

Underpass Development on the Train Cross, South Tambun Bekasi

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ABSTRACT

This study aims to improve safety and security for vehicle users passing through the tunnel, identify the construction of underpasses at railroad crossings, minimize queue lengths and delays while crossing on Jalan Sultan Hasanudin, Pasar Tambun, Bekasi and improve road smoothness, and provide recommendations for the need for pedestrian facilities on the Jalan Sultan Hasanudin section. There is a potential safety risk for pedestrians, because there are no pedestrian crossing facilities. Then analyze the benefits of underpass construction on level crossings for road users. The method used is descriptive quantitative analysis, namely in the form of calculating traffic performance, technical requirements of the railway line, the benefits of the underpass for train operations and the need for pedestrian crossing facilities. The results of the analysis identify the need for underpass maintenance costs for safety and security for passing vehicle users. It is necessary to add a zebra cross and pelican on Jalan Sultan Hasanudin on pedestrian facilities to cross, close the U-turn of the Ataqlwa mosque which is moved to the u-turn access of the police station, south Tambun, then the construction of the tunnel is very useful for rail operations and road users.

Keywords : traffic engineering, underpass development, pedestrian, train cross

A. Introduction

Level crossings or intersections and/or intersections between railway lines and other buildings are accident-prone points that are difficult to resolve given the low discipline of road users to comply with warning signs at level crossings (Aswad, 2013). Accident data from 2015 to 7 June 2019 accidents at level crossings were 1,470 incidents with details of 179 incidents at guarded level crossings and 1,291 at unguarded crossings, this shows the lack of awareness of road users to prioritize train travel. At level crossings between the railway line and the road, the vehicle driver must stop when the signal has sounded, the rail gate has begun to be closed and/or there is another signal to prioritize the train journey (UU RI, 2009).

Underpass is a road that is below ground level (Santosa, Suthanaya, &

Adnyana, 2016b), the main part of which is a road, rail, or pedestrian path. The underpass is an alternative to be able to overcome the long queue of vehicles at the intersection, the function of using the underpass is to improve the road geometry, to be able to provide comfort and safety for pedestrians and road users. In Spatial Plans of Bekasi Regency, Tambun Selatan District as the urban center is part of the Jabodetabek urban system which carries out the function of national-scale industrial development. Based on data from the Central Statistics Agency in 2018, the population of South Tambun District in Bekasi Regency is 134,067 people with an area of 4,310 Ha. Long queues and delays on roads are common problems in Bekasi Regency, especially at the Pasar Tambun intersection.

At the Pasar Tambun Intersection there is a Mekarsari Street section in the north which is a residential area and there is a Tambun Station, the west is Jalan Sultan Hasanudin I which is the Tambun market area and access to Bekasi City, then the east is Jalan Sultan Hasanudin II access to Cikarang which there is an industrial area. In the area there are long queues and delays due to the disproportionate volume of vehicles and road volume. Based on the results of the survey the performance of the existing intersection produces a delay at busy time of 14 seconds with service level B, but the service level of Jalan Sultan Hasanudin D is unstable vehicle volume with high-passing vehicles with the lowest speed of 50 km/hour. The level of service on arterial roads is at least C (PM RI, 2015).

There are no road crossing facilities, in this case there is a potential risk to pedestrian safety, pedestrians are part of the traffic movement because their activities are moving. To ensure the safety of pedestrians, their rights and obligations in traffic are regulated, and they are entitled to the availability of supporting facilities. People want safe road conditions along the pedestrians and feel comfortable when walking, also feels safe, comfortable and convenient and finally, accessible (Ghani, Shimizu, & Mokhtar, 2015).

