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Re-Design of Road Geometric Planning Using Indonesian Standard Case Study: Fly Over Cakung

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ABSTRACT

The construction of the Cakung flyover on a level Road is expected to solve traffic problems and ensure user comfort and safety. The construction of the Cakung flyover in East Jakarta is one of the DKI Jakarta Province Bina Marga Agency projects. This journal aims to redesign the Cakung flyover at STA PI 0+414 and STA PI 0+818 using the Bina Marga method, where there are two horizontal bends by recalculating the horizontal alignment to ensure the riders' comfort and safety. The study results show that the Cakung flyover highway is a class IA collector Road with flat terrain with a width of 7 m, design parameters design speed (VR) of 60 km/hour and a maximum slope (e) of 8%. From the calculations, the design radius (R) is 150 and 400 m, with intersection angles of 48.587 and 24.0147. The curved horizontal length (Lc) is 87.20 and 127.65 m, and the maximum slope (e) is 8%. In this journal, the authors take the SCS (Spiral – Circle – Spiral) type of curved horizontal line that is safe for the rider according to the conditions in the field.

1. Introduction

Road infrastructure is the lifeblood of the economy around the world which plays a role in supporting the movement of people and the distribution chain of production and services. Moreover, Road infrastructure plays a vital role as a parameter of a country's economic, social and cultural progress. Road infrastructure in every country in the world has the same function, including accelerating access and mobilising people from one place to another, facilitating the transportation of goods and services and encouraging the economic development of a region because of easy access to provide new opportunities in business development, tourism, employment opportunities, industry and increase the exchange of ideas and culture between countries. Infrastructure development is part of national development that aims to provide community services [1]. Developed cities are synonymous with mass transportation facilities that pass for Road users and bicycle crossings, buses, trains, etc. An integrated transportation system in the form of Road construction as an effective and reliable transportation infrastructure will benefit the broader community, such as economic development and ease of mobility [2] [3].

Developed cities are also synonymous with Road problems such as congestion and accidents, which generally occur at level crossing points. Congestion occurs in some areas due to increasing vehicles, swollen commuter lanes and constant Road width [4] [5] [6]. A level crossing is a crossing point between railroads and highways that meet simultaneously. This rail road crossing causes a long queue of vehicles waiting for the train to pass. The solution is to build a non-level intersection. Congestion often occurs around the station area, especially on Roads adjacent to the railway tracks, caused by the closing of train door bars, causing long traffic jams and delays around Road sections [7].

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Road infrastructure development in Indonesia has experienced rapid growth in recent years, especially in the Jakarta Metropolitan Area. The Jakarta Metropolitan Area consists of DKI Jakarta Province, Bogor Regency/City, Depok, Tangerang and Bekasi, with the second largest population in the world (33 million). While a sizeable mobile population will significantly impact the environment in a given location, lousy traffic congestion is currently the most apparent effect [8] [9] [10]. Most residents move to and from the centre of Jakarta using private or public vehicles. They are inseparable from the congestion problem and the threat of accidents, especially at level crossings. Various literature states that flyovers and underpasses are adequate for solving congestion and accidents. Efforts to reduce and prevent congestion must be addressed immediately. For this reason, the government decided to build a flyover to help motorists unravel congestion nodes at railway crossings and avoid Road accidents [11].

The construction of the flyover in Cakung itself has been completed and started operating on May 18, 2021, using the Urban Road Geometric Planning Standards, the Directorate General of Highways. The construction of Road flyovers is related to applying geometric Road planning. Road geometric is a shape that describes the cross-section, length and other aspects related to the physical condition of the Road. Good Road geometric planning is an effort to help people carry out their daily mobility safely and comfortably. The radius of the Road curve is the main element in the geometric design of the Road regarding the horizontal angle and is related to the rate of traffic accidents because the smaller the radius of the curve, the higher the chance of accidents occurring on the Road [12].

