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Evaluation of Bridge Condition Values Using the *Bridge Management System (BMS) Method* (Case Study: Three Bridge Units in Majalengka Regency)

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ABSTRACT

The bridge is an infrastructure whose existence is an important part of the transportation system and economic movement of a region. If the bridge is damaged or collapses, it will affect the transportation and development of the distribution of people and goods. Thus, maintenance of the bridge is a must. The Bridge Management System (BMS) method is a standard mechanism for evaluating the condition and function of bridges. The BMS can also be used to decide on the maintenance needed to maintain a bridge under certain circumstances. The assessment was carried out in the form of a visual assessment of the bridge to evaluate the general condition of the bridge. This research was conducted at three bridges in Majalengka Regency, namely the Citeureup Bridge, the Cideres Bridge, and the Talang Bridge. Evaluation is carried out by conducting inventory surveys and detailed inspections of objects (bridge damage elements). Then each element is given a point weight of 1 and 0 according to its damage level from the lowest (level 5) to the highest (level 1), which means the bridge completely collapsed. Elements or groups of elements are given a weight from 0 to 5 where 5 represents the total score of 5 categories. The categories are Structure (S), Damage Level (R), Damage Volume (K), Element Function (F), and Damage Effect (P). Condition studies, technical screening, and evaluation of handling for the Citeureup Bridge, Cideres Bridge, and Talang Bridge each resulted in the following conditions: 3 (Heavy Damage – Rehabilitation), 2 (Slightly Damaged – Routine Maintenance), and 2 (Slightly Damaged – Maintenance) Routine).

1. Introduction

The bridge is an infrastructure that functions to continue the road from lower obstacles, such as waterways (rivers and drainage channels) or ordinary traffic roads. The existence of a bridge as a link is an important part of the transportation system and economic movement of a region. Bridge failure is one of the most serious infrastructure problems facing the world today and usually causes significant loss of life and economic loss (Tan, Elbaz, Wang, Shen, & Chen, 2020), therefore the condition of bridges must always be maintained in good condition.

In Indonesia, more than 50% of bridges are in a state of light damage to collapse (Setiati, 2019). Every year for the last eight years in Indonesia, there have been one to two major bridge collapses, even though these bridges include fairly recently built structures, newly installed facilities, and old bridges (Oktavianus, Sofi, Lumantarna, Kusuma, & Duffield, 2020). The cause of bridge damage can be obtained from several factors, such as the age of the bridge, overload, environment (corrosion), disasters (earthquakes, volcanoes, floods, landslides), and river scouring. Even so, the factor of lack of periodic inspection and maintenance is also one of the factors causing bridge collapse which is often neglected.

There are still many bridges that are in a slightly damaged condition, but maintenance or repairs are not quickly carried out, which over time causes the bridge to collapse. In West Java throughout 2021, there were 441 units out of 857 bridges that experienced mild to severe damage. From this condition, an inspection of the condition of the bridge needs to be carried out to maintain the condition of the bridge in good condition and ensure that the reduced condition of the bridge can be returned to a stable condition according to its performance (Harywijaya, Afifuddin, & Isya, 2020), to reduce the possibility of a bridge collapse.

Likewise in Majalengka Regency, several bridges were built in the 1990s, and evaluation and inspections need to be carried out so that they can function optimally. Bridges play an important role as a complement to road infrastructure, as well as being the backbone of infrastructure that connects one region to another (Panji, Ilyas, & Bahsan, 2018). This is done to maintain transportation stability and economic growth in the Majalengka region. This study tries to evaluate the condition of bridges on several bridges in the Majalengka Regency using the Bridge Management System (BMS) method through the process of collecting physical data and the condition of the bridge structure. Thus, the condition of the bridge can be monitored and the necessary actions can be determined to ensure that the bridge is in a safe and comfortable condition through appropriate management strategies (maintenance, rehabilitation, strengthening, and replacement of bridges).

2. Literature Review

2.1 Bridge Classification

Bridges are designed to withstand a wide variety of loads, including off, on, environmental, and occasional loads throughout their service period (Shokravi, et al., 2020). Therefore, bridges have a variety of classifications and forms of construction. This classification division is important because it can guide engineers in determining what method should be applied to a particular bridge. Based on the form of construction, almost bridges around the world can be classified into four basic categories: girder bridges, arch bridges, cable bridges, and suspension bridges (Tang, 2018). Where these bridges have a historical development that is almost as old as human civilization itself, especially in terms of materials and construction materials.

