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Research paper

Performance Evaluation of Wirerope Structures on Klepu Mulya Jelita Pedestrian Suspension Bridges, Cilacap

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ABSTRACT

Purpose: This study aims to review the performance of the cable structure of the pedestrian suspension bridge, namely the Klepu Mulya Jelita suspension bridge, including the cable tension value, deformation, and wire rope cable density factor referring to the Surat Edaran Menteri Pekerjaan Umum No. 02/SE/M/2010 concerning Guidelines for Planning and Implementation of Suspension Bridge Construction for Pedestrians.
Methods/Design: Adopting a quantitative method with a case study approach conducted on the Klepu Mulya Jelita suspension bridge located in Cilacap, Central Java with validation of manual calculation results and SAP 2000 analysis. The data analyzed in this research study are the properties of wire rope cables on the geometry of a class 1 pedestrian suspension bridge with a span of 80 meters through a review of the performance of wire rope cables including cable tension values, deformation, and wire rope cable density factors referring to Surat Edaran Menteri Pekerjaan Umum No. 02/SE/M/2010.
Findings: The results of manual calculations and SAP 2000 analysis show a difference in the main span cable tension value of 1.95%, a difference in the backstay span cable tension value of 1.5%, and a difference in the cable deformation value of 2.37%. The density factor of a wire rope cable greatly influences the results of the reviewed analysis. The final results of the indicators in the reviewed case study show that the forces obtained safe and below the permitted values as referred to in Surat Edaran Menteri Pekerjaan Umum No. 02/SE/M/2010.
Practical Implication: The results of this study indicate that the cable performance on this suspension bridge is safe. with the recommendations that can be given, namely efficiency in the size of existing cables used in suspension bridges with similar characteristics while still reviewing the reliability and safety factors of suspension bridges.

INTRODUCTION

The Indonesian Ministry of Public Works launched the PU 608 Program as a key program to equitably distribute infrastructure development and improve village access to economic centers in Indonesia. The PU 608 Program aims to achieve investment efficiency with an ICOR of less than 6, reduce poverty to 0%, and drive economic growth with a target of 8% per year.

One form of implementation of the PU 608 program is the construction of basic infrastructure that is in direct contact with the community, one of which is a pedestrian suspension bridge. This research will focus on one of the suspension bridges in Central Java, namely, the Klepu Mulya Jelita Suspension Bridge located in Cilacap, Central Java. After the construction project of this bridge was completed, there was no technical evaluation of the bridge cable structure. On the other hand, the importance of technical evaluation, especially of the main cable, is to ensure the safety and reliability of the structure against real load scenarios that are not always ideal according to planning.

The absence of technical evaluations can lead to the potential for fatal structural failure in suspension bridge structures. Such functional failures can be anticipated through component evaluations(Saputra & Priyosulistyo, 2020). Several case studies have shown that structural failures have occurred due to a lack of technical evaluations of previously constructed suspension bridges.The collapse of a 120-meter pedestrian suspension bridge in Pacitan, East Java, occurred one month after construction, with the collapse occurring at a time when traffic was low (Dewobroto, 2022).A similar incident occurred with a suspension bridge in Sumedang, West Java, which collapsed while being crossed by schoolchildren (Angrainy & Windari, 2025).

The lack of information regarding technical standards for pedestrian suspension bridges also poses a challenge. This has sparked interest in evaluating the performance of suspension bridge superstructures, particularly the strength of the main cable components.

The main cable is the main element of a suspension bridge that requires attention (Neeladharan, 2017). The main cable has the characteristic of not resisting moments and is always in a state of tension when receiving loads (Supriyadi & Muntohar, 2007). The loads received by the bridge deck are transferred through the hanger rods to the main cable, so the main cable always operates in a tensioned state (Khotimah, 2020).

