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ROAD SAFETY ASSESSMENT TOOL (RSAT) FOR ROAD DESIGN

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Abstract

In Malaysia, there is an absence of standard guidelines to determine the level of safety at the design stage road project. This research aims to evaluate the road safety assessment tool for road design projects by determining the level of safety for road design projects. The survey was distributed to 250 respondents to get the respondents' opinion about the road safety issue. There were five (5) elements in the survey namely: cross-section, vertical and horizontal alignment, signage, pavement marking and delineation; and street lighting. A statistical approach was then used to obtain the multiplying factor of the elements asked in the survey. Based on this, the Road Safety Assessment Tool (RSAT) was then developed to check the level of safety for road design projects based on the multiplying factor and index ratio resulting from the analysis. The RSAT give recommendations based on the Level of Safety where a result score of more than 80% reflects that the road design project has passed the minimum safety level and can proceed with the amendment. However, a score of less than 80% means that the project is recommended to be redesigned due to noncompliance with JKR Standard. The results of the study indicate that the use of RSAT to determine the level of safety for road design projects is valid and comparable with the recommendation in the Road Safety Audit Report. It can be concluded that RSAT can be one of the complementary tools to assist in the implementation of Road Safety Audit. This study could provide a model for local agencies nationwide to implement road safety audit recommendations more effectively.

Keywords: *road safety audit (RSA); multiplying factor; level of safety; road design project; road safety assessment tool*

1.0 INTRODUCTION

1.1 Background of the study

Road transportation is an important mode of transport in Malaysia that ensures both mobility of people and delivery of goods. Transportation in Malaysia has been dominated by road transportation ever since the introduction of road networks at the end of the 19th century. The implementation of Road Safety Assessments (RSAs), also known in safety literature as Road Safety Audits, are important to improving road safety. In 1997, the Public Work Department implemented a Road Safety Audit (RSA)(Abu Mansor et al., 2019). The RSA is a new road engineering technique to identify potential safety problems during the planning, design and construction of the new road projects. RSA is basically a formal examination of the characteristics and operations of an existing road in identifying the potential safety hazards before the road becomes accident prone locations (Hildebrand & Wilson, 1999). The adoption of the RSA process, involving audits at various stages in the development of a project will make a significant contribution to achieving safe and efficient road performance and also to ensure that road safety enhancements are included in the project throughout the planning and design processes (PWD, 1997).

1.2 Problem Statement

In 2015, the General Assembly of the United Nations (UN) aimed at halving global road traffic deaths and injuries in just five years and it was part of the Sustainable Development Goals (SDGs). The Sustainable Development Goals (SDGs) for road safety were focused on Goal 3: Good Health (3.6) target of global deaths and injuries from road accidents. The other focus is on Goal 11: Sustainable Cities and Communities (11.2) which targets that by 2030 there will be access to safe, affordable, accessible and sustainable transport systems for all by improving road safety (WHO, 2017).

In Malaysia, there are inadequate numbers of certified auditors that are qualified as Road Safety Auditors. In Road Safety Audit, there are also requirements to introduce double checking measures for road designers especially for local authorities to ensure the safety aspect has been taken care into the design before construction. Standard guidelines need to be carried out to determine the level of safety for road design projects. So, this research is conducted to develop the road safety assessment tool in determining level of safety for the road design project and in assisting as a complementary tool in the implementation of Road Safety Audit.

1.3 Research Objectives

The aim of this study is to evaluate the safety assessment tool of road design project. The objectives of this study can thus be summarized to the following:

a. To design a questionnaire related to safety measures of road design
b. To identify the constant obtained from the multiply factors for the safety measure
c. To develop a road safety assessment tool to measure the level of safety for road design projects.

1.4 Scope of Work

The scope of study mostly covered on the roadside development at T junctions only. This research focused on analysed multiply factors to get the best constant. It will carry out the raw data obtained from questionnaire and measurement using statistical approaches. The survey is conducted among the expert group/practitioner to get the respondents' opinions about the road safety issue. The validation process will focus on a detailed design project stage (Stage 3 Audit).