Of course, the bridge which was originally only made of felled trees then turned into an arrangement of wood and stones piled up and locked together. However, stone and wood bridge structures have very short spans and are unable to withstand high tensile and compressive stresses due to bending and axial forces. However, after the presence of iron, concrete, and steel materials, the construction of the bridge underwent a major evolution in its shape and structure. This proves that the availability of certain materials or materials affects the choice of shape on the bridge (Tang, 2018). Thus, we can classify bridges based on the materials they are made of, such as wooden bridges, masonry bridges, precast and prestressed concrete bridges, steel bridges, and composite bridges. However, it is possible that in the future many new materials such as carbon fiber and nanomaterials can be used in the development of new bridge forms.

In addition, the development of the shape of the bridge can be made by knowing the basic structural elements contained in the bridge. If you look at the four basic forms of the bridge (girder bridge, arch bridge, cable bridge, and suspension bridge) it looks different from one another, but each has three basic structural elements: axial, bending, and curved elements (Tang, 2018). By combining or modifying these three types of basic structural elements, it is possible to create different forms of bridge structures.

Therefore, with various developments and the latest technology, the classification of bridges is not only limited to their shape and materials. Several other bridge classifications are seen based on the function of the bridge, the strength of the bridge structure, and how the floors are placed on the bridge.

2.2 Bridge Management System (BMS)

Generally, every building construction around the world has its management system, be it buildings, tunnels, dams, ports, roads, or bridges. However, most systems can only be used within one country (Saback de Freitas Bello, Popescu, Blanksvärd, & Täljsten, 2021). This is most likely due to differences in construction and regulations in each country. These differences arise because there are differences in geographical conditions and the needs of each country. But even so, the scope of management, in general, remains the same, namely consisting of inspection, monitoring, and assessment of conditions and rehabilitation.

In Indonesia, the bridge management system is regulated and used by the Directorate General of Highways which functions as a bridge activity planner, implementation, and monitoring using the *Bridge Management System method.* (Harywijaya, Afifuddin, & Isya, 2020). Not much different, this management system has the same main goal, namely bridge maintenance by identifying/examining existing deficiencies. At the inspection stage, the bridge elements are divided into 5 levels, each of which has an element code consisting of a material damage code and the element itself (Apriani, Megasari, & Putri Loka, 2018). Using this code is necessary to be able to process data and enter it into *a database* that can be monitored continuously. In addition, these codes function as validity and reliability on the bridge inspection data carried out.

This inspection phase is also divided into four types of inspection, namely inventory inspection, detailed inspection, routine inspection, and special inspection (Rahmadona, Amalia, & Marpen, 2021). However, in carrying out a bridge condition survey, it is enough to carry out an inventory check and a detailed inspection of each type of bridge (Manaha, Nainggolan, & Aditama, 2022). Inventory inspection is usually devoted to inventorying new bridges (Rustawa, 2021), which aims to find out basic administrative data and geometry on bridges, while detailed inspections aim to accurately assess the condition of elements on bridges based on the type of damage. The results of the inspection are then examined and analyzed to check whether the condition is still safe or not for use. Bridge conditions that are not safe to use will then be handled according to the severity of the damage condition.

2.3 Bridge Element Condition Value

The bridge condition value is needed to determine the condition of the elements on the bridge in good or bad condition. This assessment is also one of the bridge maintenance efforts in maintaining the age of the bridge and preventing ongoing damage to the bridge structure (Apriani, Megasari, & Putri Loka, 2018). The bridge element condition assessment system is given after elements known to be damaged have been recorded. The value given is by the existing damage to the bridge elements based on the damage assessment parameters, namely: structural results (S), damage (R), quantity (K), function (F), and influence on the bridge (P), which accumulates from the level from the lowest level, namely level 5 to the highest level, namely level 1. The value of these conditions is determined according to the criteria given in Table 2.1 below :

Table 2.1 Condition Values of Bridge Elements

Mark	Criteria	Condition Value
Structure (S)	Dangerous	1
	Not harmful	0

Damage (R)	Critical	1
	Not Bad	0
Quantity(K)	>50%	1
	<50%	0
Function (F)	Does not work	1
	Still works	0
Influence (F)	Affects other elements	1
	Does not affect other elements	0
Condition Value (NK)	(NK = S + R + K + F + P)	0 – 5

