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International Journal of Road Safety

Journal homepage: www.miros.gov.my/journal

IJRS
International Journal of Road Safety

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The Post-Mortem of Road Safety Audit Stage 5

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ABSTRACT

The Road Safety Audit (RSA) stage 5 is a proactive measure taken by the Malaysian Institute of Road Safety Research (MIROS) to improve the level of road safety along existing roads in Malaysia. Since 2008, MIROS has conducted 208 cases of RSA stage 5, and for this study, only 68 of RSA cases were chosen as samples for a desktop study. Apart from desktop analysis, eleven of previous RSA cases were chosen based on a selection criterion to be revisit. The aim of this study is to identify common deficiencies extracted from the RSA Stage 5 reports and assess the successfulness of all the recommendations proposed in the RSA-Stage 5 reports. Based on the analysis conducted from 68 RSA reports, the most common issues reported in the RSA stage 5 reports along expressway are related to access point deficiencies, for non-expressways, visual aid deficiencies issues are generally being observed (27.4%) while for signalized and un-signalized junction, issued related to geometry layout deficiencies are the most common (24.0% - 27.8%). Proper and appropriate visual aid was proven effective to reduce the speeding issue. It was strongly suggested that visual aid be given high priority countermeasure in Malaysia. We see that road authorities are willing to rectify any road deficiencies if budget for road maintenance or upgrading and the cost to conduct RSA Stage 5 are allocated. MIROS or other road safety agencies/bodies need to engage the road authorities strategically and effectively by assisting them on identifying the risky location and planning for road maintenance and upgrading budget before proceeding with the RSA Stage 5 in the future.

ARTICLE INFO

Article History:
Received 31 Jan 2022
Received in revised form
31 May 2022
Accepted
15 Sep 2022
Available online
01 Nov 2022

Keywords:
Road safety audit,
Road Safety Deficiencies,
Low-Cost Countermeasures

1. Introduction

One of the most effective proactive road safety measures is the Road Safety Audits. Road safety audit or RSA is a formal systematic road safety assessment of a road scheme carried out by an independent, qualified auditor who reports on the project's accident potential for all kinds of road users (Elvik, Høye, Vaa, & Sørensen, 2009). Road safety audits or RSA are intended to detect defects in road design or traffic control, which may affect road safety, and to ensure that these are corrected to prevent accidents (Elvik, et al., 2009). It is found out that in Germany, it was estimated that an RSA might prevent up to 70% of all crashes. At the same time, in Great Britain, the average number of casualties was reduced 1.25 per year, and in the United States RSA decreased crashes case for about 12.5 – 23. 4% (Elvik, et al., 2009). In a cost-benefit analysis, the main advantages of RSAs are that accidents can be prevented before any accidents occur and deficits can be treated before the road is built (Elvik, et al., 2009), thus this gives an effective and inexpensive road safety management (Austroads, 2002). A study by Austroads (2002), has demonstrated substantial positive benefits from the road safety audit process, and their analysis of a range of existing road safety audits indicated Benefit-cost-ratio or BCRs of implementing the proposed road safety countermeasures are between 2.4:1 and 84:1.Moreover, experience has shown that an effective road safety engineering program requires three times as much effort being put into 'blackspot' programs (i.e. the treatment of crash locations) as is put into RSA (Elvik, et al., 2009).

RSA has a long history and a foothold in European and developed countries. RSA was introduced in Great Britain and Denmark at the beginning of the 1990s and has now more or less been adopted in 23 European countries, Australia and several states in the United States (Elvik, et al., 2009). Besides, various forms of RSA have also been applied in many European countries (Elvik, et al., 2009; Lawsona, Barlowb, Poranc, Petrosyand, & Ševroviće, 2016). In European and developed countries, there are RSA and Road Safety Inspection (RSI) program (PIARC, 2012). RSA are proactive road safety management, and it deals with the design of new or reconstructed roads and RSI deals with existing roads (Elvik, et al., 2009). The purpose is to make new, reconstructed, and existing roads as safe as possible before construction is started and/or crashes occur (PIARC, 2012). Both RSA and RSI focus solely on road safety without regard for other possibly conflicting objectives. Based on findings, it is recommended that the

RSA or RSI should be conducted for every 2-4 years according to because of the new conflicts or problematic due to new road development that created a new issue (Austroads, 2002; Elvik, et al., 2009; PIARC, 2012).

Malaysia has long been a country with high rates of fatalities among its road users, compared to other developing countries (Abdul Manan & Várhelyi, 2012). In order to curb these fatalities, Malaysia has also adopted the RSA approach on all its road development (JKR, 2002). RSA in Malaysia is carried out in accordance with the Guideline for The Safety Audit or Roads and Road Projects in Malaysia (JKR, 2002) prepared by the Public Works Department (JKR). The RSA in Malaysia consists of 5 stages, i.e., Stage 1 - Planning and Feasibility Stage of the Project Development, Stage 2 - Preliminary Design Stage, Stage 3 - Detailed Design Stage, Stage 4 - At the Construction/Pre-Opening Stage and Stage 5 - Operational stage. RSA Stage 5 is widely adopted by road authorities on their existing road, and it is similar to RSI (Elvik, et al., 2009; PIARC, 2012).

