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Bridge Pier Design in the Digital Age: Leveraging Revit for Efficient Design and Analysis

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ABSTRACT

This research explores integrating Building Information Modeling (BIM) technology, specifically Autodesk Revit, into the bridge piers' design and planning process. The authors emphasize the pivotal role of technology in the advancement of infrastructure, with a focus on Indonesia's extensive toll road projects and the Barelang bridge as a prime example of sustainable infrastructure development. The transitions from AutoCAD to BIM in the construction industry are discussed, with BIM being recognized for increasing efficiency and accuracy in construction projects. The authors acknowledge the obstacles to BIM adoption, including substantial upfront costs and limited technological progress, but also highlight the potential for considerable cost savings in material procurement and building projects. Autodesk Revit is identified as a prominent BIM-based program that offers detailed 3D models, drawings, and schedules, enabling construction stakeholders to collaborate effectively. In conclusion, the document calls for adopting BIM and BrIM in the AEC sector, suggesting that these technologies can streamline bridge design and maintenance, contributing to more sustainable and cost-effective infrastructure.

1. Introduction

The advent of technology enables everyone to utilize potential resources to grow a country in various ways. Technology plays a crucial role in infrastructure by offering essential tools and support for the design and execution of building projects. Every province has multiple toll road projects under construction, which helps to accelerate the development of infrastructure projects. Bridges are part of these initiatives; one example of sustainable infrastructure development is the Barelang Bridge [1]. Structural engineers have been actively involved in extensive global research over the years to improve efficiency while taking strength and cost into account during the design process. Due to ongoing upgrades to seismic design codes and developments in engineering, existing bridges may become seismically weak. Bridge designs can differ depending on the intended use, the topography, funding sources, and material accessibility. Properly constructed piers can safely transfer loads from the superstructure to the foundation and support spans, making them a crucial structural element in bridge construction. Piers are built to withstand forces because of their structural integrity [2].

The building industry has been significantly impacted by the swift advancement of science and technology, among other sectors. Building Information Modeling (BIM) has replaced AutoCAD to digitize construction technologies for building design and structure [3]. Through cooperation between the project's components during the building's life cycle, the introduction of BIM and its ongoing evolution have contributed to an increase in the efficiency and accuracy of construction projects [4].

Although BIM can improve project efficiency, its application has been hindered by expensive upfront costs, insufficient funding for human resources, limited demand, and inadequate technological advancements [5]. However, using BIM can save up to 20% on material procurement and building projects [6]. According to Building Information Modeling (BIM) one of the most popular applications is Autodesk Revit, a program created by Autodesk that makes it easier to create new modeling tools aimed at the digitalization of construction [7]. Autodesk Revit is an application that is able to provide plan views, 3D models, detailed diagrams, schedules, and V-ray rendering software for each structural part. V-ray rendering software generates 2D and 3D section views, detail quantities, and schedules in an extremely efficient manner [8]. BIM-based technologies enable construction stakeholders, Such as MEP technicians, clients, facility manager, architects, quantity surveyors, and contractors, to carry out their operations successfully and efficiently through their various roles and obligations in managing construction projects [9].

In this study the Autodesk Revit application is used to provide the output of working drawings and 3d modeling of bridge piers. This article aims to integrate BIM technology into the design and planning process of bridge piers. This study endeavors to enhance efficiency and accuracy in the bridge pier design and planning procedure and promote cooperation and unity among the stakeholders engaged in the construction project. Hence why, this study aims to discuss how to design bridge piers using Autodesk Revit software based on BIM.

2. Literature Review

2.1 Building Information Modeling (BIM)

Building information modeling (BIM) is a digital depiction of both the functional and physical characteristics of a facility [10]. It advances design and construction via modeling technology that connects many processes to create, share, and evaluate building models. Throughout the building life cycle, BIM is a shared information source that can be trusted to inform decisions made to accomplish one or more objectives [11].

