Road Planning for Improvement of reinforced concrete at PT. Krakatau Bandar Samudra Cilegon-Banten Province

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Abstract. Road hardening is one of the elements of highway construction that is very important for smooth land transportation so as to provide comfort and safety for its users. The development of the economic and industrial sectors has increased, therefore the need for road transport facilities and infrastructure has increased and the development in PT. Krakatau Bandar Samudra, therefore the need for road repairs. Flexible hardening until rigid hardening, is expected to help improve surfing transportation services for the community and industry, so it needs to be well planned based on planning standards and applicable criteria in Indonesia. The method used in this planning uses Bina Marga T-14-2003, this plan includes to determine the thickness, dowel test diameter used and the dimensions of the drainage channel. In this planning requires primary and secondary data. Secondary data is obtained from the Public Works Agency in the form of location maps, previous technical specifications of data, and land data while the primary data is in the form of Average daily traffic data. The results of the analysis carried out obtained by the thickness of the concrete plate using Continuous Concrete Without Strengthening, the dowel test diameter and drainage channel dimensions that have fulfilled the requirements of safe numbers.

1. Introduction
Government Regulation No. 34 of 2006 and Law Number 38 of 2004 states “Roads are land transportation facilities that form a transportation network to connect the regions so that the wheels of the economy and development can rotate well”. The increasing development of the economic and industrial sectors, Cilegon City has been given priority in road construction, especially in the Industrial Estate of PT. Krakatau Bandar Samudra is expected to help improve the economy with services, facilitate transportation for the community and industry.

PT. Krakatau Bandar Samudra which is located in industrial area, its heavy traffic which is economic support route for Java. Road of area at PT. Krakatau Bandar Samudra has a visually decreasing pavement structure with many deflections which can endanger safety and even hinder the rate of transportation. In conditions such as these rigid sidewalks make a choice in improving the road at that location. Rigid pavement planning is emphasized to determine the rigid pavement thickness so as being able to withstand the load of vehicles passing on the road, and to determine the diameter of the reinforcement and drainage dimensions required in this plan.
2. Research Methods

2.1 Data Collection Techniques
Planning for rigid hardening of the road at PT. Krakatau Bandar Samudra requires data to be processed as a reference to determine the hardening thickness, the diameter of the reinforced concrete plates in supporting the load of the vehicle that passes through these parts and the drainage dimension. Data collection techniques are carried out in the following ways.

2.1.1 Primary Data Conducting surveys directly in the Industrial Estate of PT. Survey of Krakatau Bandar Samudra vehicles to obtain data. Average daily traffic is conducted for two days representing workdays and holidays. The location of the study is shown in figure 1.

![Survey Location](source: Office of Highways)

Figure 1. Survey Location

2.1.2 Secondary Data Secondary data is written data from objects in the form of maps, images, technical specifications, implementation methods, traffic data, land investigation data.

2.2 Analysis methods
Planning road repairs in the PT Krakatau Bandar Samudra area using rigid hardening to determine the thickness and diameter of the reinforcement along with the dimensions of the drainage channel while the analysis step process is shown in Figure 1. As follows.
Based on Figure 2, it can be seen the stages in planning road improvement in the PT Krakatau Bandar Samudra area starting with the preliminary stage reviewing the literature review, the relevant literature with rigid pavement planning, then specifies the problem statement based on the background and identification of the problems that occur on the road segment so that it sets the objectives of the plan. Next set up formal and administrative licensing for the data collection phase. The data needed is in the form of primary data and secondary data. Primary data consists of vehicle average daily traffic data and data obtained by means of interviews, while secondary data obtained map / site plan data as well as land data in the form of CBR. After the data is collected then analysis of calculations to find concrete thickness, dowel test diameter and drainage channel dimensions and the next step to get the results can be concluded as well as recommendations.
3. Results And Discussion

3.1 Data Planning Parameters

Table 1. Planning Parameter Data

| a. Role of Road: Special Road | b. Road Type : 2 lane 2 direction, undivided |
| c. The width of the road: 8, 00 meter | d. Load security factor 1,1 |
| e. CBR subgrade: 5% | f. Bending tensile strength (Fcf) : 4.0 MPa (F\text{c} = 285 \text{ kg/cm}^2) |
| g. Underfloor material: Thin concrete mixture | h. Quality of Reinforcing Steel: Threaded steel reinforcement 24(fy: melting stress = 2400 \text{ kg/cm}^2) |
| i. Shoulder the road: Without Shoulder Road | j. Ruji/dowel : Yes |
| k. Average Daily Traffic Data: | l. Bus (8 ton) |
| passenger car (2 ton) | 170 vehicle / day |
| m. Truck 2 small axle (6 ton) | 200 vehicle / day |
| n. Truck 2 big axle (13 ton) | 170 vehicle / day |
| o. Truck 3 big axle (20 ton) | 150 vehicle / day |
| p. Collaborative Truck (30 ton) | 60 vehicle / day |
| q. Traffic growth | 5% |
| r. Age of plan | 10 year |