Source: Directorate General of Highways Ministry of PUPR [1993]

The data on the condition values of the known bridge elements need to be handled to repair the bridge by *screening*. *Screening* is screening from a database of bridges that require treatment due to lack of traffic capacity, lack of strength, or poor condition (Marshando & Sumargo, 2020). Technical *screening* criteria can be specified in Table 2.2 below :

Table 2.2 Technical Screening Criteria

Parameter	Score	Category	Indicative Treatment
Condition	0 – 2	Good – Light Damage	Routine Maintenance
	3	Heavy damage	Rehabilitation
	4 – 5	Critical – Crash	replacement
Traffic	0	Wide Enough	Routine Care
	5	Too narrow	Duplication, Widening
Burden	0	Strong	Routine Care
	5	Does Not Meet Standards	Strengthening, Replacement

Source: Directorate General of Highways Ministry of PUPR [1993]

3. Method

This research was conducted on several truss bridges located in the Majalengka Regency, West Java, Indonesia using primary data and secondary data. Primary data is data obtained directly in the field through a bridge inspection survey to visually determine the condition of the bridge. Secondary data is data obtained from related agencies such as the Public Works and Spatial Planning Office (PUTR) of the Majalengka Regency or the Indonesian Ministry of Public Works and Public Housing (PUPR). The research locations are in three (3) bridge units, namely the Citeureup Bridge, the Cideres Bridge, and the Talang Bridge which can be seen in Figure 2.

Figure 1 Index Map of West Java

The inspection carried out on each bridge is an inventory check and a detailed inspection of the bridge. Inventory checking, namely carrying out activities by recording basic administrative data, geometry, materials, and other additional data on each bridge, including the location of the bridge, span length, and main structure type for each span. While a detailed inspection is an inspection to accurately assess the condition of a bridge. All bridge components and elements must be inspected and significant damage identified and then recorded (Manaha, Nainggolan, & Aditama, 2022). After obtaining these data, the advantages and disadvantages of each existing standard will be known, so that they can be used as references and references for improvement (Wahyudi, Satyarno, Suparma, & Mulyono, 2021). The assessment of the condition of the bridge is based on the analysis of the 1993 *Bridge Management System*, which can then be determined for the handling of repairs to be carried out on the condition of the bridge.

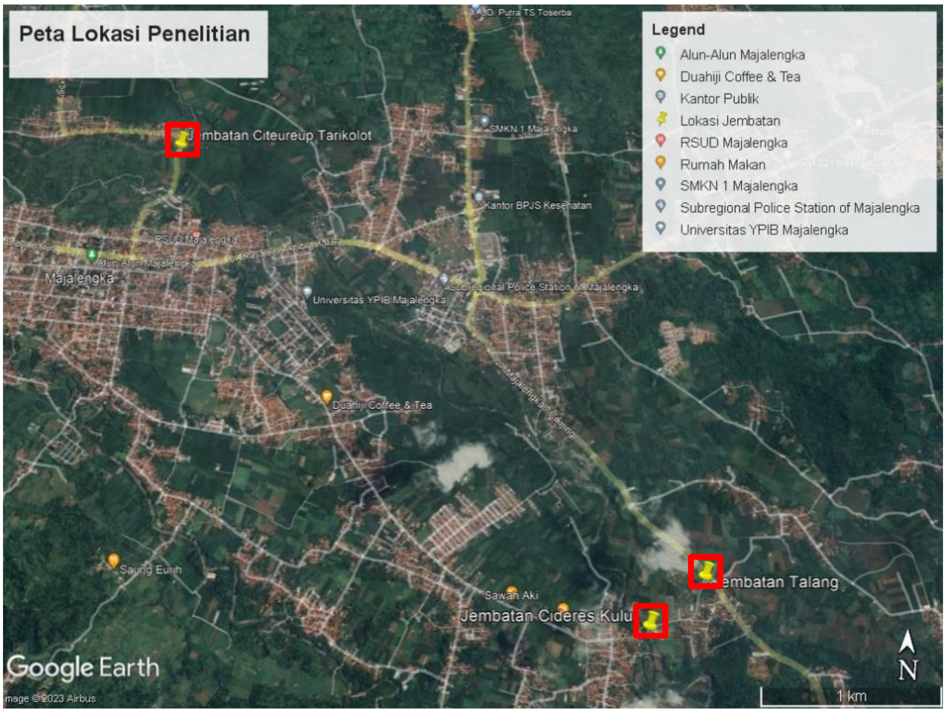

Figure 2 Map of Bridge Research Locations

4. Result and Discussion

4.1 Research Results

Existing condition values varied on the Citeureup Bridge, Cideres Bridge, and Talang Bridge. The condition of the Citeureup Bridge that has been observed shows quite worrying damage conditions, including porous concrete, accumulation of garbage in the river flow, expansion damage, and so on. The damage condition assessment is then seen in the form of Table 1 below :

