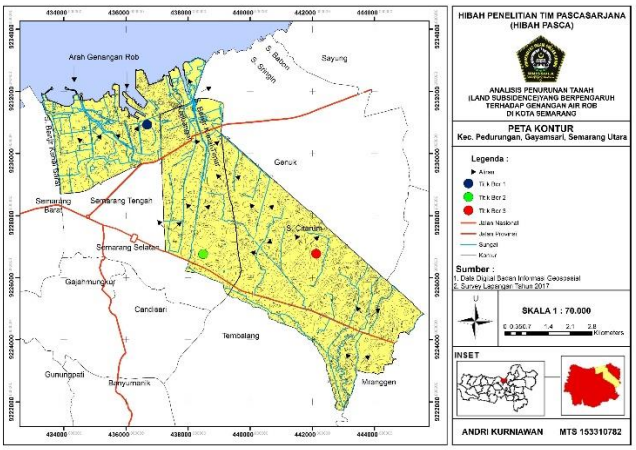

Figure 1 Land sampling location (drill)

The results of the analysis that has been done based on the three points of soil sampling obtained ground reduction by using 1D approach of Terzaghi is as follows.

Table 1 Land Subsidence T90%

Point Drill	Location	Land Subsidence (cm)	Land Subsidence (Years)
1	Tambak Lorok	127,7	29,634
2	Gayamsari	35,2	5,282
3	Plamongan Indah	19,6	8,624

Source: Result of Analysis and Calculation 2017

Table 2 Depth of Land Subsidence Achieves T90%

Depth Level	Value of Land Subsidence	Location
Level I	0 - 20 cm	Plamongan Indah
Level II	21 - 40 cm	Gayamsari
Level III	41 - 60 cm	-
Level IV	61 - 80 cm	-
Level V	> 80 cm	Tambak Lorok

Source: Result of Analysis and Calculation 2017

Table 3 Depth of Land Subsidence Every Year

Point Drill	Location	Years 2018 (cm)	Years 2019 (cm)	Years 2020 (cm)	Years 2021 (cm)	Years 2022 (cm)
1	Tambak Lorok	4.309	8.618	12.928	17.237	21.546
2	Gayamsari	6.664	13.328	19.992	26.657	33.321
3	Plamongan Indah	2.273	4.545	6.818	9.091	11.364

Source: Result of Analysis and Calculation 2017

Table 4 Depth of Land Subsidence by Amount of Every Five Years

Point Drill	Location	Years 2018 (cm)	Years 2022 (cm)	Years 2027 (cm)	Years 2032 (cm)	Years 2037 (cm)	Years 2042 (cm)	Years 2047 (cm)
1	Tambak Lorok	4.309	21.546	43.092	64.639	86.185	107.731	127.700
2	Gayamsari	6.664	33.321	35.200	-	-	-	-
3	Plamongan Indah	2.273	11.364	19.600	-	-	-	-

Source: Result of Analysis and Calculation 2017

Table 5 Depth of Land Subsidence Every Five Years

Point Drill	Location	Land Subsidence Th. 2018 - 2022 (cm)	Land Subsidence Th. 2022 - 2027 (cm)	Land Subsidence Th. 2027 - 2032 (cm)	Land Subsidence Th. 2032 - 2037 (cm)	Land Subsidence Th. 2037 - 2042 (cm)	Land Subsidence Th. 2042 - 2047 (cm)
1	Tambak Lorok	17.237	21.546	21.546	21.546	21.546	19.969
2	Gayamsari	26.657	1.879	-	-	-	-
3	Palmongan Indah	10.019	8.236	-	-	-	-

Source: Result of Analysis and Calculation 2017

b. Large predictions as well as length of land decline in alluvial plains using GEOSTUDIO Software.

In the analysis of land subsidence using 1D Terzaghi approach on alluvial land will be recalculated by using software to see the big difference and the duration of land decline. to analyze by using the software required parameters that have been determined that is E modulus, unit weight, and Poisson's ratio.

Table 6 Land Subsidence T90%

Point Drill	Location	Land Subsidence (cm)	Land Subsidence (Years)
1	Tambak Lorok	135,9	29,634
2	Gayamsari	55,1	5,282
3	Plamongan	21,6	8,624

Point Drill	Location	Land Subsidence (cm)	Land Subsidence (Years)
	Indah		

Soruce : Result of Analysis and Calculation 2017

Table 7 the depth of Land Subsidence T90%

Depth Level	Value of Land Subsidence	Location
Level I	0 - 20 cm	-
Level II	21 - 40 cm	Plamongan Indah
Level III	41 - 60 cm	Gayamasri
Level IV	61 - 80 cm	-
Level V	> 80 cm	Tambak Lorok

Soruce : Result of Analysis and Calculation 2017

Tabel 8 Depth of land Subsidence Every 5 year

Point Drill	Location	Years 2018 (cm)	Years 2019 (cm)	Years 2020 (cm)	Years 2021 (cm)	Years 2022 (cm)
1	Tambak Lorok	4.586	9.172	13.758	18.344	22.930
2	Gayamasri	10.432	20.863	31.295	41.727	52.158
3	Plamongan Indah	2.505	5.009	7.514	10.019	12.523

