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Assessing Road Accident Black Spots and Countermeasures in the State of Perak, Malaysia

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Abstract: To develop a successful strategy for improving road safety, the initial step involves is to identify the black spots that are more susceptible to high-risk traffic accidents. However, due to the high cost of implementing safety measures in these locations, only a limited number of spots/sites can be thoroughly examined with the available funding. Therefore, it is crucial to prioritize the high-risk sites and their corresponding safety measures in order to make the most efficient use of the available finances. Hence, this paper presents black spots ranking and low-cost countermeasures based on the Perak Federal trunk road traffic crash (RTC) data for three years from 2018 to 2020 recorded by the Royal Malaysian Police (RMP). The weightage point method was used for each black spot ranking exercise where as, the selection for countermeasures were based on RTC situations which are norms practiced by the Public Works Department (PWD). In total 22 black spots were ranked and it was found that the highest rank of the 2020 black spots in Perak was along route FT005 in Kinta district which had 18 RTCs and with a total weightage points (TWP) of 118.2. In balancing between limited financial allocation and improving road safety, the countermeasures were priorotized for implementation in 2021 based on the black spots ranking results. However, only six black spots were treated in 2021 with the entire cost was RM 1,834,027.19. Where for route FT005 in Kinta district, the countermeasure was done at Section 684 with a total cost of RM350,000 under the 2022 black spots countermeasure program which is an annual program funded by the Ministry of Works Malaysia. It is recommended that Perak State PWD form a Road Safety Unit to reduce the black spots along the state roads which is the second highest road fatalities recorded in Perak.

Keywords: Black spots, high-risk sites, black spots ranking, low-cost countermeasures, weightage point

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1. Introduction

According to the World Health Organization's global status on road safety 2016 statistics, approximately 1.25 million people are killed on roads worldwide each year, and millions more bear injuries (WHO, 2017). Many cities worldwide are working to reduce the traffic fatality rate, which is the number of fatalities relative to the population or registered vehicles (Akmal, 2016). Road Traffic Crash statistics are crucial in assessing road safety in a particular country. Examples of such elements are a count of fatal road crashes, the number of people who sustained injuries and the number of people who died on the road due to road crashes (Rohayu, Rizati, Allyana, Azzuhana, Nurulhuda, & Nur Zarifah, 2018). RTC represent a significant problem facing many countries around the world. RTC has been reported as the ninth most common cause of death, according to the World Health Organization (WHO, 2013).

Road safety results from deliberate and systematic efforts by government and non-government agencies to acknowledge that it is essential and valuable public information and have developed policies and programmes to support and maintain it (Younus, Ankit, Jagdeep, 2019). Thus, road safety is a collective responsibility that requires the involvement of government, civil society and businesses from both the public and private sectors. It requires a well-planned strategy and an associated plan (Zarulazam & Evdorides, 2017). For this reason, identifying road sections characterised by high-risk accidents is the first step of any successful road safety management process, considering the limited available resources (Maen & Árpád, 2017).

Malaysia, a developing country, has acknowledged that RTC is a critical problem that should be addressed and based on the statistics released by the Department of Statistics Malaysia (DOSM), road traffic injuries have ranked within the top five principal causes of death since 2013, as shown in Figure 1.

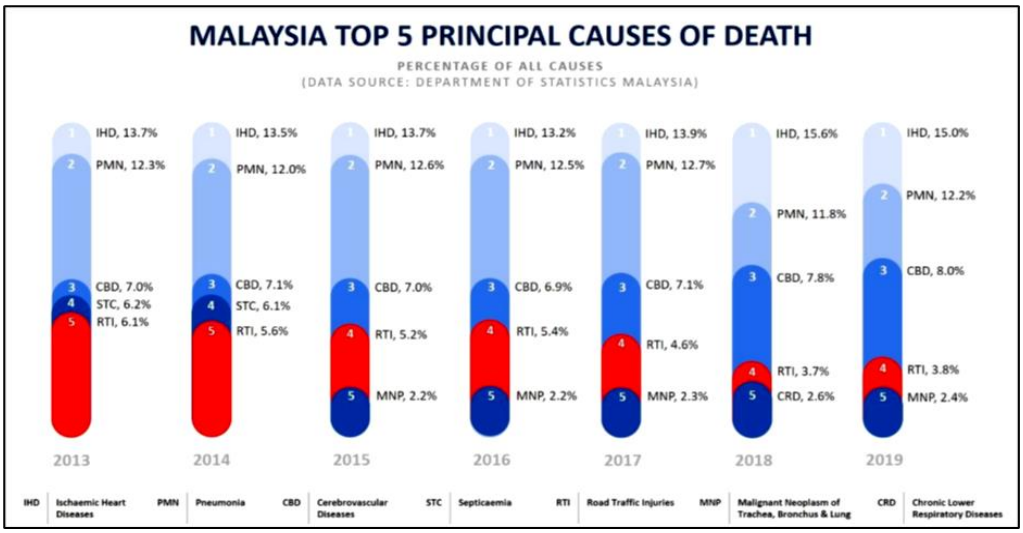

Fig. 1 - Principal causes of death in Malaysia 2013-2017 (Alvin Poi Wai Hoong, 2021)

Apart from those causes, growth in terms of urban development and also an increase in the number of vehicles in many developed countries had brought about an increase in RTC (Radin Sohadi, 2005). According to RMP, Malaysia recorded 418,237 RTC and 4,634 fatalities in 2020. The numbers decreased in 2021, with 370,286 RTC and 4,539 fatalities recorded. Traffic data also showed a downward trend of road fatalities pre-Covid-19 with 6,740 deaths in 2017, 6,284 in 2018 and 6,167 in 2019, despite the increasing number of RTCs in the country. 533,875 RTCs were reported nationwide in 2017, 548,598 in 2018 and 567,516 cases in 2019 (Nuradzimmah, 2022). Figure 2 shows the statistics of RTCs and fatalities in Malaysia from 2011 to 2020, while Figure 3 shows RTCs and fatalities for Perak.

