



(MUDIMA)



## A Conceptual Framework for Condition and Maintenance Risk Indicators for Educational Buildings

Geertje Efraty Kandiyoh<sup>1</sup>, Sandri Linna Sengkey<sup>2</sup>, Reiner W. Tampi<sup>3</sup>, Sherley Runtunuwu<sup>4\*</sup>

Manado State Polytechnics

**Corresponding Author:** Sherley Runtunuwu [sruntunuwu2016@gmail.com](mailto:sruntunuwu2016@gmail.com)

### ARTICLE INFO

*Keywords:* Building Condition Assessment, Condition Indicators, Educational Buildings, Maintenance Priority, Risk Scoring

*Received* : 3 April

*Revised* : 23 May

*Accepted* : 25 June

©2026 Kandiyoh, Sengkey, Tampi, Runtunuwu: This is an open-access article distributed under the terms of the [Creative Commons Atribusi 4.0 Internasional](https://creativecommons.org/licenses/by/4.0/).



### ABSTRACT

Educational buildings require systematic maintenance to remain safe, functional, comfortable, and supportive of learning services. Reactive maintenance practices often make repair priorities depend on user complaints or visually obvious defects rather than on the relationship between actual condition and the risk of delayed action. This article aims to develop a conceptual framework of condition and maintenance risk indicators for educational buildings as a basis for maintenance prioritization instruments. The method used is a conceptual review through the synthesis of literature on building condition assessment, facility management, risk-based maintenance, building maintenance regulations, and the operational context of educational facilities. The review produces two main constructs: building condition indicators and maintenance risk indicators. Condition indicators cover structural, architectural, roof, drainage, MEP, sanitation, safety, and space-function elements. Risk indicators cover safety, educational function, cost, comfort/health, operation, and institutional reputation. The integration of these constructs results in a conceptual condition-risk matrix to support maintenance priority decisions. This framework is important as a basis for developing visual inspection instruments, risk scoring, and maintenance prioritization models for educational buildings

## INTRODUCTION

Educational buildings are physical assets that play a direct role in supporting teaching and learning activities, practical training, administration, research, and student services. Good building performance contributes to safety, comfort, productivity, and the sustainability of educational services. Conversely, building defects that are not systematically addressed may disrupt space functionality, increase repair costs, and pose risks to users. In the context of vocational education, buildings are not only used for classroom activities but also for laboratories, workshops, and practical spaces that require safe physical conditions and reliable utilities.

A common problem in the maintenance of educational buildings is the limitation of budget, time, technical personnel, and building condition data. As a consequence maintenance actions are often carried out reactively after complaints arise or after visible defects are clearly identified. Such an approach is not sufficiently robust to support technical decision-making because not all visible defects have the same level of risk. Aesthetic damage to walls, for example, cannot be treated in the same way as exposed electrical cables or obstructed evacuation routes, although all of them may appear as “defects” during field observation.

Building Condition Assessment has long been used in facility management to evaluate the condition of building assets and support repair planning. Begić and Krstić (2024) emphasized that building condition assessment models help link physical inspection with maintenance decision-making. West et al. (2024) also showed that building condition audits need to reduce reporting ambiguity so that the resulting data can be traceable and usable for decision-making. However, condition assessment that focuses only on the level of physical deterioration is not always sufficient to determine maintenance priorities. In asset management, the Facility Condition Index (FCI) is widely used to compare facility conditions and repair needs (Re Cecconi et al., 2019). Nevertheless, FCI tends to emphasize the relationship between repair needs and asset replacement value. In educational buildings, maintenance decisions also need to consider non-financial impacts, such as student safety, continuity of practical training, room comfort, environmental

health, and the readiness of educational services. Therefore, condition assessment needs to be integrated with risk scoring.

Risk-based maintenance views defects not merely as physical problems, but as potential consequences for safety, function, cost, and operations. Khalil et al. (2016) showed that user risk and building performance indicators can be prioritized using the Analytical Hierarchy Process. Wang et al. (2022) also emphasized the importance of an integrated framework between maintenance and safety in educational and public facilities. In the context of school and campus buildings, a risk-based approach is important because buildings are used by large numbers of occupants with varying levels of vulnerability.

