THE STUDY OF LAND SUBSIDENCE RATE AT COASTAL AREA OF SEMARANG CITY, INDONESIA

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Abstrak

Semarang is a coastal city that has been suffered by rob flood for at least 25 years. One of main factors causes rob flood in Semarang is land subsidence. Land subsidence occurs in Semarang is a complex problem because the rate of land subsidence is different in places and changes in the development of time. Therefore it is necessary to monitor the land subsidence rate in Semarang. The aim of this research are to check the newest elevation of Bench Marks in coastal area of Semarang, to monitor land subsidence rate in coastal area of Semarang, To make elevation and land subsidence contour map in coastal area of Semarang.

The result of this research shows that bench marks which are above MSL + 100 m in height are stable enough. The closer to the sea, the faster land subsidence occurs. Soil type in coastal area of Semarang which is included young-soft soil type makes it still undergoes compression / consolidation. More over, coastal area of Semarang which is the center of the city activity such as industry, buildings, reclamation, crowded transportation, and many artisian well has made land subsidence happens faster.

Key Words : Bench Marks Elevation, Land Subsidence, Semarang

1. INTRODUCTION

In the last 25 years, Semarang City that lies at coastal area of Central Java has suffered “rob” flood, flood caused by the raising sea level at high tide. This kind of flood inundated many places in Semarang City. In May 2005, there are at least 14 village were inundated by “rob” flood with the width of puddle area was 2.418 Ha. One factor causes “rob” flood is sea level rise. The sea level rise rate that recorded at Tide Observation Station Tanjung Mas Harbor, Semarang was 5,43 cm/year (Wirasatriya, 2005)

Based on the previous research of Wirasatriya (2005), the dominant factor causes sea level rise in Semarang City was land subsidence. At the other side there was also global warming factor that caused sea level rise in whole part of the world but this global factor only caused sea level rise in Semarang about 2,65 mm/year. The value of land subsidence that happened in Semarang varied among one place

with others. Generally closer to coastal area the faster land subsidence occurres. Sutanta and Hobma (2002) stated that it would be very difficult to determine the value of land subsidence in Semarang since there would be a different value in different place and different time. This complexity aroses from the dynamics of natural phenomena and human intervention, which in turn make it difficult to find the most probable scenario of land subsidence in the area. Therefore it is very important to observe the land subsidence in Semarang coastal area periodically.

Based on Wirasatriya (2005) in order to observe land subsidence in Semarang coastal area, it is necessary to measure the elevation of many Bench Marks (BM) in Semarang each year. By knowing those BMs elevation each year, the value of land subsidence in many places in Semarang will be monitored. The aim of this research are :

1. To check the newest elevation of Bench Marks in coastal area of Semarang.
2. To monitor land subsidence rate in coastal area of Semarang.
3. To make elevation and land subsidence contour map in coastal area of Semarang

2. RESEARCH METHOD

This was descriptive research that had explorative character. According to Arikunto (1993) this kind of research was performed to descript the situation or status of a phenomenon. Thus the final result of this research give the description of elevation and land subsidence in coastal area of Semarang.

The research was done in June 2006. The procedure of this research was divided into 3 step, i.e. : preparation step, leveling measurement step and data analysis step. The preparation step were preparing the equipments , searching for the related literature and secondary data like previous elevation data, Semarang map, etc.

The measuring step used leveling method to observe the elevation of BMs in coastal area of Semarang. TTG 449 which is the most stable BM was used as a reference point of measurement. TTG 449 is located in front of the “Ada” store in Srondol which has 221,004 m of elevation from mean sea level (MSL) (later the elevation value will be noted as MSL + 221,004 m). According to Muhrozi et al

(1997) TTG points is gained from List Book of reference points from BAKOSURTANAL, the responsible institution for surveying and mapping data in Indonesia.

The elevation measurement followed this stripe :

1. "Go" stripe : Starting from srondol, Jl. Setia Budi, Jl. Gombel Lama, Jatingaleh, Kaliwiru, Jl. Sultan Agung, Taman Diponegoro Elisabeth, Jl. Diponegoro, Siranda, Simpang Lima, Jl. Gajah Mada, Jl Pemuda, Johar Post Office, Jl. Ronggowarsito and finished in Tanjung Emas Harbour.
2. "Back" stripe : Starting from Tanjung Emas Harbour, Jl. Ronggo Warsito, Johar Post Ofice, Jl Imam Bonjol, Tugu Muda, Kali sari, Jl S Parman, Taman Diponegoro Elisabeth, Jl Sultan Agung, Kaliwiru, Jatingaleh, Gombel , Jl Setia Budi, and finished in Srondol.

