Monitoring and evaluating infrastructure safety deficiencies towards integrated road safety improvement in Indonesia

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Abstract

The Road Infrastructure Safety Management System (RSIMS) has been recently developed by Indonesian Highway Administration (Bina Marga) to minimize the number and the impact of accidents caused by road environment deficiencies. This paper explores the development of the RSIMS and one of its activities, namely Road Safety Inspection (RSI) to monitor and evaluate safety performance of operating roads. A set of RSI guidelines has been developed to facilitate the mapping of deficiencies and hazards. As the first trial series, safety inspection using the guidelines had been carried out along a 30 km national road section in Ngawi, East Java Province. Risk evaluation was performed upon discovered deficiencies in order to suggest necessary responses and treatments. RSI is expected to produce important inputs for integrated infrastructure safety management, i.e. (1) deficiency mapping and database, (2) safety audit prioritization, and (3) programming treatments to overcome safety deficiencies.

Keywords

RSIMS, Road Safety Inspection, road environment deficiencies, risk evaluation

Introduction

At the end of 2006, Bina Marga, the Indonesian Highway Administration managed to finish a preparation study [1] on how it should contribute to road safety improvement in the country. The study was carried out following a growing attention from the society on the country's alarming traffic accident record. It was estimated that in 2004 alone accidents had caused 30,000 deaths, and costed an economic loss of Rp 41 billions or about 2.91% of Indonesian GDP [2]. The study points out the Asian Development Bank (ADB)'s 14 sectors of intervention that should be taken to comprehensively reduce accident [3]. Among the interventions, it urges Bina Marga to participate actively in four courses of action, including coordination and road safety management, development of accident database system, social campaign, and road safety research. It further recommends Bina Marga to take the leading role in two other initiatives, namely planning for safer roads and eliminating hazardous locations, as the two are within Bina Marga's domain as road infrastructure authority.

While no local study has been conducted to closely examine the contribution of road environment factors towards the current accident trends, international experiences suggest that the factors may be responsible to cause some 30 to 40% of all accidents. To name but a few, Treat *et al*. [4] at earlier time in the USA found out that in total (either as the sole contributing factor or in combination with human and vehicle factors) road environment was responsible for causing 44.2% out of the 2,000 accident cases studied. Interestingly, human-road interaction was found to contribute in 34.8% of the cases. Using Australian data, in 2002 AUSTROADS [5] also noted that road factors involved in some 28% of accident cases. Drawing from these experiences and realizing that there has been no organized effort to ensure safety aspects to be seriously considered throughout road development phases, Bina Marga took the recommended roles by first developing the Road Infrastructure Safety Management System (RISMS). Another study [6] was then conducted in 2007 to structure such a management system and its components.

In this paper, the initial development of the Indonesian RISMS is highlighted and discussed. The discussion is also extended to cover the first field trial of an activity organized in the RISMS, namely

Road Safety Inspection (RSI). RSI is expected to produce important inputs for the next steps in integrated infrastructure safety management, including deficiency mapping and database, safety audit prioritization, and programming treatment to overcome safety deficiencies and hazards.

Concept of the Indonesian RISMS

RISMS is a management system envisioned to help Bina Marga and other road authorities in provincial and district levels in achieving road network with minimum accident risks. Throughout the road development phases RISMS would manage many strategic safety mainstreaming programs including (1) assessing safety impacts of various road development planning, (2) preventing safety deficiencies caused by road design schemes, (3) identifying and eliminating dangers at blackspots and accident-prone areas, and (4) monitoring and evaluating safety performances of existing roads to prevent deficiency emergence.

Some safety mainstreaming activities are to be organized under the RISMS and integrated in the current road development practices. These include Road Safety Impact Assessment (RSIA), a series of Road Safety Audit (RSA), Road Safety Inspection (RSI), and blackspot treatment and management. A database system to manage information regarding safety deficiencies is also proposed. The processes of RISMS are as illustrated in Figure 1.

RISMS is structured with four basic pillars, namely:

- Direction that contains objective and target setting and strategies to achieve the target,
- Means to achieve the targets, including human resource (expertise, experiences, and qualification) and a set of norms, standards, guidelines, procedures, in road development
- Management processes and control, and
- Evaluation and audit regime

Currently, the system is still in its initial development. It is estimated that if the development process continues it would be ready in its full scale in the next two years. Once completed, Bina Marga and other road authorities in Indonesia are proposed to adopt it in their routines.

Road Safety Inspection Guidelines

Road Safety Inspection (RSI) is a comprehensive examination on the existing roads to identify potential safety deficiencies and hazards [7]. In RSI report, risk evaluation is assessed for each deficiency found to determine its treatment priority level. The reports must also contain suggested treatment that is deemed appropriate to overcome the findings. Routine inspection is proposed to be conducted once in four years. It is also to be carried out upon request, normally following an accident with certain number of fatalities.
A set of guidelines has been developed to facilitate the inspection. It includes the procedure, two sets of checklist for urban and rural roads, and a manual on how to evaluate risk of a deficiency.