The underground crossing with a length of 162 meters was inaugurated on 10 May 2017, in this case there is no underpass maintenance. Tunnel maintenance started 5 years after the tunnel operation. Then it is necessary to calculate the maintenance cost for the underpass (Firmansyah & Istiar, 2016; Muzdar, Heryanto, & Akil, 2018). Based on data, the number of daily train trips in the Tambun area is 49 commuterline and 18 long-distance trains with an average number of accidents of 1 accident per day. There is no benefit of underpass construction on Jalan Mekarsari for road users. Analyzing the construction of underpasses at railroad crossings. To overcome the problems that occur at the Pasar Tambun intersection, this study will examine the feasibility of

constructing an underpass at the railroad crossing at Pasar Tambun intersection. Congestion at level crossings is due to the closing of the crossing gates to prioritize train travel, resulting in a queue of motorized vehicles (Hartono, 2016).

B. Methods

The research method used is quantitative descriptive analysis in the form of calculating traffic performance, technical requirements of the railway line, the benefits of the underpass to road users, the cost of maintaining the underpass and the need for pedestrian crossing facilities. The research stages start from identification of existing problems, secondary data collection, primary data collection, traffic analysis of existing conditions, traffic analysis of plan conditions, model validation, followed by conclusions and suggestions.

This research used primary and secondary datas, primary data were obtained from survey at the intersection of the Pasar Tambun, Bekasi. The survey carried out was an inventory of roads and intersections with the target data in the form of images of the geometric conditions of the intersection as well as facilities and equipment along with a cross section, the classified turning movement counting survey conducted direct observations and enumerations at each leg of the intersection within a certain period of time, and a survey of past travel speed. traffic on a road segment by noting the length of time the obstacle, the location and the causes of the obstacle. Secondary data were obtained from government in Bekasi Regency. It was also obtained from various texts such as books, journals, and related articles as a literature review to analyze more deeply. Testing the inter-relationship between variables using chi-square test, and then compiled a recapitulation of the results of the bivariate analysis and will be known whether the five variables of the research are interconnected.

C. Results and Discussion

1. Underpass Maintenance

Regulation of the Minister of Public Works and Public Housing Number 13 PRT of 2011 concerning Procedures for Road Maintenance and Surveillance (PM RI, 2011). Development costs have increased every year due to inflation. The amount of inflation that occurred based on the inflation rate of Bank Indonesia was 4.82%. So, the tunnel maintenance cost in 2022 is Rp. 9.590.327.674.-. This research also supports several feasibility studies by (Laksono & Prastyanto, 2021; Ridwan, 2018; Safira & Antika, 2018) that have been studied related to the maintenance and financing of an underpass. Another economic analysis study with three interest rates (between 12% and 18%) explains that the underpass development in the Denpasar Bali area is economically feasible (Santosa, Suthanaya, & Adnyana, 2016a). Research by analyzing the cost of maintaining the underpass, it is in line with the feasibility of the study and is in accordance with the requirements economic feasibility analysis. Other research by related underpass construction in the region Kentungan Yogyakarta was declared eligible according to the requirements for analysis economic feasibility (Qori'atanadya, Widyastuti, & Kartika, 2021).

2. Benefits of the Underpass on the Road

Underpass needs to be done because it is very useful for the smooth running of road users (Sudarmanto, 2018). In addition, every

train that crosses the level crossing, requires a waiting time of 3 minutes for road users. Starting from the safety time before the train passes (the clapper signal for the train that will pass) + the release time (opening) of the JPL doorstep. In a day the benefits of underpass construction for road users are at least 360 minutes or the equivalent of 6 hours per day. In one day, the benefit of underpass construction for road users are at least 360 minutes or equivalent to 6 hours for each day. This research is in line with a study (Bricicaru & Beleiu, 2022) on the benefits of having an underpass related to road safety based on data from an economic assessment of accident data. In other studies, the benefits of this research are in line with the study, that the government's policy in overcoming congestion at Simpang Kentungan, Yogyakarta has been effective (Idris & Husein, 2022; Qori'atanadya et al., 2021).