The Malaysian Institute of Road Safety Research (MIROS) has conducted RSA stage 5 for more than ten years, as one of its main operations. Based on the records, there have been 208 RSA stage 5 done on various types of roads in Malaysia and local authority (PBT) has been the main client with 32% cases, as shown in Figure 1. Many corrective measures were proposed to improve road safety level at the audited location. However, the effectiveness of the adoption of the recommendations were yet to be revisited and evaluated. Thus, this paper seeks to answer the main question which: what are the most common findings in the RSA Stage 5? To achieve this aim, two objectives were sets: (1) to determine the most common findings and recommendations in RSA-Stage 5 and (2) to assess the successfulness of all the recommendations proposed in the RSA-Stage 5 reports.

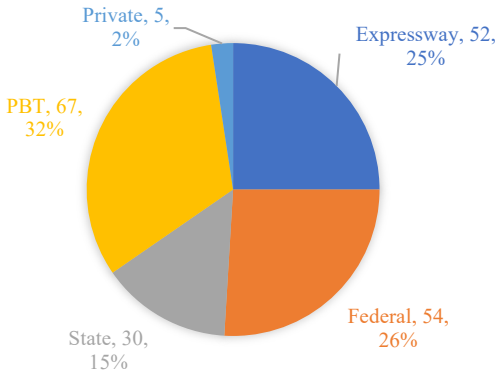


Figure 1: Percentage of RSA Stage 5 conducted by MIROS (2008-2019) based on road authority

2. Method

The study was conducted from 15th of June 2019 to 25th of December 2019. This study evaluates the RSA stage 5 reports from the year 2008 until 2018. From the total of 192 RSA stage 5 that have been carried out, only 68 RSA report are available for analysis and out of that, 11 locations were selected for RSA revisit. Overall, the framework for this study is illustrated in Figure 2.

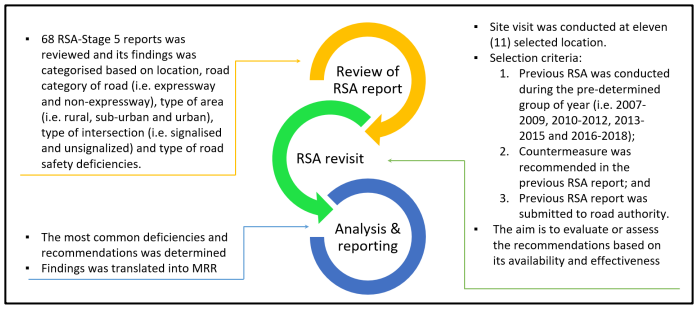


Figure 2: Overall study framework

2.2. Review of RSA Stage 5 Reports

During the review process, 68 RSA reports was studied, and its findings on the common road safety deficiencies, were categorized based on the type of road (i.e., expressway and non-expressway), type of junction (i.e., signalized, and un-signalized) and type of area (i.e., rural, suburban, and urban). At the same time, while reviewing these reports, a few suitable sites were identified for revisit.

2.3. Revisit of RSA Stage 5 sites

The revisit of sites is a process that involves re-evaluate the site to determine the improvement and changes from the previous RSA Stage 5. The revisit sites are selected based on the criteria below:

1. Previous RSA Stage 5 were conducted during the pre-determined group of year (i.e. 2007-2009, 2010-2012, 2013-2015 and 2016-2018). This is to evaluate the RSI operation effectiveness based on every 3-year period as stated in the literature.
2. There were countermeasures recommended in the RSA Stage 5 reports and
3. These RSA Stage 5 reports were submitted to road authority.

During the revisit process, data collection was conducted by applying RSA stage 5 method where amongst the data collected are speed, volume, road geometry and road deficiencies. Comparison was made with previous RSA report to identify the changes and improvement at the location.

3. Results

In general, from the 208 RSA stage 5 conducted by MIROS, the most audited road was federal and state roads with 41% from out of the total, followed by local road with 32%, expressway with 25% and private road with 2%. This proportion of RSA Stage 5 work is almost similar the proportion rate of crashes along various type of roads in Malaysia (see Abdul Manan and Várhelyi (2012) for the rate of crashes by road type).