Calculation of average daily traffic by projecting 5% growth and 10 years time is obtained: Average Daily Traffic = TOTAL VEHICLE X (1 + 1)n

Table 2. Average Daily Traffic Projected Growt 5%

| Transportation type | Number of vehicles |
|---------------------|--------------------|
| Passenger car 2 Ton | 423.54 vehicle |
| Bus 8 Ton          | 276.93 vehicle |
| Truck 2 small axle 6 Ton | 530.6 vehicle |
| Truck 2 big axle 13 Ton | 325.8 vehicle |
| Truck 3 big axle 20 Ton | 244.35 vehicle |
| Collaborative Truck 30 Ton | 97.74 vehicle |

Source: Analysis results

3.2 Calculating the Amount of Commercial Vehicle Axes

Table 3(a). Vehicle Amount Recapitulation and Load Configuration

| No | Transportation type | Axis Load Configuration | Take the Axis per vehicle | Single Wheel Single Axis | Double Wheel Single Axis | Double Wheel Tandem Axis |
|----|---------------------|-------------------------|--------------------------|-------------------------|--------------------------|--------------------------|
|    | Front wheel | Rear wheel | Front trailer wheels | Rear trailer wheels | Number of axes | Axis Load (Ton) | Number of Axes (bh) | Axis Load (Ton) | Number of Axes (bh) | Axis Load (Ton) | Number of Axes (bh) |
| 1  |            |            |                      |                        | 2             | 2400 kg/cm² | 285 kg/cm² | 2400 kg/cm² | 285 kg/cm² | 2400 kg/cm² | 285 kg/cm² |
| 2  |            |            |                      |                        | 3             | 2400 kg/cm² | 285 kg/cm² | 2400 kg/cm² | 285 kg/cm² | 2400 kg/cm² | 285 kg/cm² |
| 3  |            |            |                      |                        | 4             | 2400 kg/cm² | 285 kg/cm² | 2400 kg/cm² | 285 kg/cm² | 2400 kg/cm² | 285 kg/cm² |
| 4  |            |            |                      |                        | 5             | 2400 kg/cm² | 285 kg/cm² | 2400 kg/cm² | 285 kg/cm² | 2400 kg/cm² | 285 kg/cm² |
| 5  |            |            |                      |                        | 6             | 2400 kg/cm² | 285 kg/cm² | 2400 kg/cm² | 285 kg/cm² | 2400 kg/cm² | 285 kg/cm² |

Source: Analysis results
Table 3(b). Vehicle Amount Recapitulation and Load Configuration

|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|----|----|
| 1 | Pssenger car | 1 | 1 | - | - | 260 | - | - | - | - | - |
| 2 | Bus | 3 | 5 | - | - | 170 | 2 | 340 | 3 | 170 | - |
| 3 | Truck 2 small axle | 2 | 4 | - | - | 200 | 2 | 400 | 2 | 200 | - |
| 4 | Truck 2 big axle | 5 | 8 | - | - | 170 | 2 | 340 | 5 | 170 | 8 |
| 5 | Truck 3 big axle | 6 | 14 | - | - | 150 | 2 | 300 | 6 | 150 | - |
| 6 | Collaborative truck | 6 | 14 | 5 | 5 | 60 | - | - | - | 5 | 60 |

Total | 1620 | 950 | 460 | 210 |

Source: Analysis results

Number of commercial vehicle axis (JSKN) during the plan life:

\[
JSKN = 365 \times JSKNH \times R \quad (1)
\]

\[
= 365 \times 1620 \times 12.6
\]

\[
= 0.75 \times 10^7
\]

Where:
JSKN is the Number of Commercial Vehicle Axis
JSKNH is the Number of axes of the daily commercial vehicle when the road is opened
R is the growth rate. For 5% in the table on the guidelines Pd T-14 2003 was obtained 12.6 while the JSKN plan was obtained for:

\[
JSKN \text{ plan} = CxR \times JSKNH \times 365 \quad (2)
\]

\[
= 3.7 \times 10^7
\]

