

Analysis of Condition Value and Remaining Life of Idano Mezawa Bridge, Nias District, North Sumatera

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ABSTRACT

Bridges are an important part of a road network that functions to connect regions to support the regional economy. To function properly, bridges must be subjected to a maintenance program and periodic supervision. In Indonesia, the method used for bridge inspection and assessment is currently regulated in the 1992 Bridge Management System (BMS) developed by the Road and Bridge Engineering Development Ministry of PUPR to become an android-based application of Bridge Visual Inspection (INVI J). In addition, there is the Bridge Condition Rating (BCR) method which refers to the New York State Department of Transportation. This study aims to apply both methods to the Idano Mezawa Bridge which is located on Nias Island, Hilizalootano, Teluk Dalam, South Nias, North Sumatra. Based on the BMS method, it is known that the value of the Idano Mezawa bridge condition is 3, which means that the bridge has had possibly serious damage in the last 12 months and requires rehabilitation or strengthening. The remaining life of this bridge is 8.722 years. Meanwhile, with the BCR method, this bridge has a condition value of 4.5 which is included the bridge in the fair condition category and requires a rehabilitation process. The age of the bridge based on the BCR method is 17.910 years. The comparison of the two methods concludes that (1) the difference in condition values gives the same recommendation, namely that the bridge needs to be rehabilitated; The difference in the value of this condition is due to the different range of condition values from the two methods (2) the remaining life using the BMS method shows that it is more safety for bridges and users.

Keywords: BCR, BMS, Bridge, Condition rating, INVI J, Idano Mezawa, Remaining useful life

1. INTRODUCTION

Roads and bridges are elements of infrastructure that are closely related to land transportation infrastructure. As a means of limiting road construction (rivers, ravines, railroads, etc.), the two are interrelated. It can be said that over time the bridge grows very quickly. Through the construction of the bridge, it will be very easy for drivers or residents to choose a shorter destination route so that it saves more time.

In the road network, bridges play an important role as a means to connect regions. Each region must be connected so that the economic condition can run well. For the economy to function properly, bridge roads as the infrastructure supporting the economy must be planned for maintenance and monitored regularly.

One form of bridge supervision is to inspect the bridge condition. In Indonesia, the guidelines commonly used for bridge inspections are the Bridge Management

System (BMS) of 1992, the Bridge Condition Rating (BCR), and the application issued by the Research and Development Center of the Ministry of PUPR, namely the Inspeksi Visual Jembatan (INVI J).

The Bridge Management System (BMS) in 1992 and the Bridge Condition Rating (BCR) produced the same output, namely the condition value and the remaining life of the bridge. However, both have different methods in calculating the condition value and the remaining life of the bridge. This comparison is conducted to validate the results of the examination and calculations.

INVI J is an application that can assist inspectors to inspect the bridge condition by assembling a visual and instrumental test using condition assessment with the vibration that summarizes in one mobile application and web-based application [1].

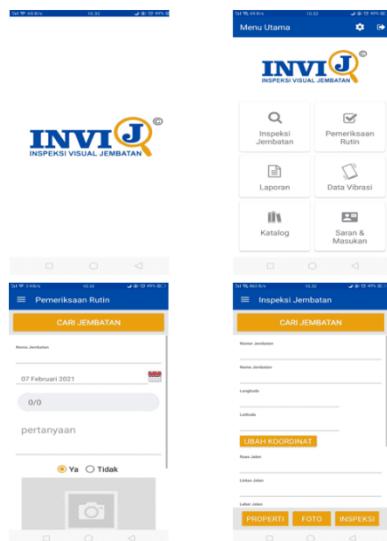


Figure 1 Display of INVI J Application on Smartphone

This study aims to determine the comparison of the analysis result between the Bridge Management System (BMS) method and the Bridge Condition Rating (BCR) method, and the INVI J application on Idano Mezawa Bridge. The input data inspection can start when the bridge is still in a new condition and continue until the bridge is old. The data collected by bridge inspectors will be current, accurate, and complete so that the published results can be trusted.

Bridge Management System (BMS) is a bridge inspection system commonly used in Indonesia. The Directorate General of Highways usually uses the BMS method to plan, implement, and monitor bridges [2]. This system will facilitate these activities to provide a systematic procedure, by conducting regular investigations on a bridge. The monitoring data obtained will be used for planning, maintaining, retrofitting, regenerating, and replacing bridges. The bridge data collection system by the BMS'92 guidelines consists of several stages, as follows: (a) inventory inspection, (b) detailed inspections, (c) routine inspections, and (d) special inspections [2].

From a direct survey in the field, the two condition assessment methods are compared both in terms of the final condition value and on the result of the remaining life obtained from the two methods used.

