POLITEKNIK UNGKU OMAR

A CASE STUDY ON THE RISK OF ROAD ACCIDENTS CAUSED BY DETERIORATING ROAD CONDITIONS CONSEQUENCE OF CRUMBLING INFRASTRUCTURE AT JALAN KUALA KANGSAR (FT001), IPOH, PERAK.

NIK ANIS AISHAH BINTI ZULKARNAIN

(01BCT21F3027)

CIVIL ENGINEERING DEPARTMENT

SESSION II 2023/2024

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A project report/thesis submitted in partial fulfilment of the requirement for the award of the degree in Bachelor of Civil Engineering Technology with Honours

CIVIL ENGINEERING DEPARTMENT

SESSION II 2023/2024

DECLARATION OF ORIGINAL AND OWNERSHIP

A CASE STUDY ON THE RISK OF ROAD ACCIDENTS CAUSED BY DETERIORATING ROAD CONDITIONS CONSEQUENCE OF CRUMBLING INFRASTRUCTURE AT JALAN KUALA KANGSAR (FT001), IPOH, PERAK.

1. I, **NIK ANIS AISHAH BINTI ZULKARNAIN (01BCT21F3027)**, am a student of the final year of **Bachelor of Civil Engineering Technology, Civil Engineering Department,** at **Politeknik Ungku Omar.**

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APPERCIATION

First of all, I would like to express my gratitude to Allah S.W.T, because of His abundance and grace, I was able to complete this case study report successfully despite encountering various challenges and obstacles. Alhamdulillah. On this occasion, I would like to express my infinite gratitude to **Mrs. Noraziah binti Hamid**, as my supervisor, for her patience, support, advice and guidance which helped me a lot in the production of this case study report. All his help, enthusiasm, strategies and wisdom have taught me a lot to be a good researcher and educator. Not forgotten to the line of lecturers of Bachelor of Civil Engineering in Technology with Honors in the Department of Civil Engineering at Ungku Omar Polytechnic who are willing to share their experience throughout this study. All the experiences passed must be unforgettable.

Thank you to the Prima Reka Konsultan company for providing full support in the field work and facilitating the process of obtaining data for this case study report also to the staff at Jabatan Kerja Raya Ipoh, Perak Encik Azizul, Puan Azrina and Puan Aswarina for providing information and data regarding the case study, without them I cannot complete my thesis. A thousand thanks to both parents whom I respect, **Mr. Zulkarnain bin Alias** and **Mrs. Nik Sharimah binti Nik Yusoff** who always give me love, encouragement, prayers, reminders and life guidance that I really need.

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Finally, thanks also to all those involved directly and indirectly in providing suggestions and assistance in completing this thesis. Hopefully this research and thesis can be used as a container of useful knowledge for future generations to see.

ABSTARCT

Jalan Kuala Kangsar (FT001) is a busy road in Ipoh, Perak, with numerous daily activities and heavy traffic. A Traffic Impact Assessment project conducted by Prima Reka Konsultan in October 2023 revealed that the road is easily damaged and prone to frequent road accidents due to its crumbling infrastructure due to heavy traffic. The road is the main communication route to Klebang and Ipoh Town Center, a dense area with schools, businesses, and industrial activities. Road accidents at FT001 have increased until 2023, causing concern for road users and road owners. The case study aims to identify traffic categories using SIDRA Intersection software to recognize the volume of vehicles contributing to the crumbling infrastructure. The Road Safety Audit (RSA) needs to produce a risk assessment to recommend actions to road owners and propose road mitigation measures to reduce the risk of road accidents at FT001. The aim of the objective is to determine the risk of road accidents caused by deteriorating road conditions as a consequence of crumbling infrastructure for road users using the Road Safety Audit (RSA) Guideline published by the Public Works Department of Malaysia (P.W.D.) second edition in 2002 by Prima Reka Konsultan to recommend P.W.D. action. The RSA report for existing road is in stage 5 based on the RSA Guidelines second edition in 2002 produced by P.W.D. This guideline is used as a reference for this case study. The expected finding is to produce the RSA report and to propose road mitigation for P.W.D. to improve road safety based on the objectives set for the case study.

ABSTRAK

Jalan Kuala Kangsar (FT001) ialah jalan yang sibuk di Ipoh, Perak, dengan pelbagai aktiviti harian dan lalu lintas sesak. Projek Penilaian Kesan Trafik yang dijalankan oleh Prima Reka Konsultan pada Oktober 2023 mendedahkan jalan itu mudah rosak dan terdedah kepada kemalangan jalan raya yang kerap disebabkan infrastrukturnya yang runtuh akibat kesesakan lalu lintas. Jalan tersebut merupakan laluan perhubungan utama ke Klebang dan Pusat Bandar Ipoh, kawasan padat dengan sekolah, perniagaan dan aktiviti perindustrian. Kemalangan jalan raya di FT001 telah meningkat sehingga 2023, menimbulkan kebimbangan kepada pengguna jalan raya dan pemilik jalan raya. Kajian kes bertujuan untuk mengenal pasti kategori trafik menggunakan perisian SIDRA Intersection untuk mengenal pasti jumlah kenderaan yang menyumbang kepada infrastruktur yang runtuh. Audit Keselamatan Jalan Raya (RSA) perlu menghasilkan penilaian risiko untuk mengesyorkan tindakan kepada pemilik jalan dan mencadangkan langkah tebatan jalan untuk mengurangkan risiko kemalangan jalan raya di FT001. Matlamat objektif adalah untuk menentukan risiko punca kemalangan jalan raya dengan keadaan jalan yang merosot akibat infrastruktur runtuh bagi pengguna jalan raya oleh Garis Panduan Audit Keselamatan Jalan Raya (RSA) yang diterbitkan oleh Jabatan Kerja Raya Malaysia (P.W.D.) edisi kedua pada tahun 2002 oleh Prima Reka. Konsultan untuk mengesyorkan untuk Tindakan P.W.D. Laporan RSA untuk jalan sedia ada berada di peringkat 5 berdasarkan Garis Panduan RSA edisi kedua pada tahun 2002 yang dihasilkan oleh P.W.D. Garis panduan ini digunakan sebagai rujukan untuk kajian kes ini. Penemuan yang dijangka adalah untuk menghasilkan laporan RSA dan mencadangkan tebatan jalan untuk P.W.D. untuk meningkatkan keselamatan jalan raya berdasarkan objektif yang telah ditetapkan untuk kajian kes.

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LIST OF ABBREVIATION

WHO	World Health Organization
MIROS	Malaysian Institute of Road Safety Research
RSA	Road Safety Audit
P.W.D	Public Works Department
LOS	Level of Service
RAMS	Road Accident Management System
I.R.	Industrial Revolution
IoT	Internet of Think
IPD	Ibu Pejabat Daerah
REAM	Road Engineering Association of Malaysia
SDG	Sustainable Development Goals
PDRM	Polis Di Raja Malaysia

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Road accidents are a global public health crisis, causing nearly 1.3 million deaths annually and causing 20 to 50 million injuries or incapacitated. Without immediate action, road traffic deaths could become the fifth leading cause of death by 2030 (Shahid & Minhans, 2015). These accidents have a significant economic impact, costing countries billions in medical expenses, property damage, and lost productivity. Human error is the most significant contributor to road accidents, with factors such as speeding, distracted driving, and impaired driving being common causes. Global efforts, including road safety campaigns, vehicle safety standards, and stricter traffic regulations, aim to reduce the devastating toll of road accidents.

Asia, particularly India and China, bear a disproportionate share of road traffic fatalities due to rapid urbanization, increased motorization, and diverse transportation systems. Factors contributing to road accidents include congested roadways, inadequate road infrastructure, lax traffic law enforcement, and the prevalence of older, less safe vehicles (Smith & Smith, 2017). Addressing road safety in Asia requires a holistic approach, including significant investments in road infrastructure, enhanced driver education, and stricter enforcement measures.

Malaysia has seen an increase in road accidents, affecting public health, frugality, and overall road safety. All parties responsible need to pay serious attention to the increase in traffic accidents that result in road traffic deaths. According to the latest findings from the WHO Global Status Report on Road Safety 2018, Malaysia ranks third on the list with the highest number of road traffic deaths amongst other countries in the ASEAN and Asia region back in 2016 (Irran, 2019). Thailand has the highest percentage of road traffic death at 32.7% and the second highest was Vietnam at 26.4% meanwhile the third highest followed by Malaysia consisted of 23.6% road deaths per 100,000 people placed in ASEAN countries based on the statistics of 2016 as shown in the Figure 1.1 below.

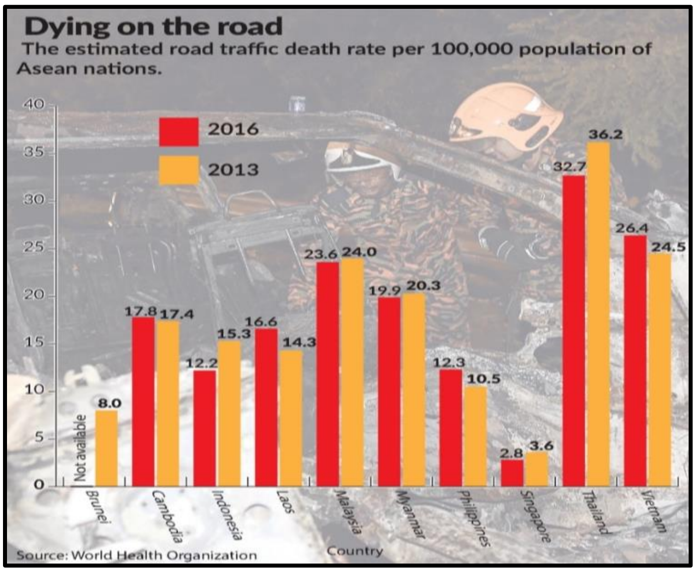


Figure 1.1: Statistic of ASEAN Country Road Accident (Irran, 2019)

Malaysia faces a significant increase in road accidents due to human factors such as reckless driving, distracted driving, poor road infrastructure, inadequate signage, and insufficient lighting. Impaired driving, often linked to alcohol and drugs, is a persistent concern. Despite strict regulations, driving under the influence persists, increasing the likelihood of accidents with severe consequences. Addressing road safety in Malaysia requires public awareness campaigns, stricter law enforcement, and improvements to road infrastructure.

Road accidents in Malaysia have increased significantly since the Covid-19 pandemic, with an average of 1,494 accidents per day and 16.6 deaths per day in 2022. Despite the prominence of Covid-19 disease in the current public health space, road crashes remain an important contributor to mortality (Blankson & Lartey, 2020). Malaysian Transport Minister Anthony Loke reported by Gerard Gimino, Rahimy Rahim, Ragananthini Vethasalam and Teh Athira Yusof from TheStar Online Newspaper on 13 June 2023 that the majority of road accidents were caused by human behaviour, road factor such as road design and road infrastructure condition, and vehicle condition.

The Malaysian Institute of Road Safety Research (MIROS) states that most accidents are caused by road design, which is included in road factors in road traffic accidents. The Malaysia Road Safety Plan was launched in January 2021 to reduce road accidents by 50% by 2030. Active and passive strategies were taken to increase vehicle safety standards, including creating vehicle research and safety test centers and improving vehicle safety evaluation mechanisms.

Despite the increase in the number of cars on the road, accident figures in 2022 are slightly lower than pre-pandemic Covid-19 in 2020, with a downward trend of deaths from 2016 to 2019 (Wong, 2023). The Malaysian government aims to reduce road accidents by 50% by 2030 said by Anthony Loke. Figure 1.2 below shows the accidents are an upward trend from 2010 to 2019, and there was a downward trend of deaths from 2016 to 2019 as shown in Figure 1.3 below.

Figure 1.2: Malaysia Road Accident 2010 – 2019 (Wong, 2023)

Figure 1.3: Malaysia Road Fatalities 2010 – 2019 (Wong, 2023)

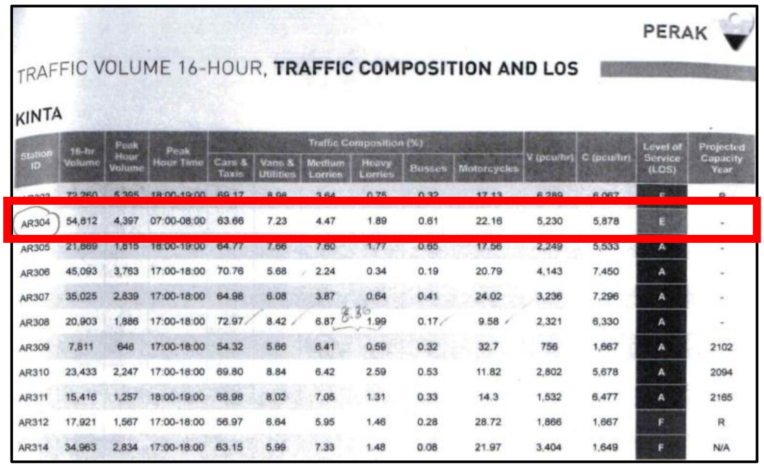
The risk of road accidents caused by deteriorating road conditions can cause accidents that can cause the death of road users. Damaged road conditions are the main contributor to road accidents in the road factor category. The risk of road accidents is caused by the condition of the crumbling infrastructure.

In year 2012, 6917 people were killed due to road traffic accidents in Malaysia. This country had the highest rate of road traffic fatalities per 100,000 population among all ASEAN countries in 2007. In fact, road traffic accidents were the fifth leading cause of certified deaths in 2008 (Yusria, Mohamed, & Sulaiman, 2017). Malaysia has implemented various initiatives to address road traffic deaths, including setting national road safety targets, providing road safety education, conducting media campaigns, and establishing the Road Safety Audit unit. However, improvements are still needed. A study evaluating Malaysian road traffic deaths from 2000 to 2011 found that rural areas have more road traffic mortality than urban areas (Yusria, Mohamed, & Sulaiman, 2017). Federal highways have the highest number of fatalities, while motorways have the highest rate per kilometer. Straight road stretches have the most fatalities, followed by bends. Junctions like Y or T junctions have the highest frequency of deaths. The most significant factor to road traffic deaths is a lack of street lighting, road shoulder edge drop-offs, and potholes.

Jalan Kuala Kangsar (FT001) is a busy road with the daily activities of the surrounding community where many users use the road. Jalan Kuala Kangsar is located in the Kinta district with Station ID AR304 indicating that the road is classified as LoS E, which means that it has unstable flow along the road in 2022 (Highway Planning Division, 2023). Figure 1.4 below show the traffic volume taken for 16-hour, traffic composition and LoS at each Station Id for year 2022. Figure 1.5 below show the data taken from Road Traffic Volume Malaysia’s website. LoS E means the traffic is at low speeds, considerable delay, vehicles volume are slightly over the road capacity as shown in Figure 1.6 below (Nilaimas Services, 2019).

Based on the Traffic Impact Assessment project that was carried out by Prima Reka Konsultan in October 2023, it was found that many vehicles pass through the road, including heavy vehicles that want to go to the factory located in the nearby industrial area. In addition, Jalan Kuala Kangsar (FT001) is the main communication road to Klebang and to Ipoh Town Centre, which is a busy and dense area with schooling, business, industrial activities and so on. This causes the road to be easily damaged and results in frequent road traffic deaths. Therefore, Jalan Kuala Kangsar

(FT001) is at high risk in road accidents due to road conditions consequence of crumbling infrastructure.



PERAK

TRAFFIC VOLUME 16-HOUR, **TRAFFIC COMPOSITION AND LOS**

KINTA

Station ID	16-hr Volume	Peak Hour Volume	Peak Hour Time	Traffic Composition (%) Cars & Taxis	Vans & Utilities	Medium Lorries	Heavy Lorries	Busses	Motorcycles	V (pcu/hr)	C (pcu/hr)	Level of Service (LOS)	Projected Capacity Year
[illegible]	72,260	5,395	18:00-19:00	69.17	8.98	3.64	0.75	0.32	17.13	6,289	6,067	[illegible]	R
AR304	54,812	4,397	07:00-08:00	63.66	7.23	4.47	1.89	0.61	22.16	5,230	5,878	E	-
AR305	21,869	1,815	18:00-19:00	64.77	7.66	7.60	1.77	0.65	17.56	2,249	5,533	A	-
AR306	45,093	3,763	17:00-18:00	70.76	5.68	2.24	0.34	0.19	20.79	4,143	7,450	A	-
AR307	35,025	2,839	17:00-18:00	64.98	6.08	3.87	0.64	0.41	24.02	3,236	7,296	A	-
AR308	20,903	1,886	17:00-18:00	72.97	8.42	6.87	1.99	0.17	9.58	2,321	6,330	A	-
AR309	7,811	646	17:00-18:00	54.32	5.66	6.41	0.59	0.32	32.7	756	1,667	A	2102
AR310	23,433	2,247	17:00-18:00	69.80	8.84	6.42	2.59	0.53	11.82	2,802	5,678	A	2094
AR311	15,416	1,257	18:00-19:00	68.98	8.02	7.05	1.31	0.33	14.3	1,532	6,477	A	2165
AR312	17,921	1,567	17:00-18:00	56.97	6.64	5.95	1.46	0.28	28.72	1,866	1,667	F	R
AR314	34,963	2,834	17:00-18:00	63.15	5.99	7.33	1.48	0.08	21.97	3,404	1,649	F	N/A

Figure 1.4: The Traffic Volume Taken For 16-Hour, Traffic Composition and LoS at each Station ID

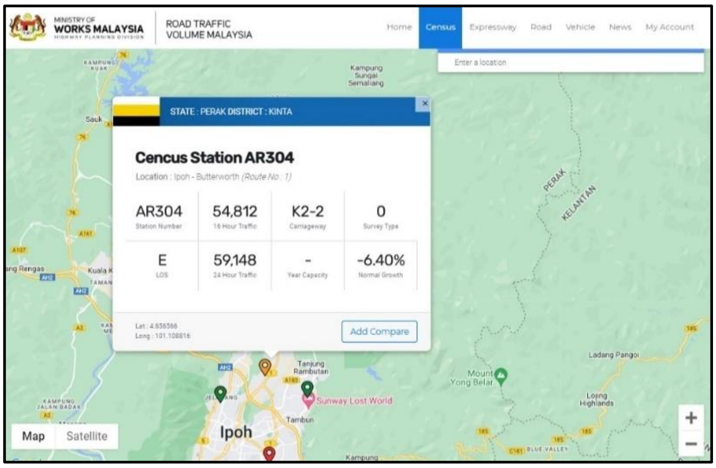


Figure 1.5: RTVM Data on Station ID 304 for Jalan Kuala Kangsar (Highway Planning Decision, 2023)

Level of Service	V/C ratio	Traffic Condition
A	<0.26	Free flow with low volumes, densities and high speeds. Drivers can maintain their desired speeds with little or no delay.
B	0.26 - 0.42	Stable flow. Operating speeds beginning to be restricted somewhat by traffic conditions. Some slight delay.
C	0.43 - 0.61	Stable flow. Operating speeds and manoeuvrability are more closely controlled by higher volumes. Acceptable delay.
D	0.62 - 0.81	Approaching unstable flow. Tolerable operating speeds which are considerably affected by operating conditions. Tolerable delay.
E	0.82 - 1.00	Unstable flow. Yet lower operating speeds and perhaps stoppages of momentary duration. Volumes are at or near capacity congestion and intolerable delay.
F	>1.00	Forced flow. Speeds and volume can drop to zero. Stoppages can occur for long periods. Queues of vehicles backing up from a restriction downstream.

Figure 1.6: Relationship between LoS, volume per capacity (v/c) ratio and Traffic Condition (Nilaimas Services, 2019)

1.2 PROBLEM STATEMENT

Road accidents at Jalan Kuala Kangsar (FT001), Ipoh, Perak, have increased significantly until 2023, posing a major concern for road users and road owners. The busy and heavy traffic road, which includes schools, offices, businesses, and logistics, is a high risk for heavy vehicles and other vehicles. According to the Road Accident Management System (RAMS) by P.W.D.'s Accidents Data Form, there have been various types of accidents, including fatal, serious, and minor accidents involving cars and motorcycles. From 2020 to 2022, fatal accidents have occurred on the road Section Number 607 until 610.

The Klebang area faces increasing accidents and traffic deaths due to congested roads, heavy vehicles, lack of streetlights at night, and no alternative routes. The rise in heavy vehicles deteriorates road surfaces and increases the likelihood of accidents, posing challenges for law enforcement and drivers. Understanding the factors contributing to this rise is crucial for developing targeted solutions.

The area is undergoing rapid development, with ongoing projects and logistics improvements indicating a positive trajectory. However, the announcement of new roads in the near future introduces a transitional phase that requires careful consideration. Understanding these factors is crucial for developing targeted solutions to address these issues.

All these problems may arise the road surface extensive damage and effected road condition and had been caused the dangerous environment and high risk in road accidents caused by deteriorating road conditions for the road users on road Section No. 607 until 610 at Jalan Kuala Kangsar (FT001), Ipoh, Perak. The owner of this road needs to act in road safety measures to prevent the escalation of accidents by RSA report. Traffic Consultant normally will be hired to make the RSA report. The main problem for action by PWD as ownership is lack of RSA report for Jalan Kuala Kangsar (FT001), Ipoh, Perak.

Industry 4.0 technologies, processes, and systems have enhanced productivity, efficiency, flexibility, agility, and profitability. They also improve user experience by offering customized and intelligent goods. Electronic applications are introduced to facilitate work in construction and various offices, including consultants' firms, high education departments, and P.W.D. departments. Software like SIDRA Intersection and PTV Vissim analyze road traffic data.

The Internet of Think (IoT) connects physical items with sensors, software, and other technologies for data sharing via the internet. This technology streamlines communication between smart devices and humans through sensors, actuators, networks, and other complex IoT integrated systems, transferring or sharing data into digital information.

RSA report important for examining the planning, design, and construction of road design, and of the point and operation of a being road by independent and good adjudicators to determine any implicit hazard of road point or functional arrangement that may negatively affect the safety of any road user. RSA report will produce based on RSA Guideline that are publish by P.W.D. second edition in 2002.

Therefore, in this case study on risk of road accidents caused by deteriorating road conditions consequence of crumbling infrastructure at Jalan Kuala Kangsar (FT001), Ipoh, Perak is to identify the traffic categories using SIDRA Intersection software to recognize the volume of vehicles that contribute to crumbling infrastructure which is, it will increase the risk of road accident caused by deteriorating road conditions for road user. Hence, the RSA need to produce in risk of road accident to recommend to the road owner (P.W.D.) to act and lastly to propose road mitigation for reducing the risk of road accidents at Jalan Kuala Kangsar (FT001), Ipoh, Perak.

1.3 OBJECTIVES

The aim of the objectives is to determine the risk of road accident cause by deteriorating road conditions consequence of crumbling infrastructure for road user by Road Safety Audit (RSA) Guideline that are publish by P.W.D. second edition in 2002 by Prima Reka Konsultan to recommend for P.W.D. action.

i. To identify traffic LoS categories using SIDRA software from the identified volume of vehicles that contribute to crumbling infrastructure.

ii. To determine the risk of road accident cause by deteriorating road conditions consequence of crumbling infrastructure for road user by P.W.D. Road Safety Audit (RSA) Guideline second edition in 2002.
iii. To produce the Road Safety Audit (RSA) report in risk of road accident by Prima Reka Konsultan to recommend for P.W.D. (JKR) action.
iv. To propose road mitigation to reduce the risk of road accidents based on the findings of the RSA report.

1.4 SCOPE OF STUDY

The scope study is at Jalan Kuala Kangsar (FT001) in 3km, specific at Section Number 607 until Section Number 610 from Aeon Klebang, Ipoh to Big Famaly Kolam Chemor, Ipoh as shown in Figure 1.7 and Figure 1.8 below. The road often has accidents based on the observation of the surrounding community. The characteristics on both directions of this study road are categorized as R5/U5 design standard with a width of 3.5 meters per lane and design speed at 80km/h for rolling terrain. Standard R5/U5 is a high geometric standard used for long to intermediate trip lengths with medium to high speeds, often with partial access control, and may be divided carriageways. Rolling terrain road are categorized by the topographical condition where normal horizontal and vertical roadway alignment is occasionally restricted by steep slopes that occasionally rise and fall above and below the road or street grade. The focus road has uneven road surface for road users, especially for surrounding communities who often use the route to get to their destination. Those following are the factors that contribute to traffic accidents that occur on the study road (Jabatan Kerja Raya, 2015).

In a real situation, the road has problems such as uneven patched pavement, potholed roads, turns on hilly roads. The tyres of a car become unable to grip the road due to holes and uneven surfaces, which makes it easy for the car to lose control. Occasionally, certain drivers attempt to evade this situation by abruptly changing their path into the path of another vehicle, making it impossible for other drivers to avoid the collision (Mohd Khairul Amri, Noorjima, & Roslan, 2018). In addition, road users will drive their vehicles at high speeds after passing traffic lights and also to go through slightly elevated roads. Therefore, road users do not have time to reduce their speed while going through the slight turn and will cause accidents to occur and also with an uneven surface will encourage more accidents.

Data collected are using MetroCount tools to determine the Level of Service (LoS) using SIDRA Intersection software. To produce the RSA report, we will use based on RSA Guideline that are produced by P.W.D. Therefore, a study will be conducted based on the Road Safety Audit Guideline that are publish by P.W.D. second edition in 2002.

Figure 1.7: Location on Study Area

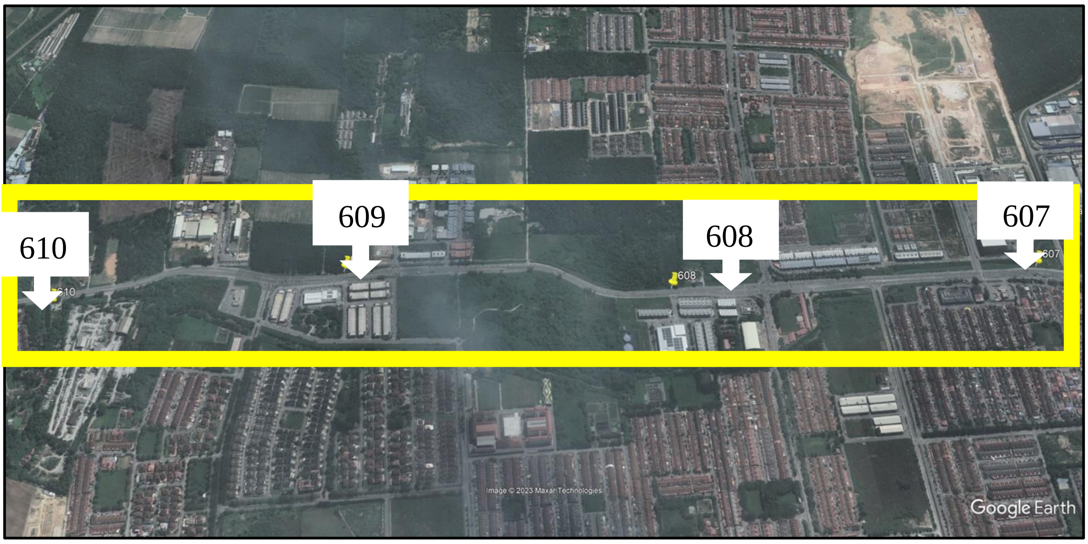


Figure 1.8: Focus Route

1.5 SIGNIFICANT OF STUDY

Based on research, the main problems occur on the focus route is many accidents happen to road users based on the IPD Ipoh Traffic Division data. The accident happened caused by deteriorating road conditions which was damaged due to crumble infrastructure. Based on observations and data obtained from traffic count conducted on a nearby project study, lots of heavy vehicles and other various vehicles use the road.

Besides that, other factors also the lack of streetlights at night, which is dangerous to road users, especially to motorcyclists who are always facing problems with the lights on their motorcycles, and it is also dangerous to road users when passing through winding and slightly hilly roads. In addition, there is no alternative route yet because of new road project nearby is still in the consultation phase between the developer and the consultant. Figure 1.9 below shows the mapping flow that should be done on this case study.

Therefore, a case study on the risk of road accidents caused by deteriorating road conditions due to crumbling infrastructure would like to be conducted based on the RSA guidelines published by REAM and P.W.D. Malaysia to be used for Prima Reka Konsultan to recommend for P.W.D. action. Also, this case study would like to suggest road mitigation method for reducing the risk of road accidents based on site inspection checklist using RSA Guideline.

