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Evaluation of Road Geometry to Tourism Areas (Case Study: East Ring Road - Jatigede Dam, Sumedang - Indonesia)

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ABSTRACT

Road geometry design is a method of planning roads geometrically or involving the computation of angles through a process. For road geometric design, it is necessary to assess the suitability of design criteria with applicable guidelines, namely the Road Geometric Design Guidelines. Therefore, this study will conduct a geometric design assessment of the application of the existing road geometric design of the Jatigede East Ring Roads and adjust it to the "Road Geometric Design Guidelines". The research method used in this research is the evaluation research method of the research object, namely the Jatigede East Ring Road Section, which is the road to the Jatigede Dam tourist area, which is not by the road geometry standards. It has a sharp bend less than Rmin = 110, which is the 1997 highway requirement for collection roads with Vr = 60 km/h. Such road conditions can cause insecurity and discomfort for road users. Therefore, the authors conducted research with the title "Case Study of Road Geometry Evaluation Towards Tourism Area Case Study: East Ring - Jatigede Dam, Sumedang - Indonesia" Geometry improvements are due to the fact that many angles are not suitable. To obtain geometry data in the field using Google Earth and Global Mapper, the measured data is coordinate data and elevation data, then using Microsoft Excel to process the measurement results and input them into the Autocad program. Based on the results drawn, geometric analysis. Conducted from 32 corners obtained from the research, only 17 corners with a radius of 115 m meet the criteria. The other 31 turns have radii smaller than the minimum radius, which is quite dangerous for a speed of 60 km/hour. There are steep descents and climbs in some locations, with 28% of the road having a slope much greater than the maximum requirement of 8%.

1. Introduction

This research focuses on evaluating urban roads to provide adequate facilities for pedestrians and cyclists by introducing good quality pedestrian and cycle paths, good on-street parking practices, and exclusive pedestrian crossings by ensuring their safety. Providing adequate facilities is critical, especially for the second largest city in the state after Chennai and the 16th largest city in India (Siva Venkatesh Anand S 4, 2021). The diverse nature of streets identifies conflicting interests for uses that are typically defined and constrained by the spatial capacity of the street. For example, the need to improve environmental quality on local business streets coexists with the need to provide convenient and suitable conditions for short and medium-distance travel. Currently, with some exciting new developments, the bottleneck in conducting road space allocation analysis is the lack of critical or reliable data that allows for a simultaneous review of the city's scale and strategy. The picture of highly effective and efficient streets is further complicated by urban growth patterns coupled with the adoption of technological emergency mobility that threatens to reproduce the dominance of private cars in many cities around the world. (Duncan A Smith1, 2022). In addition to ensuring a higher level of road safety, the secondary objectives of roads also include maximizing economic effectiveness in road infrastructure development and reasonable goal accessibility time to maintain sustainable social, environmental, and economic growth (Farid, 2022).

The growth of road infrastructure has a major role in Indonesia's economic growth. (Zulfa, 2022) However, in order to achieve economic growth, there is a need for the development of vehicles and roads in the city. Road construction is relatively slower than vehicle growth (Muhammad Taufik., 2022). Road infrastructure performance is closely related to passenger and freight transportation systems and socio-economic development. The performance of road infrastructure is generally measured by sensor-monitored indicators, and the capabilities of the indicators monitored in uncovering actual performance are generally determined by road decision-makers and users (Peng Wu, 2021).

Evaluation of road geometry is very important to determine the feasibility of the road before the improvement and development of tourist destinations continue to be pursued from time to time to ensure that tourism can develop properly and sustainably so that it has a good impact on society. One of the locations that is being focused on developing is a tourist destination located in Jatigede Reservoir, Jatigede District, Sumedang Regency. Jatigede Reservoir itself is the second largest reservoir in Indonesia after Jatiluhur Reservoir and has several leading tourist destinations, namely Panenjoan Hill, Buricak-BurinongCisema Village, TanjungDuriat, and TegalJarong. (Hilman Taufiq, 2018)
Jatigede East Ring Road is projected to be a new road connecting Wado-Tolengas. It was cut off due to submergence by the reservoir due to the construction of the Jatigede Dam. (I Gde Budi Indrawan,ST, M.Eng., Ph.D., 2019).In the Jatigede Reservoir East Ring Road Construction Project, the low quality of the work package resulted. It is clearly seen from a number of findings in the field that the unavailability of drainage in the event of heavy rain when flushing the area will cause long cracks due to the unstable contours of the soil in the area, which can endanger road users when passing through the lane especially since the lane is one of the main routes for tourists so it is very important to pay attention to the road whether it is used or not. One of the factors causing the above problems is the importance of evaluating road geometry. This evaluation is done manually through regulations in the road geometry guidelines, which can be a solution to the above problems with the evaluation can solve planning and implementation problems so that it can provide the best results, such as well-organized, comfortable and safe roads used by motorists.

