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Railway Planning Double-Double Track (Case Study of Bekasi Station km 26 + 652 - Jatinegara Station km 12 + 050

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ABSTRACT

Increasing the number of population and the development of activities will cause a growing need for space every day, this will result in physical changes and urban land use and can cause increased intensity of population movement from Megapolitan cities such as Bekasi, Bogor and Tangerang to the Metropolitan city (DKI Jakarta). Some people have now started to move from private vehicles to use public (mass) transportation such as buses, transjakarta, and electric rail trains or commonly known as KRL Commuter Line that serve Jabodetabek routes. The impact of crossing also causes buildup at each station. Train track with a single track (single track) is considered ineffective and inefficient and vulnerable to train accidents due to human error. It is necessary to develop or develop a double track to become a double-double track Bekasi Station km 26 + 652 - Jatinegara Station km 12 + 050. The research location is on the railway line from Bekasi Station to Jatinegara Station. The length of the train track is around 16 km and has 7 stations that are traversed, 5 of which are active (stop) and 2 passive stations.

Keyword: railway, structure railway, planning

INTRODUCTION

Transportation in Jakarta provides several road and toll networks to meet access for the public, but population growth and the development of the number of motorbikes and cars with a number of roads is very lame. Congestion in Jakarta is already unavoidable due to the increasing volume of vehicles every day. Some people have now started to move from private vehicles to use public (mass) transportation such as buses, transjakarta, and electric rail trains or commonly known as KRL Commuter Line that serve Jabodetabek routes.

KRL is indeed a popular transportation that is often used by the community because of the short travel time compared to buses and transjakarta. Based on data from PT Kereta Commuter Indonesia (KCI) and the Central Statistics Agency (BPS, 2018) the number of KRL throughout 2017 reaches 315.8 million passengers every day. Based on the lane, in 2017 most KRL served passengers on the Bogor-Depok route, reaching 69.95%, then the Bekasi-Cikarang route by 13.48%, Serpong-Rangkasbitung 11.87% and Tangerang 4.72 of the total passengers.

As a result, KRL trains often experience delays due to having to wait for Railroad crossings to cross out or enter the station and while KRL waits at the station to get a safe signal from the new Railroad Travel Regulator (PPKA), the KRL can cross, this is in accordance with the Law number 23 of 2007 concerning Railways. The impact of crossing also causes buildup at each station. Train track with a single track (single track) is considered ineffective and inefficient and vulnerable to train accidents due to human error. Need for the development or development of a double track (double track) into a double-double track (double-double track). (Directorate General, 2014)

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Based on the above writing, this writing aims to get the geometric planning of the Bekasi Railway Station km 26 + 652 - Jatinegara Station km 12 + 050 according to Service Regulation No. 10 concerning Railroad Construction Planning and Obtaining the method of implementation based on the Minister of Transportation Regulation No. 60 of 2012 and Dinas Regulation No. 10 concerning Railroad Construction Planning. As well as to add insight and knowledge in the planning and methods of implementing a good and efficient railroad and provide new reference material for civil engineering students to be used as media only.

Study Literatur

A. Railway Classification

Railway is classified based on annual transhipment capacity (Table. 1)

Table. 1 Railway Classification

Class Street	Traffic Capacity (ton/ year)	V maks (km/hour)	P Maks axle (ton)	Rail Type	Bearing Type / Distance Between Axis Bearings (cm)	Type Fastening	Top Thick Balas (cm)	Width Rock Balas (cm)
1	$>20.10^5$	120	18	R.80/R.54	Concrete / 60	Double Elastic	30	60
2	10.10^6-20.10^6	110	18	R.54/R.50	Concrete/ Wood / 60	Double Elastic	30	50
3	5.10^6 - 10.10^6	100	18	R.54/R.50/ R.42	Conc/Wood /Steel / 60	Double Elastic	30	40
4	$2.5.10^6$ – 5.10^6	90	18	R.54/R.50/ R.42	Conc/Wood /Steel / 60	Double Elastic	25	40
5	$<2.5.10^6$	80	18	R.42	Wood/Steel / 60	Single Elastic	25	35

Source : Minister of Transportation Regulations, 2012

B. Geometric Railway

Geometric planning of the railroad will be carried out according to the speed of the plan and the measurements of the trains that will pass by taking into account several factors, namely, safety, comfort and economy.

