EVALUATION OF ROAD ROUGHNESS AND ROAD DETERIOATION

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Abstract

There are two road condition survey methods commonly used, the roughness-based equipment such as NAASRA and the distress and severity type road evaluation method as presented by ASTM D-6433. The objective of the study is to evaluate the relationship between road condition obtained from roughness type equipment and road distress. To achieve the objective, a condition survey using the two methods were performed on two road segments in the East Java Provincial road system. Data obtained from the field was evaluated to obtain International Roughness Index (from NAASRA) and Present Condition Index value (from field condition survey). The results show that the two methods provide a comparable result when the distress type is of un-even surface such as rutting and bumping. A slight different result is observed when the major distress occurred in the road is of crack-type such as fatigue and block cracking.

Keywords: road condition survey, roughness, road condition, crack.

Abstrak

Terdapat dua metode survei kondisi jalan yang umum digunakan, yaitu metode yang berdasarkan peralatan berbasis kekasaran, seperti alat NAASRA, dan metode evaluasi kerusakan jalan sebagaimana diuraikan pada ASTM D-6433. Tujuan penelitian ini adalah untuk mengevaluasi hubungan antara kondisi jalan yang diperoleh dari peralatan jenis kekasaran dan kerusakan jalan. Untuk mencapai tujuan tersebut suatu survei kondisi jalan yang menggunakan dua metode tersebut dilakukan pada dua ruas jalan di Provinsi Jawa Timur. Data yang diperoleh dari lapangan dievaluasi untuk memperoleh International Roughness Index (metode NAASRA) dan nilai Present Condition Index (metode survei kondisi lapangan). Hasil penelitian menunjukkan bahwa kedua metode memberikan hasil yang serupa untuk permukaan jalan yang tidak rata, seperti adanya *rutting* dan *bumping*. Terdepat sedikit perbedaan di jalan yang mengalami kerusakan yang parah, seperti retak akibah lelah dan *block cracking*.

Kata-kata Kunci: survei kondisi jalan, roughness, kondisi jalan, retak.

INTRODUCTION

Highway network is one of transportation modes that plays important roles for distribution of goods and services. As such, its condition should be properly maintained. It

is true in case of national road system. For district road systems, however, maintenance sometimes was not taken in high priority (Djakfar, et al, 2012). The majority of Public Works Departments in local government levels do not have a regular road condition survey program. The maintenance was performed only for roads that have been reported to be in bad shape.

The East Java Province Public Works Department has regularly performed road condition survey using NAASRA equipment to determine its IRI value. The NAASRA is the most commonly used road condition survey equipment in Indonesia due to its capability to rate road condition in the network in short period of time and is cost effective. The roughness type road condition survey interprets road condition based on its roughness, or un-evenness of the road. The higher the IRI values the worse it interprets the road condition. One should understand that not all distresses occurring in the road are of un-even type of distress. For example, high severity fatigue crack may occur in the road, which means that the road may need a maintenance program. This distress, however, may not be detected by NAASRA since it may not create an un-even surface. Consequently, the interpretation provided by NAASRA may mislead with the real condition.

Another method that can be used to evaluate the road condition is the PCI method (Djakfar, 2012). The road condition is evaluated based on the distress types and its severity. The road is then evaluated using the ASTM D-6433 to determine its Present Condition Index (PCI) value (ASTM,2007). Figure 1 presents the rating of road based on its PCI value.

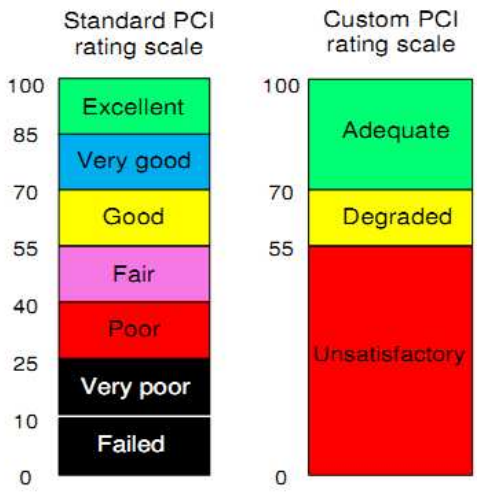

Figure 1 Interpretation of PCI values

One of drawbacks of this road condition rating method is that it takes so much effort and cost to perform the condition survey, particularly when performed manually. In other words, this rating method is not suit to rate roads in a network system. It is best suit to rate individual road condition. This rating method may be used to supplement the road

condition survey using NAASRA. In order to come to a better understand on how these two rating methods rate road with the same condition, a comparison study is needed.