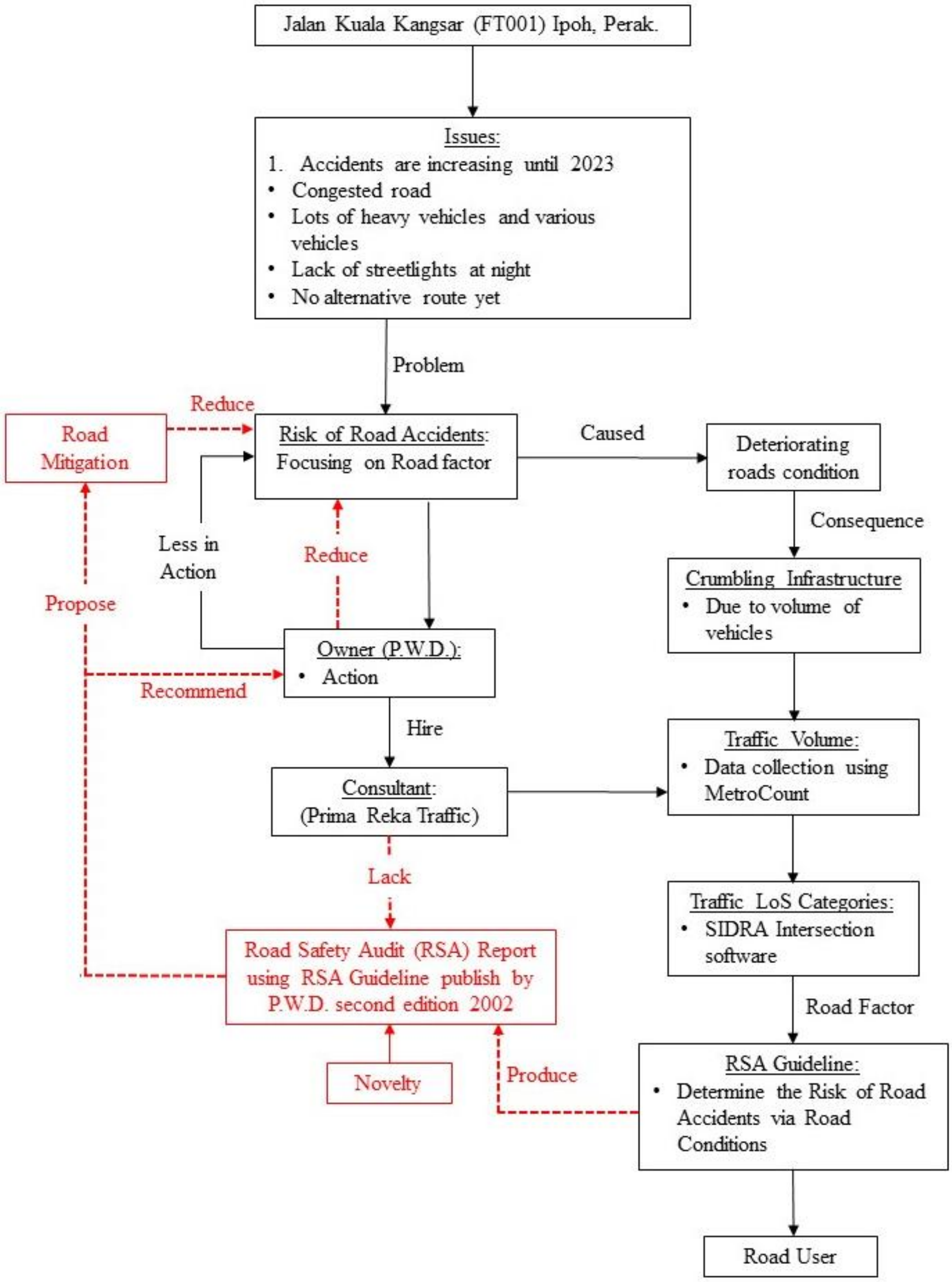


Figure 1.9: Significant of The Study

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Road accidents pose a significant challenge to the sustainable development and well-being of societies, and Malaysia is no exception. The rapid economic growth and urbanization experienced by Malaysia over the past few decades have brought about increased motorization, leading to a surge in road traffic (Al-Reesi, et al., 2013). With this growth, however, comes a pressing concern for road safety, as the rise in vehicular activity is often accompanied by an alarming increase in road accidents (MIROS, 2023). These accidents not only result in loss of lives but also impose substantial economic burdens, strain healthcare resources, and disrupt societal well-being.

Understanding the dynamics, causes, and consequences of road accidents in Malaysia is crucial for developing effective interventions and policies to mitigate their impact. This literature review aims to provide a comprehensive overview of existing research on road accidents in Malaysia. By examining the current state of knowledge, identifying trends, and exploring contributing factors, this review seeks to contribute valuable insights to the ongoing discourse on road safety in the Malaysian context. Furthermore, it aims to highlight gaps in the existing literature, paving the way for future research initiatives and evidence-based strategies to address the multifaceted challenges associated with road accidents in Malaysia.

2.2 TRAFFIC VOLUME

Traffic volume is a vital metric in transportation, indicating the number of vehicles passing through a specific point on a roadway during a designated timeframe. It is crucial for transportation engineers, urban planners, and policymakers to understand traffic flow dynamics and use real-time data to perform interventions, such as altering traffic signal timing or closing certain roads. Traffic volume also serves as the input data for computing vehicle emission, which is required in pollution monitoring systems (Zuan, Zheng, & Memeber, 2016).

Traffic volume data is used in traffic flow analysis to identify patterns, congestion points, and peak hours of activity, optimizing traffic management strategies. It also influences capacity planning, determining the capacity of roads and intersections, and aiding in evaluating existing infrastructure and planning for future expansions or improvements. Traffic volume is also essential in safety analysis to identify high-traffic areas prone to accidents, prioritizing safety improvements and reducing collision likelihood. Various methodologies, such as manual counts, video surveillance, and automated traffic counters, are used to measure traffic volume. (Kozerska, 2021).

2.3 ROAD TRAFFIC ACCIDENT

Malaysia's transportation infrastructure is facing challenges due to increasing population and vehicle numbers. The country's registered vehicle number is increasing at a 6.6% annual rate, reaching 15,790,732 in 2006 (S. KULANTHAYAN, PHANG, & K.S. HAYATI, 2007). Road accidents can result from human, vehicle, road, or environmental factors, and can be worsened by common causes like careless driving, dangerous overtaking, speeding, faulty vehicles, micro-sleeping, and poorly maintained roads. These factors contribute to the increasing risk of injuries and fatalities in Malaysia. (Zaleha, Noor Hassim, & Rosnah, 2022).

Road traffic accidents in Malaysia are a multifaceted issue influenced by human, road-related, and environmental factors. Human factors like distracted driving, speeding, and reckless driving contribute significantly to accidents, while road-related factors like poor road conditions, inadequate signage, and insufficient lighting heighten the risk. High traffic density areas face challenges in maintaining roads, enhancing signage, and strategically lighting. Environmental factors like adverse weather conditions pose additional challenges, such as reduced visibility and slippery road surfaces. Proactive measures like drainage systems and weather-appropriate road designs are crucial.

The consequences of accidents in Malaysia range from property damage to severe injuries and fatalities. The Malaysian government has initiated road safety campaigns, implemented stricter enforcement, speed limits, and public education to address accidents' root causes. Efforts to enhance road safety include continuous improvements to infrastructure, technological interventions for traffic monitoring and management, and educational initiatives promoting responsible driving behaviours. Collaboration among stakeholders is crucial for sustainable reductions in accidents and safer road environments.

2.4 FACTOR OF ROAD TRAFFIC ACCIDENTS

Road traffic accidents can be attributed to a combination of factors, including human, road-related, and environmental elements. Understanding these factors is crucial for implementing effective preventive measures. Here's an explanation of each category:

2.4.1 Human Factor

Human factors significantly contribute to road traffic accidents, including distracted driving, speeding, drunk driving, and reckless driving. Distracted driving, speeding, drunk driving, and reckless driving all pose serious risks to drivers. Addressing these factors requires education, awareness campaigns, and strict law enforcement to promote responsible driving behaviours. These factors not only violate traffic regulations but also reduce time for drivers to react to unforeseen events.

2.4.2 Road Factor

Road conditions and infrastructure significantly impact road safety. Poorly maintained roads with potholes or uneven surfaces pose hazards, while inadequate signage and lighting, particularly during nighttime, increase accidents. To improve road safety, ongoing maintenance, improved signage, and proper lighting are necessary.

2.4.3 Environment Factor

Environmental factors significantly contribute to road traffic accidents, including adverse weather conditions, natural elements like glare, vegetation overgrowth, and poorly placed obstacles. Mitigating these risks involves implementing adaptive measures, maintaining clear sightlines, and considering natural elements in road design and planning. These measures help ensure driving safety and reduce accidents.

2.5 ROAD CONDITION

The road conditions in Malaysia vary across different regions and types of roads, encompassing a mix of well-maintained highways, urban roads, and rural routes. Malaysia boasts a network of well-developed highways, often characterized by smooth surfaces and modern infrastructure. Major expressways connect key cities and regions, facilitating efficient and comfortable long-distance travel. One famous example is the North-South Expressway, which connects the northern and southern parts of the country efficiently as shown in Figure 2.1 below.

Figure 2.1: Malaysia North-South Expressway

Road conditions in Malaysia vary greatly, with some roads being modern and smooth, while others face challenges like congestion and regular maintenance. Traffic management and maintenance efforts are ongoing to address these issues. Rural roads may also face challenges like potholes, uneven surfaces, or limited lighting.

Infrastructure development projects aim to improve rural connectivity and address road conditions in less urbanized areas. Malaysia's roads are maintained by various agencies at federal, state, and local levels, with routine maintenance, repairs, and upgrades to ensure safety and functionality.

The country's tropical weather, with heavy rainfall, can cause issues like potholes, surface erosion, and reduced visibility. To mitigate these issues, good drainage systems and road designs that can handle different weather conditions are crucial. The Malaysian government invests in continuous infrastructure development, including the construction of new highways, road widening, and the integration of smart technologies for traffic management.

However, challenges such as traffic congestion in urban areas persist, and ongoing maintenance and attention are needed. This ongoing process involves planning, investments, and ensuring road users know how to use the roads safely. The diverse road conditions in Malaysia reflect the country's diverse landscapes, and ongoing efforts in maintenance, infrastructure development, and technology implementation contribute to safer and more efficient road networks.

2.5.1 Road Factor Affected In Road Condition.

The Public Works Department of Malaysia (JKR) is responsible for overseeing and managing road infrastructure in the country. It is responsible for planning, designing, constructing, and maintaining roads to ensure they meet high standards and serve the public effectively.

The JKR prioritizes the quality of road surfaces, using durable materials and proper construction techniques to create smooth roads. Regular maintenance is emphasized to address issues like potholes promptly and enhance driving comfort and safety. Road design is also crucial, considering factors such as curves, slopes, and visibility. Well-planned road designs contribute to reduced road accidents and better traffic flow.

P.W.D. determines road width and capacity specifications based on traffic requirements, alleviating congestion and accommodating vehicle volumes, contributing to smoother traffic flow. Effective drainage systems are essential for road durability, and JKR plans and implements solutions to prevent waterlogging and erosion.

JKR sets standards for the use of quality materials in road construction, emphasizing durability and consistency across projects. Regular maintenance is a cornerstone of road management strategies, with scheduled inspections, routine repairs, and proactive maintenance prioritized to identify and address issues. This commitment enhances road safety by reducing the risk of accidents resulting from deteriorating road conditions, structural weaknesses, or poor visibility.

Road safety is a critical aspect of Malaysia's development strategy, involving clear and effective traffic signage and markings that guide drivers, prevent confusion, and promote adherence to traffic rules. Adequate road lighting is a top priority, improving visibility and reducing accident risks.

A holistic road management strategy, considering factors such as surface quality, design, capacity, drainage, materials, maintenance, signage, and lighting, aims to prioritize safety and convenience while promoting efficient traffic flow. This comprehensive approach reflects Malaysia's commitment to public safety and sustainable development, ultimately reducing the occurrence of road accidents. .

2.5.2 Crumbling Infrastructure

Crumbling infrastructure refers to the gradual wear and degradation of physical components of a country's infrastructure, including roads. It can manifest as degraded road surfaces, such as potholes, cracks, and uneven surfaces, which compromise the smoothness and safety of the road. Over time, exposure to weather elements, heavy traffic, and insufficient maintenance can contribute to the deterioration of the road surface. The materials used in road construction may also degrade over time, leading to issues such as crumbling edges, weakened foundations, and reduced load-bearing capacity.

Effective drainage is crucial for preventing water-related damage to roads, as inadequate or poorly maintained systems can accumulate water on the road surface, leading to erosion and the gradual crumbling of the road structure. Insufficient maintenance practices can accelerate the deterioration of road infrastructure.

Crumbling infrastructure may also be attributed to roads with limited capacity to handle increasing traffic or design flaws that compromise their longevity. As roads age, the materials may lose their original strength, making the structure more susceptible to weather, traffic, and other environmental factors. Addressing crumbling infrastructure requires strategic planning, investment in quality materials, regular maintenance, and timely repairs. Sustainable infrastructure management practices can help mitigate the impact of aging and wear, ensuring roads remain safe, efficient, and reliable for transportation.

2.6 RISK OF ROAD ACCIDENTS

2.6.1 Risk of Road Accidents Deteriorating Road Conditions

The risk of road accidents associated with deteriorating road conditions is a multifaceted challenge that poses significant threats to road safety. Several key factors contribute to this risk, each playing a crucial role in increasing the likelihood of accidents and their severity.

As road surfaces degrade over time due to factors like weathering, heavy traffic, and inadequate maintenance, the risk of accidents rises and drivers may lose control while driving. Cracks, potholes, and uneven surfaces compromise vehicle stability, potentially leading to loss of control, skidding, and collisions (Smith & Smith, 2017).

Inadequate drainage on roadways, especially during heavy rainfall, contributes to the risk of hydroplaning. When water accumulates on poorly drained surfaces, vehicles will lose control, increased stopping distances, and a higher potential for accidents (Kroczak, Bryndal, & Żychowski, 2022).

Pavement marking on the road is a traffic control facility for road users to convey the rules, warnings and guidelines of road traffic to guide vehicles and pedestrians to pass safely, efficiently and conveniently (Hu, et al., 2022). Deteriorating road conditions often result in faded road markings, inadequate signage, and poor visibility, especially during low light conditions. Reduced visibility increases the chances of drivers missing critical information, such as road signs, pedestrian crossings, and other vehicles, leading to an elevated risk of accidents.

Worn-out or missing road markings can result in confusion among drivers, leading to improper lane usage, overtaking, and increased risks of collisions. Clear and visible road markings are essential for guiding drivers and preventing unsafe behaviours. Signs and road markings communicate vital information such as warnings, guidelines, and directions to drivers and road users (Akple, Sogbe, & Atombo, 2020).

Deteriorating road conditions often necessitate longer stopping distances. Drivers may struggle to stop in time, leading to rear-end collisions or an inability to avoid obstacles, especially in emergency situations.

Besides that, drivers navigating deteriorating roads may experience frustration, stress, and anxiety, leading to aggressive driving behaviours. The relationship between drivers' economic stress and road safety have been studied for many years but the effects of global and economic stress, its joint effects on behaviours of drivers in relations to accidents have received very little attention (Kitara & Karlsson, 2020). Speeding, reckless overtaking, and other unsafe practices become more prevalent, further elevating the risk of accidents.

Potholes and unexpected road hazards are prevalent in deteriorating road conditions leading to sudden jolts or damage to vehicles. Drivers swerving to avoid hazards may lose control, leading to accidents, damage to vehicles, and potential collisions with other vehicles.

Addressing the risk of road accidents associated with deteriorating road conditions requires proactive measures, including regular maintenance, timely repairs, and infrastructure upgrades. Governments, road authorities, and relevant stakeholders play a pivotal role in ensuring road safety by addressing these challenges to create safer and more reliable road networks.

2.7 TRAFFIC COUNT

Traffic counts are essential data sets for transportation engineers, urban planners, and policymakers to understand and manage traffic patterns. They are widely available, cost-effective, and non-disruptive, making them a preferred resource for transportation modelling. Traffic counts serve various purposes, including traffic flow analysis, capacity planning, safety analysis, traffic management, and transportation planning. Engineers can assess traffic flow behaviors, identify peak hours, and gauge demand on the transportation network. They also help determine highway capacity and prioritize safety improvements to reduce accident probability. Traffic counts are crucial for improving traffic signal timings, congestion management measures, and effective traffic operations. They can be conducted through manual counts, video surveillance, and automated traffic counters. The Figure 2.2 below shows an example of a manual calculation form for traffic counts.

TIA :................................ JUNCTION:........................ OBSERVER :......................

Time	Car	Medium/Van	Heavy	Bus	Motorcycle

Figure 2.2: Example Of Traffic Count Form for Manual Counts

Traffic counts are foundational in transportation planning and management. Planners use this data to assess the necessity for new infrastructure, such as additional lanes, intersections, or alternative transportation modes. The insights gained from traffic counts are instrumental in making informed decisions regarding the design, operation, and safety of transportation networks. Traffic counts enable experts to traverse the complexity of transportation planning, ensuring that highways are not only efficient but also safe for all users.

2.8 METROCOUNT – VEHICLE CLASSIFIER SYSTEM

MetroCount's Vehicle Classifier System is a smart instrument for gathering and analysing large amounts of traffic data is. Insights about traffic patterns and road usage are obtained by this system, which employs state-of-the-art technology to categorise cars according to their size, speed, and other pertinent factors. The technology uses sophisticated sensors and data processing algorithms to precisely identify and classify a wide range of vehicles, from heavy trucks to motorcycles. This information helps transportation experts plan ahead for infrastructure, manage traffic, and enhance safety. Greater accuracy and dependability are hallmarks of MetroCount's

Vehicle Classifier System, which helps make transportation and urban planning more successful (MetroCount, 2022).

Figure 2.3: MetroCount Tool and Its Vehicles Classifier

2.9 LEVEL OF SERVICES

Level of Services (LoS) is a quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed and travel time, freedom to manoeuvre, traffic interruptions, and convenience (Highway Capacity Manual (HCM), 2000). Traffic Level of Service (LOS) is a measure used in transportation engineering and planning to assess the quality of traffic flow on a roadway. It is a qualitative rating that characterizes the operational conditions within a traffic stream, typically expressed as a letter grade ranging from A to F, with A representing free-flowing conditions and F representing congested or near-gridlock conditions. An explanation of the traffic situation according to the LoS category is as shown in the Figure 2.4 below.

Level of Service	Flow Characteristics	Operating Conditions
A	Free Flow	Low Volumes and High Speeds.
B	Reasonable Free Flow	Speed starting to slow down due to traffic conditions.
C	Stable Flow	Restrictions as far as the freedom of the drivers to choose their own speed.
D	Flow Approaching Instability	Drivers have limited freedom of maneuver.
E	Instable Flow	Possible Brief Stops.
F	Forced Flow	Congestion.

Figure 2.4: Flow Characteristic and Operating Conditions of Each Level of Services

Each level of service represents a range of operating conditions and the driver's perception of those conditions. The specific criteria for each level of service can vary depending on the type of facility (e.g., urban street, highway, intersection) and the transportation agency's guidelines.

The factors considered when determining the Level of Service include the average speed of vehicles on the roadway, the number of vehicles per unit length of roadway, the number of vehicles passing a point on the roadway per unit of time and the degree of interference or blockage of traffic flow.

Typically, LoS A corresponds to free-flowing conditions with minimal delays, while LoS F indicates severe congestion with significant delays. An example of traffic by LoS category can be seen in the Figure 2.5 below. Engineers and planners use Level of Service as a tool to evaluate existing traffic conditions, forecast future traffic performance, and design transportation infrastructure to meet specific performance goals. Figure 2.5 below shows the LoS overview of traffic flow by categories.

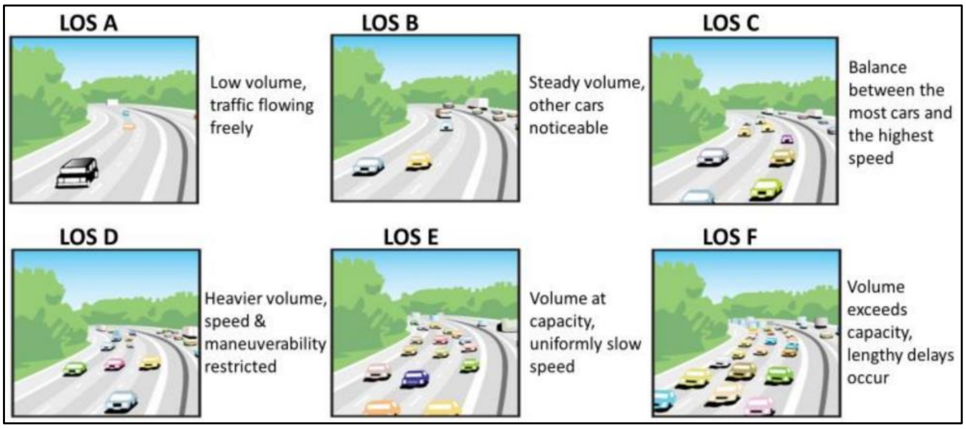


Figure 2.5: Traffic Overview by LoS Category ((ITRE), 2011)

It's worth noting that LoS is just one of many tools and metrics used in transportation planning, and it provides a high-level overview of traffic conditions but does not capture all aspects of a transportation system's performance. Additionally, transportation agencies may use other measures, such as travel time, delay, and safety, to supplement LOS evaluations.

2.10 SIDRA Intersection Software

The SIDRA Intersection software is a traffic modelling tool used in traffic and transport planning, management, design, and operations. It uses an analytical approach to model intersections, interchanges, streets, and networks, allowing for traffic impact analysis, roundabout geometric design, efficient traffic signal control systems, and balanced Movement and Place solutions. SIDRA Intersection offers unique value to transport planning and traffic engineering decision-making by considering the conflicting needs of all transport users, providing cost savings and environmental benefits. It is versatile for traffic engineers, transportation planners, and researchers to model, analyze, and optimize traffic intersections and networks, allowing users to create detailed models, simulate traffic flow, assess factors like congestion, delays, and safety. The software's user-friendly interface and extensive library of intersection types and control strategies make it a valuable resource for analysing intersection performance under different conditions and traffic scenarios (SIDRA INTERSECTION, n.d.). Figure 2.6 below shows the front website of SIDRA.

Figure 2.6: SIDRA Intersection

2.11 ROAD SAFETY AUDIT (RSA)

Road Safety Audit (RSA) is a systematic process that involves independent adjudicators examining the planning, design, and construction of road infrastructure to identify any potential hazards that may negatively impact road user safety (Masirin & Nur Athirah Mohamad, 2016). The Public Work Department (P.W.D.) published the RSA Guidelines in 1997, with the second edition published in 2002. In Malaysia, the Public Work Department mandates RSA when constructing new roads. The objectives of RSA include ensuring that the design from planning to operational stages complies with relevant design guidelines, identifying safety gaps, and eliminating deficiencies at the most appropriate time to reduce costs and minimize disruptions. Figure 2.7 below is the book manual for Road Safety Audit.

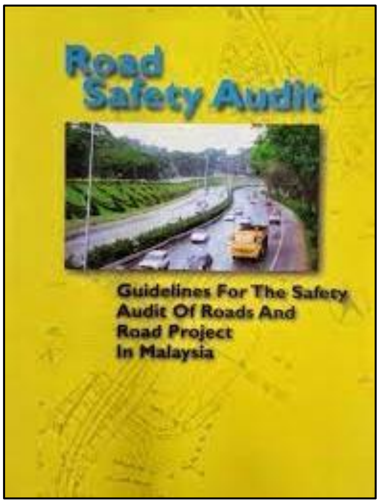


Figure 2.7: Road Safety Audit Book Manual

RSA is a crucial procedure in Malaysia aimed at improving road safety and reducing accidents. Teams of professionals, including traffic engineers, road safety specialists, and stakeholders, conduct RSAs, evaluating road elements such as visibility, traffic control devices, signs, road design, and the impact of large vehicles. The goal is to identify safety issues and suggest necessary changes to reduce hazards and enhance road network safety (ANG, 2020). RSA adheres to specific guidelines, promoting a harmonious approach that benefits both drivers and climbers. It contributes significantly to the ongoing efforts to make Malaysia's road infrastructure safer and more reliable. RSA is not only implemented in accordance with P.W.D. requirements but also ensures that all road users can use the road safely.

2.12 JABATAN KERJA RAYA (JKR) OR PUBLIC WORKS DEPARTMENT OF MALAYSIA (P.W.D.)

The Jabatan Kerja Raya (P.W.D.), or the Public Works Department of Malaysia (P.W.D.), is a government agency responsible for planning, designing, and overseeing the implementation of public infrastructure projects in the country. Established in 1870 during British colonial rule, P.W.D. has played a pivotal role in the development and maintenance of Malaysia's infrastructure (JKR, n.d.). Originating from the necessity to develop and maintain essential public infrastructure, such as roads and bridges, the department has undergone significant evolution over the years. Its inception marked a crucial step in shaping Malaysia's infrastructure landscape, laying the foundation for the department's pivotal role in the nation's development.

The Public Works Department (P.W.D.) is responsible for planning, designing, and executing public infrastructure projects in Malaysia, including road networks, critical structures like bridges, government buildings, public facilities, and infrastructure projects contributing to the nation's growth. The department sets and upholds engineering standards and guidelines to ensure the quality and safety of these projects. Figure 2.8 below is the logo of P.W.D.

Figure 2.8: Jabatan Kerja Raya's Logo

P.W.D. actively participates in the entire project life cycle, conducting feasibility studies, detailed design work, procurement processes, overseeing construction, and post-construction maintenance. It collaborates with various stakeholders, including government agencies, contractors, and consultants, to ensure successful execution of projects with a focus on quality and sustainability. The department also takes a lead role in developing and updating guidelines and standards for construction and engineering practices in Malaysia, serving as the benchmark for ensuring the quality, safety, and sustainability of infrastructure projects. Adherence to these standards is crucial for the longevity and effectiveness of public works in Malaysia.

2.13 TRAFFIC CONSULTANT

Traffic consultants in Malaysia are professionals responsible for managing and planning traffic and transportation systems. They focus on ensuring roads are safe, traffic flows smoothly, and transportation systems work efficiently. They assess the impact of new developments on traffic, analysing road layouts, traffic signals, and signs to design safe and efficient roadways. They also conduct safety audits to identify potential dangers and suggest improvements, such as better signs or lighting. They also plan for the future by considering population growth and land use, creating strategies for efficient traffic handling and planning for new roads and transportation needs.

In cities, traffic consultants plan public transportation systems, analyze data like traffic counts and surveys, and study parking needs to design facilities that are accessible and sufficient for everyone. They also contribute to environmental impact assessments by examining the impact of transportation projects on air quality and noise. Traffic consultants collaborate with government agencies, local authorities, and private companies to ensure safe, efficient, and well-planned transportation systems in Malaysia. Their advice and recommendations are crucial for meeting the needs of a growing and dynamic society. Figure 2.9 below shows traffic consultant doing site observations.

Figure 2.9 : Traffic Consultant Doing Site Observation

2.14 MIROS DATA

The Malaysian Institute of Road Safety Research (MIROS) stands as a crucial entity within the Malaysian government, tasked with the comprehensive responsibility of advancing road safety in the country. Established in 2007 under the Ministry of Transport Malaysia, MIROS operates with the primary goal of reducing road accidents, minimizing injuries, and enhancing overall road safety standards. As a research-focused institute, MIROS engages in various initiatives to understand the multifaceted factors contributing to road accidents, employing evidence-based approaches to develop effective interventions (MIROS, 2023).

MIROS is a research and development institute that focuses on identifying the causes of road accidents, assessing the effectiveness of existing safety measures, and proposing innovative solutions. It is a key contributor to developing policies and guidelines related to road safety in collaboration with other government agencies. MIROS collects and analyses data on accident statistics, road conditions, and driver behaviour to identify trends, risk factors, and formulate targeted interventions. It also conducts crash tests, assesses vehicle safety features, and provides recommendations to enhance overall vehicle safety. MIROS also conducts education and awareness programs, promoting responsible driving habits through campaigns, training programs, and community outreach initiatives. It actively participates in international collaborations and partnerships, exchanging knowledge and adopting global standards to stay at the forefront of road safety research and practices. MIROS plays a pivotal role in creating safer road environments in Malaysia, contributing significantly to mitigating road accidents and promoting a safer transportation landscape for all Malaysians. Figure 2.10 below is the logo of MIROS.

Figure 2.10: MIROS Logo

2.15 JALAN KUALA KANGSAR (FT001), IPOH, PERAK AT SECTION NUMBER 607 UNTIL SECTION NUMBER 610

Jalan Kuala Kangsar (FT001) is a federal road under the maintenance of P.W.D Ipoh, Perak. This research road is on Section No. 607 to Section No. 610 which is a distance of 3 kilometers. This study road is a focus area for local residents in the area. This is because on road Section No 607, there is a shopping centre which is Aeon Mall Klebang. However, in Section No. 608 there are fast food restaurants such as McDonalds, Econsave supermarkets, housing areas, schools and shops. At Section No.

609, there is a Honda car showroom and service centre which is Honda Ban Hoe Seng - 3S Center Ipoh. Next on Section No. 610 there is a Big Famaly fishing pond, a Chemor pond and a housing area.

2.15.1 Traffic Volume at Jalan Kuala Kangsar (FT001)

The traffic volume on Jalan Kuala Kangsar is congested with the increasing industrial development in the area. The busy and heavy traffic main road, used by various activities like school, office, business, and logistics, is a high-risk area for road accidents due to the increasing development and heavy vehicles on the road.

2.15.2 Traffic Level of Service (LoS) Categories Using SIDRA Intersection Software.

With the many activities in the area, the LoS on the study road is likely to become increasingly congested with the increase in the number of vehicles passing through the road. To identify LoS categories on the study road, an analysis will be done using the SIDRA Intersection device. Analysing the LoS at traffic intersections using SIDRA Intersection involves a straightforward process. Begin by collecting data on traffic volumes, intersection layout, and control types. Input this data into the SIDRA software and set up the project, specifying intersection details and control methods. Then, enter traffic volume data and signal timings. Calibrate the model to match observed conditions. Run the analysis to simulate traffic flow, and interpret the results, which are typically presented as letter grades indicating the Level of Service. Perform sensitivity analyses to understand parameter impacts and identify potential improvements. Finally, generate reports summarizing the analysis and compare scenarios to evaluate proposed changes or alternative designs. It's essential to refer to the software's documentation for detailed guidance on each step.

2.15.3 Road Conditions

The condition of the road at the study location is severe with problems such as uneven patching of the road surface, potholes, rolling road surface, long life span of the road pavement, delaminated road pavement where the road pavement easily comes off and rutting road surface that has many factors one of which is caused by the lifespan of the road and heavy vehicles exceeding the axle loads capacity. Pictures in the Table 2.1 below shows the example of the type of damage that occurs on the road in the study location.

Table 2.1: Examples of Damage to the Road Surface

 Uneven road surface patching	 Potholes
 Undulating or Rolling Road surface	 Long life span
 Delaminated road pavement	 Rutting road surface

Certain drivers often evade collisions by abruptly changing their path, making it difficult for others to avoid. High speeds after passing traffic lights and on slightly elevated roads also contribute to accidents. Uneven surfaces and uneven surfaces further exacerbate these issues, making it difficult for road users to reduce speed and avoid collisions.

2.15.4 Crumbling of Road Infrastructure

Roads can crumble over time due to various reasons, including heavy traffic, bad weather, poor construction methods, lack of maintenance, ground issues, exposure to harmful chemicals, tree root growth, and natural disasters like earthquakes and floods. Roads can deteriorate faster due to poor construction, lack of maintenance, and improperly built roads. To maintain good road condition, it is crucial to use quality materials, perform regular maintenance, and address problems early on. Natural disasters like earthquakes and floods can also cause severe damage.