Building information modeling (BIM), also known as virtual prototyping technology or n-D modeling, is a revolutionary technology that has rapidly changed the architecture, engineering, and construction (AEC) sector [12]. The concept, design, construction, and operation of buildings have all undergone rapid transformation due to the groundbreaking technology and technique known as Building Information Modeling (BIM). Despite the fact that the research on parametric modelling has already been carried out during the late 1970s and early 1908s, in Europe and the USA,, BIM's practical application in projects began in the mid-2000s in the Architecture, Engineering, and Construction (AEC) sector. BIM has evolved over the past seven years from a buzzword to the epicenter of AEC technology [13].

For those involved in the construction sector, BIM represents a new paradigm that can promote collaboration among project stakeholders. The potential for improved harmony and efficiency between construction stakeholders exists with this integration [14]. According to Telaga's (2018) research, the first article about building information modeling (BIM) in Indonesia was published in 2013, detailing the experience of implementing BIM in multiple construction projects in the country. In Indonesian construction industry, the use of BIM was first documented and recorded in 2012, indicating that Indonesia's adoption of BIM has been trailing behind developed nations' use since 2000 [15].

2.2 Bridge Information Modeling (BrIM)

Building information modeling (BIM) has transformed many aspects of engineering design in this era of information and technology, including the construction, maintenance, and management of infrastructure assets, especially bridges [16]. Professionals in the field have shown keen interest in BIM, recognizing it as a transformative technological advancement in the construction industry. They think it's essential to use this technology creatively and in a variety of construction projects. The idea behind

Bridge Information Modeling (BrIM), which is similar to Building Information Modeling (BIM) but focuses only on bridges, was inspired by this sentiment [17].

Similar to BIM, BrIM was created to make it easier for stakeholders to share information on bridge structures. It has been suggested that BrIM applications be used to integrate data from the domains of design, engineering, construction, and operation [18]. Since BIM has demonstrated effectiveness in managing building design, construction, and long-term performance, it is anticipated to significantly contribute to providing viable design options for bridge construction, maintenance, and rehabilitation. BrIM enables designers to animate bridge geometries during the design phase by creating intelligent virtual 3D models containing comprehensive data and information about bridge components [19].

2.3 Bridge Pier Design

A pier is an elevated bridge structure that is usually held up by pillars or widely spaced piles. Piers plays a crucial role in the load passage that connects the foundation to the superstructure. Piers are made to withstand both the horizontal loads that are not supported by the abutments and the vertical loads from the superstructure. Piers are needed to support the ends of the spans between these abutments in a multi-span bridge [21]. Building bridge piers is an essential part of developing Indonesia's infrastructure because of the nation's extensive island chain and varied topography. In order to evaluate soil conditions, water depths, and environmental effects, the construction process usually starts with thorough site surveys and geotechnical studies [22]. Indonesian bridge pier building calls for a holistic strategy that incorporates community involvement, environmental management, and engineering know-how. Indonesia is constantly improving its infrastructure network to ensure safe and dependable transportation links throughout its islands and varied landscapes. This is achieved by following precise design requirements, using suitable building techniques, and utilizing creative solutions [23].

Designing a bridge pillar, also known as a pier, involves a complex process aimed at ensuring structural integrity, durability, and safety under various loads and environmental conditions. The design process begins with thorough site investigation to assess soil conditions, water depth, seismic activity, and hydraulic forces, which are particularly relevant in areas like river crossings or coastal regions. The design typically incorporates a vertical or near-vertical pier shaft that carries vertical loads downward, topped by a horizontal pier cap that distributes these loads horizontally. Throughout the design phase, structural analysis and computer modeling tools aid in ensuring the pier can withstand anticipated loads, including dynamic forces from traffic and environmental conditions. Overall, the meticulous design of bridge piers integrates engineering expertise with technological advancements to create robust structures that support safe and efficient transportation infrastructure [24].

3. Method

The 3D modeling of pier designs is the methodology employed in this study. Using Autodesk Revit software, a 3D model of the bridge pier will be produced based on the data gathered. This model will have features and structural details specific to the bridge pier. The resulting 3D model will go through analysis and evaluation to determine the accuracy and efficiency of this process for designing and planning bridge piers. In addition to using Mendeley software for citation, this research employs Google Scholar to conduct international and national journal searches for literature references, which facilitates the search for standard international and national literature sources.

