GEOMETRY AND MAINTENANCE ANALYSIS OF ALL WHEATER ROAD (AWR) TS +35 TO TLS 2 TAMBANG AIR LAYA, PT. BUKIT ASAM, TBK. TANJUNG ENIM, SOUTH SUMATRA

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Abstract Indonesia has many coal resources that can play an important role in meeting domestic energy needs.The mining system applied by PT Bukit Asam Tbk is open mining with open pit mining method.The mining industry is one of the industries that is capital intensive,technology intensive, and very risky.Some factors that affect the conveyance cannot operate optimally include narrow haul road conditions so that when the conveyance passes one of the conveyances must stop,bumpy road conditions so that during transportation a lot of material is scattered,the purpose of this study is to control the condition of the haul road to be traversed so that production targets and operator safety in the mining area can be maintained properly.From the results of the calculations that have been carried out, the haul road geometry on the TS +35 to TLS 2 road has a length of 3,125 m by making as many as 5 segments,namely 10 straight road sections and 6 bend road segments.On the straight road there are 2 sections whose road width still does not meet the standards of Kepmen No. 1827/K/30/MEM/2018,which will have an impact on the performance of the conveyance used and can cause human error when vehicles pass each other.

Keywords: *Haul Road Geometry, Coal, Road Maintenance*

1. Introduction

Indonesia's generous coal resources have significant capacity to meet domestic energy needs. Coal is currently the most widely used type of fuel due to its lower cost compared to other types of fuel such as natural gas or petroleum. Coal is also the main source of energy in electricity generation. PT Bukit Asam Tbk uses an open-pit mining system. The mining sector has a high risk because it involves a lot of capital and technology. In mining activities, one of the things that is of particular concern is the transportation of coal, because the coal transportation process can affect the achievement of production targets [2]. In order for mining operations to run in accordance with predetermined production targets, careful planning is required in the coal transportation process, including mine roads. Mine roads are useful for connecting the mine site with the excavation material processing area, smelting plant, office, and other locations in the mining area [3].

Mine roads have special features that distinguish them from general transportation roads. It is necessary to determine the geometry of the road in order to adjust to the dimensions of the conveyance to be used. The condition of haul roads is one of the reasons why production targets are not achieved. Factors that cause the conveyance to not function properly include narrow roads and require one of the conveyances to stop when the conveyance passes, uneven road conditions can cause material on the conveyance to fall scattered. The geometry of the road must meet standards to ensure that the road width matches the dimensions of the haulage equipment, the right cross slope and good drainage standards. Therefore, it is necessary to control the condition of the haul road geometry. Which aims to monitor the condition of the haul road to ensure the production targets that have been set and ensure the safety of workers in the mining area [4].

When conducting a mining road study, standardization is required which refers to Kepmen No. 1827/K/30/MEM/2018, therefore the author is interested in conducting this research because there are still few studies that examine the Geometry Analysis and Maintenance of the Air Laya Mine Main Road (AWR) at PT Bukit Asam, Tbk. Tanjung Enim, South Sumatra. Located in Tanjung Enim, Lawang Kidul Sub-district, Muara Enim Regency, South Sumatra Province, the Mining Business License Area (WIUP) of PT Bukit Asam Tbk is ± 186 km from the center of Palembang. The IUP area of PT Bukit Asam Tbk is located at coordinates 103˚ 45' East - 103˚ 50' East and 3˚ 42' 30" LS - 4˚ 47' 30". Tanjung Enim Mining Unit consists of: Air Laya (TAL): 7,621Ha. WIUP map of PT Bukit Asam can be seen in Figure 1.

