

**ANALYSIS OF EXTENSION AND ELEVATION OF DOCK CONTAINER
TERMINAL (TPKS) OF *TANJUNG EMAS SEMARANG* PORT**

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Abstract

Tanjung Emas Semarang port has an important role in economic activities inter-islands in Indonesia and overseas. *Tanjung Emas Semarang* serves loading and unloading goods by container, unloading process in *Semarang* Container Terminal always increase each year, so it needs expansion and addition of moorings in the dock to anticipate the surge in the loading and unloading happened in each year. Analyzing the development of extension and elevation dock in *Tanjung Emas Semarang* port in terms of the influence of additional forces due to wave, the horizontal forces due to wind, as well as due to tide.

This research was conducted by collecting secondary data, that is, a data of port operations during last 5 years (2011 to 2015) and oceanography data in 2014 and 2015. Analysis of extension and elevation of dock container terminal of *Tanjung Emas Semarang* port is conducted based on the ship flow estimation and container flow by using linear regression method. As well as based on the oceanography data in the forms of wind data, tide, flow, and wave.

The result of the research in 2011 showed that there were flow ships as many as 596 units and 427.468 TEUs of container, it will increase into 1023 units and 1089,520 TEUs in 2025. It also influenced the value of Berth Occupancy Ratio (BOR) which is in 2011 amounted as 33,58%, it will increased into 57,665 in 2025. In 2025 the value of BOR has exceeded the value of 50% as suggested by the United Nations Conference On Trade And Development (UNCTAD), which means that the use of the dock has already quite crowded. However to analyze the extension and elevation of dock, it also needs oceanography data analysis as supporting data. It was found in the research that fender system was able to detain ship collision energy, it can be proved by checking the requirements $F < R$ that is 1.51 tons < 64 tons. The estimation of the dominant wind directions came from the west with a percentage of 20.30%. For force due to the dock bollard flow, it was able to retain the force which work 1,767 tons that met the requirements. Based on the depth of 4,5 m, *tanjung emas* port has the split wave height of 6.432 m with the the split wave depth 6,505 m. The wave pressure was calculated based on *airy* theory amounted to 31 340 t.m and base on *minikin* methods of 42.772 kN / m² and has a total moment of 25.559 kN / m.

Keywords: container terminal of *tanjung emas semarang* port, fender, bollard

Introduction

The Harbour was site of the terminal or as a cruise ship after a backrest. One of the activities in the port

of *Tanjung Emas Semarang* in particular is the loading and unloading container managed by instances of Terminal Petikemas Semarang (TPKS). Pier of container have type wharf because it

requires a large courtyard, is usually more than 10 ha each moorings as well as considering the ships container large dock should be sufficiently long and within (Triatmodjo, 2003).

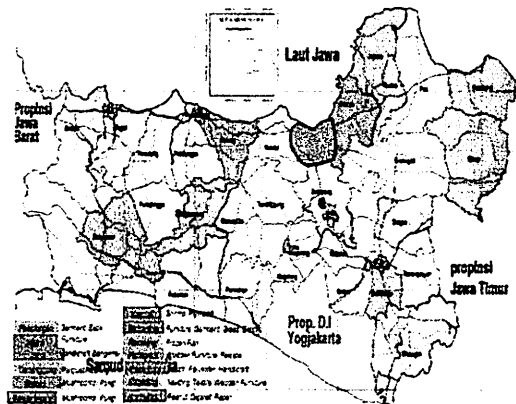


Figure 1. Hinterland Tanjung Emas Port of Semarang
(Source: Pelindo III, TPKS, 2015)

In relation with the development TPKS Pier Semarang increased flow of loading and unloading of goods. It must the construction of a new pier for the anticipated surge in flows of goods, and doing the pier due to elevation of sea level is higher and land subsidence, which will affect safety in the service of loading and unloading of goods. TPKS pier development includes the construction of a new pier and the elevation of the existing pier. Some things that can be used as a reference in planning pier is the port's performance such as the current condition of the ship and loading and unloading of container flows and oceanographic conditions such as wind, current, tide and wave. Based on the above, the authors

compile final report on the topic of the development of a container wharf Semarang title "Analysis Of Extension And Elevation Of Dock Container Terminal (TPKS) Of Tanjung Emas Semarang Port".