According to the guidelines [7], accident risk, R, is defined as multiplication between the chance of a deficiency to cause an accident, P, and the severity level most likely to occur, D.

$$R = P \times D \qquad (1)$$

In practice, P may assume one of the values 1, 2, 3, 4, or 5, if the deficiency has very low, low, fair, high, or very high probability to cause accident, respectively. Value can also be assigned according to how large it departs from a prescribed figure in a road standard. In this approach, 1, 2, 3, 4, and 5 correspond to a deviation of <20%, 20 to 40%, 40 to 60%, 60 to 80%, and >80%, respectively. D may assume one of the values 1, 10, 40, 70, and 100, if an accident caused by the deficiency would cost a victim with negligible injury, minor injury, serious injury, critical injury, and death, respectively. R value is the used to classify the level of treatment a deficiency deserves (Table 1).

Table 1. Risk valuation and expected responses [7]

Range	Risk	Response	Range	Risk	Response
1 – 50	Negligible	Passive response	250 – 350	High	Active response
50 – 100	Low	Monitoring	> 350	Extreme	Immediate response
100 – 250	Fair	Active response			

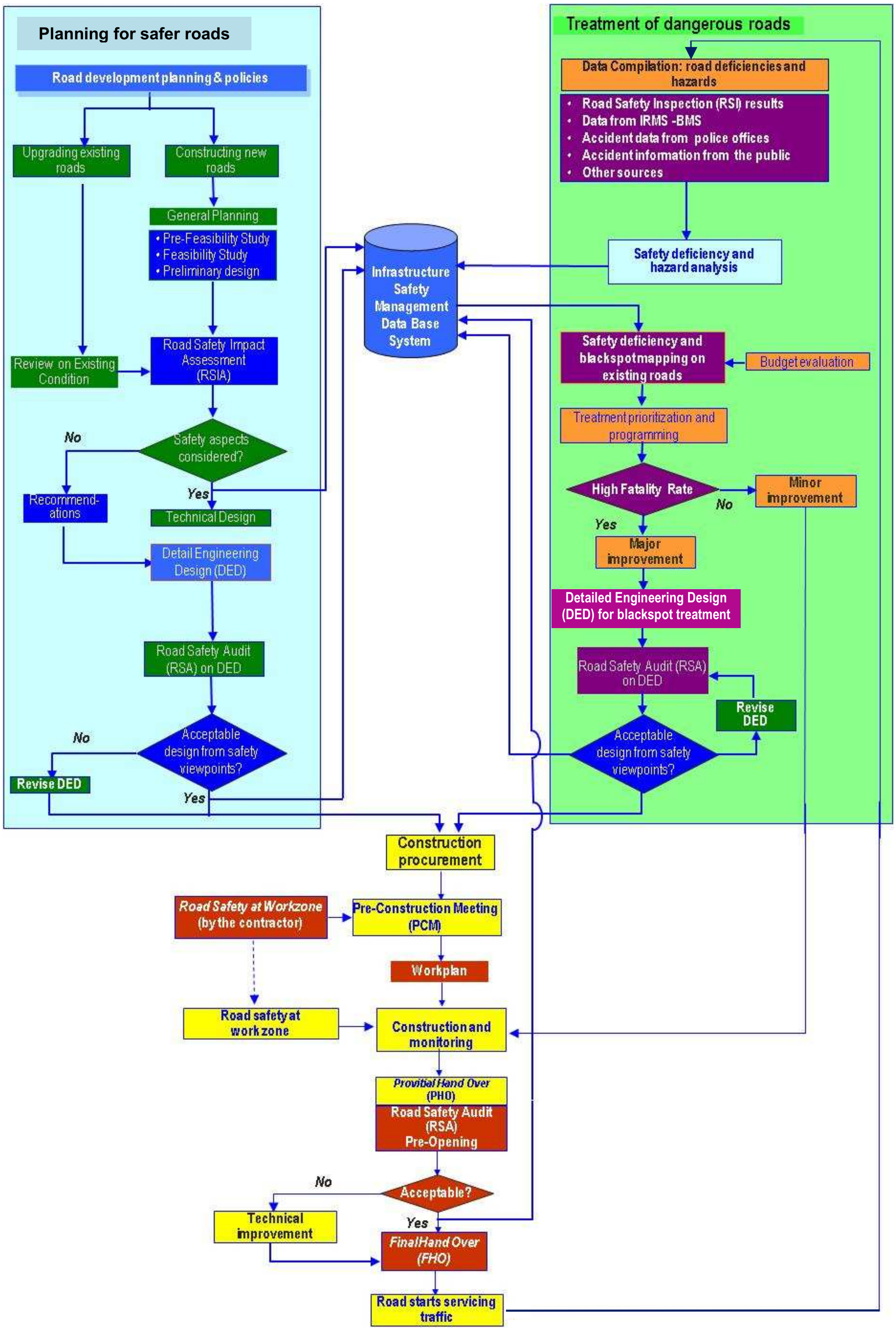

Figure 1 RISMS processes.