The author will compile the geometric re-planning of the Cakung Fly-Over Road using the 2021 Bina Marga Road Planning Guidelines. This re-planning includes planning criteria, general provisions, Road geometric technical criteria and procedures for geometric Road planning using horizontal alignment. The Bina Marga Method is a geometric Road planning method used by civil engineers in Indonesia to design Road infrastructure projects [13]. The limitations of the replanning method in this journal are using vertical and horizontal alignment planning. The Road geometric re-planning in this journal aims to recalculate compliance with the latest Road geometric planning guidelines issued by the Directorate General of Highways.

2. Literature Review

2.1. Road Geometry

Road geometry is included in a Road planning technique that focuses on calculating the Road's shape, dimensions, slope and geometric position, such as bend radius, visibility, gradient, pavement thickness, Road shoulder height and width. The geometric design of the route includes alignment of the horizontal and vertical alignments of intersections, cross sections and facilities for cyclists and pedestrians. The alignment of a good Road geometric design is influenced by the characteristics of the driver and the number of passing riders. Several factors, such as driver characteristics and the number of motorists passing in the future, become good Road geometry design standards [14].

The purpose of implementing this Road geometry is inseparable from optimising the capacity and characteristics of the Road according to its function to improve smoothness, safety and comfort for Road users. Road project planning is developed to meet the high levels of mobility, address accident problems, improve Road landscaping, create spaces passable by pedestrians, and rehabilitate existing Road infrastructure [15].

Road geometric design is the process of designing the physical configuration of the Road regarding the elements mentioned above. The Road geometric design is a design that produces the output of dimensions and cross-sections of the Road, vertical and horizontal alignments. In addition, the criteria

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for safe routes must be met as Road facilities. Therefore, the level of safety is the primary condition in the geometric planning of Roads [16]. In Indonesia, the latest regulation governing Road Geometric Design Guidelines was issued by the Ministry of PUPR through the Directorate General of Highways in 2021.

2.2. Guidelines for Road Geometric Design of the Directorate General of Highways

The guidelines for the geometric design of Roads in Indonesia follow the Directorate General of Highways' provisions as the regulator regulating the requirements for implementing highways and bridges in Indonesia. Geometric designs in Indonesia follow the standards of Bina Marga. The Bina Marga Method is a manual calculation method that contains design criteria that must be met to obtain a geometric design of the Road that meets its primary purpose, namely safety factors [17]. This guide contains general provisions, technical provisions and Road geometric design procedures.

The Bina Marga Guidelines are intended as a technical reference for geometric Road planners to be able to provide limitations in the design parameters so that in designing Roads, they can consider ideal design requirements, which will then produce accurate design products to guarantee good Road quality and guarantee safety for users Road. Using the Bina Marga Guidelines, planners can integrate calculations for transition length and visibility in analysing horizontal alignments. Using the Bina Marga Method, one can incorporate visibility and transition length calculations to analyse horizontal alignment [13]

In the technical provisions chapter, important rules are used by the author in this journal: design criteria, determining corridors, visibility and free space around corners, and vertical and horizontal alignment design stages that will be applied to the Cakung Fly Over case study, East Jakarta. The Bina Marga Method describes Road geometry design, including general provisions, Road geometry design criteria, design procedures and geometric technical provisions of Roads for horizontal and vertical alignment [13].

2.3. Fly Over

An overpass, commonly known as a flyover, is a non-level Road that speeds up traffic flow and reduces congestion, mainly due to level crossings. Overpasses are civil engineering that uses high-tech and cutting-edge, and many resources to improve transportation [18]. Flyovers and bridges are similar because both are Road constructions that connect the ground level, or two Roads are separated, and both are flying.

In Jakarta, almost every crossing point at a crossroads between the railway line and the highway has built a flyover. In dealing with the congestion problem, flyovers can be an effective solution. Still, mitigation also needs to be considered related to construction costs that are not cheap and require unique methods in the construction process so that they do not become a new problem. Infrastructure development is also a benchmark of technological progress and population growth, therefore infrastructure development, especially highways, dramatically affects the productivity of activities, fly over is also helpful in reducing congestion that occurs [11].