Below some of the equations used in this study as follows:

1. Port Performance Indicators

a. Berth Occupancy Ratio (BOR)

Berth occupancy ratio (BOR) or level of usage the pier indicate port performance is a compare between the amount of usage time of each pier provided with the amount of time available during the period in percent. Port performance indicators used to measure the extent of the dock facility and supporting infrastructure used intensively.

In general, the BOR can be calculated by equation:

$$BOR = \frac{Vs \times St}{Waktu\ Efektif \times n} \times 100\%$$

with:

- BOR : berth occupancy ratio (%)
- Vs : total of ships service (units/year)
- St : service time (hour/day)
- n : total mooring
- effective time : total of days in a year

UNCTAD (United Nation Conference On Trade And Development)

recommends level of usage the pier does not exceed the values given in the following table.

Table 1. Rated BOR recommend based UNCTAD

Total Mooring in Group	Recomend of BOR(%)
1	40
2	50
3	55
4	60
5	65
6 s/d 10	70

The maximum grades for the BOR container dock suggested UNCTAD is 50%. If the BOR value of more than 50% of the flow of containers is already quite dense and needed improvement and increased productivity in service of the pier TPKS Semarang.

b. Berth Throughput

Berth Throughput (BTP) is the throughput of container traffic served on a pier in periods per year.

BTP rated can be calculated by equation:

$$BTP = \frac{\Sigma TEUs \times BOR\%}{Lp \times n}$$

where:

BTP :Berth throughput (TEU's/year)

$\Sigma TEU's$:total of containers (TEU's/year)

BOR% : total of the pier usage rate per year (%)

Lp : length of the pier (berth)

n : total of the pier / mooring

The installed capacity of the pier is a pier ability be able to receive the flow of container loading and unloading, the installed capacity can be calculated using equation:

$$KD = L \times BTP \times n$$

c. Linear Regression Method

Linear regression method used to find projected increase in the flow of containers and vessels flow in subsequent years. The linear regression method compares causation of the increasing flow of containers and the current going vessels. Results of linear regression projection is used to recalculate and find solutions as a result of the increase in the currents are impacting on the productivity of container loading and unloading.

2. Force Works

a. Force to due current

Current work on part of the ship submerged in water will also cause the occurrence of a force on the vessel which was then forwarded to the pier and fastening address. Great force created by the current is given equation:

$$Rf = Cc \cdot \gamma_0 \cdot Ac \cdot \left(\frac{V_c^2}{2 \cdot g} \right)$$

b. Pressure Wave

(1) Airy Theory

The pressure wave caused by waves, is a combination of hydrostatic pressure

and dynamic cause wave, can be calculated using equation:

$$p = -\rho gy + \left(\frac{\rho g H}{2}\right) \frac{\cosh k(d+y)}{\cosh kd} \cos(kx - \sigma t)$$

(2) Method Minikin

Look for the maximum pressure value using minikin with equation:

$$P_m = 101. w. \frac{H_b}{L_D} \cdot \frac{d_s}{D} \cdot (D + d_s)$$

Moment total

$$M_t = M_m + M_s$$

Purpose research include: (1) determine the level of service the port's performance; (2) the effect of force due to current; (3) influence of tide to the pier TPKS.

Research Method

Final project research method is processing secondary data from intances such as PT. Pelindo III Semarang and BMKG Maritim Semarang. Data obtained from PT. Pelindo III Semarang form of data flow container and the flow ships, data used in 2011 – 2015 to get a projection can be use estimate the performance of port operations in the following years. The data from BMKG Calculation berth troughput (BTP) Berth troughput Container Terminal Semarang on the condition that it operates

Maritim Semarang includes data of wind, current, tide and wave. Data used in 2014 – 2015, because the weather forecastt for the year near the time study. Tuhs the completion of thsi study used teh method analysis.

Research Results and Discussion

The following data flow ships and flow containers in 2011 – 2015:

Tabel 2. Data Ships Call and Data Containers at TPKS Semarang

No	Year	Ship Call	Flow Container	
		(unit)	(Box)	(TEUs)
1	2011	596	265,478	427,468
2	2012	528	286,405	457,055
3	2013	566	311,525	498,703
4	2014	662	359,136	575,671
5	2015	701	375,654	608,201

Source: PT. PELINDO III banch Semarang

1. Performance Indicator of Harbour:

Calculate Berth Occupancy Ratio (BOR). BOR value or level of use the pier one period can be seen in Table 3:

$$BOR = \frac{Vs \times St}{Waktu \ efektif \times n} \times 100\% = \frac{596 \times 24}{8520 \times 2} \times 100\% = 33,58\%$$

can be calculated from data loading and unloading in 2011-2015.