4. Result & Discussion

4.1 Bridge Design Specifications

The bridge design specifications for this project encompass several critical elements to ensure structural integrity, safety, and functionality. When designing a bridge pier in Revit, you typically need to consider and input various data points to accurately model it. The data required to design a bridge pier are:

Table 1. Pier Base Data

PIER BASE	
Description	Specification
Thickness	1000
Length	4000
Width	6000

(Table 1) The data used to design the pier base includes: Thickness (1000) – Length (4000) – Width (6000).

Table 2. Column Data

COLUMN	
Description	Specification
Height	12000
Depth	2000
Width	3000

(Table 2) The data used to design the column includes: Height (12000) – Depth (2000) – Width (3000).

Table 3. Pier Head Data

PIER HEAD	
Description	Specification
Bottom Length	2000
Bottom Width	3000
Height 1	1000
Top Length	3500
Top Width	1000
Height 2	4500

(Table 3) The data used to design the pier head includes: Bottom Length (2000) – Bottom Width (3000) – Height 1 (1000) – Top Length (3500) – Top Width (1000) – Height 2 (4500).

When designing a bridge pier, it's crucial to detail the specific requirements and criteria that will guide the entire design and construction process. By compiling and utilizing these data, the author can effectively model and document the bridge pier in Revit, ensuring accuracy and compliance with project requirements and industry standards. Each of these aspects contributes to creating a comprehensive and reliable digital representation of the bridge pier within author's Revit project.

4.2 Bridge Pier Modeling

Designing a bridge pier involves a structured process to ensure accuracy, compliance with standards, and integrations with the overall bridge structure. Designing a bridge pier using Revit involves several steps to accurately model and document the pier within the project.

Modeling stage:

- Launch Revit and start a new project.
- Choose a template that suits the project type (e.g., Structural Analysis-DefaultMetric)

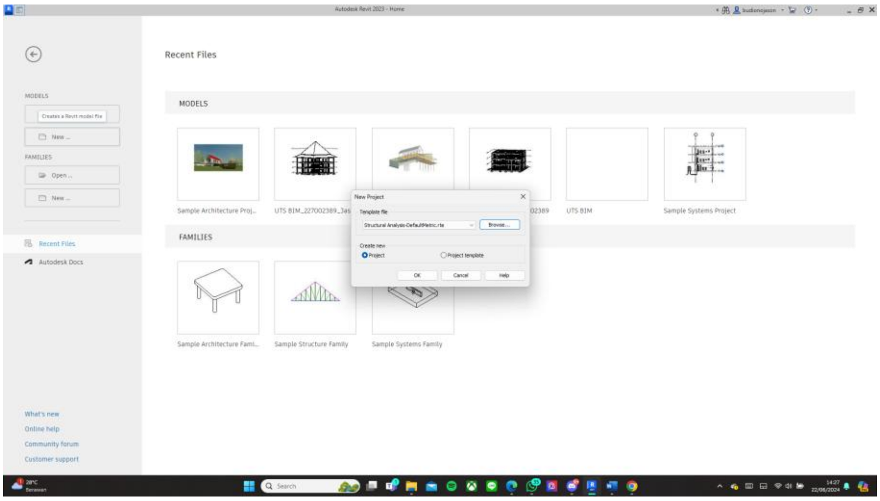

Figure 1. Revit Project Template

- ➢ Configure project units and establish necessary levels for the bridge, including foundation levels and pier levels.