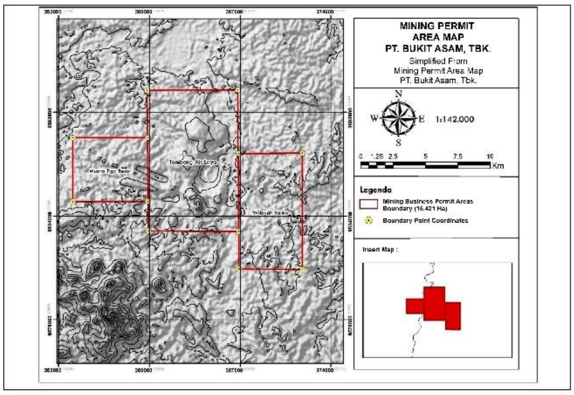


Figure 1. Map of Research Location

2. Geological Conditions

Overall, geologically, the South Sumatra Basin is a Tertiary sedimentary basin flanked by two major faults, the Semangko Fault and the Bukit Barisan Mountains. The main tectonic activity on Sumatra Island is faulting. With an area of 330 x 510 km2, the South Sumatra Basin is an arcuate basin bounded by the outcrop of the Pre-Tertiary Bukit Barisan to the southwest and the Sunda Shelf of Lampung Plateau to the northeast, northwest of the Tigapur Mountains, dividing the South Sumatra Basin and Central Sumatra Basin (Wisnu & Nazirman, 1997). In the outcrops encountered, there are fine quartz veins measuring up to 10 cm in the mineralized river. The macroscopic appearance is brown to blackish, medium to fine grained, looks compact and contains sulfide minerals such as pyrite and chalcopyrite and the presence of iron oxide as an impurity in the silica base period.

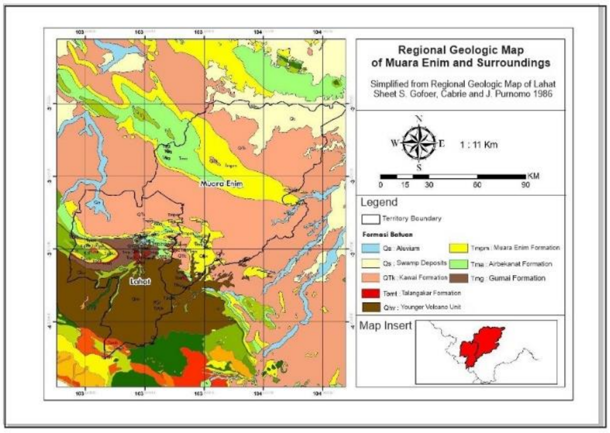


Figure 2. Regional geological map of Muara Enim

In the South Sumatra Basin, Tertiary rocks consist of three sections or cycles, depending on the period of uplift and erosion. The fluviatile and lacustrine section of the Eocene-Oligocene or Miocene (Lahat and Talangakar Formations), the marine inundation section of the Middle Miocene-Plistocene (Airbenakat, Muaraenim, and Kasai Formations), and the marine shrinkage section of the Late Miocene-Plistocene. The Tanjung Enim area in general has a stratigraphy that lies in the stratigraphic column. Keladi, Merapi, Petai, Suban, and Mangus are exposed coal seams.

3. Theory Review

3.1 Coal Hauling

Transportation is one of the most important activities in coal mining. Generally, coal mines that are located far from the mining site utilize transportation so that efficient coal transportation is needed [5]. In mining in Indonesia, transportation generally uses trains, trucks, and barges, while coal exports are carried out using large-capacity ships.

PT Bukit Asam Tbk has 2 livestock, namely stockpile 1 and stockpile 2. Coal transportation from Temporary stockpile to stockpile, besides being transported using a belt conveyor, is also assisted by transportation using a dump truck. The smoothness of the dump truck road to stockpile 1 and stockpile 2 must be supported by road geometry that is in accordance with standards and routine maintenance so that the road does not prevent the dump truck from transporting coal.

3.2 Mining Support Road

Mining roads refer to pathways within the mining district and project area, which are used by mechanized earthmoving equipment and other support units during tailings mining, excavation and mining support activities. Mine roads are also used to facilitate mining operations or provide mining facilities. Mine roads must be able to accommodate the largest vehicles traveling over them. Maintenance of mining roads does not affect transportation.