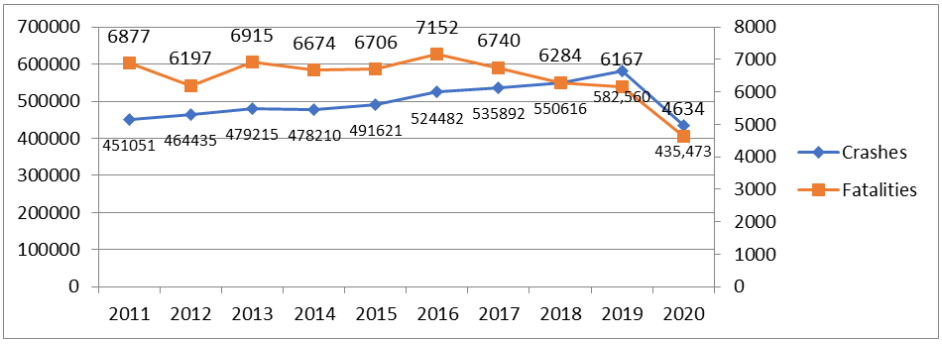

Fig. 2 - Malaysia RTCs and fatalities (2011-2020)

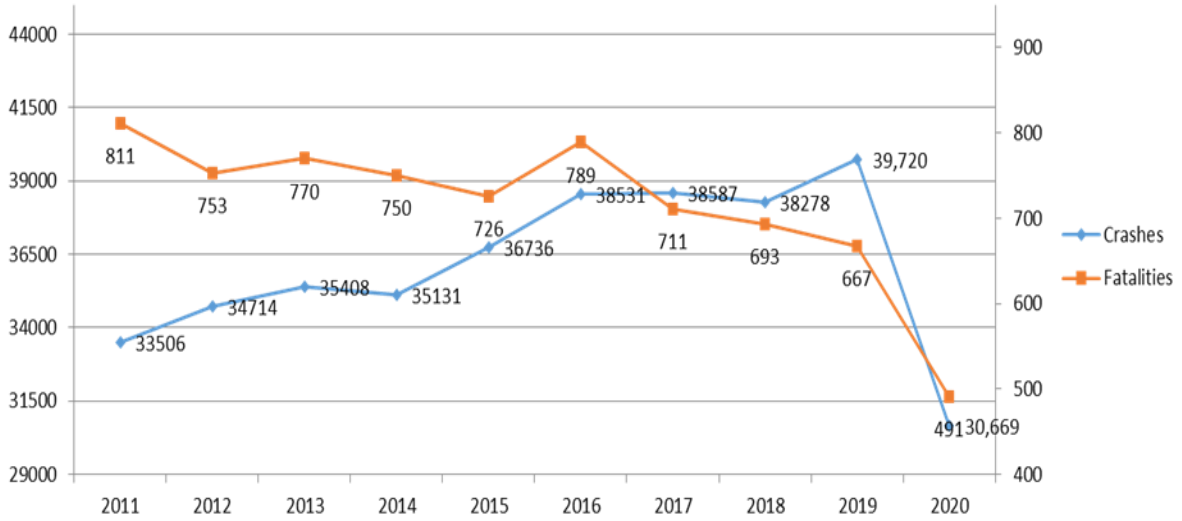

Fig. 3 - RTCs and Fatalities in Perak (2011-2020): (RMP, 2021)

Figure 3 shows 491 deaths cases in 2020 and 667 cases in 2019. The substantial decrease in numbers was because, in 2020, the implementation of the Movement Control Order (MCO) enforced on 18 March 2020 to 31 March 2021 nationwide due to COVID-19, affecting the total number of vehicles travelling on the road. Consequently, a downward trend was observed for fatalities in Perak from 2016 onwards.

For this study, Perak was chosen as a case study. Perak has an area of 20,976 km² and 12 districts (Perak official portal, 2022). It is the 2nd largest state in Peninsula Malaysia (West Malaysia) after Pahang. Perak has 40,076.133 lane-km (JKR Malaysia Road Statistics, 2021), the longest in Peninsula Malaysia. Regarding road fatalities, Perak recorded the third highest consistently over a decade ago amongst 16 States, including Federal Terrorists in Malaysia.

2. RTC Black Spots

A significant societal issue has arisen as a result of the dramatically increased number of motor vehicles on the road with fatal RTCs. To comprehend the issue and offer a solution, a multidisciplinary approach is required. Numerous roadway characteristics have an impact on the safety of the vehicle and other road users, which causes RTC and may call for modifications. Traffic and highway engineers must come up with strategies to minimise RTCs based on the statistics by improving the planning, design, construction, and maintenance of traffic operations with the proper regulatory measures. According to statistics from the Royal Malaysian Police (RMP) in 2021, Perak had 38,278 and 39,720 RTCs in 2018 and 2019, respectively. There were 253 RTCs and 22 black spots identified along the Federal trunk (FT) roads in the districts of Perak between 2018 and 2020.

A RTCs black spot, sometimes known as a "black spot," is a location where traffic crashes have historically been prevalent. It might have happened for a few reasons, including an abrupt turn or dip in a straight road that hides incoming vehicles, a hidden junction on a busy route, or inadequate or hidden warning signs at a crossroads. The treatment of RTCs black spots such as whether by signs, speed limits, better sightlines, straightening curves, or speed cameras, was a cornerstone of road safety policy for several decades, but contemporary thought contends that the advantages of these interventions are sometimes exaggerated.

2.1 Causes of Black Spots

The causes of RTC black spots can be multifaceted. Factors such as poor road design, inadequate signage, insufficient lighting, inadequate traffic control measures, and lack of driver awareness or education can contribute to the occurrence of accidents. Identifying and analysing these causes accurately is essential to develop effective countermeasures. However, the provided information does not delve into specific causes or provide a comprehensive analysis. The lack of specificity limits the depth of understanding and hinders the formulation of targeted countermeasures. A more thorough examination of accident data, road infrastructure assessments, driver behaviour studies, and other relevant factors is necessary to gain insights into the root causes of accidents at black spots.

Regarding countermeasures, the information lacks specific strategies or interventions to address accident black spots. Effective countermeasures typically involve a combination of engineering, enforcement, and education measures. These may include road design modifications, improved signage and lighting, enhanced traffic control systems, increased law enforcement presence, driver education campaigns, and targeted awareness programs. Without specific countermeasure suggestions, it is challenging to assess the feasibility and effectiveness of the proposed solutions.