2. Literature Review

2.1 Road Geometric

Road geometry is part of road planning, which emphasizes physical form planning to provide optimal service to traffic and access between locations. In general, road geometry design involves several aspects, such as road width, curvature, road flatness, and visibility, as well as a combination of these parts for roads and crossings between two or more road sections. (Gunawan, Gunawan, RY, Rifai, AI, & Irianto, MA (2022). AutoCAD® 2D untuk Desain Geometrik Tol Terbanggi Besar–Pematang Panggang (Sta. 28+ 650–Sta. 53+ 650). Warga Negara: Jurnal Ilmiah Multidisiplin Indonesia , 2 (5), 757-765., 2022). The purpose of geometric planning is to produce safe infrastructure and efficient traffic flow services and maximize the ratio of the level of use/cost of implementation. The space, shape, and size of the street are said to be good if they can provide a sense of security and comfort to road users. (Lubis, Evaluasi geometrik jalan pada tikungan Laowomaru., 2019).

Road geometric design has the principle that the road alignment must be designed in such a way with its geometric elements. In addition, it must optimize the effectiveness and efficiency of meeting the needs of the quantity and quality of vehicle movements that will pass through it with the availability of resources, the environment, and society, and refer to applicable laws and regulations. (EndryZ.Djamal R. A., 22).

In determining the geometric design of a road, one must pay attention to several criteria. User safety is the main criterion in the geometric planning of a road. Geometric features can determine the shape of the driveway, such as curve radius, deflection angle, spiral length, tangent length, and road/lane/shoulder width, and any or all of these can be customized by the designer. These elements are elements in the geometric path used in planning (Nugroho, 2022). Road geometrics can be divided into three main parts: horizontal alignment, vertical alignment and cross-section, which, when combined, provide a three-dimensional layout for the roadway. (A.B. Osunkunle, 2017).

2.2 Horizontal Alignment

The horizontal alignment of a road is a line extending from the axis of the road perpendicular to the plane of the situation map, which is commonly called a bend and turn (coordinates, distance, azimuth, bend angle). Horizontal alignments are often called road situations or road traces consisting of straight lines or tangents and curved circles curved lines that consist of circular arcs with transitional curves or only transitional curves. (Manalu, 2023). Horizontal alignment mainly focuses on road axis planning. In horizontal alignment planning, you will see whether the road is straight, bends to the left, or the right. The road axis consists of a series of straight lines, circular curves, and transition curves from straight lines to circular arcs. Horizontal curvature is one of the most critical aspects affecting road efficiency and safety. The design will result in lower speeds and result in a reduction in road performance in terms of safety and comfort (Adiputra, Adiputra, DS, Rifai, AI, & Bhakti, SK (2022). Desain Geometrik Jalan dengan AutoCAD® 2D: Kasus Wirosari-Ungaran Semarang, Indonesia. Warga Negara: Jurnal Ilmiah Multidisiplin Indonesia , 2 (5), 729-738., 2022).

Horizontal alignment has three curves: full circle, spiral circle spiral, and spiral spiral. A full circle (FC) is an arch that takes the form of a full circle of arcs. Only some curves can be entirely circled. Only curves with a large radius are allowed. A Spiral Circle Spiral (SCS) is a curve consisting of one circular arch and two spiral curves. A transition curve connects the straight and circular parts. That is, before and after the curve in the form of a circular arc. A Spiral-spiral (SS) is a curve without a circular or curved arc consisting of two spiral arches (Arifin, 2022).