3. Railroad Free Space

The railroad free space in the tunnel takes into account the type of rail facilities operated and the ballasted or unballasted system. The dimensions of the tunnel are determined by the free space plus at least 100 mm for maintenance. The railroad free space of track complies with the standard provisions of PM Number 60 Year 2012 About Railroad Technical Requirements (PerMenHub RI, 2011), the following is an image free space on the rail road (Figure 1).

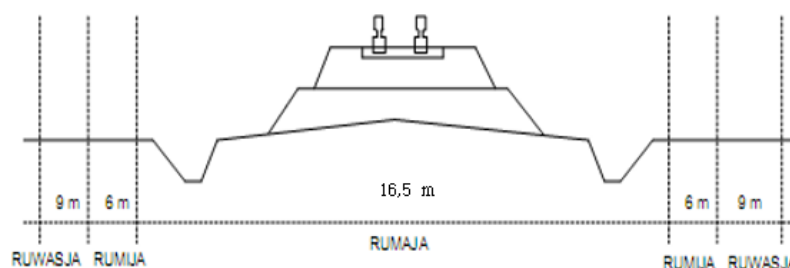


Figure 1 Free Space on Railroads

The free space on the rail road complies with the standard provisions, namely: (a) Railroad Benefit Space at least 2.75 meters

from the axle. For the benefit space of the railway line, it has met the standard provisions of 2.75 meters, (b) Space Owned

by Railroad 6 meters. The space belonging to the railroad has met the 6 meter standard. The space belonging to the railway line is intended to secure the construction of the rail road, (c) Railway Track Control Room (no minimum limit) and (d) A piece of land outside the road belonging to the road that must be monitored, so that all activities and development within the boundaries of the Ruwasja do not interfere with train operations. The field on the Rumija has a function to secure and expedite the train.

4. Pedestrian Facilities

From the results of the pedestrian survey, it was found that the volume of pedestrians crossing, then obtained reference data in determining crossing facilities (Junaedi, 2014). Then the recommendations for crossing facilities will be obtained by looking at the number of people crossing and the volume of vehicles. The results of this pedestrian research are in line with the study by (Cantillo, Arellana, & Rolong, 2015), showing that the variables of safety and attractiveness of each crossing model are quite relevant and related to pedestrian crossing behavior. This research is in line with the study by (Asadi-Shekari,

Moeinaddini, & Shah, 2014), which states that through good facilities through improving pedestrian safety will be able to improve the safety of older pedestrians and persons with disabilities.

This study supports previous studies by (Ratnaningsih, 2020), that the number of pedestrians and traffic volume is high on Jl MT Haryono Malang but is not balanced pedestrian facilities that cause road performance to be low. In addition, this study also supports the results of the analysis by (Erlangga & Handayani, 2021), that facilities on Jalan Slamet Riyadi, Surakarta related to conflicts on pedestrian paths and motorized vehicle behavior, driver at the crossing location as well as facility infrastructure, maintenance and cleaning. Finally, this research also supports a review by (Leather, Fabian, Gota, & Mejia, 2011). Walkability and pedestrian facilities in Asian cities state and issues, which recommends solutions involving multiple stakeholders who should play a role in developing policies and projects focused on increasing the cruising range of Asian cities. The following is the result of determining the crossing facilities (Table 1).

Table 1 Calculation of Recommendation for Selection of Types of Crossings for Pedestrian Facilities

Time 60 Minutes	Pedestrian Crossing (P)	Vehicle (V)	V ²	PV ²
07:00-08:00	83	1375	1890625	156921875
08:00-09:00	69	1324	1752976	120955344
12:00-13:00	66	1497	2241009	147906594
13:00-14:00	46	1285	1651225	75956350
15:00-16:00	55	1451	2105401	115797055
16:00-17:00	48	1526	2328676	111776448
Average				121.552.277,67

From the results of the calculations above, it is obtained recommendations for different crossing facilities, namely the zebra cross and pelican recommendations. This is influenced by the number of pedestrians and

the average number of vehicles which are in the range of 50 – 1100 (PU RI, 1997). Then for the recommended image of crossing facilities (Figure 2).