Furthermore, the effectiveness of countermeasures may vary depending on the specific context and underlying causes of accidents at each black spot. Adopting a one-size-fits-all approach may not adequately address the unique challenges and complexities of individual black spots. A thorough analysis of each location is necessary to tailor countermeasures to the specific circumstances and mitigate the identified causes effectively.

Although the subject of accident black spots, their causes, and mitigation strategies is essential, the information offered lacks depth and detail. For a more critical study, a more thorough investigation of the causes and a thorough examination of efficient countermeasures are required. In order to successfully address accident black spots and improve road safety, future research and assessment should concentrate on collecting empirical data, conducting in-depth analyses, and offering specific and evidence-based measures (McGuigan, 1981; Elvik, 2007; Fekadu, & Wuezon, 2013; Ghadi & Török, 2019; Abdolmanafi, & Karamad, 2019; Elena, Sergei, & Jarosław, 2020).

2.2 Investigating Black Spot

Investigating black spot involved several processes, including collecting the accident's information from respective agencies, police stations, analysis of the location using spot speed studies, vehicle classification and driver studies, cost benefits and another relevant set of studies. Additional measures taken for the examination of black spots include documenting the incidents and entering the data onto a computer; discovering places with a high frequency of accidents and which are frequently referred to as black spots; and weighing the sites for severity and exposure.

For the initial accident investigation and site visits, rank locations for in-depth investigations, additional data collection from accident forms and site studies, data analysis, more detective work, and human factors; choose and evaluate packages of countermeasures; rank locations for treatment, implementation, and construction; observe behaviour during the first days and months; assess the effects on accidents; and perform a cost-benefit analysis.

In the context of this study, the black spot is referred to be a hazardous area in the JKR Guide on Identifying, Prioritising and Treating Hazardous Locations on Roads in Malaysia published in 1995. RTCs have worsened human suffering and caused significant economic loss, both of which require society's attention and a fix. There are several reasons for accident, including driver error, vehicle malfunction, adverse weather, poor road design, and a host of other factors. A site is a "black spot" if accidents commonly happen there (Yashas, Harish, & Muralidhar, 2015). The collection data for RTCs in identifying black spots are from Highway Planning Unit (HPU) under the Ministry of Works, Malaysia. The process of eliminating or improving the RTC-prone spots is shown in Figure 4.

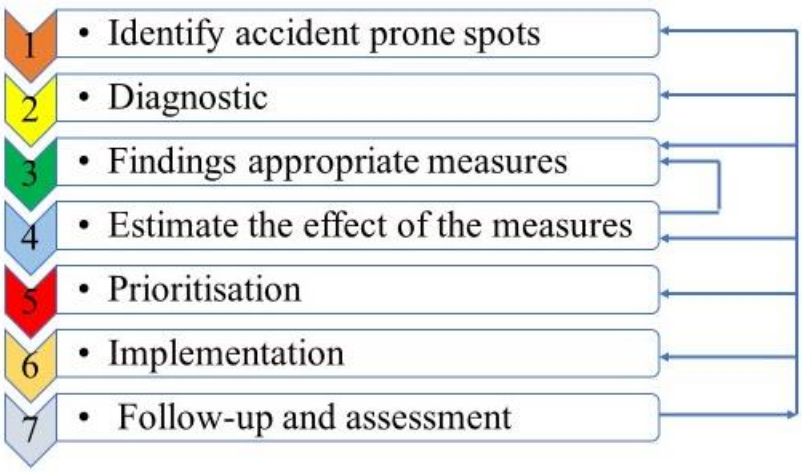

Fig. 4 - Interim Guide of RTC-prone spots in Malaysia, (1995)

Figure 4 depicts the procedure for locating black spots on RTCs. The procedure aims to pinpoint and address locations or regions where RTCs regularly happen. This procedure aims to increase security while lowering the frequency and seriousness of RTCs at these locations. First, information is gathered to determine the regions where RTCs are most likely to occur. This can entail examining RTC reports, traffic flow statistics, and other pertinent data to identify regions with a disproportionately high number of RTCs. The root cause of the RTCs is investigated further after the black spots have been located. This can entail researching the road's design, traffic flow, and other elements that might affect RTCs in certain areas.

2.3 Ranking of Perak Black Spots

Prior to rank the RTCs black spot severity, firstly, it requires studying the RTC data problematic sites. It is essential to define a "reaction level", that is, the number of road traffic crashes above which the investigator takes some action. A black spot is a section of road where three similar types of RTC or five different forms of RTC occurred in a

radius of 50 to 100 metres along a route over the course of three years. The ranking severity of the black spot is determined using Highway Planning Unit's (HPU) current Weightage Point Method (JKR, 2007), as shown in Table 1.

Table 1 - Weightage Point Method [JKR 2007]

Nos.	RTC Casualty	Point
1	Fatality	6
2	Serious injury	4
3	Slight injury	2
4	Vehicle damage	1

Table 1 shows the Weightage point method established by JKR 2007, comprising four casualties, with fatality having the highest point of 6 and vehicle damage only having the lowest point of 1. These points are used in calculating the total weightage points for a black spot area along a route and are described as follows;

Black spot weightage points for current year = [(a*0.2) +(b*0.35) +(c*0.45)] x casualty point (1)

Where;
- a: RTC data 2 years before
- b: RTC data 1 year before
- c: RTC data for the current year
- casualty point from Table 1

For example, the RTC casualty data for a black spot area along route FT001 at Salak, Sungai Siput (Utara) in Kuala Kangsar is shown as in Table 2 below;

Table 2 - Number of RTCs [FT001]

Year	Formula coefficient	Fatal	Serious injury
2018	a	5	20
2019	b	12	0
2020	c	0	0
	Total RTCs:	**17**	**20**

Based on Table 2 data, the black spot total weightage points are as follow;
- Weightage points for 2020 of fatal = [(5*0.2) +(12*0.35) +(0*0.45)] x **6 = 31.2**
- Weightage points for 2020 of serious injury = [(20*0.2) +(0*0.35) +(0*0.45)] x **4 = 16**
- Black spot total weighrage points for 2020 = 31.2 + 16 = **47.2**

For ranking the black spot for a stretch of road, the total weightage points of each black spot in that stretch of road is compared with other black spot weightage points. Black spot with the highest point is ranked first while black spot with the lowest point is ranked last. For the year 2020, Perak had 253 RTCs and 22 black spots along its Federal trunk roads. The ranking process was done for all the black spots along the routes in the respective districts. The results of the ranking process are shown in Table 3. The route with the highest points is ranked number 1, and the one with the lowest points is ranked last.