3.3 Definition of AWR Road (All Wethering Road)

AWR Mining Support Roads are defined as compacted, graded, and/or gravel roads that vehicles can travel on in both wet and dry weather. These roads must be at least ten (10) feet wide and suitable for emergency vehicles in all weather conditions. These roads are constructed to support mining operations or provide mining facilities in mining areas and associated project areas. In the construction of mining roads, aspects such as road width, grade, bend radius, and super elevation should be carefully considered. Furthermore, the number, capacity and type of roads have been increased by 25% of production levels [6]. The design of mine roads must also take into account the size of the largest vehicles that will travel over them. In an effort to support transportation, roads in mining areas are regularly updated and maintained [7].

3.4 Haul Road Geometry

Generally, transport roads play an important role in supporting the smooth running of mining operations, especially in transportation activities. Road conditions that have an impact on traffic activity can be improved through road design changes. Factors that must be considered are the width of the mine haul road and the slope of the road, or road grade.

3.1.1 Straight Haul Road Width

The width of the haul road in the mine is designed according to the type and shape of transportation equipment that will use the access road. Roads are designed for one-way and two-way traffic, making it easier and more efficient to transport equipment. Figure 3 shows the requirements and requirements for the width of a straight haul road.

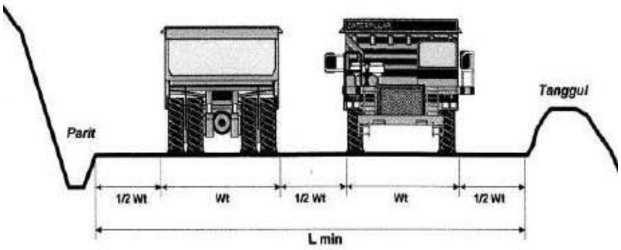


Figure 3. Width of Straight Haul Road

$$Lmin = n \times wt(n + 1) \times (1/2 \times wt) \quad (1)$$

Descriptions:
Lmin = minimum width of straight lane (m)
n = number of lanes
Wt = leba width of one vehicle (m)

3.1.2 Width of Bend Haul Road

To minimize conveyance width deviations arising from the angle between the truck's front wheels and the truck body when traveling around curves, mine roads are always designed to be wider than straight roads. Details on the specifications for road widths on curves can be found in Figure 4. The following formula can be used to determine the road width on curves:

$$Wmin = n(U + Fa + Fb + Z) + C \quad (2)$$

$$C = 1/2\,(U + Fa + Fb) \quad (3)$$

Description:
Wmin = Road width at the bend lane (m)
U = Truck wheel track distance (m)
Fa = Front span width (m)
Fb = Rear span width (m)
Z = Distance from the outside of the truck to the edge of the road (m)
C = Distance between trucks (m)

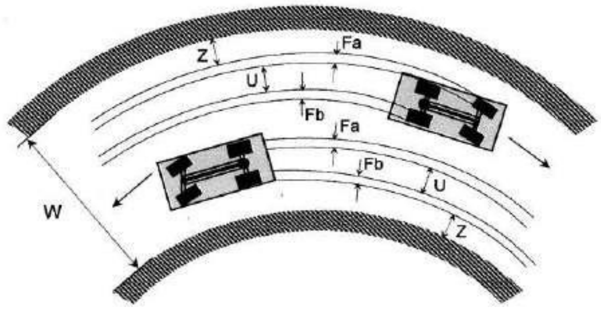
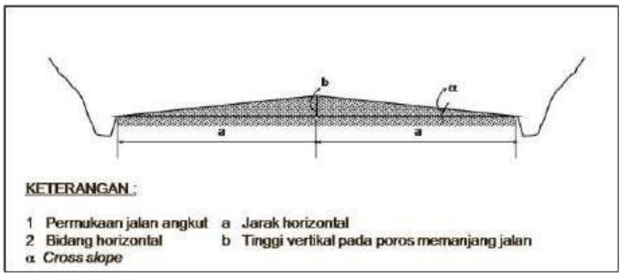


Figure 4. Width of Bend Haul Road

3.1.3Cross Slope

Cross-slope refers to the angle formed by the two sides of the road surface with the horizontal plane. In the context of improving drainage, mine haul roads generally have a convex cross section. Ideally, mine road cross slope ranges from 20 mm/m to 40 mm/m, or equivalent to 2% to 4% for every meter of mine haul road width [6]. Road slope requirements can be seen in Figure 5.