1. Horizontal Alignment

Table. 2 Minimum allowable radius

Speed of the plan (km/hour)	The radius of the minimum is a loop without a transitional curve (m)	The minimum radius of the curved circle is permitted with a transitional dimple (m)
120	2370	780
110	1990	660
100	1650	550
90	1330	440
80	1050	350
70	810	270
60	600	200

Source : Minister of Transportation Regulations, 2012

$Lh = 0{,}06\,(\frac{V^3}{R})$ ....(1)

$h = 5{,}94\,(\frac{V^3}{R})$ ....(2)

Lh = 0,01.h.V

information :

Lh = The minimum length of the curve (m)

h = Rail High (mm)

V = Speed of plan (km/hour)

2. Vertical Alignment

Table. 3 Minimum allowable radius

Speed Plan (km/hour)	Minimum Vertical Alignment Radii (meter)
More > 100	8.000
Until ≥ 100	6.000

Source : Minister of Transportation Regulations, 2012

$Xm = \frac{R}{2}\,.\,\varphi$ ....(3)

$Ym = \frac{R}{8}.\,\varphi^2$ ....(4)

information :

Xm = Transitional Curved Length

Ym = High

φ = (elevasi 2 – elevasi 1)

3. Arch of Transition

$Lh = 0{,}06\,(\frac{V^3}{R})$ ....(5)

$h = 5{,}94\,(\frac{V^3}{R})$ ....(6)

Lh = 0,01.h.V

Information :

Lh = The minimum length of the curve (m)

h = High (mm)

V = Speed of plan (km/hour)

3. Rail

According to the length of the train tracks can be divided into three parts :

1. The standard rail has a length of 25 meters
2. Short rails are rails that have a maximum length of 100 meters
3. Long rails are rails whose minimum lengths are listed in table 4

Table. 4 Minimum allowable radius

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Pads Type	Rail Type			
	R.42	R.50	R.54	R.60
Wood Pads	325 m	375 m	400 m	450 m
Concrete Pads	200 m	225 m	250 m	275 m

Source : Minister of Transportation Regulations, 2012

Table. 5 Section Rail

Speed of Plan	V Maks (km/hour)	D1 (cm)	B (cm)	C (cm)	K2 (cm)	D2 (cm)	E (cm)	K2 (cm)
I	120	30	150	235	240	15-50	25	375
II	110	30	150	235	240	15-50	25	375
III	100	30	140	225	240	15-50	22	325
IV	90	25	140	215	240	15-35	20	300
V	80	25	135	210	240	15-35	20	300

12

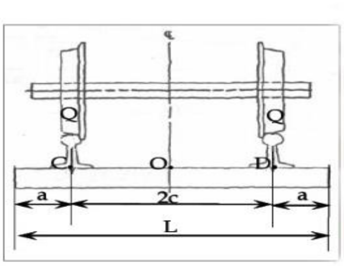
4. Sleepers Rail

Table 6 Permission Required Conditions

Concrete Quality	Permission Voltage Press (kg/cm²)	Permission Voltage Pull (kg/cm²)
K-350	120	17.5
K-500	200	35

Source : Minister of Transportation Regulations, 2012

4.1 Sleeper Analysis



$$\lambda = \sqrt[4]{\frac{k}{4EI}} \qquad \text{......................................(7)}$$

$$E = 6400\sqrt{F_{CU}} \qquad \text{......................................(8)}$$

Picture 1 Cross section concrete pads

Information :

λ : dumping factor (cm^1)

E : sleeper elastic (kg/cm^2)

f_{cu} : concrete quality (kg/cm^2)

Ix :moment of inertia of the rail x-x (cm^2)
A : distance of rail center to sleeper center (cm)
C :distance of rail center to sleeper center (cm)

4. Ballas

$$x = \frac{b}{2 \times h} \times \tan \alpha \times P \quad \text{.....(7)}$$

Information : x = Voltage happens (kg/cm^2)
b = sleeper width (cm)
h = Thickness of Ballas (cm)
α = Angle of pressure spread (broken stone = 60°)
P = Pressure double axle (kg)

Terzaghi's formula for finding the carrying capacity of the soil.

$$qult = 1{,}3.c.Nc + q.Nq + 0{,}4.\gamma.B.N\gamma \quad \text{.....(8)}$$

$$xijin = \frac{qult}{FK} \quad \text{.....(9)}$$

Information : qult = Ultimate soil carrying capacity (kg/cm^2)
FK = Safety factor (FK = 2)
Xijin = Voltage Soil (kg/cm^2)

