Geometric and Road Environmental Effects against Total Number of Traffic Accidents in Kendari

M. Akbar Kurdin [*]**, La Welendo, Nur Annisa**

Halu Oleo University, Kampus Bumi Tri Dharma, Anduonohu, Kendari, Indonesia

*E-mail: akbarnanang71@yahoo.com

Abstract. From the large number of traffic accidents that occurred, the carrying of Kendari as the biggest contributor to accidents in the Southeast. The number of accidents in Kendari row since 2011 was recorded at 18 accidents due to the influence of geometric road, in 2012 registered at 13 accident and in 2013 amounted to 6 accidents, with accident data because of the influence Geometric recorded for 3 consecutive years the biggest contributor to accidents because of the influence of geometric is Abeli districts. This study aimed to determine the road which common point of accident-prone (Black spot) in Kecamatan Abeli as accident-prone areas in Kendari, analyze the influence of geometric and road environment against accidents on roads in Kecamatan Abeli, provide alternative treatment based on the causes of accidents on the location of the accident-prone points (blackspot) to reduce the rate of traffic accidents. From the results of a study of 6 curve the accident-prone locations, that the curve I, II, and VI is the "Black Spot" influenced by the amount and condition of traffic accidents, while at the curve II, a traffic accident that occurred also be caused by unsafe geometric where the type of geometric should be changed from Spiral-Spiral type to Spiral-Circle-Spiral type. This indicates geometric effect on the number of accidents.

1. Introduction

Currently there are some indications that land transport services, particularly urban transport decreased or not optimal. Indications that can be perceived by the public is irregularity, congestion, low travel speed, and the accident rate is relatively high, a fairly large number of victims will give economic and social impact. In anticipation of the indications mentioned above, the planning highway becomes very important to get a safe and comfortable roads, where the road geometric aspect becames the main thing in planning roads.

From the large number of traffic accidents that occurred, was recorded of Kendari as the biggest contributor to accidents in the Southeast Sulawesi. Number of accidents in Kendari since 2011 stood at 18 accidents due to the effect of road geometric (sharp turns), in 2012 stood at 13 accidents and in 2013 stood at 6 accidents, with accident data because of the effect of geometric recorded for 3 consecutive years the biggest contributor to accidents because of the effect of geometric is Kecamatan Abeli.

The aim of this study was to answer the above mentioned problems concerning the location of black spots on curve area, as well as analyzing the roads geometric and environmental conditions on the roads black spots under review.

2. Literature Review

Roads geometric is part road planning emphasis on physical form planning, so that it can fulfill its function to provide optimum services on traffic and access to inter-city [16]. In general, geometric planning involves several aspects such as road width, curve, the flatness of roads, and visibility as well as combinations of these parts, both for the road, as well as for a crossing between two or more road segments [14].

Geometric element in the planning of roads and consists of horizontal alignment and vertical alignment. Planning road pavement and road drainage is not included in the planning of roads geometric although included in the planning of roads completely. For roads in Indonesia, roads geometric planning refers to the rules, namely: (1) Peraturan Perencanaan Geometrik Jalan Raya no. 130/1990; (2) Standar Perencanaan Geometrik untuk Jalan Perkotaan, 1992; (3) Peraturan Perencanaan Geometrik untuk Jalan Antar Kota No. 038/T/BM/1997; and (4) Standar Geometrik Jalan Perkotaan RSNI T-14-2004.

2.1 Horizontal Alignment

Horizontal alignment is mainly focused on the axis roads planning which will see the road is a straight road, swerved to the left or to the right. Horizontal alignment consists of three (3) types of curve are: Full Circle, Spiral-Circle-Spiral and Spiral-Spiral. Full Circle is a form of bow-shaped curve with a characteristic full circle, having a radius of curvature (R) which is large in order to avoid fracture [9], where the super elevation required <3% [15]. While Spiral-Spiral has the characteristics that is composed of 2 (two) curved spiral and has a super elevation (e) is small, and are used if the form Spiral -Circle-Spiral cannot be used. Spiral-Circle-spiral consisting of 1 (one) curved Circle and 2 (two) curved spiral, and is used if the form of Full Circle cannot be used. Geometric forms of each type of the curve can be seen in **FIGURE 1** below:
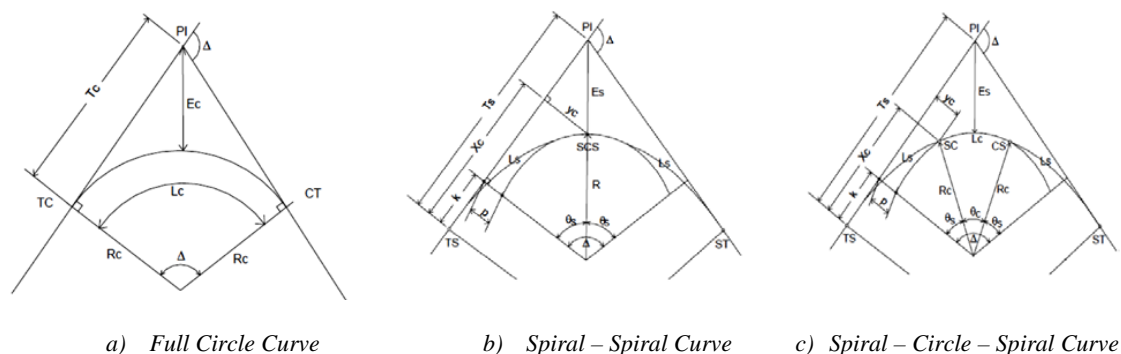