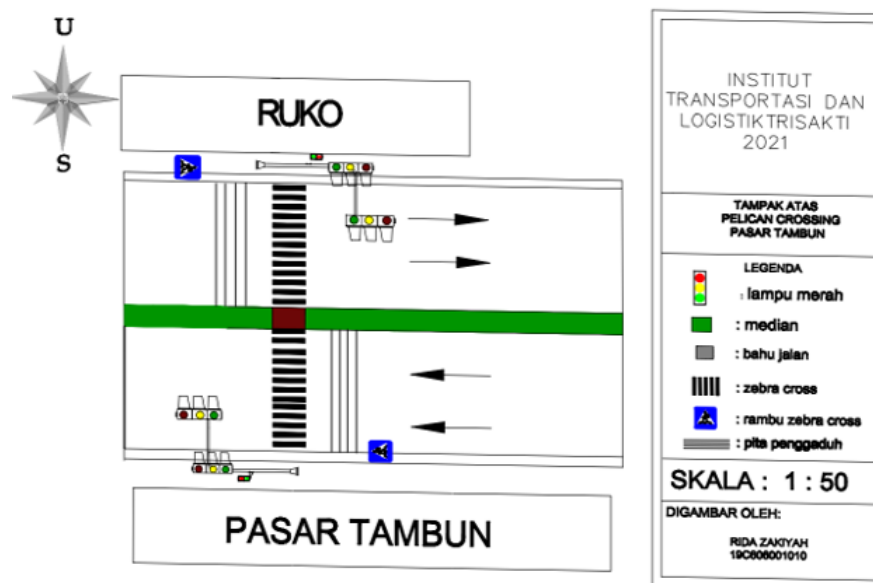


Figure 2 Top View of Pelican Crossing Pasar Tambun

In planning the duration of the pelican crossing lights, it is calculated only in period 4 as shown in the table below, while for period 1 the standard time is 7 seconds (Transport, 1995).

$$PT = \frac{12}{1,2} + 1,7 \left(\frac{83/60}{2,5-1} \right) = 11,57 = 12 \text{ seconds}$$

Table 2 The Period of the Pasar Tambun Pelican Crossing Lights

Period	Traffic Lights		Duration (Seconds)
	Vehicle	Pedestrian	
1	Green	Red	7
2	Yellow	Red	3
3	Red	Red	3
4	Red	Green	12
5	Red	Flashing Green	3
6	Red	Red	3

5. Closing of U-Turn Access

One of the effects when making a reverse motion is the speed of the vehicle where the vehicle will slow down or stop. This slowdown will affect the flow of traffic in the same direction (Maer, Lefrandt, & Timboeleng, 2019). In certain vehicles, to make a U-turn motion, it is not possible to directly make a rotation due to the condition of the vehicle that does not have a sufficient turning radius, so that it will cause other vehicles to be disturbed and even stop either from the same direction or from the opposite direction to be traversed (Balaka & Djalante, 2017). Jalan Sultan Hasanudin in Bekaasi

Regency, West Java Province, is an arterial road with a relatively high traffic volume and there is a median opening (U-turn). This study supports the previous study by (Wu, Sun, Li, & Chen, 2020), that U-turn integration has an effect on traffic performance by analyzing the relationship with main-lane vehicles and U-turns.

This research is also in line with several other studies, related to the relationship between U-turn vehicles with a narrower median width and significantly longer openings will result in traffic accidents (Chu & Tran, 2021; Kay, Gates, Savolainen, & Shakir Mahmud, 2022; Shao et al., 2022).