Table 3 - Ranking of black spots along FT routes in Perak State

No.	District	Route No.	No. of Black spot	No. of RTC	Total casualty points	Ranking
1	Kinta	FT001	1	5	39.6	12
		FT005	1	18	**118.2**	**1**
2	Perak Tengah	FT005	1	9	36.8	13
3	Larut, Matang & Selama	FT001	1	11	22.2	19
		FT060	1	8	**14.2**	20
		FT074	1	13	35.1	15
4	Manjung	FT005	1	12	73.65	6
		FT060	1	5	27.6	17
5	Kuala Kangsar	FT001	1	7	**47.2**	10
		FT076	1	7	24.9	18

No.	District	Route No.	No. of Black spot	No. of RTC	Total casualty points	Ranking
6	Hulu Perak	FT004	1	6	35.0	16
		FT076	1	4	8.9	21
7	Mualim	FT001	1	7	28.8	17
8	Hilir Perak	FT005	1	14	88.6	4
		FT058	1	20	112.3	**2**
		FT069	1	16	72.3	8
9	Kampar	FT001	1	19	73.1	7
		FT070	1	8	43.9	11
10	Kerian	FT001	1	22	90.7	**3**
		FT075	1	13	83.8	5
11	Batang Padang	FT001	1	22	54.5	9
		FT059	1	9	36.2	14
12	Bagan Datok	-	-	-	-	
		Total	**22**	**253**	**1,167.55**	**22**

Table 3 indicates that the highest rank of the black spots in Perak is along route FT005, with 18 RTCs and total weightage points score of 118.2 in the Kinta district. At the same time, the lowest rank of the black spots was along route FT060, with 8 RTCs and total weightage points score of 14.2 in the Larut, Matang & Selama, Taiping district.

3. Priority for Implementing Black Spot Countermeasures

The next stage is to decide whether countermeasures should be carried out on the detected black spots as a priority after the black spots on a particular road segment have been discovered and ranked. It is necessary to decide whether the portions demand further investigation. Further investigation requires several formulae as suggested by Malaysia Public Works Department (JKR 2007) as follows;

$$\sigma = \sqrt{\frac{(\sum Xi^2 - nXi^2)}{(n-1)}} = standard\ deviation \quad (2)$$

$$Xm = \frac{\sum Xi}{n} = \text{norm or mean} \quad (3)$$

$$Cv = \frac{\sigma}{Xm} = \text{Coefficient of variation} \quad (4)$$

Where,

- n = number of equal − length sections in the route
- X_i = number of accidents in the road section i

The coefficient of variation is a priority indicator. Priority is assigned if the coefficient of variation (Cv>1), is greater than one. To compute the Cv, firstly compute the standard deviation (σ) of the RTC data. Then compute the data's norm or mean (Xm) and calculate the Cv to assess whether a countermeasure is necessary. To demonstrate the neediness to conduct the countermeasure, values in Table 4 that shows the number/frequency of RTC for road section from 412 to 421 and the severity of the injury in three (3) years are used.

Table 4 - RTC Section 412-421

Nos.	Equal length	No. of RTC/accidents	Severity
1	412 – 412.9	8	Non-fatal (NF)
2	413 – 413.9	0	-
3	414 – 414.9	4	NF
4	415 – 415.9	12	NF
5	416 – 416.9	1	NF
6	417 – 417.9	28	2 Fatal, 26 NF
7	418 – 418.9	3	NF
8	419 – 419.9	16	NF
9	420 – 420.9	12	NF
10	421	0	-
	Total	**84**	

Using the values in Table 4, the Cv for the road section number from 412 to 421 can be calculated as follow;

Number of accidents in the road section, $\sum X_i$= 84
Number of equal lengths, $n = 10$
Mean, $X_m = \frac{84}{10} = 8.4$
Number of square accidents, X_i^2= 64, 0, 16, 144, 1, 784, 9, 256, 144, 0
Total number of square accidents, $\sum X_i^2$ = 1,418
Standard deviation, $\sigma = \sqrt{\frac{(1418 - 10\ (8.4^2)}{(10-1)}} = 8.9$
Coefficient of variation, $C_v = \frac{8.9}{8.4} = 1.06$

Thus, the calculated Cv value is more than 1 which is 1.06. This indicates that the section 412 to 421 requires for countermeasure to resolve the RTC black spot.

3.1 JKR Manual Countermeasures for Blackspot

In Malaysia, all road-related issues are handled by the Public Works Department, also known as JKR. Single site or black spots, mass action schemes, route action plans, and area-wide schemes are the four fundamental tactics employed by JKR to reduce accidents. The JKR Interim Guide on Identifying, Prioritising, and Treating manual's accident black spot countermeasure procedures were adopted by JKR in 1995. The manual has numerous classifications of countermeasures for general accident situations, urban accident situations, and rural accident situations. Table 5 shows the general accident situations countermeasures as an example.

