Journal of Safety Engineering 2018, 7(1): 37-41
DOI: 10.5923/j.safety.20180701.04

Development of Assessment Tools for Road Safety Performance during Execution of National Road Project Improvement in Bali-Indonesia

Dewa Ketut Sudarsana*, Putu Darma Warsika, Mayun Nadiasa

Department of Civil Engineering, Udayana University, Bali, Indonesia

Abstract Bali's economy dominantly grew from the tourism sector's revenue, while tourism growth depends on availability of accessibility Road infrastructure as a means of accessibility is expected to deliver a steady level of road inspection. In order to provide a steady service, the road infrastructure condition required maintenance. However, the phenomenon during road maintenance execution always has a negative impact. Negative impacts posed in road work zones include congestion, noise, accidents and air pollution. Implementation of road safety performance of work zone inadequate and frequent highlights of road users is studied in this paper. The weighting of safety attributes performance is designed using the Analytical Hierarchy Process (AHP) method. Scoring for the implementations and performance scales using Likert scales. The result of identification found 4 zone in the road work zone consist of area into work zone, initial taper zone, work zone and end taper zone with a weight of 27%, 9%, 59% and 6% respectively. Design of assessment of performance of safety in a work zone is applied to execute West Gatot Subroto link road as National road improvement project fiscal year 2017 in Bali province, Indonesia. The road safety performance is found in good performance category (scale 3.6).

Keywords Road infrastructure, Maintenance, Design, Performance, Safety

1. Introduction

Bali is one of most popular tourist destinations in Indonesia, which contributes 40% of tourist arrivals in Indonesia. To further increase tourist visits and economic growth, adequate accessibility is required, such as a steady-state road infrastructure. Therefore, road infrastructures require maintenance. The type of road maintenance handling depends on the level of the road damage. The execution of road maintenance handling stage always has a negative impact on road users and the surrounding environment. This impact occurs due to traffic arrangements, such as constringency of road width, closure of lane sections and diversion of traffic flows [1-4]. These negative impacts often generally appear in Indonesia and especially in the province of Bali. For instance, The Bali Post media of June 1, 2016 highlighted the implementation of a sidewalk project in Krobokan, Badung regency causing congestion. The implementation of Sunset road project that endangered the motorists was highlighted by the media of Tribun Bali on October 1, 2015. In addition, Beritabali.com media in October 19, 2015 reported death accident from falling motorcycle. Media Harapan Rakyat on December 15, 2016 announced the potential accidents on drainage excavation projects along Uluwatu road in Badung regency. The description of the accident case at the road project location highlighted by the media reflects the performance of the road safety aspect inadequate, so it is necessary to conduct a study.

2. Materials and Methods

This paper discusses the design of road safety performance in the work zone of National road improvement project. The case study of the implementation of this model is the improvement project on West Gatot Subroto link road for the fiscal year 2017. The framework research is presented in Figure 1.

Identification road safety attributes are conducted using with literature study method. The work zone design designed based on safety factors for workers and road users, as shown in Figure 2 [1, 6, 7].

Method of safety attributes weighting analysis in work zones used is Analytical Hierarchy Process (AHP) method [8, 9]. The scale of safety attribute implementation, assessment uses Likert scale [10-12].

* Corresponding author:
dksudarsana@unud.ac.id (Dewa Ketut Sudarsana)
Published online at http://journal.sapub.org/safety