Despite the growing body of literature on building condition assessment, facility condition indices, and risk-based maintenance, several gaps remain. Existing studies generally focus either on physical condition assessment or on maintenance prioritization methods, with limited integration between condition deterioration and the risks associated with delayed maintenance actions. Widely used approaches such as the Facility Condition Index primarily emphasize financial considerations and do not adequately capture the broader consequences of building deterioration in educational environments, including impacts on user safety, learning continuity, environmental health, and institutional performance. Furthermore, most risk-based maintenance frameworks have been developed for industrial, infrastructure, or public facilities in general, while conceptual models specifically tailored to educational buildings remain limited. As a result, building managers often lack a practical framework that systematically links observable defects, potential risks, and maintenance priorities.

To address these gaps, this study proposes a conceptual framework that integrates building condition indicators and maintenance risk indicators specifically for educational buildings. The novelty of the framework lies in the development of a condition–risk perspective that combines physical deterioration assessment with the potential consequences of inaction, including safety, educational function, cost, comfort and health, operational continuity, and institutional reputation. The framework also introduces a conceptual

condition–risk matrix designed to support maintenance prioritization and provide a foundation for developing visual inspection instruments, risk-scoring systems, and decision-support tools for educational facility management.

The originality of this article lies in the integration of building condition indicators and maintenance risk indicators into a conceptual framework specifically designed for educational buildings. This framework is expected to serve as a basis for developing inspection checklists, condition

assessment rubrics, risk scoring rubrics, priority matrices, and further research based on field trials.

Table 1 summarizes previous studies relevant to building condition assessment and risk-based maintenance prioritization. The comparison highlights the research gap addressed by this study, namely the limited integration between physical condition assessment and maintenance risk, particularly for educational building.

Table 1. Comparison of Previous Studies

No	Author (Year)	Research Focus / Topic	Method / Approach	Main Contribution	Limitation / Gap
1	Begić & Krstić (2024)	Building condition assessment models	Comparative review of BCA models	Links physical inspection with maintenance decision-making	Not specific to educational buildings
2	West et al. (2024)	Building Condition Auditing (BCA)	Condition auditing	Reduces reporting ambiguity so data is traceable and usable for decisions	Focuses on auditability, not risk
3	Re Cecconi et al. (2019)	Facility Condition Index (FCI)	Review of asset performance measurement	Widely used to compare facility conditions and repair needs	Emphasizes financial aspects; ignores non-financial impacts
4	Khalil et al. (2016)	Building performance & user risk indicators	Analytical Hierarchy Process (AHP)	Prioritizes performance and user-risk indicators	Not conceptually integrated with condition indicators
5	Wang et al. (2022)	Integrated maintenance & safety for educational/public facilities	Integrated framework case study	Emphasizes integration of maintenance and safety	Does not develop a condition–risk matrix
6	Liu & Arifin (2021)	Preventive maintenance of school buildings in Indonesia	Constraint programming	Preventive model considering budget constraints	Focuses on scheduling, not risk scoring
7	Besiktepe et al. (2021)	Condition assessment framework for	Fuzzy sets theory	Condition assessment	Does not integrate educational risk consequences

		facility management		under uncertainty	
8	Ilter & Ergen (2015); Pärn et al. (2017)	BIM for maintenance & refurbishment	Literature review	Identifies BIM research directions in facility management	Does not address risk-based prioritization for educational buildings
9	Mostafa et al. (2015)	Lean maintenance	Lean maintenance roadmap	Improves maintenance process efficiency	Generic/industrial; not tailored to educational context
10	Putra et al (2018)	Maintenance priority determination	AHP / local case studies	Prioritizes maintenance of buildings (schools/tenants)	Limited to prioritization methods; minimal condition–risk integration

## METHODS

This article employs a conceptual review method. A conceptual review was selected because the purpose of the article is to develop a framework of indicators and relationships among constructs, rather than to test hypotheses using field data. The research stages include problem identification, review of literature and regulations, indicator synthesis, construct determination, development of a conceptual matrix, and formulation of an instrument development framework.

The literature search was carried out through academic databases, including Scopus, Science Direct, and Google Scholar, complemented by official Indonesian regulatory documents on building maintenance and repair. The search combined the keywords building condition assessment, condition indicators, educational buildings, maintenance priority and risk scoring, and covered publications from 2015 to 2025.

The initial search identified approximately 45 documents. After removing duplicates and screening titles, abstract, and full text for relevance to the study objectives, 22 sources were retained as the primary basis for the conceptual synthesis.