Table 5 - JKR manual countermeasures for general accident situations

Accident type	Possible Remedy	Possible accident saving
Wet road:		
Skidding	Restore micro/macro texture with the use of high psv aggregate in a) Surface dressing b) Bituminous surfacing or surface grooving	40-45% 45% (80% in wet accidents)
Spray reducing visibility	Restore macro texture Use of porous asphalt	
Aquaplaning	Improve drainage/road camber	
Darkness	Improve macrotexture	
Poor delineation	Make texture of markings contrast well with road surface Improve road surface texture	
Darkness:		
Poor surface luminance	Match surface texture with installation	15-30% dark accidents
Inadequate luminance	Renew surface Street lighting	50% dark rural accidents
Poor delineation	Lane/edge marking: reflectorised pavement markers, delineator posts	
Roadside obstacles:		
Loss of control/ drowsiness	Apply paint and reflectors to fixed object Road markings to guide around obstruction Re-site obstacles Frangible columns (rural non footpath) Improve/ install lighting Safety fences/ guard rail Crash cushions	10% fatal Reduce severity 15% fatal 90% cross-overs Reduce severity

From this study, it was found that 6 locations need to implement the low-cost countermeasures of accident black spots in Perak. The black spots are in districts of Kampar (Section 559, FT001 and Section 34, FT070), Kuala Kangsar (Section 633, FT001), Manjung (Section 42, FT060), Larut, Matang & Selama (Section 15, FT074), and Kerian (Section 8, FT075). To adopt the JKR low-cost countermeasures scheme, the scheme states that for the single site or black spot it should comply with the following terms (**JKR, 1995)**:

- An average First Year Rate of Return (FYRR) of 50% for schemes should be achievable nationally.

- Schemes with a smaller FYRR may be worth considering as time passes, provided they meet the other two objectives.
- Under the Ministry of Works Malaysia, a maximum of RM25,000 is suggested to be an appropriate level for the first application of RTC remedial work.
- After that, it can be increased between RM250,000 to RM500,000 based on the allocation given by the government.

Under the scheme, the Ministry of Works Malaysia has approved a maximum of RM25,000 for conducting the low-cost countermeasure for the first application of RTC remedial work and after which it can be increased to RM500,000 for each black spot. Thus, for the entire cost of six black spots, the total cost of the low-cost countermeasures scheme was RM 1,834,027.19 executed in 2021. For the black spot along route FT005 in Kinta district, the countermeasure was carried out in 2022 at Section 684 with a total cost of RM350,000.

However, this scheme is allocated only for federal roads under the Ministry and not for the state roads under Perak State PWD. Thus, it is recommended that the State PWD form a Road Safety Unit to carry out the scheme to reduce the black spots along the state roads which recorded the second highest road fatalities against the federal roads that had the most fatalities in Perak. For implementation of the low-cost countermeasures, State PWD has to plan for the allocation under the State Government annual development budget.

3.2 Implementation of Countermeasure

In the implementation of low-cost countermeasures according to the Guideline of JKR 20708-0022-95, several countermeasures can be implemented to improve safety at accident black spots such as:

- Install traffic calming measures: This could include speed humps, roundabouts, chicanes, or other physical features that encourage drivers to slow down and pay closer attention to their surroundings.
- Improve visibility: Visibility can be improved by installing better lighting, reflective signs, or other visual aids that help drivers see the road and potential hazards more clearly.
- Redesign the roadway: In some cases, the layout of the road itself may be contributing to accidents. Redesigning the roadway to include wider shoulders, bike lanes, or other features can improve safety for all users.
- Increase enforcement: Increasing police patrols or automated enforcement (e.g. speed cameras) can deter drivers from engaging in dangerous behaviour and help ensure that they are following traffic laws**.**
- Provide education and outreach: Educating drivers and pedestrians about the risks associated with accident black spots, and providing information about safe driving and walking practices can help reduce the likelihood of accidents.
- Improve public transportation: Encouraging people to use public transportation instead of driving can reduce the number of vehicles on the road and decrease the likelihood of accidents.

Overall, the most effective countermeasure will depend on the specific characteristics of the accident black spot. Implementing a combination of these strategies may be necessary to achieve the best results.

The process of implementing countermeasures to address accident black spots typically involves several steps, including:

i. Identification: Identify the location of the black spot by collecting and analysing data, such as accident reports, traffic volumes, and other relevant information.

ii. Analysis: Analyse the data to identify the factors that contribute to accidents at the black spot, such as speed, visibility, or road design.

iii. Develop countermeasures: Based on the analysis, develop a set of countermeasures that will address the specific factors contributing to black spot accidents. The countermeasures may include physical changes to the roadway, traffic control measures, or other strategies.

iv. Prioritisation: Prioritise the countermeasures based on their potential impact on safety and feasibility of implementation.

v. Implementation: Implement the countermeasures, which may involve constructing physical changes to the roadway, installing traffic control devices, or implementing other strategies, such as increased enforcement.

vi. Monitoring and evaluation: Monitor the effectiveness of the countermeasures over time and make adjustments as necessary to ensure that they continue to be effective in reducing accidents at the black spot.

vii. Communication and outreach: Communicate the changes to the public, and conduct outreach to educate drivers and pedestrians about the new measures and how to use the roadway safely.

By following these steps, transportation agencies can systematically identify and address accident black spots, making the roadway safer for all users. However, for Malaysia's authority on road accidents, it is the JKR Black Spot Countermeasure Report, (2021) is adopted as described in Figure 5.

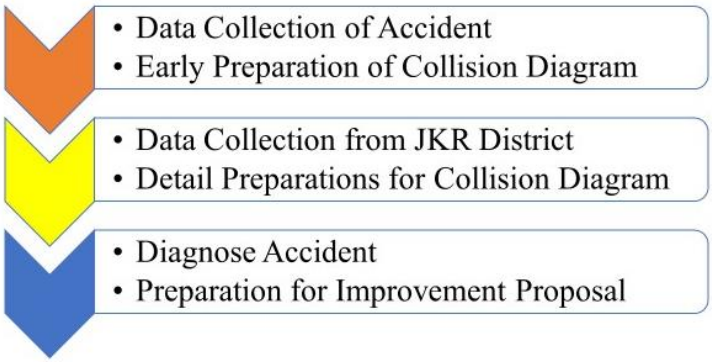

Fig. 5 - JKR Black Spot Countermeasure Report, (2021)

After identifying the cause of the accidents, solutions are developed and implemented to address the problem as shown in Figure 5. This could involve anything from installing new traffic lights or signs, redesigning the roadway, and improving the area's visibility. The goal is to reduce the likelihood of accidents occurring and to make the area safer for drivers, pedestrians, and other users.