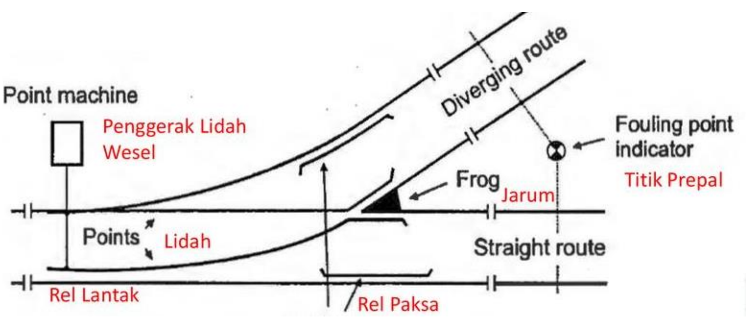
5. Sub Ballas

Table 7 Thickness Sub-Ballas

Speed (km/hour)	Transport Traffic	Thickness Sub Ballas cm
120 – 160	> 12 billion	38
120 - 160	2 - 12 billion	30
120 - 160	< 2 billion	23
80 – 120	> 12 billion	30
80 - 120	< 12 billion	23
< 80	> 2 billion	23

(*Source : Railway management & engineering*)

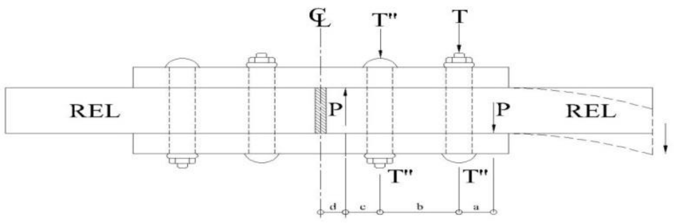
6. Wesel



Picture 2 wesel component

Volume 04 Number 01 September 2020

6. Rail Connection



Picture 3 Rail Connection

The connecting plate bolt must withstand the following:

H = T' + T"

M = H x (a + b + c)

M' = H x (a + b)

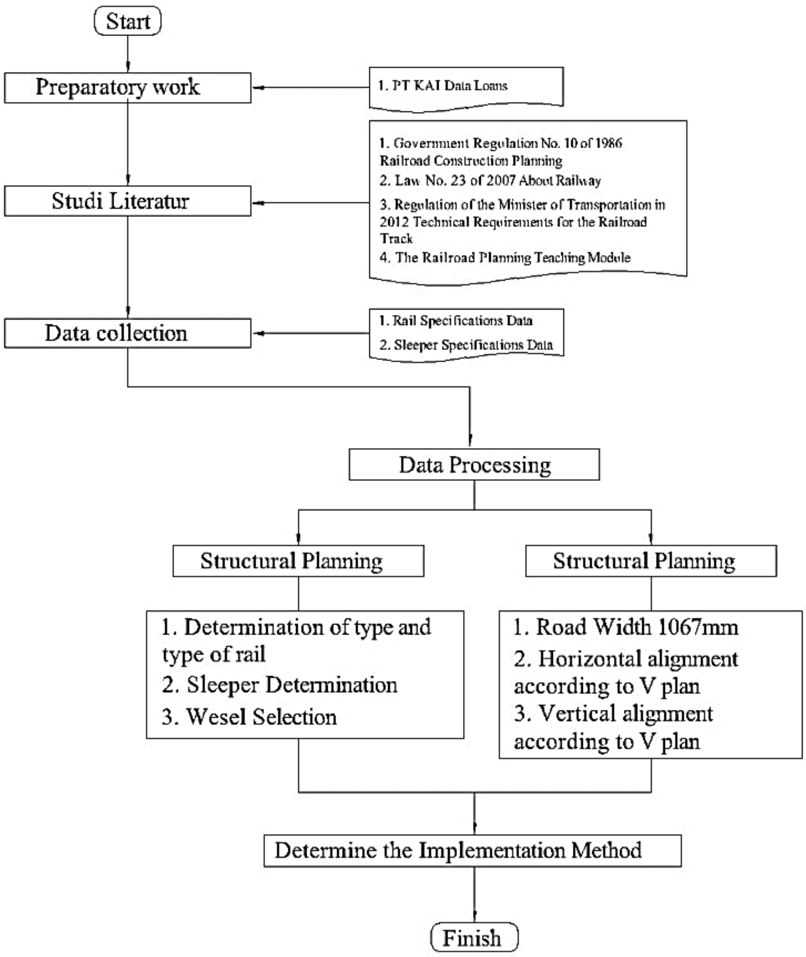
M" = T" x (a + b) + T" x c

Information:

H	= Lateral force that works in the middle of the connection plate
T' & T"	= Tensile strength of outer and inner bolts
M' & M"	= Momentary in and out of plate between rail pressure centers
M	= Moment total lateral direction

METHODOLOGY

Field research methodology can be illustrated through the flow chart as follows:



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The planning data used in this Final Project is based on data obtained from related parties, in this case the relevant party is PT Kereta Api Indonesia (PT KAI) Daop 1 Jakarta.
Literature studies used include :
1. Government Regulation no 10 of 1986 Railway Construction Planning
2. Law No. 23 of 2007 concerning Railways
3. Minister of Transportation Regulation No. 60 of 2012 - Technical Requirements for Railway Tracks.
4. The Railroad Planning Teaching Module

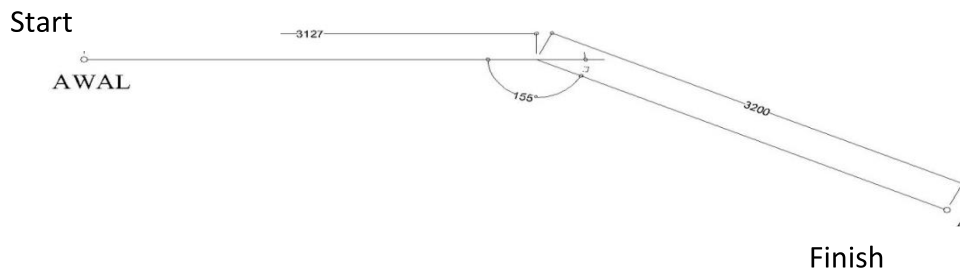
1. Calculated Geometric Planning:
   A. Vertical Alignment
   B. Horizontal Alignment

2. Structural planning to be carried out in the field :
   A. Rail Profile Planning
      Determination of rail dimensions that will be used in planning
   B. Sleeper
      Planning about determining the type of bearing to be used,
   C. Sub Ballas and Ballas
      Planning about the ballas material to be used
   D. Wesel
      Proper money order planning that will be used in accordance with field data.

RESULTS AND DISCUSSION

1. Horizontal Alignment Planning

In planning horizontal curvature using the spiral - circle - spiral curvilinear parameters. Examples of calculation of horizontal arcs on PV-15 Km 23 + 800 to Km 23 + 525, as for the steps in completing the calculation as follows.



Picture 10 Horizontal Alignment

Vplanning = 60 km/jam
Δ = 180° - 155° = 25°
Rplanning = 869 m

A. Elevation of the outer side of the rail

$$h = 5{,}95\ (\frac{V^3}{R})$$

$$h = 5.95\ \left(\frac{60^3}{869}\right) = 24.65\ \text{mm} < 60\ \text{mm}$$

B. The minimum length of the transition arc

Lh = 0,01 x h x V

Lh = 0,01 x 24,65 x 60 = 14,79 mm

C. Arc spiral

$$\theta s = \frac{90° \text{ x Lh}}{(\pi \text{ x R})} = \frac{90 \text{ x } 14{,}79}{(3{,}14 \text{ x } 869)} = 0{,}478°$$

$$\Delta c = \Delta - 2 \text{ x } \theta s$$

$$\Delta c = 25° - (2 \text{ x } 0{,}478°) = 24{,}044°$$

D. Long arc circle

$$Lc = \frac{(\Delta - 2 \text{ x } \theta s) \text{x } (\pi \text{ x R})}{180} = \frac{12° - (2 \text{ x } 0{,}478°) \text{x } (3.14 \text{ x } 869)}{180} = 167{,}12 \text{ m}$$

E. Long transitional coordinate point length

$$p = \frac{(lh^2)}{(6 \text{ x R})} - \text{R x } (1 \cos \theta s)$$

$$= \frac{(14{,}79^2)}{(6 \text{ x } 869)} - 869 \text{ x } (1 \cos 0{,}478°) = 0{,}0104 \text{ m}$$

$$k = lh - \frac{(lh^3)}{(40 \text{ x } R^2)} - \text{R x } (1 \sin \theta s)$$

$$= 14{,}79 - \frac{(14{,}79^3)}{(40 \text{ x } 869^2)} - 869 \text{ x } (1 \sin 0{,}478°) = 7{,}390 \text{ m}$$