2.3 Road Geometric Design Guidelines

Road geometric design guidelines serve as a reference or benchmark in road planning in order to increase the road functions' effectiveness and efficiency in the future. Each country has different guidelines depending on the conditions in that country in order to produce accuracy in design, adjust to technical needs and regulations, and be implemented in the field (Joice, Rifai, & Taufik, 2022). The applicable guidelines for road planning in Indonesia are the Road Geometric Design Guidelines (PDGJ). So, in planning the geometric design of roads in Indonesia, the design results must comply with these guidelines. In addition to the effectiveness and efficiency of road functions, good road geometric design planning can also improve security and safety on the road. Road geometry is designed in a way that adapts to the road function (Rizki, Irfan Rifai, & Djamal, 2022).

To build a well-planned road geometric design, some things require more attention in their implementation. Road geometric planning and design involves planning horizontal and vertical alignments, calculating visibility, and determining horizontal and vertical curvature radii must be done carefully (Nurjannah, Rifai, & Fajarika Akhir, 2022). By referring to the Guidelines for Road Geometric

Design, the matters involved in planning a road design can get more precise so that a well-planned road geometric design can also be obtained. The geometric design of the road is not necessarily the only major cause that influences the occurrence of traffic accidents. However, elements of road geometrics design, such as short visibility and small radii, can significantly increase the severity of traffic accidents (Islam, Teik Hua, Hamid, & Azarkerdar, 2019). So, a guide is needed to take into account the geometric design planning of the road to reduce the risk of traffic accidents caused by the geometric design of the road.

3. Method

Data is one of the precis forces in developing scientific research and modelling (Immanuel, 2022). This is, of course, based on the theoretical basis and the role of related institutions. According to the data obtained from the Department of Public Planning and Spatial Planning (PUPR), December 2019 is the secondary data used in this study. Topographic acquisition data is obtained directly from the results of surveys in the field, which will then be used as a reference for evaluating the road geometry of this study. Therefore, the research methodology used in this research is to process quantitative data (Nurjannah S. N., 2022). Based on the Road Geometry Design Guidelines (PDGJ) book. Location Evaluation of Road Geometry to Tourism Areas Case Study: East Ring - Jatigede Dam, Sumedang, Indonesia. The location of the work can be seen on the location map in Figure 1.