The process of improving accident black spots also involves the ongoing monitoring and evaluation of the solutions that have been implemented. This allows for adjustments to be made if necessary to improve safety further and reduce RTCs. Overall, the process of eliminating or improving RTCs black spots is critical for creating safer roadways and reducing the number of RTCs and casualties that occur on them.

4. Conclusion

The black spot total weightage point values have a significant influence on the selection and ranking of RTCs black spot sites. This criterion will significantly impact all RTC locations with a different ranking order and the kind of RTC locations that will be judged "dangerous" and decisions for future traffic safety black spot regions. Based on the collected secondary data, the study found that Perak had 253 RTCs and 22 black spots along its Federal trunk roads in 2020. The outcomes of the black spot rating identification exercises found that the highest rank of the black spots in Perak is along route FT005, with 18 RTCs and a total weightage points score of 118.2 in the Kinta district.

At the same time, the lowest rank of the black spots was along route FT060, with 8 RTCs and a total weightage points score of 14.2 in the Larut, Matang & Selama, Taiping district. However, six black spots were treated in 2021 as there was limited funding. The six locations were selected from the district of Kampar (Section 559, FT001 and Section 34, FT070), Kuala Kangsar (Section 633, FT001), Manjung (Section 42, FT060), Larut, Matang & Selama (Section 15, FT074), and Kerian (Section 8, FT075). From this study it was found that the entire cost of countermeasures for the six black spots was RM 1,834,027.19.

Besides the six locations treated in 2021, the black spot at Section 684 along route FT005 in Kinta district, was also treated under the black spot low-cost countermeasure scheme for 2022 with a total cost of RM350,000. For implementing the black spot low-cost countermeasures scheme, the Ministry of Works Malaysia had allocated a maximum of RM25,000 for the first application of RTC remedial work; after that, this maximum may be increased to between RM250,000 and RM500,000. However, this scheme is not for the black spots along the State roads.

Thus, it is recommended that the State PWD take up this matter to the State Government so that such scheme can be established for the state roads in which the black spots low-cost countermeasures can be implemented under the development annual budget. By having such a scheme, road fatalities along the state roads which recorded the second highest fatalities besides the federal roads, can be reduced every year.

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Appendix A: Countermeasure at FT075 & FT001

Implementations of countermeasures were carried out in the year 2021. Countermeasures were implemented at 6 locations in 5 districts. However, this paper gives two examples of the countermeasures as shown in Figures 6 and 7. These two examples of the black spot countermeasures were carried out at Route Number FT075 in Kerian and FT001 in Kuala Kangsar.

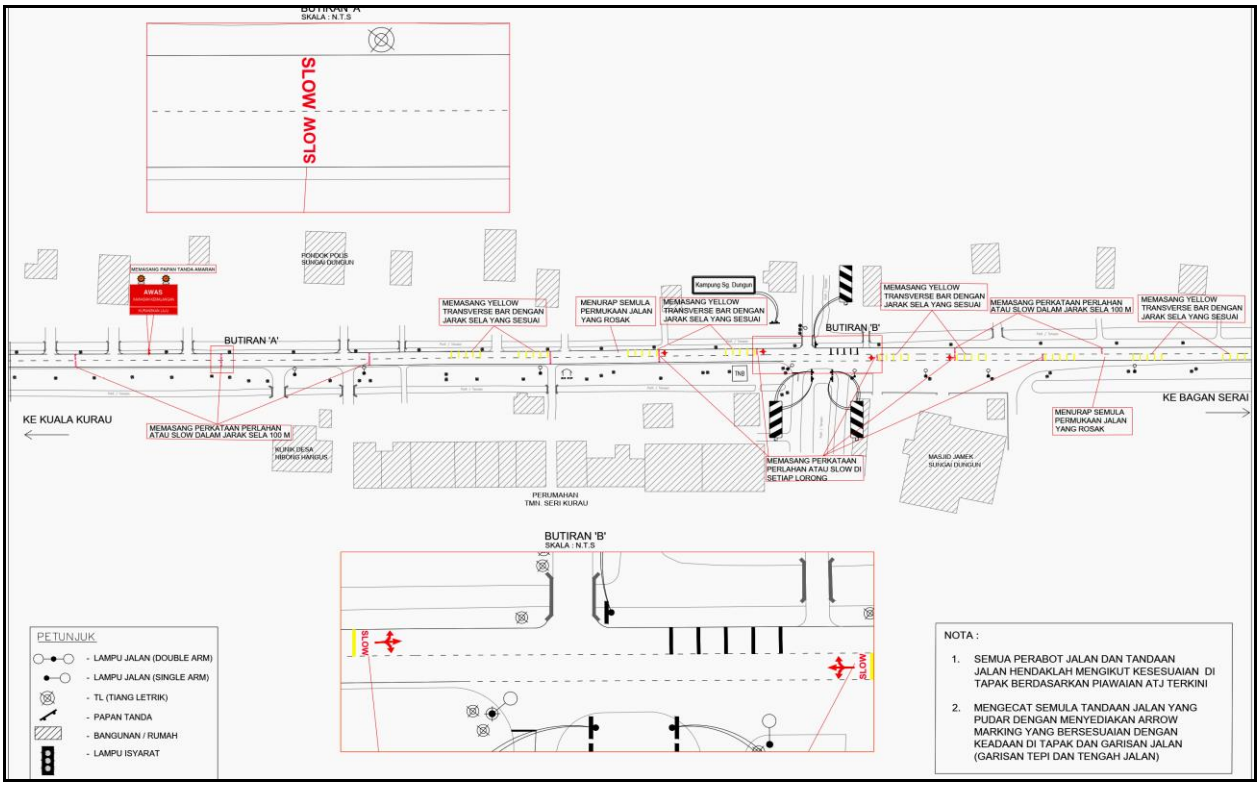

Fig. 6 - Countermeasure at FT075 in Kerian (JKR Perak, 2021)

Based on Figure 6, the countermeasure at FT075 in Kerian are based on the JKR countermeasures. The countermeasures are installing warning signs with lights and the slow warning sign fixed between 100 meters along the road. In addition, JKR painted yellow transverse bars with a suitable distance with the slow signboard as a warning to road users. JKR also paved the damaged road to improve the skid resistance and delineation to reduce the road accident. Apart from that, streetlamp posts, either single-arm or double arm were also installed along the roadsides as in Figure 6. The cost for the countermeasure at FT075 in Kerian was RM 349,985.79, which complied with JKR (1995) requirements for the project under low-cost countermeasures.