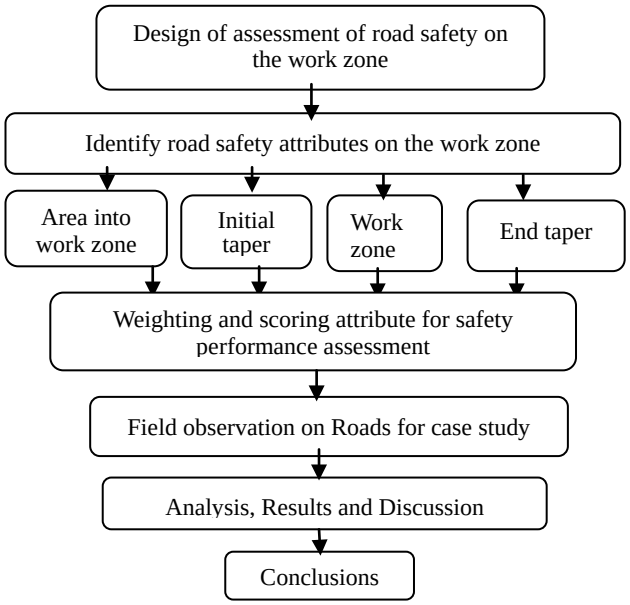

Figure 1. Research Framework

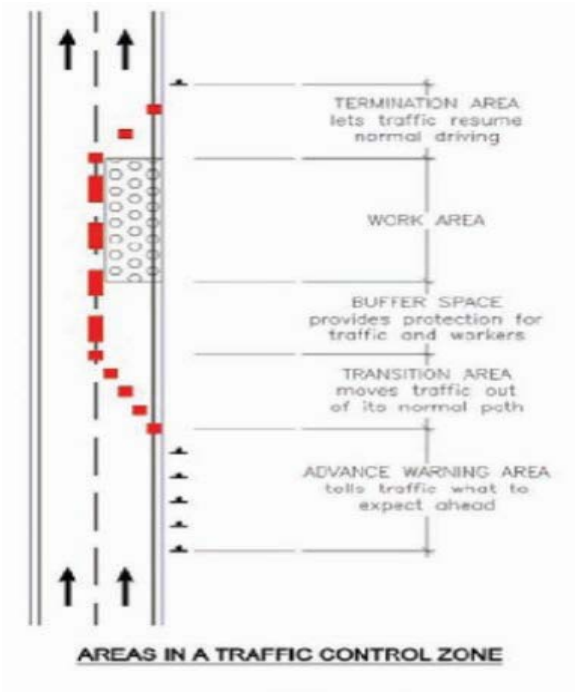

Figure 2. Basic work zone design [1]

Element or attribute of safety aspect whose performance has not been adequately sought by solution with Brainstorming method with stakeholders related to execution of road maintenance project.

2.1. Determining the Priority Weight

Determining the priority weights are used the Analytical Hierarchy Process (AHP) method. AHP is a decision-making method developed by [8], a mathematician from the University of Pittsburg, USA in the early 1970s. The AHP method is a method for solving a complex and unstructured situation into several components.

The basic principle of the AHP method is to set up hierarchy, assign priorities, and logical consistency. The principle of composing a hierarchy is to describe and describe hierarchically, by solving the problem into fragmentary and hierarchical elements [8]. The second principle is to set decision priorities. Establishing this decision is made by making pairwise comparisons. This appeal scale has been set by [8]. The third principle is logical consistency. For the AHP method, comparison matrices may be accepted if the value of consistent ratio (CR) <0.1. CR value <0.1 is a good consistency level and can be accounted for. There are four axioms contained in the AHP method:

1). A reciprocal axiom is a pairwise comparison between element A and element B, where the value of element A is inversely proportional to eleman B. The preference must satisfy the reciprocal requirement that if A is preferred over B by x, then B is preferred over A with 1/x.
2). Homogeneity is one's preference must be expressed in a limited scale, or its elements can be compared with each other. If these axioms are not met, then the comparable elements are not homogeneous and new clusters must be formed.
3). Independence is a preference expressed by assuming that the criteria are not influenced by alternatives, but by overall objectives.
4). Expectation is a fully assumed hierarchical structure. If this assumption is not met, then decision-making does not use all available criteria or objectives.

2.2. Scale of Assessment

The scale of assessment of the implementation of safety attributes used Likert scale [11, 12]. Likert scale creator by Rensis Likert from the United States. The Likert scale is the scale used to measure a people or group's perceptions, attitudes or opinions about an event or a social phenomenon. With Likert Scale, the variables to be measured are translated into variable indicators. The Likert scale is a bipolar scale method that measures positive or negative responses to a statement. There are two forms of questions on a Likert scale: positive question form for measuring positive scales, and negative question form for measuring negative scales. Positive questions are given a score of 5, 4, 3, 2, and 1. And for the form of questions negative given the score 1, 2, 3, 4, and 5.

3. Results and Discussions

According to DGH [6] it can be identified the division of work zones and attributes of the safety aspect in the work zone of the implementation of the arterial or national road improvement project as shown in Table 1.

In Table 1 it can be seen the division of work zones on the road work zone and safety attributes for artery or National

roads. The results of the identification in Table 1 are weighted using the AHP method. The results from weighting are shown in Table 2 [7].

Scoring of safety attributes implementation uses the values 1 to 5 which is categorized worst to satisfy good [10-12].

The safety aspect implementation scores also adopt the Quality Audit Assessment approach. The assessment score of safety aspects in the work zone is presented in Table 3.