3.1. Findings from the review of RSA Stage 5 reports

Figure 3 shows the percentage of reported road safety deficiencies issues based on the 18 cases (i.e., seven (7) cases on rural, eight (8) cases on urban and 3 cases on sub-urban) from the reviewed RSA stage 5 conducted along expressway. In general, the highest percentage of deficiencies issues being reported on RSA Stage 5 works along expressways are related to access points (24.4%) (see Figure 3). However, if we analyzed based on the location of the expressways, speeding issues was the most frequently reported on rural expressways (29.2%), access point deficiencies on urban expressway (36.8%) while visual aid deficiencies are more along sub-urban expressways (44.4%). On a special note, besides speeding issues, rural expressways have also more issues related to the safety of roadside barriers. In urban expressway, the major problem was more on access point

density and this finding was contradict with rural expressway since rural expressways are full control access facilities.

Expressways	Rural	Urban	Sub-urban	Total
Total Number of reports	7	8	3	18
Total Number of issues related to safety	24	57	9	90
Road Elements Category				
Speeding	**29.2%**	10.5%	33.3%	17.8%
Alignment	16.7%	19.3%	-	16.7%
Access points	4.2%	**36.8%**	-	**24.4%**
Visual aids	16.7%	19.3%	**44.4%**	21.1%
Roadside safety	20.8%	7.0%	11.1%	11.1%
Road surface	12.5%	7.0%	11.1%	8.9%

% - The percentage is based on the number of deficiencies issues

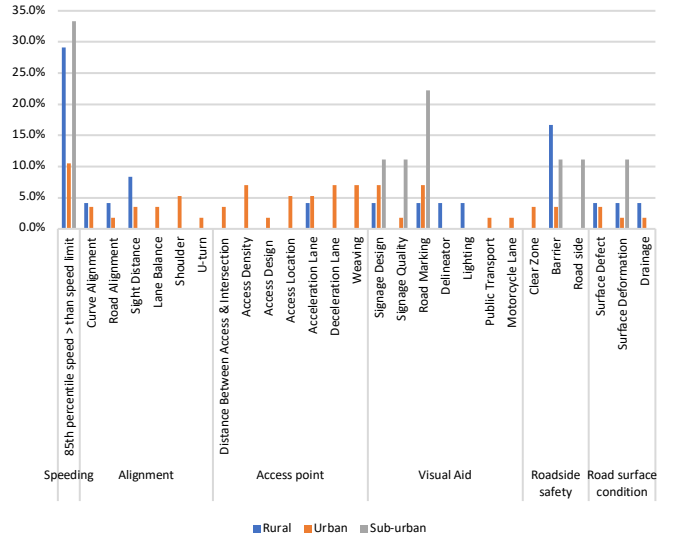


Figure 3: Percentage of reported road safety deficiencies issues on cases along expressways

From the RSA Stage 5 reports, we gather that, non-expressways (i.e. Primary, Secondary, Collector and Local or Municipal roads) have more issues related to visual aid, i.e., deficiencies in road marking and signages, compared to deficiencies along expressways. As for non-expressway road, a total of 49 cases were analyses which includes 14 cases in rural area, 23 cases in urban area and 12 cases in sub-urban area. All types of areas show that deficiencies on visual aid are consistently high (28.4% for Rural, 26.6% for Urban and 27.9% for Sub-urban) (see Figure 4). The most-reported deficiencies related to visual aid are faded road marking, absence of signage, improper signage location, inadequate number of signage and road marking, vandalized and blocked signage. On the other hand, non-highway on sub-urban areas reported many cases of speeding issues, which has the rate of 14.8% from the total number of issues. At the same time, roadside safety deficiencies such as damaged barriers, inappropriate barrier type, insufficient barrier height and absence of barrier, are more reported in the RSA Stage 5 reports on non-expressways along rural areas (14.7%).

Non-expressways	Rural	Urban	Sub-urban	Total
Total Number of reports	14	23	12	49
Total Number of issues related to safety	95	154	61	310
Road Elements				
Speeding	8.4%	6.5%	14.8%	8.7%
Alignment	7.4%	11.0%	4.9%	8.7%
Cross section	9.5%	8.4%	6.6%	8.4%
Access point	17.9%	12.3%	4.9%	12.6%
Visual Aid	**28.4%**	**26.6%**	**27.9%**	**27.4%**
VRU Infrastructure	6.3%	14.9%	21.3%	13.5%
Roadside Safety	14.7%	7.8%	6.6%	9.7%
Road Surface	7.4%	12.3%	13.1%	11.0%