2.15.5 Risk of Road Accidents for Road Users

Road users face numerous hazards due to factors such as high traffic numbers, reckless driving, speeding, aggressive conduct, motorcycles, poor road conditions, heavy rain, uneven traffic law enforcement, driver weariness, poorly maintained vehicles, and a lack of understanding about road safety. High traffic numbers in congested cities can lead to clogged roadways, increasing the likelihood of accidents (Miller, 2021). Additionally, heavy rain in tropical weather can make roads slippery, lowering visibility and increasing the risk of accidents. Traffic law enforcement is crucial, but uneven enforcement and mild punishments can lead to a culture of noncompliance. Driver weariness, especially for long-distance travellers or long-hour workers, and poorly maintained vehicles increase the risk of accidents (Nordfjærn & Rundmo, 2013). A comprehensive approach combining government agencies, law enforcement, and community participation is needed to promote responsible driving, reduce accidents, and build safer roads for everyone.

2.15.6 Road Traffic Death

Deaths due to road accidents are increasingly worrying local residents, road users and road owners. Road accident records at the study location show that there are accidents that claim the lives of road users. There are various types of road accidents such as fatal accidents, serious accidents and minor accidents involves vehicles such as cars and motorcycles. In the last three years, from 2020 to 2022, there have been cases of fatal accidents on those roads section according to Road Accident Management System (RAMS) by P.W.D.'s Accidents Data Form.

Road traffic fatalities occur in Malaysia for a variety of reasons. Motorcycles are frequently involved in accidents, and riders are particularly vulnerable to serious injury. Unsafe driving habits such as speeding and irresponsibility, as well as inadequate road infrastructure such as poorly maintained roads and insufficient signage, all contribute to deadly accidents. Tropical weather, particularly heavy rains, makes roadways slick and raises the danger of accidents.

The primary difficulties on this road include accidents, which are expected to rise until 2023, congested roads, a large number of heavy trucks and other vehicles, a shortage of illumination at night, a lack of alternate routes, and an increase in road traffic mortality. The rise in heavy trucks not only contributes to road surface deterioration, but also increases the chance of accidents, creating a challenging scenario for both law enforcement and drivers. The current growth in the Klebang region has led to an increase in activities and the usage of logistics on this route, which has resulted in an increase in traffic volume, which may cause road damage and decaying infrastructure.

2.16 ROAD SAFETY AUDIT (RSA) REPORT IN RISK OF ROAD ACCIDENTS

RSA report is a method to identify the risk of possible road accidents that can happen to road users due to road furniture, road design, road surface and so on that can harm road users. RSA will detect and eliminate unsafe features on road (Jabatan Kerja Raya, 2002).

2.16.1 RSA Guideline Second Edition in 2002 by P.W.D.

Road Safety Audit (RSA) is defined as the systematic process of independent and qualified auditors examining the planning, design, and construction of a road project, as well as the features and operation of an existing road, to determine any potential hazard of road feature or operational arrangement that may adversely affect the safety of any road user.

RSA is done by professionals to review and provide their professional opinion on the proposed road design by the project consulting engineers. The work done is to inspect the road design from a few aspects such as design mistakes or non-compliance, lack of attention to design detail, lack of knowledge of road safety issues, interaction of design elements, substandard provisions for vulnerable road users, and poor or misleading road design.

RSA is best carried out at five phases throughout the construction of road projects.

a. **Stage 1: Feasibility and Planning Stage** – Conducted to determine safety problems associated with overall design concepts, standards, and classification of road development.
b. **Stage 2: Preliminary Design Stage** – Carried out to examine the proposed design as well as the land acquisition and project layout process, including design criteria, cross-sections, road alignments, interchanges or junctions, access control, lane and carriageway layouts, sight distances, 'Right-of-Way' requirements, and provisions for other users such as motorcyclists and pedestrians. The detailed design shall not have begun until all road safety issues highlighted in this stage have been resolved.
c. **Stage 3: Detailed Design Stage** – To audit and inspect viewing distance, the undesirable mix of vertical and horizontal alignment, slopes, interchanges/intersections, road markings, drainage, roadside safety, traffic signs and controls, street lighting, landscape elements, and accommodations for special road users are all examples of characteristics. Mitigation factors must be given for design elements that cannot be changed. Similarly, the project should not have moved on to the building stage until all of the safety issues identified in Stage 3 were properly remedied.
d. **Stage 4: Traffic Management Plan (TMP)/ During Construction/ Pre-opening** - The project is divided into three stages: Traffic Management Plan auditing, construction during construction, and pre-opening. JKR determines each stage's requirements. RSA Stage 4 ensures traffic management and construction works align with specifications and designs, ensuring road safety standards are met.
e. **Stage 5: After Construction/ Operational Stage** – Carried out to identify the road safety problems and hazards which may exist due to the traffic operation.

The safety hazards such as traffic signs obstruction and sight distance impairing due to the mature landscaping such as grown trees and foliage shall also be determined at this stage. The inspection shall be conducted for both day and night to inspect the inadequacies in road delineation and visibility.

2.16.2 Checklist of Site Inspection for Stage 5

There are twelve (12) elements including in the checklist of site inspection by RSA Guideline second edition in 2002. The elements of the checklist are as below:

a. **Vertical and Horizontal Alignment**:

Ensuring consistency in vertical and horizontal road alignment is crucial for driver safety. Any abrupt changes in alignment standards can surprise drivers and lead to accidents. Curves that are significantly below the standard speed, specifically more than 10 km/h below the 85th percentile approach speed, need to be identified as they pose a danger if vehicles cannot decelerate adequately, leading to vehicles potentially running off the road. Additionally, locations with inadequate stopping sight distance should be recorded, as these areas prevent drivers from seeing far enough ahead to stop safely. Similarly, locations with inadequate overtaking sight distance, especially where double lines are marked, must be documented to prevent unsafe passing manoeuvres.

i. **Vertical Alignment** refers to the road's profile in the vertical plane, including elevation, grades, crests, and sags. It ensures safe ascending and descending without strain or loss of control. Proper design of these features provides adequate sight distance, allowing drivers to see oncoming traffic and obstacles in time. Vertical curves also enhance driver comfort and safety by providing smooth transitions between different grades, preventing abrupt changes that could lead to loss of control.

ii. **Horizontal Alignment** refers to the road's layout in the horizontal plane, including straight sections and curves. Straight sections provide visibility and navigation but must be balanced with curves to avoid monotony. Horizontal curves are crucial for changing the road's direction and must be designed with appropriate radii and superelevation for safe navigation.

Superelevation, the banking of the roadway at curves, maintains vehicle stability by counteracting lateral forces.

b. **Cross Section**:

Identifies any inconsistencies in the road's cross-section standard, restricts the roadway's capacity, and addresses traffic congestion spots. It also checks for inadequate shoulder width and proper curb usage, particularly for 'barrier curb' usage at speeds exceeding 50km/h. The inspection also ensures the cross section accommodates vulnerable road users like pedestrians, cyclists, and motorcyclists, including paved footpaths, refuge width, and proper ramps. It also checks for areas with segregated areas for these users.

c. **Intersections**:

Intersections should meet sight distance requirements, including approach, entering, and safe intersection sight distance, to ensure drivers can see and react to cross-traffic and potential hazards. The layout should cater to all road users and facilitate safe traffic movements. Issues like lack of auxiliary lanes, discontinuity of through lanes, and trap lanes should be addressed. Roundabouts should address operational problems like inadequate deflection and high entry speeds, and channelisation islands should be large enough for pedestrian refuge and sign protection.

d. **Expressway & Other Interchanges**:

Interchanges should be strategically located and spaced for efficient traffic management. Consistent standards for entry and exit ramps are crucial for safe and efficient traffic flow. Auxiliary lanes should be adequate and designed to match the speed of entering and exiting traffic, considering deceleration needs and potential queuing. Sight distance requirements at entry and exit points should be checked for safety, ensuring safe merging and divergence.

e. **Traffic Signal Installations**:

Traffic signals should be installed only for safe and efficient traffic flow, aligning with a sensible traffic management strategy. They should operate effectively with adequate hardware for traffic movements and pedestrian crossings. Clear visibility of signal faces and redundant systems are essential for failures. In urban areas, specific signal faces and phasing are necessary for safe crossings. Ensuring signal visibility and positioning helps maintain safe pedestrian and vehicle movements.

f. **Street Lighting**:

Street lighting is crucial in urban areas, particularly for pedestrians and parked vehicles. It should meet specific standards and avoid posing a traffic hazard. Poles on small islands, medians, or sharp curves should be carefully positioned to reduce collision severity. Street lighting should also enhance route guidance, helping drivers navigate safely in low-visibility conditions.

g. **Traffic Signing – General aspects**:

Traffic signs should be standardized in shape and color for consistency and recognisability, avoiding unauthorised or non-standard signs. They should be clearly visible and legible at appropriate distances without being too close or providing excessive information. Observing signs in nighttime conditions can identify deficiencies in reflectivity and effectiveness, ensuring visibility and clear guidance.

h. **Regulatory And warning Signs**:

Regulatory signs and warning signs are crucial for traffic control and safety, with the latter being used only when necessary to prevent drivers from desensitizing them to potential hazards, thus enhancing road safety.

i. **Guide And Direction Signs**:

Guide and direction signs should follow a systematic route or regional strategy, providing clear, actionable guidance to unfamiliar drivers. They should be logically positioned, ensuring consistency in destination names and route numbers, allowing drivers to make timely decisions, reducing confusion, and enhancing road safety.

j. **Pavement Marking**:

Pavement markings should be visible and adequate in all weather conditions, including night and wet. The correct line marking should be used for different situations, such as merging and diverging areas. Markings should clearly delineate hazards and guide traffic, and discontinuities in lane markings should be corrected to prevent errors.

k. **Roadside Safety & Landscaping**:

The road should have a clear zone width for safe recovery, with fixed objects treated or removed for safety. Guardrails should be provided and treated at the ends to prevent collisions. Bridge railings should be strong enough to restrain vehicles, with proper transitions from approach guardrails. Trees and vegetation should not obstruct sight lines, and poles should be frangible or positioned safely to minimize collision risks.

l. **General Traffic Management Items**:

Special provisions for motorcycles, such as paved shoulders or segregated lanes, should be considered to enhance safety. Pedestrian safety should be improved near schools and town centers, with traffic calming measures. Speed limits should be credible and appropriate for traffic situations, with adequate signs for sub-standard curves. Overtaking opportunities should be provided regularly on two-lane roads, and rest areas and safe stopping places should be available. Roadside stalls and businesses should be regulated for safety, and bus stop locations should be safe for patrons.

2.16.3 Road Mitigation for Reducing Risk of Road Accidents Based on The Finding from RSA Report

Road mitigation refers to various strategies and actions taken to make roads safer and reduce the chances of accidents. Focus on improving different aspects of the road system to ensure the well-being of everyone using the roads. One important part of road mitigation is making changes to how roads are designed.

Road mitigation is done with the aim of improving road conditions to reduce the risk of road accidents. The proposed solution is based on the findings from the RSA report that has been done by professionals in their field. This includes things like improving intersections, road signs, and markings to make them clearer and easier to understand. Another aspect involves using measures like speed bumps or roundabouts to slow down traffic in specific areas, especially where there are many pedestrians or homes.

2.17 POLICE TRAFFIC AT JALAN KUALA KANGSAR (FT01) SECTION NUMBER 607 UNTIL SECTION NUMBER 610

In Malaysia, the traffic police collect a lot of information to make sure our roads are safe for everyone. They keep track of accidents, noting how many happen, where they happen, and how serious they are. This information helps them understand where problems might be and how to make things safer. They also pay attention to when people don't follow the traffic rules, like speeding or running red lights. This helps the police keep everyone on the roads safe by making sure everyone follows the rules. The police keep records of registered cars, drivers' licenses, and who owns the cars. This is to make sure that everyone driving has the right to do so and is doing it legally. They also note programs and campaigns that teach people about road safety.

These programs help everyone learn how to be safer on the roads and follow the rules. To make the roads even safer, the police look at how they do their job, like how many times they go on patrols and set up checkpoints. They also study how traffic moves on the roads and when it gets really busy. This information helps them plan and improve traffic flow, making it easier for everyone to get around.

Technology is also used by the police, like cameras and automated systems, to keep an eye on traffic and make sure people are following the rules. This helps the police do their job more effectively. All this information is important for the government, researchers, and the police to Figure out how to make our roads safer and manage traffic better. It's like putting together pieces of a puzzle to understand what's happening on the roads and how to make things better for everyone.

2.18 INDUSTRIAL REVOLUTION 4.0 (IR 4.0)

Technology is important in numerous areas of our lives; it has provided faster access to information, leading in a revolution in the way we consume and engage with data. The corporate world is becoming increasingly involved with the rapid advancement of technology. Automation and connectivity have increasingly become more common in the industrial sector. The recent and most advanced concept of industrial revolution is 4th industrial revolution or Industry 4.0 which was coined in

Germany in 2011 (Sherwani, Asad, & Ibrahim, 2020). Figure 2.11 below shows the evolutionary of Industrial Revolution changes over the years.

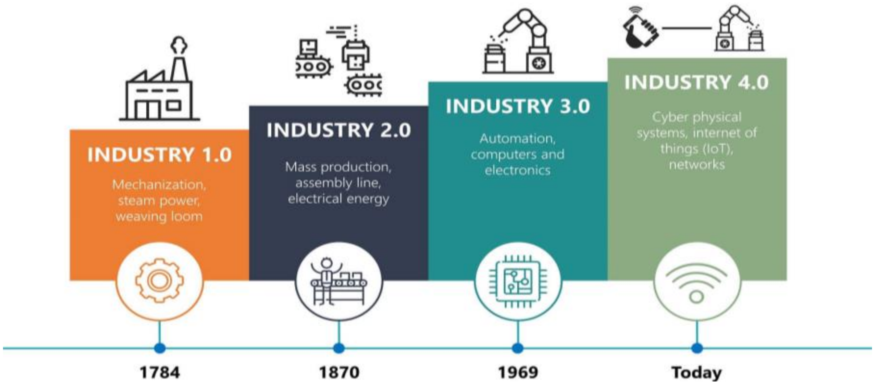


Figure 2.11: Evolution of Industrial Revolution

Industry 4.0 is a global shift in industrial business, involving the integration and digitalization of all industrial processes within the value chain. This fourth industrial revolution is expected to increase from 33% to 72% over the next five years. It represents a qualitative advance in the organization and management of the entire value chain across the manufacturing and distribution life cycle of a product. The convergence of physical and digital technologies across various industries is a fundamental aspect of Industry 4.0, ushered in by the adoption of advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), machine learning, big data analytics, robotics, 3D printing, and sophisticated sensor technologies. These technologies create a highly interconnected network of devices, machines, and systems, enabling seamless communication and data sharing within the production process.

2.19 INTERNET OF THINGS (IOT)

The Internet of Things (IoT) is a concept that connects various physical devices, objects, and systems using sensors, software, and network connections. These devices gather, send, and receive data without human interaction, monitoring and measuring various characteristics like temperature, humidity, and motion. IoT development is facilitated by communication technologies like Wi-Fi, Bluetooth, cellular networks, and Low Power Wide Area Networks (LPWAN). This connectivity allows devices to share data and communicate, creating a dynamic and responsive network. IoT applications are versatile and can be found in sectors like smart homes, industrial settings, and cloud computing. Figure 2.12 below shows the branches of IoT development.

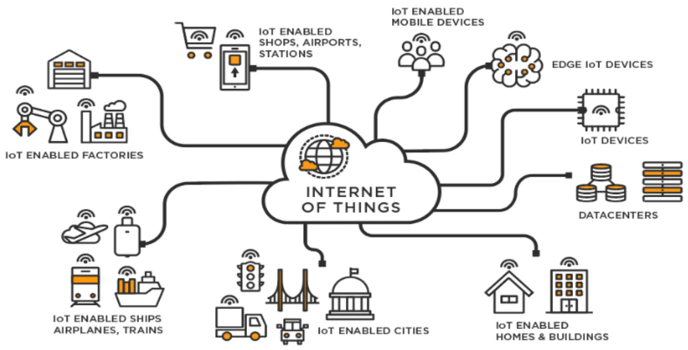


Figure 2.12: The Branches of Internet of Things (IoT) Development

Devices like thermostats and security cameras can adjust based on occupancy and operate household appliances. Cloud computing is essential for managing large volumes of data generated by IoT devices, providing computing capacity and analytics capabilities (Mahmood, Puttini, & Erl, 2013). However, IoT presents challenges such as data privacy concerns, security risks, and ethical implications. Addressing these issues is crucial for the safe and secure implementation of IoT technology, contributing to Industry 4.0.

2.20 SUSTAINABLE DEVELOPMENT GOALS

The United Nations developed the Sustainable Development Goals (SDGs) as a collection of 17 global goals to address a wide variety of social, economic, and environmental concerns. In September 2015, all United Nations Member States formally embraced the SDGs as part of the 2030 Agenda for Sustainable Development. The goals are intended to serve as a worldwide call to action to alleviate poverty, safeguard the environment, and create universal prosperity by 2030 (United Nation, n.d.). Figure 2.13 below shows the 17s' Sustainable Development Goals.

Figure 2.13: 17s' Sustainable Development Goals.

2.20.1 Goal 3: Good Health and Well-being

Target 3.6: By 2020, reduce the number of worldwide road traffic deaths and injuries by half. Road traffic accidents are a serious public health hazard, causing numerous injuries and fatalities. To achieve this goal, steps must be implemented to minimize the incidence and severity of traffic accidents, hence encouraging excellent health and well-being.

2.20.2 Goal 9: Industry, Innovation, and Infrastructure

Target 9.1: Create high-quality, dependable, long-lasting, and resilient infrastructure, including transportation networks. Improving road safety contributes to this goal by stressing the need for infrastructure upgrades. These may include the adoption of current and safe road design standards, the use of long-lasting materials, and the incorporation of cutting-edge technology to improve traffic safety.

2.20.3 Goal 11: Sustainable Cities and Communities

Target 11.2: By 2030, all people will have access to secure, cheap, accessible, and sustainable transportation systems. The importance of road safety in establishing safe and sustainable urban settings cannot be overstated. Improved road design, effective traffic management, and the provision of safe pedestrian and bicycle infrastructure all contribute to the achievement of this goal, which promotes sustainable and accessible transportation networks.

2.20.4 Goal 16: Peace, Justice, and Strong Institutions

Target 16.1: Significantly reduce all types of violence and related fatality rates throughout the world, including traffic accidents. Road accidents can be considered a kind of road violence. Improving road safety include enforcing traffic regulations, encouraging responsible driving behaviour, and establishing strong institutional structures to govern and control road transportation, all of which contribute to the overarching objective of fostering peaceful and just communities. Each of these points highlights the interdependence between road safety and larger sustainable development goals. Road safety efforts help to enhance health outcomes, infrastructure, sustainable urban development, climate action, and the formation of peaceful and just communities.

2.21 SUMMARY

Malaysia's rapid economic growth and urbanization have led to increased motorization, resulting in a surge in road traffic, causing a rise in road accidents. This has led to loss of lives, economic burdens, strain on healthcare resources, and disruptions in societal well-being. Understanding the dynamics, causes, and consequences of road accidents is crucial for developing effective interventions and policies.

This literature review provides a comprehensive overview of existing research on road accidents in Malaysia, identifying trends and contributing factors. It aims to identify gaps in existing literature and propose future research initiatives to address these challenges. The literature review serves as a roadmap for researchers to navigate the current knowledge landscape and add fresh insights to the subject through the case study.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter will cover the system's methodology as well as its development process. This chapter will explain the method and technique approach that will be used to solve the objectives of this case study. This chapter will cover the details explanation of methodology that being used to complete the case study and will accomplish a perfect result. The purpose of this chapter is to layout the procedures and approaches to solve the aim of the study, research framework research flow methodology, research design, data collection, data analysis, to produce report and to propose the idea from the finding of the study.

3.2 RESEARCH DESIGN

In general, research design refers to a framework for planning and carrying out a study. The research design is an important step to identify the problem that will occur during the implementation of the case study. The research design for a case study on road accidents involves a meticulous plan aimed at comprehensively understanding the factors contributing to and the consequences of road accidents within a specific context. The design typically begins by defining the research questions, which may encompass the identification of key risk factors, assessment of road infrastructure, evaluation of driver behaviour, and examination of existing safety measures. The selection of cases, such as specific accident-prone locations or particular types of accidents, is a crucial aspect of the research design.

Data collection methods commonly include a combination of quantitative and qualitative approaches, utilizing sources such as accident reports, traffic patterns, and infrastructure assessments. The design also incorporates strategies for analysing the collected data, ranging from statistical analyses to thematic coding for qualitative insights. Ethical considerations, such as ensuring the privacy of accident victims and adhering to legal regulations, are integral components of the research design. A well-structured research design for a road accidents case study serves as a systematic guide to uncovering valuable insights, contributing to the development of effective road safety measures and accident prevention strategies.

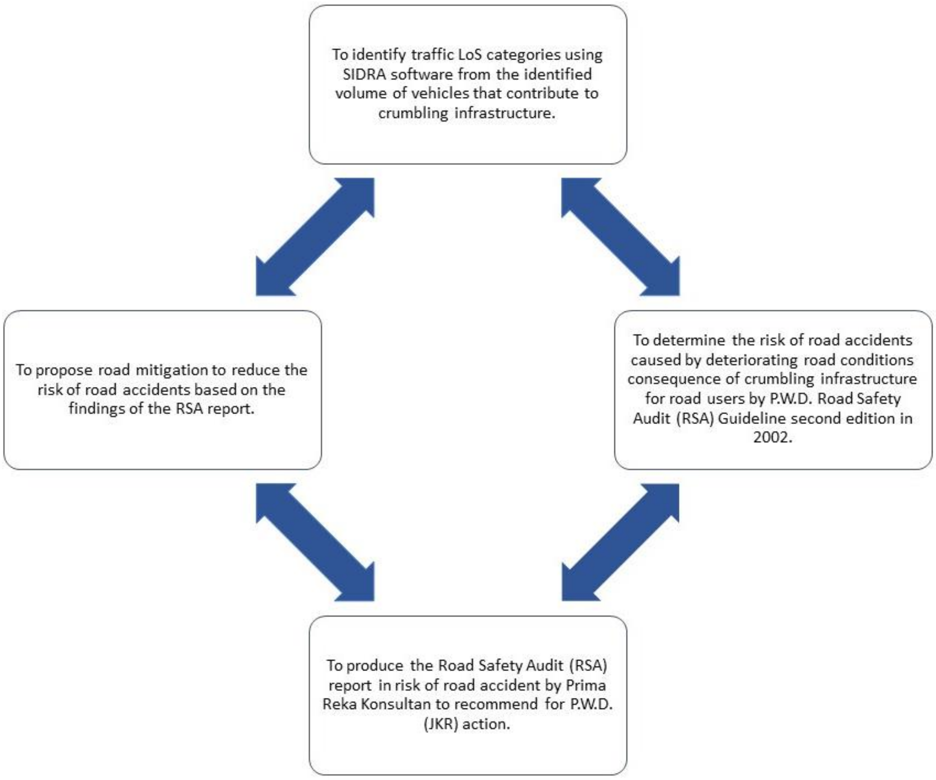


Figure 3.1: The Method of Illustrated for Case Study at Jalan Kuala Kangsar (FT001), Ipoh, Perak.

3.2.1 Table Research Design

The purpose of the research design id to discuss and explains method used to provide a plan of study that permits accurate assessment in conducting the case study the risk of road accidents at Jalan Kuala Kangsar (FT001) section number 607 until section number 610, Ipoh, Perak as shown in Table 3.1 Research Design below.

Table 3.1: Research Design

OBJECTIVES	METHOD	INSTRUMENT	ANALYSIS	FINAL OUTCOME
1. To identify traffic LoS categories using SIDRA software from the identified volume of vehicles that contribute to crumbling infrastructure.	Data collection: Vehicle volume	MetroCount tool	SIDRA Intersection software: • LoS categories	To identify traffic LoS categories using SIDRA software from the identified volume of vehicles that contribute to crumbling infrastructure.
2. To determine the risk of road accident cause by deteriorating road conditions consequence of crumbling infrastructure for road user by P.W.D. Road Safety Audit (RSA) Guideline second edition in 2002.	P.W.D. RSA Guideline second edition in 2002.	Checklist of Site Inspection by P.W.D. RSA Guideline second edition in 2002.	Risk of road accidents. Focus on road factor: • Road condition • Crumbling infrastructure • Checklist of Site Inspection by RSA Guideline second edition in 2002.	To determine the risk of road accident cause by deteriorating road conditions consequence of crumbling infrastructure for road user by P.W.D. Road Safety Audit (RSA) Guideline second edition in 2002.

OBJECTIVES	METHOD	INSTRUMENT	ANALYSIS	FINAL OUTCOME
3. To produce the Road Safety Audit (RSA) report in risk of road accident by Prima Reka Konsultan to recommend for P.W.D. (JKR) action.	Produce RSA report.	Checklist of Site Inspection by P.W.D. RSA Guideline second edition in 2002 • Vertical and Horizontal Alignment	Risk of road accident by: Prima Reka Konsultan to recommend for P.W.D. (JKR) action.	To produce the Road Safety Audit (RSA) report in risk of road accident by Prima Reka Konsultan to recommend for P.W.D. (JKR) action.
4. To propose road mitigation to reduce the risk of road accidents based on the findings of the RSA report	Road mitigation	Checklist using P.W.D. RSA Guideline second edition in 2002.	Reducing the risk of road accidents	To propose road mitigation to reduce the risk of road accidents based on the findings of the RSA report.

3.3 DEVELOPMENT RESEARCH

The progress of research is depicted as research of framework of the case study. The graphic depicts the path of research development from literature review through problem statement identification, research objectives. The development of research is used as a research framework in this case study. A research framework serves as the backbone for organizing information and understanding the relationships between different factors influencing the development phenomenon. It provides a structured way to analyze and interpret data, contributing to a deeper understanding of the complexities involved in the chosen development context. The framework is often iterative, evolving as new insights emerge during the research process. Figure 3.2 below show the research framework flow to be considered. A development process can be anything interrelate to solve the objectives.

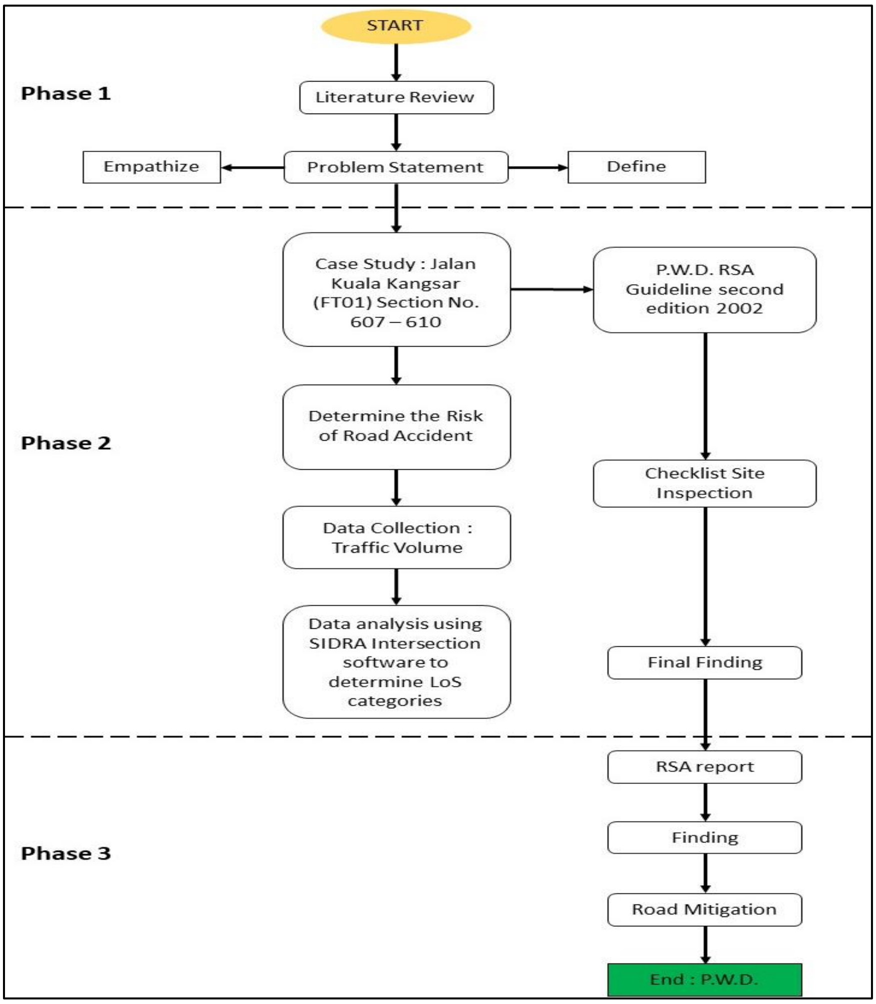


Figure 3.2: Flow of Research Framework

This study's methodology is break down into four phases, each of phase will be detailed in depth. The research flow methodology as shown in Figure 3.3 below. Throughout the process to complete this study, there are four phases of approach will be use.

Phase 1 is the preliminary study to identify the problem statements, aims and objectives, scope of study and significance. Issues related to the selected topic were identified during this phase. Besides that, the study's goal to solve the problem has also been set. Phase 2 is to state the method and the instruments to be used to solve the objectives of the case study. Further with Phase 3 is the stage of the analysis to achieve the objectives. Lastly, Phase 4 is the expected outcome for the overall phases.

Objective 1 is to identify traffic LoS categories using SIDRA software to recognize the volume of vehicles that contribute to crumbling infrastructure. The data will be gather by doing Traffic Count and the results will be entered in the SIDRA software to get the LoS readings on the road. Objective 2 is to determine the risk of road accident cause by deteriorating road conditions consequence of crumbling infrastructure for road user by P.W.D. Road Safety Audit (RSA) Guideline second edition in 2002. For objective 3 is to produce the Road Safety Audit (RSA) report and propose road mitigation to reduce the risk of road accidents based on site inspection checklist using RSA Guideline second edition in 2002 by Prima Reka Konsultan to be recommended for P.W.D. (JKR) action.