The bench marks that were measured for the elevation were :

1. "Go and Back" Stripe :
   a. TTG 449 in front of ADA Store Srondol
   b. DTK 348 in forked road of Jl Setia budi and Jl Kyai Mojo
   c. DTK 346 in forked road of Jl Setiabudi and Jl Gombel Lama
   d. BM Gombel in Jl Gombel Lama
   e. TTG 447 at the clock monument at Kaliwiru
   f. DTK 341 in front of AKPOL
   g. DTK 340 at Diponegoro park near Elisabeth Hospital
   h. Go back to TTG 449 passing the same BM.
2. Circle stripe :
   a. DTK 340 at Diponegoro park near Elisabeth Hospital
   b. BM 6 Pelabuhan in front of Siranda Hotel
   c. DTK 002 at simpang lima field
   d. DTK 335 at Jl Gajah mada
   e. BM Sub-District Border in front of Johar Post Office
   f. BM Tidal Observation Station at Tanjung Emas Harbour Semarang
   g. BM Drip in front of Johar Post Office
   h. TTG 446 at Tugu Muda Park
   i. DTK 338 at the crossroad of Jl Ngaglik lama, Jl Rinjani and Jl S Parman

j. BM Kop A Yani 16 in front of Gajah Mungkur Sub-District office
k. DTK 014 in front of Gajah Mungkur Sub-District office
l. DTK 340 at Diponegoro park near Elisabeth Hospital

BM elevation data gained were compared with the previous elevation data to analyze the value of land subsidence. More over the value of land subsidence was also compared with the previous data to know the change of subsidence rate. The elevation and subsidence rate data were input for making elevation contour map and land subsidence contour map in coastal area of Semarang.

3. RESULT AND DISCUSSION

Result

The elevation of BMs in Coastal area of Semarang are shown in table 1, Based on the leveling measurement from TTG 449 as a reference point.

Table 1. BM elevation in Semarang City

BM Name	Location	Coordinate Position		Elevation (m from MSL)		
		LS	BT	Sep 02	Sep 05	Jun 06
TTG - 449	Srondol	07^{0}03’43,4”	110^{0}24’49,1”	221,004	221,004	221,004
DTK - 348	Srondol	07^{0}03’06,8”	110^{0}25’01,7”	232,418	232,418	232,418
DTK - 346	Gombel	07^{0}02’39,1”	110^{0}25’17,1”	-	247,639	247,639
BM 5	Gombel	07^{0}02’23,7”	110^{0}25’15,9”	222,492	222,487	-
BM Gombel	Gombel	07^{0}02’01,7”	110^{0}25’01,4”	-	167,068	167,068
TTG - 447	Kaliwiru	07^{0}01’24,4”	110^{0}25’14,4”	-	105,250	105,250
DTK - 341	Akpol	07^{0}00’56,1”	110^{0}25’07,1”	100,102	99,996	99,996
KopYani 15	Diponegoro Park	07^{0}00’28,2”	110^{0}24’58,0”	90,120	89,991	-
DTK - 340	Diponegoro Park	07^{0}00’28,2”	110^{0}24’58,1”	90,365	90,237	90,235
DTK 339	Siranda	07^{0}00’03,7”	110^{0}25’06,3”	-	58,671	58,669
BM 6 .Pel.	Siranda	06^{0}59’52,8”	110^{0}25’06,1”	-	34,211	34,207
DTK-002	Simpang lima	06^{0}59’26,4”	110^{0}25’19,6”	-	3,647	3,604
DTK-335	Jl Gajah Mada	06^{0}58’44,3”	110^{0}25’15,4	-	2,566	-
BM. Kec. 1	Johar	06^{0}58’09,6”	110^{0}25’28,4”	-	1,420	-
BM. Kec. 2	Kalisari	06^{0}59’46,4”	110^{0}24’28,7”	-	-	38,430
BM. Drip	Johar	06^{0}58’10,5”	110^{0}25’27,4”	-	1,110	1,053
TTG-446	Tugu Muda	06^{0}59’01,6”	110^{0}24’34,3”	4,7145	4,512	4,467
DTK - 338	Ngaglik Lama	06^{0}59’49,4”	110^{0}24’25,0”	43,121	42,945	42,934
KopYani 16	Gajah Mungkur	07^{0}00’16,5”	110^{0}24’23,0”	91,070	90,925	90,927
DTK - 014	Gajah Mungkur	07^{0}00’16,5”	110^{0}24’32,8”	91,532	91,385	91,338
BM 7 TPKS	Harbour	06^{0}56’52,5”	110^{0}25’33,6”	-	1,242	1,171
BM 6 TPKS	Harbour	06^{0}56’46,5”	110^{0}25’38,8”	-	1,507	1,434
BM.I SPPII1	Harbour	06^{0}56’41,5”	110^{0}25’39,3”	-	2,989	2,931
BM 8 TPKS	Harbour	06^{0}56’31,7”	110^{0}25’28,4”	-	0,965	0,880