Based on observations at the study site, it is seen that there are vehicles that cannot perform U-turn movements smoothly, wherein the vehicle must perform additional maneuvers in order to fully adjust the turning

movement. These conditions can cause security problems and U-turn and straight vehicles. Here, is recommendations for Closing the Pasar Tambun Intersection (Figure 3):

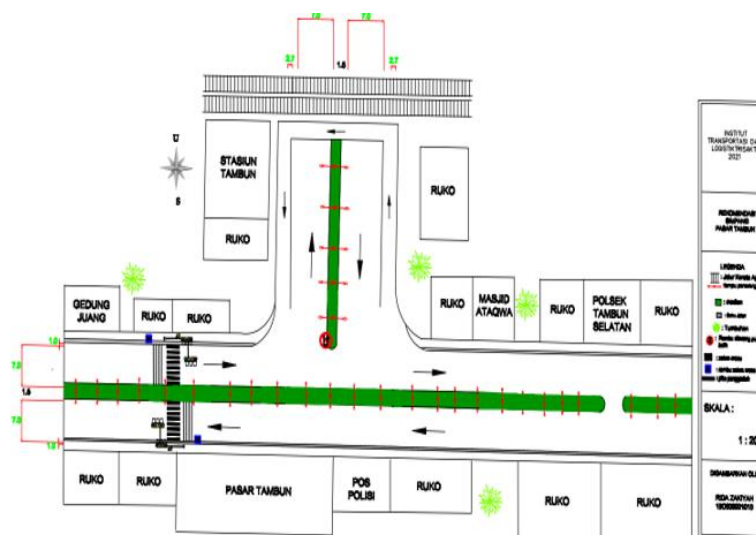


Figure 3 Recommendations for Closing the Pasar Tambun Intersection

On this road, congestion often occurs due to the flow being too high, and is influenced by several activities of shops, offices and markets located in the location of the road segment (Figure 3). With traffic flow and high side barriers activities that can hinder economic development and development, in this case it is necessary to close the U-turn so that it is useful to be able to facilitate the flow of traffic in the area (Tamin, 2003). Vehicle users who want to make a U-turn can do a U-turn at the Tambun Selatan Police, which is 290 meters from the foot of the intersection or 110 meters from the U-turn access that will be closed.

D. Conclusion

Maintenance of periodic underpass construction started in the 5th year since it was operated in 2017. The cost of maintenance costs in 2022 is Rp. 9.590.327.674.-. In this case, development has increased every year due to the inflation that occurs, the magnitude of the inflation rate that occurs is based on the inflation rate of Bank Indonesia of 4.82%. The recommendation for pedestrian crossing facilities with zebra cross and pelican

crossing with a cycle time of 31 seconds and a pedestrian duration of 12 seconds, this is influenced by the number of pedestrians on Jalan Sultan Hasanudin and the number of vehicles in $< 10^8$ for provision crossing facility. Closing the U-turn access on Jalan Sultan Hasanudin, can eliminate the 25 second delay caused by the vehicle making a U-turn. Then the vehicle can make a U-turn at the Tambun Selatan Police Station, 290 meters from the foot of the intersection.

In the free space the rail road has complied with the standard provisions, are; The Railroad Benefit Space of 16.5 m has complied with the minimum standard of 2.75 m from the axle, the Railway Owned Space is 6 m and the Railway Track Control Room is 9 m. The number of daily train trips in the Tambun area is 49 commuter line and 18 long-distance trains with an average number of accidents of 1 accident per day. Based on the facts, that is because the crossing gate is in a damaged or malfunctioning condition and there is no free space for drivers to see the arrival of the train that will pass. There are benefits to the construction of the underpass, namely the waiting time of 3 minutes for each

train or 6 hours a day for trains crossing level crossings for road users.