Table 4(a). Axis Plan Repetition Calculation

| Axis Type | Axis Load (ton) | Amount of Axis | Proportion of Expenses | Proportion of Axes | Traffic Plans | Repetition that occurs |
|-----------|-----------------|----------------|-----------------------|--------------------|---------------|------------------------|
|           | (1)             | (2)            | (3)                   | (4)                | (5)           | (7) = (4) x(5) x(6)    |
| Single    | 6               | 210            | 0.22                  | 0.59               | \(3.7 \times 10^7\) | 0.48 x 10^6           |
| Wheel     | 5               | 170            | 0.18                  | 0.59               | \(3.7 \times 10^7\) | 0.39 x 10^6           |
| Single Axis | 4           | 200            | 0.21                  | 0.59               | \(3.7 \times 10^7\) | 0.45 x 10^6           |
| Total Single Wheel |     | 950            | 1.00                  |                    |               |                        |

| Double Wheel Single Axis | 8 | 290 | 0.63 | 0.28 | \(3.7 \times 10^7\) | 0.65 x 10^6 |
| Single Axis | 5 | 170 | 0.36 | 0.28 | \(3.7 \times 10^7\) | 0.37 x 10^6 |

Total Double | 460 | 1.00 |
Table 4(b). Axis Plan Repetition Calculation

| Wheel Single Axis | 14 | 210 | 1.00 | 0.13 | 3.7 x 10^7 | 0.48 x 10^6 |
|-------------------|----|-----|------|------|------------|-------------|
| Double Wheel Tandem Axis | 210 | 1.00 |
| Total Double Wheel Tandem Axis | 3.7 x 10^6 |

Based on Table 4 above, it can be seen that the values the Single Wheel Single Axis, Double Wheel Single Axis or Double Wheel Tandem Axis in column 4 load are obtained by the following formula equation:

For example 210/950 = 0.22 as well as for Double Wheel Single Axis and Double Wheel Tandem Axis Total STRT

The proportion of axes in column 5 is obtained by the equation of division between the total number of axes and the number of axes based on the load with the following example:

\[
\frac{\text{Total STRT JS}}{\text{Total Jumlah Sumbu (JSKNH)}}
\]

As an example: 950/1620 = 0.59

3.3 Determining the Bottom Base Layer

This value is obtained by aligning the graph on the Bina Marga 2002 guideline with the CBR (California Bearing Ratio) data of 5% and the number of axis repetitions from the analysis of 3.7 x 10^6, which is obtained

![Figure 3. Minimum bottom layer thickness](image)

Based on Figure 3, the bottom foundation layer thickness of 100 mm was taken and the effective CBR was 14%. JSK value is 0.75 x 10^7 with 4.0 Mpa concrete tensile strength, so that the estimated concrete thickness of 25 cm can be taken, the value shows that the total fatigue that occurs <100%, it can be concluded that the calculation is sufficient and the plate thickness is 25 cm can be used.
3.4 Determining Dowel / Ruji Diameter

After determining the estimated thickness of 250 mm, the test diameter can be determined based on the table in the Planning Guidelines for Cement Bina Marga Concrete Road Pd T-14 2003 as follows:

| No | Concrete Plate Thickness, \( h \) (mm) | Ruji's Diameter (mm) |
|----|---------------------------------|----------------------|
| 1  | 125 < \( h \) ≤ 140              | 20                   |
| 2  | 140 < \( h \) ≤ 160              | 24                   |
| 3  | 160 < \( h \) ≤ 190              | 28                   |
| 4  | 190 < \( h \) ≤ 220              | 33                   |
| 5  | 220 < \( h \) ≤ 250              | 36                   |

Source : Bina Marga Pd-T-14-2003

Based on the table above the diameter of the test is 36 mm with a distance of 300 mm and a length of 450 mm

Coefficient of friction plate with foundation = 1.3
Distance Between Connections (L) = 4 m, transverse 5 m
Plate Thickness (h) = 200 mm
Steel Tensile Voltage (f_s) = 4.0 MPA
Concrete Quality (f_c) = 350 kg/cm²
Concrete Specific Gravity = 2400 kg/cm²
Concrete Tensile Strength (f_{ct}) 0.4-0.5 = 40 kg/cm²
MR Modulus Elastic Steel (E_s) = 20000 kg/cm²
Steel Melt Voltage (f_y) = 3900 kg/cm²
Modulus Elastic Beton (E_c) = 1400 \sqrt{f_c}
Gravitasi (g) = 9.81 m/s²

Transverse Reinforcement

\[
A_s = \frac{\mu L M g h}{2 f_s}
\]  
(4)

Lengthening Reinforcement

\[
\rho_s = \frac{1}{f_c} \left( \frac{1.3 - 0.2 \mu}{(f_y - n f_c)} \right)
\]  
(5)

here \( A_s \) is the area of reinforcement

Based on the data above transverse reinforcement obtained \( A_s = 48.46 \) mm² with \( A_s \) min = 0.1% x 190 x 1000 = 282.76 mm² then using D12 - 300 reinforcement, while longitudinal reinforcement can get \( A_s \) min = 0.1% x 200 x 1000 = 200 mm² then use D12 - 400 mm.