The remaining life of the bridge is an estimate of the remaining time of a bridge due to damage that occurs in the design life. The factors that affect the remaining life of the bridge are the condition of the bridge itself, while the condition of the bridge can be influenced by the level of damage [3]. The result of the calculation of the remaining life of the bridge can help visual inspection of the bridge.

2. METHODOLOGY

Bridge inspection is one of the most important parts of a bridge management information system. This is because the bridge inspection process concerns the condition of the bridge and plans for future maintenance or improvement. The purpose of the bridge inspection is to ensure that the bridge is in a good and safe condition and to ascertain whether certain actions need to be planned for periodic maintenance and repair.

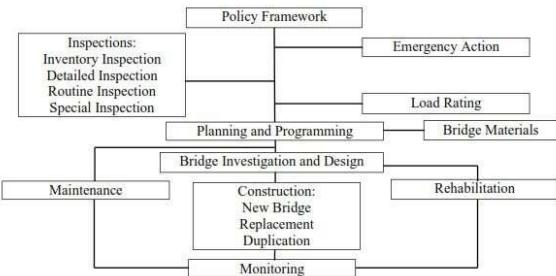


Figure 2 The Procedure of Bridge Condition Inspection with BMS Method

Inventory inspections are carried out only once during the life of the bridge unless there is a change in the information on the bridge properties. The data collected includes administrative data, bridge geometry, and the general condition of the bridge (filled in Level-2 of the bridge element hierarchy system). Bridge condition data can be filled with general information and the procedure used is not the same as the 1992 BMS, which is used to determine the condition of the bridge [2].

Detail inspection is carried out at the latest within 5 or 3 years depending on the situation of the bridge. Generally, wooden bridges deteriorate faster than steel or concrete bridges, so a quicker inspection is required. The data collected is in the form of structural conditions of bridge elements [2].

Routine inspections are carried out to ensure that if there is a sudden or unexpected change in the condition of the bridge, it can be immediately reported and action is taken. Generally carried out annually and carried out by the Routine Maintenance Team [2].

Special inspections should be made in case of detailed inspections requiring test equipment or auxiliary measuring instruments. Specialized examinations would require some state-of-the-art techniques and equipment without compromise on visual technique, knowledge, and judgment in the technical field [2].

The whole inspection process should start from the left of the bridgehead. The following is a schematic sequence of bridge inspections [4] (Figure 3).

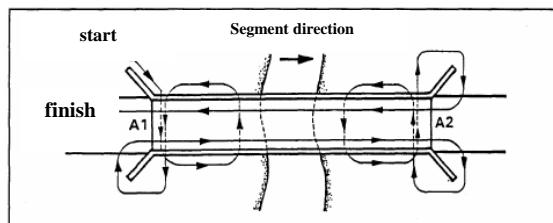


Figure 3 Illustration of Bridge Inspection Direction

The rating state of the bridge with the BMS method uses five (5) levels or the level of inspection and condition assessment phases of the bridge elements. These five levels explain the state of the bridge starting from a single element with a certain location (Level 5), a combination of similar elements (Level 4 – 3), then a combined element in one component (Level 2), and the last is Level 1 which performs overall element assessment by the code and evaluation of the damage elements that occur [5].

The Bridge Condition value at Level 1 can establish a maintenance strategy for the bridge. The element condition assessment system is presented in Table 1.

Table 1. Element or bridge condition assessment system

Condition Value	Description
0	Very good/Bridge in new condition
1	Good/No damage
2	Lightly damage
3	Damage
4	Critically damage
5	Collapse/Doesn't work

To calculate the remaining life of the bridge based on the BMS method (1993), the following equation is used [3]:

$$CV = 5 - \left\{ \frac{100 - \frac{Y}{N\%}}{a} \right\}^{\frac{1}{b}} \quad (1)$$

note:

- CV = Condition value
- Y = Age of bridge
- N = Design life of bridge
- a = Coefficient (4.66)
- b = Coefficient (1.9051)

BCR is a bridge condition index that is oriented to the NYSDOT (New York State Department of Transportation) in Bridge Management (2001) and Inventory Manual (2004) [6]. Evaluation of the condition of the bridge aims to obtain a condition rating

(CR) which is an important element in assessing the condition of the bridge [7].

$$\frac{\sum(\text{component rating} \times \text{weight})}{\sum \text{Weightings}} \quad (2)$$

Note:

- Component rating = Bridge condition components value
- Weight = Components weight value
- Weightings = Total components weight

Each bridge component consists of several sub-components. The value given is the lowest value of the bridge sub-component condition under review. Based on NYSDOT on Bridge and Tunnels Annual Condition Report, there are 9 levels of bridge condition assessment. The rating is usually written from number 1 to 9 but it is often given only from 1 to 7, while for the value of 9 is the condition of an unknown (invisible) component, such as a bridge foundation and several embedded piles. In addition, the value of 8 can be given if the condition of the bridge has no components under review [6].