E. References

- Asadi-Shekari, Z., Moeinaddini, M., & Shah, M. Z. (2014). Pedestrian safety index for evaluating street facilities in urban areas. *Safety Science*, 74, 1-14.
- Aswad, Y. (2013). Studi Kelayakan Perlindungan Sebidang antara Jalan Kereta Api dengan Jalan Raya. *Media Komunikasi Teknik Sipil*, 19(2), 183-189.
<https://doi.org/10.14710/mkts.v19i2.8430>
- Balaka, R., & Djalante, S. (2017). Kajian Perbandingan U-Turn (Putar Balik Arah) Pada Jalan Menerus Dan Jalan Simpang (Studi Kasus: Jalan Kapt. P. Tendean Depan RS. Bahteramas Dan Simpang Tiga Pasar Baruga). *STABILITA|| Jurnal Ilmiah Teknik Sipil*, 5(3), 18-26.
- Bricicaru, C., & Beleiu, I. N. (2022). Cost-Benefit Analysis of Road Infrastructure Projects. *Revista de Management Comparat International*, 23(1), 150-162.
- Cantillo, V., Arellana, J., & Rolong, M. (2015). Modelling pedestrian crossing behaviour in urban roads: A latent variable approach. *Transportation Research Part F: Traffic Psychology and Behaviour*, 32, 56-67.
- Chu, T. D., & Tran, D. H. (2021). Gap Acceptance at U-turn Median Openings A Case Study in Hanoi, VietNam. *Proceedings of the Eastern Asia Society for Transportation Studies (Vol. 13)*, 1-10.
- Erlangga, D., & Handayani, D. (2021). Analysis of Walkability Index and Handling of Pedestrian Facilities of Slamet Riyadi Street, Surakarta. *Journal of Physics: Conference Series*, (Vol. 1858, No. 1, 012011). IOP Publishing.
- Firmansyah, N., & Istiar, I. (2016). Studi Kelayakan Pembangunan Fly Over di Simpang Gedangan Sidoarjo Ditinjau dari Segi Lalu Lintas dan Ekonomi Jalan Raya. *Jurnal Teknik ITS*, 5(2), E66-E70.
<https://doi.org/10.12962/j23373539.v5i2.18895>
- Ghani, N. A., Shimizu, T., & Mokhtar, S. (2015). Assessment of pedestrian facilities in Malacca world heritage site, Malaysia using p-index method. *Journal of the Eastern Asia Society for Transportation Studies*, 11, 1535-1554.
- Hartono, H. (2016). Perlindungan Sebidang Kereta Api di Kota Cirebon. *Jurnal Penelitian Transportasi Darat*, 18(1), 45-62.
<https://doi.org/10.25104/jptd.v18i1.110>
- Idris, M. F., & Husein, R. (2022). Efektivitas Kebijakan Pembangunan Underpass Simpang Kentungan dalam Mengurai Kemacetan di Daerah Istimewa Yogyakarta. *Journal of Social and Policy Issues*, 2(1), 14-20.
- Junaedi, T. (2014). Analisis Keselamatan Pejalan Kaki Pada Simpang Bersinyal. *Jurnal Rekayasa Teknik Sipil Universitas Lampung*, 18(3), 140649.
- Kay, J., Gates, T. J., Savolainen, P. T., & Shakir Mahmud, M. (2022). Safety Performance of Unsignalized Median U-Turn Intersections. *Transportation Research Record*.
<https://doi.org/10.1177/03611981221086936>
- Laksono, I. D., & Prastyanto, C. A. (2021). Studi Kelayakan Pembangunan Underpass di Bundaran Waru Ditinjau dari Segi Lalu Lintas dan Ekonomi Jalan Raya. *Jurnal Teknik ITS*, 9(2), E284-E290.
- Leather, J., Fabian, H., Gota, S., & Mejia, A. (2011). *Walkability and pedestrian facilities in Asian cities state and issues*.
- Maer, J., Lefrandt, L. I., & Timboeleng, J. A. (2019). Analisis pengaruh U-Turn terhadap karakteristik arus lalu lintas di ruas Jalan Robert Wolter Monginsidi Kota Manado. *Jurnal Sipil Statik*, 7(12), 1569-1584.
- Muzdar, M. A., Heryanto, B., & Akil, A. (2018). Fenomena Spasial Pada Fly-