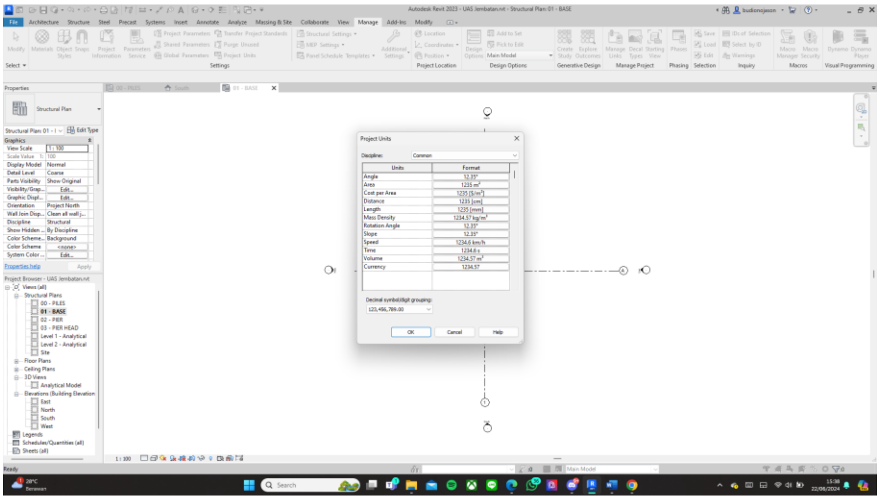

Figure 2. Project Units

- ➢ Define levels and reference planes that will guide the placement and alignment of the bridge pier components.
- ➢ Levels should include ground level, pier cap level, and any intermediate levels required for detailing.
- ➢ Depending on the bridge design, model the foundation or the base for the piers. This typically involves creating footing or pads to support the columns.
- ➢ Ensure the foundation elements are correctly sized and positioned relative to the pier column.

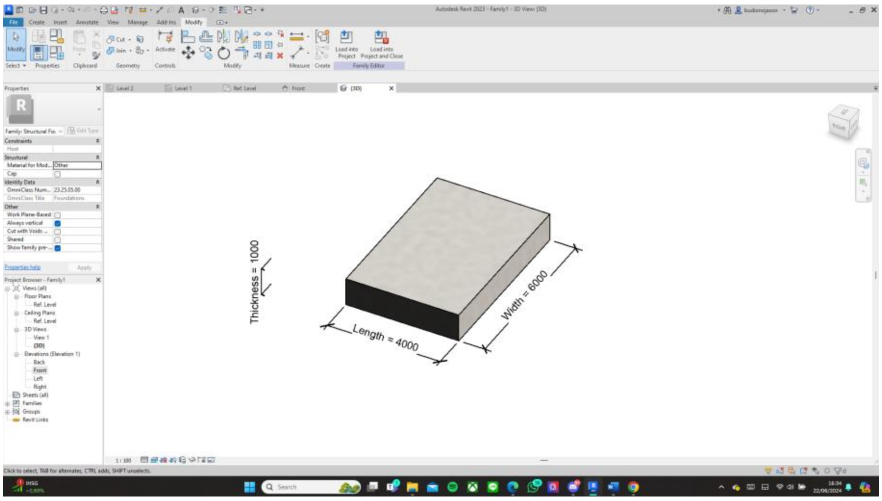

Figure 3. Pier Base

- Use the structural column tool to place columns that represent the locations and layout of the bridge piers.
- Use modeling tools (e.g., Extrusion, Sweep) to create the vertical column.
- Adjust column properties such as dimensions and alignment based on the bridge design specifications, considering any tapering or variations along its height.