NYSDOT uses 13 bridge components in the BCR analysis as listed in Table 2.

Table 2. Bridge element component in BCR analysis

No	Components	BCR
1	Main girder	10
2	Abutment	8
3	Bridge pillar	8
4	Deck	8
5	Bridge stand	6
6	Bearing	6
7	Wing wa II	5
8	Back wall	5
9	Secondary girder	5
10	Joint	4
11	Wearing Surface	4
12	Trotoar	2
13	Curb	1

This visual evaluation system of bridge conditions is obtained from the value of the final condition of the bridge. The final result used is 3 digits behind the comma so that the results are more accurate. Below is a table of the final value of the bridge condition according to the BCR method [6].

Table 3. Bridge condition assessment based on NYSDOT

BCR	Condition	Treatment Recommendation
1.000-3.000	Poor	Replacement
3.001-4.999	Fair	Rehabilitation
5.000-6.000	Good	Routine and periodic maintainance
6.001-7.000	Very good	

After assessing the condition of the bridge, the equivalent age of the bridge is calculated using the following equation [6]:

$$EA = \frac{\left(100-a\left(5-\left(\frac{5}{6}(7-CR)\right)\right)^b\right)}{100} \times \text{Design life of bridge} \quad (3)$$

Note:

- EA = *Equivalent age*
- CR = *Condition rating*
- a = Coefficient (4.66)
- b = Coefficient (1.9051)

Similar to the calculation of the age of the bridge using the BMS'1992 method, the design age in the above formula is filled with 50 (general and permanent bridges) and 100 for special bridges. The CR value can be obtained from the total multiplication of the weights with the bridge component system.

The stages of the activities were carried out are by conducting a literature study to find references that can support the theoretical basis related to the problem. After conducting a literature study, the location was determined as study material, that preparation was made for a field inspection. The field inspection was carried out to obtain data on the bridge under review.

In the field inspection, administrative data and bridge physical data were obtained. The input data obtained from the implementation of the field inspection was then processed for later assessment based on the weighting of the 1992 BMS and BCR methods, after which the remaining life of the bridge was calculated based on the 1992 BMS and BCR methods.

This research also used the INVJ (Visual Inspection Bridge), an application issued by Balitbang Pusjatan Ministry of PUPR. The report is displayed on the INVJ application that can be illustrated as follows:



Figure 4 Display of the Report Menu on INVJ Application

3. RESULT AND DISCUSSION

Administratively, the Idano Mezawa Bridge is located on Nias Island, Hilizalootano, Teluk Dalam, South Nias Regency, North Sumatra. This bridge is provincial because it is located on a provincial road that connects Tetehosi sub-districts with Lahusa. The following are the technical data and photos of the Idano Mezawa Bridge.

Bridge's Name	: Idano Mezawa Bridge
Bridge's Number	: 03.084.002.0
Location (From + To)	: Sitoli Mountain (GST) +39.15
Road	: Tetehosi – Lahusa
Year	: 1990
Coordinat	: N 01.01739 E 97.78785
Length	: 45.30 meter
Amount	: 1
Width	: 6.0 meter
Type	: RBR
Bridge's Service Time	: 50 Years



Figure 5 Idano Mezawa Bridge from Above

Based on the results of visual observations using the BMS method on the Idano Mezawa Bridge, the condition value is 3, which means the bridge is in a damaged condition. Details of the assessment can be seen in the following Table 4.

Table 4. Condition value of Idano Mezawa bridge

Code	Bridge's Element	CV
2.400	Superstructure	1
2.300	Substructure	4
2.200	Watershed	2
2.500	Wearing Surface	1
1.000	Bridge	3

In the superstructure of the bridge, corrosion occurs on the lower edge of the bridge and is overgrown by wild plants, so that the damage to the bridge elements is not too significant. Meanwhile, the building under the bridge suffered severe damage, including the new abutment that tipped over, the Teluk Dalam side abutment rolled or tipped over but was restrained by the old abutment that had cracked, and the parapet tipped over the top of the Sitoli Mountainside abutment.

In the Watershed, there is excessive silt in the river flow coupled with the presence of waste in the form of building waste materials (IWF steel) on the upstream side, this can obstruct river flow under the Idano Mezawa Bridge. Finally, the condition of the bridge floor does not have serious damage, only the asphalt layer began to peel off on the left and the right edges due to obstruction of the drainage channel so that puddles damaged the surface layer.