2.0 LITERATURE REVIEW

The experiences in Europe and Australia have shown that RSA's as a constructive safety enhancement tool are both effective and cost beneficial. Studies in the United Kingdom have shown that the total number of fatal and injurious accidents at 19 audited project sites fell by 1.25 accidents per year while crashes at 19 equivalent non-audited sites fell by 0.26 crashes per year (Wilson & Lipinski, 2004).

In Virginia, they developed the Field Review Assessment Tool to provide a repository of information and data collected before and during the field review and a checklist of site characteristics and conditions to review and guide the safety countermeasures proposal (VDOT, 2008).In United State of America, Box 9.5: Safety Analyst is a set of software tools used by implements state-of-the-art analytical procedures for use in the decision-making process to identify and manage a systemwide program of site-specific improvements to enhance highway safety by cost-effective means (AASHTOWare, 2001). In Australia, the development of toolkit based on the Austroads Guide to Road Safety – Part 6: Road Safety Audit, 2009 (Dr Aut Karndacharuk & Hillier, 2019). Road Safety Audit Toolkit has been developed to assist practitioners in the comprehensive and efficient completion of road safety audits (Austroads, 2009).

Several international approaches and initiatives are analysed, concerning handbooks and manuals but also research project results like SUPREME (E.Commission, 2007, 2010), ROSEBUD (E.Commission, 2006), PROMISING(Institute for Road Safety Research, 2001) and and in reports of other studies.These comprehensive manuals, handbooks and other tools have been developed in the recent years, aiming to gather, harmonize and improve the existing knowledge on effectiveness of road safety measures (Yannis et al., 2012). The Norwegian researchers Elvik and Vaa (2004), the authors of The Handbook of Road Safety Measures provide a systematic overview of current knowledge regarding the effects of road safety measures.

In 2019, the International Road Assessment Programme (iRAP) announced the launch of the Malaysian Road Assessment Programme (MyRAP), in collaboration with the Malaysian Institute of Road Safety Research (MIROS) and local agencies, attempts to highlight the highest risk roads across the country (MIROS, 2019). The development of Road Attribute Data-logger and Inspection System (RADIS) with collaborative effort between MIROS and Universiti Teknikal Malaysia Melaka (UTeM) which provide a portable survey system for road assessment work (MIROS, 2017). (text)

3.0 METHODOLOGY

3.1 Introduction

A tool was developed by identifying the constant obtained from multiply factors analysed from questionnaire data. The RSAT was developed and validated by using a road design project which consists of the development of a piece of land into a housing scheme. After the evaluation of the road design, the level of safety was identified. Figure 1 shows the flow of methodology that was conducted in development of the Road Safety Assessment Tool.

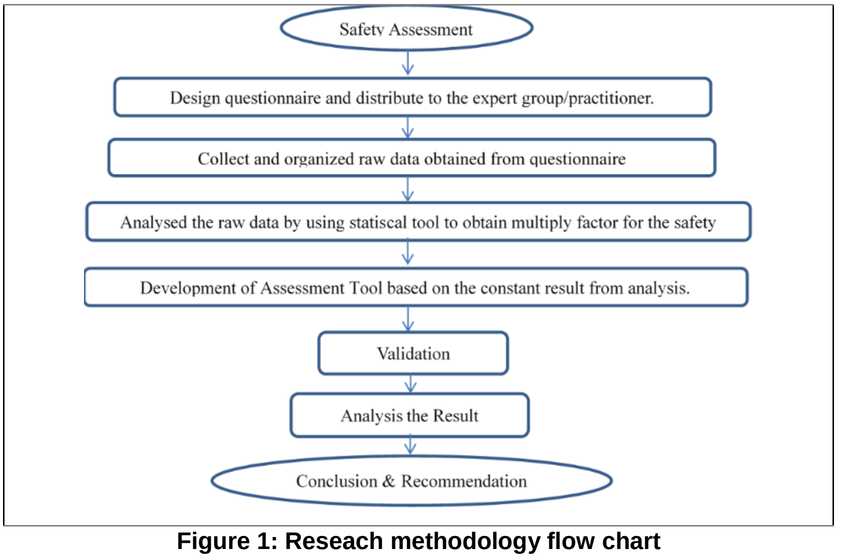

Figure 1: Reseach methodology flow chart

The selected study location was in three (3) areas of roadside development in Kedah Darul Aman. The study was carried out by distributing the designed questionnaire to the expert group/practitioner.