This study, "Performance Evaluation of Wire Rope Structures on Pedestrian Suspension Bridges (Study Case: Klepu Mulya Jelita Suspension Bridge, Cilacap)," serves as a reference and review for technical evaluations of the performance of the main cables of suspension bridges under the loads applied to the bridge, in accordance with the standards set out in Surat Edaran Menteri Pekerjaan Umum No. 02/SE/M/2010 concerning Guidelines for Planning and Implementation of Suspension Bridge Construction for Pedestrians.

METHODS/DESIGN

This study adopts a quantitative approach with an analytical descriptive approach. The performance analysis of the wire rope cable structure was carried out using Microsoft Excel software as a formula-based calculation and SAP 2000 as a model-based calculation to review stress and deformation, according to Surat Edaran Menteri Pekerjaan Umum No. 02/SE/M/2010 concerning Guidelines for Planning and Implementation of Suspension Bridge Construction for Pedestrians.

This study was conducted on the Klepu Mulya Jelita suspension bridge, located in Cilacap Regency, Central Java Province. This study represents the performance of cables along the main span and backstay of the suspension bridge. Data collection and processing were conducted from January to March 2026.

The data used in this study consists of primary and secondary data. Primary data includes field observations and technical documents on bridge construction. Meanwhile, secondary data includes the references/standards used and supporting journals.

The analysis was carried out using bridge cable tension formula calculations and numerical model computations using SAP2000.

1. Bridge Cable Tension Formula

   Analysis calculations are carried out starting from load calculations to obtaining the yield stress of the wire rope cable according to safe provisions with reference to Surat Edaran Menteri Pekerjaan Umum No. 02/SE/M/2010 concerning Guidelines for Planning and Implementation of Suspension Bridge Construction for Pedestrians.

2. SAP 2000

   The analysis calculations are carried out starting from modeling the suspension bridge, determining the cross-section properties, placing loads, creating load combinations referring to SNI 1725:2016, and ending with running a model analysis to review the results.