Damage to the Idano Mezawa Bridge needs to be considered and rehabilitated immediately because it is feared that it will experience more serious damage in the future [3].

Table 5 Condition rating of Idano Mezawa Bridge

Component	Bobot	CR	Bobot x CR	Condition	Recommendation
Main Girder	10	4	40	Fair	Rehabilitation
Abutment	8	3	24	Fair	Rehabilitation
Pillar	8	5	40	Good	Routine and periodic maintenance
Deck	8	5	40	Good	Routine and periodic maintenance
Bridge's Stand	6	5	30	Good	Routine and periodic maintenance

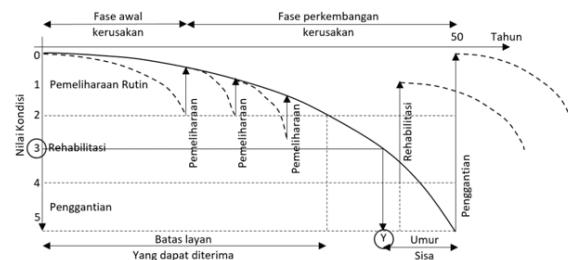


Figure 6 Graph of Remaining Life of Idano Mezawa Bridge based on Condition Value

Based on the equation according to the Dirjen Bina Marga: ISBN 978-602-97229-3-2 [8], the calculation of the remaining life of the bridge is as follows:

$$5 - 3 = \left\{ \frac{100 - \frac{Y}{50\%}}{4,66} \right\}^{0,525}$$

$$2 \times 4,66^{0,525} = \left\{ 100 - \frac{Y}{50\%} \right\}^{0,525}$$

$$\sqrt[0,525]{4,486} = \left\{ 100 - \frac{Y}{50\%} \right\}$$

$$17,444 = \left\{ 100 - \frac{Y}{50\%} \right\}$$

$$100 - 17,444 = \left\{ \frac{Y}{50\%} \right\}$$

$$82,556 = \left\{ \frac{Y}{50\%} \right\}$$

$$Y = 41,278 \text{ years}$$

The remaining life of the bridge is calculated based on the inspection if the damage continues can be calculated by reducing the service life of the bridge, which is 50 years with the calculation results the remaining life of the bridge has a condition value of 3 which is 41.278 years. Thus, the remaining life of the Idano Mezawa Bridge is 8.722 years.

Meanwhile, based on the BCR method, the inspection of each bridge element can be calculated as presented in Table 5.

Component	Bobot	CR	Bobot x CR	Condition	Recommendation
Bearing	6	5	30	Good	Routine and periodic maintenance
Wing Wall	5	5	25	Good	Routine and periodic maintenance
Back Wall	5	5	25	Good	Routine and periodic maintenance
Secondary Girder	5	5	25	Good	Routine and periodic maintenance
Joint	4	4	16	Fair	Rehabilitation
Wearing Surface	4	4	16	Fair	Rehabilitation
Trotoar	2	5	10	Good	Routine and periodic maintenance
Curb	1	5	5	Good	Routine and periodic maintenance
Total				72	
Total x CR				326	
Bridge Condition Rating				4.5	
Condition				Fair	
Recommendation				Rehabilitation	

The age of the Idano Mezawa bridge based on the BCR method, the value of age equivalent, is 32.089 years. The design life of this bridge is 50 years, so the remaining service life is 17.910 years.

4. CONCLUSION

The results of the analysis of the condition of the bridge damage using the method *Bridge Management System* (BMS) show that the Idano Mezawa Bridge may have suffered severe damage within the last 12 months and requires special attention to be rehabilitated immediately. This is indicated by the value of the condition which is worth 3 (damaged). The remaining life of the Idano Mezawa Bridge after the calculation is 8.722 years.

Based on the method *Bridge Condition Rating* (BCR), the Idano Mezawa Bridge has a CR value of 4.5 which is included in the moderate category (*fair*) with proposed maintenance in the form of rehabilitation of the bridge elements. With a design life of 50 years, this bridge has a remaining life of 17.910 years.

The calculation and inspection of the bridge using two methods (BMS and BCR) resulted in a deviation of 9.188 years. This difference exists because, in the BMS method, bridge assessment is based on the subject conducting a visual investigation in the field, while in the BCR method there is a separate weighting item for each bridge component.

The solutions for handling damage to the Idano Mezawa Bridge that can be done include patching or coating new asphalt, repairing cracked/porous concrete, removing rust/corrosion on reinforcement and main

steel frame, *chipping and patching* to overcome weathering, filling holes in abutments, cleaning garbage and weeds on riverbanks, and removing weeds that grow around the structural environment.

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