The selection of references was guided by explicit inclusion and exclusion criteria. The inclusion criteria were: (1) sources directly related to building condition assessment, risk-based maintenance or maintenance prioritization; (2) sources providing indicators, framework, or methods

that could be adapted to the context of educational buildings; (3) official building maintenance regulations; and (4) literature written in English or Indonesian. The exclusion criteria were: (1) sources not relevant to building condition or maintenance risk; (2) publications focusing solely on financial valuation without addressing condition or risk indicators; (3) non-academic sources such as commercial product brochures; and (4) documents whose full text could not be accessed.

The analysis was conducted using thematic synthesis. First, building elements commonly observed in educational building inspections were grouped into structure, architecture, roof, drainage, mechanical, electrical, and plumbing (MEP), sanitation, safety, and space function. Second, condition indicators were developed based on visually observable signs of deterioration, such as cracks, leakage, dampness, corrosion, sagging, breakage, blockage, exposed electrical cables, and unavailable safety facilities. Third, risk indicators were developed based on the potential impacts that may arise if the defects are not promptly addressed.

The conceptual stages of the study are presented in Figure 1. The figure shows that the framework begins with the identification of building elements, followed by condition and risk assessment, which are then integrated into a maintenance priority matrix. This framework can be used as a basis for developing observation instruments and conducting limited field trials in subsequent research stages.

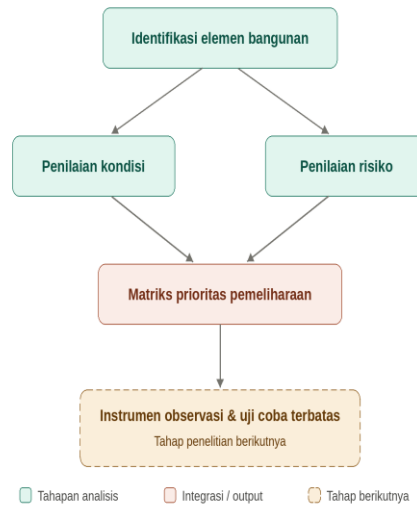


Figure 1. Conceptual Framework of Condition and Maintenance Risk Indicators for Educational Buildings

1. Stages in Developing the Conceptual Framework.

The development of the conceptual framework begins with the identification of instrument needs. This need arises because building managers require a decision-support tool that can transform visual inspection data into priority information. Subsequently, a review of literature and

regulations is conducted to obtain initial indicators. These indicators are then organized into an instrument blueprint based on variables, dimensions, data sources, and instrument forms. The final stage is to formulate the relationship among condition scores, risk scores, and maintenance priorities.

Table 2. Stages in Developing the Conceptual Framework

Stage	Activity	Output
1	Identification of instrument needs	Formulation of data requirements for condition, risk, and priority assessment
2	Review of literature and regulations	Initial list of condition and risk indicators
3	Construct determination	Constructs of building condition and maintenance risk
4	Development of an instrument blueprint	Mapping of the relationships among variables, dimensions, and indicators
5	Development of a conceptual matrix	A condition–risk–priority relationship model
6	Formulation of further instruments	Draft checklist, scoring rubrics, and priority matrix

**RESULTS AND DISCUSSION**

The first construct in the conceptual framework is building condition indicators. Condition indicators are used to assess the physical state and functional deterioration of building elements. In educational buildings, condition indicators should be simple enough to be applied through visual observation, yet

sufficiently comprehensive to represent defects that may affect safety, comfort, and space functionality.

Building condition should not be assessed only from structural elements. Architectural elements, roofs, drainage, utilities, sanitation, and safety facilities also need to be evaluated because they directly influence educational activities. Liu and Arifin (2021) showed that school buildings require a

preventive maintenance model that considers budget constraints. This reinforces the need for indicators that can help identify which elements should receive earlier attention.

Table 3 presents the proposed condition indicators for educational buildings. These indicators are designed to be observable during visual

inspection. For structural defects that appear to be serious, this conceptual instrument is not intended to replace in-depth technical assessment, but rather to serve as an initial detection tool for recommending further evaluation.