The objective of the study is to evaluate the relationship between road deterioration and road roughness. The road deterioration is measured using ASTM D-6433, known as PCI method while the road roughness is measured in the International Roughness Index (IRI).

To achieve the objective, a road condition survey was conducted on two segments of the East Java Provincial Road,Gedek–Kesamben (7.13 km), and Kesamben – Ploso (13.79 km) in Mojokerto Regency. Figures 2 and 3 present the roads location on the map. The survey consisted of road condition survey using ASTM D-6433 (ASTM, 2007) to measure the road distress, and roughness survey using NAASRA to measure the road roughness.

The road segment is divided into sections each of 1 km length. The survey was conducted each lane, so that the PCI and IRI are analyzed in km/lane. Figure 4 presents a sample of road condition survey, while Table 1 presents a sample of field data collection form. Road condition data collected from the field was analyzed to determine its PCI value based on the procedure presented in ASTM D-6433. The roughness data collected from NAASRA was analyzed to determine its IRI value. After PCI and IRI value were determined, a t-test was performed to determine the relationship between the PCI and IRI. To assess its relationship in a more elaborative way, additional review based on field condition was also performed.

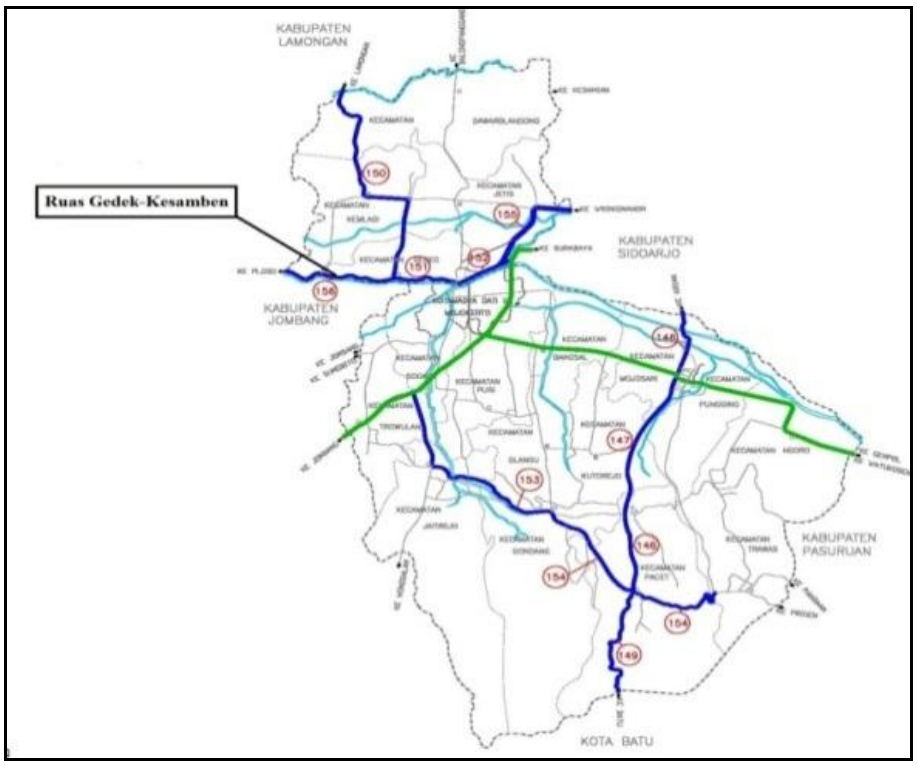

Figure 2 Location of Gedek-Kesamben Road Segment

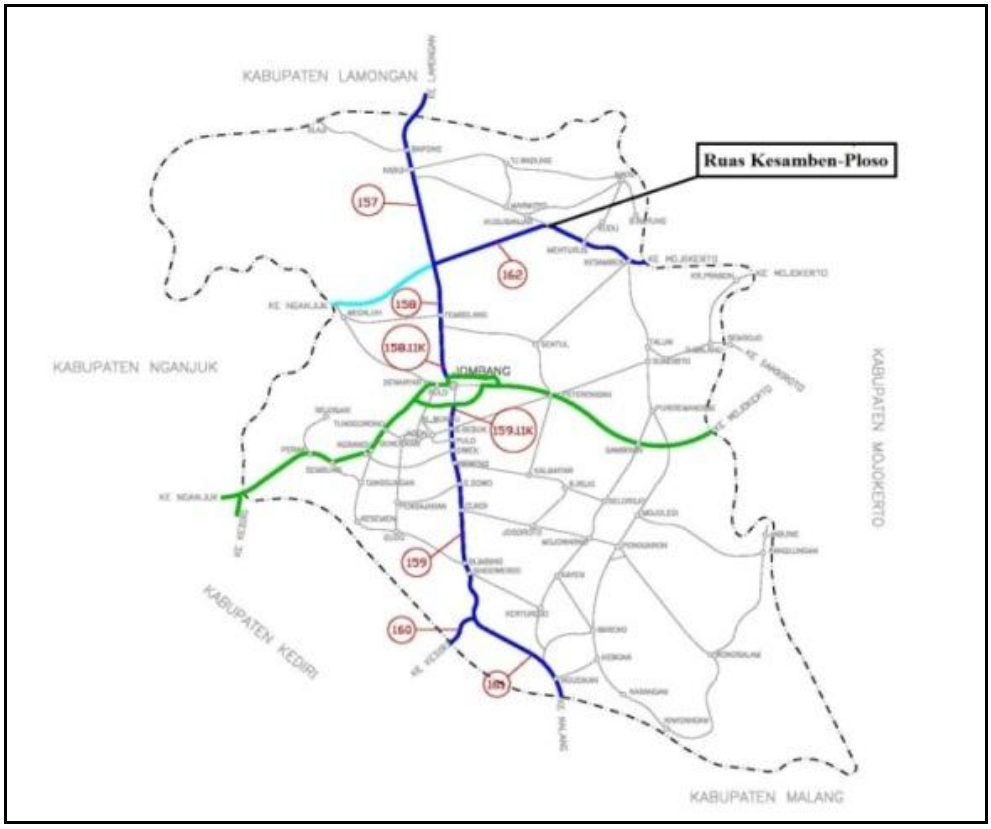

Figure 3 Location of Kesamben-Ploso Road Segment

Figure 4 Sample Road Condition Survey

RESULTS AND DISCUSSION

Tables 2 and 3 present the PCI values while Tables 3 and 4 present the roughness values for each segment, respectively. It can be seen from Tables 1 and 2 that the road condition on Gedek–Kesamben segment appear to be better than that of Mojokerto–Ploso

