# Analysis of Leveling Container Field At Tanjung Mas Port, Semarang Based on the British Port Association Method

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**ABSTRACT:** *The increasing growth of container flows at the Semarang Container Terminal which encourages the economy in the city of Semarang and its surroundings. For this reason, it is necessary to have a stacking field other than a large one, also the stacking field is not flooded so that container loading and unloading operations can run smoothly. There are several CY fields (Container Yard/CY) in Tanjung Mas Port, namely Cy-01 to CY-03). CY-01 and CY-02 are relatively newer so that their position is higher than CY-03, so CY-03 needs to be raised in the pavement. The function of CY-03 in addition to container stacking is also a long room whose function is to check the contents of containers that are considered suspicious, so CY-03 needs to be safe against puddles due to rain or high tide. To calculate the elevation of the field, the method from the British Association Ports is used according to the need to be able to withstand the load of the Reach Stacker (RS) transportation equipment and its cargo, namely a durable container according to the plan which is for 30 years. In this study, apart from the hospital load and the container, the dynamic load resulting from the movement of the hospital and the container as well as when placing the container in the stacking yard is also taken into account, so it is hoped that the results will be as planned, safe, strong and effective.*
**KEY WORD***:* container yard, reach stacker, British Association Ports.

## INTRODUCTION

The container terminal is located in the Tanjung Mas port area, Semarang, with a container pier size of 495 m long, 25 m wide and -11 m deep (MLWS), with a container yard (CY) of 18.7 hectares consisting of CY- 01 to CY-03, for CY-03 the area is ± 2 Ha.

CY-2 and CY-03 are located side by side separated by a road, the height of CY-02 is higher than CY-03, the height difference is ± 1.40 m, this is when it rains quite heavily and for a long time or high tide then most of the CY -03 flooded. The function of CY-03 other than for container stacking with 4 tier stacking, is for inspection of container contents by customs and excise officers, where if the contents of the container are doubtful/dangerous.

Especially for CY-03, a Long Room is provided, which is a room for checking chests that are protected from weather, dark and safe. The equipment facilities that operate here include types such as Reach Stacker (RS) with a capacity of 45 tons, Truck Traillers and Forklifts with a capacity of 5 tons.

Considering the role of ports in supporting the regional and national economy, it is necessary to provide a variety of services for loading and unloading goods and container stacking that are effective and safe.

This study plans the thickness of the pavement for container stacking areas, as a development of knowledge and contribution of ideas for the elevation of container stacking areas, especially CY-03, at the Container Terminal of Tanjung Mas Port, Semarang.

**Figure. 1** CY-03 *Exiting Condition*

## RESEARCH METHODS

The research method according to Andi (2016), research methodology is a strategy in collecting and analyzing data needed according to research objectives so that they can reveal objective truth in a scientific way.

Research sites

The research location will be carried out at the Tanjung Mas Port Container Terminal, Semarang City. The selection of this location is based on the existing problems and in the context of collecting primary and secondary data.

Research Stages

Stage I

The primary data in this study were obtained from the results of the field CBR and CPT tests, which were later used to select the charts found in the British Port Association (The Structural Design of Heavy-duty Pavement for Ports and Other Industries), to determine the thickness of the pavement layer in the container field. secondary data include; equipment operating in the container yard and the number of containers and contours were obtained from Pelindo III Semarang Branch.

Stage II

Based on stage I, primary data is used later to determine pavement thickness according to the British Port Association (The Structural Design of Heavy-duty Pavement for Ports and Other Industries) and secondary data is analyzed to determine the maximum load that occurs that affects the container yard.

Stage III

From the results of Phase II, it is then analyzed the influence of dynamic loads due to the load of the Reach Stacker (RS) and containers when traveling and when placing containers.

Stage IV

From the results of the dynamic load, it is planned that the pavement will be able to match the design life, which is for the next 30 years.

## RESEARCH RESULT

Calculation of Pavement Backfill

This pavement planning will refer to the British Port Association (The Structural Design of Heavy Duty Pavements for Ports and Other Industries). The stacking field, in this case the pavement, is planned to have a service life of 30 years.

The types of containers used are 20 ft (6 m x 2.5 m) with a weight of 20 tons, and 40 ft (12 m x 2.5 m) with a maximum weight of 35 tons. The planned container stack is 4 tiers. The loading and unloading equipment used are: Reach Stacker and Road Trailer.