Table 1. Work Zone and Safety Attributes

Zoning of the work zone	Attributes
Approaching Zone/ Area Approaching into Work Zone (A)	Warning and road work signs (A1)
	Road lane usage sign (A2)
	Maximum vehicle speed signs (A3)
	Warning signs for the merging road (A4)
	Range zone distance for artery road of 300-500m (A5)
Initial Taper (B)	Minimum initial Taper length of 280 m (B1)
	Installation of traffic cones/ guardrail (B2)
	Joint of initial Taper and Work Zone installed by Reflector / Blinking (B3)
Work zone (C)	Minimizing work zone (C1)
	Minimizing work zone width (C2)
	Installation of traffic cones / guardrail (C3)
	Distance between work zones of at least 1 km (C4)
End Taper (D)	Length of end Taper of at least 45-90 m (D1)
	Installation of traffic cones / guardrail (D2)

Table 2. Weighting the Safety Zones and Attributes in the Work Zone

Work zone		Attributes of safety	
Zoning	Weight	Attributes	Weight
Area into work zone (A)	27%	Warning and road works signs (A1)	46%
		Road lane usage sign (A2)	23%
		Maximum vehicle speed signs (A3)	5%
		Warning signs for the merging road (A4)	11%
		Range zone distance for artery road of 300-500 m (A5)	15%
Initial Taper (B)	9%	Minimum initial Taper length of 280 m (B1)	17%
		Installation of traffic cones/ guardrail (B2)	53%
		Joint of initial Taper and Work Zone installed by Reflector / Blinking (B3)	30%
Work zone (C)	58%	Minimizing work zone (C1)	70%
		Minimizing work zone width (C2)	15%
		Installation of traffic cones / guardrail (C3)	9%
		Distance between work zones of at least 1 km (C4)	6%
End Taper (D)	6%	Length of end Taper of at least 45-90 m (D1)	18%
		Installation of traffic cones / guardrail (D2)	82%

Table 3. Scale of Assessment of the Level of Implementation of Safety Aspects

Score	Category	Description
1	Worst	Lack of safety system, lack of documentation, lack of implementation
2	Bad	Safety system available, lack of documentation, safety attributes have not been implemented
3	Average	Availability of Safety systems, documentation is available and unorganized, safety attributes have not been implemented
4	Good	Availability of Safety systems, the documentation is available and organized, the implementation is not fully conducted in the field [less or equal to 80%).
5	Satisfy	Availability of Safety systems, the documentation is in accordance with the guidelines, the implementation is fully implemented (applied more than 80%)

The scale of performance assessment of safety aspects in work zones on roads using Likert scale 1 to 5 is presented in Table 4 [10-12].

Table 4. Scale and Categories

Scale	Category
1 - 1.4	Worst
1.5 - 2.4	Bad
2.5 - 3.4	Average
3.5 - 4.4	Good
4.5 - 5	Satisfy

Table 5. Score of Implementation of Safety Attributes for Case Study

Zoning and attributes	Weight	Score	Scale
(1)	(2)	(3)	(4)=(2)x(3)
A. Area into work zone			
Warning and road works signs (A1)	46%	4	1.8
Road lane usage sign (A2)	23%	4	0.9
Maximum vehicle speed signs (A3)	5%	4	0.2
Warning signs for the merging road (A4)	11%	4	0.4
Range zone distance for artery road of 300-500m (A5)	15%	5	0.8
Subtotal A	100%		
B. Initial Taper			
Minimum initial Taper length of 280 m (B1)	17%	3	0.5
Installation of traffic cones/ guardrail (B2)	53%	4	2.1
Joint of initial Taper and Work Zone installed by Reflector / Blinking (B3)	30%	5	1.5
Subtotal B	100%		4.1
C. Work zone			
Minimizing work zone (C1)	70%	3	2.1
Minimize work zone width (C2)	15%	3	0.5
Minimizing work zone width (C3)	9%	5	0.5
Distance between work zones of at least 1 km (C4)	6%	3	0.2
Subtotal C	100%		3.2
D. End Taper			
Length of end Taper at least 45-90 m (D1)	18%	3	0.5
Installation of traffic cones / guardrail (D2)	82%	5	4.1
Subtotal D	100%		4.6

Observations on the execution of the road improvement project on the West Gatot Subroto link road (National road of fiscal year 2017), found the level of implementation of safety aspects in the work zone for each attribute is presented in Table 5, column (3).