a) Full Circle Curve   b) Spiral – Spiral Curve   c) Spiral – Circle – Spiral Curve
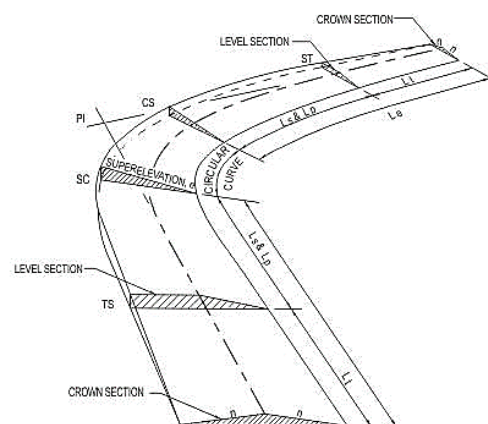
FIGURE 1. Forms of Curved, Source: [14]

FIGURE 2. Transverse Slope the Curve Changes

2.2 Super Elevation

Super elevation achieved gradually from normal transverse slope on the straight road to full slope (super elevation) in the curved. At curve Spiral-Circle-Spiral and Full Circle super elevation attainment

conducted linearly, while at curve Spiral - Spiral super elevation attainment entirely done on the spiral [9].

2.3 Vertical Alignment

Vertical alignment or longitudinal cross section of road which can be a road without slope, incline or decline. Hendarsin (2000) states that vertical alignment is planning elevation axis road at any point in the review, in the form of longitudinal profile. In the planning of vertical alignment is to consider how to put the axis of the according field conditions with regard to the nature of vehicle operations, safety, visibility, and the function of road. Observed from the starting point of planning, the straight sections can be either positive slope (incline), or negative slope (decrease), or zero slope (flat). Vertical curved sections can be concave curved or convex curved [15].

Vertical Curved should be provided at each location experiencing gradient changes, with the aim of reducing the shock due to gradient changes and to provide stopping visibility.

The minimum length of vertical convex curved by stopping visibility, for each design speed (V_R) can be seen in **TABLE 1** below:

TABLE 1. Planning control for Convex Curved Vertical by visibility stopping

Design-speed (km/h)	Visibility of Stopping (m)	Value Curved Vertical (K)
20	20	1
30	35	2
40	50	4
50	65	7
60	85	11
70	105	17
80	130	26
90	160	39
100	185	52

Source: [15]

2.4 Traffic Accident

Traffic accidents are incident on the road traffic where involves one or more vehicles resulting in damage of adverse owner or victim. According to the Law of the Republic of Indonesia Number 22 of 2009 regarding Traffic and Road Transport, traffic accident is an event on the road unexpected and unintentional involve vehicles with or without other road users which resulted in human victims and / or loss of property. Accidents are events that occur in a traffic movement due to an error in the traffic forming system, namely the driver (human), vehicles, road and environment. According Pignataro (1993) that most traffic accidents caused by several factors, the behavior of the driver or the pedestrian, road conditions, poor weather conditions and a bad view. Meanwhile, several other factors are factor condition of the vehicle, other vehicles, signs or traffic control devices, other objects on the road and planning road geometry that is not appropriate, or a combination of the above factors.

There are four factors of environmental conditions that affect human behavior so that potentially cause traffic accidents, namely:
a. Land use and activity, crowded areas, deserted, which instinctively driver reduces speed or vice versa.
b. The weather and the possibilities that looks, for example during fog, heavy smoke, heavy rain in such a way so as to reduce the visibility of the driver.
c. The existing facilities on the road network, the traffic signs, traffic lights and traffic markings.
d. Traffic flow and traffic characteristics, number, type and composition of the vehicle will greatly affect the speed of travel.