% - The percentage is based on the number of deficiencies issues

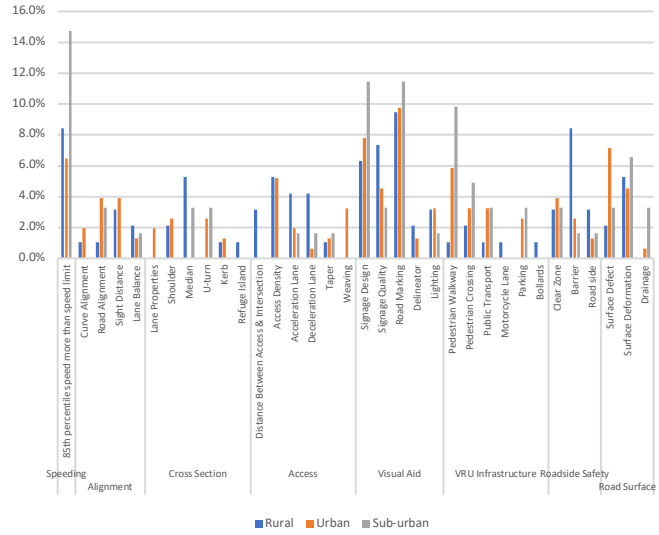


Figure 4: Common deficiencies at non-expressways

In general, un-signalized junction has more issues related to the deficiencies on the vulnerable road user's (VRU) infrastructure. Figure 5 shows the main deficiencies at un-signalized junctions in urban (n=5), rural (n=4) and sub-urban (n=3) areas. Most un-signalized junction have issues with VRU infrastructure (27.8%) such as discontinuity of walkway, absence of pedestrian crossing and illegal parking at junction. Second highest issue was visual aid (23.6%) which includes faded road marking, vandalized signage, inadequate or absence of signage to warn or inform drivers of the road condition ahead and signage installed at improper locations.

In terms of area, un-signalized junction in rural areas have issues on geometry layout deficiencies (51.9%) where, lack of acceleration and deceleration lanes were recorded the highest (see Figure 5). Based on the analysis, most (15%-20%) of the audited un-signalized junctions along rural areas, do not have acceleration or deceleration lane where required, and has insufficient length of acceleration or deceleration lane. In urban area, clear zone within junction seems to be the most common issues where limited space was available for sufficient clear zone. For sub-urban area, highest frequency of deficiencies was observed for VRU infrastructure.

Un-signalized junctions	Rural	Urban	Sub-urban	Total
Total Number of reports	4	5	3	12
Total Number of issues related to safety	27	27	18	72
Road Elements Category				
Speeding	-	3.7%	11.1%	4.2%
Alignment	-	11.1%	-	4.2%
Geometry Layout	**51.9%**	11.1%	11.1%	26.4%
Visual Aid	25.9%	22.2%	22.2%	23.6%
VRU Infrastructure	14.8%	**25.9%**	**50.0%**	**27.8%**
Roadside Safety	7.4%	18.5%	5.6%	11.1%
Road Surface	-	7.4%	-	2.8%

% - The percentage is based on the number of deficiencies issues

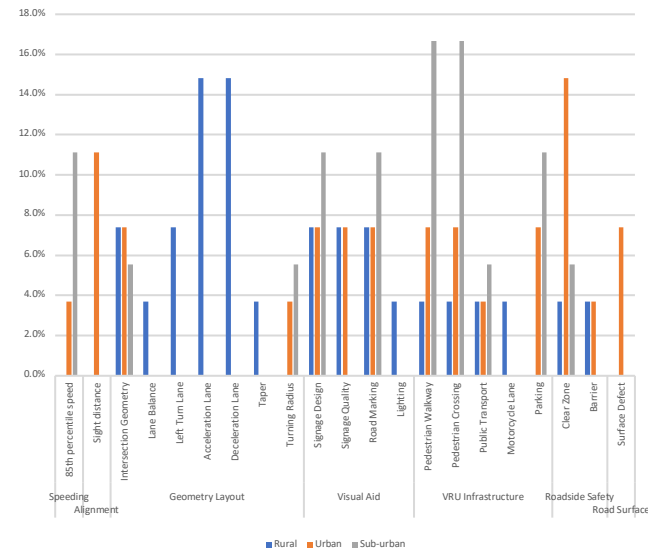


Figure 5: Common deficiencies at un-signalized junction

For signalized junction, most of the deficiencies occurred at urban area, with issues pertaining to visual aid are the most reported (see Figure 6). Other than that, geometric layout issue (e.g., inadequate right turn lane length, inappropriate lane balance, insufficient lane balance, etc.) was also highly reported on rural signalized junctions. Other safety issues concern at rural signalized junction are flaws in VRU infrastructure (20.0%) and in roadside safety measures (13.3%). For sub-urban signalized junction, frequent deficiencies were centered at road surface defects (33.3%), speeding behavior, inappropriate road alignment and traffic signal operation.