First Trial of Applying RSI Guidelines

The first trial of RSI Guidelines application was conducted on a 30 km long national highway in District Ngawi, East Java Province. The location was selected according to accident information reported by Ngawi Police Office. Three specific sections were inspected, including (B1) KM 192 to 193, (B2) KM 199 to 200, and (B3) KM 212 to 213 from Surabaya, the province's capital (Figure 2). Along these sections, 39 accidents have occurred only between January and May 2008, resulting to 22 deaths, 30 victims seriously injured, and 54 others got minor injuries. Property damage caused by these accidents is estimated around Rp 112.8 million (USD 12,500). Motorcycle, bus, and passenger car are the common modes involved in accidents at B1, while truck and passenger car are common in B2 and B3. Most of the crashes occurred during night time.

Site investigation shows that safety deficiencies are caused by sub standard shoulders, poor pavement conditions, insufficient curve radius, and insufficient marking, signing, lightning, and railing. Road deficiencies found in each location and risk evaluation of these deficiencies are presented in Tables 2, 3, and 4.

Table 2 Safety deficiencies from road geometric aspects

Location	Geometric aspects found as deficient	P-value	D-value	Risk, R	Risk category
B1	Curve radius	4	70	280	High
	Shoulder width	2	40	80	Low
	Difference between shoulder and adjacent lane elevations	3	40	120	Medium
	Stopping sight distance	4	70	280	High
B2	Shoulder width	2	40	80	Low
	Difference between shoulder and adjacent lane elevations	4	70	280	High
B3	Shoulder width	4	40	160	Medium
	Difference between shoulder and adjacent lane elevations	4	70	280	High

Table 3 Safety deficiencies from road pavement aspects

Location	Pavement aspects found as deficient	P-value	D-value	Risk, R	Risk category
B2	Area/km of deformed pavement with depth > 5 cm	4	70	280	High
B3	Area/km of potholes with depth > 10 cm	5	70	350	High
	Area/km of rutting	5	70	350	High
	Area/km of deformed pavement with depth > 5 cm	4	70	280	High

Table 4 Safety deficiencies from road furniture aspects

Location	Road furniture aspects found as deficient	P-value	D-value	Risk, R	Risk category
B1	Road marks	3	40	120	Medium
	Signing	4	70	280	High
	Lightning	4	70	280	High
	Guard railing	3	40	120	Medium
B2	Road marks	4	70	280	High
	Signing	4	100	400	Extreme
	Lightning	4	70	280	High
	Guard railing	3	70	210	Medium
B3	Road marks	4	100	400	Extreme
	Signing	5	100	500	Extreme
	Lightning	5	100	500	Extreme
	Guard railing	4	100	400	Extreme