Table 1 List of Damage to Citeureup Bridge Elements

No. _	Element Name	Damage			Photo	Handling Recommendations	Condition Value (NK)
		Code	Type	Reason			
1	River flow	502	Debris accumulation	Garbage Pile		Rehabilitation / Cleaning of accumulating debris	3
2	Bridge Head	201	Porous Concrete	Overload		Performed Patching (*Patching*)	4
		205	Cracked Concrete	Aging / Decreasing Quality of Concrete		Performed Patching (*Patching*)	4
		551	Deformation	Go down/ *Settle*		Structural Element Rehabilitation	3
3	Steel frame	302	Rust on the gusset plate bolts	Humid Weather (Due to Corrosion)		Cleaning of rust and repainting of rusted parts.	2
4	Floor Surface Coating	722	perforated	Traffic Services and Overload		The need for *overlay* on the asphalt pavement of the bridge	3
5	Sidewalks and Kerb	201	Lost Concrete	clash		Patching _ _	2
6	Broadcast Expansion / Connection	803	Missing Connection Steel Plate	Past service cross and		Replacement of Type Expansion Connection	4

		806	Asphalt Crack	broadcast quality expand that decrease		Asphalt Type Expansion Joints and *Overlays*	3
7	Traffic Device	911	Unclear Writing	Dirty and Mossy		Handling light/simple	1
8	Safety Device	912	Missing Horizontal Backrest	Backrest horizontally on the bridge missing/no There is.		Reinstallation of the lost backrest	1

Source: Author Survey Data

Significant damage that occurred on the Cideres Bridge was part of the surface pavement on the bridge in the form of cracks and holes in the asphalt. This can be seen by a large number of trapped puddles, even though the drainage system/disposal pipe on the bridge floor is still functioning properly. The condition value of the Cideres Bridge can be seen in the following Table 2 :

Table 2 List of Damaged Elements of the Cideres Bridge

No.	**Element Name**	**Damage**			**Photo**	**Handling Recommendations**	**Condition Value (NK)**
		Code	**Type**	**Reason**			
1	River flow	501	precipitate	River Flow		Handling light/simple	1
		502	Flow Barriers	Garbage Pile		Cleaning the river body from piles of garbage	1
2	Bridge Head	201	Loose / Porous Concrete	Carbonation / Decreased Quality of Concrete		Patching (*Patching*)-	2
		204	Seepage	Aging / Decreasing Quality of Concrete		Protective painting on concrete structural elements.	2

3	Steel frame	302	Rust on the gusset plate bolts	Humid Weather (Due to Corrosion)		Cleaning of rust and repainting of rusted parts.	2
4	Floor Surface Coating	722	perforated	Traffic Services and Overload		The need for *overlay* on the asphalt pavement of the bridge	3
		723	Wavy	Traffic Services and Overload		The need for *overlay* on the asphalt pavement of the bridge	2
5	Sidewalks and Kerb	201	Lost Concrete	Carbonation / Impact		Patching _ _	2
6	Broadcast Expansion / Connection	806	Asphalt Crack	Traffic Service and Broadcast Quality Expand to Decline		Asphalt Type Expansion Joints and *Overlays*	2
7	Loning Structure	103	Broken and Missing Parts	Collision, Eroded		Patching _ _	2
8	Railing iron	308	Loose Connection	Rust and Corrosion		Cleaning of rust and repainting of rusted parts.	3
9	Bridge Marker	911	Inscriptions are not clear	Dirty and Mossy		Easy/simple handling and cleaning	1

Source: Author Survey Data

Talang Bridge is the last bridge whose condition value is observed. The condition value of the Talang Bridge can be seen in the following Table 3 :