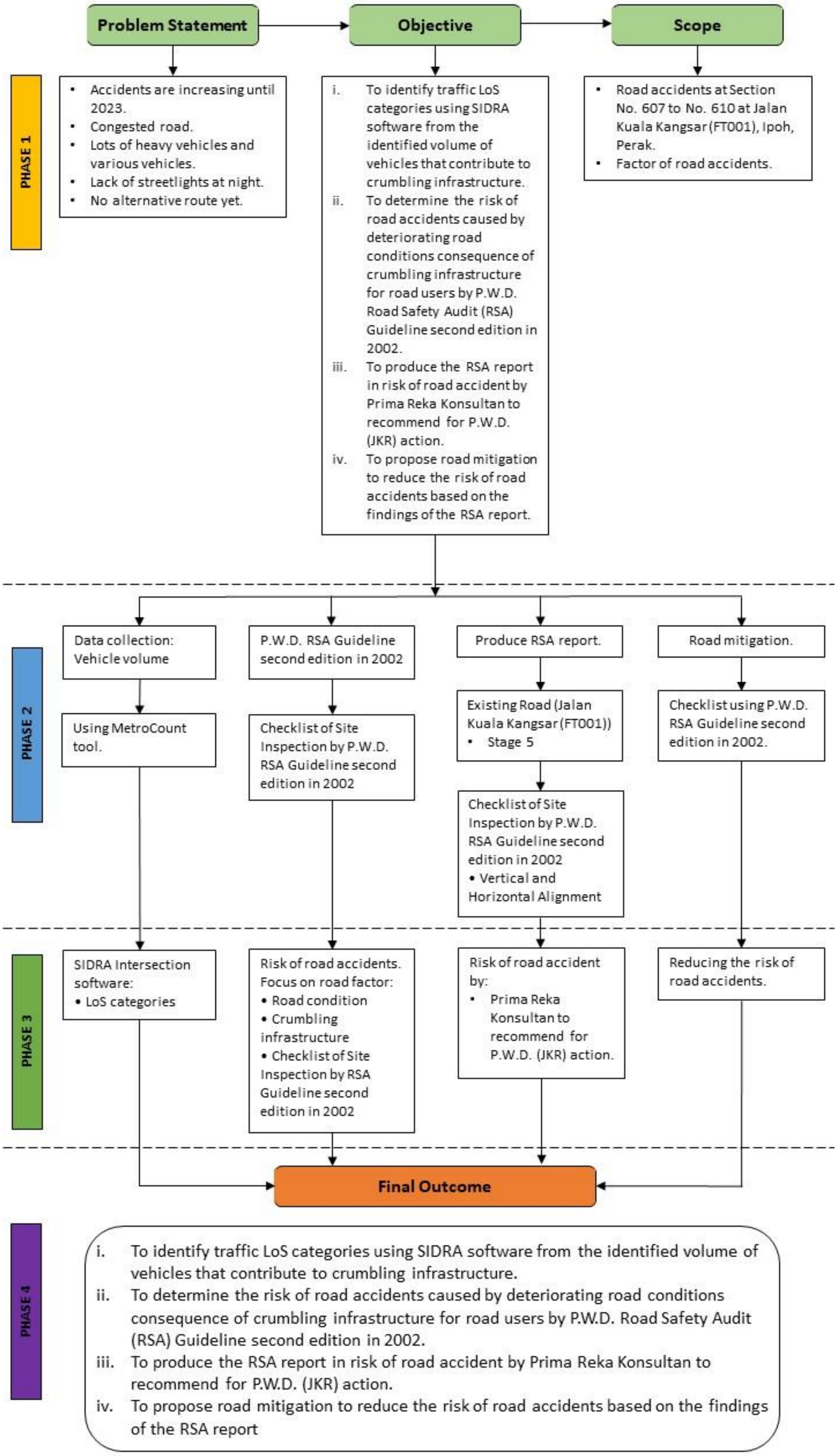


Figure 3.3: Research Flow of Methodology

3.4 DATA COLLECTION

3.4.1 Location

Data will be collected at each study location or at each section number which is 607, 608, 609 and 610. Each location is 1 kilometer apart.

3.4.2 Case Study at Jalan Kuala Kangsar

The case study to be done on Jalan Kuala Kangsar is a federal road that has many vehicle accidents every year referring to the Road Accident Management System (RAMS) by P.W.D.'s Accidents Data Form. In addition, on the road there are also many activities that are being carried out and Industry is developing. This causes the road condition to worsen and the accident rate to increase.

3.4.3 Traffic Volume's Data

Traffic volumes data will be collected manually using human power, which is by taking video recordings at each desired location. As a result of the recording, manual vehicle counting will be done in detail so that the PCU calculation is accurate to ensure the number of vehicles passing through the road is correct and for the purpose of entering the data into the SIDRA software to obtain an analysis of the road category at each location.

3.4.4 MetroCount – Vehicle Classifier System Tool

MetroCount is an optional tool used and installed on site to know the vehicles volume, vehicles categories and the peak hours for the road. The peak hour is intended to collect traffic volume data. MetroCount is designed for accurate traffic monitoring. It counts vehicles, classifies them based on characteristics, and detects axle counts. The system also helps to provide directional data, supports wireless data transmission, and includes analysis software for interpreting traffic patterns. However, this tool is not accurate because the tube installed on the road surface cannot detect vehicles that are too light such as motorcycles or vehicles that are too fast. Therefore, manual methods are still performed to obtain accurate data.

3.5 DATA ANALYSIS

3.5.1 SIDRA Intersection Software

SIDRA Intersection software is used to assess road intersection performance, determining the Level of Service (LoS). It uses input data, traffic flow simulation, capacity analysis, and LoS calculation to provide detailed output reports. All the data obtained at each study location will be analysed using SIDRA devices to obtain LoS category readings at each location. With this, the accident rate can be related to the existing traffic level. Figure 3.4 below shows the steps taken to get the LoS category of a road.

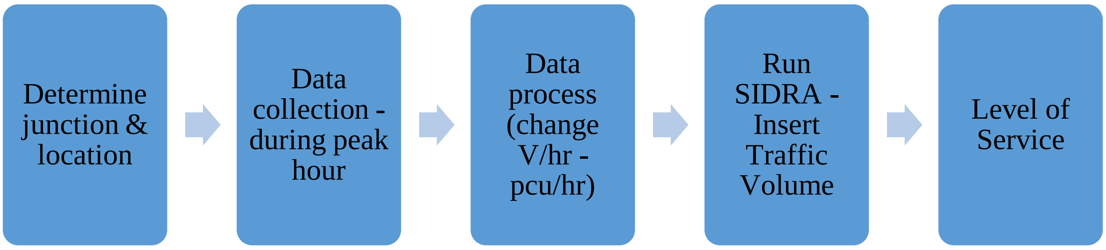


Figure 3.4: Steps To Get the LoS Category

*** V/hr** : Vehicles per hour

*** Pcu** : Passenger Car Unit or Passenger Car Equivalent is a measure of the impact of a vehicle on the capacity of a road, measured in its equivalent impact as a car. The term passenger car equivalent (pce) is the American usage. As a more detailed understanding of Malaysian characteristics are developed, traffic engineers may wish to use updated P.C.U. factors or other PCU factors that have been tailored to a specific analysis problem (Mohd Sadullah, 1997). Table 3.2 below shows the PCU Conversion Factors in Highway Capacity Manual Malaysia.

Table 3.2: PCU Conversion Factors (Highway Capacity Manual Malaysia, 2011)

Types of Vehicles	Equivalent Value in pcu			
	Two Lane Highways	**Multilane Highways**	**Expressways**	**Traffic Signal Design**
Cars/Small vans/Utilities	1.00	1.00	1.00	1.00
Lorries (with 2 axles)/(Large Vans)	1.44	1.58	1.47	1.19
Large lorry, Trailers, Heavy vehicles with 3 axles and more	1.83	1.76	1.95	2.27
Buses	1.93	1.65	1.66	2.08
Motorcycles	0.96	0.84	0.63	0.22

3.5.2 LoS Categories

The LoS grade corresponds to a specific range of intersection performance, helping assess the overall efficiency of traffic flow whether the road has smooth traffic or is congested with vehicles. Congested roads with vehicles are one of the contributors to the risk of accidents.

3.5.3 P.W.D. RSA Guideline second edition in 2002

P.W.D. RSA Guideline second edition in 2002 have 5 stages. For this case study, audit on stage 5 will be used for the existing road. The audit work done is site inspection. For this case study, audit stage 5 will be used for the existing road.

3.5.4 Checklist of Site Inspection

In Stage 5 of the audit process, the site inspection becomes a critical activity that demands careful planning and thorough execution. It involves observing the site both during the day and night, and preferably during periods of high risk, such as adverse weather or peak holiday times. The inspection is conducted with the perspective of various road users in mind, paying particular attention to the needs of vulnerable users like pedestrians, bicyclists, and motorcyclists.

Additionally, the safety implications for public transport vehicles, large trucks, and the interaction of abutting land-use with the road network are considered. For longer road sections exceeding 20 km, a phased approach is recommended. The first phase involves driving the road in both directions to identify key safety concerns and capture general features using tools like video or still cameras. The second phase entails a detailed on-foot examination of identified areas, with measurements, notes, video, and photographs taken to thoroughly document safety aspects for the subsequent report formulation. During these inspections, detailed comments can also be recorded using a handheld tape recorder. This meticulous approach ensures a comprehensive understanding of the site's safety dynamics.

Those following are important items need to be check during site inspection and the explanation is on Chapter 2:

i. Vertical and Horizontal Alignment
ii. Cross Section
iii. Intersections
iv. Expressway & Other Interchanges
v. Traffic Signal Installations
vi. Street Lighting
vii. Traffic Signing – General Aspects
viii. Regulatory and Warning Signs
ix. Guide And Direction Signs
x. Pavement Marking
xi. Roadside Safety & Landscaping
xii. General Traffic Management Items

3.5.5 Site Inspection for Risk of Road Accidents

The audit work done on Stage 5 is site inspection. Some important aspects should be observed when conducting a site inspection such as vertical and horizontal alignment, cross section, traffic signing and so on. All accident risks found on the road should be emphasized.

3.6 PRODUCE ROAD SAFETY AUDIT (RSA) REPORT

The RSA report will be conducted with the guidance of experts and professionals in their field. After producing the RSA report, researcher would like to propose road mitigation for P.W.D. action on the case study location based on the findings from RSA report with the guidance from the professionals. The proposal presented is entirely in reference to the needs of the road conditions. All the suggestions given are intended to provide safety for road users and further reduce the risk of road accidents caused by bad road conditions.

3.6.1 Site Inspection of Vertical and Horizontal Alignment

One of the few checklists that may be found from the rough observation from the researcher, the vertical and horizontal alignment aspects are the most significant aspects that can be seen as a risk for road accidents to occur. The road was found to be a type of rolling terrains road that is steep slopes that occasionally rise and fall above and below the road or street grade.

3.6.2 Stage 5 : After Construction/ Operational Stage

Carried out to identify the road safety problems and hazards which may exist due to the traffic operation. The safety hazards such as traffic signs obstruction and sight distance impairing due to the mature landscaping such as grown trees and foliage shall also be determined at this stage. The inspection shall be conducted for both day and night to inspect the inadequacies in road delineation and visibility.

3.7 PROPOSE ROAD MITIGATION

3.7.1 Road Mitigation Based on Site Inspection Checklist

The proposed road mitigation refers to the site inspection checklist specified in the RSA report. The proposed solution is in accordance with road standards used throughout Malaysia with guidance from professionals and experts in their field.

3.8 SUMMARY

This chapter describes the method and technique approach that will be used in general and briefly to solve the objectives of this case study. The content of this chapter also includes a detailed description of the methodology used to complete the case study to achieve perfect results. The goal of this chapter is to arrange the methods and ways for achieving the research objectives, research framework, research flow methodology, research design, data collecting, data analysis, producing reports, and proposing suggestions based on the research findings.

The disclosure in this chapter is about how to use the SIDRA Intersection device to obtain the Level of Service on a study road. In addition, an explanation to the RSA report guide at stage 5 for inspections on existing roads. Furthermore, this chapter briefly addresses about the road mitigation that is proposed on the study road based on the results of the RSA report.

CHAPTER 4

DATA AND ANALYSIS

4.1 INTRODUCTION

This chapter discusses the results of the data and analysis based on the case study's data obtained as according to the objective achievement. This analysis was performed to answer the objectives sated in the first chapter of this study through result discussion. Overall results had been analysed. For Objective 1, SIDRA Intersection software been used to obtain the LoS category on the study road and to identify the volume and type of vehicles that contribute to crumbling the road structure. A detailed analysis is done using SIDRA Intersection software to get accurate results to achieve objective 1. Objective 2, using P.W.D. Road Safety Audit (RSA) Guidelines Second Edition Year 2002 to identify the cause of road accidents caused by damaged road structures. Finally, producing RSA report using the Second Edition of the RSA Guidelines in 2002 and Recommendations for road improvements were listed based on the results of the report to reduce the risk of road accidents to road users.

4.1.1 Existing Road Conditions

The study road is a straight road starting from Section No 607 to Section No 610 which is from Aeon Mall Klebang, Ipoh to Big Famaly Kolam Chemor, Ipoh. Figure 4.1 below shows the location of the study road along with the section number. Each kilometer of the road study has been highlighted according to the section number as shown in the Figure 4.1 below.

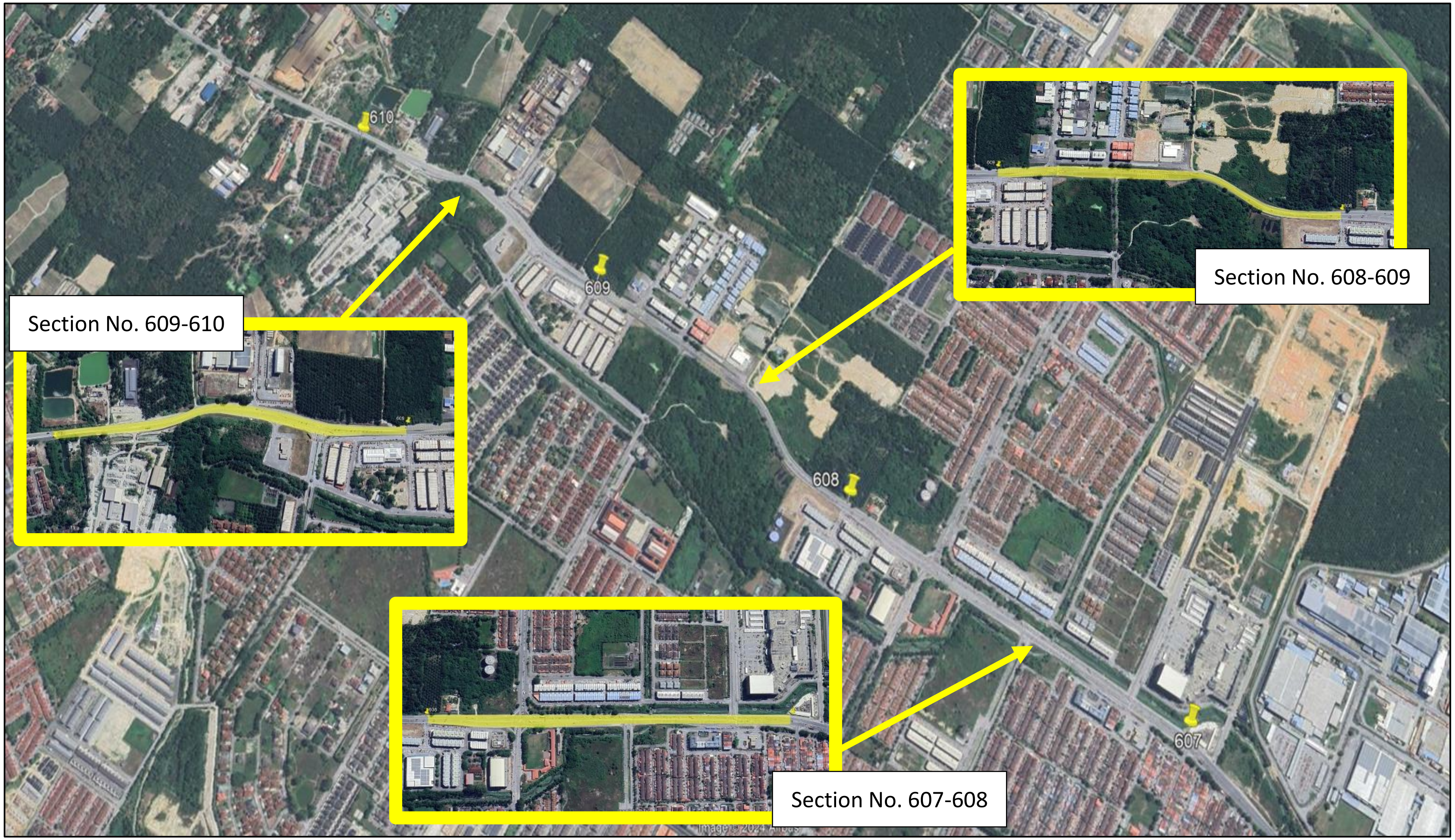


Figure 4.1 : Study Road Location by Section Number

4.2 IDENTIFY TRAFFIC LOS CATEGORIES USING SIDRA SOFTWARE FROM THE IDENTIFIED VOLUME OF VEHICLES THAT CONTRIBUTE TO CRUMBLING INFRASTRUCTURE

4.2.1 Data Collection Via Traffic Count Surveys

Traffic count surveys are a valuable tool for identifying road deterioration issues. They help authorities determine the stress on a road stretch by counting the number of cars passing through it over time. Higher traffic numbers and heavier cars can accelerate road wear and tear, leading to potholes, cracks, and surface deterioration. Traffic patterns, such as congested areas or heavy truck traffic, can also be identified.

Identifying vehicle types and weights based on axles helps identify potential sources of road damage. Heavy trucks or specialized equipment may cause pavement deterioration faster than passenger cars. Traffic count data helps authorities make informed decisions about maintenance, repair, and infrastructure enhancements to reduce road degradation. It can also serve as a basis for future research on Traffic Forecasting and Analysis of Future Scenarios.

4.2.2 Obtained Data of Vehicles Volume from MetroCounts – Vehicle Classifier System Tool to Get Peak Hour

Several MetroCount devices were installed for a week at the location of the study road. Peak hour field traffic studies were conducted throughout the week (24 Hour Survey Counts) to collect site data and determine current service levels on accessible routes. Figure 4.2 below shows the results of data collection from the tool and illustrates the variance in traffic volume recorded at the assigned census location. A three-day continuous traffic count was done to determine the frequency of peak-hour traffic at the census site. The highest peak hour volume was found throughout the morning, lunchtime, and evening survey periods, while being lower throughout the remainder days.

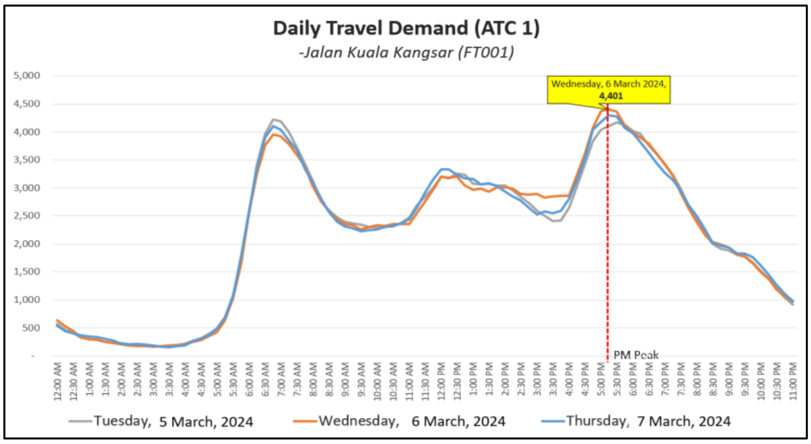


Figure 4.2: Highest peak hour Recorded at Jalan Kuala Kangsar (FT001) are 4071 pcu/hour at 7.00 p.m. – 8.00 p.m.

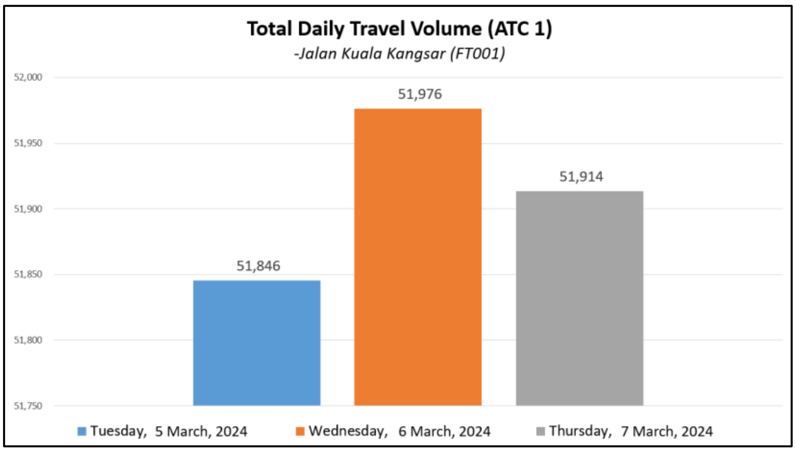


Figure 4.3: Total Daily Travel Volume

Figure 4.3 shows the highest total daily vehicle recorded via MetroCount on Wednesday 6 March 2024 with 51,976 vehicles along Jalan Kuala Kangsar (FT001). Fluctuation of daily volume was observed on the rest of weekday between 51,846 to 51,914 vehicles.

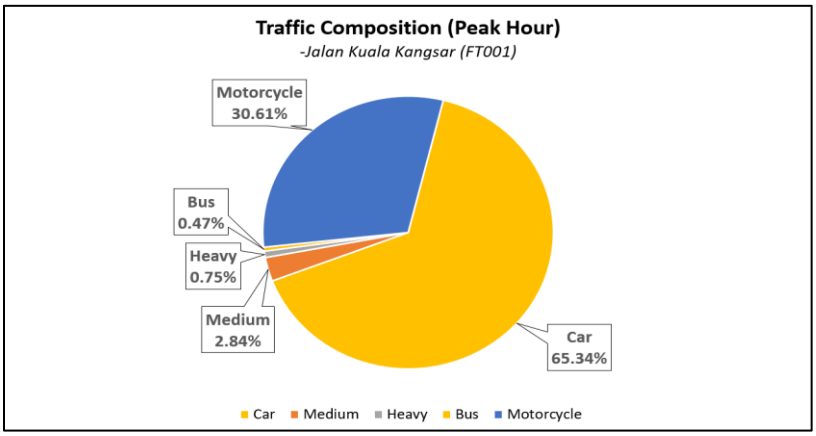


Figure 4.4: Peak Hour Traffic Composition

Figure 4.4 above shows the Pie-Chart shows obtained traffic composition along study route from MetroCount data. Majority of the traffic volume contributed by car (63.34%) and followed by motorcycles (30.61%), Medium (2.84%) & Heavy vehicles (0.75%) and Bus (0.38%).

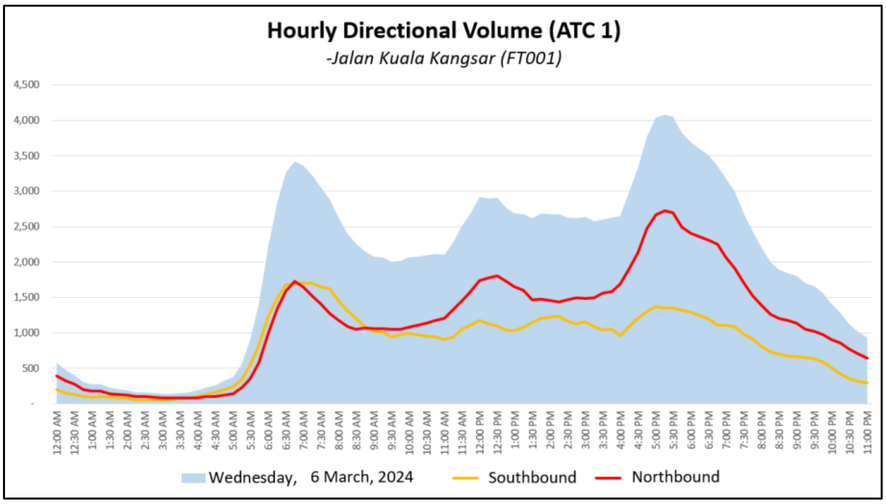


Figure 4.5: Hourly Directional Volume

In term of directional traffic distribution, at the installation location (Jalan Kuala Kangsar) the distribution of traffics are slightly to Northbound during morning period. This is due to the location of the study road is in between Central Business District (CBD) and industrial area. Figure 4.5 above shows the trend shows significant different during evening period where it was observed people going Northbound are much higher than to the Southbound.

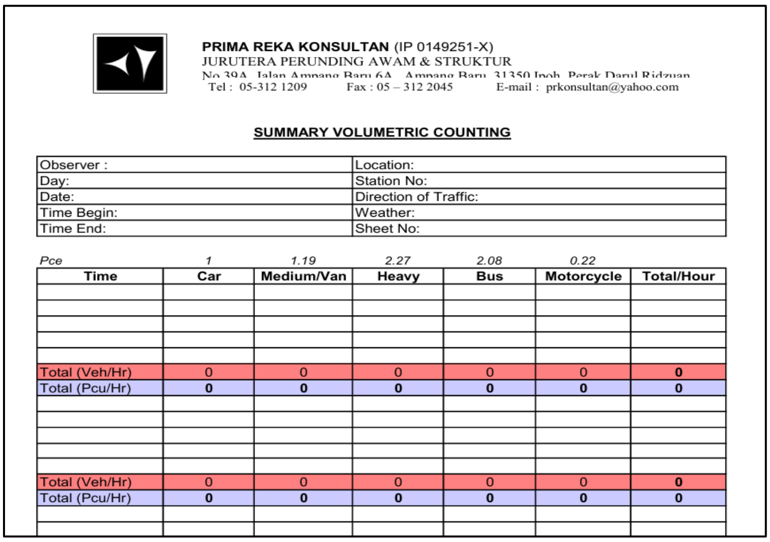
4.2.3 Data of Vehicles Volume by Manual Calculation

Traffic count data is a valuable resource for optimizing traffic signal timing, implementing congestion management strategies, and planning for efficient traffic operations. These insights enable transportation authorities to make well-informed decisions that improve the overall performance of transportation networks. Traffic counts can be conducted through various methods, including manual counts by observers, video surveillance, and automated traffic counters.

Manual calculations were done for the case studies on the study road. The purpose is to obtain a more accurate amount of vehicle data compared to the results obtained from the MetroCount tool. In addition, it is possible for the MetroCount tool not to be able to detect the type and number of vehicles crossing the MetroCount rubber tube. This is because, to get accurate data, the MetroCount tool can be installed on one lane of the road only. The fewer the number of road lanes the MetroCount device is installed on, the more accurate the reading to track the number and type of vehicles.

Traffic volumes data will be collected manually using human power, which is by taking video recordings at each desired location. The date **13 March 2024** has been chosen based on a week after the installation of the MetroCount tool. The selection of the day and date is to get the day with the most vehicles in the week so that any plan in the future can focus on the number and capacity of vehicles that pass through the road.

As a result of the recording, manual vehicle counting will be done in detail so that the PCU calculation is accurate to ensure the number of vehicles passing through the road is correct and for the purpose of entering the data into the SIDRA software to obtain an analysis of the road category at the study location. The manual calculation form to record traffic counts data using Microsoft Excel is as shown in Figure 4.6 below.



PRIMA REKA KONSULTAN (IP 0149251-X)
JURUTERA PERUNDING AWAM & STRUKTUR
No 39A, Jalan Ampang Baru 6A, Ampang Baru, 31350 Ipoh, Perak Darul Ridzuan
Tel : 05-312 1209 Fax : 05 – 312 2045 E-mail : prkonsultan@yahoo.com

SUMMARY VOLUMETRIC COUNTING

Observer :	Location:
Day:	Station No:
Date:	Direction of Traffic:
Time Begin:	Weather:
Time End:	Sheet No:

Pce	*1*	*1.19*	*2.27*	*2.08*	*0.22*	
Time	**Car**	**Medium/Van**	**Heavy**	**Bus**	**Motorcycle**	**Total/Hour**
Total (Veh/Hr)	0	0	0	0	0	**0**
Total (Pcu/Hr)	**0**	**0**	**0**	**0**	**0**	**0**
Total (Veh/Hr)	0	0	0	0	0	**0**
Total (Pcu/Hr)	**0**	**0**	**0**	**0**	**0**	**0**

Figure 4.6: Manual Calculation Form by Microsoft Excel

The manual calculation is done based on the results of observation from the video recording that was done on 13 March 2024. The calculation is recorded in an

Excel form and according to the classification of the type of vehicle. The result of the number of vehicles from the results of manual calculation is Figure 4.7 below.