The construction of the Cakung flyover aims to reduce the level of congestion and increase the level of safety and comfort for Road users crossing Jl. I Gusti Ngurah Rai near Cakung Station and East Flood Canal (BKT). Some of the intersections that cause traffic jams are the Jl. Raya Damai with Jl. I, Gusti Ngurah Rai, and the existence of a railroad crossing (Commuter Line) that crosses the side of the Road.

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Access to the intersection can later be managed after the construction of the Cakung flyover, which broke the queue of drivers from Jl. I Gusti Ngurah Rai headed for Jl. Great Peace. The advantages of flyovers development to overcome severe congestion resulting from the buildup of vehicles waiting for red lights or train intersections [4].

2.4. Horizontal and Vertical Alignment

Traffic accidents are the most common cause of death and severe injury to Road users in Indonesia. Therefore, in planning Road geometry, the main factor that needs to be considered is safety for Road users. It can also be concluded that the horizontal curved radius and vehicle speed are essential factors in the occurrence of Road accident rates [19]. Road geometric planning is one of the sciences in Road engineering that focuses on the Road's physical shape to minimize safety and driving comfort problems for Road users. Road geometric design generally consists of vertical and horizontal alignment analysis. Vertical alignment relates to the elevation of the Road above the ground, while horizontal alignment relates to the direction and turning angles of the Road. The combination of horizontal and vertical alignment planning must produce a design that meets safety requirements and can be realized in the field [20].

Horizontal alignment is often referred to as Road alignment or Road situation, which has a simple meaning as setting the width, height, and bends of the Road. The horizontal design of a highway generally begins with creating related tangents on a topographic map or development map [21]. Each setting has its basis for analysis; for example, setting Road width considering vehicle speed and the number of Road users passing, elevation setting is influenced by existing contour and topography conditions, while for location bends considering curve design and sufficient visibility so Road users can see delineate the Road and avoid accidents. Poor vision in horizontal arches affects the increased risk of accidents. Engineering principles that consider traffic flow similar to reaction time perception and longitudinal friction characteristics to meet appropriate visibility can also be applied to vehicles. Poor vision in horizontal arches affects the increased risk of accidents. Engineering principles that consider traffic flow similar to reaction time perception and longitudinal friction characteristics to meet appropriate visibility can also be applied to vehicles [22]. Horizontal alignment planning design has an important role that affects the level of efficiency and safety of Road users.

Vertical alignment is the intersection of the pavement surface with the vertical plane. The vertical alignment follows the original ground level to reduce earthworks but will result in the Road having too many bends. Redesigning the vertical alignment is an effort to adapt the Road design to the existing topography. To reduce costs caused by excavation and landfill work without lowering the safety value [23]. Vertical alignment describes the planning of the Road going up and down, often referred to as a longitudinal section consisting of straight lines (flat Road conditions, climbing or descending) and curved lines (Road ramps in %). Changes in vertical alignment can significantly affect the quality of the geometric design of the Road due to the steep concave curve where the intersection point of the two tangents is below the Road surface [24]. The purpose of vertical alignment is to provide adequate visibility, minimize steep inclines and reduce the consequences of loss of vehicle control. Vertical alignment planning should always consider subgrade conditions, flood water levels, groundwater levels, Road functions, slopes, and terrain conditions, which are required with safe and economic requirements [20].

3. Methodology

The Cakung flyover was built in 2019 by the DKI Jakarta Province Bina Marga Service. The Cakung flyover has a length of 760 meters and a width of 18 m, with STA 0+000 – STA 1+100 located at the Jl.

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I Gusti Ngurah Rai near Cakung Station and East Flood Canal (BKT). The following is the location of the Cakung flyover when viewed from a broader context located in Cakung, East Jakarta City, located on the Indonesian Island of Java, or can be seen in Figure 1.

Figure 1. Macro Location of the Cakung Flyover Case Study

The Cakung flyover stretches from Jl. I Gusti Ngurah Rai (West-East) to Jl. Raya Damai (North-South). It has two lanes with four lanes with a horizontal alignment design of the S-C-S (Spiral-Circle-Spiral) type. 2-dimensional images and 3-dimensional images can be seen in Figure 2 on the following page.

