ROAD RECONSTRUCTION WORK ZONE MANAGEMENT TOWARD A GREEN CONSTRUCTION CONCEPT

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Abstract

During road reconstruction period, a negative impact was imposed on road users and the surrounding environment. These impacts are the result of the work zone which is used as working space and road reconstruction. This work zone is potential to influence the drivers' stress and to decrease road traffic performance such as travel delays, congestions and road accidents. Guidelines for green (environmentally friendly) infrastructure defined in New Road Construction Concept (NR2C) in European infrastructure vision 2040 concept, can be used to mitigate this negative impact. Twenty projects of Balai V National Roads Improvement in East Java, and Balai VIII in Bali for fiscal year 2013 is used as a case study. Descriptive method used for the discussion of case studies. Management traffic safety in work zones assessed the suitability of the setting up of signs, markings and guardrail. Shift arrangements work during the day (peak hours) or night (off peak hour), is used as an indicator of the negative impact of road users and the environment. The analysis showed that the work zone management in the implementation of national road reconstruction projects toward green (environmentally friendly) construction concept. It is shown from the implementation of safety attributes average 68%, and the implementation of the reconstruction in the off peak hours by 55% of the projects.

Keywords: road reconstruction, work zone, negative impact, green construction

Abstrak

Pada saat pelaksanaan rekonstruksi jalan, dampak negatif akan terjadi pada pengguna jalan dan lingkungan sekitarnya. Dampak ini akibat zona pekerjaan yang digunakan untuk pekerjaan rekonstruksi. Zona pekerjaan ini berpotensi membuat pengemudi strees dan menurunnya kinerja lalulintas seperti tundaan perjalanan, kemacetan dan kecelakaan lalulintas. Pedoman untuk infrastruktur hijau (ramah lingkungan) menetapkan konsep konstruksi jalan baru (NR2C) dalam Visi Infrastruktur Eropa 2040. Konsep ini dapat memitigasi dampak negatif ini. Dua puluh proyek pada Balai V Jalan Nasional di Jawa Timur dan Bali VIII di Bali pada tahun fiscal 2013 digunakan untuk kasus studi. Metode deskriptif digunakan untuk dalam diskusi kasus studi. Manajemen keselamatan lalulintas di lokasi kerja dinilai terhadap keberlanjutan penempatan rambu, marka dan pagar pelindung. Pengaturan perubahan kerja pada siang hari (jam sibuk) atau malam hari (jam tidak sibuk) digunakan untuk indikator dampak negative pada pengguna jalan dan lingkungan. Dari analisis menunjukan manajemen zona kerja pada implementasi proyek-proyek rekonstruksi jalan nasional menuju konsep konstruksi hijau (ramah lingkungan). Terlihat dalam implementasi atribut keselamatan rata-rata 68% dan implementasi pada jam tidak sibuk hanya 55%.

Kata-kata kunci: konstruksi jalan, zona kerja, dampak negatif, konstruksi hijau.

INTRODUCTON

National roads connectivity serves as a national logistics and tourism. In its life cycle, such as the reconstruction requires maintenance to improve service capacity. During road reconstruction period, a negative impact was imposed on road users and the surrounding environment. These impacts are the result of the work zonewhich is used as working space and road reconstruction. This work zone is potential to influence the drivers' stress and to decrease road traffic performance such as travel delays, congestions and road accidents. Efforts to mitigate these negative impacts continue to be carried out continuously for toward green construction. Innovation concepts of green road construction is now being developed is New Road Construction Concept (NR2C) in European Infrastructure Vision 2040 (FEHRL, 2008). Implementation of safety and traffic management for National road projects have been set forth in the tender document. In this document, the service providers (contractors) are required to prepare a "plan of management and traffic safety, which comply with the provisions and guidelines of the Directorate General of Highways (2010).

New Road Construction Concept

The relevant aspect of the vision have been labelled with typical characteristics showing the color of the demands of the future at a more recognisable level linked to the present jargon of policy makers and engineers concerning road infrastructure. Clustering related characteristics produces this selected number of statements, called new road construction concepts in the context of NR2C, representing and expressing the major users and stakeholders' requirements.