Table 3 List of Gutter Bridge Element Damage

No. –	Element Name	Damage			Photo	Handling Recommendations	Condition Value (NK)
		Code	Type	Reason			
1	River flow	501	precipitate	River Flow		Cleaning the river body from piles of stones.	2
2	jangle	201	Fall out	Carbonation		Patching _ _	2
		204	Dirty and Mossy	Aging and chemistry		Protective painting on concrete structural elements	2
3	Floor Surface Coating	722	Perforated /Cracked	Traffic Services and Overload		The need for *overlay* on the asphalt pavement of the bridge	2
4	Broadcast Expansion / Connection	806	Asphalt Crack	Traffic Service and Broadcast Quality Expand to Decline		Asphalt Type Expansion Joints and *Overlays*	2
5	Loning Structure	101	Cracked	Moving and Wild Plants		Demolition of old masonry and rebuilding	3
		205	Broken / Missing Parts	Collision, Eroded		Patching _ _	2
6	Sidewalks and Kerb	202	Cracked	Overload or Insufficient Capacity		Demolition of old concrete using *grouting* and *concrete jacketing*	3

Source: Author Survey Data

Data on the condition values of the three (3) bridges are then summarized in Table 4 for an overall bridge condition assessment by finding the average condition value of each bridge so that the damage category can be determined and the proposed treatment according to the damage category.

Table 4 Recapitulation of Condition Values at Three Bridges

No. _	Name Bridge	Location	Long (m)	Wide (m)	Upper Building Type	Year	NK All	Category	Handling
1	Citeureup	Taricolot	43	4,5	RBA	1992	3	Heavy damage	Rehabilitation
2	Cideres	Kulur	52	5	RBA	2012	2	Minor Damage	Routine Maintenance
3	Gutters	Kulur	18	6	GTI	2017	2	Minor Damage	Routine Maintenance

Source: Author Survey Data

4.2 Discussion

From the results of the assessment of the condition of the bridge and its components for the three (3) bridges above, the condition values of each bridge were obtained. First, on the Citeureup bridge, damage was found to the elements of the river flow, bridge abutments/heads, steel frames, floor coatings, sidewalks/curbs, joints/expansion joints, and traffic and safety devices. These damages are identified by a damage code, including 502 (Pile of Debris), 201 (Porous Concrete), 205 (Broken Concrete), 551 (Deformation of Abutments), 302 (Rust on Steel), 722 (Perforated Asphalt), 803 (Loose Concrete), 806 (Cracked Asphalt), 911 (Unclear Inscription), and 912 (Missing Horizontal Support). Then, the results of the overall condition value on the Citeureup Bridge obtained a condition value of 3 which means the condition of the bridge was heavily damaged. Thus, the proposed treatment is in the form of rehabilitation.

Second, on the Cideres bridge, damage was found to the elements of the river flow, bridge abutments/heads, steel framing, floor coatings, sidewalks/curbs, joints/expansions, loning structures, iron railings, and bridge markers. These damages are identified by damage codes including 501 (Sediment), 502 (Heaps of Debris), 201 (Porous Concrete), 204 (Seeping on Concrete), 302 (Rust on Steel), 722 (Perforated Asphalt), 723 (Wavy Asphalt), 806 (Cracked Asphalt), 103 (Pair of Broken Stone), 308 (Loose Joint), and 911 (Unclear Inscription). Then, the results of the overall condition value on the Cideres Bridge obtained a condition value of 2, which means the condition of the bridge was slightly damaged. Thus, the proposed treatment is in the form of routine maintenance.

Finally, on the Talang bridge, damage was found to the elements of the river flow, girders, floor layers, sidewalks/curbs, joints/expansion joints, and loning structures. These damages are identified by damage codes including 501 (Sediment), 201 (Lolled Concrete), 204 (Mossy Concrete), 722 (Perforated Asphalt), 806 (Cracked Asphalt), 101 (Cracked Stone Pair), 205 (Concrete broken), and 202 (cracked concrete). Then, the results of the overall condition value on the Cideres Bridge obtained a condition value of 2, which means the condition of the bridge was slightly damaged. Thus, the proposed treatment is in the form of routine maintenance.