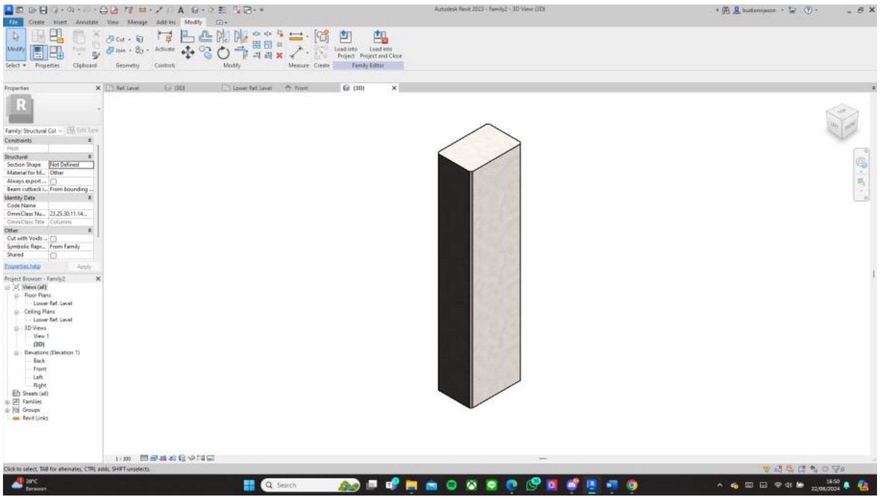

Figure 4. Column

- Model the pier caps that connect the column or pier shafts that support the bridge superstructure.
- Ensure that the pier head or cap are accurately placed and sized to accommodate the load transfer from the superstructure.

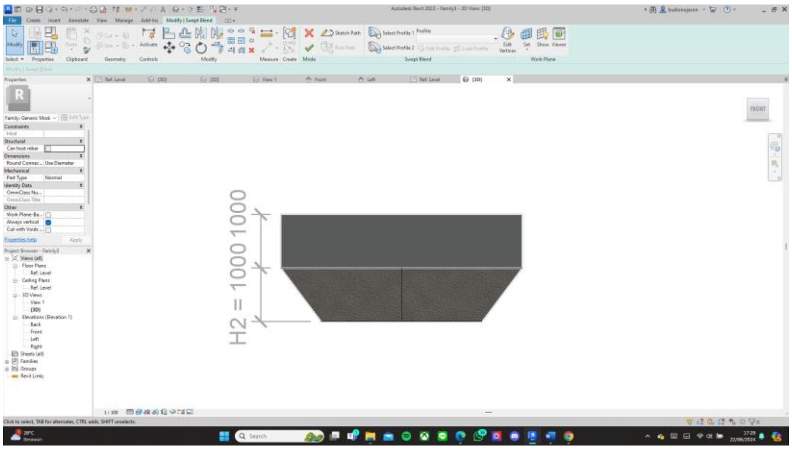

Figure 5. Pier Head or Pier Cap

- After designing all the elements (Pier Base, Column, and Pier Cap) needed to design the bridge pier, the next step is to combine them into one.
- Start by clicking on the shared box and load it into another project.
- In **Figure 6.** It shows the final looks of the bridge pier.

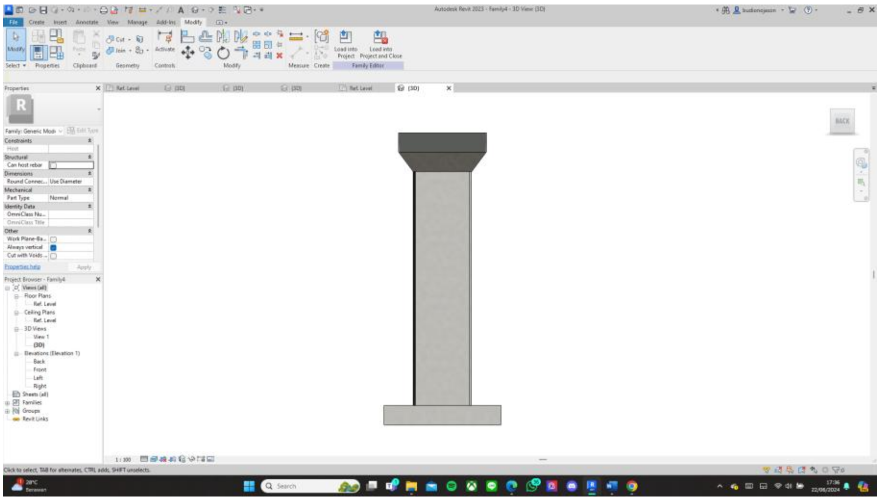

Figure 6. Bridge Pier 3D View

Revit 3D capabilities empower design professionals to create, analyze, simulate, and document building projects comprehensively and efficiently. By leveraging BIM principles and advanced 3D modeling tools, Revit enhances project visualization, coordination, and communication, ultimately supporting the delivery of high-quality, well-coordinated building designs from concept through construction and beyond. In designing a bridge pier design specification, it's essential to articulate precise details that guide the construction and ensure the structural integrity and safety of the pier. By following this structured process, you can effectively design a bridge pier in Revit, ensuring it meets structural requirements, complies with design standards, and integrates seamlessly within the broader project. Collaboration and adherence to best practices in modeling and documentation will contribute to a successful bridge pier design and construction process.