segment, with the overall rating is good for the former and fair for the latter. The IRI values for both segments, as presented in Tables 4 and 5, also show that Gedek–Kesamben segment has better road condition as shown by its lower IRI value than that of Mojokerto–Ploso.

In other words, when comparing the two segments, the overall conclusion based on surface condition and surface roughness may come up to different conclusion. Therefore, further elaboration on how this different occurs is needed.

Table 1 Sample of Field Survey Form

SURVEY FORM									Sketch: 200 / 2.25	
Branch :Moker-Ploso			Section : Km 4-5			Unit sampel : 1				
Surveyor : Vita Dwi R.			Date : 14 Desember 2012			Area sampel : 450 m²				
1. Alligator Cracking			6. Depression			11. Patching &Utill Cut Patc			16. Shoving	
2. Bleeding			7. Edge Cracking			12. Polished aggregate			17. Slippage Cracking	
3. Block Cracking			8. Jt. Reflection Cracking			13. Potholes			18. Swell	
4. Bumps and Sags			9. Lane/Shoulder Drop Off			14. Railroad Crossing			19. Weathering Raveling	
5. Corrugation			10. Long & Trans Cracking			15. Rutting				
Distress Severity			Quantity (m)						Total	Density %	Deduct Value
			Area sampel	=	450	m²				
1L	2.5	1								
1M	2	1.5	0.25	1.5	3.5	4				
3L	2.5	1.5	2.5	1	5.5	12.75				
6M	0.75									
7L	1.5	2.5								
7M	1.5	3.5	2	1.25	2.5					
13M	1									
19L	6	7.5	6							

Table 2 PCI Values for Gedek-Kesamben Segment

KM	PCI		PCI/km	Road Condition
	Left Lane	Right Lane		
0 - 1	65.88	65.00	65.44	Fair
1 - 2	83.64	61.39	72.52	Good
2 - 3	78.30	51.00	64.65	Fair
3 - 4	86.26	63.20	74.73	Good
4 - 5	77.54	68.40	72.97	Good
5 - 6	88.02	64.20	76.11	Good
6 - 7	85.02	58.04	71.53	Good
Average PCI			71.14	Good