Table 3 Construct of Condition Indicators for Educational Buildings

<b>Element Group</b>	<b>Example Elements</b>	<b>Condition Indicators</b>	<b>Meaning of Assessment</b>
Structure	columns, beams, slabs, stairs	cracks, spalling, deformation, corrosion	indication of reduced reliability and the need for further assessment
Architecture	walls, floors, ceilings, doors, windows	cracks, dampness, peeling paint, breakage, slippery surfaces, sagging	disturbance to comfort, safety, and space functionality
Roof	roof covering, gutters, roof frame	leakage, corrosion, cracks, displacement, blockage	potential subsequent damage to ceilings, walls, and electrical systems
Drainage	rainwater channels, ponding areas	blockage, overflow, ponding	risk of dampness, site deterioration, and access disruption
MEP	electrical systems, lighting, ventilation, plumbing	exposed cables, non-functioning lamps, poor ventilation, leaking pipes	disturbance to safety, comfort, and operations
Sanitation	toilets, washbasins, wastewater channels	blockage, odor, leakage, unhygienic conditions	disturbance to health and basic user services
Safety	fire extinguishers, signs, evacuation routes, emergency lights	unavailable, damaged, obstructed, unreadable	safety risk during emergency conditions
Space Function	classrooms, laboratories, workshops, offices	impaired function, limited access, discomfort	direct impact on educational services

## 2. Construct of Maintenance Risk Indicators

The second construct is maintenance risk indicators. Maintenance risk is defined as the consequences that may arise when building defects or deterioration are not promptly addressed. Risk assessment is important because the level of physical damage is not always proportional to the urgency of action. For example, minor damage to an electrical system may pose a higher safety risk than extensive wall finishing deterioration.

Risk scoring in the context of this article is designed to assess five main dimensions: safety, educational function, cost, comfort/health, and operations. These dimensions were selected because they reflect the primary requirements of educational buildings, namely protecting users, ensuring the continuity of learning activities, controlling repair costs, and maintaining the quality of the learning environment. Reputational or accreditation-related consequences may also be considered as secondary impacts, particularly in higher education institutions.

This approach is consistent with the principles of risk-based maintenance, which place the consequences of failure as a basis for prioritization. In educational facilities, Wang et al. (2022) demonstrated that safety and maintenance need to be

understood in an integrated manner, as the failure of building components may affect both safety and the continuity of facility functions.

Table 4. Construct of Maintenance Risk Indicators

<b>Risk Dimension</b>	<b>Key Question</b>	<b>Example Indicators</b>	<b>Implication for Prioritization</b>
Safety	Does the defect endanger users?	exposed electrical cables, ceilings at risk of falling, slippery floors, obstructed evacuation routes	high-risk conditions should become the main priority
Educational function	Does the defect disrupt learning or practical activities?	unusable rooms, disrupted laboratories, non-functioning lighting	affects academic services
Cost	Does delayed action increase repair costs?	roof leakage damaging ceilings and electrical systems, drainage problems causing dampness	encourages preventive repair
Comfort/health	Does the room become uncomfortable or unhealthy?	toilet odor, mold, poor ventilation, damp rooms	affects the quality of the learning environment
Operations	Does the defect disrupt institutional activities?	disrupted room access, room relocation schedules, delayed services	affects the efficiency of building management
Reputation/accreditation	Does the condition of facilities reduce the institution's image?	poorly maintained buildings, weak maintenance documentation	strengthens the need for documentation and follow-up actions

### 3. Relationship among Condition, Risk, and Maintenance Priority.

The proposed conceptual framework positions building condition and maintenance risk as two complementary constructs. The condition score addresses the level of physical deterioration, whereas the risk score addresses the consequences that may arise if action is delayed. Integrating these two constructs provides a stronger basis for prioritization than the use of a defect checklist alone.

A simple conceptual formula that can be used at the instrument development stage is the priority score, calculated as the product of the condition score and the risk score. This formula is practical for

technicians or facility managers because it only requires condition and risk assessments on a scale of 1 to 5. At a later stage, the model can be strengthened using expert weighting, the Analytical Hierarchy Process (AHP), Delphi, or other multicriteria decision-making methods.

$$\text{Priority Score} = \text{Condition Score} \times \text{Risk Score} \quad (1)$$

Equation (1) indicates that the highest priority is assigned to elements that have both poor condition and high risk. Elements that pose risks to safety, learning functions, and the cost of subsequent damage can therefore be identified more quickly as maintenance priorities.