- Over Urip Sumoharjo KM. 4 Makassar. Nature: National Academic. *Nature: National Academic Journal of Architecture*, 5(2), 105-114. <https://doi.org/10.24252/nature.v5i2a3>
- PerMenHub RI. (2011). *Peraturan Menteri Perhubungan Republik Indonesia PM Nomor 13 Tahun 2011 Tentang Tata Cara Pemeliharaan dan Pengawasan Jalan*. Jakarta : Kemenhub RI.
- PM RI. (2011). *Regulation of The Minister of Transportasion of The Republic of Indonesia PM Number 13 PRT Year 2011 About Road Maintenance and Surveillance Procedures*. Jakarta: Minister of Transportation of the Republic of Indonesia.
- PM RI. (2015). *Regulation of The Minister of Transportasion of The Republic of Indonesia PM Number 95 Year 2015 About Guidelines for the Implementation of Traffic Management and Engineering Activities*.
- PU RI. (1997). *Indonesian Road Capacity Manual*.
- Qori'atanadya, E. F., Widyastuti, H., & Kartika, A. A. G. (2021). Studi Kelayakan Lalu Lintas dan Ekonomi Pembangunan Underpass Kentungan, Yogyakarta. *Jurnal Teknik ITS*, 9(2), E213-E218.
- Ratnaningsih, D. (2020). Analysis of Pedestrian Facilities on MT Haryono Street at Malang City. *ICMASES 2019, 9-10 February 2019, Malang, Indonesia.*, 1–8.
- Ridwan, M. (2018). *Studi Kelayakan Pembangunan Underpass/Fly Over Pada Jalan Yos Sudarso Simpang Glugur By Pass (Studi Kasus)*. [Doctoral dissertation]. Universitas Muhammadiyah Sumatera Utara Medan.
- Safira, S. K., & Antika, A. (2018). *Estimasi Waktu dan Biaya Pada Metode Pelaksanaan Underpass Mayjend Sungkono-HR*. (Doctoral dissertation, Institut Teknologi Sepuluh Nopember).
- Santosa, L. S., Suthanaya, P. A., & Adnyana, I. B. R. (2016a). Studi Kelayakan Ekonomi Pembangunan Underpass Pada Simpang Jl. Gatot Subroto-Jl. Ahmad Yani di Kota Denpasar. *Jurnal Spektran*, 4(1).
- Santosa, L. S., Suthanaya, P., & Adnyana, I. (2016b). Studi Kelayakan Ekonomi Pembangunan Underpass Pada Simpang Jl. Gatot Subroto-Jl. Ahmad Yani Di Kota Denpasar. *Jurnal Spektran*, 59-68.
- Shao, Y., Han, X., Wu, H., Shan, H., Yang, S., & Claudel, C. G. (2022). Evaluating the sustainable traffic flow operational features of an exclusive spur dike U-turn lane design. *Plos One*, 14(4), e0214759.
- Sudarmanto, B. (2018). Kajian Kebutuhan Perlintasan Tidak Sebidang Jalur Kereta Api Dengan Jalan Raya di Titik Perlintasan Ganefo Kecamatan Mranggen. *Teknika*, 13(2), 65-71. <https://doi.org/10.26623/teknika.v13i2.1303>
- Tamin, O. Z. (2003). *Perencanaan dan Pemodelan Transportasi*. Bandung: Institut Teknologi Bandung.
- Transport, U. D. of. (1995). *The Design of Pedestrian Crossings. Local Transport Note LTN-1/95*. London, United Kingdom: Department of Transport.
- UU RI. (2009). *Law of the Republic of Indonesia Number 22 of 2009 concerning Road Traffic and Transportation*. Jakarta: Law of the Republic of Indonesia.
- Wu, W., Sun, R., Li, Y., & Chen, R. (2020). Cooperative U-Turn Merging Behaviors and Their Impacts on Road Traffic in CVIS Environment. *Journal of Advanced Transportation*.