Soruce : Result of Analysis and Calculation 2017

Table 9 Depth of Land Subsidence by amount Every 5 year

Point Drill	Location	Years 2018 (cm)	Years 2022 (cm)	Years 2027 (cm)	Years 2032 (cm)	Years 2037 (cm)	Years 2042 (cm)	Years 2047 (cm)
1	Tambak Lorok	4.586	22.930	45.859	68.789	91.719	114.649	135.900
2	Gayamsari	10.432	52.158	55.100	-	-	-	-
3	Plamongan Indah	2.505	12.523	21.600	-	-	-	-

Soruce : Result of Analysis and Calculation 2017

Table 10 Depth of Land Subsidence level Every 5 year

No. Titik Bor	Location	Land Subsidence Th. 2018 - 2022 (cm)	Land Subsidence Th. 2022 - 2027 (cm)	Land Subsidence Th. 2027 - 2032 (cm)	Land Subsidence Th. 2032 - 2037 (cm)	Land Subsidence Th. 2037 - 2042 (cm)	Land Subsidence Th. 2042 - 2047 (cm)
1	Tambak Lorok	18.344	22.930	22.930	22.930	22.930	21.251
2	Plamongan Indah	41.727	2.942	-	-	-	-
3	Gayamsari	10.019	9.077	-	-	-	-