Calculation of Existing Load Analysis

Reach Stacker Tool Load Calculation

**Table 1.** Calculation of Damage Effect Value with Variation in Container Weight (Wc)

| Wc | $W_1$ | $W_2$ | $D_{manjang}$ | $D_{lintang}$ | $D_{used}$ | Distribution 40/60 | Proportional Damaging Effect |
|---|---|---|---|---|---|---|---|
| 0 | 7119 | 34203 | 59,18 | 60,89 | 60,89 | 0,00 | 0,00 |
| 1000 | 7613 | 33914 | 57,43 | 59,63 | 59,63 | 0,00 | 0,00 |
| 2000 | 8107 | 33626 | 55,74 | 58,53 | 58,53 | 0,28 | 16,39 |
| 3000 | 8601 | 33337 | 54,12 | 57,60 | 57,60 | 0,89 | 51,27 |
| 4000 | 9096 | 33049 | 52,56 | 56,85 | 56,85 | 1,84 | 104,61 |
| 5000 | 9590 | 32760 | 51,07 | 56,30 | 56,30 | 2,59 | 145,82 |
| 6000 | 10084 | 32472 | 49,64 | 55,96 | 55,96 | 2,76 | 154,45 |
| 7000 | 10578 | 32183 | 48,28 | 55,85 | 55,85 | 2,93 | 163,63 |
| 8000 | 11073 | 31895 | 47,00 | 55,97 | 55,97 | 3,27 | 183,03 |
| 9000 | 11567 | 31606 | 45,79 | 56,36 | 56,36 | 3,17 | 178,65 |
| 10000 | 12061 | 31318 | 44,65 | 57,02 | 57,02 | 3,52 | 200,70 |
| 11000 | 12556 | 31029 | 43,59 | 57,97 | 57,97 | 4,20 | 243,47 |
| 12000 | 13050 | 30740 | 42,61 | 59,23 | 59,23 | 4,99 | 295,56 |
| 13000 | 13544 | 30452 | 41,72 | 60,82 | 60,82 | 4,69 | 285,25 |
| 14000 | 14038 | 30163 | 40,91 | 62,76 | 62,76 | 5,14 | 322,58 |
| 15000 | 14533 | 29875 | 40,18 | 65,06 | 65,06 | 5,29 | 344,19 |
| 16000 | 15027 | 29586 | 39,55 | 67,76 | 67,76 | 5,76 | 390,28 |
| 17000 | 15521 | 29298 | 39,02 | 70,86 | 70,86 | 5,91 | 418,78 |
| 18000 | 16015 | 29009 | 38,57 | 74,39 | 74,39 | 6,10 | 453,78 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 19000 | 16510 | 28721 | 38,23 | 78,37 | 78,37 | 6,98 | 547,04 |
| 20000 | 17004 | 28432 | 37,99 | 82,83 | 82,83 | 8,58 | 710,67 |
| 21000 | 17498 | 28144 | 37,86 | 87,78 | 87,78 | 8,19 | 718,93 |
| 22000 | 17992 | 27855 | 37,84 | 93,25 | 93,25 | 6,43 | 599,62 |
| 23000 | 18487 | 27567 | 37,92 | 99,27 | 99,27 | 3,69 | 366,31 |
| 24000 | 18981 | 27278 | 38,13 | 105,86 | 105,86 | 1,25 | 132,32 |
| 25000 | 19475 | 26990 | 38,45 | 113,03 | 113,03 | 0,47 | 53,13 |
| 26000 | 19969 | 26701 | 38,90 | 120,83 | 120,83 | 0,27 | 32,62 |
| 27000 | 20464 | 26413 | 39,47 | 129,27 | 129,27 | 0,29 | 37,49 |
| 28000 | 20958 | 26124 | 40,18 | 138,38 | 138,38 | 0,21 | 29,06 |
| 29000 | 21452 | 25836 | 41,02 | 148,19 | 148,19 | 0,17 | 25,19 |
| 30000 | 21946 | 25547 | 42,00 | 158,73 | 158,73 | 0,11 | 17,46 |
| 31000 | 22441 | 25259 | 43,12 | 170,01 | 170,01 | 0,01 | 1,70 |
| 32000 | 22935 | 24970 | 44,38 | 182,08 | 182,08 | 0,01 | 1,82 |
| 33000 | 23429 | 24682 | 45,80 | 194,96 | 194,96 | 0,00 | 0,00 |
| 34000 | 23923 | 24393 | 47,37 | 208,68 | 208,68 | 0,02 | 4,17 |
| 35000 | 24418 | 24105 | 49,11 | 223,27 | 223,27 | 0,02 | 4,47 |
| | | | | | | | 7234,45 |