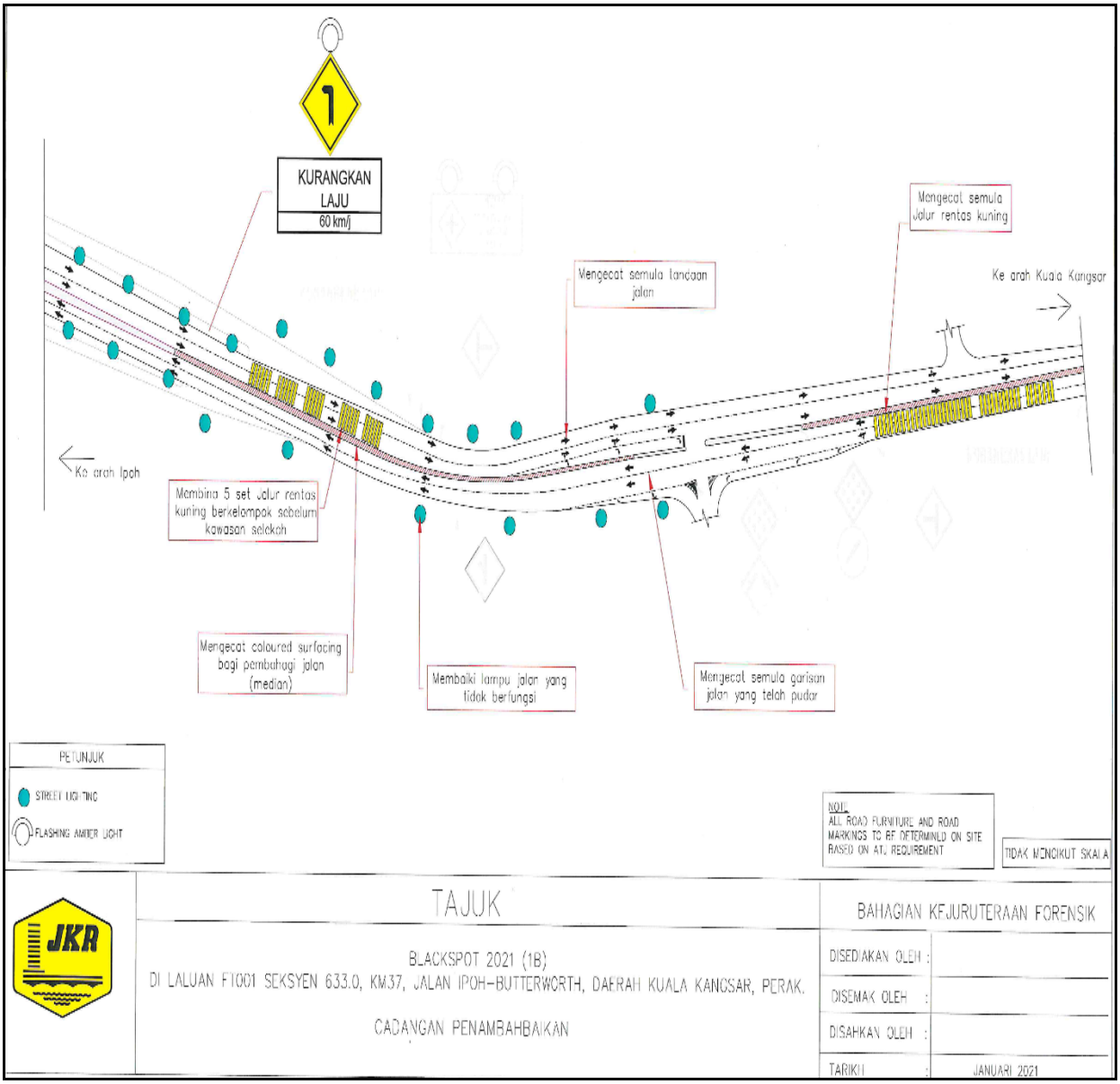

Fig. 7 - Countermeasure at Section 633, FT001 in Kuala Kangsar (JKR Perak, 2021)

Figure 7 shows the countermeasure done at section 633, FT001 in Kuala Kangsar by JKR Perak in 2021. JKR has installed a streetlamp on both sides of the road using a single-arm streetlamp post and a double arm streetlamp post along the road. Furthermore, JKR also repaints road marking and yellow crossline to reduce the speed of vehicles. The countermeasure cost for FT001 in Kuala Kangsar was RM350, 000.00.

Appendix B: Perak Map with Black Spots

Figure 8 shows the Perak map indicating the Federal trunk routes with black spots in 2020.