Figure 2. Figures 2 and 3 Dimensions of the Cakung Fly Over Case Study

In this research methodology, the author only calculated the geometric planning horizontal alignment of the Cakung flyover at STA PI 0+414 and STA PI 0+818 using the Bina Marga method based on the Road Geometric Design Guidelines from Bina Marga in 2021. This guideline is a revision of the Code of Conduct. The 1997 Inter-City Road Geometric Planning was prepared by the Directorate General of Highways, Ministry of Public Works and has referred to A Policy on Geometric Design of Highways And Streets (AASHTO, 2011, 2018) and Geometric Design (AUSTROADS, 2016).

The data used in reference in this study is secondary data obtained from library data, contacts, and written studies from the Provincial Government of DKI Jakarta, especially the Department of Highways as the project owner. Data is the leading force in preparing a research and scientific modeling [25]. The data is then identified, analyzed, and summed up to produce appropriate calculations in the geometric planning of the horizontal alignment of the Cakung flyover using the latest Road Geometric Design Guidelines from Bina Marga in 2021. The process of systematic scientific research must begin with the identification of the right problem [26].

4. Result and Discussion

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Road geometric planning for horizontal alignment at the Cakung flyover at PI STA 0+411 and PI STA 0+818 uses calculations from the 2021 Bina Marga Road Geometric Design Guidelines. The Road data obtained in the measures at the case study location is known to be the radius value radius (R) 150 m at bend 1 and 400 m at bend 2, transition curve (Ls) 40 m, design speed 60 km/h, maximum superelevation slope (e) 8% average cross slope (en) 2%. The calculation of the geometric design of the Road on the Cakung flyover can be seen in Table 1 on the following page.

Table 1. Horizontal Alignment Calculation Results

NO . PI			**1**	**2**
TYPE			**S - C - S**	**S - C - S**
STA PI			**0 + 411**	**0 + 818**
PI		**X**	**10392**	**10702**
KOORD.		**Y**	**9845**	**10702**
Δ		deg	63' 51' 57"	24' 0' 53"
Δ		deg	48.587	24.0147
V		km/hour	60	60
Ls		m	40	40
R		m	150	400
	FORMULA		**RESULT**	
Ɵs	$\frac{90 . Ls}{\pi . Rc}$	deg	7.6394	2.8648
Ɵc	$\Delta.1 - 2\theta s$	deg	33.3082	18.2851
Lc	$\frac{\theta c}{180} \times \pi \times Rc$	m	87.20 Check Lc > 70 m (OK) The Curve Conditions : Lc > 25 m (OK)	127.65 Check Lc > 70 m (OK) The Curve Conditions : Lc > 25 m (OK)
L	$Lc + 2 \times Ls$	m	167.2005	207.6542
P	$\frac{Ls^2}{24\, Rc}$	deg	0.4442 The Curve Conditions : P > 0,25 m (OK)	0.1667
K	$Ls - \frac{Ls^3}{40\, Rc^2} - Rc \sin\theta s$	deg	19.9881	19.9983
Ts	$(Rc + P) \tan\frac{1}{2}\, \Delta.1 + K$	m	87.8967	105.1101
Es	$Es = (Rc + P) \sec\frac{1}{2} - Rc$	m	15.0627	9.1179
L_{tot}	$Lc + 2\, Ls$	m	167.2 Check L < 2 Ts , 167.2 < 175.8 (OK)	207.65 Check L < 2 Ts , 207.65 < 210.22 (OK)
Relative Slope	$\frac{(e + en) \times B}{Ls}$		0.88	0.44

Based on the calculation results in Table 1 above, using the 2021 Highways Guidelines for the type of bend on the Cakung fly over PI STA 0+411 and PI STA 0+818, the appropriate ones are S-C-S (Spiral-Circle-Spiral), namely a curve consisting of curved planes (circle) with a transition plane (spiral) to connect with a straight plane. The calculation results above determine the angle and horizontal

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alignment calculations. At the PI STA 0+411 bend, TS is 87.9 m, Es is 15.0627, P is 0.4442, and ϴs is 7.6394, as shown in Figure 3.