Land subsidence rate was known based on elevation data in September 2005 and Jun 2006 as shown in table 2

Table 2. Land subsidence rate of BMs in Semarang

BM name	Location	Coordinate Position		Average Subsidence rate (cm/thn)
		LS	BT	
TTG – 449	Srondol	07^{0}03’43,4”	110^{0}24’49,1”	0
DTK – 348	Srondol	07^{0}03’06,8”	110^{0}25’01,7”	0
DTK – 346	Gombel	07^{0}02’39,1”	110^{0}25’17,1”	0
BM 5	Gombel	07^{0}02’23,7”	110^{0}25’15,9”	-
BM Gombel	Gombel	07^{0}02’01,7”	110^{0}25’01,4”	0
TTG – 447	Kaliwiru	07^{0}01’24,4”	110^{0}25’14,4”	0
DTK – 341	Akpol	07^{0}00’56,1”	110^{0}25’07,1”	0
KopYani 15	Diponegoro Park	07^{0}00’28,2”	110^{0}24’58,0”	-
DTK – 340	Diponegoro Park	07^{0}00’28,2”	110^{0}24’58,1”	0,267
DTK 339	Siranda	07^{0}00’03,7”	110^{0}25’06,3”	0,267
BM 6 .Pel.	Siranda	06^{0}59’52,8”	110^{0}25’06,1”	0,533
DTK-002	Simpang lima	06^{0}59’26,4”	110^{0}25’19,6”	5,733
DTK-335	Jl Gajah Mada	06^{0}58’44,3”	110^{0}25’15,4	-
BM. Kec. 1	Johar	06^{0}58’09,6”	110^{0}25’28,4”	-
BM. Kec. 2	Kalisari	06^{0}59’46,4”	110^{0}24’28,7”	-
BM. Drip	Johar	06^{0}58’10,5”	110^{0}25’27,4”	7,6
TTG-446	Tugu Muda	06^{0}59’01,6”	110^{0}24’34,3”	6,0
DTK – 338	Ngaglik Lama	06^{0}59’49,4”	110^{0}24’25,0”	1,467
KopYani 16	Gajah Mungkur	07^{0}00’16,5”	110^{0}24’23,0”	0
DTK – 014	Gajah Mungkur	07^{0}00’16,5”	110^{0}24’32,8”	6,267
BM 7 TPKS	Harbour	06^{0}56’52,5”	110^{0}25’33,6”	9,467
BM 6 TPKS	Harbour	06^{0}56’46,5”	110^{0}25’38,8”	9,733
BM.I SPPII1	Harbour	06^{0}56’41,5”	110^{0}25’39,3”	7,733
BM 8 TPKS	Harbour	06^{0}56’31,7”	110^{0}25’28,4”	11,333

The linear trend assumption was used in determining the land subsidence rate. Sutanta and Hobma (2002) explained that it was very hard to determine the most accurate scenario for land subsidence in Semarang since the dynamic of natural factor and human intervention. A simplicity had been made to determine it. It was the land subsidence was assumed following linier trend and using the newest data as a base of subsidence forecasting.