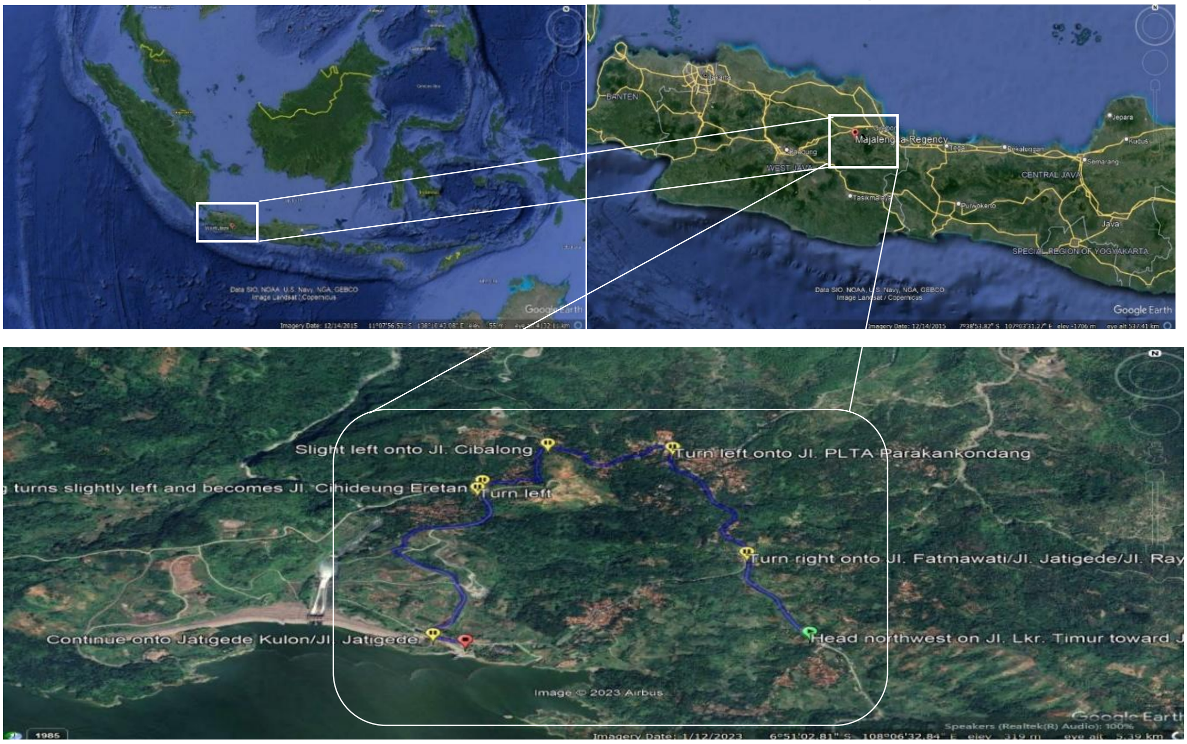

Figure 1. Location of Research
Source: Google Earth

4. Result & Discussion

4.1 Field data

Road Trace Plan From the results of the Field Survey, at the bend of the East Ring Road - Jatigede, Subang, Indonesia, the following road trace plan was obtained (Figure 2).

Figure 2. Trase Jalan

Table 1. Road Trace

No	Coordinates		Distance D (m)	Bend Angle (Δ)	Bend radius R (m)
	X	Y			
A	637972,1904	54276,0550			
PI 1	637966,3406	54259,0951	17,94	23	26
PI 2	637932,6095	54221,6188	50,42	79	17
PI 3	637971,8960	54170,3617	64,58	50	32
PI 4	637952,1869	54084,2762	88,31	27	34
PI 5	637924,3573	54051,3016	43,15	89	17
PI 6	638001,4475	53989,473	98,82	19	56
PI 7	638016,6045	53963,2756	28,55	16	40
PI 8	638041,0241	53943,1911	32,92	15	69
PI 9	638068,9106	53900,2748	51,18	37	35
PI 10	638062,7384	53820,3604	80,15	41	86
PI 11	638160,0638	53691,0049	161,88	90	22
PI 12	638070,5180	53623,5302	112,12	34	23
PI 13	638055,3778	53579,9753	46,11	87	19
PI 14	638008,9227	53593,6707	48,43	74	9
PI 15	637985,4709	53557,0734	43,47	28	83
PI 16	637917,5991	53518,5303	78,05	52	13
PI 17	637968,7203	53497,7151	55,20	12	115
PI 18	638022,4724	53461,7038	64,70	32	26
PI 19	638038,2233	53461,7038	38,48	59	21
PI 20	638092,0992	53419,8360	54,30	49	43
PI 21	638141,9601	53346,4341	88,74	23	63
PI 22	638216,1273	53299,0633	88,00	43	48
PI 23	638280,5473	53311,3019	65,57	73	9
PI 24	638271,8384	53228,4063	83,35	82	29
PI 25	638347,1824	53209,0491	77,79	69	12

PI 26	638299,8568	53142,5231	81,64	32	55
PI 27	638245,9590	53119,5878	58,57	68	24
PI 28	638246,6593	53052,8174	66,77	37	30
PI 29	638216,6593	53052,8174	50,08	69	17
PI 30	638240,3971	52975,3652	44,24	59	12
PI 31	638222,0129	52938,3602	41,32	47	21
PI 32	638235,2264	52904,0439	36,77	42	31
B	638225,4637	52878,4200	27,42		

Data source: ms. excel calculation

From the road alignment drawing, is known that there are 32 bends between point A (Km. 41 + 000) as the starting point of the study and point B (Km. 43 + 041) at the end of the study. Each turn is analyzed and evaluated against the road geometry criteria developed by Bina Marga.

Table 2. PI Coordinate Data, Distance, and Bend Radius

No	Coordinates	
	X	Y
A	637972,1904	54276,0550
PI 1	637924,3573	54051,3016
PI 2	638068,9106	53900,2748
PI 3	638160,0638	53691,0049
PI 4	638092,0992	53419,8360
PI 5	638299,8568	53142,5231
B	638225,4637	52878,4200

Additional curve data, including lane width, elevation, and side clear, were obtained directly from field measurements. Meanwhile, superelevation is calculated as the height difference between the curved outer and inner edges divided by the width and multiplied by 100%.