Based on the crossing distance of 4.00 m and the distance of the longitudinal joint of 5.00 m in the form of a square, then for a single woven plain reinforcement taken an diameter of 8 mm with a distance of 200 mm which has a length of 251 mm² and 251 mm² transverse axles it is safe to be used as single woven plain reinforcement.
3.5 Planning dimensions of drainage channels

3.5.1 Calculation of Debit Flow Plans (Q)

Regional Data on Road Watering Area of PT Krakatau Bandar Samudra, Cilegon City Banten

| Channel Length Plan | 300 m | Width of drainage area |
|---------------------|-------|------------------------|
| I1 Road Pavement    | 4.0 m | I2 roadside             |
| I2 Outside Road     | 10 m  | Area of Jetting         |
| A1 Road Pavement    | 1.200 m² | A2 Road Shoulder Section |
| A3 Outside Road     | 3.000 m² | total area = 4.200 m² = 0.00420 km² |
| Average Material Coefficient | 0.70 - 0.95 |
| Average Land Use Coefficient | 0.60 – 0.90 |
| Runoff Factor       | 1.2   |                        |

\[
C = \frac{C_1 A_1 + C_2 A_2 + C_3 A_3 . F_k}{A_1 + A_2 + A_3} \quad (6)
\]

Where:
- \(C_1 = 0.70\) is the value of the flow coefficient for concrete roads
- \(C_2 = 0\) is the value of the flow coefficient not to use the shoulder of the road
- \(C_3 = 0.60\) is the value of the flow coefficient for the outer part of the regional road
- Industry \(F_k = 1.2\) for industrial runoff factors
- \(A_1 = 1.200\) m² Extent of Pavement area.
- \(A_2 = 0\) m² The width of the road shoulder area.
- \(A_3 = 3.000\) m² Extensive area of the outer part of the road.

Then Value C for Industrial Estate Road PT. Krakatau Bandar Samudra Cilegon Banten are: 0.71. with the concentration time (Tc) of this industrial area the road is 5,978 minutes.

3.5.2 Rainfall Data Analysis

From BMKG Data Class 1 Serang in 2017/2018 The average rainfall is 152.07 mm and the 10-year calculation return is 333 mm. Then the flow debit (Q) can be calculated by the equation:

\[
Q = \frac{1}{3,6} C \times I \times A = 0.455 \text{ m}^3/\text{seconds} \quad (7)
\]

Where:
- \(C = \) average coefficient
- \(I = \) Rain intensity (mm / hour)
- \(A = \) Area of drainage area (m²)
3.5.3 Drainage channel dimensions

Flow (Q) = 0.296 m³ / seconds
Channel Basics (B) = 0.75 channel height (H)
Wide channel appearance Fs = B.H
= 0.75 H x H
=0.75 H²

Around the Wet Channel Ps = B + 2 H
= 2.75 H

Radius hidrolik Rs = Fs / Ps
= (0.75 H²) / (2.75 H)
= 0.275 H

Formula Manning \( V = \frac{1}{n} \cdot \frac{R_{s}^{2/3}}{I^{1/2}} \)
= (1/0.014) (0.273H)²/³ 0.02²/³
= 71.4 0.273²/³ 0.15²/³ H²/³
-2.92 H²/³

Debit Aliran Q = 0.455 m³ / seconds Q
= Fs.V

From these calculations the dimensions of the channel dimensions are set to H = 0.99 m and B = 0.45 m. What was previously done was checking the channel dimensions that the Q debit channel > 0.455 m³/ sec.

4. Conclusion

Increasing the road using rigid pavement on the roads in the PT Krakatau Bandar Samudra area can be concluded as follows:

a. The estimated thickness of the concrete plate is 250 mm or 25 cm

b. Dowel / Ruji diameter is 36 mm with a distance of 300 mm and a length of 450 mm while the longitudinal reinforcement joints use reinforcement rods 4D12 mm - 400 mm, transverse reinforcement per connection using reinforcement rods 4D12 mm - 300 mm, as well as for single woven plain reinforcement using D8 mm - 200 mm.

c. The dimensions of the drainage channel that can accommodate the discharge occur are B × H = 0.99 m × 0.45 m with 1SP: 4 Sandstone pair.

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