The Comparison of Condition Evaluation of Siak II Steel Frame Bridge between the FCM Method and the Bridge Management System

Widya Apriani and Shanti Wahyuni Megasari

1Dept. of Civil Engineering. Universitas Lancang Kuning, Pekanbaru. 28265. Indonesia
Email: widyaapriani@unilak.ac.id,
2Dept. of Civil Engineering. Universitas Lancang Kuning, Pekanbaru. 28265. Indonesia
Email: shanti@unilak.ac.id

Abstract: An accurate bridge condition evaluation system is the main factor of a bridge maintenance management. The Government of Indonesia has a bridge evaluation guide based on Australian rules namely the Bridge Management System. In this method, a visual field check is performed to determine the value of the bridge condition and then analyzed by using the bridge management information system program (sim-ibms) through a technical screening process. By using this method, it can be determined several actions are needed to be reported that the bridge is safe or damaged. But this method has been used for 25 years by Indonesia. Nowadays, research and methods are developed to evaluate the condition of bridges, such as the Fracture Critical Member (FCM) method. This method can directly measure displacement through computer programs based on the traffic volume. The evaluation conducted in two ways such are numerical methods with computer programs and visual bridge surveys. Numerical analysis is performed to estimate the critical elements of the bridge which will then evaluated visually. This research aims to compare the condition evaluation of steel frame bridge of Siak II regarding the level of damage and bridge repairing period to obtain appropriate maintenance.

Keywords: Steel Frame Bridge, Bridge Management System, Bridge Evaluation.

1. Introduction

Siak II Bridge is a national bridge built in 1990. The type of this bridge is an Australian-RBA steel frame bridge that has a length of 1.83 km, a width of 7 meters and a type of bridge girder is reinforced concrete with two traffic lanes [1]. This bridge is the only national access that connects Pekanbaru city and other cities in Sumatra. Based on LHR data obtained from Bina Marga [2] it is known that the average vehicle volume that passed every day was 8052 vehicles in 2015. This value increased by 1.16% from the previous year. An accurate bridge condition assessment system greatly determines the maintenance management of the bridge. There are several methods developed to assess bridge conditions such as the BMS (Bridge Management System) method. This method can be used to maintain the condition of the bridge through a periodic investigation process so that it can determine the steps of maintenance and repair. The method can assess the condition of the bridge through a visual survey method with digital cameras, binoculars, flashlights for the type of physical damage both material and structural on the bridge [3].
This research focused on assessing the condition of Siak II bridge in Riau which indicated a damaged condition using the Bridge Management System Standard (SMJ). The process included the collection of bridge physical data then analyzed by a computer in the Bridge Management Information System. The aim of this research was to make appropriate repairs or maintenance the bridge.

According to the Bridge Management System [4], the step of using this management system consists of taking data in the bridged field and then enters it into the system. Both systems rank bridges and prepare bridge handling plans based on the priority scale. The inspection phase of the bridge element is divided based on its level. According to BMS, there are five levels that each have an element code. The use of the code is needed to process the data. The research of the FCM method was carried out by Michael J. Parr [5] where his research was conducted on the bridges of the United States. There was scoring to determine the next inspection time. The points proposed were based on bridge structure failures that had occurred in the United States. FHWA, 2012 defines that a Fracture Critical Member (FCM) [6] is a component of a steel bridge with tensile stresses or components that have a tensile part, in which failure of the rod will cause a partial or total collapse of the bridge. Based on the condition survey, the data obtained including load data [7] is used to calculate the bridge age based on material fatigue analysis. In the data analysis phase, the target rod/component collapses is called the target structure [5].