The site of a traffic accident can be in various places, at the crossroads, in streets, on bridges, in rural areas, in urban areas, and so on, so it needs identified areas that the frequent occurrence of accidents or accident-prone areas [10]. Areas prone to accidents is an area that has accident rate is high, the risk of accidents is high, the accident can be identified in specific locations on the roads (black spot) and also on certain roads (black site) or on a specific area (black area). The provisions of accident-prone locations (Black spots) based on "Pedoman Penanganan Lokasi Rawan Kecelakaan Lalu Lintas (2004)" can be seen in **TABLE 2** below:

TABLE 2 The provisions of Accident Prone Location (Black Spot)

Black Spot	Urban	Suburb
On roads and intersections	At least 2 traffic accidents with consequent death (per year), or At least 5 traffic accident with injuries / loss of material (per year)	At least 3 traffic accidents with consequent death (per year), or At least 5 traffic accident with injuries / loss of material (per year)

3. Research Methodology

The research location is located in the District Abeli Kendari, namely the curve I, II, and III on the main road between Abeli - Nambo which is at the Kelurahan Nambo, curve IV and V on the main road Abeli - Moramo located in the Kelurahan Sambuli, curve VI on the road the main Abeli - Moramo located on the Kelurahan Tondonggeu. Survey data retrieval begins with accident data and identify the accident because of effects of road geometric. The next survey of the condition of geometric and environmental survey on each street curve that has been identified as accident-prone locations. The data obtained from this survey is then analyzed horizontal alignment and vertical alignment. The processing of data using the theories and formulas of the study of literature as well as regulations issued by Bina Marga.

3.1 Geometric Parameters

There are some parameters in geometric analysis namely the design speed (VR), the centrifugal force, visibility, side-curve-free areas.

3.1.1 Design-Speed (VR)

Design-speed (V_R) on a road section is chosen speed as the basic geometric design that allows vehicles to move safely and comfortably in sunny weather conditions, traffic deserted, and road side effects are by no means [14].

TABLE 3. Design-speed (V_R) according to the classification of road in urban areas

Road Functions	V_R (km/h)
Primary Artery	50 – 100
Primary Collector	40 – 80
Secondary Artery	50 – 80
Secondary Collector	30 – 50
Secondary Local	30 – 50

Source: [15]

3.1.2 Centrifugal Force

Centrifugal force is the force exerted on a vehicle moving at a constant speed on the road with a curved-shaped trajectory, pushing the vehicle radially outward of the track road to a direction perpendicular to force the pace. To compensate for the centrifugal force, takes the friction force between the tire and the road surface, as well as the weight of a vehicle component due to the transverse slope of the road surface [14].

3.1.3 Visibility

Saodang (2004) states that visibility is a distance that is required by the driver in response to a dangerous obstacle, to take action to avoid the obstacle, which consists of stopping visibility (J_h) and visibility precedes (J_d).

TABLE 4. Stopping Visibility

V_R (km/h)	100	90	80	70	60	50	40	30
J_h minimum (m)	185	160	130	105	85	65	50	35

Source: [15]

3.1.4 Widening Line Traffic in Curve

Widening of the curve is meant to maintain operational service traffic conditions at the curve, so that same with the operational service on the straight road. If it's widening less than 0.60 m can be ignored [15].

4. Results Discussion
4.1 Black Spot Analysis

Based on traffic accident data years 2001 – 2013 were obtained from Kendari Police shows that 6 (six) curve as the research object, only curve I, curve II and curve IV expressed as the Black Spot. Results of the analysis of the determination of the Black Spot can be seen in **TABLE 5**.

TABLE 5. The Results of the Black Spot Analysis

Black Spot Parameters	Curve I	Curve II	Curve III	Curve IV	Curve V	Curve VI
Death	0	1	0	0	1	0
Injuries	5	5	1	3	0	6
Black Spot	YES	YES	NO	NO	NO	YES

4.2 Horizontal Alignment and Vertical Alignment Analysis

From the results of a survey of geometric conditions, it is known that the curve I, curve III, curve IV, and curve VI using Spiral-Circle-Spiral type, whereas the curve II and curve V using Spiral-Spiral type. Road class at a location to be reviewed is a primary arterial road class. Curve I have a hill slope category analyzed using design-speed (V_R) is 60 km/h, curve II have a flat slope category analyzed using design-speed (V_R) is 70 km/h, curve III and curve IV which has slope the flat category is analyzed using design speed (V_R) are 80 km / h, curve V which is a flat area with design-speed (V_R) is 50 km/h, and curve V which is a flat area with design-speed (V_R) is 60 km/h. The value of design speed (V_R) is determined based on the radius of curvature of each curve.