Signalized junctions	Rural	Urban	Sub-urban	Total
Total Number of reports	2	6	3	11
Total Number of issues related to safety	15	26	9	50
Road Elements				
Speeding	-	15.4%	11.1%	10.0%
Alignment	-	3.8%	11.1%	4.0%
Traffic Signal	-	3.8%	11.1%	4.0%
Geometry Layout	**40.0%**	19.2%	11.1%	**24.0%**
Visual Aid	26.7%	**23.1%**	-	20.0%
VRU Infrastructure	20.0%	19.2%	11.1%	18.0%
Roadside Safety	13.3%	3.8%	11.1%	8.0%
Road Surface	-	11.5%	**33.3%**	12.0%

% - The percentage is based on the number of deficiencies issues

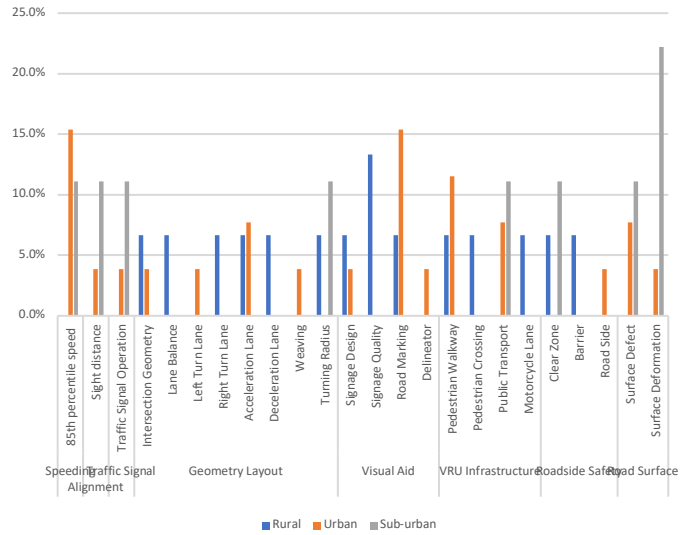


Figure 6: Common deficiencies at signalized junction

3.2. Findings from the RSA Stage 5 site revisit

There were eleven (11) locations that were selected for RSA revisit (see Figure 7) based on the selection criteria explain the previous section. These locations vary from local university inner and outer roads, municipal roads, state and federal own roads, and also specific infrastructure, i.e., bicycle lanes. Table 1 to 3 shows samples of our analysis comparing previous RSA Stage 5 with the revisit RSA Stage 5.

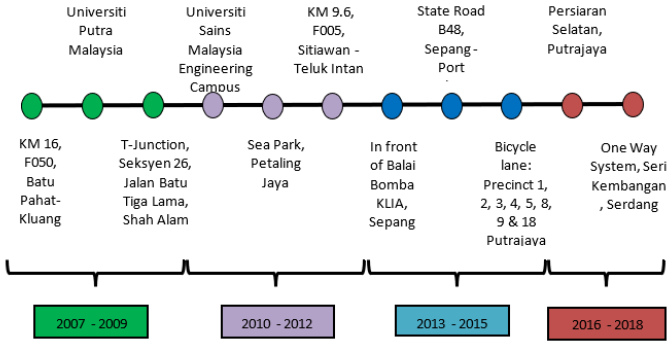


Figure 7: The selected sites for the RSA Stage 5 revisit

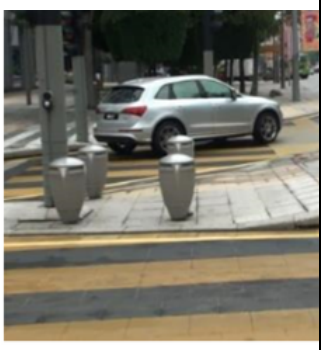
Table 1: Sample finding obtained from RSA Stage 5 revisit at KM 16, F050, Batu Pahat-Kluang, Johor, MALAYSIA

2009	2019
	
The location is a four-lane single carriageway road during RSA Stage 5 in 2009. High number of access road was observed along the road. Risky and uncontrolled traffic movement was seen by traffic entering and exiting from the main road to access road.	The four-lane single carriageway was upgraded to a four-lane dual carriageway with a concrete median. The traffic movement at the location was improved and safer where the presence of the concrete median able to control the number of access.

Table 2: Sample finding obtained from RSA Stage 5 revisit at Sea Park, Petaling Jaya, Selangor, MALAYSIA

2010	2019
	
The road alignment after the curve was not visible by drivers approaching the junction. In other words, the alignment of the of the curve is 'hidden' from the view of drivers who are driving towards the junction.	Based on the recommendation by MIROS in 2010, Majlis Bandaraya Petaling Jaya (MBPJ) has realigned the road to improve the road visibility and sight distance. The realignment not only enhanced the visibility of road alignment approaching the signalized junction, but it also improves decision sight distance of the said junction.

Table 3: Sample finding obtained from RSA Stage 5 revisit at bicycle lanes in Putrajaya, Federal Territory, MALAYSIA

2014	2019
	
The installation of the bollard aims to prevent the misuse by the motorist. However, the gap between the bollards was insufficient for the bicyclists to manoeuvre the area smoothly.	The distance between the bollards was increased, and enough space was given for bicyclist.