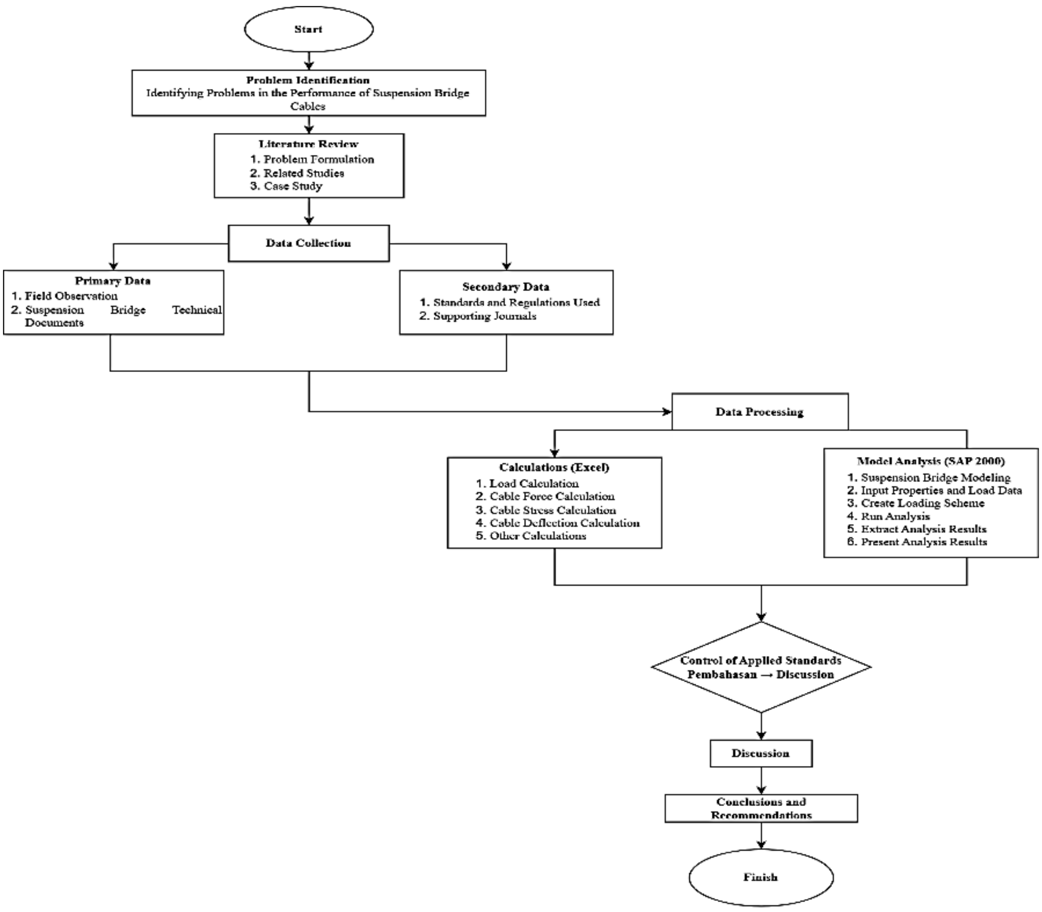


Figure 1. Flowchart of the Research Methodology

FINDINGS

Suspension Bridge Cable Tension Formula

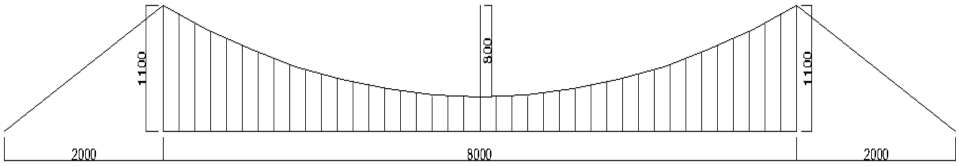


Figure 2. Sketch of the Klepu Mulya Jelita suspension bridge

The results of the calculation of the stress and deformation of the existing wire rope cable conditions that have been carried out have produced the results presented as follows:

Table 1. The results of the calculation of the suspension bridge cable tension

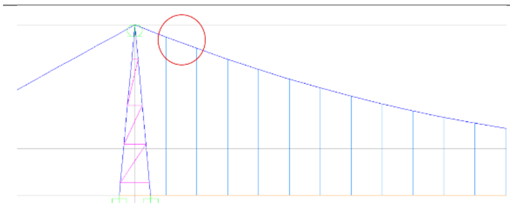
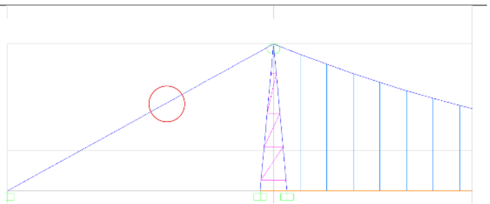
Output	Bridge Cable Tension Formula
Main Cable (kN)	741,976
Backstay Cable (kN)	795,097
Maximum/Yielding Stress (kN)	871,662
Deformation (m)	0,136

Based on the calculation results using the Suspension Bridge Cable Tension Formula, as presented in table 1, all results obtained meet the standards in the calculation of the Suspension Bridge Cable Tension Formula. This is evidenced by the main cable tension value being smaller than the backstay cable, the yield stress value being greater than the backstay cable and the deformation value still being below 1/200 L of the suspension bridge.

SAP 2000 Analysis Results

The results of the wire rope cable analysis using SAP 2000 software, the tension values of the main cable and backstay cable reviewed will be standardized in the section marked with a red circle in the tabel 2 below.

Table 2. Cable section reviewed

main cable	backstay cable
	

1. Existing cable condition diameter 53mm

   The output results of the SAP 2000 analysis of 11 loading combinations, the largest output value occurs in the KUAT 1 combination for the main cable section, rear retaining cable, and the cable deformation obtained is presented as follows:

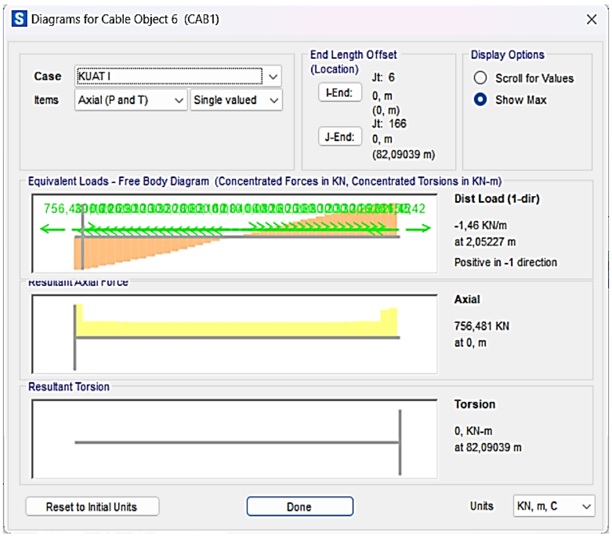


Figure 3. KUAT 1 load output (main cable) diameter 53mm

Figure 3 shows the results of the main cable performance from the combination of KUAT 1 loading with the results of a uniform working load distribution of 1,46 kN/m with a tension of 756,48 kN.

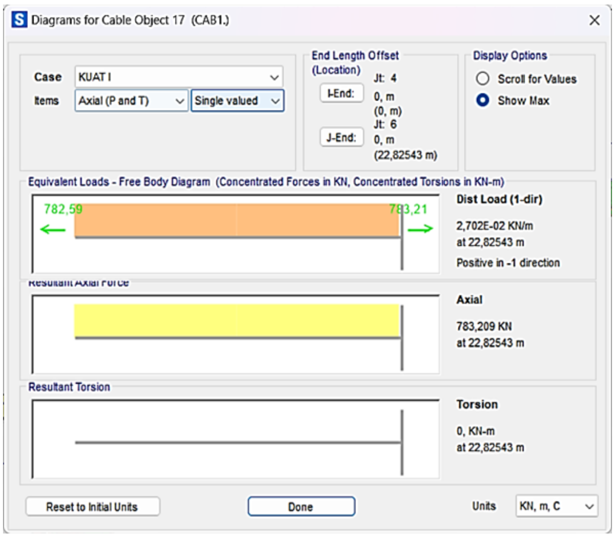


Figure 4. KUAT 1 load output (backstay cable) diameter 53mm

Figure 4 shows the results of the backstay cable performance from the combination of KUAT 1 loading with the results of a uniform working load distribution of 2,7 kN/m with a tension of 783,2 kN. The deformation output obtained in Figure 5 at half the cable span has a value of 0,139 meters.

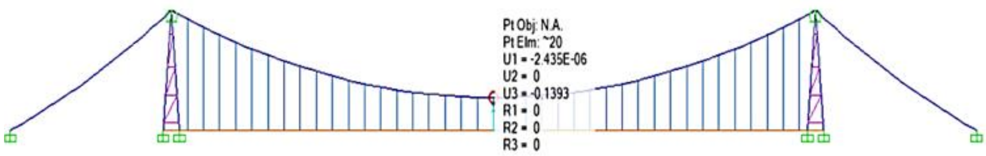


Figure 5. Output deformation KUAT 1 cable diameter 53mm

2. Condition of cable diameter 50mm

Based on the results of the SAP 2000 analysis output on the main cable and backstay cable sections, it is possible to achieve efficiency in the dimensions of the wire rope cable which was originally 53 millimeters to 50 millimeters with the largest output also being in the KUAT 1 combination with the following results:

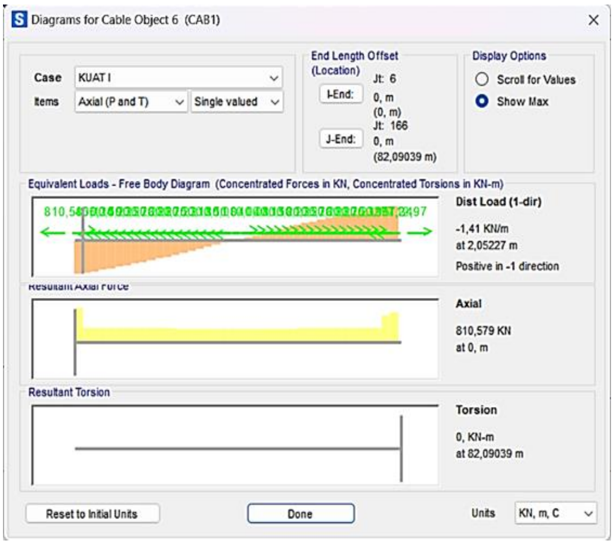


Figure 6. KUAT 1 load output (main cable) diameter 50mm

Based on Figure 6, it shows the results of the main cable performance from a combination of Strong 1 loading on a 50 mm diameter cable with a uniform load distribution of 1,41 kN/m with a tension of 810,57 kN.

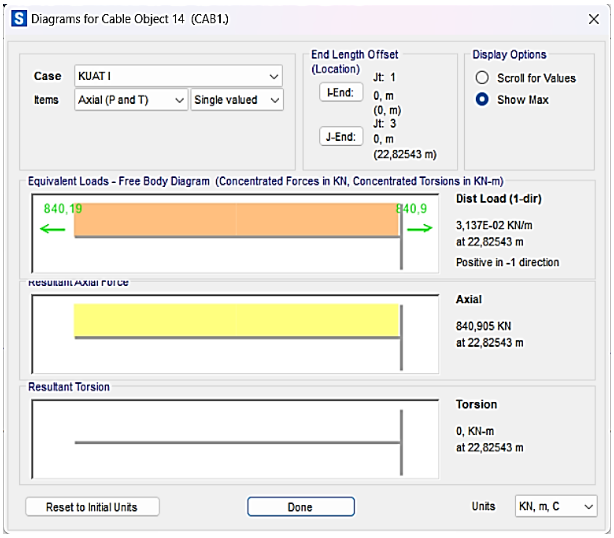


Figure 7. KUAT 1 load output (backstay cable) diameter 50mm

Based on Figure 7, it shows the results of the backstay cable performance from the KUAT 1 loading combination of 50 mm diameter cables with a uniform load distribution of 3,13 kN/m with a tension of 840,9 kN. The maximum/yielding tension value of the cable is 861,97 kN.

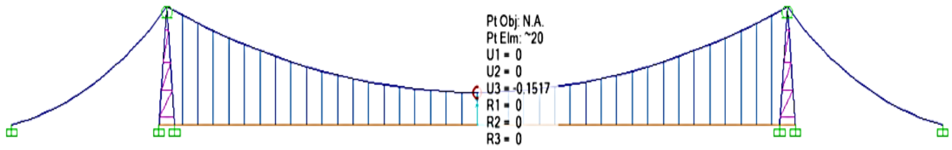


Figure 8. Output deformation KUAT 1 cable diameter 50mm

Figure 8 shows the largest deformation output from the analysis results which occurred in half the span of the suspension bridge cable by KUAT 1 loading combination of a 50 mm diameter cable with a value of 0,152 meters.

Furthermore, based on the values obtained from manual calculations and SAP 2000 analysis regarding the strength of wire rope cables (main cables and backstay cables) on existing cables with a diameter of 53 mm, including tension and repeating the results obtained as follows:

Table 3. Wire Rope Cable Tension Results 53 mm

Out	Results of the calculation	SAP 2000	% Δ	Description
Main Cable (kN)	741,976	756,481	1,95%	meets standards
Backstay Cable (kN)	795,097	783,200	1,50%	
Maximum/Yielding Stress (kN)	871,662	871,662	-	

Table 4. Deformation Results of 53 mm Wire Rope Cable

Out	Results of the calculation	SAP 2000	Permit Limit/maximum L/200	% Δ	Description
Deformation (m)	0,136	0,139	0,400	2,37%	meets standards