The results of the analysis are shown in Table 4:

$$\begin{aligned}
 BTP &= \frac{\Sigma TEUs \times BOR\%}{Lp \times n} \\
 &= \frac{427,468 \times 33,58\%}{495 \times 2} \\
 &= 57,99 \text{ TEUs/m/year}
 \end{aligned}$$

The installed capacity can be calculated using equation:

$$\begin{aligned}
 CP &= L \times BTP \times n \\
 &= 495 \times 57,99 \\
 &= 28706,583 \text{ TEUs/year}
 \end{aligned}$$

Table 3. Calculation Berth Occupancy Ratio

No	Year	Ship Call	Flow Container		TEUs/ship	Service Time	Operation Time	BOR (%)
		(unit)	(Box)	(TEUs)		(hour/day)		
1	2011	596	265,478	427,468	717	24	8520	33,58
2	2012	528	286,405	457,055	866	24	8520	29,75
3	2013	566	311,525	498,703	881	24	8520	31,89
4	2014	662	359,136	575,671	870	24	8520	37,30
5	2015	701	375,654	608,201	868	24	8520	39,49

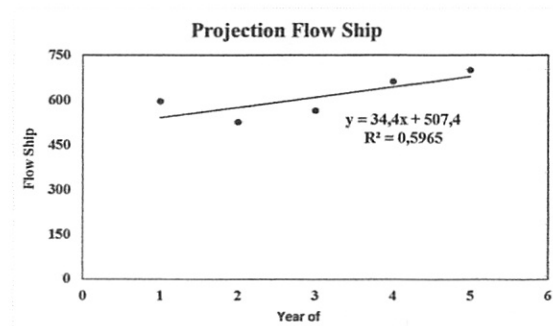
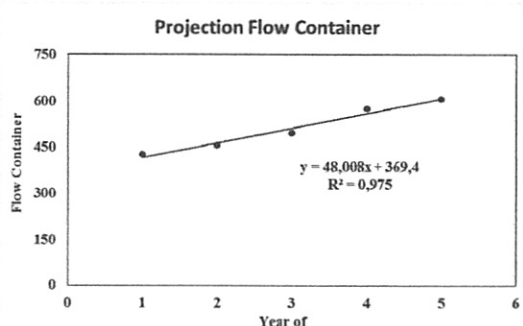
Table 4 Calculation BTP (Berth Throughput) and Capacity of Port (CP)

No	Year	Container	BOR (%)	Length of Port	Total Mooring	BTP	Capacity of Port
		(TEUs)					
1	2011	427,468	33,58	495	2	57,99	28706,583
2	2012	457,055	29,75	495	2	54,93	27191,554
3	2013	498,703	31,89	495	2	64,25	31804,608
4	2014	575,671	37,30	495	2	86,75	42940,192
5	2015	608,201	39,49	495	2	97,05	48039,313

Projected Flow Ship and Container

Projection flow ships and flow containers predicted using regression analysis. The data used is the data of the year 2011 to

2015. The regression result for current ship and container is shown in the graph:



From the graph regression linear current ship and container obtained function equation used to predict the current of ship and container in year to come. For the current ship equation is $y = 34,4x + 507,4$ and the current container $y = 48,008x + 369,4$. Of function linear equations above projections shown result obtained in table 5.

The projection in Table 5 recalculated to determine the level of use of the pier and power density of traffic the pier in the next 15 years. With the above data analysis services TPKS Semarang the pier shown in Table 6.

Table 5. Projection Flow Ships and Flow Containers

No	Year	Year Of	Flow Ship (unit)	Flow Container (TEUs)
1	2011	1	596	427,468
2	2012	2	528	457,055
3	2013	3	566	498,703
4	2014	4	662	575,671
5	2015	5	701	608,201
6	2016	6	714	657,448
7	2017	7	748	705,456
8	2018	8	783	753,464
9	2019	9	817	801,472
10	2020	10	851	849,480
11	2022	12	920	945,496
12	2025	15	1023	1089,520
13	2030	20	1195	1329,560