Our analysis shows that the rectifications done based on MIROS's recommendations from the RSA Stage 5 report were not done completely. Table 4 summarized the main deficiencies and countermeasures suggested in the previous 11 RSA Stage 5 cases, and the status of rectification works done by road authority. A total of **50** major road safety deficiencies were highlighted from the eleven (11) cases (this excludes the State Road B48, Sepang - Port Dickson because the road was under construction). From that, only **46% of deficiencies were rectified** by road authority and furthermore, most of these cases/sites with rectification are those sites where the road authority had engaged MIROS formally and request for RSA Stage 5.

Table 4: Summary of deficiencies and recommendation for 11 RSA revisit location

Location	Deficiencies	Recommendations	Rectification
(1) KM16, F050, Batu Pahat - Kluang	High number of access	Close some of the access and provide an alternative route	✗
	Faded road marking	Repaint	✓
	Absence of auxiliary lane	Provide auxiliary lane where necessary	✗
	No protected lane provided for right turn vehicle	Provide protected lane for right turn vehicle	✓ (upgraded into 4-lane dual carriageway)
(2) Universiti Putra Malaysia	Inappropriate crossing location	Relocate the pedestrian crossing area	✓
	Insufficient zebra crossing dimension	Increase the dimension according to guidelines (raised pedestrian crossing)	✓

Table 4: Summary of deficiencies and recommendation for 11 RSA revisit location (cont.)

Location	Deficiencies	Recommendations	Rectification
	Improper signage location	Relocate the signboard at the appropriate location	✗
	Poor junction sight distance	Trim the trees	✗
	Poor crosswalk marking	Repaint	✓
	Poor quality on pedestrian walkway & crossing facility	Installation of proper pedestrian crossing facility (e.g. flushed kerb, fencing)	✗
	Uneven road surface (interlocking block)	Scheduled maintenance/ change surface type	✓ (occur at other location)
(3) T-Junction, Seksyen 26, Jalan Batu Tiga Lama, Shah Alam	Evasive/risky maneuver to avoid encroach area	Remove encroach area	✓
	Roadside features (visibility of junction)	Relocation of feeder pillar, lighting post and construction of new kerb	✓
	Landscaping blocking sight distance	Trimmed or remove the tree	✓ (temporary steel sheeting blocking sight distance)
	Inadequate warning signs	Install warning sign	✓ (vandalised sign)
	Faded road marking	Repaint road markings	✓ (still faded)
	Poor stopping sight distance and junction visibility	Clear the bushes	✓
	Poor lane balance - motorcycle lane suddenly changed to through lane	Improve the road marking and lane distribution	✗
(4) Universiti Sains Malaysia Engineering Campus	Bus layby sharing the main carriageway	Separate bus layby and main carriageway	✗
	Edge line marking covered with vegetation and sand	Scheduled maintenance	✓
	Sharp radius of left turning lane	Provide the storage lane for merging vehicle	✓
	Two-way service road creates complex traffic maneuvers	Turn the service road into a one-way road	✓
	Obstructed road signage	Trim the trees and make it visible	✓ (more improvements needed)
	Unmaintained pedestrian walkway	Regular maintenance on pedestrian walkway	✗
	Absence of fencing/ railing at the bus stop	Install fencing/railing	✗
	Improper traffic signal channelization (seagull arrangement)	Remove the seagull arrangement	✓
(5) Sea Park, Petaling Jaya	Alignment of curve hidden	Realigned the road to improve visibility and sight distance	✓
	Poor termination of acceleration lane (no road marking)	Paint road marking to indicate a merging lane	✗
	Pedestrian walkway to junction	Provide raised pedestrian walkway from the housing area to junction	✓
(6) KM9.6, F005, Sitiawan - Teluk Intan	Speeding	-	✓ (lane was upgraded into 4-lanes dual carriageway)
	Insufficient and inconsistent of paved shoulder width	Provide shoulder where necessary	✗
	Sub-standard guardrail	Revise the guardrail post spacing	✗
	Bullnose end treatment type	Install the flared end treatment type	✗
	Faded road marking	Repaint	✗

Table 4: Summary of deficiencies and recommendation for 11 RSA revisit location (cont.)

Location	Deficiencies	Recommendations	Rectification
(7) In front of Balai Bomba, KLIA, Sepang	Improper lane design	Repaint new lane arrangement	✗
	Misuse of access road	Close the access for public	✗
	Poor visibility of traffic signal	Provide mast arm signal	✗
	Road surface deterioration	Schedules maintenance and pavement resurface	✗
(8) State Road B48, Sepang - Port Dickson	Limited sight distance	Speed limit signage and traffic calming (e.g. RRPM)	The road was under construction
	Broken and substandard guardrail	Regular maintenance	
	Faded/unmaintained road marking	Repaint	
(9) Bicycle Lane: Precinct 1, 2, 3, 4, 5, 6, 9 &18	Confusing bicycle surface travel path	Paint the bicycle path area with contrast colour	✓
	Close gap between bollard for bicycle manoeuvre	Increase the bollard gap	✓
	Obstruction from bus stop area to the travel path of bicycle	Realign the bicycle travel path	✓
	Illegal parking	Provide a conducive motorcycle parking	✗
(10) Persiaran Selatan, Putrajaya	Inappropriate guardrail end treatment (Bullnose)	Replace the end treatment to the flare type	✗
	Blocked signage	Trim the trees	✗
	Illegal U-turn from the main carriageway	Provide a proper right turn area	✗
(11) One-way system, Seri Kembangan, Serdang	Pedestrian crossing was blocked by the concrete barrier	Remove the concrete barrier	✗
	Unmaintained pedestrian walkway	Regular maintenance	✗
	Poor location of bus stop	Change the bus stop location	✗
	Roadside hazard	Regular maintenance	✗
	Faded road marking	Repaint	✗