Table 3 PCI Values for Mojokerto-Ploso Segment

KM	PCI		PCI/km	Road Condition
	Left Lane	Right Lane		
0 - 1	74.06	43.04	58.55	Fair
1 - 2	54.90	49.66	52.28	Poor
2 - 3	65.30	65.80	65.57	Fair
3 - 4	77.20	59.20	68.20	Fair
4 - 5	41.80	32.92	37.36	Very Poor
5 - 6	38.14	36.80	37.47	Very Poor
6 - 7	49.80	40.36	45.08	Poor
7 - 8	61.30	49.90	55.59	Fair
8 - 9	66.20	44.80	55.50	Fair
9 - 10	69.00	67.45	68.43	Fair
10 - 11	95.54	76.50	86.02	Very Good
11 - 12	95.68	77.90	86.79	Very Good
12 - 13	96.14	82.00	89.07	Very Good
13 - 13.8	95.33	79.13	87.23	Very Good
Average PCI			63.79	Fair

Table 4 IRI Values for Gedek-Kesamben Segment

KM	IRI (m/km)	Road Condition
0 - 1	3.09	Very good, even surface
1 - 2	3.51	Very good, even surface
2 - 3	4.31	Good
3 - 4	3.09	Very good, even surface
4 - 5	4.92	Good
5 - 6	6.14	Fair. Holes in some places, not even surface
6 - 7	3.82	Very good, even surface
Average *IRI*	4.13	Good

To do that, one can compare head to head per km not only the IRI and PCI value, but also the dominant distressesthat occur for each km. Tables 6 and 7 present this comparison.

As can be seen from Tables 6 and 7, both methods provide slightly different conclusion on overall road condition. The different is more apparent at the type of major distresses occurring in the road. When the major distressesare of un-even type, i.e., rutting, depression and bump and sag, PCI tends to provide better rating compared to the IRI for the road condition, while when the dominant distressesoccurring in the roadare of even-type, i.e., block cracking and alligator cracking, IRI tends to provide better rating.

The plausible explanation on this is that roads with dominant cracking distresses tend to have a smoother road compared to those with un-even surface types. Thus, no matter how high the distress intensity, as long as a road is even, NAASRA equipment will

rate the road as good. And vice versa for road with un-even surface. Even though the distress intensity is low, when the majority of distresses in a road of this type NAASRA will rate this as fair or poor.

Table 5 IRI Values for Mojokerto-Ploso Segment

KM	IRI (m/km)	Road Condition
0 - 1	3.51	Very good, even surface
1 - 2	4.61	Good
2 - 3	5.83	Good
3 - 4	5.83	Good
4 - 5	10.71	Poor, un even surface, with potholes in some places
5 - 6	11.63	Poor, un even surface, with potholes in some places
6 - 7	6.44	Fair, Few Potholes, un-even surface
7 - 8	5.63	Good
8 - 9	6.75	Fair, Few Potholes, un-even surface
9 - 10	2.61	Very good, even surface
10 - 11	4.42	Good
11 - 12	2.48	Very good, even surface
12 - 13	2.78	Very good, even surface
13 - 13.8	3.98	Very good, even surface
Average	5.52	Good

Table 6 Comparison or Road Condition Based on PCI and IRI Values, Gedek-Kesamben Segment

KM	PCI		IRI		Dominant Distress
	Value	Remark	Value	Remark	
0 - 1	65.44	Fair	3.09	Very good, even surface	Alligator cracking (H), Potholes (H), and Bumps and sags (H)
1 - 2	72.52	Good	3.51	Very good, even surface	Alligator cracking (H,M), and Patching and utility cut patching (M)
2 - 3	64.65	Fair	4.31	Good	Alligator cracking ((H), Shoving (H), Patching and utility cut patching (M)
3 - 4	74.73	Good	3.09	Very good, even surface	Bumps and sags (H), Alligator cracking (H), and Shoving (M)
4 - 5	72.97	Good	4.92	Good	Weathering and raveling (H), and Alligator cracking (M, H)
5 - 6	76.11	Good	6.14	Fair. Holes in some places, not even surface	Weathering and raveling (H), Alligator cracking (M), and Bumps and sags (H)
6 - 7	71.53	Good	3.82	Very good, even surface	Alligator cracking (H), Weathering and raveling (H), and Alligator cracking (M)

Table 7 Comparison or Road Condition Based on PCI and IRI Values, Mojokerto-Ploso Segment