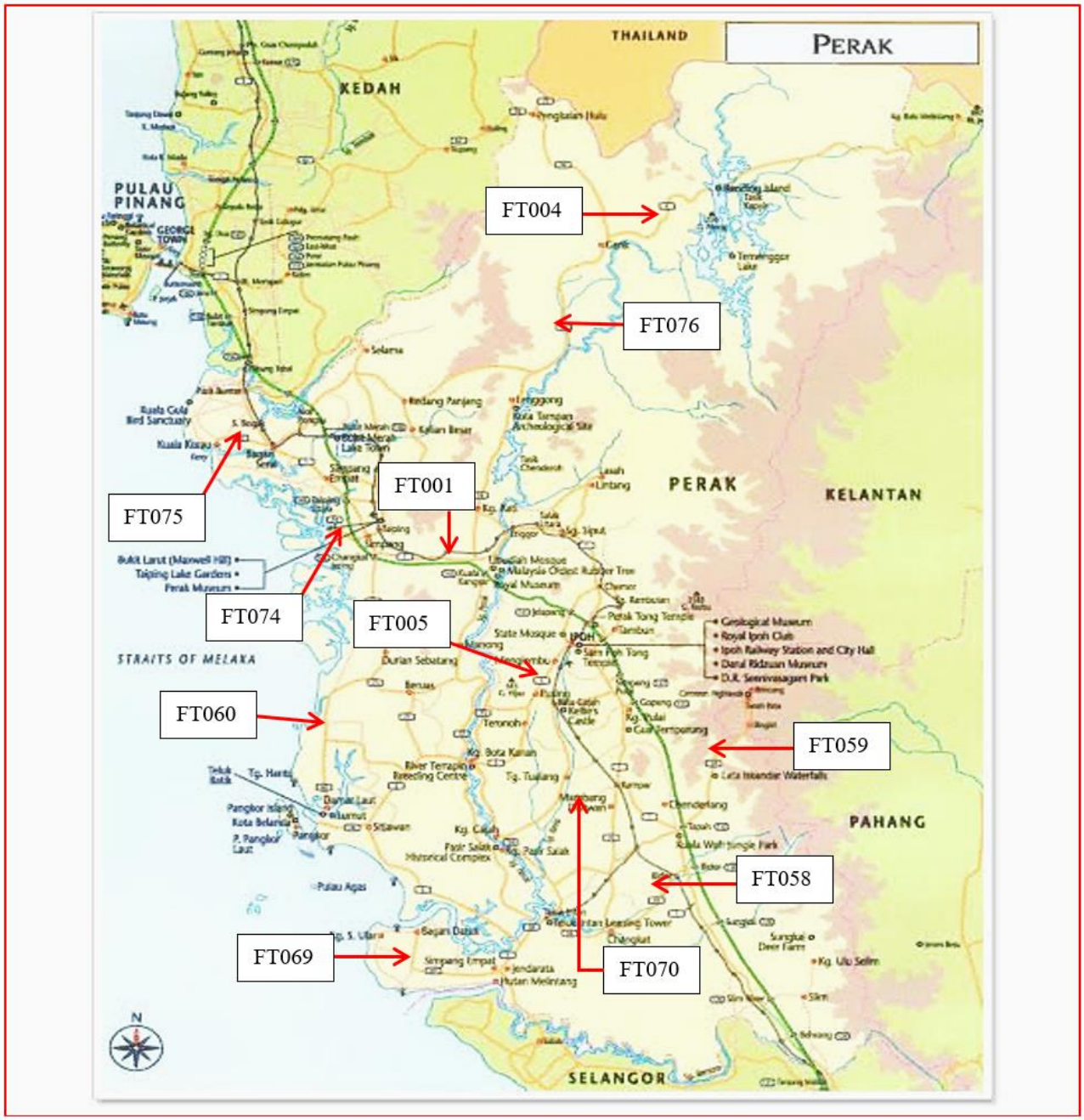

Fig. 8 - Federal trunk routes with black spots in Perak [JKR, 2020]

Among the routes shown on the map, route FT001 has the most black spots, which was 7, followed by FT005 with 4numbers, FT060 and FT076 with 2 numbers each, where as the rest had one each. The total number of black spots recorded in Perak for the year 2020 was 22 numbers.

References

Abdolmanafi, S. E., & Karamad, S. (2019). A new approach for resource allocation for black spot treatment (case study: The road network of Iran). *Journal of Safety Research*, *69*, 95-100.

Akmal, A. (2016). Traffic Fatality Causes and Trend in Malaysia. Malaysia Sustainable Cities Program, Working Paper Series.

Alvin Poi, WH (2021). Road Traffic Injuries in Malaysia.

Elena, K., Sergei, E., & Jarosław, R. (2020). Potential for improving the procedure of inspecting road traffic accident black spots. *Architecture and Engineering*, *5*(3), 56-62.

Elvik, R. (2007). *State-of-the-art approaches to road accident black spot management and safety analysis of road networks*. Oslo: Transportøkonomisk institutt.

Fekadu, G., & Wuezon, E. T. (2013). Identification of Road Traffic Accident Black spot locations and its countermeasures in Oromi Region, Ease Wolega Zone. *International Journal of Scientific& Engineering Research*, *7*(10), 1372-1379.

Ghadi, M., & Török, Á. (2019). A comparative analysis of black spot identification methods and road accident segmentation methods. *Accident Analysis & Prevention*, *128*, 1-7.

Jabatan Kerja Raya (1995) Interim Guide on Identifying, Prioritising and Treating Hazardous Location on Roads In Malaysia. (Jkr-20708-0022-95)

Jabatan Kerja Raya (2007) Highway Planning Unit (HPU) Point System.

Kementerian Kerja Raya. (2021). Statistik Jalan Edisi 2021. kkr.gov.my.

Maen, G., Árpád, T. (2017). Comparison Different Black Spot Identification Methods. 20th EURO Working Group on Transportation Meeting, EWGT 2017, 4-6 September 2017, Budapest, Hungary.

McGuigan, D. R. D. (1981). The use of relationships between road accidents and traffic flow in" black-spot" identification. *Traffic Engineering & Control*, *22*(HS-032 669).

Nuradzimmah, D. (2022). New hope in reducing accidents. NST.com.my

Radin Sohardi, R.U. and Baquely, C.J. (2005). The Identification, Prioritising and Analysis of Accident Blackspots in Malaysia, REAAA Journal/January 1994

Sarani, R. Mohd Marjan, J. and Shaw Voon, W (2018). Road Safety in Malaysia. 2nd Conference of ASEAN Road Safety2018.

Washington, S., Karlaftis, M. G., Mannering, F., & Anastasopoulos, P. (2020). *Statistical and econometric methods for transportation data analysis*. CRC press.

Yashas,S.R, Harish,S.N. and, Muralidhar, HR, 2015. Accident Analysis at The Blackspot: A Case Study. IOSR Journal of Mechanical and Civil Engineering (IOSR- JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 6 Ver. II (Nov. - Dec. 2015), PP 105-114

Younus, M., Ankit, S., Jagdeep, S. (2019). Road safety and Road Accidents: An Insight. researchgate.net

Zarulazam, E. (2015). The efficiency & effectiveness of the safety management system in Malaysia: The Way Forward. PSKLM International Expressway Conference & Exhibition, Kuala Lumpur.