In Table 5, it can be seen that the implementation of the attributes of safety aspect whose score is not adequate (score 3) is related to the inadequate length of safety. This is due to the density of commercial buildings in the road work zone. If it is conducted in accordance with the guidelines, the installation of safety instruments can greatly affect the economic activities of the community.

In Table 5, column (4) it can be seen the assessment of each attribute of the safety aspect and the safety implementation value of each zone. The performance values of the respective aspects of the safety of each zone are good in the area into work zone with category (value 4.2); good in the initial taper (4.1), average in the work zone (3.2) and very good in the end taper (4.6).

Assessment of safety performance at a further stage providing the weight of the assessment as presented in Table 6 column (2). Furthermore, multiplication of each zone (A, B, C and D) values can be seen in Table 6, column (3). Table 6, column (3) is the value obtained from Table 5, for the subtotals of each zone (A, B, C and D).

The total values of the four zones in Table 6 column (4) are on a scale of 3.6 or in either category. Therefore the implementation of safety aspects in a work zone in the case study can be stated in good performance.

In Table 6 shown the assessment of the performance of safety aspects in the work of the National road improvement project of Gatot Subroto Barat link road, Denpasar, Bali fiscal year 2017.

Table 6. Road Safety Performance in Work Zone for Case Study

Zoning of road work	Weight	Scale (Table 4)	Scale
(1)	(2)	(3)	(4)=(2)x(3)
Area into work zone	27%	4.2	1.1
Initial Taper	9%	4.1	0.4
Work zone	58%	3.2	1.8
End Taper	6%	4.6	0.3
Total	100%		3.6
Safety performance category			Good

4. Conclusions

The results of the analysis can be concluded, that from the four zones in the work zone on the execution National road improvement project, the work zone area becomes the most important concern (weight 58%). Implementation of safety performance assessment in the work zone for the case study found that its performance has good category, with a value fraction of 3.6. This value is obtained from several implementation scores of safety attributes and it is found to be average (score 3), this is due to the density of commercial activities around the work zone, therefore that the safety instrument installed is not in accordance with the guidelines.

ACKNOWLEDGMENTS

We would like to thank all those who have contributed to this research, such as LPPM Udayana University and BPJN Bali, Indonesia.

REFERENCES

[1] J. Atkinson, B. Chandler, H. Rigdon, K. Donoughe. 2013. *Work Zone Road Safety Audit Guidelines and Prompt Lists*. American Traffic Safety Services Association with Federal Highway Administration, U.S. Department of Transportation.

[2] D.K. Sudarsana and P. A. Sanjaya. 2017. *Analysis of Loss of Time Value during Road Maintenance Project*, AIP Conference Proceedings.

[3] D.K. Sudarsana, H. Sulistio, A.Wicaksono and L. Djakfar. 2014. *A study of Safe and Green Infrastructure on Road Reconstruction Project*, Advances in Environmental Biology, Vol. 8 (10): 616-620.

[4] D.K. Sudarsana, H. Sulistio, A.Wicaksono and L. Djakfar. 2014. The Analysis of Work Zone Road User Costs Due To The Delay Completion Of The Road Maintenance Project. Adv. in Nat. Appl. Sci., 8(3): 103-108.

[5] DGH (Directorate General of Highways). 2010. *Road Safety Practical Instructions at Working Zone on the Road.*

[6] IndII (Indonesia Infrastructure Initiatives). 2011. *Practical Guide - Road Safety at Workplace Zone on the Road, In Support of EINRIP Projects.*

[7] D.K. Sudarsana, M. Nadiasa, I.B.M. Artamana. 2016. *Pembobotan Penilaian Apek Keselamatan di Zona Kerja pada masa Pelaksanaan Proyek Peningkatan Jalan,* Vol. 14 (1): 29-35.

[8] T.L. Saaty. 1993. *Analytic Hierarchy Process for Decision Making in Complex Situations*. Jakarta: PT. Reader Binaman Pressindo.

[9] Anonymous. 2017. *Analytic Hierarchy Process.* https://en.wikipedia.org/wiki/Analytic_hierarchy_process.

[10] A. Ferdinan. 2011. *Metode Penelitian Manajemen*: *Pedoman Penelitian Untuk Penulisan Skripsi, Tesis dan Disertasi Ilmu Manajemen*, Edisi 3, Badan Penerbit Universitas Diponogoro, Semarang.

[11] M. Nazir. 2003. *Metode Penelitian*. Ghalia, Jakarta.

[12] Anonymous. 2017. *Likert scale*. Https://en.wikipedia.org/wiki/Likert_scale.