4.2 Excavation and Backfill Work (Cut & Fill)

The work includes excavation and piling at the road mark to meet the required road slope and cross-section. Calculate the excavation volume of the embankment using the average end area method of the two cross sections of the product road Distance between two contours.

Table 3. Recapitulation of Excavation Volume Calculation

Sta	Excavation Volume (m3)
Sta. 0 + 094,19	
s/d	416,35
Sta. 0 + 127,93	
Sta. 0 + 155,75	

s/d	5.143,01
Sta. 0 + 294.95	
Sta. 0 + 700,07	
s/d	1.306,90
Sta. 0 + 821,04	
Sta. 0 + 319,80	
s/d	974,59
Sta. 0 + 454,41	
Total Galian	8.040,86

Table 5. Recapitulation of Volume Calculation

Sta	Excavation Volume (m3)
Sta. 0 + 000,00	
s/d	1.637,49
Sta. 0 + 094,19	
Sta. 0 + 127,93	
s/d	751,22
Sta. 0 + 155,75	
Sta. 0 + 482,11	
s/d	1.028,46
Sta. 0 + 621,11	
Sta. 0 + 841,04	
s/d	2.013,36
Sta. 0 + 119,93	
Sta. 0 + 119,93	
s/d	1.571,67
Sta. 0 + 299,80	

Sta. 0 + 475,16	
s/d	1.484,05
Sta. 0 + 567,55	
Total Backfill	8.486,,25

The profile area was obtained by coordinate method calculation using the original ground elevation data and the road plan elevation.

5. Conclusions

From the results of the evaluation that has been carried out, there are the following conclusions:

1. Average slope km. 41+ 000 up to km. 43+ 041 or 2.041 km long is 5.2%. According to the Road Geometric Design Guidelines book, this road section includes roads with hilly terrain conditions.
2. Evaluation Along this road section, there ware 32 bends, and only the 17th bend with a radius of 115m meets the criteria. The other 31 bends have a smaller radius and minimum radius and would be dangerous to travel at 60 km/h. Speed 60 km/h.
3. The distance between adjacent bends is such that they overlap each other the drivers does not have sufficient clearance when moving from one bends to the next.
4. Most carrier bends meet the minimum lane width (4.5) m, including the widening lane (1.4 m). Only seven bends still require widening improvements.
5. The re-planned length is shorter than 2,041 km to 1,567.55 km.
6. There are three bends with Spiral-circle-spiral bend type, one bends.
7. Spiral-Spiral and 1 Full Circle curve get 5 vertical curves, namely 3 convex vertical curves and 2 concave vertical curves.

References

Duncan A Smith1, N. P. (2022). Palominos, N., & Smith, DA (2022). Memeriksa geometri jalan melalui aksesibilitas: wawasan baru dari analisis alokasi ruang jalan. Lingkungan dan Perencanaan B: Analisis Perkotaan dan Ilmu Kota , 23998083221139849. *Examining the geometry of streets through accessibility: new insights from streetspace allocation analysis*, 2.

Siva Venkatesh Anand S 4, E. G. (2021). Elangovan, K., Gowtham, G., Pranav Srinidhi, B., & Siva Venkatesh Anand, S. (2021). Perencanaan Lalu Lintas dan Persimpangan Utama Desain ulang Persimpangan Empat Lengan yang Ada di jalan DB, Coimbatore, India. International Journal of Applied Engineering. *Traffic Planning and Major Intersection Re-design of an Existing FourArmed Intersection at DB road, Coimbatore, India*, 424-440.

A.B. Osunkunle, S. A. (2017). Raji, SA, Zava, A., Jirgba, K., & Osunkunle, AB (2017). Desain Geometrik Jalan Raya Menggunakan Autocad Civil 3d. Jurnal Sains dan Teknologi Teknik Multidisiplin (JMEST) , 4 (6), 7415. *Geometric Design of a Highway Using Autocad*, 7415.

Adiputra, D. R. (2022). Adiputra, DS, Rifai, AI, & Bhakti, SK (2022). Desain Geometrik Jalan dengan AutoCAD® 2D: Kasus Wirosari-Ungaran Semarang, Indonesia. Warga Negara: Jurnal Ilmiah Multidisiplin Indonesia , 2 (5), 729-738. *DesignofRoadGeometricwithAutoCAD®2D: ACaseWirosari-UngaranSemarang,Indonesian*, 729-738.