The society of 2040 expects:

a. reliable infrastructure; standing for optimising the availability of infrastructure,
b. green (environmentally-friendly) infrastructure; standing for reducing the environmental impact of traffic and infrastructure on the sustainable society,
c. safe and smart infrastructure; standing for optimising flows of traffic of all categories of roadusers and safe road construction working, and
d. human (-friendly) infrastructure; standing for harmonising infrastructure with the human dimensions.

These four concepts apply to the three fields of the NR2C project, namely urban and interurban roads and constructions. Society demands reliable, green, human, and safe and smart infrastructure in a stable composition. The transformation of the vision 2040 into new road construction concepts with solution directions has schematised in the Figure 1.

Impact of Traffic Flow

The functional relationship between m (accidents per unit of time) and the traffic flow is a 'safety performance function'. A safety performance function is depicted schematically in Figure 2. For the moment its shape is immaterial and it tells how for some entity the expected frequency of accidents of some type would be changing if traffic flow on the entity changed while all other conditions affecting accident occurrence remained fixed (AHB45, 2001).

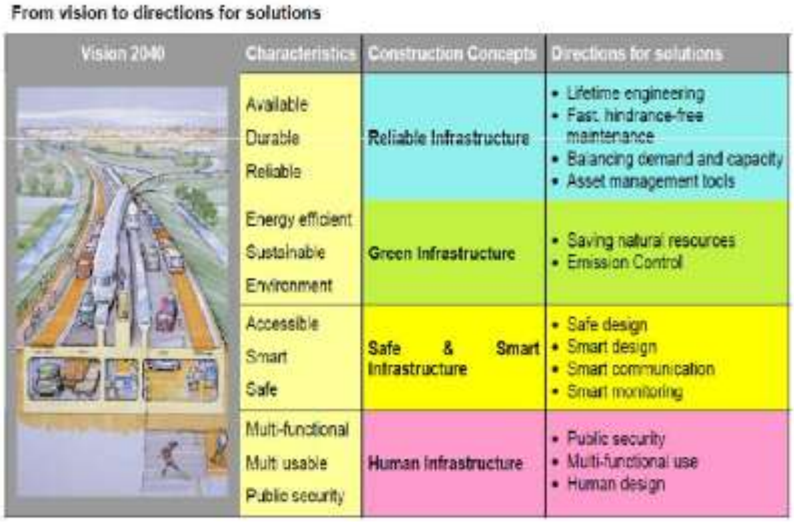

Figure 1 Schematically of the NR2C Vision 2040 (Fehrl.org, 2008)

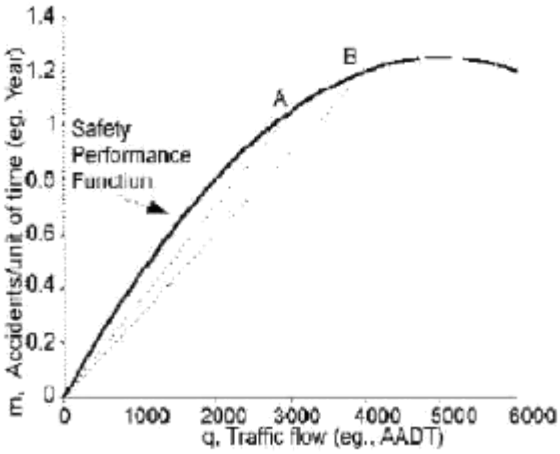

Figure 2 Flow and Accidents Relationship (AHB45, 2001)

Fuel consumption depends on the variable speed of the vehicle. The relationship of speed with fuel consumption are presented in Figure 3. The fuel consumption for each vehicle can be calculated using the following equation, namely (KPUDJBM, 2005):

$$KBBMi = (+ {}_{1}/V_R + {}_{2} \text{ x } V_{R2} + {}_{3} \text{ x } R_R + {}_{4} \text{ x } F_R + {}_{5} \text{ x } F_{R2} + {}_{6} \text{ x } DT_R + {}_{7} \text{ x } A_R + {}_{8} \text{ x } SA + {}_{9} \text{ x } BK + {}_{10} \text{ x } BK \text{ x } A_R + {}_{11} \text{ x } BK \text{ x } SA)/1000 \quad (1)$$

with:

KBBMi = Consumption of fuel for vehicle type i, in liters/km

V_R = mean speed (km/h)

R_R = average road ramp up

F_R = average road sloop down

DT_R = degree of average road curve

A_R = average acceleration (m/s^2)

SA = standard deviation of acceleration

BK = heavy vehicles

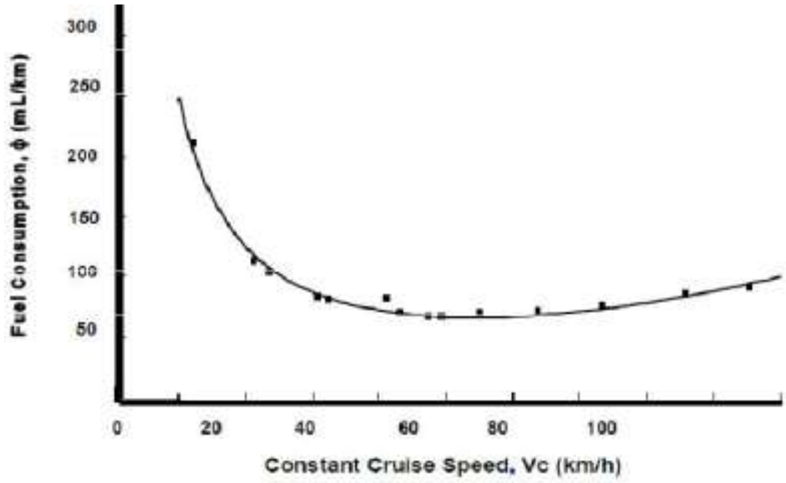

Figure 3 Speed and Fuel Consumtion Relationship (AHB45, 2001)

Air pollution from road traffic model has been developed by the British Transport and Road Research Laboratory (TRRL) and it predicts air pollution from road traffic (Hickman and Waterfield, 1984). The estimations of air pollution are in the form of hourly average concentrations of carbon monoxide at selected locations around a network of roads. The input data required are the configuration of the road network, the location of the receptor, traffic volumes and speeds, wind speed, and wind direction. The concentration of carbon monoxide may be used as to approximate the likely levels of other pollutants using the following formulas (AHB45, 2001):

HC Emission (gram/sec) = 0.018 + 5.668*10-3 (A*S) + 2.165*10-4 (A*S2) (2)

CO Emission (gram/sec) = 0.182 - 8.587*10-2 (A*S) + 1.279*10-2 (A*S2) (3)

NO_x Emission (gram/sec) = 3.86*10-3 + 8.767*10-3(A*S) (for A*S>0) (4)

NO_x Emission (gram/sec) = 1.43*10-3 - 1.830*10-4(A*S) (for A*S<0) (5)

with:

A = acceleration (meters/sec^2) and

S = speed (meters/sec).

Work Zone

According to Jiang Yi et al (2010), FHWA (2011), the work zone (work zone) is an area or street segment where one or more lanes of the road closed for road construction. This resulted in a reduction in traffic movements and reduced the capacity of the road.

Implementation lane closures on road reconstruction often cannot be avoided. Various methods of work zone lane closures are planned with the aim of minimizing losses due to the impact of lane closures (Jiang Yi et al, 2009; Jiang Yi et al, 2010). The conceptual design and work of planning zones that have been successfully implemented for many highway work zone implementation at high speed is (NCHRP, 2007): (a) alternate one-way operation; (b) detour; (c) lane diversion; (d) total road closure; (e) intermittent closure; (f) lane closure; (g) cross over the median; and (h) use of road shoulder. Several design alternatives lane closures in the work zone are presented in Figure 4, Figure 5, and Figure 6.