4. Discussion

The aim of this study is to conduct a post-mortem of all Road Safety Audit Stage 5 conducted by MIROS over the past 10 years. MIROS's records shows that there have been 208 RSA Stage 5 done on various types of roads since 2008 to 2019, but these RSA have never been analyzed or evaluated. Out of the 208 RSA Stage 5 reports, only 68 reports were chosen as a sample based on several selection criterion. Road safety deficiencies were extracted and analyzed from the 68 RSA reports and the objective mainly to identify common deficiencies on Malaysian road. In addition, eleven (11) RSA from 68 cases were chosen, and RSA revisit was conducted to investigate any improvement done by road authority based on MIROS suggestion.

This study shows that the most common issues reported in the RSA stage 5 reports along expressway are related to access point deficiencies (24.4%) (see Table 5). A study has shown that road with more access points posed more risk to road users especially for motorcycles (Abdul Manan, Jonsson, & Várhelyi, 2013). Focusing on rural expressways, speeding issues was glaring among other issues. This finding is in line with studies from Abdul Manan, Ho, Syed Tajul Arif, Abdul Ghani, and Várhelyi (2017), Abdul Manan, Zulkiffli, and Jamil (2020) and Yunin and Abdul Manan (2020), which indicates clearly shows that Malaysian expressways have speeding problems and that road authorities in Malaysia have yet to effectively execute speed management along the expressways. On the other hand, for non-expressways, visual aid deficiencies issues are generally being reported (27.4%) while for signalized and un-signalized junction, issued related to geometry layout deficiencies are common (24.0% - 27.8%) (see Table 5). It was clear that other than the speeding behavior issue, visual aid are also the most prevalent road safety deficiencies in Malaysia. Moreover, for rural signalized junctions, the most common deficiencies are related to Visual aids, while the sub-urban and urban are Speeding and Road Surface deficiencies. Based on our observations, maintenance of visual aids (e.g., faded road markings, damage signs, and infra, etc.) along rural areas may have not been as efficient as in the urban area due to budget constraints.

Table 5: Summary of highest percentage of deficiencies reported based on area type and type of road

Road Criteria	Rural	Suburban	Urban	Overall
Expressway	Speeding (29.2%)	Access (36.8%)	Visual aids (44.4%)	Access (24.4%)
Non-expressway	Visual Aid (28.4%)	Visual Aid (26.6%)	Visual Aid (27.9%)	Visual Aid (27.4%)
Signalized junctions	Geometry Layout (40.0%)	Visual Aid (23.1%)	Road Surface (33.3%)	Geometry Layout (24.0%)
Un-signalized junctions	Geometry Layout (51.9%)	VRU Infrastructure (25.9%)	VRU Infrastructure (50.0%)	Geometry Layout (27.8%)

The rectification of deficiencies along Malaysian roads is highly dependent on the road maintenance budget or road upgrading allocation for each road authorities in Malaysia. This is shown by our analysis that only 46% of deficiencies (based on the 11 selected report, see Table 4) were rectified by road authority and 80% of these road authorities have engaged MIROS to conduct the RSA Stage 5, in order to identify the best countermeasures and thus spends their allocation for road maintenance and upgrading efficiently. On the other hand, MIROS proactive approach on conducting RSA Stage 5 without the knowledge or consent from the road authorities may be fruitless and ineffective due to the fact that they may have not have the budget for the rectification works or they might have it allocated for other roads.

We strongly suggested that maintenance and rectification on all existing types of visual aids along Malaysia roads be given high priority as many studies have shown that sufficient visual aid could help to curb the speeding issue (Charlton, Starkey, & Malhotra, 2018; Diamandouros & Gatscha, 2016; Edquist, Rudin-Brown, & Lenné, 2009; Guo, Liu, Liang, & Wang, 2016; Yan, Radwan, Guo, & Richards, 2009), but also correcting and guiding road user behavior to suit the condition of the roads (Goh & Wong, 2004; Yan, et al., 2009). Moreover, previous studies also demonstrated that visual aid related

issues can be overcome with low-cost countermeasures and can provide tremendous benefit to both road users and road authority (Guo, et al., 2016).