SUMMARY VOLUMETRIC COUNTING

		Car	Medium/Van	Heavy	Bus	Motorcycle	Total/Hour	
D1	Total (Veh/Hr)	939	30	17	4	637	**1627**	AM PEAK
	Total (Pcu/Hr)	**939**	**36**	**39**	**8**	**140**	**1162**	
	Total (Veh/Hr)	644	39	23	13	192	**911**	PM PEAK
	Total (Pcu/Hr)	**644**	**46**	**52**	**27**	**42**	**812**	
D2	Total (Veh/Hr)	186	5	3	0	46	**240**	AM PEAK
	Total (Pcu/Hr)	**186**	**6**	**7**	**0**	**10**	**209**	
	Total (Veh/Hr)	157	7	0	0	56	**220**	PM PEAK
	Total (Pcu/Hr)	**157**	**8**	**0**	**0**	**12**	**178**	
D3	Total (Veh/Hr)	158	4	1	0	93	**256**	AM PEAK
	Total (Pcu/Hr)	**158**	**5**	**2**	**0**	**20**	**185**	
	Total (Veh/Hr)	105	8	1	0	63	**177**	PM PEAK
	Total (Pcu/Hr)	**105**	**10**	**2**	**0**	**14**	**131**	
D4	Total (Veh/Hr)	205	10	0	3	143	**361**	AM PEAK
	Total (Pcu/Hr)	**205**	**12**	**0**	**6**	**31**	**255**	
	Total (Veh/Hr)	306	4	0	2	204	**516**	PM PEAK
	Total (Pcu/Hr)	**306**	**5**	**0**	**4**	**45**	**360**	
D5	Total (Veh/Hr)	383	12	0	3	264	**662**	AM PEAK
	Total (Pcu/Hr)	**383**	**14**	**0**	**6**	**58**	**462**	
	Total (Veh/Hr)	218	13	1	2	84	**318**	PM PEAK
	Total (Pcu/Hr)	**218**	**15**	**2**	**4**	**18**	**258**	
D6	Total (Veh/Hr)	233	15	1	3	119	**371**	AM PEAK
	Total (Pcu/Hr)	**233**	**18**	**2**	**6**	**26**	**286**	
	Total (Veh/Hr)	428	6	2	1	215	**652**	PM PEAK
	Total (Pcu/Hr)	**428**	**7**	**5**	**2**	**47**	**489**	
D7	Total (Veh/Hr)	708	43	14	18	356	**1139**	AM PEAK
	Total (Pcu/Hr)	**708**	**51**	**32**	**37**	**78**	**907**	
	Total (Veh/Hr)	962	60	15	5	389	**1431**	PM PEAK
	Total (Pcu/Hr)	**962**	**71**	**34**	**10**	**86**	**1163**	
D8	Total (Veh/Hr)	195	7	0	2	113	**317**	AM PEAK
	Total (Pcu/Hr)	**195**	**8**	**0**	**4**	**25**	**232**	
	Total (Veh/Hr)	414	10	4	2	202	**632**	PM PEAK
	Total (Pcu/Hr)	**414**	**12**	**9**	**4**	**44**	**484**	
D9	Total (Veh/Hr)	452	7	2	4	542	**1007**	AM PEAK
	Total (Pcu/Hr)	**452**	**8**	**5**	**8**	**119**	**592**	
	Total (Veh/Hr)	212	8	1	2	119	**342**	PM PEAK
	Total (Pcu/Hr)	**212**	**10**	**2**	**4**	**26**	**254**	
D10	Total (Veh/Hr)	289	3	0	1	200	**493**	AM PEAK
	Total (Pcu/Hr)	**289**	**4**	**0**	**2**	**44**	**339**	
	Total (Veh/Hr)	242	10	0	2	221	**475**	PM PEAK
	Total (Pcu/Hr)	**242**	**12**	**0**	**4**	**49**	**307**	
D11	Total (Veh/Hr)	320	5	2	0	164	**491**	AM PEAK
	Total (Pcu/Hr)	**320**	**6**	**5**	**0**	**36**	**367**	
	Total (Veh/Hr)	230	3	1	0	91	**325**	PM PEAK
	Total (Pcu/Hr)	**230**	**4**	**2**	**0**	**20**	**256**	
D12	Total (Veh/Hr)	198	8	1	0	99	**306**	AM PEAK
	Total (Pcu/Hr)	**198**	**10**	**2**	**0**	**22**	**232**	
	Total (Veh/Hr)	236	11	0	1	101	**349**	PM PEAK
	Total (Pcu/Hr)	**236**	**13**	**0**	**2**	**22**	**273**	
D13	Total (Veh/Hr)	2	1	0	0	5	**8**	AM PEAK
	Total (Pcu/Hr)	**2**	**1**	**0**	**0**	**1**	**4**	
	Total (Veh/Hr)	17	2	0	0	17	**36**	PM PEAK
	Total (Pcu/Hr)	**17**	**2**	**0**	**0**	**4**	**23**	

Figure 4.7: Data Manual Calculation Form by Microsoft Excel

Data from the Excel form must be summarized for the purpose of being entered into the SIDRA software to identify the LoS traffic category on the study road. A summary of the movement direction data in the morning and evening on 13 March 2024 recorded in the Manual calculation form by excel is as in Table 4.1 below.

Table 4.1: Summary of Morning and Evening Movement Direction Data

AM	**Movement**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
	Total (veh/hr)	1627	240	256	361	662	371	1139
	Total (pcu/hr)	1162	209	185	255	462	286	907
	Movement	**8**	**9**	**10**	**11**	**12**	**13**	**14**
	Total (veh/hr)	317	1007	493	491	306	8	0
	Total (pcu/hr)	232	592	339	367	232	4	0
PM	**Movement**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
	Total (veh/hr)	911	220	177	516	318	652	1431
	Total (pcu/hr)	8122	178	131	360	258	489	1163
	Movement	**8**	**9**	**10**	**11**	**12**	**13**	**14**
	Total (veh/hr)	632	342	475	325	349	36	0
	Total (pcu/hr)	484	254	307	256	273	23	0

Each movement will be summarized to the direction of the traffic route A, B, C and D as shown in Figure 4.8 below. Table 4.2 below is the total volume per direction which has been summarized into four traffic routes.

Table 4.2: Total Vehicles Volume per Direction

TOTAL VOLUME/DIRECTION					
	A	**B**	**C**	**D**	
AM	1827	2181	1279	1991	veh/hr
	1425	1607	902	1298	pcu/hr
	A	**B**	**C**	**D**	
PM	2715	1516	1011	1142	veh/hr
	2136	8596	749	817	pcu/hr

The road in direction A in the morning is 1,827 veh/hr from Klebang, Ipoh. Followed by direction B by 2,181 veh/hr vehicles from the direction of Chemor. Meanwhile, the C direction from Klebang Putra is as much as 1,279 vehicles/hr and then the D direction of Klebang Restu is as much as 1,991 vehicles/hr. In conclusion, direction B has the greatest number of vehicles in the morning from Chemor to Klebang, Ipoh compared to other directions.

Next, during the evening peak, the road in direction A is 2,715 veh/hr from Klebang, Ipoh. Followed by direction B by 1,516 veh/hr vehicles from the direction of Chemor. Meanwhile, the C direction from Klebang Putra is as much as 1,011 vehicles/hr and then the D direction of Klebang Restu is as much as 1,142 vehicles/hr. In conclusion, direction A has the greatest number of vehicles in the morning from Klebang, Ipoh to Chemor compared to other directions.

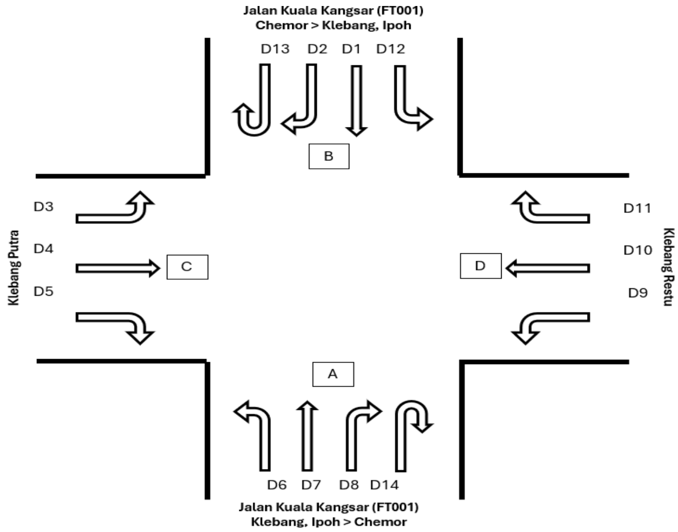


Figure 4.8: Intersection Direction Indicator at the location of Traffic Counts

Table 4.3 below shows the explanation of the direction to the indicator by path for Figure 4.8 above.

Table 4.3: Indicator by Path and Direction for Kuala Kangsar Intersection

MOVEMENT	INDICATOR	DIRECTION
A	D6	Klebang, Ipoh to Klebang Putra
	D7	Klebang, Ipoh to Chemor
	D8	Klebang, Ipoh to Klebang Restu
	D14	Klebang, Ipoh to Klebang, Ipoh (make a U-turn)
B	D1	Chemor to Klebang, Ipoh
	D2	Chemor to Klebang Putra
	D12	Chemor to Klebang Restu
	D13	Chemor to Chemor (make a U-turn)
C	D3	Klebang Putra to Chemor
	D4	Klebang Putra to Klebang Restu
	D5	Klebang Putra to Klebang, Ipoh
D	D9	Klebang Restu to Klebang, Ipoh
	D10	Klebang Restu to Klebang Putra
	D11	Klebang Restu to Chemor

4.2.4 Recognize the Problem of Crumbling Infrastructure Due to the Volume of Vehicles

Crumbling infrastructure, especially deteriorating roads, is a significant issue linked to traffic volumes exceeding the capacity limits set during their design. Initially, roads are designed based on expected traffic, vehicle types, design lifespan, and material durability. However, population growth, economic development, urban sprawl, and limited public transit often lead to higher-than-anticipated traffic volumes. This excessive use accelerates road deterioration, causing frequent potholes, structural damage, increased maintenance costs, and safety risks. Table 4.4 below shows the volume vehicles that can cause Crumbling Infrastructure and risk to that condition.

Table 4.4: Volume of Vehicles May Caused Crumbling Infrastructure

Volume vehicles (Time : am + pm)	Direction	Crumbling infrastructure	Risk
4542	A	Vehicles volume that exceeds the road capacity limit during the design of the road.	1. Road deposits. 2. Road congestion. 3. Risk of road accidents. 4. Risk of death and permanent disability
3697	B		
2290	C		
3133	D		

The number of vehicles that exceed the road capacity limit can be known through the LoS category on the road.

4.2.5 Identify Traffic LoS Categories using SIDRA Software

SIDRA software is a traffic engineering software used to analyze and evaluate the performance of intersections, including signalized and unsignalized types, roundabouts, and network intersections. It assesses key performance indicators such as delay, queue length, capacity utilization, and stop rate to determine LoS categories, which range from A (free flow) to F (breakdown flow).

To find out the LoS on a road using SIDRA software, vehicle volume data needs to be entered for analysis. After several processes have been done, the results of the analysis will be obtained as shown in Figure 4.9 below.

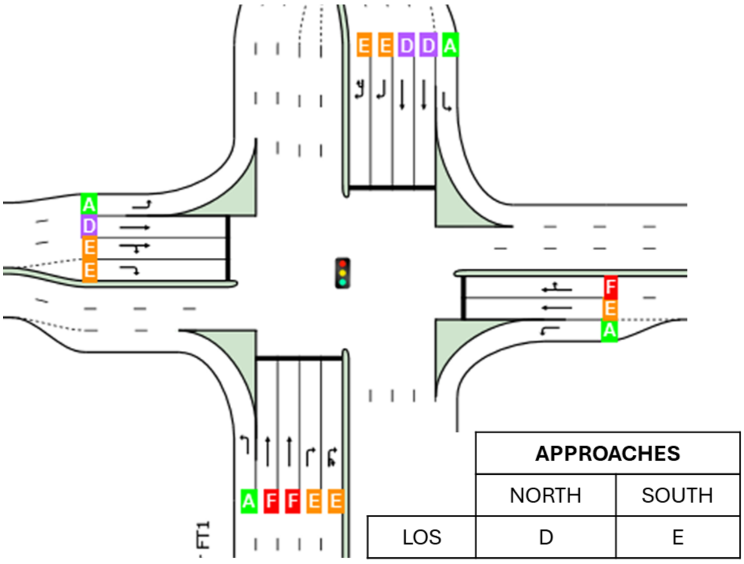


Figure 4.9: LoS Categories at Intersection

The study road from Klebang, Ipoh to Chemor is towards the north showing the LoS category D while the road towards the North which is from Chemor to Klebang, Ipoh shows the LoS category of the road is E based on the results from the SIDRA software referring to Figure 4.9 above.

This shows that the road in both directions is not smooth and unstable flow during peak hours in the morning and evening. LoS traffic condition D means the road is almost at capacity, causing high vehicle density and restricted manoeuvrability. Speeds are reduced, and drivers frequently face delays and stop-and-go conditions, leading to significant frustration. The traffic flow is congested but still moving, though with limited space for lane changes or overtaking, contributing to driver stress.

Meanwhile LoS E describes a traffic condition where the road is at full capacity, resulting in extremely slow speeds and highly unstable flow. Traffic is densely packed, with minimal room for manoeuvring, causing frequent stops and starts. This leads to severe congestion, unpredictable travel times, and high driver stress. Any slight disruption can cause gridlock, making LOS E highly undesirable for efficient travel. The description of the operational conditions for each LoS category can be refer to Figure 2.4 in Chapter 2.

4.2.6 Conclusion

As a result of the traffic count that has been done, the vehicles volume is entered into the SIDRA software to find out the Level of Service category on the road Section Number 607 to 610. Analysis results been generated from the SIDRA software show the study road is categorized as LoS D and LoS E for both- two way Klebang, Ipoh to Chemor. This proves the vehicle volumes on the road caused the instability of traffic flow during peak hours which means almost at capacity for the road, causing high vehicle density and restricted manoeuvrability. Many vehicles, especially heavy vehicles, are a contributor to road damage that leads to the risk of road accidents

4.3 DETERMINE THE RISK OF ROAD ACCIDENT CAUSE BY DETERIORATING ROAD CONDITIONS CONSEQUENCE OF CRUMBLING INFRASTRUCTURE FOR ROAD USER BY P.W.D. ROAD SAFETY AUDIT (RSA) GUIDELINE SECOND EDITION IN 2002

4.3.1 Road Accidents on Jalan Kuala Kangsar (FT001) at Section Number 607 until Section Number 610

The study reveals that numerous accidents occur along Jalan Kuala Kangsar (FT001), a Federal Road in Malaysia, and also in Section Number 607 to 610. These accidents often result in fatalities, serious injuries, minor injuries, and damage to the victim's vehicle. Police Data data comes from accident reports from victims, while RAMS data is derived from accident reports from Polis Di Raja Malaysia (PDRM) and Public Work Department (P.W.D.). The results highlight the need for improved road safety measures.

There are different types of information stated in the Accident Data Form from Police Data. All victims report information is recorded based on the elements in the report form. The categories recorded are Type of Accidents, Type of First Violation, Road Defect and Type of Vehicles involved. Most of the types of accidents that occur are fatal accidents and minor injuries to road accident victims. While accidents caused by road defects tend to be "Not Applicable" which means that the category of road defects reported by the victim is not included in the elements provided in the Police Accident Form.

Based on interviews with P.W.D (JKR) Ipoh, Perak representatives, it was found that the cause of the accident was due to road defects. Other than the categories stated in the list of road defects will be classified as "Not Applicable". Sometimes the cause of road accidents can be caused by the victim's own negligence and not due to engineering factors on the road itself. Therefore, the police will state "Not Applicable". Below is the Accident Data from Polis Perak and publish from Perak P.W.D under Road Planning Department as Figure 4.10 below and in **Appendix A.**

BORANG DATA KEMALANGAN

BAHAGIAN PERANCANG JALAN
KEMENTERIAN KERJA RAYA MALAYSIA

DAERAH : KINTA
NEGERI : PERAK
TAHUN : 2018

BIL	NO. ADUAN	TARIKH KEMALANGAN	MASA	NAMA JALAN DAN NO. LALUAN	NO. SEKSYEN	LOKASI (KOORDINAT)		JENIS KEMALANGAN (Sila √)				JENIS PELANGGARAN PERTAMA*	KECACATAN JALAN**	JENIS KENDERAAN (Sila √)							CATATAN (HPU)
						Latitude	Longitude	MAUT	PARAH	RINGAN	ROSAK			Mkar	Van	Lori	Bas	Msikal	P/Kaki	Bsikal	
1	026432	12.12.2018	4.00 ptg	Jalan Kuala Kangsar (FT001)	607	4.41.01	101.07.16	/				12	12					/			

DAERAH : KINTA
NEGERI : PERAK
TAHUN : 2019

BIL	NO. ADUAN	TARIKH KEMALANGAN	MASA	NAMA JALAN DAN NO. LALUAN	NO. SEKSYEN	LOKASI (KOORDINAT)		JENIS KEMALANGAN (Sila √)				JENIS PELANGGARAN PERTAMA*	KECACATAN JALAN**	JENIS KENDERAAN (Sila √)							CATATAN (HPU)
						Latitude	Longitude	MAUT	PARAH	RINGAN	ROSAK			Mkar	Van	Lori	Bas	Msikal	P/Kaki	Bsikal	
1	011950	30.05.2019	8.30 pg	Jalan Kuala Kangsar (FT001)	610.10	4.42.17	101.07.20	√				10	12	√					√		
2	010410	10.05.2019	12.00 tgh		607.80	4.41.4	101.07.15	√				4	12			√		√			lampu Isyarat Klebang Restu (Mcdonald Klebang)
3	010283	08.05.2018	4.45 ptg		609	4.41.21	101.07.17	√				12	12	√√				√			Bandar Baru Sri Klebang

DAERAH : KINTA
NEGERI : PERAK
TAHUN : 2020

BIL	NO. ADUAN	TARIKH KEMALANGAN	MASA	NAMA JALAN DAN NO. LALUAN	NO. SEKSYEN	LOKASI (KOORDINAT)		JENIS KEMALANGAN (Sila √)				JENIS PELANGGARAN PERTAMA*	KECACATAN JALAN**	JENIS KENDERAAN (Sila √)							CATATAN (HPU)
						Latitude	Longitude	MAUT	PARAH	RINGAN	ROSAK			Mkar	Van	Lori	Bas	Msikal	P/Kaki	Bsikal	
1	020190	30.11.2020	12.04 tgh	Jalan Kuala Kangsar (FT001)	607.8	4.41.05	101.07.15		√			4	12	√				√			
2	008880	12.06.2020	8.03 pg		609.25	4.6975911	101.122387	√				5	12	√				√			

DAERAH : KINTA
NEGERI : PERAK
TAHUN : 2021

BIL	NO. ADUAN	TARIKH KEMALANGAN	MASA	NAMA JALAN DAN NO. LALUAN	NO. SEKSYEN	LOKASI (KOORDINAT)		JENIS KEMALANGAN (Sila √)				JENIS PELANGGARAN PERTAMA*	KECACATAN JALAN**	JENIS KENDERAAN (Sila √)							CATATAN (HPU)
						Latitude	Longitude	MAUT	PARAH	RINGAN	ROSAK			Mkar	Van	Lori	Bas	Msikal	P/Kaki	Bsikal	
1	000457	07.01.2021	11.24 mlm	Jalan Kuala Kangsar (FT001)	607.95	4.41.11	101.7.16	√				1	12	√						√	
2	000537	09.01.2021	7.31 pg		609.55	4.42.00	101.7.381	√				7	12					√			berdekatan kilang Hovid Klebang
3	000753	12.01.2021	07.33 mlm		609.2	4.69.81	101.12.37				√	4	12	√				√			lampu isyarat sri klebang
4	000762	13.01.2021	3.15 ptg		606.88	4.40.34	101.7.14			√		7	12					√			
5	001204	21.01.2021	10.45 pg		606.95	4.40.27	101.7.16			√		12	12					√			berdekatan AEON Klebang
6	003551	03.03.2021	9.10 mlm		609.5	4.41.58	101.07.22	√				12	12					√			berdekatan kilang Hovid Klebang
7	003809	07.03.2021	10.56 pg		608.1	4.41.19	101.07.16			√		12	6	√							
8	004422	16.03.2021	9.49 pg		607.2	4.67.8413	101.121.043			√		12	12					√			berdekatan AEON Klebang
9	011941	07.08.2021	11.26 mlm		607.81	4.41.4	101.7.16			√		4	12	√				√			
10	014575	30.09.2021	8.29 mlm		607.4	4.40.28	101.07.13				√	2	12	√				√			
11	013716	14.09.2021	1.26 ptg		610.8	4.35.56	101.4.25	√				2	12	√				√			
12	014722	02.10.2021	3.20 ptg		607.6	4.41.03	101.07.16			√		2	12					√√			
13	014745	02.10.2021	9.45 mlm		607.4	4.40.54	101.07.15	√				12	12					√			
14	015008	06.10.2021	8.57 mlm		607.2	4.40.43	101.07.15			√		4	12	√				√√			
15	020534	28.12.2021	11.54 pg		607.17	4.40.43	101.07.15			√		1	12	√				√			

DAERAH : KINTA
NEGERI : PERAK
TAHUN : 2022

BIL	NO. ADUAN	TARIKH KEMALANGAN	MASA	NAMA JALAN DAN NO. LALUAN	NO. SEKSYEN	LOKASI (KOORDINAT)		JENIS KEMALANGAN (Sila √)				JENIS PELANGGARAN PERTAMA*	KECACATAN JALAN**	JENIS KENDERAAN (Sila √)							CATATAN (HPU)
						Latitude	Longitude	MAUT	PARAH	RINGAN	ROSAK			Mkar	Van	Lori	Bas	Msikal	P/Kaki	Bsikal	
1	004962	14.03.2022	7.25 pg	Jalan Kuala Kangsar (FT001)	607	1.1.1	1.1.1	√				10	12	√					√		
2	005156	16.03.2022	8.05 mlm		607.37	1.1.1	1.1.1	√				4	12	√				√			
3	008049	25.04.2022	1.15 ptg		609.07	4.42.35	101.7.19			√		7	12					√			
4	9381	11.05.2022	1.18 ptg		610.9	4.42.42	101.07.20	√				12	12					√			
5	13791	05.07.2022	8.48 mlm		609.8	4.42.07	101.07.21			√		5	12					√			
6	26068	11.12.2022	5.38 ptg		609	0	0	√				12	12	√				√			

DAERAH : KINTA
NEGERI : PERAK
TAHUN : 2023

BIL	NO. ADUAN	TARIKH KEMALANGAN	MASA	NAMA JALAN DAN NO. LALUAN	NO. SEKSYEN	LOKASI (KOORDINAT)		JENIS KEMALANGAN (Sila √)				JENIS PELANGGARAN PERTAMA*	KECACATAN JALAN**	JENIS KENDERAAN (Sila √)							CATATAN (HPU)
						Latitude	Longitude	MAUT	PARAH	RINGAN	ROSAK			Mkar	Van	Lori	Bas	Msikal	P/Kaki	Bsikal	
1	1.61E+13	4/2/2023	6.19 ptg	Jalan Kuala Kangsar (FT001)	609.1	4.6981	101.1225	√				12	12								
2	1.61E+13	12/4/2023	5.35 ptg		610.5	4.6533	101.1322			√		4	12								
3	1.61E+13	18/4/2023	6.35 ptg		610.5	-76.300003	-148	√				4	12								
4	1.61E+13	16/5/2023	9.30 pg		610.1	4.7058	101.1222	√				4	12								
5	1.61E+13	22/5/2023	8.50 mlm		607.6	4.6814	101.1211			√		8	12								

Figure 4.10: Accidents Data by Road Planning Department from Perak P.W.D on Year 2018 until Year 2023

4.3.2 Total Accidents at Jalan Kuala Kangsar (FT001) Section Number 607 until Section Number 610

As a result of the findings of the PDRM's Accident Data Form report received, a summary of understanding has been done as in Figure 4.11, Figure 4.13 and Figure 4.14. A description of each diagram is described below the diagram.

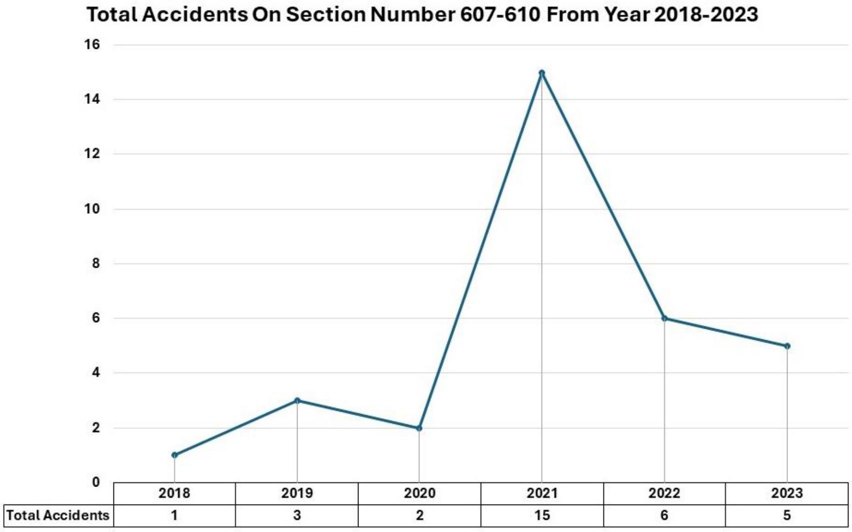


Figure 4.11: Line Marker on Total Accidents from Year 2018 until 2023

Figure 4.11 above shows the line graph illustrates the total number of accidents on road section number 607 to 610 over the six-year period from 2018 to 2023. In 2018, there was only one recorded accident. This initial low number indicates relatively safer conditions on this section of the road, or possibly lower traffic volume compared to subsequent years. The number of accidents increased to three in 2019. This moderate rise suggests a potential decline in road conditions or an increase in traffic density, contributing to a higher accident rate.

In 2020, the total number of accidents slightly decreased to two. This slight dip could indicate temporary improvements in road safety measures or a reduction in traffic, potentially due to external factors such as the COVID-19 pandemic leading to fewer vehicles on the road. The year 2021 saw a dramatic spike in accidents, with a total of 15 incidents. This significant increase highlights a severe deterioration in road safety, possibly due to worsening road conditions, increased traffic, or other contributing factors such as poor weather or road maintenance issues. This year marks the highest number of accidents recorded in the six-year period.

In 2022, the number of accidents decreased to six. Despite the decline, this number remains significantly higher than the years before 2021, indicating that while conditions may have improved from the previous year, they were still not as safe as in earlier years. By 2023, the total number of accidents further decreased to five. This continued decline suggests ongoing efforts to improve road safety or a natural stabilization of traffic patterns. However, the number is still higher than the initial years of the study, pointing to a need for sustained or enhanced safety measures to bring the accident rate down to the levels seen in 2018 and 2019.

However, the number of accidents has decreased in 2022 and 2023 after the work has been done in 2022 based on the maintenance schedule that has been done as shown in the Figure 4.12 below.

Tahun	Pejabat Pelaksana	Perihal Kerja	Tarikh Sebenar Mula	Tarikh Sebenar Siap	Nama Kontraktor
2022	JKR Daerah Kinta	Kerja-kerja Mill and Pave dan lain-lain kerja berkaitan (CRMA) di Jalan Spg Klebang – Kanthan FT001 seksyen 609.00 – 610.00 (L&R), Daerah Kinta (Fasa 3)	6-Oct-22	31-Oct-22	BELATI WANGSA (M) SDN. BHD.
2023		Berkala Pavemen / Fasa 1 / 2023 / Kinta / Jalan Ipoh - Jalan Butterworth / FT001 / 606.00 - 607.00 (L&R) / Kerja-Kerja Mill and Pave Dan Lain-Lain Kerja Berkaitan (MR6)	29-Mar-23	30-Jun-23	
		Berkala Pavemen / Fasa 2 / 2023 / Kinta / Jalan Ipoh – Jalan Butterworth / FT0001 / 608.00 – 611.00 L&R (LOC) / Kerja-Kerja Mill and Pave Dan Lain-Lain Kerja Berkaitan (SFM)	1-Aug-23	31-Oct-23	
2024		Berkala Pavemen / Fasa 1 / 2024 / Kinta / Jalan Ipoh - Butterworth/ FT001 / 611.50 / 612.50 / L&R / Kerja-Kerja Mill And Pave Dan Lain-Lain Kerja Berkaitan (AC14)	1-Mar-24	On Progress	

Figure 4.12: List of P.W.D Maintenance Works Approved on Jalan Kuala Kangsar (FT001)

Overall, the data from 2018 to 2023 shows a troubling trend with a peak in 2021, followed by gradual improvements in subsequent years. This pattern underscores the importance of continuous monitoring and maintenance of road conditions to ensure the safety of road users.

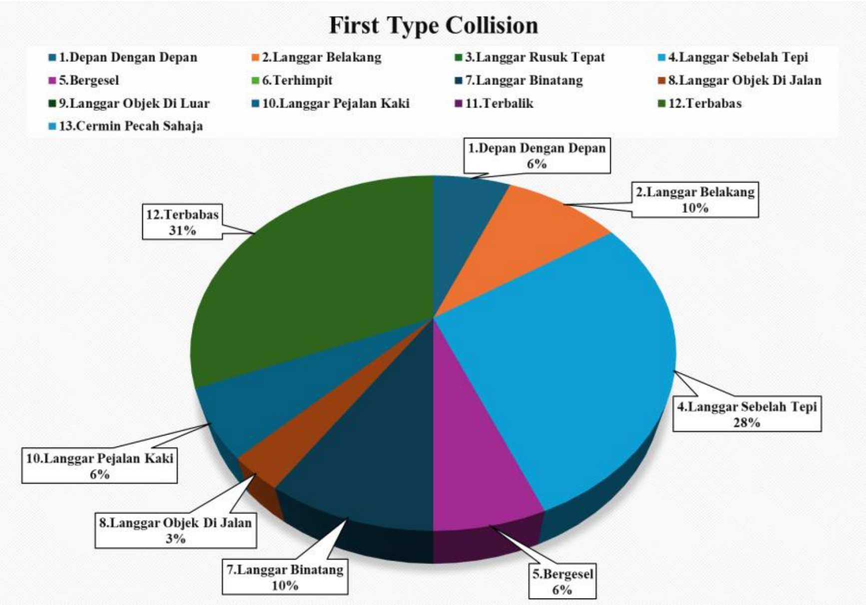


Figure 4.13: Pie Chart on Accidents First Type of Collision

Figure 4.13 above shows a pie chart provides a visual representation of the various types of collisions that occurred on road sections 607 to 610 from 2018 to 2023. The most common type of collision is skidding or losing control (*Terbabas*), accounting for 31% of the incidents. This indicates potential issues with road conditions, driver behaviour, or vehicle maintenance that need addressing to improve safety.

Side-swipe collisions (*Langgar Sebelah Tepi*) make up 28% of the incidents, highlighting problems with lane discipline or driver awareness. Rear-end collisions (Langgar Belakang) and animal collisions (Langgar Binatang) each constitute 10% of the total, suggesting frequent sudden stops or close following distances and the presence of wildlife or stray animals, respectively.

Other notable collision types include Front-To-Front Collisions (*Depan Dengan Depan*) and Pedestrian Collisions (*Langgar Pejalan Kaki*), each at 6%. These Figures underscore the importance of safe driving practices and pedestrian safety measures. Minor collision types, such as Scraping Collisions (*Bergesel*) and Collisions With Road Objects (*Langgar Objek Di Jalan*), are less frequent but still significant. These account for 6% and 3%, respectively, and indicate issues like minor vehicle interactions and obstacles on the road.