Adiputra, D. R. (2022). Adiputra, DS, Rifai, AI, & Bhakti, SK (2022). Desain Geometrik Jalan dengan AutoCAD® 2D: Kasus Wirosari-Ungaran Semarang, Indonesia. Warga Negara: Jurnal Ilmiah Multidisiplin Indonesia , 2 (5), 729-738. *DesignofRoadGeometricwithAutoCAD®2D: ACaseWirosari-UngaranSemarang,Indonesian*, 729-738.

Arifin, A. &. (2022). Arifin, A., & Rifai, A. I. (2022). Geometric Design of Upper Cisokan Hydroelectric Power Plant Access Road with AutoCAD® Civil 3D (STA 3+ 000-STA. 4+ 800). Citizen: Jurnal Ilmiah Multidisiplin Indonesia, 2(5), 851-858. *Geometric Design of Upper Cisokan Hydroelectric Power Plant Access Road with AutoCAD® Civil3D (STA 3+000 - STA. 4+800)* , 851-858.

EndryZ.Djamal, R. A. (22). Rizki, R., Rifai, AI, & Djamal, EZ (2022). Redesain Geometrik Jalan Cisauk–Jaha, Banten dengan Metode Manual (Sta. 0+ 000-Sta. 0+ 350). Warga Negara: Jurnal Ilmiah Multidisiplin Indonesia , 2 (5), 859-864. *GeometricRedesignofJalanCisauk–Jaha,BantenwithManualMethod(Sta.0+000-Sta.0+350)* , 859-864.

Farid, M. R. (2022). The Alignment Horizontal Design of Alternative Road: A Case of Jalan Subang--Cikamurang, West Java. *Indonesian Journal of Multidisciplinary Science* , 344--356.

Gunawan, R. R. (2022). Gunawan, RY, Rifai, AI, & Irianto, MA (2022). AutoCAD® 2D untuk Desain Geometrik Tol Terbanggi Besar–Pematang Panggang (Sta. 28+ 650–Sta. 53+ 650). Warga Negara: Jurnal Ilmiah Multidisiplin Indonesia , 2 (5), 757-765. *AutoCAD®2DforGeometricDesignofTerbanggiBesar–PematangPanggangHighway(Sta.28+650–Sta.53+650)* , 757-765.

Gunawan, R. R. (2022). Gunawan, RY, Rifai, AI, & Irianto, MA (2022). AutoCAD® 2D untuk Desain Geometrik Tol Terbanggi Besar–Pematang Panggang (Sta. 28+ 650–Sta. 53+ 650). Warga Negara: Jurnal Ilmiah Multidisiplin Indonesia , 2 (5), 757-765. *AutoCAD®2DforGeometricDesignofTerbanggiBesar–PematangPanggangHighway(Sta.28+650–Sta.53+650)* , 757-765.

Hilman Taufiq, L. D. (2018). Alia, LN, Turgarini, D., & Taufiq, H. (2018). STRATEGI PENGEMBANGAN WISATA KULINER DI WADUK JATIGEDE KECAMATAN JATIGEDE KABUPATEN SUMEDANG. Jurnal Wisata Gastronomi , 5 (2), 139-150. *STRATEGI PENGEMBANGAN WISATA KULINER DI WADUK JATIGEDE KECAMATAN JATIGEDE KABUPATEN SUMEDANG* , 139-150.

I Gde Budi Indrawan,ST, M.Eng., Ph.D., R. R. (2019). AZIZI, R. R. (2019). Karakteristik Geologi Teknik dan Kestabilan Lereng Jalan Lingkar Timur Jatigede KM 08+ 150-17+ 500, Kabupaten Sumedang, Jawa Barat (Doctoral dissertation, Universitas Gadjah Mada). *Karakteristik Geologi Teknik dan Kestabilan Lereng Jalan Lingkar Timur Jatigede KM 08+150 - 17+500, Kabupaten Sumedang, Jawa Barat* , 1.

Immanuel, G. R. (2022). Immanuel, G., Rifai, A. I., & Prasetijo, J. (2022). The Road Performances Analysis in Jalan Laksamana Bintan, Batam-Indonesia. Indonesian Journal of Multidisciplinary Science, 1(1), 17-26. *THE ROAD PERFORMANCES ANALYSIS IN JALAN LAKSAMANA BINTAN, BATAM-INDONESIA* , 17-26.