3.2 Data Analysis using statistical tools.

There were five (5) elements in the survey namely: cross-section, vertical and horizontal alignment, signage, pavement marking and delineation; and street lighting (PWD, 1986). The safety rating for these elements were rated as 1 to 5 in which 1 and 5 represents low and high safety ratings respectively. The study considered the Safety Rating 4 and 5 because both ratings are the critical road safety impact based on respondent perception (higher total response). This study might be represented by the following equation used to obtain multiple factors for the elements of road design.

Calculation of Multiply Factor for Road Design Element;

$$= \frac{\text{Total numbers of question respond in Safety Rating of 4 and 5}}{\text{Total numbers of question in one element of road design x Total respondents}}$$

3.3 Validation of Road Safety Assessment Tool

The RSAT was validated using three (3) real road design projects with JKR standard compliance. For this study, road safety audit in stage 3: Detail Design Stage had been selected.

The questions were then quantified in the RSAT by assigning different degrees of safety. The numerical numbers associated with each RSAT safety rating were chosen on a 0 to 1 scale to represent JKR Standard Compliance based on the road design project. The following equation is used to get percentage scoring for Level of Safety of the project.

$$\text{Calculation of Level of Safety} = \frac{\text{Total Index Ratio}}{\text{Total of Multiply Factor}} \times 100\%$$

4.0 RESULT & ANALYSIS

4.1 Background of Respondent

There were a total of 250 respondents for a 90% confidence level involved in answering the questionnaire. The number of samples were determined based on study by (James E. Bartlett et al., 2001; Krejcie & Morgan, 1970). The elements of road design were obtained from Arahan Teknik (Jalan) 8/86. Most of the respondents were PWD engineers (88%), followed by road designer (6%), academician (3%), contractor (2%) and Road Safety Auditor (1%). Most of the respondents had working experience of more than 10 years.

4.2 Analysis

All questionnaires had been collected and organized accordingly to the element of road design. Table 1 shows data collection from the questionnaire.

Table 1: Data collection from questionnaire

Safety Rating / **Element of the road design**	**1**	**2**	**3**	**4**	**5**
	Total Response				
Cross Section	0	2	23	140	85
Vertical & Horizontal Alignment	0	20	20	180	30
Signage	0	6	24	156	64
Pavement Marking And Delineation	0	0	25	96	129
Street Lighting	0	7	18	130	95

Table 2 shows the result of a total of multiply factor 4.42 that will represent as the best constant in the Road Safety Assessment Tool. The JKR Standard Compliance scale then been validated and the result shown in Table 3.

Table 2: Multiply Factor for each element of road design obtained from Safety Rating 4 and 5

Element of road design	Safety Rating		Multiply Factor
	4	5	
Cross Section	140	85	0.90
Vertical & Horizontal Alignment	180	30	0.84
Signage	156	64	0.88
Pavement Marking And Delineation	96	129	0.90
Street Lighting	130	95	0.90
Total of Multiply Factor/ constant			**4.42**

Table 3: Level of safety scoring to JKR standard compliance scale

Element of Road Design	Multiply Factor	JKR Standard Compliance					Index Ratio				
		Case 1	Case 2	Case 3	Case 4	Case 5	Case 1	Case 2	Case 3	Case 4	Case 5
Cross Section	0.9	0	1	1	1	1	0	0.9	0.9	0.9	0.9
Vertical & Horizontal Alignment	0.84	1	0	1	1	1	0.84	0	0.84	0.84	0.84
Signage	0.88	1	1	0	1	1	0.88	0.88	0	0.88	0.88
Pavement Marking And Delineation	0.9	1	1	1	0	1	0.9	0.9	0.9	0	0.9
Street Lighting	0.9	1	1	1	1	0	0.9	0.9	0.9	0.9	0
Total of Multiply Factors:	4.42	Total of Index Ratio:					3.52	3.58	3.54	3.52	3.52
					Level Of Safety Scoring		80	81	80	80	80

Legend;
Case 1- Case 5: Road Design Project
Scale 0: The element does not comply with JKR Standard
Scale 1: The element complies with JKR Standard