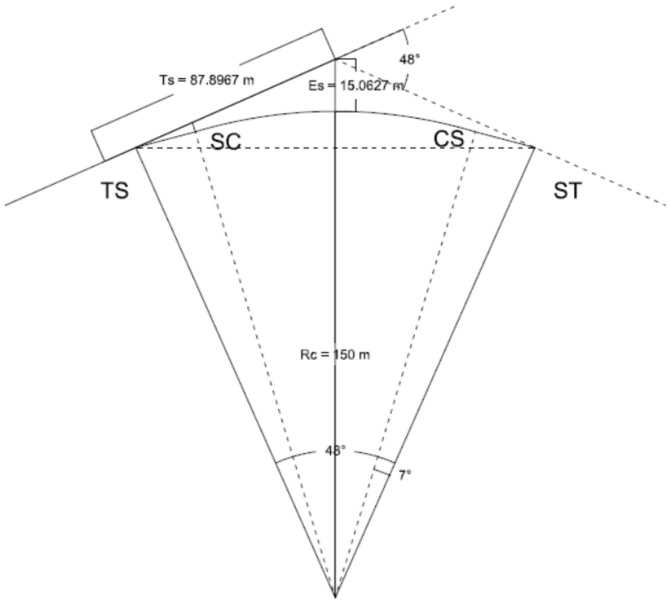

Figure 3. Horizontal alignment curve of PI STA 0+411 bend

From the calculation table above results at the PI STA 0+818 bend, the TS value is 105.11 m, Es is 9.11798 m, P is 0.1667, and ϴs is 2.8648, as shown in Figure 4.

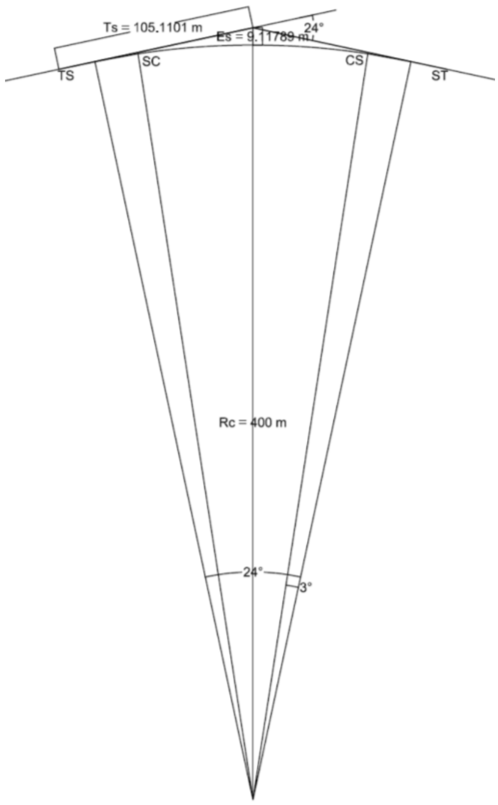

Figure 4. Horizontal alignment curve of PI STA 0+818 bend

The results of the PI STA 0+411 and PI STA 0+818 bends were obtained using a formula based on the 2021 Directorate General of Highways Road geometric design guidelines page 127. The horizontal

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alignment curves in Figures 3 and 4 are then made into superelevation diagrams to illustrate the achievement of superelevation and cross slope. The PI STA 0+411 and PI STA 0+818 superelevation diagrams can be seen in Figure 5 and Figure 6