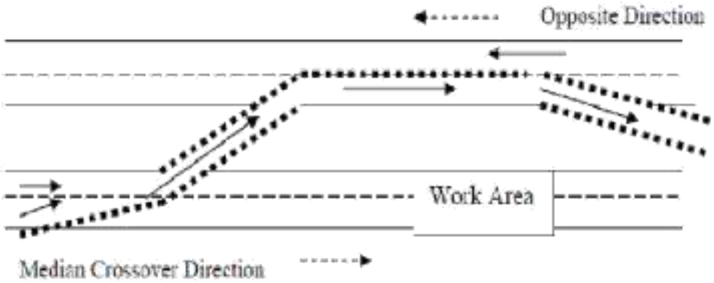

Figure 4 Partial Closure Work Zone **(**Jiang Yi et all, 2009; Jiang Yi et all, 2010)

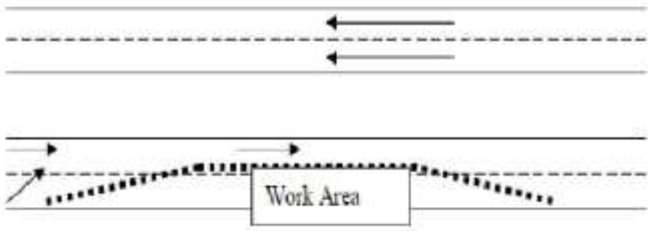

Figure 5 Crossover Work Zone (Jiang Yi et all, 2009; Jiang Yi et all, 2010)

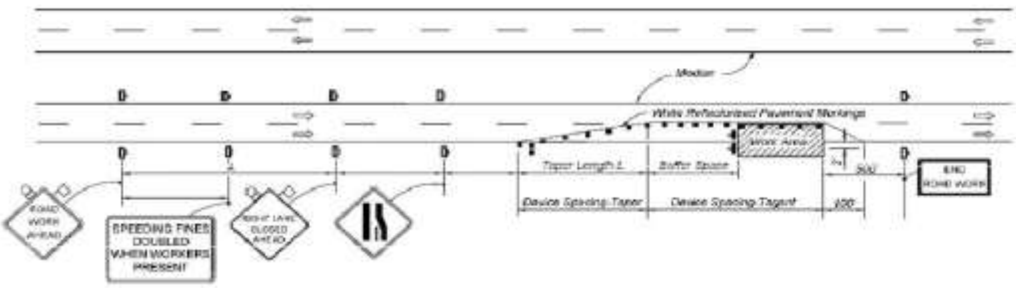

Figure 6 Work Zone Design for Multilane (Morgan J.F. et al, 2010)

METHODOLOGY

The study used a descriptive method with a case study of the national road reconstruction projects, in Balai Besar Pelaksanaan Jalan Nasional V of East Java Province and Balai Pelaksanaan Jalan Nasional VIII of Bali Province, for the fiscal year 2013. The number of cases is 20 projects, consisting of 12 projects located in the Province of East Java 12 projects and 8 projects located in the Province of Bali.

Indicator refers to the concept of green construction NR2C Vision Europe 2040. The concept used is limited to the aspects of safety and efficiency related to energy consumption and air pollution. Evaluation based on the safety aspects of the implementation of the safety management of traffic in the work zone using 9 attributes available in the practical guidance on road safety working zone (IndII, 2011). Assessment scores in this study were conducted using the zero-one (1-0) system. If an attribute met the implementation plan, it was given a value of one (1), if not the value of zero (0) was given to the attribute.

The efficiency aspects of energy, fuel consumption, and pollution were assessed during the time of project implementation. When a project was done in the normal hours (afternoon), it was then categorized as not environmentally friendly because during these normal hour periods, peak hour traffic flows occur at the peak hours of the periods, and the score of zero (1) was given to the project. On the other hand, when a project took time at night, it was categorized as green construction and was given the score of one (1).

DATA AND ANALYSYS

The results of attribute assessment of road safety management aspects of 20 cases are presented in Table 1. Case number 1 to 8 came from projects in the Province of Bali while case number 9 to 20 were obtained from projects in the Province of East Java.