Average Damaging Effect = 7234,45/ 100 = 72,345

Maksimum Proportional Damaging effect = 718,930

Critical Damage Effect = 87,781

Unladen Damage Effect = 60,888

**Determination of Load Classification Index (LCI) Value**

Calculation of Design Life (L)

$$L = \frac{Total\ number\ of\ plant\ movements \quad x \quad average\ damaging\ effect}{critical\ damaging\ effect}$$

$$L = \frac{50\ tahun \quad x \quad 52\ minggu \quad x \quad 931 \quad x \quad 72{,}345}{87{,}781}$$

= 1.994.945,45 trip

= 1,99 x $10^6$ trip

**High Truck Vehicle Load Calculation**

Road Trailer Spesification :

Tipe : Hino

Empty weight of road trailer:

- front axle ($U_1$) = 3.000 kg
- middle axle ($U_2$) = 850 kg
- rear axle ($U_3$) = 500 kg

Number of wheels of road trailer:

- front axle ($M_1$) = 2 bh
- middle axle ($M_2$) = 4 bh
- rear axle ($M_3$) = 8 bh

Container weight (Wc) = 35,0 ton

Wheel pressure (P) = 9.0 kg/cm2

Distance between axles = 2.0 m

Dinamik Factor (fD) = 1.1 (assumptions during braking)

$X_B = 2.5$ ; $X_C = 8$ ;

$X_2 = 3.0$ ; $X_3 = 11.0$ ;

$$A = \frac{X_C}{X_3} = \frac{8}{11} = 0{,}73\ ;$$

$$B = \frac{X_B}{X_2} = \frac{2{,}5}{3{,}0} = 0{,}83$$

**Wheel Load :**

*For containers weighing 35,000 kg*

$$W_1 = f_D \text{ x } \left( Wc \times \frac{(1-A)\times(1-B)}{M_1} + U_1 \right) \text{ x number of wheels in one side}$$

$$= 1{,}1 \text{ x } \left( 35.000 \times \frac{(1-0{,}73)\times(1-0{,}83)}{2} + 3.000 \right) \text{ x } 1$$

$$= 4.175 \text{ kg}$$

$$W_2 = \left( Wc \times \frac{(1-A)\times B}{M_2} + U_2 \right) \text{ x jumlah roda dalam satu sisi}$$

$$= \left( 35.000 \times \frac{(1-0{,}73)\times 0{,}83}{8} + 450 \right) \text{ x } 4$$

$$= 5.677{,}27 \text{ kg}$$

$$W_3 = \left( Wc \times \frac{A}{M_3} + U_3 \right) \text{x jumlah roda dalam satu sisi}$$

$$= \left( 35.000 \times \frac{0.73}{8} + 500 \right) \text{ x } 4$$

$$= 13.927{,}27 \text{ kg}$$

*Damaging Effect :*

For containers weighing 35,000 kg

$$d_1 = \left(\frac{W_1}{12.000}\right)^{3.75} \times \left(\frac{P}{0,8}\right)^{1.25}$$

$$= \left(\frac{4.175}{12.000}\right)^{3.75} \times \left(\frac{0,9}{0,8}\right)^{1.25}$$

$$= 0,02 \text{ PAWLS}$$

$$d_2 = \left(\frac{5.677,27}{12.000}\right)^{3.75} \times \left(\frac{0,9}{0,8}\right)^{1.25}$$

$$= 0,107 \text{ PAWLS}$$

$$d_3 = \left(\frac{13.927,27}{12.000}\right)^{3.75} \times \left(\frac{0,9}{0,8}\right)^{1.25}$$

$$= 2,03 \text{ PAWLS}$$

➔ D = $(d_1 + d_2 + d_3)$ x 40/60 Distribution

= (0,02 + 0,07 + 2,03) x 40/60 = 0,0424 PAWLS

As for the value of the effect of damage when it is not loaded (unladen damaging effect), namely Wc = 0 kg, and the value of the average damaging effect (average damaging effect) can be seen in the following table:

**Table 2.** Calculation of Damage Effect Value with Variation of Container Weight (Wc) for High Truck

| Wc ( Kg ) | W1 ( Kg ) | W2 ( Kg ) | W3 ( Kg ) | d1 ( PAWLS ) | d2 ( PAWLS ) | d3 ( PAWLS ) | D ( PAWLS ) | 40/60 Distribution | Proportional Damaging Effect |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 3300 | 1800 | 2000 | 0.009 | 0.001 | 0.001 | 0.012 | 0.00 | 0.00 |
| 1000 | 3332.083 | 1945.83 | 2325 | 0.009 | 0.001 | 0.002 | 0.013 | 0.00 | 0.00 |
| 2000 | 3264.167 | 2091.67 | 2650 | 0.009 | 0.002 | 0.004 | 0.014 | 0.28 | 0.00 |
| 3000 | 3396.25 | 2237.5 | 2975 | 0.010 | 0.002 | 0.006 | 0.019 | 0.89 | 0.02 |
| 4000 | 3428.33 | 2383.33 | 3300 | 0.011 | 0.003 | 0.009 | 0.022 | 1.84 | 0.04 |
| 5000 | 3460.42 | 2529.17 | 3625 | 0.011 | 0.003 | 0.013 | 0.027 | 2.59 | 0.07 |
| 6000 | 3492.5 | 2675 | 3950 | 0.011 | 0.004 | 0.018 | 0.033 | 2.76 | 0.09 |
| 7000 | 3524.58 | 2820.83 | 4275 | 0.012 | 0.005 | 0.024 | 0.041 | 2.93 | 0.12 |
| 8000 | 3556.67 | 2966.67 | 4600 | 0.012 | 0.006 | 0.032 | 0.050 | 3.27 | 0.16 |
| 9000 | 3588.75 | 3112.5 | 4925 | 0.013 | 0.007 | 0.041 | 0.061 | 3.17 | 0.19 |
| 10000 | 3620.83 | 3258.33 | 5250 | 0.013 | 0.009 | 0.052 | 0.074 | 3.52 | 0.26 |
| 11000 | 3652.92 | 3404.17 | 5575 | 0.013 | 0.010 | 0.065 | 0.089 | 4.20 | 0.37 |
| 12000 | 3685 | 3550 | 5900 | 0.014 | 0.012 | 0.081 | 0.107 | 4.99 | 0.53 |
| 13000 | 3717.083 | 3695.83 | 6225 | 0.014 | 0.014 | 0.099 | 0.127 | 4.69 | 0.60 |
| 14000 | 3749.17 | 3841.67 | 6550 | 0.015 | 0.016 | 0.120 | 0.151 | 5.14 | 0.77 |
| 15000 | 3781.25 | 3987.5 | 6875 | 0.015 | 0.019 | 0.144 | 0.178 | 5.29 | 0.94 |
| 16000 | 3813.33 | 4133.33 | 7200 | 0.016 | 0.021 | 0.171 | 0.208 | 5.76 | 1.20 |
| 17000 | 3845.42 | 4279.17 | 7525 | 0.016 | 0.024 | 0.202 | 0.242 | 5.91 | 1.43 |
| 18000 | 3877.5 | 4425 | 7850 | 0.017 | 0.028 | 0.236 | 0.281 | 6.10 | 1.71 |
| 19000 | 3909.58 | 4570.83 | 8175 | 0.017 | 0.031 | 0.275 | 0.323 | 6.89 | 2.23 |
| 20000 | 3941.67 | 4715.47 | 8500 | 0.018 | 0.035 | 0.318 | 0.371 | 8.58 | 3.18 |
| **21000** | **3973.75** | **4862.5** | **8825** | **0.018** | **0.039** | **0.366** | **0.424** | **8.19** | **3.47** |
| 22000 | 4005.83 | 5008.33 | 9150 | 0.019 | 0.044 | 0.420 | 0.482 | 6.43 | 3.10 |
| 23000 | 4037.92 | 5154.17 | 9475 | 0.020 | 0.049 | 0.478 | 0.547 | 3.69 | 2.02 |
| 24000 | 4070 | 5300 | 9800 | 0.020 | 0.054 | 0.543 | 0.617 | 1.25 | 0.77 |
| 25000 | 4102.083 | 5445.83 | 10125 | 0.021 | 0.060 | 0.613 | 0.694 | 0.47 | 0.33 |
| 26000 | 4134.17 | 5591.67 | 10450 | 0.021 | 0.066 | 0.691 | 0.778 | 0.27 | 0.21 |
| 27000 | 4166.25 | 5737.5 | 10775 | 0.022 | 0.073 | 0.775 | 0.869 | 0.29 | 0.25 |
| 28000 | 4198.33 | 5883.33 | 11100 | 0.023 | 0.080 | 0.866 | 0.969 | 0.21 | 0.20 |
| 29000 | 4230.42 | 6029.17 | 11425 | 0.023 | 0.088 | 0.965 | 1.076 | 0.17 | 0.18 |
| 30000 | 4262.5 | 6175 | 11750 | 0.024 | 0.096 | 1.072 | 1.192 | 0.11 | 0.13 |
| 31000 | 4294.58 | 6320.83 | 12075 | 0.025 | 0.105 | 1.187 | 1.317 | 0.01 | 0.01 |
| 32000 | 4326.67 | 6466.67 | 12400 | 0.025 | 0.114 | 1.312 | 1.451 | 0.01 | 0.01 |
| 33000 | 4358.75 | 6612.5 | 12725 | 0.026 | 0.124 | 1.445 | 1.596 | 0.00 | 0.00 |
| 34000 | 4390.83 | 6758.33 | 13050 | 0.027 | 0.135 | 1.589 | 1.750 | 0.02 | 0.04 |
| 35000 | 4422.92 | 6904.17 | 13375 | 0.027 | 0.146 | 1.742 | 1.916 | 0.02 | 0.04 |
| | | | | | | | | Total | 24.70 |