Table 6. Calculate Projection of Level Use of The Pier

No	Year	Year Of	Flow Ship (unit)	Flow Container (TEUs)	Service Time (jam/hari)	Waktu operasional	BOR(%)
1	2011	1	596	427,468	24	8520	33,58
2	2012	2	528	457,055	24	8520	29,75
3	2013	3	566	498,703	24	8520	31,89
4	2014	4	662	575,671	24	8520	37,30
5	2015	5	701	608,201	24	8520	39,49
6	2016	6	714	657,448	24	8520	40,21
7	2017	7	748	705,456	24	8520	42,15
8	2018	8	783	753,464	24	8520	44,09
9	2019	9	817	801,472	24	8520	46,03
10	2020	10	851	849,480	24	8520	47,97
11	2022	12	920	945,496	24	8520	51,84
12	2025	15	1023	1089,520	24	8520	57,66
13	2030	20	1195	1329,560	24	8520	67,35

Table 7. Calculate Projection of Berth Throughput (BTP)

No	Year	Year of	Container (TEUs)	BOR(%)	Length of Port	Total Mooring	BTP	Capacity of Port
1	2011	1	427,468	33,58	495	2	57,99	115,986
2	2012	2	457,055	29,75	495	2	54,93	109,865
3	2013	3	498,703	31,89	495	2	64,25	128,503
4	2014	4	575,671	37,30	495	2	86,75	173,496
5	2015	5	608,201	39,49	495	2	97,05	194,098
6	2016	6	657,448	40,21	600	2	88,13	176,258
7	2017	7	705,456	42,15	600	2	99,12	198,243
8	2018	8	753,464	44,09	600	2	110,73	221,469
9	2019	9	801,472	46,03	600	2	122,97	245,935
10	2020	10	849,48	47,97	600	2	135,82	271,642
11	2022	12	945,496	51,84	600	2	163,39	326,778
12	2025	15	1089,52	57,66	600	2	209,39	418,785
13	2030	20	1329,56	67,35	600	2	298,47	596,941

2. Working Style

a. Due Style Flow

$$R_f = C_c \cdot \gamma_0 \cdot A_c \cdot \left(\frac{V_c^2}{2 \cdot g}\right)$$

where, $A_c = B \cdot d$

$$= 25 \times 9,5$$

$$= 237,5 \text{ m}$$

then,

$$R_f = C_c \cdot \gamma_0 \cdot A_c \cdot \left(\frac{V_c^2}{2 \cdot g}\right)$$

$$= 1 \times 1,025 \times 237,5 \times \left(\frac{0,05^2}{2 \times 9,8}\right)$$

$$= 0,031 \text{ ton}$$

Checking against bollard strength are as follows:

$$P = R_f + R_w$$

$$= 0,031 + 1,736 = 1,767 \text{ ton}$$

Check the conditions : $P < R$

$$1,767 \text{ ton} < 150 \text{ ton} \quad \dots \text{ OK!!!}$$

After checking strength of the bollard, it can be seen that bollard is able to withstand the force exerted.

b. Due Style Wave

Calculation fetch using West wind direction, the calculation here using a map with a scale of 1: 25.000. Here are the results of calculations based direction of the wind fetch:

Table 8. Calculation fetch direct of the wind

No	α (°)	$\cos \alpha$	Distance of Map (km)		Actual Distance (km)	No. Cor. w
1	42	0,7431	8,70	217500	2,175	1,616
2	36	0,8090	10,00	250000	2,500	2,023
3	30	0,8660	11,80	295000	2,950	2,555
4	24	0,9135	15,30	382500	3,825	3,494
5	18	0,9511	19,50	487500	4,875	4,636
6	12	0,9781	31,00	775000	7,750	7,581
7	6	0,9945	1,90	47500	0,475	0,472
8	0	1,0000	1,90	47500	0,475	0,475
9	6	0,9945	1,90	47500	0,475	0,472
10	12	0,9781	2,60	65000	0,650	0,636
11	18	0,9511	2,40	60000	0,600	0,571
12	24	0,9135	2,10	52500	0,525	0,480
13	30	0,8660	2,30	57500	0,575	0,498
14	36	0,8090	2,40	60000	0,600	0,485
15	42	0,7431	2,60	65000	0,650	0,483
Total	13,511		116,400	2910000	29,100	26,477

It can be search F_{eff} :

$$F_{eff} = \frac{\sum X_i \cdot \cos \alpha}{\sum \cos \alpha}$$

$$= \frac{26,477}{13,511}$$

$$= 1,960 \text{ km}$$

Based on the maximum speed happens each month in a year, for example in January 2014 for wind direction, wind velocity = 23,00 Knots, then $U_L = 23,00$ Knots $\times 0,514 = 11,822$ m/st. Based on the chart relationship between wind speeds sea (U_W) and on land (U_L) obtained value $R_L = 1,11$.