Islam, M. H., Teik Hua, L., Hamid, H., & Azarkerdar, A. (2019). Relationship of Accident Rates and Road Geometric Design. *IOP Conference Series: Earth and Environmental Science* (p. 7). Bristol: IOP Publishing.

Joice, E. O., Rifai, A. I., & Taufik, M. (2022). The Link Road Design of Jalan Plupuh Tanon and Jalan Gabugan Section 1, Sragen Indonesia. *Indonesian Journal of Multidisciplinary Science,* , 214.

Lubis, M. R. (2019). Evaluasi geometrik jalan pada tikungan Laowomaru. *In Seminar Nasional Teknik (SEMNASTEK) UISU* , 37-43.

Manalu, S. S. (2023). Manalu, S., Situmorang, TS, & Debataraja, S. (2023). EVALUASI PERENCANAAN JALAN PARTIBI LAMA-SIOSAR KABUPATEN MERK (STA 4+ 000 S/D STA 6+ 000) KARO. JURNAL ILMIAH TEKNIK SIPIL , 11 (1), 273-281. *EVALUAIS PERENCANAAN JALAN PARTIBI LAMA - SIOSAR, KECAMATAN MEREK (STA 4+000 S/D STA 6+000) KABUPATEN KARO* , 273-281.

Muhammad Taufik., N. A. (2022). Road Geometric Design used AutoCAD® Civil 3D: A Case Study Jalan Campaka-Wanaraja Garut, Indonesia. *Zulfa, N., Rifai, A. I., & Taufik, M. (2022). Road Geometric Design used AutoCAD® Civil 3D: A Case Study Jalan Campaka-Wanaraja Garut, Indonesia. Citizen: Jurnal Ilmiah Multidisiplin Indonesia, 2(5), 843-850.* , 1.

Nugroho, R. B. (2022). Nugroho, R. B., Rifai, A. I., & Akhir, A. F. (2022). The Geometric Design of Horizontal Alignment: A Case of Bojonggede-Kemang Area Route, West Java Indonesia. Indonesian Journal of Multidisciplinary Science, 1(1), 331-343. *THE GEOMETRIC DESIGN OF HORIZONTAL ALIGNMENT: A CASE OF BOJONGGEDE-KEMANG SECTION ROAD, WEST JAVA INDONESIA* , 331-343.

Nurjannah, S. N. (2022). Nurjannah, S. N., Rifai, A. I., & Akhir, A. F. (2022). Geometric Design for Relocation of National Road Sei Duri-Mempawah Section, West Kalimantan using AutoCAD® 2D. Citizen: Jurnal Ilmiah Multidisiplin Indonesia, 2(5), 692-702. *Geometric Design for Relocation of National Road Sei Duri-Mempawah Section, West Kalimantan using AutoCAD®2D* , 692-702.

Nurjannah, S. N., Rifai, A. I., & Fajarika Akhir, A. (2022). Geometric Design for Relocation of National Road Sei Duri-Mempawah Section, West Kalimantan using AutoCAD ® 2D. *CITIZEN: Jurnal Ilmiah Multidisiplin Indonesia* , 693.

Peng Wu, Y. D. (2021). Developing sustainable road infrastucture performance ndicators using a model-driven fuzzy spatial multi-citeria decision making method. *Song, Y., Thatcher, D., Li, Q., McHugh, T., & Wu, P. (2021). Developing sustainable road infrastructure performance indicators using a model-driven fuzzy spatial multi-criteria decision making method. Renewable and Sustainable Energy Reviews, 138, 110538.* , 1.

Rizki, Irfan Rifai, A., & Djamal, E. Z. (2022). Geometric Redesign of Jalan Cisauk-Jaha, Banten with Manual Method (Sta. 0+000-Sta. 0+350). *CITIZEN: Jurnal Ilmiah Multidisiplin Indonesia* , 861.

Zulfa, N. a. (2022). Road geometric design used AutoCAD{\textregistered} Civil 3D: a case study jalan campaka-wanaraja garut, Indonesia. *Citizen: Jurnal Ilmiah Multidisiplin Indonesia* , 843--850.