So, the calculation of the value of the effect of damage can be concluded:

Nilai PAWL’S kritis = 0,424 PAWL’S

- Nilai PAWL’S rata – rata = $\frac{24,7}{100}$ = 0,247 PAWL’S

- Nilai PAWL’S tanpa beban = 0,012 PAWL’S

Determination of Load Classification Index (LCI) Value

In accordance with the table for determining the value of the loading classification index (LCI) Table 2. with a critical PAWL'S value of 0.424 PAWL'S, the road trailer is classified as a class A LCI.

Calculation of Number of Repetition (N) High Truck Vehicles

The number of tool movements (trips) is as follows:

For the week it is estimated that there are 954 x 2 movements = 1908 container trips served by road trailers, where each trip is a full or empty container condition.

so the value of N is:

$$\mathbf{N} = \sum \frac{\text{Kumulatif Pergerakan} \times \text{PAWLS}}{\text{Maksimum PAWLS terkritis}}$$

$$= \frac{50 \text{ tahun} \times 52 \text{ Minggu} \times \begin{bmatrix} (1908 \times 0{,}424) + (1908 \times 0{,}247) \\ + (1908 \times 0{,}012) \end{bmatrix}}{0{,}424}$$

= 7991100 trip

= $0{,}79 \times 10^{7}$ trip

Comparison of the Force Due to the Load that Occurs

Comparative analysis of the load force is obtained by comparing the load force that occurs in the Reach Stacker to be compared with the design load that occurs on the Road Trailer. From these two comparisons, the largest / critical load value is sought to be used as a design load in finding the required pavement thickness.

From the above calculation analysis obtained:

**Table 3.** Comparison of Load Analysis for Reach Stacker with High Truck

| Load Type | LCI | Traffic Design |
|---|---|---|
| Reach Stacker | G | 1,99 E+06 |
| Road Trailer | A | 0.79 E+07 |

From the comparison table above, data is obtained that the type of analysis of the Reach Stacker load is greater / critical when compared to the road trailer so that it is used as a reference for calculations.

Flexible Pavement Layer Design

This pavement planning will refer to the British Port Association (The Structural Design of Heavy-Duty Pavements for Ports and Other Industries).

- Tebal *concrete block* = 10 cm, f'c 40 Mpa.
- *Bedding sand*, d = 5 cm.

- CTB, d = 30 cm
- *Base Course* layer
- *Sub Grade*, minimal CBR 30 %.

From the British Port Association Chart *( The Structural Design of Heavy Duty Pavements for Ports and Other Industries )* :

From the graph 80 mm BLOCKS Sub Base 600 mm CBR 30 %

Reach Stacker tool load:

| | |
|---|---|
| CTB thickness | : 29 cm |
| Sub base thickness | : 60 cm |

High Truck tool load:

| | |
|---|---|
| CTB thickness | : 17 cm |
| Sub base thickness | : 60 cm |

From the graph above, 80 mm BLOCKS Sub Base 600 mm CBR 30% CTB is used with a thickness of 30 cm and a sub base of 60 cm thick.

## CONCLUSIONS

From the results of the analysis above, it can be concluded that the provisional results are as follows:

1. The value of the CBR used is 30%, because the embankment is on a soil that already has a pavement layer.
2. The maximum calculated vehicle load is the result of the Reach Stracker tool.
3. The pile layer obtained as a result of the Reach Stacker is in the form of a 60 cm thick sub base with type B base course material, and the base layer using 30 cm thick CTB material.
4. For paving blocks 8 cm thick is used, with K-500 concrete quality.
5. From the results of dynamic analysis and referring to the existing soil conditions, it is necessary to add a pile at the end of the pier with a batter pile type so that the deflection that occurs is smaller.

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