Gambar 5. Cross Slope

The cross slope value of the transportation path can be calculated using the following formula:

$$\alpha = \frac{1}{2} \times Lmin \quad (4)$$

Description:
(α) : *Cross Slope*
Lmin : Minimum road width

4. Research Methods

Based on the type of data to be obtained, this activity is included in quantitative data collection. Quantitative data collection methods are activities that are systematized, structured and planned very clearly from the beginning to the end of the activity design. Quantitative methods can also be defined as activities carried out starting from data collection, data interpretation, and display of data results.

4.1 Activity Implementation Stages

4.1.1 Preparation

The initial stage before carrying out activities in the field which includes:

a. Administrative arrangements and licensing letters from the campus and company.
b. Consultation with academic supervisors and supervisors.
c. Collection of relevant data in accordance with the title.

4.1.2 Literature Study

The literature study includes materials from related agencies that contain research titles. Data from companies and libraries (literature).

4.2 Steps of Data Collection

4.2.1 Onsite Orientation

Direct observation in the field is carried out to obtain information about the condition of the research location.

4.2.2 Primary Data

Primary data such as straight road width, winding road width, and cross slope are examples of road parameters collected and observed directly in the field.

4.2.3 Secondary Data

This is data that is obtained indirectly, but exists, such as information from company reports. Secondary information includes the company's IUP coordinates, company profile, and geological characteristics of the research location.

4.2.4 Data Processing and Analysis

The data processing obtained is analyzed as follows:

a. Compilation of field data using microsoft excell.
b. Calculation of coal haul road geometry.
c. Arranging the flow of implementation of coal material transportation road maintenance.
d. Conduct scientific analysis of the results of geometry calculations and maintenance of coal material transport roads produced.

The data obtained will be analyzed to obtain temporary conclusions. Furthermore, a recheck is carried out to ensure whether the conclusion is feasible to determine.

5. Research Results and Discussion

5.1 Road Geometry

The mine road geometry is adjusted to the equipment that will be used, especially the Dump Truck that will move the material from TS + 35 to TLS 2. Therefore, the road geometry dimensions must be set according to the size of the Dump Truck. The discussion of transportation road geometry involves aspects of road width, both in straight and winding conditions, as well as cross slope. An explanation of each of these points is given below.

Figure 6. Road Segment PT Bukit Asam, Tbk

5.1.1 Straight Haul Road Width

After knowing the specifications of the Hino FM260JD dump truck.
Next, we can calculate the minimum width of the haul road that meets the standards using equation 1.

$$Lmin = n.wt + (n+1).(1/2 .wt)$$
$$Lmin = 2 \times 2{,}49 + (2+1).(1/2 .2{,}49)$$
$$Lmin = 4{,}98 + (3) \times (1{,}245)$$
$$Lmin = 8{,}715\ m$$

The design road width based on the calculation results is 8.715 m and the actual conditions in the field have met the road width standards, even exceeding the standards. However, some parts of the road do not meet the standard requirements. Table 1 lists the measurement results of the width of the transportation road in a straight line from TS +35 to TLS 2.

Table 1. Straight Haul Road Width

Section	Design Road Width Based on Calculation(m)	Actual Road Width (m)	Road Widening(m)
A-B	8,715 m	7,5 m	1,215 m
C-D	8,715 m	12,7 m	-
D-E	8,715 m	13, 2 m	-
E-F	8,715 m	13,4 m	-
I-J	8,715 m	7,1 m	1,615
J-K	8,715 m	28,5 m	-
L-M	8,715 m	27,2 m	-
M-N	8,715 m	25,5 m	-
N-O	8,715 m	21,4 m	-
P-Q	8,715 m	11,3 m	-