Table 4: Level of safety rating

A+	**90%-100%**	**Safe with no amendment to design**
A-	**80%-89%**	Safe with design amendment
B	**60%-79%**	Unsafe design to be reviewed
C	**40%-59%**	Unsafe design to be reviewed
D	**20%-39%**	Unsafe design to be reviewed
E	**0%-19%**	Unsafe design to be reviewed

The study found that multiple factors in range 0.84 to 0.9 gave the highest safety rating with 90% score which gave recommendation that the road design has safety compliance with no amendment while safety rating that range 80%-89% score give recommendation that the road design has safety compliance with amendment. Below then 80% score was chosen for a safety rating of non compliance design so that it is considered unsafe and required design review. Table 4 shows the summary of Level of Safety Rating which resulted from JKR Standard Compliance scale validation.

The RSAT was performed on three (3) different road design projects for validation purposes. As seen in Table 5, Table 6 and Table 7, the level of safety rating for project 1, project 2 and project 3 is 80%, 60% and 60% respectively. Safety ratings 80% indicate that the road design is safe with design amendment required. The safety rating 60% for project 2 and 3 indicates the road design is unsafe and needs design review. In the Road Safety Audit Report for these two (2) projects, the auditor would like to advise the designer to review the road design because of not fulfilling the JKR Standard compliance.

Table 5: Final analysis of the road safety assessment tool of road design project 1

Group	**Element**	**JKR Standard Compliance**	**Scale of Actual Validation**	**Multiply Factors**	**Index Ratio**
1	Cross Section	1\0	1	0.9	0.90
2	Horizontal & Vertical Alignment	1\0	1	0.84	0.84
3	Signage	1\0	1	0.88	0.88
4	Pavement Marking And Delineation	1\0	0	0.9	0.00
5	Street Lighting	1\0	1	0.9	0.90
			Total of Multiply Factors	**4.42**	3.52
				Level Of Safety Scoring	**80**

Table 6: Final analysis of the road safety assessment tool of road design project 2

Group	**Element**	**JKR Standard Compliance**	**Scale of Actual Validation**	**Multiply Factors**	**Index Ratio**
1	Cross Section	1\0	1	0.9	0.90
2	Horizontal & Vertical Alignment	1\0	1	0.84	0.84
3	Signage	1\0	0	0.88	0.00
4	Pavement Marking And Delineation	1\0	1	0.9	0.90
5	Street Lighting	1\0	0	0.9	0.00
			Total of Multiply Factors	**4.42**	2.64
				Level Of Safety Scoring	**60**

Table 7: Final analysis of the road safety assessment tool of road design project 3

Group	Element	JKR Standard Compliance	Scale of Actual Validation	Multiply Factors	Index Ratio
1	Cross Section	1\0	1	0.9	0.90
2	Horizontal & Vertical Alignment	1\0	1	0.84	0.84
3	Signage	1\0	0	0.88	0.00
4	Pavement Marking And Delineation	1\0	0	0.9	0.00
5	Street Lighting	1\0	1	0.9	0.90
			Total of Multiply Factors	**4.42**	2.64
				Level Of Safety Scoring	**60**

5.0 CONCLUSION & RECOMMENDATION

The aim of this study is to develop a Road Safety Assessment Tool for road design. From the study, it is found that the design criteria of vertical and horizontal alignment element give the highest overall respondent with safety rating 4 (safety impact: Slightly Not Safe). The highest respondent in safety rating 5 (safety impact: Not Safe) is design criteria of pavement marking and delineation. It is concluded that the respondents are aware about the safety impact of not complying to the element of road design. The result using the Road Safety Assessment Tool showed that the Level of Safety of road design project is valid and comparable with the recommendation in the Road Safety Report. It can be concluded that RSAT can be one of the complementary tools to assist in the implementation of Road Safety Audit. From this study, it is recommended that for future research we can ;

a. develop multiple factors for RSAT in others design criteria of road design.
b. compare the result using RSAT showing the Level of Safety of road at early Road Safety Stage (Stage 1: Planning).This will test and calibrate the weighing of the different stages in the RSAT.
c. develop a RSAT for intersections and rural roadways using the methodology presented in this research.

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Sekian, terima kasih.

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