Therefore U_W value can be found using equation:

$$U_W = U_L \times R_L$$

$$= 11,822 \times 1,11$$

$$= 13,122 \text{ m/s}$$

$$\text{then : } U_A = 0,71 \times U_W^{1,23}$$

$$= 0,71 \times 13,122^{1,23}$$

$$= 16,843 \text{ m/d}$$

Based on the graph wave forecasting approach U_A value are obtained: high (H): 0,4 m; period (T): 2,00 s; duration (t) :35 minute

Table 9. Result Calculation High Wave on 2015

No	Month	Dirctio a wind	V.Wind (Knot)	V. (U _L) (m/s)	R _L	U _W (m/s)	U _A (m/s)	Fetch eff. (km)	High Wave (H) (m)	Period (T) (s)	Time (t) (minute)
1	January	SE	20	10,28	1,13	11,616	14,498	1,407	0,28	1,75	27,00
2	February	SE	21	10,794	1,13	12,197	15,394	1,407	0,30	1,78	28,00
3	March	SE	20	10,28	1,13	11,616	14,498	1,407	0,28	1,75	27,00
4	April	SE	22	11,308	1,12	12,665	16,124	1,407	0,32	1,78	27,00
5	May	N	14	7,196	1,28	9,211	10,898	1,407	0,22	1,57	31,00
6	June	N	17	8,738	1,22	10,660	13,044	1,407	0,25	1,69	29,70
7	July	N	16	8,224	1,25	10,280	12,474	1,407	0,24	1,68	29,80
8	August	N	17	8,738	1,22	10,660	13,044	1,407	0,25	1,69	29,70
9	September	N	18	9,252	1,18	10,917	13,432	1,407	0,28	1,70	29,50
10	October	N	18	9,252	1,18	10,917	13,432	1,407	0,28	1,70	29,50
11	November	SE	20	10,28	1,13	11,616	14,498	1,407	0,28	1,75	27,00
12	December	N	23	11,822	1,11	13,122	16,843	1,407	0,35	1,78	26,00

Wave lenght in the deep ocean can be calculated:

$$L_0 = 1,56 \times T^2$$

$$= 1,56 \times 2^2$$

$$= 6,240 \text{ m}$$

$$\text{thus, } d/L_0 = 4,5/4,943$$

$$= 0,721$$

$$c_0 = L_0/T$$

$$= \frac{6,240}{2}$$

$$= 3,12 \text{ m/det}$$

Based on value d/L_0 above, using table A-1, the value d/L can be seen in the amount of 0,72116.

$$\text{that } L = \frac{4,5}{0,72116} = 6,240$$

$$c_1 = L/T$$

$$= 6,240/2$$

$$= 3,12 \text{ m/s}$$

Wave direction at a depth of 4,5m can be calculate:

$$\begin{aligned} \sin\alpha_1 &= \left(\frac{c_1}{c_0}\right)\sin\alpha_0 \\ &= \left(\frac{3,12}{3,12}\right) \times (-0,866) \\ &= -0,866 \\ \alpha_1 &= 59,999 \end{aligned}$$

The coefficient of refraction can be calculated using the equation:

$$\begin{aligned} Kr &= \sqrt{\frac{\cos\alpha_0}{\cos\alpha_1}} \\ Kr &= \sqrt{\frac{\cos 300}{\cos 59,999}} \\ Kr &= 1,00 \end{aligned}$$

Value $d/L_0 = 0,72116$, it is known based on Table A-1, $n_1 = 0,5011$ and $n_0 = 0,5$ (for deep sea). Silting coefficient can be calculated by the equation:

$$\begin{aligned} Ks &= \sqrt{\frac{n_0 \times L_0}{n_1 \times L}} \\ Ks &= \sqrt{\frac{0,5 \times 6,240}{0,5011 \times 6,240}} \\ Ks &= 0,999 \end{aligned}$$

Then the wave height at a depth of 4,5m is obtained using the equation:

$$\begin{aligned} H_1 &= Kr \cdot Ks \cdot H_0 \\ &= 1,00 \times 0,999 \times 0,4 \\ &= 0,4 \text{ m} \end{aligned}$$