CONCLUSION

This research discusses the integration of Building Information Modeling (BIM) technology, specifically Autodesk Revit, into the design and planning process of bridge piers. The study emphasizes the role of structural engineers in improving design efficiency, considering seismic design codes, and the need for properly constructed piers to safely transfer loads and withstand forces. The advancement of BIM has significantly impacted the building industry, offering increased efficiency and accuracy in construction projects. Despite the potential cost savings and improved project efficiency, the adoption of BIM faces challenges such as expensive upfront costs and limited technology advancements.

The study aims to enhance the efficiency and accuracy of bridge pier design and planning using Autodesk Revit. It provides a detailed methodology for creating a 3D model of a bridge pier, including the data required for its design and the steps for modeling in Revit. The research also reviews the specifications for bridge pier design, including the dimensions and the importance of adhering to rigorous design standards. It suggests that BIM (Building Information Modeling) and BrIM (Bridge Information Modeling) can revolutionize that AEC sector by automating and integrating processes across the entire lifecycle of bridge infrastructure.

References

[1] Muhammad Yusuf and Fahmy Hermawan, "Comparison Analysis of Existing Bridge Design Based on Bms 1992 and Sni 1725-2016," *Int. J. Livable Sp.*, vol. 8, no. 2, pp. 43–52, 2024, doi: 10.25105/livas.v8i2.19483.

[2] S. B. Ev, "a Study on Behaviour of Bridge Piers in Various Seismic Zonal Conditions," vol. 11, no. 1, pp. 129–138, 2020.

[3] S. P. Zotkin, E. V Ignatova, and I. A. Zotkina, "The Organization of Autodesk Revit Software Interaction with Applications for Structural Analysis," *Procedia Eng.*, vol. 153, pp. 915–919, 2016, doi: https://doi.org/10.1016/j.proeng.2016.08.225.

[4] Y. D. Mamedmuradov and A. I. Kovalev, "HVAC design in Autodesk Revit using Dynamo," *AlfaBuild*, vol. 14, no. 1402, 2020, doi: 10.34910/ALF.14.2.

[5] A. Herzanita, Y. Latief, and F. Lestari, "The Application of BIM-Based OHSMS Information Systems to Improve Safety Performance," *Int. J. Saf. Secur. Eng.*, vol. 12, no. 1, pp. 31–38, 2022, doi: 10.18280/ijsse.120104.

[6] L. Pinti, R. Codinhoto, and S. Bonelli, "A Review of Building Information Modelling (BIM) for Facility Management (FM): Implementation in Public Organisations," *Appl. Sci.*, vol. 12, no. 3, 2022, doi: 10.3390/app12031540.

[7] F. Banfi, "THE INTEGRATION OF A SCAN-TO-HBIM PROCESS IN BIM APPLICATION: THE DEVELOPMENT OF AN ADD-IN TO GUIDE USERS IN AUTODESK REVIT," *ISPRS - Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.*, vol. XLII-2/W11, pp. 141–148, May 2019, doi: 10.5194/isprs-archives-XLII-2-W11-141-2019.

[8] E. Reddy and K. K. Singaram, "Design and Modelling of G+5 Commercial Building by Autodesk Revit Architecture," *Int. J. Eng. Adv. Technol.*, vol. 9, pp. 4732–4736, Dec. 2019, doi: 10.35940/ijeat.B5136.129219.

[9] A. Ahmad Latiffi and M. S. Fathi, *Roles and Responsibilities of Construction Players in Projects Using Building Information Modeling (BIM)*. 2016. doi: 10.1007/978-3-319-33111-9_16.