Overall, the data emphasizes the need for improved road safety measures, better driver education, and enhanced wildlife management to reduce the frequency of these collisions on the specified road sections.

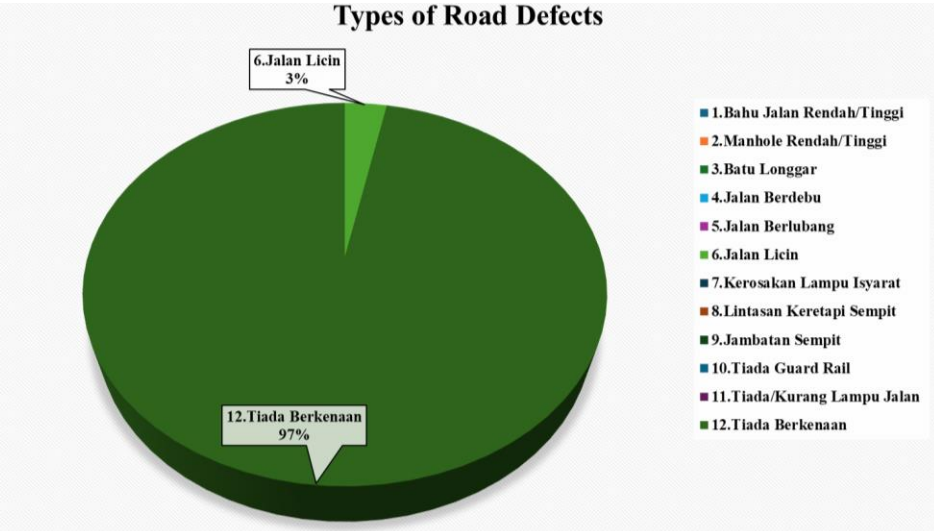


Figure 4.14: Pie Chart on Accident Types of Road Defects

Figure 4.14 above shows the pie chart to illustrate the types of road defects that have caused accidents on road sections 607 to 610 from Year 2018 to Year 2023. The majority of accidents, 97%, are Not Related To Road Defects (*Tiada Berkenaan*). This indicates that factors other than road conditions, such as driver behaviour or vehicle issues, are primarily responsible for most accidents in these sections.

A small portion, 3%, of accidents are due to Slippery Roads (*Jalan Licin*). Slippery conditions can be caused by rain, oil spills, or other substances on the road, which reduce traction and increase the likelihood of vehicles losing control. Other potential road defects listed but not significantly represented in the data include Uneven Road Shoulders (*Bahu Jalan Rendah/Tinggi*), Uneven Manholes (*Manhole Rendah/Tinggi*), Loose Stones (*Batu Longgar*), Dusty Roads (*Jalan Berdebu*), And Potholes (*Jalan Berlubang*). These issues can pose various risks to drivers, such as difficulty maintaining control or damage to vehicles.

Additional listed defects include Traffic Light Malfunctions (*Kerosakan Lampu Isyarat*), Narrow Railway Crossings (*Lintasan Keretapi Sempit*), Narrow Bridges (*Jambatan Sempit*), Absence Of Guard Rails (*Tiada Guard Rail*), and Insufficient Street Lighting (*Tiada/Kurang Lampu Jalan*). These defects, though not significantly represented, highlight potential areas for infrastructure improvements to enhance road safety.

The chart emphasizes that while road defects are not the primary cause of most accidents in these sections, attention to even minor defects like slippery roads can contribute to improved safety measures.

The conclusion to the entire analysis that has been made regarding the accidents data from Police Data, the data from Year 2018 to Year 2023 highlights the need for continuous monitoring and maintenance of road conditions, improved road safety measures, better driver education, and enhanced wildlife management to reduce collisions. While road defects are not the primary cause of most accidents, addressing minor defects like slippery roads can further enhance safety.

4.3.3 Road Factor

Poor road conditions and crumbling infrastructure significantly increase the risk of road accidents. Potholes, cracks, uneven surfaces, and faded road markings can cause drivers to lose control, leading to crashes. Structurally weak bridges, inadequate signage, and poor drainage systems also pose serious hazards. These issues are exacerbated by excessive traffic volume, substandard construction materials, and delayed maintenance. To mitigate these risks, regular maintenance, infrastructure upgrades, effective traffic management, and clear signage are essential. Addressing these factors can significantly enhance road safety for all users.

4.3.3.1 Road Conditions on Jalan Kuala Kangsar (FT001) at Section Number 607 until Section Number 610

An observation to conduct a road audit inspection was carried out on the study road which is at Jalan Kuala Kangsar (FT001) at Section Number 607-610 with an engineer experienced in the field of road sections. The observation carried out was on April 30, 2024 as a rough and random observation while on May 17, 2024, video was taken along the study road to record the actual condition of the road. Gross observation and video taking are in two sessions, during the day and at night to find out the actual condition of the study road and the level of safety for road users.

Based on the research that has been done on the study road, it was found that various problems and damages can be identified that exist especially on the road surface.

4.3.3.2 Crumbling Infrastructure

Crumbling infrastructure can be explained with the support of the Priority Criteria Checklist Form by P.W.D, Kinta. This form explains the priority of work that needs to be focused and taken immediate action by P.W.D Malaysia. On the form, the route number, district and road section, road topography and road type are stated. The Figure 4.15 below is an example of the Priority Criteria Checklist Form by P.W.D Malaysia. The entire form can be seen in the **Appendix B**.

[No. Borang :..........]
JabatanKerja Raya Malaysia

RANKING: 5

BORANG SENARAI SEMAK KRITERIA KEUTAMAAN
SKOP : PAVEMEN

NomborLaluan / Nama Jalan :FT001 / Jalan Ipoh - Butterworth
Daerah / Seksyen : Kinta / 608.00 – 609.20
Bentukmukabumi / Terrain : (*Flat* / ~~*Rolling / Mountainous / Selekoh*~~)
*silapotong mana yang tidakberkaitan
Luas kawasanpembaikan (m²) :
Jenis jalan (*C/way, No.of Lanes*) : 3 Lanes, Dual C/way

BIL	KRITERIA PERTIMBANGAN	PENILAIAN	LAIN -LAIN
1	**KESELAMATAN** Bilangan Kemalangan dan Jenis Kemalangan dalam masa 3 tahun terkini. *(Rujukan: POL 27 / RekodJabatan / Agensi)*	**PENILAIAN** (Nota: NyatakanBilangan)	**CATATAN**
	CederaRingan	3 nos	2020,2022
	Parah	-	
	Maut	2nos	
2	**KEROSAKAN** a) Kategori Kerosakan	**PENILAIAN** (Nota: Tandakan √)	**CATATAN**
	KerosakanPermukaan (Functional)	√	KRITIKAL
	KerosakanStruktur (Structural)		
	b) Jenis Kerosakan Permukaan	**PENILAIAN** (Nota: Tandakan √)	***LEVEL OF SEVERITY*** (Silanyatakan Level of Severity berdasarkanrujukanLampiran1)
	Pavement Cracks		
	Crocodile crack	√	3
	Block Crack	√	3
	Longitudinal Cracks	√	3
	Transvers Cracks		
	Edge Cracks		
	Crescent Shaped Cracks		
	Surface Deformations		
	Rutting	√	3
	Depression	√	3
	Corrugation		
	Shoving		
	Surface Defects		
	Bleeding		
	Polishing		
	Raveling	√	3
	Delamination	√	3
	Lain – lain (silanyatakan)		

[No. Borang :..........]
JabatanKerja Raya Malaysia

RANKING: 8

BORANG SENARAI SEMAK KRITERIA KEUTAMAAN
SKOP : PAVEMEN

NomborLaluan / Nama Jalan :FT001 / Jalan Ipoh – Butterworth
Daerah / Seksyen : Kinta / 609.80 – 611.30
Bentukmukabumi / Terrain : (*Flat* / ~~*Rolling / Mountainous / Selekoh*~~)
*silapotong mana yang tidakberkaitan
Luas kawasanpembaikan (m²) :
Jenis jalan (*C/way, No.of Lanes*) : 2 Lanes, Dual C/way

BIL	KRITERIA PERTIMBANGAN	PENILAIAN	LAIN -LAIN
1	**KESELAMATAN** BilanganKemalangandanJenisKemalangandalam masa 3 tahunterkini. *(Rujukan: POL 27 / RekodJabatan / Agensi)*	**PENILAIAN** (Nota: NyatakanBilangan)	**CATATAN**
	CederaRingan	1 nos	2022
	Parah	1 nos	2021
	Maut	1 nos	2021
2	**KEROSAKAN** a) KategoriKerosakan	**PENILAIAN** (Nota: Tandakan √)	**CATATAN**
	KerosakanPermukaan (Functional)	√	KRITIKAL
	KerosakanStruktur (Structural)		
	b) JenisKerosakanPermukaan	**PENILAIAN** (Nota: Tandakan √)	***LEVEL OF SEVERITY*** (Silanyatakan Level of Severity,berdasarkanrujukanLampiran1)
	Pavement Cracks		
	Crocodile crack	√	3
	Block Crack	√	3
	Longitudinal Cracks	√	3
	Transvers Cracks		
	Edge Cracks		
	Crescent Shaped Cracks		
	Surface Deformations		
	Rutting		
	Depression	√	3
	Corrugation		
	Shoving		
	Surface Defects		
	Bleeding		
	Polishing	√	3
	Raveling		
	Delamination		
	Lain – lain (silanyatakan)		

Figure 4.15: Priority Criteria Checklist Form by P.W.D Updated in 2023 for Section Number 608-609.2

a. Surface Damage

Based on the Figure 4.15 of the form above and the support from the observations that have been made, the damage to the study road surface is at a critical level. This is because the number of accidents is 8, with 3 fatal accidents and 1 serious injury while 4 minor injuries. The number of these accidents is based on the years

2020 to 2022 recorded in the Priority Criteria Checklist Form by the P.W.D according to the priority of the case.

b. Type of Surface Damage

Table 4.5 below shows the elements found at the location of the road based on the ranking of the Work Priority Criteria Checklist Form In Year 2023 and the Level of Severity for each element of road surface damage.

Table 4.5: Consideration Criteria from Year 2020 to 2022

Type of Surface Damage	Work Priority Criteria Checklist Form In 2023				Level of Severity
	2020	2022	2021	2022	
	Ranking 5		Ranking 8		
Pavement Cracks					
Crocodile crack	√	√	√	√	3 (High)
Block Crack	√	√	√	√	3 (High)
Longitudinal Cracks	√	√	√	√	3 (High)
Transvers Cracks	-	-	-	-	
Edge Cracks	-	-	-	-	
Crescent Shaped Cracks	-	-	-	-	
Surface Deformations					
Rutting	√	√	-	-	3 (High)
Depression	√	√	√	√	3 (High)
Corrugation	-	-	-	-	
Shoving	-	-	-	-	
Surface Defects					
Bleeding	-	-	-	-	
Polishing	-	-	√	√	3 (High)
Ravelling	√	√	-	-	3 (High)
Delamination	√	√	-	-	3 (High)
Others	-	-	-	-	

4.3.4 Type of Road Surface Damage from Priority Criteria Checklist Form by P.W.D Updated on Year 2023

4.3.4.1 Data Collection

Jalan Kuala Kangsar (FT001) has a risk of road accidents with evidence of crumbling infrastructure. The summary of the Priority Criteria Checklist Form by P.W.D as Table 4.6 below which has been updated in 2023 by P.W.D from Figure 4.15 above.

Table 4.6: Type of Surface Damage and the Risk of Road Accidents on Priority Criteria Checklist Form by P.W.D at Jalan Kuala Kangsar (FT001) Section Number 607 until 610

Type of Surface Damage	**2020**	**2022**	**2021**	**2022**	**Level of Severity**	**Volume Vehicles 2023: 2181 veh/hr**	**Risk of Road Accidents**			
	Ranking 5		**Ranking 8**				**Death**	**Light Injured**	**Badly Injured**	**Damage**
Pavement Cracks										
Crocodile crack	√	√	√	√	3 (High)	-	√	√		
Block Crack	√	√	√	√	3 (High)	-	√	√		
Longitudinal Cracks	√	√	√	√	3 (High)	-	√	√		
Transvers Cracks						-				
Edge Cracks						-				
Crescent Shaped Cracks						-				
Surface Deformations										
Rutting	√	√			3 (High)	-	√	√		
Depression	√	√	√	√	3 (High)	-	√	√		
Corrugation						-				
Shoving						-				
Surface Defects										
Bleeding						-				
Polishing			√	√	3 (High)	-	√	√		
Ravelling	√	√			3 (High)	-	√	√		
Delamination	√	√			3 (High)	-	√	√		
Others						-				

From the data collection Table 4.6 above, it shows that in 2022 it is at two rankings and the Level of Severity is at level 3, which is a high level of damage to the road. It can be said that the surface damage in 2022 is very bad with all the average Level of Severity at level 3.

Data collection of Critical Ranking for The Type of Surface Damage and Level of Severity from the Priority Criteria Checklist Form by P.W.D at Jalan Kuala Kangsar (FT001) as in Table 4.7 below.

Table 4.7: Critical Ranking for The Type of Surface Damage and Level of Severity

Crumbling Infrastructure		Assessment of Types of Surface Damage : Year 2023		Level of Severity		
Surface Damage	Structural Damage	Critical Ranking To Act				
Type of Surface Damage		5	8	1 (Low)	2 (Moderate)	3 (High)
		Pavement Cracks				
Crocodile crack	-	1	1	-	-	1
Block Crack	-	1	1	-	-	1
Longitudinal Cracks	-	1	1	-	-	1
Transvers Cracks	-	-	-	-	-	-
Edge Cracks	-	-	-	-	-	-
Crescent Shaped Cracks	-	-	-	-	-	-
		Surface Deformations				
Rutting	-	1	-	-	-	1
Depression	-	1	1	-	-	1
Corrugation	-	-	-	-	-	-
Shoving	-	-	-	-	-	-
		Surface Defects				
Bleeding	-	-	-	-	-	-
Polishing	-	-	1	-	-	1
Ravelling	-	1	-	-	-	1
Delamination	-	1	-	-	-	1
Others	-	-	-	-	-	-

1	: Have defect reported
-	: No defect reported

4.3.4.2 Analysis

The following Table 4.8 below is an analysis that has been done based on the crumbling infrastructure factor caused by the type of surface damage and the level of severity on the road.

Table 4.8: Analysis of Type and Elements of Surface Damage Relate with Level of Severity

Crumbling Infrastructure		Level of Severity		
Type of Surface Damage	Elements of Surface Damage	1 (Low)	2 (Moderate)	3 (High)
Pavement Cracks	Crocodile crack	0	0	2
	Block Crack	0	0	2
	Longitudinal Cracks	0	0	2
	Transvers Cracks	0	0	0
	Edge Cracks	0	0	0
	Crescent Shaped Cracks	0	0	0
Surface Deformations	Rutting	0	0	1
	Depression	0	0	2
	Corrugation	0	0	0
	Shoving	0	0	0
Surface Defects	Bleeding	0	0	0
	Polishing	0	0	1
	Ravelling	0	0	1
	Delamination	0	0	1
	Others	0	0	0

a. Result

The results of the analysis are as shown in Figure 4.16 below.

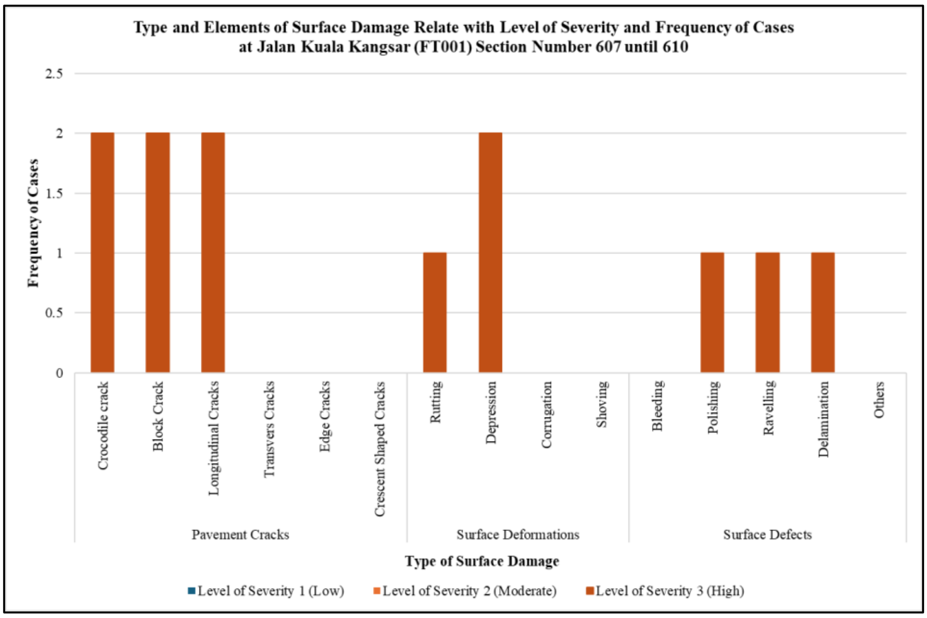


Figure 4.16: Level of Severity via of Type and Elements of Surface Damage at Jalan Kuala Kangsar (FT001) Section Number 607 until 610

Figure 4.16 above shows that the level of severity is at level 3, which is a high level means that the type of damage to the road surface is severe. This shows that the existing damage is at a critical level and has a risk of road accidents to road users on Jalan Kuala Kangsar (FT001) if no maintenance action is taken by the authorities.

4.3.5 Risk of Road Accident Cause by Deteriorating Road Conditions Consequence of Crumbling Infrastructure for Road User

4.3.5.1 Analysis The Risk of Road Accidents

The analysis that has been done on the risk of road accidents caused by deteriorating road conditions consequence of crumbling infrastructure for road users can be seen in the line graph of Figure 4.17 below.

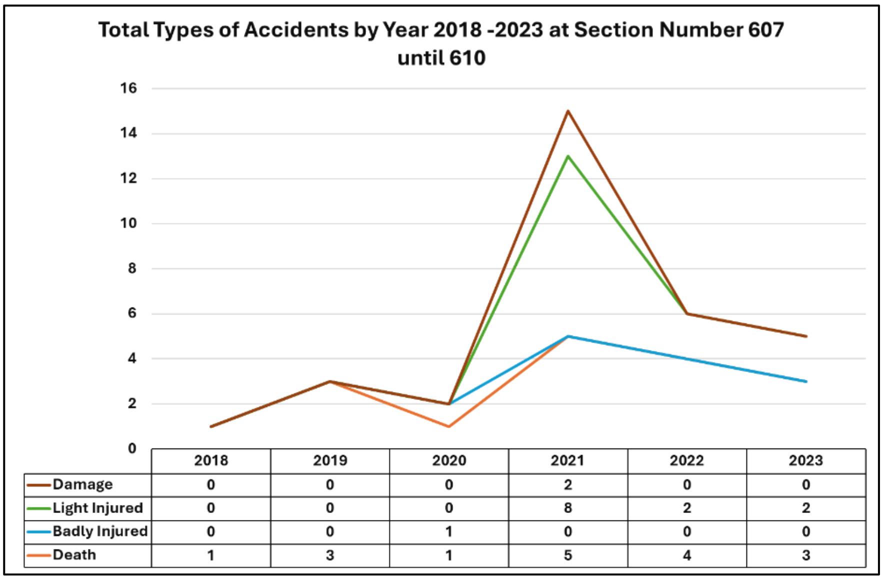


Figure 4.17: Total Number of Types of Accidents by Year 2018-2023 at Jalan Kuala Kangsar (FT001)

Figure 4.17 above shows "Number of Types of Accidents by Year" for the road Section Number 607 to 610 from year 2018 to year 2023 provides a breakdown of accident types. The types of accidents are categorized into Damage, Light Injured, Badly Injured, and Death.

In 2018, the road section number 607 to 610 experienced relatively fewer accidents. The only recorded incident was a fatal accident, resulting in one death. There were no incidents categorized as vehicle damage, light injuries, or serious injuries this year, indicating a lower overall. The year 2019 saw an increase in fatalities, with three deaths recorded. Similar to 2018, there were no accidents reported that resulted in vehicle damage, light injuries, or serious injuries. This increase in fatal accidents highlights a growing concern for road safety on this section of the road.

In 2020, the number of fatalities decreased to one. However, this year also saw the first recorded incident of a serious injury. There were no incidents of vehicle damage or light injuries. The presence of serious injuries alongside fatalities suggests a variation in the severity of accidents occurring on this road section.

The year 2021 marked a significant spike in accidents. There were eight incidents involving light injuries, which is a considerable increase compared to previous years. Additionally, there were five fatalities and two incidents resulting in vehicle damage. The substantial rise in both light injuries and fatalities points to a particularly hazardous period for this road section, potentially due to worsening road conditions or increased traffic.

Accidents in 2022 showed a decrease from the previous year but remained concerning. Four fatalities were recorded, alongside two incidents of light injuries. No accidents were categorized as vehicle damage or serious injuries. While the number of light injuries decreased, the persistence of fatal accidents indicates ongoing safety issues. The result of the maintenance that has been done in 2022 can be seen in Figure 4.17 above shows a drastic decrease in the total risk of road accidents in Section Number 607 to 610.

In 2023, the number of fatalities slightly decreased to three, and there were two incidents involving light injuries. No incidents were recorded for vehicle damage or serious injuries. This year showed a slight improvement in accident statistics compared to the peak in 2021, yet the continuing occurrence of fatalities and injuries underscores the need for sustained road safety measures.

4.3.6 Crumbling Infrastructure – Vertical and Horizontal Alignment of Road Safety Audit

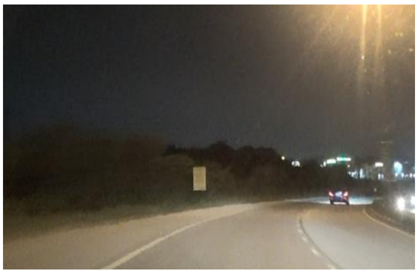
a. Observation

Site Inspections and observation on the study roads were carried out on 30 April 2024 and 17 May 2024 with guidance from Experienced Engineers in the Road Division. Observation was done during daylight and nighttime to know the view and situation on both times in with the view aspect of road user. Observation that been carried out shows various problems on the road Section Number 607-610. Among the problems found in the study path are as shown in the Table 4.9 (a) and Table 4.9 (b) below include with description of the problems. The reference to identify the type of surface damage is based on the book A Guide To The Visual Assessment Of Flexible Pavement Surface Condition by P.W.D.

Table 4.9 (a): List of Problems Occur on Road Section Number 607-610

 1. Longitudinal crack	 2. Crocodile crack
 3. Polishing	 4. Rutting & Longitudinal Crack
 5. Delamination & Depression	 6. Edge crack
 7. Shoving and Delamination	 8. Rutting and Depression
 9. Line marking not clear	 10. Signage not clear for sight distance

Table 4.9 (b): List of Problems Occur on Road Section Number 607-610

 11. Confusing line marking	 12. Curve Chevron Signage is not clear and not enough
 13. Signage not clear	 14. No signage to turn
 15. Stagnant water and no drain	 16. Streetlight does not function
 17. No streetlight, guardrail, road stud	 18. No detour signage and reduced speed limits

b. Data Collection Based On Site Inspection from RSA Guideline

After the observations have been made for both day and night, the problems that occur at the location of the study road should be identified for the purpose of analysis. The analysis performed is based on the RSA Guideline by emphasizing the Vertical and Horizontal Alignment elements as a focus on the crumbling infrastructure due to the damaged road condition. Table 4.10 below is the result of the analysis done.

Table 4.10: Analysis of The Risk of Road Accidents Caused by The Type of Surface Damage Factor Associated with Vertical and Horizontal Alignment Based on Observation

Type of Surface Damage	Volume Vehicles Collected by October 2023: 2181 veh/hr LoS by SIDRA Software : Category D				Checklist Site Inspection - Road Elements					
	Risk of Road Accidents				Vertical Alignment (↕)			Horizontal Alignment (↔)		
	Death	Light Injured	Badly Injured	Damage	Grades (Slopes)	Crests & Sags	Vertical Curves	Straight Section (Tangent)	Horizontal Curves	Superelevation
Pavement Cracks					**Observation on 30 April 2024 and 17 May 2024**					
Crocodile crack	√	√	-	-	-		√	√	√	-
Block Crack	√	√	-	-	-	√	-	-	-	-
Longitudinal Cracks	√	√	-	-	-	-	-	√	-	√
Transvers Cracks	-	-	-	-	-	-	-	-	-	-
Edge Cracks	-	-	-	-	√	-	-	-	-	√
Crescent Shaped Cracks	-	-	-	-	√	-	-	-	-	-
Surface Deformations										
Rutting	√	√	-	-	-	√	-	√	-	√
Depression	√	√	-	-	-	-	-	-	-	-
Corrugation	-	-	-	-	-	-	-	√	-	-
Shoving	-	-	-	-	-	-	-	-	-	-
Surface Defects										
Bleeding	-	-	-	-	-	-	-	-	-	-
Polishing	√	√	-	-	-	-	-	-	-	-
Ravelling	√	√	-	-	√	-	-	√	-	-
Delamination	√	√	-	-	√	-	-	-	-	-
Others	-	-	-	-	-	-	-	-	-	-

c. Total Data of Vertical and Horizontal Alignment

Observations that have been made along the road location show that the type of surface damage that occurs is on the Vertical and Horizontal Alignment elements. The results based on observations that have been made on 30 April 2024 and 17 May 2024 can be seen in the Table 4.11 below.

Table 4.11 : Total Data of Vertical and Horizontal Alignment from Observation

Crumbling Infrastructure	Road Safety Audit (RSA) Checklist Site Inspection - Road Elements Observation on 30 April 2024 and 17 May 2024							
Type of Surface Damage	Vertical Alignment (↕)			Total Vertical Alignment	Horizontal Alignment (↔)			Total Horizontal Alignment
	Grades (Slopes)	Crests & Sags	Vertical Curves		Straight Section (Tangent)	Horizontal Curves	Superelevation	
Pavement Cracks				**18**				**18**
Crocodile crack	1	0	0	3	1	0	0	6
Block Crack	1	0	0		1	0	0	
Longitudinal Cracks	0	0	0		1	0	1	
Transvers Cracks	0	0	0		0	0	0	
Edge Cracks	1	0	0		1	0	1	
Crescent Shaped Cracks	0	0	0		0	0	0	
Surface Deformations				**12**				**12**
Rutting	0	1	0	2	1	1	0	5
Depression	0	1	0		1	0	1	
Corrugation	0	0	0		0	0	0	
Shoving	0	0	0		1	0	0	
Surface Defects				**15**				**15**
Bleeding	0	0	0	2	0	0	0	4
Polishing	0	1	1		1	0	0	
Ravelling	0	0	0		1	0	0	
Delamination	0	0	0		1	0	0	
Others	0	0	0		1	0	0	

d. Analysis

The analysis that has been made is about the crumbling infrastructure that is done based on Site Inspection in the Vertical and Horizontal Alignment category for the road surface for the study road which is on Jalan Kuala Kangsar (FT001) Section Number 607-610. Table 4.12 below shows the analysis that has been made.

Table 4.12: Road Elements for Vertical and Horizontal Alignment in Percentage (%) for The Type of Surface Damage

Crumbling Infrastructure		Road Safety Audit (RSA) Checklist Site Inspection - Road Elements			
		Observation on 30 April 2024 and 17 May 2024			
Type of Surface Damage	**Element of Surface Damage**	**Total Vertical Alignment**	**Total Vertical Alignment in Percentage (%)**	**Total Horizontal Alignment**	**Total Horizontal Alignment in Percentage (%)**
Pavement Cracks	Crocodile crack Block Crack Longitudinal Cracks Transvers Cracks Edge Cracks Crescent Shaped Cracks	3	16.7%	6	33.3%
Surface Deformations	Rutting Depression Corrugation Shoving	2	16.7%	5	41.7%
Surface Defects	Bleeding Polishing Ravelling Delamination Others	2	13.3%	4	26.7%

e. Conclusion for Crumbling Infrastructure in Road Surface Damage

The conclusion from Table 4.12 above is issued in the form of a bar graph in Figure 4.18 below. The bar graph below shows values in decimal form for various types of surface damage on the road surface in Jalan Kuala Kangsar (FT001) in Section Number 607-610. From the chart below a comparison can be made between Vertical Alignment and Horizontal Alignment. Figure 4.18 below shows a bar chart effectively highlights the prevalence of various types of road surface damage in different alignments.

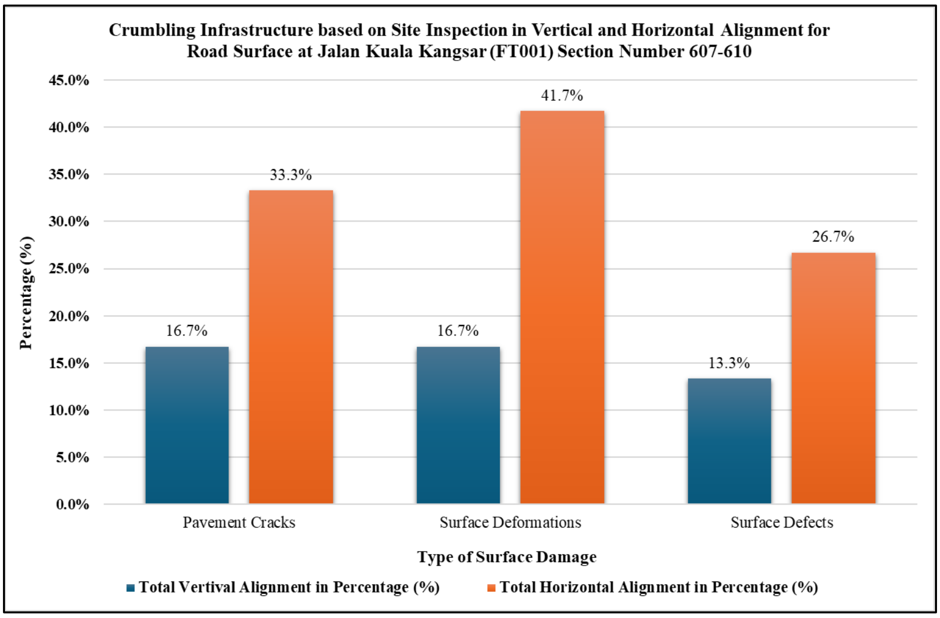


Figure 4.18: Comparison in Percentage (%) for Vertical Alignment and Horizontal Alignment

For pavement cracks, the data shows an equal percentage for both vertical and horizontal alignments at 16.7%. Pavement cracks in vertical alignment might be due to issues such as water pooling and poor drainage, which are exacerbated by changes in elevation. On the other hand, cracks in horizontal alignment could result from stresses caused by vehicles turning and braking, which exert lateral forces on the pavement.