Based on the results presented in Table 3 and Table 4, the results of the comparison of values between the results of manual calculations and SAP 2000 analysis were obtained. The results of the difference in the values of the main cable tension obtained were 1.95%, the backstay cable tension obtained was 1.5%, and the difference in deformation values was 2.37%. Where the results obtained are still said to have a good and optimal level of accuracy in structural analysis. The tolerance for the percentage difference in values between manual analysis and software analysis generally ranges between 2% - 15% and this value is below the allowable value (Anjani et al., 2025). Then based on the results of the SAP 2000 analysis on the main cable and retaining cable sections that have been carried out, results were obtained that make it possible to make efficiencies in the dimensions of the wire rope cable which was originally 53 millimeters to 50 millimeters with the following comparative results:

Table 5. Output Comparison between 53 mm and 50 mm Wire Rope Cable Tension

Out	SAP 53mm	SAP 50 mm	% Δ	Description
Main Cable (kN)	756,481	810,57	6,67%	meets standards
Backstay Cable (kN)	783,200	840,9	6,86%	
Maximum/Yielding Stress (kN)	871,662	861,97	-	

According to Table 5, the output of the existing condition of the wire rope cable tension and dimensional efficiency are presented with the resulting values, namely that the tension of the main cable section has increased by 6.67% and the backstay cable section has increased by 6.86%. It is analyzed that the values obtained have increased but are still within the tolerance limit and the values obtained are still below the permissible yield stress value.

Table 6. Output Comparison of deformation of 53 mm and 50 mm Wire Rope Cable

Out	SAP 53mm	SAP 50mm	Permit Limit/maximum L/200	% Δ	Description
Deformation (m)	0,139	0,152	0,400	8,36%	meets standards

Based on Table 6, the results of wire rope cable deformation under existing conditions and dimensional efficiency are presented, with the results obtained for the 50 mm cable condition experiencing an increase of 8.36%. However, this value still meets and is still below the L/200 permit value of 0.4 meters.

In suspension bridge systems, one of the most important and influential parameters is the cable density. Density is directly related to the properties of the cables that exert permanent loads on the structure. Factors affecting cable density include the cable material density, cable type and configuration, cable diameter and length, and the shape of the cable arch (catenary). Density, or variations in cable properties, will systematically affect the deflection value (Firdausi et al., 2018). The asymmetry of the bridge geometry (span and backstay distance) also influences the balance of the suspension bridge structure (Fischer, 2025).

PRACTICAL IMPLICATION

Conclusion The results obtained from the calculation and analysis of SAP 2000 show a high level of accuracy for the reviewed values, namely stress and deformation with a percentage difference below the tolerance limit (2% - 15%) and the values obtained are still below the permitted limit. Thus, the wire rope cable structure is declared optimal both in the existing condition of 53 mm and with the recommended efficiency condition of 50 mm diameter.

In the suspension bridge system, one of the important parameters that has a very influential factor is the density factor of the wire rope cable. Because the density itself is directly related to the cable properties that cause permanent loads on the structure. The density factor of the wire rope cable includes the density of the cable material, the type and configuration of the cable, the diameter and length of the wire rope cable, and the shape of the cable curve (catenary).

The structural analysis carried out has met the criteria of Surat Edaran Menteri Pekerjaan Umum No. 02/SE/M/2010 concerning the technical Guidelines for the Construction of Pedestrian Suspension Bridges , where this study can be used as a reference for similar research/reviews in the future.

As for the recommendations that can be given from the analysis results, suggestions can be given for the future, namely the efficiency of cable dimensions from the existing size of 53 mm to a cable size of 50 mm on suspension bridges with similar characteristics while still reviewing the reliability and safety factors of suspension bridges.

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DISCLOSURE STATEMENT

The author declares that this research topic was carried out without any conflict of interest.

NOTES ON CONTRIBUTOR

Singgih Budi Hartoko is a bachelor's degree student in the Department of Applied Civil Engineering Faculty of Vocational, Universitas Negeri Yogyakarta. His research interests are structural engineering. Elviana is a lecturer in the Department of Applied Civil Engineering Faculty of Vocational, Universitas Negeri Yogyakarta.

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