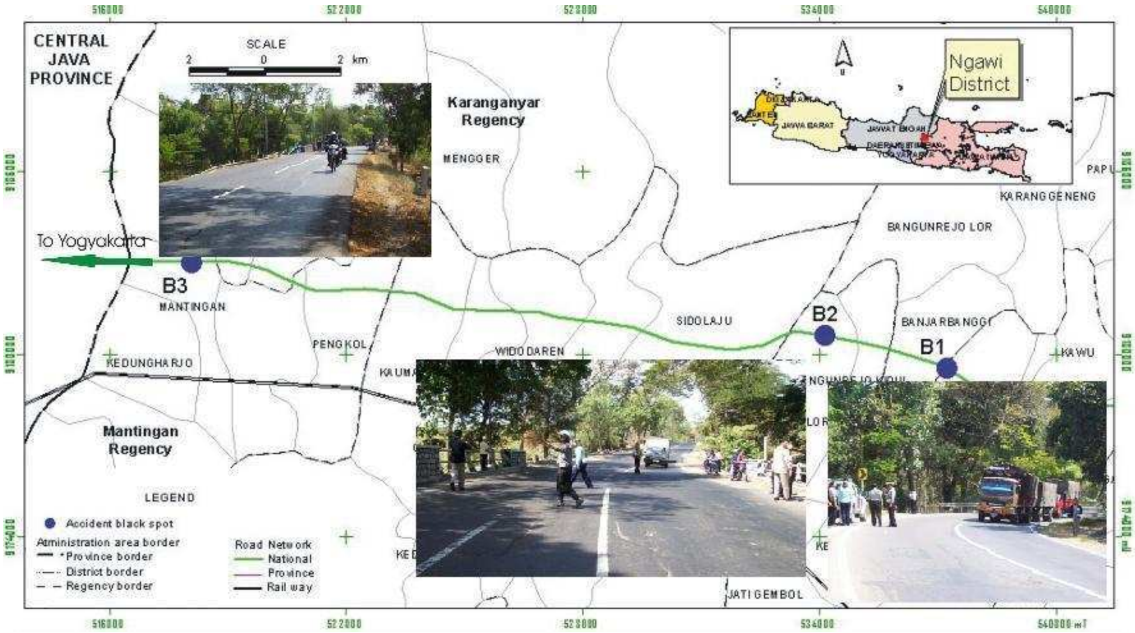

Figure 2 Locations of RSI first trial

Comparing the accumulated deficiencies and risk valuation between locations, it is advised that the first priority should be given to B3 for treatment, and then B1 and B2 follow. This advise appears to be in agreement with accident data, where 10 deaths in just 1 accident occurred at B3, while 8 deaths in 19 accidents and 4 deaths in 14 accidents occurred in B1 and B2, respectively. The inspection went further to propose appropriate treatments as follows (Table 5).

Table 5 General recommendations for location treatment

Location	Geometric aspects	Pavement aspects	Road furniture aspects
B1	Improve shoulder to 2 meters wide and level its elevation with lane edge	Improve shoulder construction	• Paint 100 m solid mark on road centerline and edges from the curve • Install maximum speed limit sign of 40 km/h • Improve lightning along the curve • Install guard rail along the curve
B2	Improve shoulder to 2 meters wide and level its elevation with lane edge	• Improve shoulder construction • Fix excessive surface deformation by syrface levelling	• Solid line mark along road edges • Install maximum speed limit sign of 60 km/h • Improve lightning
B3	Improve shoulder to 2 meters wide and level its elevation with lane edge	• Improve shoulder construction • Fix excessive deformation, rutting, and potholes by surface levelling	• Paint 100 m solid mark on road centerline and edges from the curve • Install maximum speed limit sign of 40 km/h • Improve lightning along the curve • Install guard rail along the curve

Discussion

Developing a management system to approach road infrastructure safety problems promises a number of benefits to contribute to road safety improvement. As pointed out by Greenwood *et al* [8], these include among others ensuring safety to be considered in decisions about construction, maintenance and management of the road network, assisting in the achievement of safety targets and goals, ensuring consistent and efficient implementation of road management procedures, better managing safety risk, and better documenting road safety knowledge and expertise needs. To realize these benefits, however, strong commitment and leadership are needed. Bina Marga should be determined to continue developing the RISMS and to integrate the 'safety processes' in its routines and already established management systems. Further, it needs to market this system to other road authorities at provincial and district levels. Learning that the responsibility to maintain roads has been decentralized, marketing the system is an important issue to cover as many road networks as possible for safety checks.

Another important issue is on the practice of conducting road safety audits. It is a common practice in some countries to involve a third party to conduct a safety audit on road schemes on behalf of the project owner. While this practice is healthy to produce independent and unbiased reports, it may be difficult to realize such a practice in Indonesia. Audit series in Indonesia's government offices including the Ministry of Public Works are normally conducted internally through their respective Inspectorate Generals. There is no legal basis for the involvement of a third party in auditing state funded-projects. Therefore, inviting a third party to conduct road safety audits may pose a serious bottleneck to the safety management process.

Regarding the Road Safety Inspection, this process is acknowledged in the RISMS as a means to maintain safety performance of the existing road networks. Periodic inspection, therefore, is required to provide feedback on the safety performance of the roads from time to time. The obvious issue here is about the coverage, i.e. how to routinely inspect the safety aspects of national, provincial, and district roads once in four years. Proper arrangement should be made to distribute the task. Inspection procedure may also be improved to incorporate a time efficient method by using suitable information-communication technologies. On the monitoring of the safety performance of the new and existing roads, it is advisable to enhance the tasks of road inspectors. It was a good practice in the past that a permanent road inspector was appointed to monitor the structural performance of a certain section of road and to regularly report to the related Office of Public Works. One way is to upgrade the capacity of these inspectors so that safety inspection can be included as an integrated part of their routine.

On the application of the RSI Guidelines in the case studies, it was found that an inspector with good knowledge in road safety engineering, road geometry problems, pavement performance, and road furniture was needed. Expertise in these fields is frequently needed to estimate the risk value and propose appropriate treatment because in many cases accident data to help decide the values is not present. At present practice, safety deficiencies were identified largely based on the opinion of expert engineers. Another case is that checklists with detailed description such as used in Australia may be more appropriate than the simple one such as used in the UK. A standardized format to record road deficiency is also needed in order to efficiently record it in the database.

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