5.1.2 Width of Bend Haul Road

Curves are always wider than straight roads. The goal is to predict the width deviation due to the angle of the front wheels with the truck body when passing through a bend. Based on the specifications of the HINO FM 260 JD truck, the following data is obtained:

a. Wheel distance (U) = 2,05 m
b. Overall truck length= 8,645 m
c. Distance of the front axle to the front of the truck (Fa) = 1,28 m
d. Rear axle distance with the rear of the truck (Fb) = 1,985 m
e. Front wheelbase with rear axle (Wb) = 5,38 m
f. Minimum turning radius = 8,5 m
g. Wheel deviation angle (α) = 39,3

$$Sin\,\alpha = \frac{Wb}{Turning\ Radius}$$

$$\alpha = Sin^{-1}\frac{5{,}38}{8{,}5}$$

$$\alpha = 39{,}3^{\circ}$$

From this data, the width of the road at the bend can be calculated, namely:

a. Width of the front staircase
   Fa = 1,28 m × sin 39,3°= 0,810 m
b. Width of the rear stalk
   Fb = 1,985 m × sin 39,3°= 1,257 m
c. Distance from the outside of the truck to the curb (Z) and Distance between two trucks that will intersect
   $C = Z = 0{,}5 \times (U + Fa + Fb)$
   $C = Z = 0{,}5 \times (2{,}05 + 0{,}81 + 1{,}257)$
   $C = Z = 2{,}06\,m$
   So, the minimum haul road width (2 lanes) at the bend is :

$Wmin = n \times (U + Fa + Fb + Z) + C$
$Wmin = 2 \times (2{,}05 + 0{,}81 + 1{,}257 + 2{,}06) + 2{,}06$
$Wmin = 14{,}41\,m$

According to the Road Width Design based on the calculation results of 14.41 m and the actual road width conditions in the field from TS +35 to TLS 2 can be seen in Table 2.

Table 2. Width of Bend Haul Road

Section	Design Road Width Based on Calculation (m)	Actual Road Width (m)	Road Widening (m)
B-C	14,41 m	20 m	
F-G	14,41 m	14,25 m	0,16 m
G-H	14,41 m	15,2 m	
H-I	14,41 m	15,2 m	
K-L	14,41 m	22 m	
O-P	14,41 m	15,5 m	

The table indicates that the average road width for an actual bend with two lanes is 17.5 m. Therefore, the entire road section is sufficiently standardized so that when the dump truck passes through the bend, there will be no deviation when passing.

5.1.3 Cross Slope

A haul road with a transverse slope of 40 mm/m, which means that every 1 meter of horizontal distance has a height difference of 40 mm = 4 cm. Therefore, a haul road with a width of 8.715 m (two lanes) will have an elevation difference at the road axis of :

a. Two lane haul road
   $(\alpha) = {}^{1}/_{2}\ Lmin$
   $= {}^{1}/_{2} \times 8{,}715m$
   $= 4{,}35\ m$
b. Height difference:
   $b = 4{,}35\text{ m} \times 40\,mm/m$
   $= 174\,mm = 17{,}4\,cm$

The optimal cross slope for a transport road with a width of 8.715 m is 17.4 cm. The cross slope calculation data from TS +35 to TLS 2 can be referred to in Table 3.

Table 3. Cross Slope Value

Cross slope on straight roads				
Section	Design Road Width Based on Calculation(m)	Actual Road Width (m)	Road Widening (m)	Cross Slope (Cm)
A-B	8,715 m	7,5 m	1,215 m	17,4 cm
C-D	8,715 m	12,7 m	-	25,4 cm
D-E	8,715 m	13, 2 m	-	26,4 cm
E-F	8,715 m	13,4 m	-	26,8 cm
I-J	8,715 m	7,1 m	1,615 m	17,4 cm
J-K	8,715 m	28,5 m	-	57 cm
L-M	8,715 m	27,2 m	-	54,4 cm
M-N	8,715 m	25,5 m	-	51 cm
N-O	8,715 m	21,4 m	-	42,8 cm
P-Q	8,715 m	11,3 m	-	22,6 cm

5.2 Maintenance Flow of Coal Rehandling Road From Ts +35 - Tls 2

5.2.1 Road Inspection

Inspection is an activity carried out using standardized methods to obtain data and information related to mining operations through a process of observation and monitoring.

During the inspection of the coal rehandling road segment 0+400 m to 0+500 m. inspection by the supervisor of the civil mine found that the road was bumpy and formed rutting. Rutting is damage in the form of a longitudinal decline in the road due to deformation of the pavement layer caused by heavy equipment loads.