Table 1 Assessment of Safety Management Aspects in the Work Zone

Atribut	Case Number																				Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Signs Before the Approach Zone																					
1a) Roadworks Warning	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20
1b) Instructions for Lane Use	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	19
1c) Maximum Speed Limit	0	0	0	0	1	1	1	1	0	0	0	0	1	1	0	0	0	1	0	0	7
1d) Instructions of Traffic Diversion	1	1	1	0	1	1	1	1	1	1	0	1	1	0	0	0	0	1	1	1	14
1e) Instructions of Merging Lane	0	1	1	1	1	1	1	1	0	0	0	1	0	1	1	0	0	1	1	1	13
Initial Taper																					
2a) Installation of Traffic Cones	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	1	0	0	11
2b) Installation of Reflector Stick (Lamp)	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	13
Work Zone Area																					
3a) Installation of Traffic Cones (Guardrail)	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	0	1	1	0	14
End of Taper																					
4a) Installation of Traffic Cones	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	1	0	12
Total																					123
Percentage																					68%

There are 9 attributes observed in the work zone as shown in Table 1. In the initial approach zone, in the initial taper, in work zone, and in the end of the taper, have 5 attributes (1a, 1b, 1c, 1d, 1e), 2 attributes (2a, 2b), 1 attribute (3a), and 1 attribute (4a), respectively. The total score for 9 attributes in 20 cases is 180. The score observed was only 123 or 68%.

Data for the evaluation of environmentally friendly fuel consumption and pollution were identified from the working time shift during the implementation of reconstruction projects. Table 2 shows cases of projects executed in the afternoon or peak hours with major risks and in the evening or off peak hours with minor risks. It can be found that 11 of 20 projects, or 55% of the project, were executed on working night shifts. At night usually traffic flow Q (pcu/h) is lower and traffic speed V (km/h) is higher (see Figure 7 and Figure 8) causing minimal impact on fuel consumption and pollution. It can be said that the project execution during night shifts is more environmentally friendly than that of the afternoon shift.

Table 2 Data of Working Time of Road Reconstruction Project

Working time shift	Case Number																				Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Afternoon shift (Peak Hour)	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	1	1	1	1	0	9
Night shift (Off Peak Hour)	1	1	1	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	1	11
Percentage Night Working (Off Peak Hour)																					55%

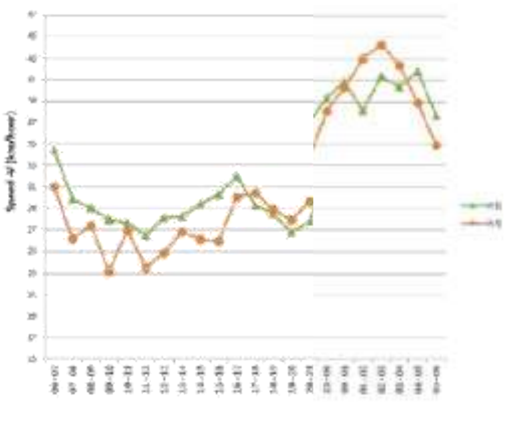

Figure 7 Fluctuation of Speed (km/h), for Case 3 and Case 4

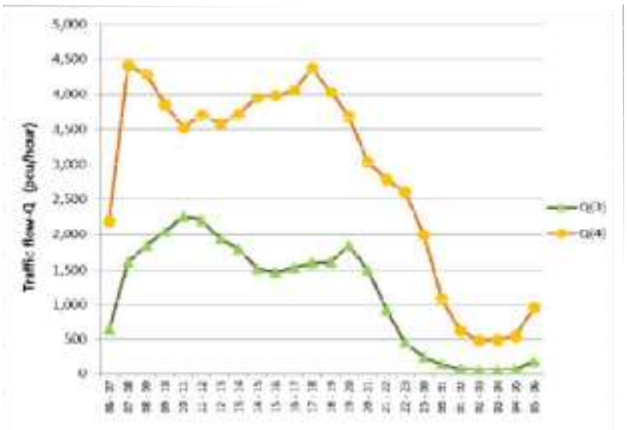

Figure 8 Fluctuation of Traffic Flow Q (pcu/h) for Case 3 and Case 4

CONCLUSION AND RECOMMENDATION

The implementation of 20 national road reconstruction projects in East Java and Bali Provinces, for fiscal year 2013, indicates that several road reconstructon projects were executed toward the green construction concept. It is shown, based on the evaluation results, that 55% of the projects were executed during night time and such execution can be considered more environmentally friendly.

Regarding the concept of green road construction, it can be recommended that more research work on green road construction concept be performed. Also, the implementation of green construction for road projects needs more commitment of all stakeholders so that the green road construction concept can be fully implemented.

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