[10] D. Damayanti, L. Vella, and M. Nazar, "Evaluation of Building Information Modeling (Bim) Implementation As a Strategy To Accelerate Planning in Toll Road Construction …," *Pros. KRTJ HPJI*, no. August, 2023, [Online]. Available: https://proceeding.hpji.or.id/index.php/test/article/view/315%0Ahttps://proceeding.hpji.or.id/index.php/test/article/download/315/304

[11] R. G. Kreider and J. I. Messner, "The uses of BIM: Classifying and selecting BIM uses." Computer integrated Construction Research Program, 2013.

[12] A. Salman, M. Khalfan, and T. Maqsood, "Building information modeling (BIM): Now and beyond," *Australas. J. Constr. Econ. Build.*, vol. 12, p. 15, Dec. 2012, doi: 10.5130/ajceb.v12i4.3032.

[13] R. Sacks, C. Eastman, G. Lee, and P. Teicholz, *BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers*. 2018. doi: 10.1002/9781119287568.

[14] A. Salman, "Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry," *Leadersh. Manag. Eng.*, vol. 11, no. 3, pp. 241–252, Jul. 2011, doi: 10.1061/(ASCE)LM.1943-5630.0000127.

[15] J. Pantiga and A. Soekiman, "Kajian Implementasi Building Information Modeling (BIM) di Dunia Konstruksi Indonesia," *Rekayasa Sipil*, vol. 15, no. 2, pp. 104–110, 2021, doi: 10.21776/ub.rekayasasipil.2021.015.02.4.

[16] M. Mohammadi, M. Rashidi, Y. Yu, and B. Samali, "Integration of TLS-derived Bridge Information Modeling (BrIM) with a Decision Support System (DSS) for digital twinning and asset management of bridge infrastructures," *Comput. Ind.*, vol. 147, p. 103881, 2023, doi: https://doi.org/10.1016/j.compind.2023.103881.

[17] A. G. Mohamed, A. Khaled, and I. S. Abotaleb, "A Bridge Information Modeling (BrIM) Framework for Inspection and Maintenance Intervention in Reinforced Concrete Bridges," *Buildings*, vol. 13, no. 11. 2023. doi: 10.3390/buildings13112798.

[18] Q. Yidong, X. Rucheng, W. Yang, and K. H. Law, "A Bridge Information Modeling Framework for Model Interoperability. Comput," *Civ. Eng*, vol. 2022, pp. 447–454, 2019.

[19] M. Brendan, A. Rebecca, C. Caroline, and O. Mehmet, "Bridge Information Modeling for Inspection and Evaluation," *J. Bridg. Eng.*, vol. 21, no. 4, p. 4015076, Apr. 2016, doi: 10.1061/(ASCE)BE.1943-5592.0000850.

[20] A. Jrade, F. Jalaei, J. J. Zhang, S. Jalilzadeh Eirdmousa, and F. Jalaei, "Potential Integration of Bridge Information Modeling and Life Cycle Assessment/Life Cycle Costing Tools for Infrastructure Projects within Construction 4.0: A Review," *Sustainability*, vol. 15, no. 20. 2023. doi: 10.3390/su152015049.

[21] A. Katkar, "Parametric study of bridge piers," pp. 656–660, 2018.

[22] M. Kiraga and A. Y. Wicaksono, "An Overview of Bridge Pier Construction Solutions, Including the Indonesian Approach," *Acta Sci. Pol. Archit.*, vol. 19, no. 2, pp. 3–20, 2020, doi: doi:10.22630/aspa.2020.19.2.13.

[23] M. F. M. Fahmy, A. M. A. Moussa, and Z. Wu, "Precast bridge piers: Construction techniques, structural systems, and seismic response," *Adv. Struct. Eng.*, vol. 26, no. 4, pp. 611–639, Oct. 2022, doi: 10.1177/13694332221133596.

[24] Elisa Khouri Chalouhi, *Optimal design solutions of concrete bridges considering environmental impact and investment cost*. 2019.