5. Conclusion and Recommendations

The Road Safety Audit (RSA) stage 5 may be beneficial to many parties if suggested remedial is implemented. RSA may prevent a crash from happen or reduce the severity of crash. We see that road authorities are willing to rectify any road deficiencies if they have some budget for road maintenance or upgrading and the cost to conduct RSA Stage 5. MIROS or other road safety agencies/bodies need to engage the road authorities strategically and effectively by assisting them on identifying the risky location and planning for road maintenance and upgrading budget before proceeding with the RSA Stage 5.

Acknowledgements

The authors would like to express their sincerest appreciation to the former Director-General of the Malaysian Institute of Road Safety Research (MIROS), Ts. Dr Siti Zaharah Ishak, for providing a research grant to conduct this project entitled 'The Post-Mortem of Road Safety Audit Stage 5' and extending her support to produce this report. Special gratitude also to the following research officer: Alvin Poi Wai Hoong, Nora Sheda Mohd Zulkiffli, Nor Aznirahani Mhd Yunin, Nusayba Megat Johari, Nur Zarifah Harun, Rizati Hamidun (PhD), Sharifah Allyana Syed Mohamed Rahim and Syed Tajul Malik Syed Tajul Arif for their help and contribution towards the completion of this project.

References

Abdul Manan, M. M., Ho, J. S., Syed Tajul Arif, S. T. M., Abdul Ghani, M. R., & Várhelyi, A. (2017). Factors associated with motorcyclists' speed behaviour on Malaysian roads. Transportation Research Part F: Traffic Psychology and Behaviour, 50, 109-127.10.1016/j.trf.2017.08.006

Abdul Manan, M. M., Jonsson, T., & Várhelyi, A. (2013). Development of a safety performance function for motorcycle accident fatalities on Malaysian primary roads. Safety Science, 60, 13-20.http://dx.doi.org/10.1016/j.ssci.2013.06.005

Abdul Manan, M. M., & Várhelyi, A. (2012). Motorcycle fatalities in Malaysia. IATSS Research, 36, 30-39.http://dx.doi.org/10.1016/j.iatssr.2012.02.005

Abdul Manan, M. M., Zulkiffli, N. S. M., & Jamil, H. M. (2020). Motorcycle Crash Causation Study (MCCS) Along Malaysian Expressways. InternationalJournal of Road Safety (IJRS), 1, 26-34

Austroads. (2002). Road Safety Audit: Second Edition. In. Sydney, Australia: AUSTROADS.

Charlton, S. G., Starkey, N. J., & Malhotra, N. (2018). Using road markings as a continuous cue for speed choice. Accid Anal Prev, 117, 288-297.10.1016/j.aap.2018.04.029

Diamandouros, K., & Gatscha, M. (2016). Rainvision: The Impact of Road Markings on Driver Behaviour – Wet Night Visibility. Transportation Research Procedia, 14, 4344-4353.10.1016/j.trpro.2016.05.356

Edquist, J., Rudin-Brown, C. M., & Lenné, M. (2009). Road design factors and their interactions with speed and speed limits. In. Victoria, Australia: Monash University Accident Research Centre.

Elvik, R., Høye, A., Vaa, T., & Sørensen, M. (2009). The Handbook of Road Safety Measures (Second Edition). Bingley, United Kingdom: Emerald Group Publishing Limited.

Goh, P.-K., & Wong, Y.-D. (2004). Driver Perception Response Time During the Signal Change Interval. Applied Health, Economics and Health Policy 3, 9-15

Guo, Y., Liu, P., Liang, Q., & Wang, W. (2016). Effects of parallelogram-shaped pavement markings on vehicle speed and safety of pedestrian crosswalks on urban roads in China. Accid Anal Prev, 95, 438-447.10.1016/j.aap.2015.07.001

JKR. (2002). Road Safety Audit: Guidelines for the Safety Audit of Roads and Road Projects in Malaysia. Kuala Lumpur, Malaysia: Public Works Department Malaysia (JKR).

Lawsona, S., Barlowb, A., Poranc, C., Petrosyand, H., & Ševroviće, M. (2016). A star rating for safety, Safer Roads Investment Plan, road safety audit and post-construction assessment for the M2-R7 in Moldova In 1st European Road Infrastructure Congress Leeds, United Kingdom

PIARC. (2012). Road Safety Inspection Guidelines for Safety Checks of Existing Road. In 2012R27EN. La Défense cedex, France: World Road Associations (PIARC).

Yan, X., Radwan, E., Guo, D., & Richards, S. (2009). Impact of "Signal Ahead" pavement marking on driver behavior at signalized intersections. Transportation Research Part F: Traffic Psychology and Behaviour, 12, 50-67.10.1016/j.trf.2008.07.002

Yunin, N. A. M., & Abdul Manan, M. M. (2020). Causation of Road Traffic Crash Severity on Malaysian Expressways. InternationalJournal of Road Safety (IJRS), 1, 49-52