Soruce : Result of Analysis and Calculation 2017

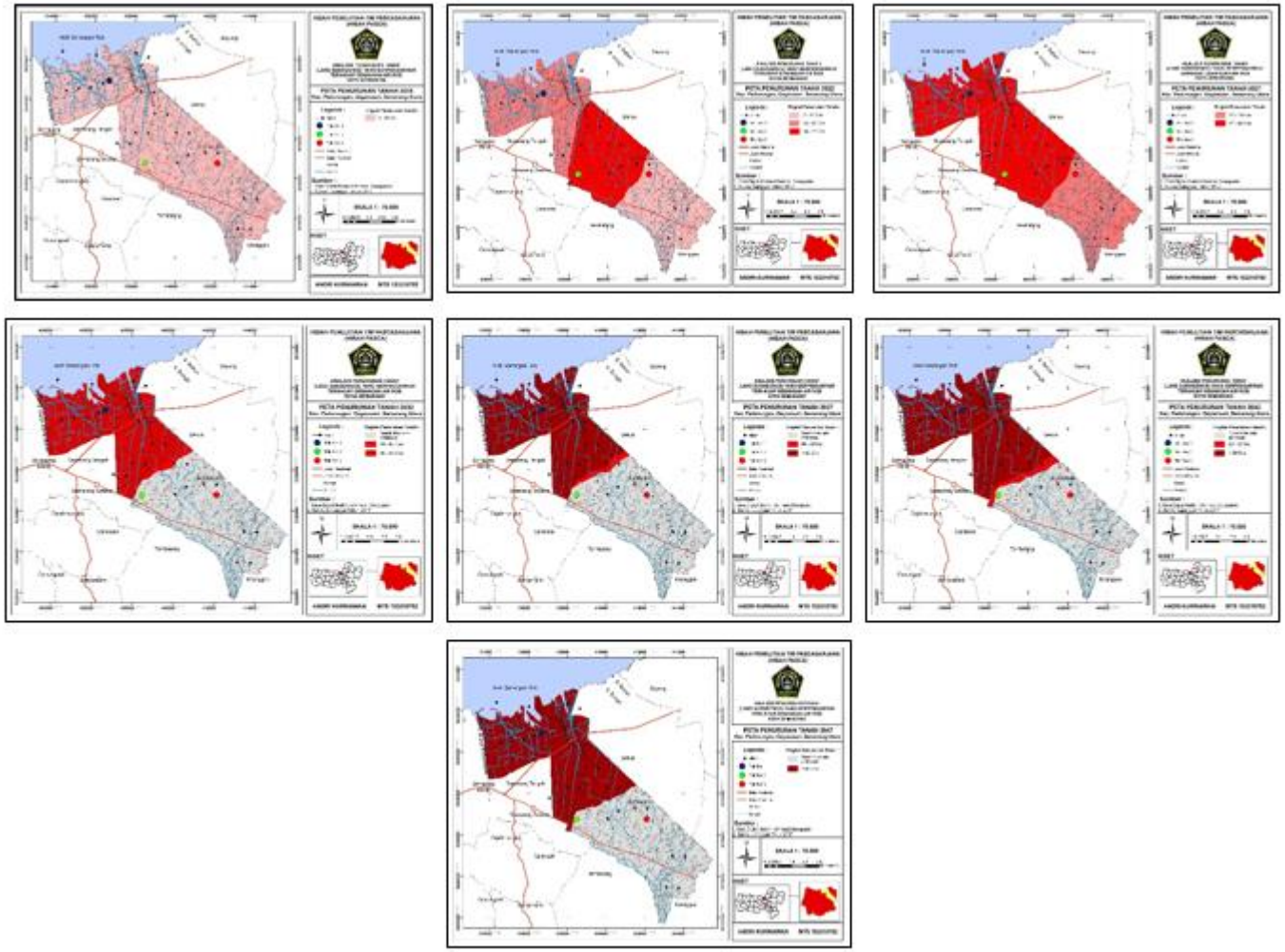

Figure 2: Land Subsidence Map

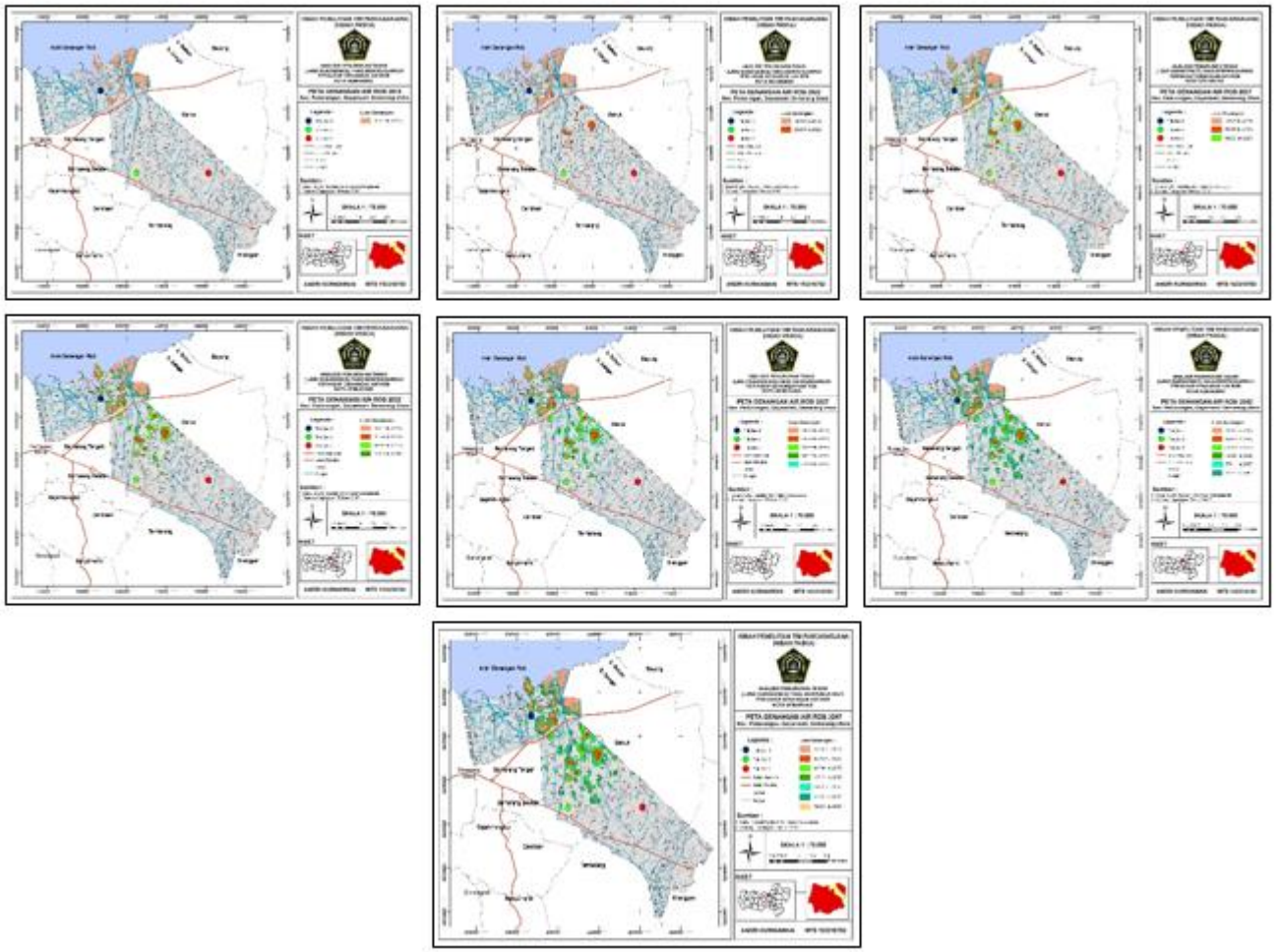

Figure 3: Inundation Due To Land Subsidence Map

5. Conclution and Suggestion

A. Conclution

1) Land subsidence which occurred at the research site is influenced by physical and mechanical properties.
2) the greatest Land subsidence being is on Area of Tambak Lorok 127.7 cm with long decline of 29,634 year in approach of 1D Terzaghi.
3) The smallest land subsidence decline occurred in 19.6 cm Plamongan Area with a decline of 8.62 years
4) Land subsidence which occur most in the area of Tambak Lorok 135.9 cm with a long decline of 29,634 years in the approach Geostudio.
5) Land subsidence the smallest occurred in Plamongan Area 21.6 cm with a decline of 8.62 years.

B. Sugggestion

1) Need to divide the region in development city of Semarang
2) Need handling with the polder system on the stagnant area
3) Need to be analyzed in relation to the pool caused by rainwater and merging with sea water puddles

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