F. The distance of the starting point starts into the curved region

$$Ts = (R + p) \text{ x} \tan(\tfrac{1}{2} \text{ x } \Delta) + k$$

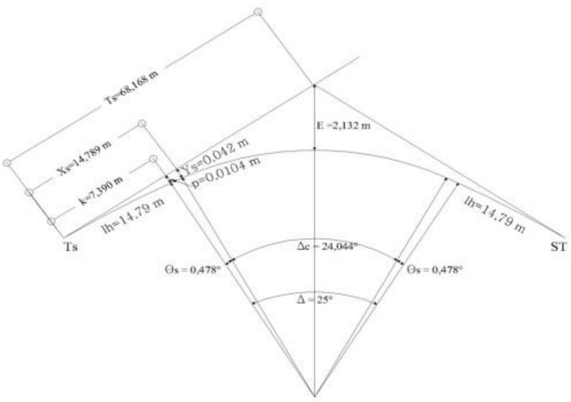
$$Ts = (869 + 0{,}0104) \text{ x } \tan(\tfrac{1}{2} \text{ x } 25) + 7{,}390 = 68{,}158 \text{ m}$$

$$E = \frac{(R + p)}{\cos(\frac{1}{2} \text{ x } \Delta)} - R = \frac{(869 + 0{,}0104)}{\cos(\frac{1}{2} \text{ x } 25)} - 869 = 2{,}132 \text{ m}$$

$$Xs = Lh \text{ x } \left(1 - \frac{lh^2}{40 \text{ x } R^2}\right)$$

$$= 14{,}79 \text{ x } \left(1 - \frac{14{,}79^2}{40 \text{ x } 869^2}\right) = 14{,}789 \text{ m}$$

$$Ys = \frac{lh^2}{6 \text{ x R}} = \frac{14{,}79^2}{6 \text{ x } 869} = 0{,}042 \text{ m}$$



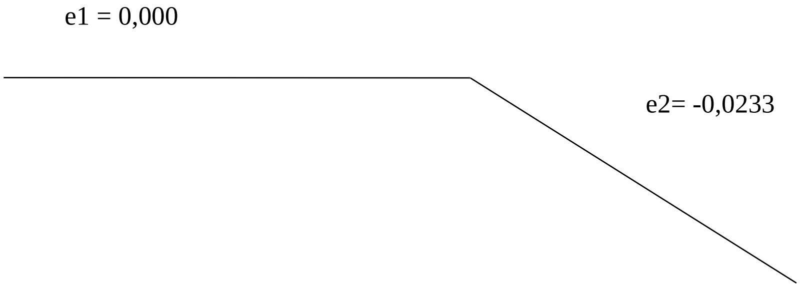
Volume 04 Number 01 September 2020

Picture 11 Horizontal Alignment

2. Vertical Alignment Planning

Vertical curve is a circular element that connects two different slopes which are determined by the elevation of the height and the magnitude of the vertical arch radius

Examples of calculation of vertical arcs at Km 26 + 262, as for the steps in the completion of the calculation as follows.



Picutre 12 Vertical Alignment

Vplanning = 80 km/jam

Ralign = 6000 m

Long transitional arc (Xm) & high (Ym)

$$\mathrm{Xm} = \frac{(\mathrm{R})}{2} \mathrm{x}\ \varphi$$

$$= \frac{(6000)}{2} \mathrm{x}\ (\mathrm{e2} - \mathrm{e1})$$

$$= \frac{(6000)}{2} \mathrm{x}\ (-0{,}0233 - 0{,}000) = 69{,}90\ \mathrm{m}$$

$$\mathrm{Ym} = \frac{\mathrm{R}}{8} \mathrm{x}\ \varphi^2$$

$$= \frac{6000}{8} \mathrm{x}\ (-0{,}0233 - 0{,}000)^2 = 0{,}4071\ m$$

CONCLUSIONS

In accordance with the analysis of data and conditions in the field of the railway track in the Planning of Double-Double Track (Jatinegara Station (12 + 050) to Bekasi Station (26 + 652)

1. Horizontal and vertical curvilinear planning for plan speed, arch angle and radius (R) follows the data obtained from PT Kereta Api Indonesia (KAI).

2. Results of railroad structure planning
   a. Road type = Type I
   b. Rail type = R.54
   c. Vmax = 80 km/hr
   d. Axle load = 5,6 ton
   e. Width = 1067 mm
   f. Space of Sleeper = 60 cm

Volume 04 Number 01 September 2020

3. Method of Implementing Railway Construction:
   1. Temporary Facility and Self Protective Equipment
   2. Clearance Top Soil
   3. Cut & Fill Work
   4. Soil Compacted
   5. Work Sub-Ballas
   6. Work Ballas
   7. Installation Sleeper
   8. Installation Rail
   9. Installation Fastening
   10. Work Joint Rail

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