2. Method

This research was conducted by taking secondary data obtained from the Ministry of Public Works and Public Housing Indonesia, among others: bridge administration data, road, and geometric trajectory, landscape data, and major components, traffic volume data reports. Next, an analysis was carried out with the bridge management information system program (sim-ibms). Based on the bridge conditions obtained from the BMS programming results then analyzed the actions needed to be reported about the bridge condition. The evaluation was done by using the FCM method. The next step was conducting a condition survey using the BMS 1993 method and the proposed FCM assessment method. A material fatigue analysis was carried out to predict the age of the bridge and the possible time for fatigue cracks to occur. The next inspection was determined based on condition assessment and material fatigue analysis. If the damaged or deficient were found, the concept of repair would be proposed. After that, a comparison was made with all steps and methods.

Picture 1. Below showing the damage of changes forms in the upper part of the structure namely the Wind Bond Profile caused by the collision.

Picture 1. A layer over the bridge floor was porous
3. Result and Discussion

The results of the comparison of the two methods used are as follows:

3.1. Preparation Step

The FCM method performed the numerical analysis to obtain the target structure. The structural target was bridge elements that caused the collapse of the bridge structure if the part was weakened. This step was a condition for determining the screening step. After analysis [8], it was obtained potential elements for collapse (target structure) in the upper trunk and diagonal bridge trunk. The results of the upper trunk and diagonal trunk were 180-185, 2155-216, 251, and 252 which the largest stress ratio was 2.7 of 183 trunks. In the BMS method, the preparation step included secondary data retrieval in the field about types of physical damage both material and structural of the bridge. Bridge administration data, types of road and geometric trajectories, span data and main components, the report of traffic volume data.

3.2. Screening Stage

After conducting numerical analysis in the previous stage to find out the elements classified as FCM, then the screening phase was carried out on 8 criteria. It included FCM trunk conditions in rehabilitation / retrofit period, bridge pin / anger conditions, bridge redundancy, bridge hole welds, active fatigue cracks on FCM trunks, vulnerability to fractures, maintenance remnants, and NBI bridge values all scoring results then assessed as maximum was 40. After the screening process of 8 criteria, it was obtained a score of 15 which meant that the bridge needed to be assessed between 6 to 24 months. If the score did not fulfill at this screening step, a maximum re-assessment carried out after 24 months [5].

In the BMS method, the screening phase was ranked to determine the proposed handling scale. There were 8 screening criteria used consisting of the condition of bridge structure damage, traffic density condition, and bridge load. The criteria had a range of 0-5 with a maximum number of 15. The value of 0-2 meant that the condition was good until it was lightly damaged and it needed to be handled regularly. The 3 value meant the condition of the structure was severely damaged and needed to be carried out Rehabilitation. Values 4 and 5 meant the condition of the bridge was critical or collapsed and needed replacement. The result of BMS method for Siak II bridge was valued 3 which meant that the condition of the bridge was severely damaged and needed rehabilitation.

3.3. Assessment Step

This step was carried out by assessing the bridge towards 12 criteria including bridge design used, number of vehicles passing by (AADT), rules for heavy vehicles, type of FCM classified as Hgh Performance Steel or not, Corrosion conditions, Redundancy on FCM rods < Age of Plan, Category Fatic type whether there was a weld or not, and an assessment from a team of experts. It was done to determine the period for the next assessment.

From the results of the FCM method assessment towards the condition of the bridge and its components of Siak II bridge in Riau Province, the value of the assessment step was 78; it meant that the period of subsequent inspection was conducted within 6 months. Whereas regarding the results of the BMS method, the assessment phase was to determine the handling of the bridge based on the results of the screening done. The results of the analysis showed that the Siak II bridge needed rehabilitation for the period within 6 months.

4. Conclusions

This study revealed from the analysis showing that after conducting the comparison in determining the period of subsequent inspection, the FCM method is more detail in an analysis. While in the BMS method, the evaluation is carried out more concisely limited to the results of field observations. Moreover, After conducting the comparison in determining the damage condition of the actual bridge structure, the FCM method uses numerical analysis and visual observation in the field. While the BMS method is based on field observations. In the FCM, there are 3 steps that are covered including the preparation, screening and assessment steps. By using this method, the damage of Siak II bridge is found in several parts; such are the upper, diagonal, connection and bridge floor decks that must be repaired.
5. Acknowledgment

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