KM	PCI		IRI		Dominant Distress
	Value	Remark	Value	Remark	
0 - 1	58.55	Fair	3.51	Very good, even surface	Alligator cracking (H), Block cracking (H), and Potholes (H)
1 - 2	52.28	Poor	4.61	Good	Alligator cracking (M,H), Weathering and raveling (H)
2 - 3	65.57	Fair	5.83	Good	Alligator cracking (H,M), and Block cracking (H)
3 - 4	68.2	Fair	5.83	Good	Potholes (H), Corrugation (M), and Shoving (H)
4 - 5	37.36	Very Poor	10.71	Poor, un even surface, with potholes in some places	Alligator cracking (H,M), and Potholes (H)
5 - 6	37.47	Very Poor	11.63	Poor, un even surface, with potholes in some places	Alligator cracking (H, M), and Bumps and sags (H)
6 - 7	45.08	Poor	6.44	Fair, Few Potholes, un-even surface	Rutting (H), Alligator cracking (H), and Patching and utility cut patching (M)
7 - 8	55.59	Fair	5.63	Good	Rutting (H), Patching and utility cut patching (H), and Potholes (M)
8 - 9	55.50	Fair	6.75	Fair, Few Potholes, un-even surface	Alligator cracking (H), Bumps and sags (H), and Shoving (H)
9 - 10	68.43	Fair	2.61	Very good, even surface	Alligator cracking (M), Shoving (H), and Alligator cracking (L)
10 - 11	86.02	Very Good	4.42	Good	Rutting (L), Weathering and raveling (M), and Shoving (H)
11 - 12	86.79	Very Good	2.48	Very good, even surface	Rutting (L), Bumps and sags (M), and Depression (L)
12 - 13	89.07	Very Good	2.78	Very good, even surface	Rutting (L), Bumps and sags (M), and Depression (M)
13 - 14	87.23	Very Good	3.98	Very good, even surface	*Depression* (H), *Rutting* (L), and *Bumps and sags* (M)

One point from this phenomenon is that IRI should not be used solely to rate road condition. It should be checked with other road evaluation method in order to come up to better evaluation of road condition.

Another point this study would like to evaluate is the relationship between IRI and PCI. Therefore, a regression analysis is performed for the data collected. From the analysis it was found that the relationship could be expressed as follows:

$$IRI = 12.905 - 0.119\ PCI$$

or

$$PCI = 108.445 - 8.4\ IRI$$

with: $r^2 = 0.56$

CONCLUSION AND RECOMMENDATION

Based on the analysis, the following conclusions can be drawn:

1. Generally both distress and roughness methods provide a satisfactory result in evaluating and predicting road condition.
2. In case where dominant distresses occurring in the road consist of crack types of distress, generally roughness method provide a conservative result; where dominant distress is un-even surface type of distress, such as rutting or bump, both method produce almost similar result.
3. Both methods have advantages and disadvantages. Therefore, when evaluating the road network condition, roughness method may provide more advantages due to cost and time. It is recommended that the distress method still be performed sporadically to verify the roughness data. Model presented above can be used to predict roughness value (IRI) given the PCI value, and vice versa.

REFERENCES

American Society for Testing and Materials. 2007. *Standard Practice for Roads and Parking Lots Pavement Condition Index Survey.* Philadelphia, PA.

Djakfar, L., Alamsyah, A., and Agung, *D.* 2012. *Development of Road Maintenance Prioritization Program for Small Region: Case Study in District of Malang, East Java, Indonesia*. Proceeding of the Seventh International Conference on Maintenance and Rehabilitation of Pavements And Technological Control. Auckland.

Hu, F. 2004. *Development of Direct Type Road Roughness Evaluation System.* University of South Florida. Tampa, FL.

Kartika, A.A.G., Widyastuti, H., Herijanto, W., Buana, C., and Arif, P. C. 2006. *Validation of Correlation Model between International Roughness Index (IRI) and Distress Value (DV): A Case Study of Surabaya-Gempol Toll Road.* Jurnal Transportasi, 6 (1), 1-10.

Martin, T. 1999. *The Effect of Climate on The Cost of Road Maintenance in Australia.* ARRB Transport Research, Ltd. Melbourne, VIC.

Paterson, W.D.O. 1987. *Road Deterioration and Maintenance Effects. Models for Planning and Management*. The International Bank for Reconstruction and Development, Washington, DC.

Sayer, M.W., Gillespie T.D. and Queisoz C.A.V. 1986. *The International Road Riding Quality Experiment: Establishing Correlative and Calibration Standard for Measurement, Technical Paper 45*. World Bank. Washington, DC.

Shahin, M.Y. 1994. *Pavement Management for Airports, Roads, and Parking Lots*. New York, NY: Springer Science and Business Media.

Suherman. 2008. *A Correlation Study of Road Roughness and Road Condition Index (RCI): A Case Study of Labuan–Cibaliung Road Segment (Indonesian).* Jurnal Teknik Sipil. XIII (3): 206-214.