Figure 7. Condition of the road to be treated

5.2.2 Maintenance Planning

There are three maintenance recommendations that can be made:

1. Excavation and replacement of subgrade material with suitable material.
2. Addition of surfacing material stone gradation A with a thickness of ± 15 cm.
3. Re-establishment of double crossfall to the west and east.

Based on these recommendations, road maintenance planning can be made as follows:

Planning resource requirements (tools, materials, operators, and supervisors). The tools and materials needed are:

1. Transportation of materials to the treatment site using a 7-ton DT as many as 12 units.
2. Sanding and cutting using a motor grader as many as 1 unit.
3. Compaction of materials using a 10-ton compactor as many as 1 unit.
4. The material used is andesite stone. The andesite stones used are BP 200, BP 20, and BP 60. BP 200 is an andesite stone that is reduced using a crusher and which passes when sieved using a 20 mm size screen. So that BP 20 andesite stone is a rock with a size of 0 mm to 20 mm. the following is the size of andesite rock based on screen size:

Table 4. Classification of materials used

Material Type	Size
BP 20	0 – 20 mm
BP 60	>20 – < 60mm
BP 200	>60 – < 200 mm

5. The above materials are only used for certain parts that need to be treated, the number of stones to be used adjusts to the area that needs to be treated.
6. Two operational supervisors and operators are required for each unit of equipment.

5.2.2 Road Maintenance

1. Resurfacing
   The first step when carrying out rehandling road maintenance is resurfacing. The material for resurfacing is applied to the bumpy part of the road. PT Bukit Asam Civil Mine uses andesite stone as the material for road resurfacing. Based on the inspection results found that some parts of the subbase are soft, then first coated with Crushed Stone 200 (BP200). After the subbase was coated with BP200, the next step was to coat the surfacing section with a mixture of BP20 and BP60 (Aggregate A). Transportation of BP200 material uses 4 units of dump trucks and 8 units of dump trucks to transport BP60/20 material.

Figure 8. Resurfacing

2. Re-Grading
   Re-grading activities or Sanding and cutting material on the maintenance road section using a motor grader (GD 705-A).

Figure 9. Grading activities of BP200 and BP60 materials on TS +35 - TLS 2 road

3. Compaction
   The next step is compaction. Compaction work is carried out using 1 unit compactor (BW211D) with a capacity of 10 tons. The compaction stage in road maintenance is the final stage.

Figure 10. Road Compaction Activity

6. Conclusions and Suggestions

6.1 Conclusion

From the analysis and calculations in this study, the following conclusions can be drawn :

1. Rehandling road geometry at +TS 35 - TLS 2 by making a total of 16 segments, 10 straight roads and 6 bend roads. As a result of different measurements, the distance difference caused by road width conditions continues to decrease in segments A-B and segments I-J, with minus 1.215 and 1.615, respectively. This reason may affect the performance of the conveyance used and result in human error when vehicles pass each other. The rehandling + TS 35 - TLS 2 road treatment was carried out at the same time as production hours, so there were few obstacles during the work. The target completion plan time is one day to two days for the actual completion time.With a road width of 8.715 m, a good cross slope value is 17.4 cm. The purpose of the cross slope is for the drainage system on the road.
2. The maintenance of mining roads is very necessary, because the material used for mining roads tends to use soil and is traversed by various kinds of heavy equipment and transport equipment causing the road surface to become uneven. Therefore, it is necessary to maintain the mine road in accordance with the stages that have been made, the first stage is to inspect the road, then carry out maintenance planning, after which maintenance is carried out on the mine road.

6.2 Suggestions

The following are some recommendations that can be given regarding this study :

1. Conduct routine inspections on the rehandling road which is very crucial, because the rehandling road is very influential in coal production.
2. Plan routine maintenance of the rehandling road.
3. Optimizing road maintenance time
4. Using appropriate road materials and workmanship.
5. On mine roads, the use of single cross fall and double cross fall systems depends on the actual situation in the field.

Notation List

TS = Temporary Stockpile
TLS = Train Load Station
BP = Andesite Crushed Stone

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