5. Conclusion

With the BMS (*Bridge Management System)* bridge condition assessment application, recommendations for handling can be determined and orders based on a priority scale can be determined. The element damage that occurs on the three bridges tends to be the same between one another, there are only a few differences that are not too striking. The damage that generally occurs is the occurrence of deposits or accumulation of debris in the river flow, rust on the steel frame, loss and porous of the concrete elements, and holes and cracks in the asphalt surface layer. It is known that there are damages on the Citeureup bridge with damage codes including (502), (201), (205), (551), (302), (722), (803), (806), (911), and (912) with an overall condition score (NK), namely three (3) and a proposed treatment in the form of rehabilitation. On the Cideres bridge, the damage is known with damage codes including (501), (502), (201), (204), (302), (722), (723), (806), (308), (911), and (103) with an overall condition (NK) value of two (2) and the proposed handling is in the form of routine maintenance. Meanwhile, on the Talang bridge, the damage is known with damage codes including (501), (201), (204), (722), (806), (202), and (205) with a total condition value (NK) of two (2) as well as proposed handling in the form of routine maintenance.

Bibliography

Apriani, W., Megasari, SW, & Putri Loka, WA (2018). Assessment of the condition of steel frame bridges in Riau using the bridge management system method. Civil Engineering Study Program, 4(2), 103-106.

Harywijaya, W., Afifuddin, M., & Isya, M. (2020). Bridge condition assessment uses the bridge management system (BMS) and bridge condition rating (BCR). Journal of Civil Engineering and Planning Archives, 3(1), 80-88.

Manaha, YP, Nainggolan, TH, & Aditama, V. (2022). ANALYSIS OF BRIDGE CONDITIONS DATABASE INFORMATION SYSTEM USING THE BRIDGE MANAGEMENT SYSTEM METHOD. SEMSINA Proceedings, 3(1), 165-172.

Marshando, P., & Sumargo, S. (2020). CONDITION ASSESSMENT, HANDLING SOLUTIONS, AND PREDICTION OF THE REMAINING LIFE OF THE WAY KENDAWAI I BANDAR LAMPUNG BRIDGE USING THE BRIDGE MANAGEMENT SYSTEM (BMS). Journal of Civil Engineering, 16(1), 39-49.

Oktavianus, Y., Sofi, M., Lumantarna, E., Kusuma, G., & Duffield, C. (2020). Long-term performance of trestle bridges: A case study of an Indonesian marine port structure. Journal of Marine Science and Engineering, 8(5), 358.

Panji, PS, Ilyas, T., & Bahsan, E. (2018). Assessment of Bridge Substructure in Java Island. In MATEC Web of Conferences, Vol. 147, p. 07005.

Rahmadona, E., Amalia, KR, & Marpen, R. (2021). BRIDGE MANAGEMENT SYSTEM TRAINING FOR BRIDGE CONDITION ASSESSMENT. SNAPTEKMAS, 3(1), -.

Rustawa, NW (2021). CONDITION ASSESSMENT AND PREDICTION OF REMAINING LIFE BASED ON THE BRIDGE MANAGEMENT SYSTEM 1993 (CASE STUDY OF ATINGGOLA BRIDGE, GORONTALO PROVINCE). Journal of Theoretical and Applied Civil Engineering, 9(1), 1-12.

Saback de Freitas Bello, V., Popescu, C., Blanksvärd, T., & Täljsten, B. (2021, Sept. 22). Bridge Management Systems: Overview and framework for smart management. ABSE Congress 2021: Structural Engineering for Future Societal Needs, (pp. pp. 1014-1022). Ghent, Belgium: International Association for Bridge and Structural Engineering (IABSE).

Setiati, NR (2019, February). The study of mitigation potential hazards of scouring the substructure of Cipamingkis Bridge. IOP Conference Series: Earth and Environmental Science, Vol. 235 No. 1, p. 012082.

Shokravi, H., Shokravi, H., Bakhary, N., Heidarrezaei, M., Rahimian Koloor, SS, & Petrů, M. (2020). Vehicle-assisted techniques for health monitoring of bridges. Sensors, 20(12), 3460.

Tan, JS, Elbaz, K., Wang, ZF, Shen, JS, & Chen, J. (2020). Lessons learned from bridge collapse: A view of sustainable management. Sustainability, 12(3), 1205.

Tang, MC (2018). Forms and aesthetics of bridges. Engineering, 4(2), 267-276.

Wahyudi, A., Satyarno, I., Suparma, LB, & Mulyono, AT (2021). Quality Assurance and Quality Control of Bridge Inspection with the Invi-J Application. Journal of Transportation, 21(2), 81-92.