Elevation and land subsidence contour map in Semarang is shown in figure 1 and 2 below

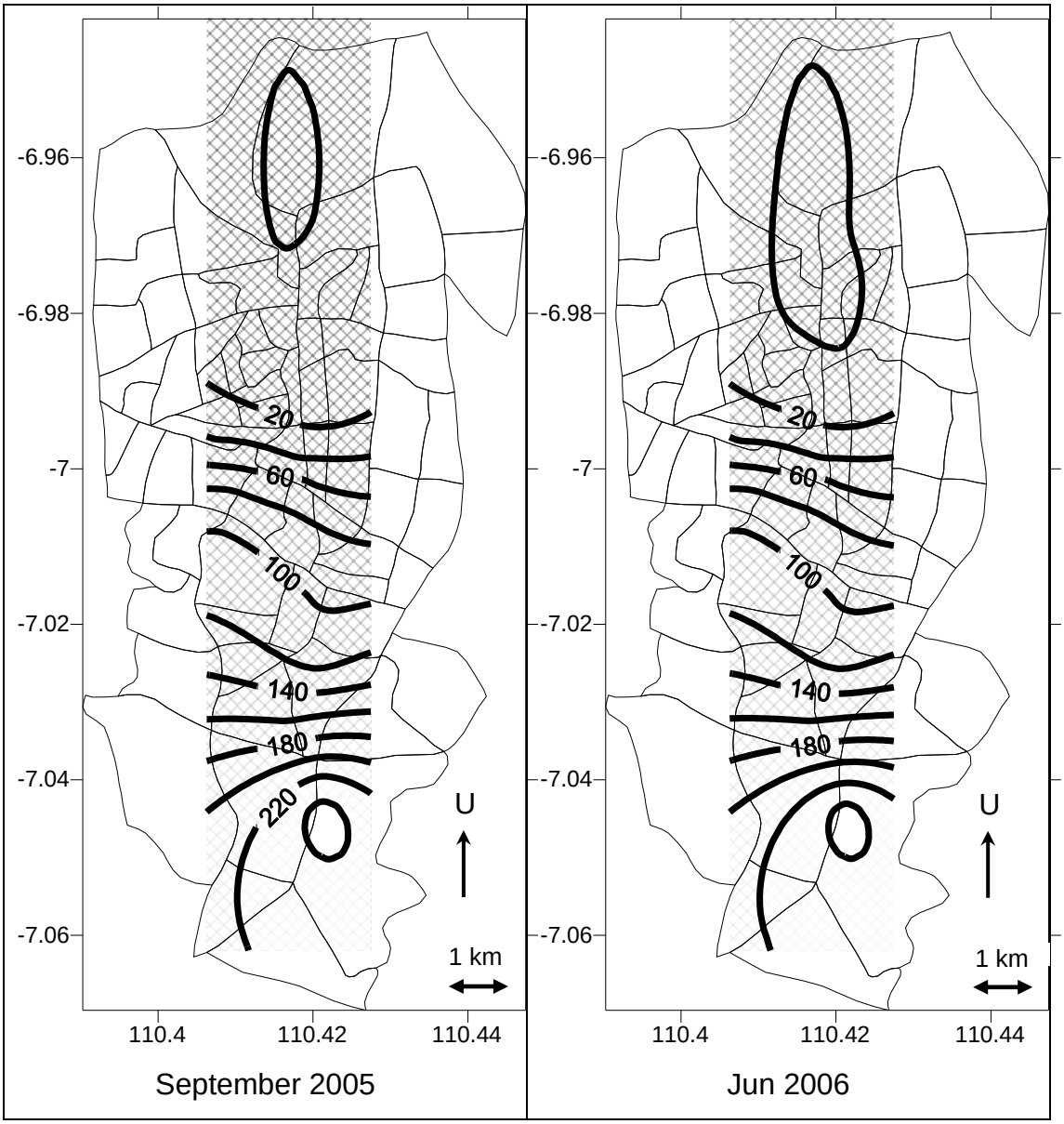

Fig 1. Elevation Contour Map of Semarang (in M + MSL)