Surface deformations are more prevalent, particularly in horizontal alignments, which account for 41.7% compared to 33.3% in vertical alignments. Surface deformations in vertical alignment can occur due to insufficient support or compaction under the road surface, often exacerbated by heavy loads and poor subgrade conditions. In horizontal alignment, deformations are more pronounced, possibly due to repeated stress from turning vehicles and the centrifugal forces acting on the pavement during curves.

Surface defects show a significant difference between vertical and horizontal alignments. In vertical alignment, they account for 13.3%, whereas in horizontal alignment, they account for 26.7%. Surface defects in vertical alignment may arise from uneven settlement or issues with the road base material, leading to an uneven road surface. Horizontal alignment defects can be attributed to the dynamic forces exerted by vehicles, especially in areas with high traffic volume or sharp curves.

From these comparison shows on bar chart underscores the need for targeted maintenance strategies to address the specific issues found in vertical and horizontal road alignments. By focusing on these areas, it is possible to improve the overall safety and durability of the road infrastructure, ultimately benefiting all road users.

4.3.6 Risk of Road Accident due to Crumble Infrastructure

Crumbling infrastructure significantly elevates the risk of road accidents by compromising road safety. This can be see through Table 4.13 below shows the various types of surface damage, such as pavement cracks, surface deformations, and surface defects, and the associated risks. Damages like crocodile cracks, block cracks, longitudinal cracks, rutting, depression, and ravelling are linked to serious accident outcomes, including deaths and injuries.

Table 4.13: Type of Surface Damage Align with Vertical and Horizontal Alignment in Percentage (%) with The Risk of Road Accident

Crumbling Infrastructure		**Assessment of Types of Surface Damage : Year 2023**				**Checklist Site Inspection - Road Elements**	
		LoS by SIDRA Software : Category D				**Observation on 30 April 2024 and 17 May 2024**	
Type of Surface Damage	**Element of Surface Damage**	**Risk of Road Accidents**				**Total Vertical Alignment in Percentage (%)**	**Total Horizontal Alignment in Percentage (%)**
		Death	Light Injured	Badly Injured	Damage		
Pavement Cracks	Crocodile crack	√	√			16.7%	33.3%
	Block Crack	√	√				
	Longitudinal Cracks	√	√				
	Transvers Cracks						
	Edge Cracks						
	Crescent Shaped Cracks						
Surface Deformations	Rutting	√	√			16.7%	41.7%
	Depression	√	√				
	Corrugation						
	Shoving						
Surface Defects	Bleeding					13.3%	26.7%
	Polishing	√	√				
	Ravelling	√	√				
	Delamination	√	√				
	Others						

The checklist from site inspections in April and May 2024 reveals the extent of vertical and horizontal alignment issues, with notable percentages indicating substantial road surface misalignments. These deteriorations highlight the urgent need for regular maintenance and infrastructure upgrades to ensure safer travel conditions for all road users.

Horizontal road curves high risk in road accidents. Crumble in surface deformations with a percentage of 41.7% contributes to the risk of death and also minor injuries for the type of surface damage such as rutting and depression. The second highest percentage is also in the horizontal category with a number of 33.3% for the type of surface damage Pavement cracks which also contribute to the risk of death and minor injuries. The third highest percentage is also in the Horizontal category of 26.7% on the type of surface damage Surface defects.

It can be concluded that the risk of road accidents is in the horizontal category for all three types of road surface damage in crumbling infrastructure, namely Surface deformations, Pavement cracks and Surface defects. Table 4.13 above also shows that the percentage in the vertical category is lower for all three types of road surface damage, namely Surface deformation and Pavement cracks each at 16.7% and Surface defects at 13.3%. In conclusion, the horizontal road category is more at risk of road accidents compared to the vertical road category. Even so, the vertical road also has the risk of death.

4.3.6.1 Level of Severity on Road

The percentage of total Vertical and Horizontal Alignment associated with the Level of Severity of the type of road surface damage can be seen in Table 4.14 and Figure 4.19 is an analysis of the percentage data.

Table 4.14: Total of Vertical and Horizontal Alignment in Percentage (%) and Level of Severity in Percentage (%)

Type of Surface Damage	Total Vertical Alignment in Percentage (%)	Total Horizontal Alignment in Percentage (%)	Level of Severity 1 (Low)	Level of Severity 2 (Moderate)	Level of Severity 3 (High)
Pavement Cracks	16.70%	33.30%	0%	0%	100%
Surface Deformations	16.70%	41.70%	0%	0%	100%
Surface Defects	13.30%	26.70%	0%	0%	100%

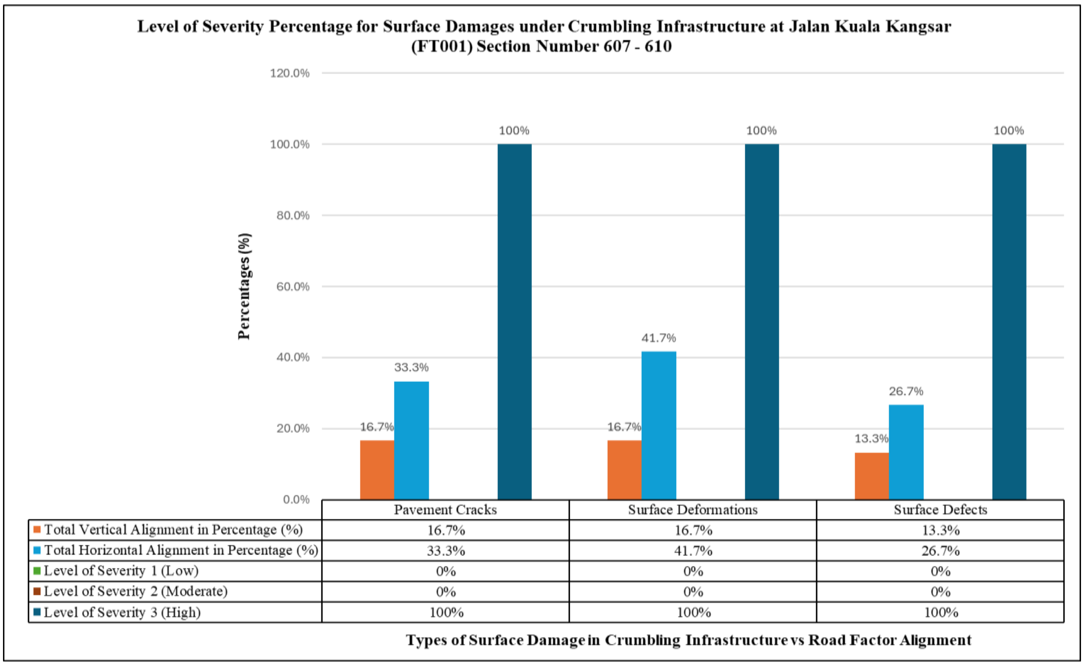


Figure 4.19: Level of Severity in Percentage (%) for Surface Damage under Crumbling Infrastructure at Jalan Kuala Kangsar (FT001) Section Number 607-610

Figure 4.19 above shows that pavement cracks result in 16.7% vertical alignment and 33.3% horizontal alignment issues. All these cracks are categorized as high severity (Level 3), indicating that pavement cracks severely disrupt the road surface, making driving conditions dangerous due to significant misalignment.

Surface deformations, such as rutting and depressions, cause 16.7% vertical alignment and 41.7% horizontal alignment problems. With 100% of these deformations classified as high severity (Level 3), they create major road surface undulations and misalignments, posing a serious risk to vehicle stability and road safety.

Surface defects, including bleeding and ravelling, lead to 13.3% vertical alignment and 26.7% horizontal alignment issues. All these defects are rated as high severity (Level 3), indicating that they significantly compromise road conditions, increasing the likelihood of accidents due to hazardous driving surfaces.

From the findings of the highest percentage on Surface Deformation, for the Surface Damage element, it shows that the Depression type damage is the highest compared to all elements which is 66.67% with the Level of Severity being 100% at Level 3. It can be concluded that Crumbling Infrastructure occurs a lot on Horizontal Alignment with depression-type surface damage that causes the risk of road accidents.

4.3.7 Conclusion

Accident data from P.W.D (JKR) Kinta from 2018 to 2023 underscores the link between crumbling infrastructure and accident rate with the highest recorded accidents in 2021 highlighting the severe consequences of deteriorating road conditions.

From data analysis for the entire objective, the results show that it is true that the risk of road accidents to road users is caused by damaged road infrastructure. The cause of the accident is due to the bad road condition factor with a high Level of Severity with 100% for the entire Type of Surface Damage which has been analyzed based on Vertical and Horizontal Alignment elements.

In addition, the Vertical and Horizontal Alignment element is also a factor in the risk of accidents to road users in Section Number 607 to 610. This can be proven by the data from Table 4.14 which shows 41.7% of surface deformations contributing to death and minor injuries. Pavement cracks and surface defects also contribute to this risk, with 26.7% of surface defects based on the Site Inspection that has been done.

4.4 PRODUCE THE ROAD SAFETY AUDIT (RSA) REPORT IN RISK OF ROAD ACCIDENT BY PRIMA REKA KONSULTAN TO RECOMMEND FOR P.W.D. (JKR) ACTION.

4.4.1 Road Safety Audit Report

RSA report at Stage 5 for Existing Road, was made to identify road factors that contribute to the risk of accidents for road users. The report is based on RSA Guidelines from P.W.D. 2nd edition in 2002. In Stage 5 of the audit process, the site inspection becomes a critical activity that demands careful planning and thorough execution. Site Inspections and observation on the study roads were carried out on 30 April 2024 and 17 May 2024 with guidance from Experienced Engineers in the Road Division with observing the site on both the day and night.

The inspection is conducted with the perspective of various road users in mind, paying particular attention to the needs of vulnerable users like pedestrians, bicyclists, and motorcyclists. Observation done shows various problems on the road Section

Number 607-610. Every problem that exists on the study road is recorded based on the Checklist of Site Inspection in the RSA Guideline. Among the problems that exist can be referred to Table 4.9 List of Problems Occur on Road Section Number 607-610 in Objective 2.

The front page of the RSA report is as the Figure 4.20 below while the full RSA report that has been made can be referred to **Appendix C**. The content list of the RSA report is as follows:

1. Introduction
2. Information Available to The Auditors
3. Road Safety Audit – Stage 5
    i. Accidents Prevention Technique
    ii. Site Inspection
    iii. Vertical and Horizontal Alignment
    iv. Cross Section
    v. Intersections
    vi. Street Lighting
    vii. Traffic Signing – General Aspects
    viii. Regulatory and Warning Signs
    ix. Guide and Direction Signs
    x. Pavement Marking
    xi. Roadside Safety & Landscaping
    xii. General Traffic Management Items
4. Conclusion

KERAJAAN MALAYSIA

JABATAN KERJA RAYA MALAYSIA

MENGAUDIT JALAN SEDIA ADA PADA JALAN KUALA KANGSAR (FT001) NOMBOR SEKSYEN 607 SEHINGGA 610, IPOH, PERAK BAGI TUJUAN KAJIAN KES PROJEK TAHUN AKHIR JURUSAN IJAZAH SARJANA MUDA TEKNOLOGI KEJURUTERAAN AWAM, POLITEKNIK UNGKU OMAR, 31400 IPOH, PERAK.

ROAD SAFETY AUDIT REPORT
STAGE 5
(Existing Road)
June 2024

JKR

JABATAN KERJA RAYA
NEGERI PERAK DARUL RIDZUAN
Jalan Panglima Bukit Gantang Wahab,
30000 Ipoh,
Perak Darul Ridzuan.

Prepared By:

Nik Anis Aishah Binti Zulkarnain
Pelajar Tahun Akhir
Politeknik Ungku Omar
31400 Ipoh, Perak

Figure 4.20: Road Safety Audit Report Front Page

4.4.2 Documentation of Road Safety Audit Report

The method of online storage of the Road Safety Audit report that has been made is through storage in Google Drive. The storage method used is to make it easier for Syarikat Prima Reka Konsultan to obtain and access complete reports. In addition, to meet the Internet of Thing (IoT) for the grading rubric of the thesis report. The report can be read online by scanning the QR code in Figure 4.21 below also in **Appendix D**.

Figure 4.21: QR Code to Access Full Report of Road Safety Audit Stage 5

4.5 PROPOSE ROAD MITIGATION TO REDUCE THE RISK OF ROAD ACCIDENTS BASED ON THE FINDINGS OF THE RSA REPORT.

Road mitigation strategies for maintenance are important in reducing road accidents and minimizing risks for road users. Effective road maintenance involves various techniques and measures aimed at improving road conditions, managing traffic flow, and enhancing overall safety. All suggestions are focused and considered on the guidance from *Arahan Teknik Jalan* by P.W.D.

4.5.1 Road Maintenance

Road maintenance is one of the proposed methods to overcome the problem of road conditions at the study location at Jalan Kuala Kangsar (FT001) Section Number 607-610. Road maintenance is crucial for ensuring safe and efficient travel. Different techniques are used based on the extent of deterioration and the specific needs of the road. The appropriate method used for road maintenance on the study road is as stated below. This mitigation is referring the *Arahan Teknik Jalan* 5/85 by P.W.D – Manual on Pavement Design and Standard Operating Procedure (SOP) for Road Maintenance by P.W.D.

a. **Reconstruction**

Used when a road is severely damaged and simple repairs are insufficient. The process involves completely removing the existing pavement, including the surface layer, base, and sometimes the subgrade. The subgrade is then improved if necessary, followed by constructing a new base layer and new pavement layers. Each layer is compacted for stability and durability, resulting in a completely renewed road that significantly extends its lifespan and improves load-bearing capacity. Figure 2.22 below is a cross-section of the road pavement layer.

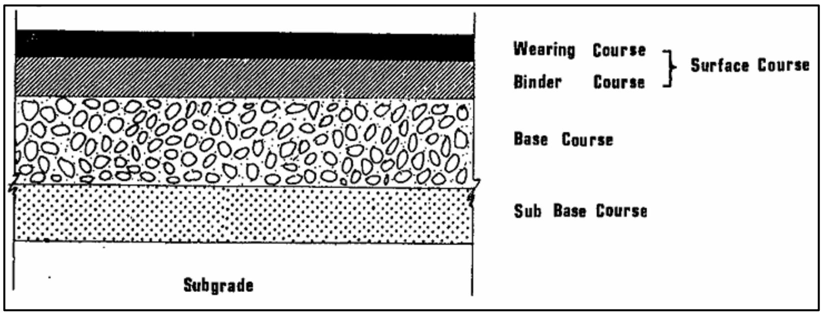


Figure 4.22: Cross Section for Pavement Structure.

b. **Mill and Pave**

Ideal for roads with surface distress that doesn't affect deeper layers. This process involves removing the top layer of the existing pavement using a milling machine. The milled surface is then cleaned, and a new layer of asphalt is laid and compacted. This method restores surface smoothness, removes irregularities, and improves ride quality. It is cost-effective and faster than full reconstruction, causing less traffic disruption. This mill and paved work are usually made with a thickness of 50mm which is on the wearing course layer only.

c. **Overlay**

Used for roads that are structurally sound but have minor surface distresses. The existing pavement is cleaned, minor repairs are made, and a tack coat is applied to ensure a strong bond between the old surface and the new overlay. A new layer of asphalt is then applied and compacted. This method quickly restores the road surface, seals minor cracks and wear, and extends the pavement's lifespan. It is a cost-effective and time-efficient solution for maintaining road quality.

Overlay works consist of cleaning the surface prior to overlaying, furnishing, placing, shaping and compacting all in accordance with the specification.

Each of these road maintenance techniques serves a specific purpose depending on the condition of the road. Reconstruction is necessary for severely damaged roads, mill and pave addresses surface issues without full-depth repairs, and overlay provides a quick and cost-effective solution for minor surface distresses. Each type of maintenance method helps in maintaining road infrastructure efficiently and effectively, ensuring safety and comfort for road users.

4.5.2 Road Equipment and Furniture

Road equipment and furniture are essential components of modern road infrastructure, playing a crucial role in ensuring safety, efficiency, and convenience for all road users. Implementing and maintaining equipment and road furniture elements is important to ensure the safety of road users. Help guide, warn and protect drivers, cyclists and pedestrians, ultimately reducing the risk of accidents and improving the safety of the entire road network.

The following below is a list of required improvements to Section Number 607-610 roads based on problems that can be identified through observations that have been made and can be referred to Table 4.9 List of Problems Occur on Road Section Number 607-610.

a. Traffic Signs and Signals

The lack of traffic signs on the study road can be detected. It provides essential information and instructions to drivers, cyclists, and pedestrians. Helps to regulate traffic flow, indicate hazards, and guide users, reducing the risk of accidents.

Among the suggestions for improvement are to place speed limit signs on curved roads, place warning signs before the curve and Curve Chevron signage, as well as signage entering and exiting the junction. Signs are also vital for maintaining order and safety on the roads.

b. **Road Markings**

Road marking on the study road is faded and confusing. This is very dangerous for road users. Collisions between vehicles can occur because road users are not on the right path, resulting in the risk of road accidents.

Road markings delineate lanes, indicate pedestrian crossings, and provide other important visual cues that help maintain orderly traffic movement and enhance safety. Types of road markings include lane dividers, crosswalks, stop lines, and directional arrows. These markings are crucial for guiding road users and ensuring that traffic flows smoothly and safely.

c. **Guardrails and Barriers**

The absence of guardrails and barriers is very dangerous. Guardrails and barriers are installed to prevent vehicles from veering off the road, especially in hazardous areas such as sharp curves, steep embankments, and bridge approaches. These safety features include metal guardrails, concrete barriers, and crash cushions. They play a significant role in mitigating the severity of accidents by keeping vehicles on the roadway and away from dangerous areas. If an accident occurs, the percentage for the risk of death is low but instead there is only damage to the vehicle.

d. **Street Lighting**

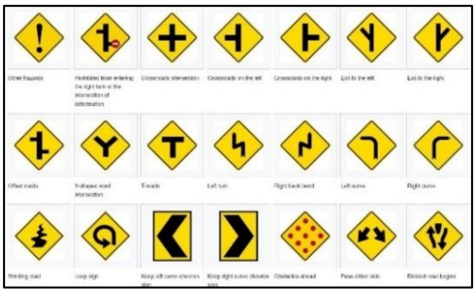
In the location of the study road, the streetlights are not lit and there are no streetlights in a dark area. Adequate street lighting improves visibility for drivers and pedestrians, reducing the likelihood of nighttime accidents and increasing overall safety. This includes overhead streetlights, illuminated signs, and pedestrian crossing lights. Effective street lighting is vital for ensuring that all road users can see and be seen, thereby enhancing safety during low-light conditions.

e. **Road Furniture**

Road furniture includes all the fixtures and fittings installed on the road to aid in traffic management and safety. This encompasses items like bollards, and road stud. These elements contribute to the functionality of roadways by providing necessary support and amenities for both traffic flow and pedestrian convenience.

The proper implementation and maintenance of road equipment and furniture are indispensable for creating a safe and efficient road environment. These elements help regulate traffic, guide road users, enhance visibility, and prevent accidents, contributing to the overall functionality and safety of the transportation infrastructure. Table 4.15 below is an illustration of the Road Equipment and Furniture required on the study road.

Table 4.15: Illustration of Road Equipment and Furniture Required on Road Section Number 607-610

 a. speed limit signs on curved roads, place warning signs before the curve and Curve Chevron signage, as well as signage entering and exiting the junction
  b. lane dividers, crosswalks, and directional arrows
  c. metal guardrails and concrete barriers
  d. overhead streetlights and illuminated signs
  e. Bollards and Road Studs for Road Furniture

4.5.3 Preventive Maintenance

Preventive maintenance involves regular inspections and minor repairs to prevent road deterioration, such as sealing cracks, filling potholes, and cut tree branches that block road signs from being seen by road users. This type of maintenance helps maintain a smooth road surface, reducing the risk of accidents caused by potholes and ruts. By improving tire grip, it reduces the risk of skidding and loss of control, especially during wet conditions. Preventive maintenance enhances overall road safety and is a cost-effective way to extend the pavement's life and reduce the frequency of major repairs.

4.5.4 Routine Maintenance

Routine maintenance and inspection must be done by the road concessionaire who has been responsible for road maintenance works such as cleaning debris, repainting road markings, and repairing minor damages, ensuring that the road remains in good condition and all safety features function properly. Regular repainting of road markings ensures lane divisions, pedestrian crossings, and other important indicators are visible, reducing confusion and accidents. Removing debris from the road prevents accidents caused by obstructions, particularly for motorcycles and bicycles. This type of maintenance ensures all traffic signs and markings are clearly visible, improving driver awareness and response, and quick repairs of minor damages prevent them from worsening and causing accidents.

CHAPTER 5

CONCLUSION

Data and analysis conducted for Jalan Kuala Kangsar (FT001) reveal critical insights into the contributing factors to road accidents and the deteriorating infrastructure that exacerbates these issues. Analysis using SIDRA software indicated that the road segment from 607 to 610 is categorized as LoS D and LoS E, signifying unstable traffic flow and high vehicle density during peak hours.

This near-capacity situation restricts maneuverability, with heavy vehicles significantly contributing to road damage and increased accident risk. Accident data from P.W.D (JKR) Kinta from Year 2018 to Year 2023 underscores the link between crumbling infrastructure and accident rate with the highest recorded accidents in Year 2021 highlighting the severe consequences of deteriorating road conditions. Besides that, Site Inspections identified that surface deformations and pavement cracks on Horizontal Alignments were predominant issues, contributing 41.7% and 33.3% respectively to road accidents.

From the RSA report produced, multiple road factors that contribute to road accidents can be identified. Site inspections conducted in April and May 2024 revealed numerous problems, meticulously recorded in the RSA checklist. RSA report emphasizes the importance of comprehensive and careful site observations, considering various road users, especially vulnerable ones like pedestrians and cyclists. Addressing the issues of crumbling infrastructure at Jalan Kuala Kangsar (FT001) is important for improving road safety. Implementing the proposed mitigation measures and maintaining infrastructure can significantly reduce the risk of accidents, ensuring safer travel for all road users.

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APPENDIX A:

Accident Data

BORANG DATA KEMALANGAN

BAHAGIAN PERANCANG JALAN
KEMENTERIAN KERJA RAYA MALAYSIA

DAERAH : **KINTA**
NEGERI : **PERAK**
TAHUN : **2018**

BIL	NO. ADUAN	TARIKH KEMALANGAN	MASA	NAMA JALAN DAN NO. LALUAN	NO. SEKSYEN	LOKASI (KOORDINAT)		JENIS KEMALANGAN (Sila √)				JENIS PELANGGARAN PERTAMA*	KECACATAN JALAN**	JENIS KENDERAAN (Sila √)							CATATAN (HPU)
						Latitude	Longitude	MAUT	PARAH	RINGAN	ROSAK			Mkar	Van	Lori	Bas	Msikal	P/Kaki	Bsikal	
1	026432	12.12.2018	4.00 ptg	Jalan Kuala Kangsar (FT001)	607	4.41.01	101.07.16	/				12	12					/			

DAERAH : **KINTA**
NEGERI : **PERAK**
TAHUN : **2019**

BIL	NO. ADUAN	TARIKH KEMALANGAN	MASA	NAMA JALAN DAN NO. LALUAN	NO. SEKSYEN	LOKASI (KOORDINAT)		JENIS KEMALANGAN (Sila √)				JENIS PELANGGARAN PERTAMA*	KECACATAN JALAN**	JENIS KENDERAAN (Sila √)							CATATAN (HPU)
						Latitude	Longitude	MAUT	PARAH	RINGAN	ROSAK			Mkar	Van	Lori	Bas	Msikal	P/Kaki	Bsikal	
1	011950	30.05.2019	8.30 pg	Jalan Kuala Kangsar (FT001)	610.10	4.42.17	101.07.20	√				10	12	√					√		
2	010410	10.05.2019	12.00 tgh		607.80	4.41.4	101.07.15	√				4	12			√		√			lampu Isyarat Klebang Restu (Mcdonald Klebang)
3	010283	08.05.2018	4.45 ptg		609	4.41.21	101.07.17	√				12	12	√√√				√			Bandar Baru Sri Klebang

DAERAH : **KINTA**
NEGERI : **PERAK**
TAHUN : **2020**

BIL	NO. ADUAN	TARIKH KEMALANGAN	MASA	NAMA JALAN DAN NO. LALUAN	NO. SEKSYEN	LOKASI (KOORDINAT)		JENIS KEMALANGAN (Sila √)				JENIS PELANGGARAN PERTAMA*	KECACATAN JALAN**	JENIS KENDERAAN (Sila √)							CATATAN (HPU)
						Latitude	Longitude	MAUT	PARAH	RINGAN	ROSAK			Mkar	Van	Lori	Bas	Msikal	P/Kaki	Bsikal	
1	020190	30.11.2020	12.04 tgh	Jalan Kuala Kangsar (FT001)	607.8	4.41.05	101.07.15		√			4	12	√				√			
2	008880	12.06.2020	8.03 pg		609.25	4.6975911	101.1223869	√				5	12	√				√			

***Jenis Perlanggaran Yang Pertama**

1. Depan Dengan Depan
2. Langgar Belakang
3. Langgar Rusuk Tepat
4. Langgar Sebelah Tepi
5. Bergesel
6. Terhimpit
7. Langgar Binatang
8. Langgar Objek Di Jalan
9. Langgar Objek Di Luar
10. Langgar Pejalan Kaki
11. Terbalik
12. Terbabas
13. Cermin Pecah Sahaja

**** Sebab-Sebab Utama Kecacatan Jalan**

1. Bahu Jalan Rendah/Tinggi
2. Manhole Rendah/Tinggi
3. Batu Longgar
4. Jalan Berdebu
5. Jalan Berlubang
6. Jalan Licin
7. Kerosakan Lampu Isyarat
8. Lintasan Keretapi Sempit
9. Jambatan Sempit
10. Tiada Guard Rail
11. Tiada/Kurang Lampu Jalan
12. Tiada Berkenaan

BORANG DATA KEMALANGAN

BAHAGIAN PERANCANG JALAN
KEMENTERIAN KERJA RAYA MALAYSIA

DAERAH : KINTA
NEGERI : PERAK
TAHUN : 2021

BIL	NO. ADUAN	TARIKH KEMALANGAN	MASA	NAMA JALAN DAN NO. LALUAN	NO. SEKSYEN	LOKASI (KOORDINAT)		JENIS KEMALANGAN (Sila √)				JENIS PELANGGARAN PERTAMA*	KECACATAN JALAN**	JENIS KENDERAAN (Sila √)							CATATAN (HPU)
						Latitude	Longitude	MAUT	PARAH	RINGAN	ROSAK			Mkar	Van	Lori	Bas	Msikal	P/Kaki	Bsikal	
1	000457	07.01.2021	11.24 mlm	Jalan Kuala Kangsar (FT001)	607.95	4.41.11	101.7.16	√				1	12	√						√	
2	000537	09.01.2021	7.31 pg		609.55	4.42.00	101.7.381	√				7	12					√			berdekatan kilang Hovid Klebang
3	000753	12.01.2021	07.33 mlm		609.2	4.69.81	101.12.37				√	4	12	√				√			lampu isyarat sri klebang
4	000762	13.01.2021	3.15 ptg		606.88	4.40.34	101.7.14			√		7	12					√			
5	001204	21.01.2021	10.45 pg		606.95	4.40.27	101.7.16			√		12	12					√			berdekatan AEON Klebang
6	003551	03.03.2021	9.10 mlm		609.5	4.41.58	101.07.22	√				12	12					√			berdekatan kilang Hovid Klebang
7	003809	07.03.2021	10.56 pg		608.1	4.41.19	101.07.16			√		12	6	√							
8	004422	16.03.2021	9.49 pg		607.2	4.67.8413	101.121.043			√		12	12					√			berdekatan AEON Klebang
9	011941	07.08.2021	11.26 mlm		607.81	4.41.4	101.7.16			√		4	12	√				√			
10	014575	30.09.2021	8.29 mlm		607.4	4.40.28	101.07.13				√	2	12	√				√			
11	013716	14.09.2021	1.26 ptg		610.8	4.35.56	101.4.25	√				2	12	√				√			
12	014722	02.10.2021	3.20 ptg		607.6	4.41.03	101.07.16			√		2	12					√√			
13	014745	02.10.2021	9.45 mlm		607.4	4.40.54	101.07.15	√				12	12					√			
14	015008	06.10.2021	8.57 mlm		607.2	4.40.43	101.07.15			√		4	12	√				√√			
15	020534	28.12.2021	11.54 pg		607.17	4.40.43	101.07.15			√		1	12	√				√			

DAERAH : KINTA
NEGERI : PERAK
TAHUN : 2022

BIL	NO. ADUAN	TARIKH KEMALANGAN	MASA	NAMA JALAN DAN NO. LALUAN	NO. SEKSYEN	LOKASI (KOORDINAT)		JENIS KEMALANGAN (Sila √)				JENIS PELANGGARAN PERTAMA*	KECACATAN JALAN**	JENIS KENDERAAN (Sila √)							CATATAN (HPU)
						Latitude	Longitude	MAUT	PARAH	RINGAN	ROSAK			Mkar	Van	Lori	Bas	Msikal	P/Kaki	Bsikal	
1	004962	14.03.2022	7.25 pg	Jalan Kuala Kangsar (FT001)	607	1.1.1	1.1.1	√				10	12	√					√		
2	005156	16.03.2022	8.05 mlm		607.37	1.1.1	1.1.1	√				4	12	√				√			
3	008049	25.04.2022	1.15 ptg		609.07	4.42.35	101.7.19			√		7	12					√			
4	9381	11.05.2022	1.18 ptg		610.9	4.42.42	101.07.20	√				12	12					√			
5	13791	05.07.2022	8.48 mlm		609.8	4.42.07	101.07.21			√		5	12					√			
6	26068	11.12.2022	5.38 ptg		609	0	0	√				12	12	√				√			

DAERAH : KINTA
NEGERI : PERAK
TAHUN : 2023

BIL	NO. ADUAN	TARIKH KEMALANGAN	MASA	NAMA JALAN DAN NO. LALUAN	NO. SEKSYEN	LOKASI (KOORDINAT)		JENIS KEMALANGAN (Sila √)				JENIS PELANGGARAN PERTAMA*	KECACATAN JALAN**	JENIS KENDERAAN (Sila √)							CATATAN (HPU)
						Latitude	Longitude	MAUT	PARAH	RINGAN	ROSAK			Mkar	Van	Lori	Bas	Msikal	P/Kaki	Bsikal	
1	1.61E+13	4/2/2023	6.19 ptg	Jalan Kuala Kangsar (FT001)	609.1	4.6981	101.1225	√				12	12								
2	1.61E+13	12/4/2023	5.35 ptg		610.5	4.6533	101.1322			√		4	12								
3	1.61E+13	18/4/2023	6.35 ptg		610.5	-76.300003	-148	√				4	12								
4	1.61E+13	16/5/2023	9.30 pg		610.1	4.7058	101.1222	√				4	12								
5	1.61E+13	22/5/2023	8.50 mlm		607.6	4.6814	101.1211			√		8	12								

APPENDIX B:

Borang Senarai Semak Kriteria Keutamaan

[No. Borang :..........]