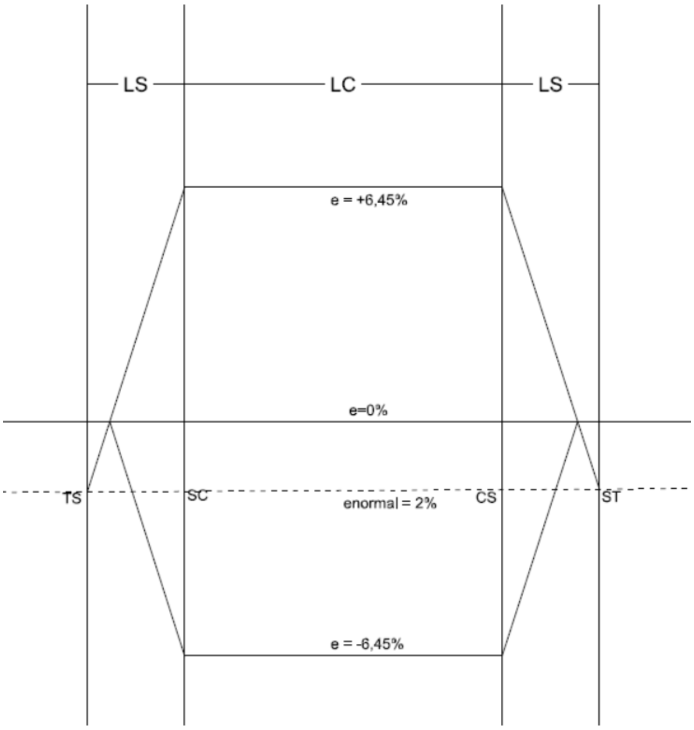

Figure 5. PI STA 0+411 Superelevation Diagram

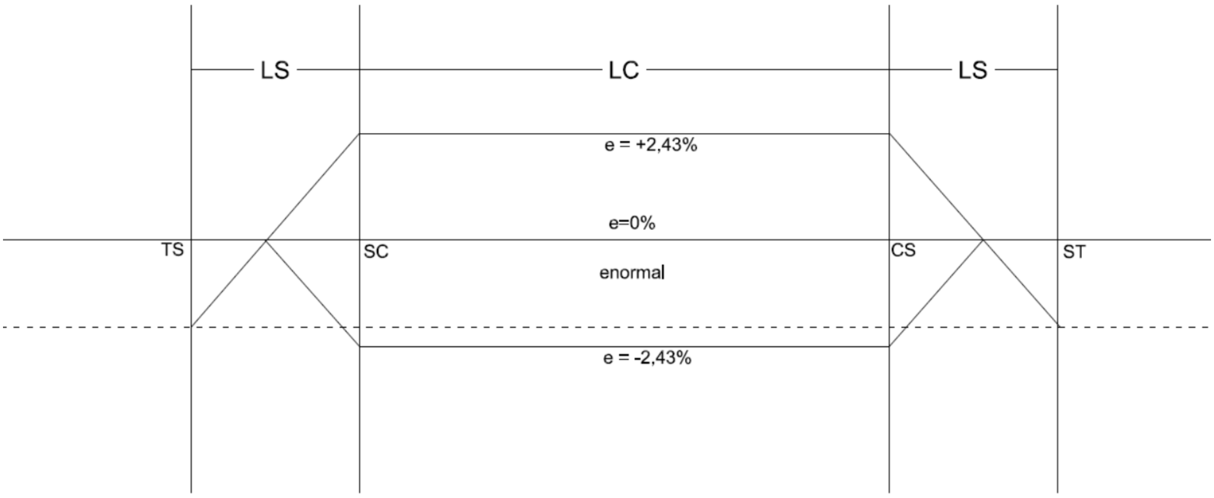

Figure 6. PI STA 0+818 Superelevation Diagram

5. Conclusions

Calculate the geometric design of the Cakung flyover Road for PI STA 0+411 and PI STA 0+818 at a non-level intersection Jl. I Gusti Ngurah Rai near Cakung Station and East Flood Canal (BKT), using the geometric design guidelines for the Directorate General of Highways for 2021, it can be concluded that the Cakung flyover is a class IA collector Road with a flat Road with a width of 7 m and design parameters design speed (VR) 60 km/h, maximum slope (e) 8% and average cross-fall (en) 2%. From the calculations, the design radius (R) is 150 and 400 m, with intersection angles of 48.587 and 24.0147.

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The curved horizontal length (Lc) is 87.20 and 127.65 m, and the maximum slope (e) is 8%. In this journal, the authors take the SCS (Spiral – Circle – Spiral) type of curved horizontal line that is safe for motorists according to field conditions.

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