Calculate the height and depth of a breaking wave using the following equation:

$$\begin{aligned} H'_0 &= Kr \cdot H_0 \\ &= 1,00 \times 0,4 \\ &= 0,4 \\ H'_0/gT^2 &= 0,4/(9,8 \times 2^2) \\ &= 0,010 \end{aligned}$$

Based on the graph breaking wave height. Then it can be seen breaking wave height, that is equal to:

$$\begin{aligned} H_b/H'_0 &= 1,07 \\ H_b &= (H_b/H'_0) \cdot H'_0 \\ &= 0,432 \end{aligned}$$

Based on the depth chart breaking waves (Figure 2.16). Then it can be seen breaking wave height, that is equal to:

$$\begin{aligned} d_b/H_b &= 1,17 \\ d_b &= (d_b/H_b) \cdot H_b \\ &= 0,505 \end{aligned}$$

From the previous calculations, the value obtained:

$$\text{High waves break } (H_b) = 0,432 \text{ m}$$

$$\text{Depth of breaking waves } (d_b) = 0,505 \text{ m}$$

(2) Pressure Wave Minikin Method

$$\begin{aligned}P_m &= 101 \cdot w \cdot \frac{H_b}{L_D} \cdot \frac{d_s}{D} \cdot (D + d_s) \\&= 101 \times 1,025 \\&\quad \times \frac{0,43}{6,20} \cdot \frac{3,120}{3,431} \cdot (3,431 + 3,120) \\&= 42,772 \text{ kN/m}^2\end{aligned}$$

Search moment total (Mt) :

$$M_t = M_m + M_s$$

with :

$$R_m = \frac{P_m + H_b}{3}$$

$$= \frac{42,772 + 043}{3}$$

$$= 6,159 \text{ kN/m}$$

$$R_s = \frac{w (d_s + \frac{H_b}{2})^2}{2}$$

$$= \frac{1,025 \left(3,120 + \frac{0,43}{2}\right)^2}{2}$$

$$= 5,704 \text{ kN/m}$$

$$\text{then : } R_t = R_m + R_s$$

$$= 6,159 + 5,704 \text{ m}$$

$$= 11,863 \text{ kN/m}$$

$$M_m = R_m \cdot d_s$$

$$= 6,159 \times 3,12 = 19,217 \text{ kN/m}$$

$$M_s = \frac{w (d_s + \frac{H_b}{2})^3}{6}$$

$$= \frac{1,025 \left(3,120 + \frac{0,43}{2}\right)^3}{6} = 6,342 \text{ kN/m}$$

Moment total can be formulated by the equation:

$$M_t = M_m + M_s$$

$$= 19,217 + 6,342$$

$$= 25,559 \text{ kN/m}$$

Conclusions and suggestions

Conclusion obtained from this research from this study can be summarized as follows:

- Year 2011 - 2020 berth throughput (BTP) is smaller than the capacity of the pier. However BOR value of less than 50% for ports that have two terminations as suggested UNCTAD, which means the Container Terminal Semarang are still able to serve the flow of vessels and the flow of goods well. Year 2022 - 2030 BOR value more than 50% it would require an extension of the pier, to overcome the surge vessel and the flow of goods in the hope of later years so that the ship does not experience the delay time.
- The results of the analysis of the force due to the current, it can be seen that the pier bollard Semarang Container Terminal is able to withstand the forces acting, 1,767 ton already qualified.
- Based on the analysis wave Tanjung Emas Semarang area can be seen that:
 - Based on the depth 4,5 m, the high breaking wave (H_b) of 0,432 m with a depth of breaking wave (d_b) 0,505 m, while the depth 9,5 m, high breaking wave (H_b) 0,317 m

with a depth of breaking wave (d_b) sebesar 0,333 m.

- (2) The pressure wave is calculated using Airy theory amounted to 31.340 tm and pressure waves using Minikin amounted to 42.772 kN / m². As well as the moment of a total of 25.559 kN / m.

From the research conclusion can be obtained suggestions:

- a. Reducing the time delay and queues vessel by way an extension of the dimensions of the pier as well as increase the number of moorings in the pier, so it can accommodate the productivity of container port Semarang increasing every year.
- b. The force due to currents and wave action that affects bollard to be used in a the pier, then fender system and bollard used to be more robust to withstand these forces.
- c. As time goes by their global warming is not possible that the volume of sea water will also be increased as well as possibility to decrease the soil so it will need checking elevation of the

existing condition of the pier Container Terminal Semarang.

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