JabatanKerja Raya Malaysia

RANKING: 5

BORANG SENARAI SEMAK KRITERIA KEUTAMAAN
SKOP : PAVEMEN

NomborLaluan / Nama Jalan :FT001 / Jalan Ipoh - Butterworth

Daerah / Seksyen : Kinta / 608.00 – 609.20

Bentukmukabumi / Terrain : (*Flat* / ~~*Rolling / Mountainous /* Selekoh~~)
**silapotong mana yang tidakberkaitan*

Luas kawasanpembaikan (m^2) :

Jenis jalan (*C/way, No.of Lanes*) : 3 Lanes, Dual C/way

BIL	KRITERIA PERTIMBANGAN	PENILAIAN	LAIN -LAIN
1	**KESELAMATAN**	**PENILAIAN** (Nota: NyatakanBilangan)	**CATATAN**
	Bilangan Kemalangan dan Jenis Kemalangan dalam masa 3 tahun terkini. *(Rujukan: POL 27 / RekodJabatan / Agensi)*		
	CederaRingan	3 nos	2020,2022
	Parah	-	
	Maut	2nos	
2	**KEROSAKAN**	**PENILAIAN** (Nota: Tandakan √)	**CATATAN**
	a) Kategori Kerosakan		
	KerosakanPermukaan (Functional)	√	KRITIKAL
	KerosakanStruktur (Structural)		
	b) Jenis Kerosakan Permukaan	**PENILAIAN** (Nota: Tandakan √)	***LEVEL OF SEVERITY*** (Silanyatakan *Level of Severity*,berdasarkanrujukanLampiran1)
	Pavement Cracks		
	Crocodile crack	√	3
	Block Crack	√	3
	Longitudinal Cracks	√	3
	Transvers Cracks		
	Edge Cracks		
	Crescent Shaped Cracks		
	Surface Deformations		
	Rutting	√	3
	Depression	√	3
	Corrugation		
	Shoving		
	Surface Defects		
	Bleeding		
	Polishing		
	Raveling	√	3
	Delamination	√	3
	Lain – lain (silanyatakan)		

[No. Borang :..........]

JabatanKerja Raya Malaysia

RANKING: 8

BORANG SENARAI SEMAK KRITERIA KEUTAMAAN
SKOP : PAVEMEN

NomborLaluan / Nama Jalan :FT001 / Jalan Ipoh – Butterworth

Daerah / Seksyen : Kinta / 609.80 – 611.30

Bentukmukabumi / Terrain : (*Flat* / ~~*Rolling / Mountainous* / Selekoh~~)
**silapotong mana yang tidakberkaitan*

Luas kawasanpembaikan (m^2) :

Jenis jalan (*C/way, No.of Lanes*) : 2 Lanes, Dual C/way

BIL	KRITERIA PERTIMBANGAN	PENILAIAN	LAIN -LAIN
1	**KESELAMATAN**	**PENILAIAN** (Nota: NyatakanBilangan)	**CATATAN**
	BilanganKemalangandanJenisKemalangandalam masa 3 tahunterkini. *(Rujukan: POL 27 / RekodJabatan / Agensi)*		
	CederaRingan	1 nos	2022
	Parah	1 nos	2021
	Maut	1 nos	2021
2	**KEROSAKAN**	**PENILAIAN** (Nota: Tandakan √)	**CATATAN**
	a) KategoriKerosakan		
	KerosakanPermukaan (Functional)	√	KRITIKAL
	KerosakanStruktur (Structural)		
	b) JenisKerosakanPermukaan	**PENILAIAN** (Nota: Tandakan √)	***LEVEL OF SEVERITY*** (Silanyatakan *Level of Severity*,berdasarkanrujukanLampiran1)
	Pavement Cracks		
	Crocodile crack	√	3
	Block Crack	√	3
	Longitudinal Cracks	√	3
	Transvers Cracks		
	Edge Cracks		
	Crescent Shaped Cracks		
	Surface Deformations		
	Rutting		
	Depression	√	3
	Corrugation		
	Shoving		
	Surface Defects		
	Bleeding		
	Polishing	√	3
	Raveling		
	Delamination		
	Lain – lain (silanyatakan)		

APPENDIX C:

RSA Report

KERAJAAN MALAYSIA

JABATAN KERJA RAYA MALAYSIA

MENGAUDIT JALAN SEDIA ADA PADA JALAN KUALA KANGSAR (FT001) NOMBOR SEKSYEN 607 SEHINGGA 610, IPOH, PERAK BAGI TUJUAN KAJIAN KES PROJEK TAHUN AKHIR JURUSAN IJAZAH SARJANA MUDA TEKNOLOGI KEJURUTERAAN AWAM, POLITEKNIK UNGKU OMAR, 31400 IPOH, PERAK.

ROAD SAFETY AUDIT REPORT
STAGE 5
(Existing Road)
June 2024

JABATAN KERJA RAYA
NEGERI PERAK DARUL RIDZUAN
Jalan Panglima Bukit Gantang Wahab,
30000 Ipoh,
Perak Darul Ridzuan.

Prepared By:

Nik Anis Aishah Binti Zulkarnain
Pelajar Tahun Akhir
Politeknik Ungku Omar
31400 Ipoh, Perak

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POLITEKNIK MALAYSIA UNGKU OMAR

PRIMA REKA KONSULTAN

MENGAUDIT JALAN SEDIA ADA PADA JALAN KUALA KANGSAR (FT001) NOMBOR SEKSYEN 607 SEHINGGA 610, IPOH, PERAK BAGI TUJUAN KAJIAN KES PROJEK TAHUN AKHIR JURUSAN IJAZAH SARJANA MUDA TEKNOLOGI KEJURUTERAAN AWAM, POLITEKNIK UNGKU OMAR, 31400 IPOH, PERAK.

For

Jabatan Kerja Raya Perak

Road Safety Audit - Stage 5
(Existing Road)

June 2024

MENGAUDIT JALAN SEDIA ADA PADA JALAN KUALA KANGSAR (FT001) NOMBOR SEKSYEN 607 SEHINGGA 610, IPOH, PERAK BAGI TUJUAN KAJIAN KES PROJEK TAHUN AKHIR JURUSAN IJAZAH SARJANA MUDA TEKNOLOGI KEJURUTERAAN AWAM, POLITEKNIK UNGKU OMAR, 31400 IPOH, PERAK.

Road Safety Audit (Stage 5)
(Existing Road Stage)

Summary of Audit

No.	Item	Auditors Comment & Recommendation	Contractor's Response	Decision of Meeting
	OPERATIONAL STAGE (STAGE 5) **Audited Element :**			
4.1	**<u>Vertical & Horizontal Alignment</u>**			
4.1.1	General Alignment Standard -check for consistency throughout the route, note any location where alignment standard changes abruptly and is not as expected by driver	Vertical and horizontal alignment plan are not able to acquire. Based on site observation, the vertical and horizontal alignment of the road section sturdy, some road sections are quite good.		
4.1.2	Sub-Standard Curves -identify any curve with a speed value more than 10km/h below the 85th %ile approach speed. Note any evidence of vehicle running off the	Speed reduction measure and signage was not provided on curve approaching the intersection.		

Summary of Audit

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	roadway			
4.1.3	Inadequate Sight Distance -check and record any location with inadequate Stopping Sight Distance -Check and record any location with inadequate Overtaking Sight Distance at which 'double lines' have been marked	1. Sight distance cannot be estimated on a road section after passing vertical curves and horizontal curves 2. Overtaking is not allowed in this area via road marking and signages.		
4.2	**<u>Cross Section</u>**			
4.2.1	-note any location where the cross section standard changes abruptly along the route, or is otherwise inconsistent with driver expectation	The cross section are not able to acquire.		
4.2.2	-identify any locations where the Capacity of the roadway is restricted	N/A.		

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4.2.3	-note location of regular traffic congestion	Yes, based on traffic volume and Level of Service D along the study road.		
4.2.4	-note any absence of provisions protecting 'turning vehicles' at intersection	No issues regarding the absence of provisions protecting 'turning vehicles' at the intersection.		
4.2.5	-note any locations with inadequate Shoulder Width	No issues on inadequate shoulder width.		
4.2.6	-check that the correct type of kerb has been used and note any location where speeds are greater than 50km/h and 'barrier kerb' has been used.	No issues on this matter.		
4.2.7	-motorcyclist: segregated lanes (paved shoulder), separate roadways, where warranted by demand.	Paved shoulder are provided.		

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4.3	**Intersection**			
4.3.1	Sight distance: Check that the various sight distance requirements, (applicable to the traffic speed) are achieved:	No issue.		
4.3.2 4.3.3 4.3.4	-any location where 'Seagull' types of layouts are used in urban or other 'built-up' areas. Identify any location where the length and width of the 'right turn' merge is sub-standard and instances where pedestrian movements across the continuous traffic flow movement is not properly catered for.	Seagull is low and it is an issue to not be seen by vehicle users.		
4.4	**Expressway & Other Interchanges**			
4.4.1	Check that interchanges are appropriately located (e.g. at the	N/A.		

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	important roads), properly spaced and suit a logical traffic management strategy for the region.			
4.5	**Traffic Signal Installations**			
4.5.1	-Check that traffic signals are provided only where warranted for safe, efficient and equitable management of traffic flow along and across arterial roads and for the safe crossing of pedestrians.	No issue.		
4.6	**Street Lighting**			
4.6.1	-that street lighting is provided on arterial roads and highway in cities, towns and other 'built-up' areas, particularly where there are the pedestrians and parking along the road.	The installed street lights are not lit at night. No street lights are installed in areas that have no development.		

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4.6.2	-that where lighting is installed, it is of an appropriate standard, consistent with the needs of the location, pedestrians and other factors.	Street lighting is provided is at appropriate standard.		
4.6.3	-identify locations where the street lighting poles constitute a hazard to traffic, e.g. on small islands, noses of medians, on the outside of sharp curves, etc.	The wiring for the previous street light installation was not properly maintained.		
4.7	**<u>Traffic Signing</u>** General Aspect			
4.7.1	-for any cases of unauthorised traffic signs and use of non-standard signs, (Colour and Shape).	No issues.		

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4.7.2	**-**the location and spacing of signs and note locations where there are too many signs, or the signs are to close together.	N/A.		
4.7.3	-that all traffic signs are clearly visible and are prominently displayed to the intended road users.	Few signages are broken and the writing is illegible.		
4.7.4	-the effectiveness of traffic signs by observing them at night and identify any lack of reflectorisation.	Signage cannot be seen clearly and the reflection on the signage is faint.		
4.8	**Regulatory and Warning Signs**	Warning and regulatory signage has been provided at site. However, the Auditor have some comments & recommendation that may take into consideration; a) The view of signage needs to be clear from any obstruction and is needed for maintenance.		

Road Safety Audit (Stage 5)
(Existing Road Stage)

Summary of Audit

No.	Item	Auditors Comment & Recommendation	Contractor's Response	Decision of Meeting
		b) Warning signboard needs to be added especially on winding road. c) Speed limit signage needs to be installed.		
4.9	**<u>Guide and Direction Sign</u>**	Guide and direction signage has been placed correctly and systematically at site. However, the Auditor have some comments & recommendation that may take into consideration; a) Additional (WD.39a) signboard needs to be added. b) Additional (WD.27b) signboard needs to be added. c) Additional (WD.36) signboard needs to be added. d) Additional (WD.10a) signboard needs to be added. e) Additional (WD.14) signboard needs to be added. f) Additional (WD.11) signboard needs to be added.		

Summary of Audit

No.	Item	Auditors Comment & Recommendation	Contractor's Response	Decision of Meeting
		g) Additional (WD.13) signboard needs to be added. h) Additional (WD.24) signboard needs to be added.		
4.10	**Pavement Marking**	Few comments from the Auditor regarding pavement marking as following; a) Road marking along the road needs to be repainted. b) Old road marking line at traffic light junction need to be eliminated with black paint. c) Pedestrian crossing markings needs to be repainted. d) Transverse bars need to be repainted.		
4.11	**Roadside Safety & Landscaping**	Few comments from the Auditor regarding roadside safety as following;		
4.11.1	-the 'Clear Zone Width' (CZW) generally available along both sides	a) Guardrail should be installed along the winding road shoulder.		

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	of the road, and comment on this aspect in the RSA report.	b) Few trees block the view of signboard close.		
4.11.2	-the 'Fixed Roadside Objects' which occur within the CZW and comment on the need to treat them in the interests of road safety.	c) Road median need to be repainted		
4.11.3	-the provision of Guardrail along the road, consider whether it is really justified and identify locations where it is not justified and locations where it has not been provided where it is warranted.	Guardrail should be installed along the pipe culvert close the road shoulder.		
4.11.4	-the extent to which trees and other vegetation obstructs driver and pedestrian sight lines which are essential for safe traffic operation.	Few trees block the view of signboard.		
4.11.5	-the degree of hazard associated with large trees, boulders etc, and	Few trees block the view of signboard.		

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	whether these can be treated to improve roadside safety.			
4.12	**General Traffic Management Items**			
4.12.1	-the adequacy and credibility of existing Speed Limits and comment if they are not appropriate to the traffic situation and the nature of abutting development or are otherwise unrealistic in the view of most motorists.	Speed Limits signage are not provided.		
4.12.2	-the effectiveness of Speed Limit signing: consider the need for more prominent signing of the start of 'restricted' speed zones and for 'reminder signs' within the speed zone, particularly near intersections	Proper speed Limits signage are not provided.		

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	where large numbers of vehicles enter the road in question from side roads.			
4.12.3	-sub-standard curves and low speed curved sections of the road, consider the need for 'positive' advice to motorists about the safe travel speed and consider the need for 'Advisory Curve Speed' signing.	Not provided.		
4.12.4	-the need at sub-standard curves, for other delineation improvements such as the provision of 'guide post' delineation, the placement of 'Chevron Alignment' signs and the use of retro-reflective road studs.	Not provided.		

1.0 INTRODUCTION

Deteriorating road conditions increase the risk of road accidents. Road Safety Audit report produced to identify the risk of road accidents based on Checklist of Site Inspection. Submission of the report to the road owner JKR Perak for recommending action and finally suggest road mitigation for reducing the risk of road accidents at Jalan Kuala Kangsar (FT001) Section Number 607 until 610. The study location starting from Aeon Mall Klebang, Ipoh junction straight until Big Famaly Kolam Chemor. The road location is as shown in Figure 1.1 below and Appendix A in Road Safety Audit Report.

This report will present the study and findings of the Road and Safety Audit carried out for approval.

1.1 Objective of Road Safety Audit

Among others, the objectives of Road Safety Audit Stage 5 are:

i. To identify potential safety hazards at the study road that have risk to road accidents for road users.
ii. To ensure the safety requirements of all road users are considered.
iii. To reduce the overall cost implication on the community.

Figure 1.1: Key Plan / Location Plan

2.0 INFORMATION AVAILABLE TO THE AUDITOR

In carrying out the Road Safety Audit Stage 5 (Existing Road), the following information was made available to the Auditor :

The Guidelines Standard used are:

a) NTJ 25/07 - Guidelines on the Contents of a Road Safety Audit Report
b) ATJ 8/86 (2015) - A Guide on the Geometric Design of Roads

References are also made to the latest design guidelines produced by the Road Engineering Association of Malaysia (REAM).

2.1 General Design Criteria

Based on the information given by JKR Ipoh, Perak Jalan Kuala Kangsar (FT001) is adopted to be design as JKR R5/U5.

2.2 Design Speed

The design speed for Federal Road Jalan Kuala Kangsar (FT001) is adopted to be 80km/hr.

3.0 ROAD SAFETY AUDIT - STAGE 5 : EXISTING ROAD

3.1 ACCIDENTS PREVENTION TECHNIQUE

Stage 5 Auditing is an important accident prevention technique that focuses on field observations rather than design plans and maps. It includes aspects such as checking sight distance, legibility, and traffic sign positioning. Responsible for large road networks need to establish a systematic auditing procedure for their entire network, either initially or subsequently, on a periodic basis. This involves setting up a program of auditing routes, road sections, or parts of the road network on a systematic or 'Priority' basis. The responsible authority may select or prioritize routes based on known accident history, traffic flow, or operational performance.

Some road authorities may systematically audit a percentage of their total road network each year, breaking it up into manageable size RSA projects/sections. A systematic step-by-step process is preferred, but additional points need to be considered. For long lengths of road, it is better to break the length into sub-projects. Independent auditors should have independence from the day-to-day operation and management of the road being audited to achieve objectivity and credibility. The responsible road authority should arrange an initial meeting with the selected auditors to officially start the audit.

3.2 SITE INSPECTIONS

The site inspection is a crucial part of the Stage 5 Audit, requiring thorough planning and execution. It was conducted both day and night on 30 April and 17 May 2024, and during high-risk periods. The inspection considered the needs of different road users, including vulnerable ones like pedestrians and motorcyclists. Also consider the safety implications of land-use and road network interactions. For long sections of road, it is conduct two or more phases: driving the road in each direction and identifying key safety concerns. Auditors then conduct a detailed notes, video, and photographs of each safety aspect.

3.3 VERTICAL AND HORIZONTAL ALIGNMENT

3.3.1 Vertical Alignment

Road on Section Number 607-610 have a slightly a curve road. Sight distance is sufficient. Providing signage WD.39a/WD.39b is recommended.

3.3.2 Horizontal Alignment

Road on Section Number 607-610 have a slightly rolling road. Sight distance is sufficient. Providing transverse bar when descending and approaching exit slip junction.

3.4 CROSS SECTION

Cross section detail is not available and cannot be provided.

3.5 INTERSECTION

The problem that exists is related to 'Seagull' which is low and it is an issue to not be seen by vehicle users.

3.6 STREET LIGHTING

The installed street lights are not lit at night. In undeveloped areas, no street lights have been installed. Where street lighting is provided, it meets appropriate standards. However, the wiring for the previous street light installation has not been properly maintained.

3.7 TRAFFIC SIGNING

Some signage are broken, making the writing illegible. Additionally, the signage is not clearly visible, and the reflective surfaces are faint especially for night sight.

3.8 REGULATORY AND WARNING SIGNS

Warning and regulatory signage has been provided at site. However, few things need to be considered such as the view of signage needs to be clear from any obstructions and requires regular maintenance. Additionally, warning signboards should be added, especially on winding roads, and speed limit signage needs to be installed.

3.9 GUIDE AND DIRECTION SIGN

The guide and direction signage have been placed correctly and systematically at site but few signage needs to be added considering for road user alert.

3.10 PAVEMENT MARKING

The road markings along the road need to be repainted. Additionally, old road markings at the traffic light junction should be eliminated with black paint. Pedestrian crossing markings and transverse bars also require repainting.

3.11 ROADSIDE SAFETY & LANDSCAPING

Guardrails should be installed along the winding road shoulder and near the pipe culvert close to the road shoulder. Additionally, a few trees block the view of nearby signboards, and the road median needs to be repainted.

3.12 GENERAL TRAFFIC MANAGEMENT ITEMS

There are not many issues within the special provisions, but proper speed limit signs are not provided.

4.0 CONCLUSION

The Road Safety Audit Stage 5 (Existing Road) had identified several aspects of the conceptual design which requires attention at RSA Stage 5. At this final stage, it is very necessary to correct most of identified risk led to accident. In principle, this Road Safety Audit Stage 5 (Existing Road) is expected to propose measures to deal with problems that pose a risk to road accidents to users.

5.0 DETAIL OF AUDITOR

Road Safety Audit Stage 5 prepared by:

Auditor,

……………………………….

Nik Anis Aishah Binti Zulkarnain,

Final Year Project,

Student of Politeknik Ungku Omar,

31400 Ipoh,

Perak Darul Ridzuan.

APPENDIX A:
Location Plan

MENGAUDIT JALAN SEDIA ADA PADA JALAN KUALA KANGSAR (FT001) NOMBOR SEKSYEN 607 SEHINGGA 610, IPOH, PERAK BAGI TUJUAN KAJIAN KES PROJEK TAHUN AKHIR JURUSAN IJAZAH SARJANA MUDA TEKNOLOGI KEJURUTERAAN AWAM, POLITEKNIK UNGKU OMAR, 31400 IPOH, PERAK.

Road Safety Audit - Stage 5
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Location Plan

APPENDIX D:

QR Code

SCAN TO READ

A CASE STUDY ON THE RISK OF ROAD ACCIDENTS CAUSED BY DETERIORATING ROAD CONDITIONS CONSEQUENCE OF CRUMBLING INFRASTRUCTURE AT JALAN KUALA KANGSAR (FT001), IPOH, PERAK.

NIK ANIS AISHAH BINTI ZULKARNAIN
FINAL YEAR PROJECT
POLITEKNIK UNGKU OMAR
31400 IPOH, PERAK.

https://drive.google.com/drive/u/0/folders/17liFHvKaWUuAegLMej0LfRq1AXKfW-rl

APPENDIX E:
Gantt Chart

APPENDIX D – Gantt Chatt Semester 7

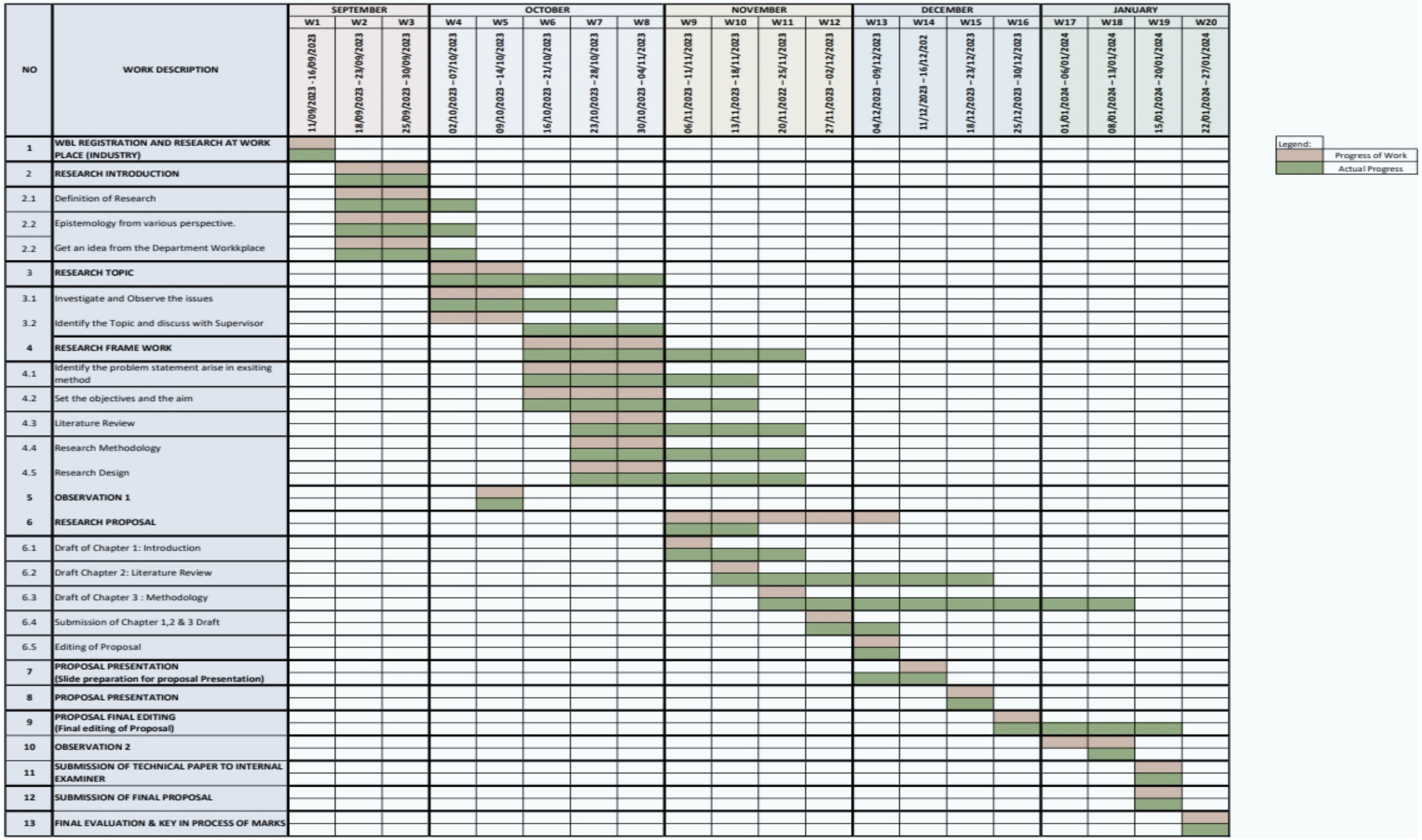

Figure : Work Gantt Chart During Semester 7

APPENDIX D – Gantt Chart Semester 8

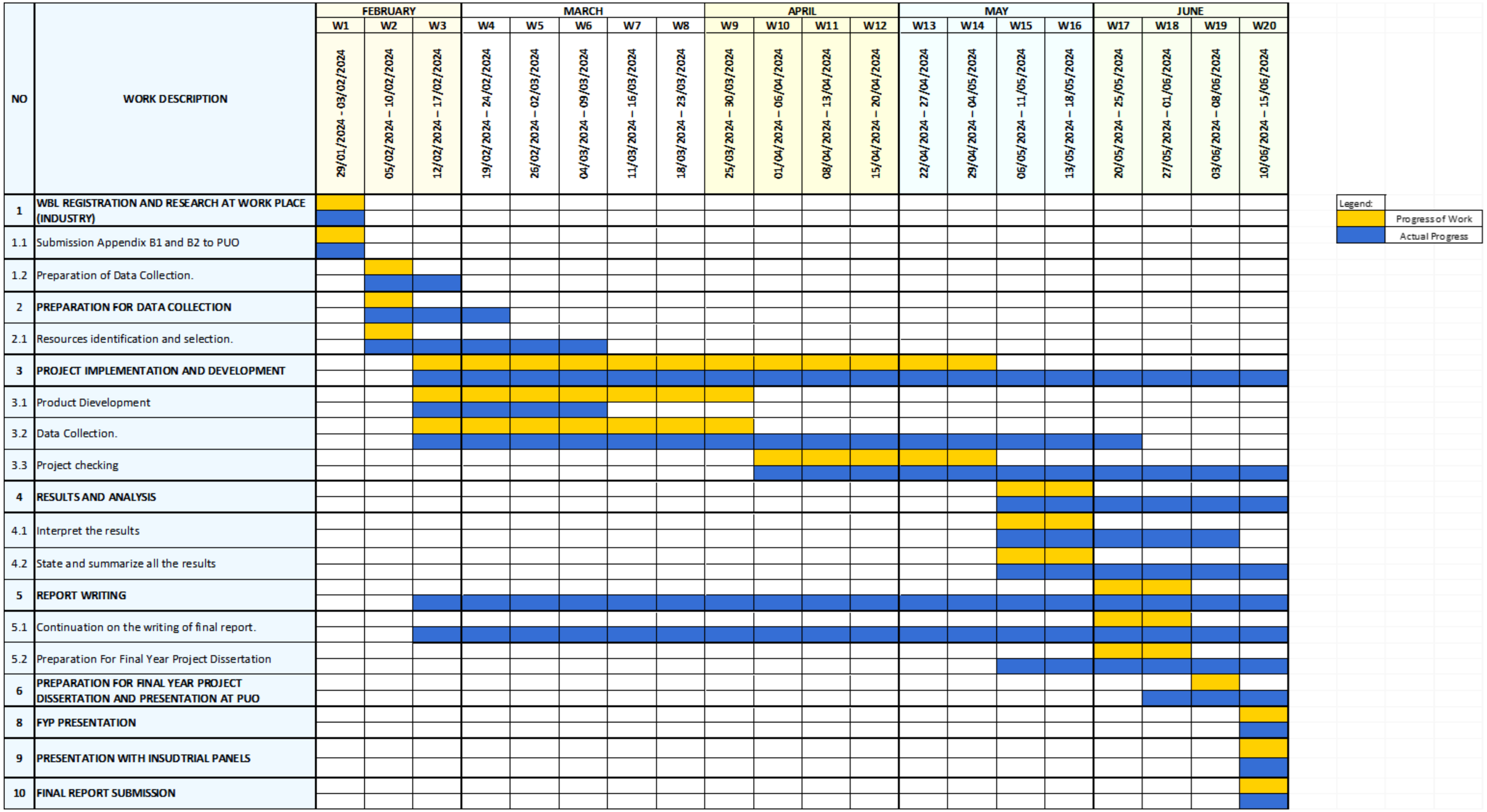

Figure : Work Gantt Chart During Semester 8