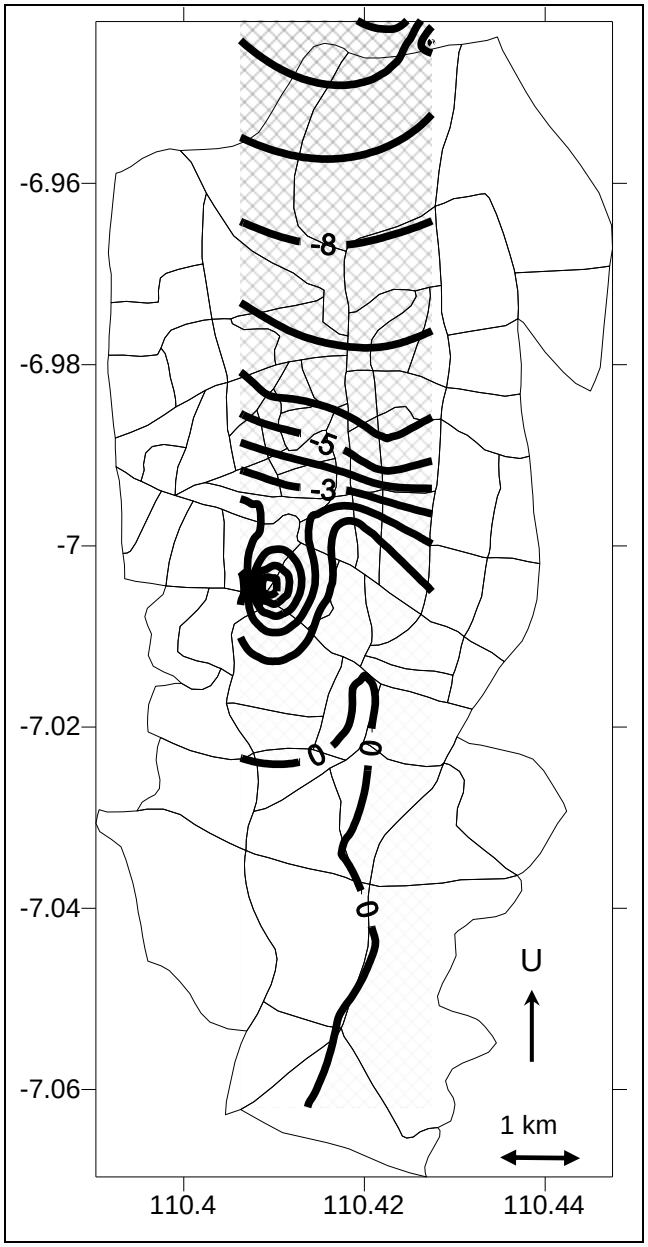

Fig 2. Land Subsidence Contour Map of Semarang (in cm/tahun)

Discussion

According to table 1 and 2; figure 1 and 2, Bench marks which are above MSL + 100 m in height were stable enough. The closer to the sea, the faster land subsidence occurs. Based on Wirasatriya (2005) soil type in coastal area of Semarang which included young-soft soil type makes it still underwent compression / consolidation. More over, coastal area of Semarang which is the center of the city

activity such as industry, buildings, reclamation, crowded transportation, and many artisian well has made land subsidence happens faster. Based on Suhandini (2004) in http://www.landpolicy.org, the land subsidence rate depended on the burden on the land. The heavier burden, the faster land subsidence happens. It was observed in Semarang that because of 5 tons burden, it would be lower the land about 0,0102 m - 0,4098 m. Suripin (2002) had found the correlation between the land subsidence rate and the height of pilling and also between the land subsidence rate and the reduction of under ground water elevation. Those correlation are shown at equations below :

$Y = 0{,}159\ X^{2{,}5069}$ $R^2 = 0{,}9954$

Y = Land Subsidence rate (m) X = Pilling Height (m)

$S = 6{,}5267\ SU^{0{,}6394}$ ($R^2 = 0{,}9904$)

S = Land Subsidence Rate (m) SU = The reduction of under ground water (m)

A research team from Mineral Engineering Faculty, Bandung Institute of Technology stated that the reduction of under ground water elevation in Semarang caused the degradation of the land about 0,6 – 1,2 cm/year in rate (Suripin, 2002). Data from Geology and Environment Management Agency (1999) showed that the amount of artisian well pipes increased fast in Semarang. In 1982 there were 127 pipes noted and they sucked under ground water about 13,49 million m^3. In 1998, there were 776 pipes noted and it caused 35,64 million m^3 of under ground water is sucked. There fore it is necessary to make an effective rule to control the under ground water sucking.

The fastest land subsidence occurs in Tanjung Emas Harbour (Pelabuhan Tanjung Emas). It reached more than 10 cm/year. Tanjung Emas harbor has very crowded industry activity where in that area is located many large factories. Those large factories are also have artisian well to supply their water demand. More over, loading and unloading activity of trailer truck that bring tons of cargo and the existing of north main street with its traffic add to the burden of soil in Tanjung Emas Harbor. Therefore it is important to manage the human activity at coastal area of Semarang City in order to prevent the worsening of land subsidence.

4. CONCLUSIONS

The conclusion of this research are :

1. Areas at Semarang city where have elevation above 100 m + MSL are stable enough and do not undergo land subsidence
2. The closer to the sea, the faster land subsidence occurs and the fastest land subsidence occurs in Tanjung Emas Harbour (Pelabuhan Tanjung Emas).

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