Based on the analysis of vertical alignment, the incline and decline area in the research location is safe. Based on a survey of the road environmental condition, all of the study locations located in the deserted area, without fog and smoke, with the condition of traffic signs, street lights and road markings that are still incomplete, so that the environment does not affect the accident that occurred at research locations. Results of the geometric and the road environment analysis can be seen in **TABLE 6** below:

TABLE 6. Results of the Geometric and the Road Environment Analysis

Geometric Parameter	Curve I	Curve II	Curve III	Curve IV	Curve V	Curve VI
Type of Curve	SCS	SS	SCS	SCS	SS	SCS
Super elevation	Safe	Not Safe	Safe	Safe	Safe	Safe
Widening the bend	0,22 m	0,51 m	0,25 m	No Need	0,58 m	0,56 m
Vertical Alignment	Safe					
Road Environment	No Problem					

From **Table 6** above, it appears that the geometric of curve II is not safe, so the type of curve should be changed from Spiral-Spiral type to Spiral-Circle-Spiral type. After analyzed by Spiral-Circle-Spiral type, the value of super elevation on the Curve II to be safe.

On the other hand, almost all the curve require widening, but its widening less than 0.60 m, so the widening can be ignored.

5. Conclusion

Based on the results of the discussion can be concluded that the curve I, II, and VI is the "Black Spot" influenced by the amount and condition of traffic accidents, while at the curve II, a traffic accident that occurred also be caused by unsafe geometric, where the type of geometric should be changed from Spiral-Spiral type to Spiral-Circle-Spiral type. To maintain the environmental conditions are still safe for traffic, it is advisable to do routine maintenance on the condition of signs, road markings, road shoulders

and pavement conditions.For further research, it is advisable to add the factor of pavement conditions, besides factors geometric, to determine Back Spot, Black Site, and Black Area, because the design of geometric and pavement conditions that do not qualify potentially cause of accidents, such as the curve is too sharp, the condition pavement ineligible (slippery and / or damaged).

References
1. Agus. T.M, Audit Keselamatan Infrastruktur Jalan, Yogyakarta: Jurnal Ilmiah Teknik Sipil UGM vol. 16 No.3. 2009
2. Agus, T.M, Kushari, B., Faisol, Kurniawati dan Gunawan, H.E., Modul Pelatihan Inspeksi Keselamatan Jalan (IKJ) dalam Penyelenggaraan Jalan Berkeselamatan, FSTP. 2008
3. Agus. S, Model Kecelakaan Lalu Lintas Di Tikungan Karena Pengaruh Konsistensi Alinyemen Horizontal Dalam Desain Geometrik Jalan Raya, Solo: Jurnal Ilmiah Teknik Sipil Universitas Sebelas Maret Vol. X, 2010.
4. Ditjen Bina Marga, Kajian Kebutuhan Pelaksanaan Keselamatan Jalan di Indonesia, Jakarta: Departemen Pekerjaan Umum, 2006.
5. Ditjen Bina Marga, Penyusunan Sistem Manajemen dan Pedoman Keselamatan Jalan dalam Kegiatan Pembangunan Jalan, Jakarta: Departemen Pekerjaan Umum, 2007.
6. Departemen Pekerjaan Umum, , Manual Kapasitas Jalan Indonesia (MKJI), Jakarta, 1997.
7. Elly. T.P, Pengaruh Geometrik Jalan Terhadap Kecelakaan Lalu Lintas Di Jalan Tol (Studi Kasus Tol Semarang Dan Tol Cikampek, Semarang: Program Pascasarjana, Universitas Diponegoro, 2006.
8. Francesco, S.C, Accidents And Geometric Characteristic Of Road Layout : Some Quantitative Evaluations, journal of Oregon State University, 2000.
9. Hendarsin, S.L, Penuntun Praktir Perencanaan Teknik Jalan Raya, Bandung, Politeknik Negeri Bandung, 2000.
10. NAASRA, Guide to Traffic Engineering Practice, Sydney Australia, NAASRA, 1988
11. Pignataro, Traffic Engineering Category Practice, New Jersey, USA, Ent. in Englood Cliffs, 1993
12. Pedoman Penanganan Lokasi Rawan Kecelakaan Lalu Lintas. Departemen Permukiman Dan Prasarana Wilayah. Pd T-09-2004-13
13. Rasmussen, J, The Definition of Human Error and a Taxonomy for Technical System Design, in New Technology and Human Error, Chicester: John Wiley & Sons, 1987
14. Saodang, H, Konstruksi Jalan Raya, Bandung, Penerbit Nova, 2004
15. Standar Geometri Jalan Perkotaan, RSNI T-14-2004 Departemen Pekerjaan Umum Direktorat Jenderal Bina Marga, 2004.
16. Sukirman, S, Dasar-dasar Perencanaan Geometrik Jalan, Bandung, Penerbit Nova, 1999.
     Tata Cara perencanaan Geometrik Jalan antar Kota DPU Direktorat Jend. Bina Marga, Jakarta, 1997
17. Warpani, P.S, Keselamatan Lalu Lintas, Simpusium ke-4 FSTPT, Bali: Universitas Udayana, 2001.