Table 5. Categories of Maintenance Priority Scores

Priority Score	Category	Meaning	Recommended Action
1–5	Low	minor damage with limited impact	routine maintenance
6–10	Moderate	requires monitoring and minor repair	scheduled according to available resources
11–15	High	included in the maintenance priority list	scheduled in the nearest maintenance program
16–20	Very high	requires immediate attention	immediate repair and strict monitoring
21–25	Critical	poses risks to safety or main building functions	emergency action or further technical evaluation

#### 4. Conceptual Matrix of Condition and Risk Indicators

The conceptual matrix was developed to link building elements, condition indicators, main risks, and priority outputs. This matrix is not intended to represent the final validated result but rather serves as an initial framework to be further developed into a research instrument. At the empirical stage, the matrix needs to be tested through expert validation and limited field trials.

Table 6 presents an example of conceptual mapping. Roofs, electrical systems, toilets, drainage, and safety facilities receive particular attention because, in educational buildings, these elements often have a direct impact on space functionality and user safety. Wall and finishing elements are still assessed; however, their priority may be lower if their impact is limited to aesthetic aspects.

Table 6. Conceptual Condition–Risk Matrix for Educational Buildings

Element	Condition Indicators	Main Risk	Decision Output
Roof	leakage, corrosion, cracks, clogged gutters	subsequent damage to ceilings, walls, and electrical systems	immediate repair if the functional risk is high
Ceiling	dampness, sagging, holes, mold	falling materials and reduced comfort	treatment after the source of leakage has been controlled
Electrical system	exposed cables, damaged sockets, unsafe panels	electric shock, short circuit, fire	emergency action or immediate repair
Toilet/sanitation	blockage, odor, leakage, unhygienic conditions	disturbance to health, comfort, and basic services	priority repair in buildings with high user density
Drainage	blockage, ponding, water overflow	dampness, subsequent damage, access disruption	cleaning and repair of drainage channels
Safety facilities	unavailable fire extinguishers, damaged signs, obstructed routes	failure of emergency response	provision or repair of safety facilities
Wall/finishing	peeling paint, hairline cracks, damp stains	aesthetics and indication of dampness	routine maintenance unless further risks are identified

## 5. Position of the Conceptual Framework in Instrument Development

This conceptual framework can be translated into several operational instruments. First, the building identity form is used to document the building function, age, intensity of use, and environmental context. Second, the building element identification checklist is used to ensure that all major building components are observed. Third, the condition checklist is used to record defect findings and photographic documentation. Fourth, the risk assessment form is used to evaluate the impacts of defects on safety, educational function, cost, comfort/health, and operations.

Expert validation is required before field trials to ensure that the indicators are relevant, clear, and observable. After the field trial, usability evaluation is needed to assess whether the instruments are easy

to use by assessors, technicians, or facility managers. Through this sequence, the instruments are not only conceptually robust but can also be adjusted to the operational needs of educational building maintenance.

From the perspective of research development, this framework can serve as the basis for three subsequent stages. The first stage is indicator validation and limited testing in one building. The second stage is a multi-case study involving several educational buildings or schools to identify different risk patterns. The third stage is integration with Life Cycle Cost, Building Information Modelling, Computerized Maintenance Management System, or a digital inspection dashboard.

Table 7. Derivation of the Conceptual Framework into Research Instruments

Framework Component	Derived Instrument	Function in the Research
Object identity	building identity form	records function, age, intensity of use, and location context
Condition indicators	condition observation checklist	records physical defects and functional deterioration of building elements
Condition score	1–5 condition rubric	standardizes the assessment of damage severity
Risk indicators	risk assessment form	assesses the consequences of delayed action
Risk score	1–5 risk rubric	standardizes the assessment of risk impacts
Maintenance priority	priority score matrix	generates a ranking of maintenance actions
Follow-up action	recommendation format	links assessment results with technical actions

## 6. Implications for Applied Civil Engineering

This conceptual framework has implications for the development of Applied Civil Engineering, particularly in the field of building maintenance and restoration engineering. The proposed approach bridges physical condition assessment and managerial decision-making. Thus, building inspection does not stop at recording defects, but is extended into priority-based action recommendations.

At the practical level, this framework can assist facility managers in preparing annual maintenance programs, estimating budget requirements, and documenting the technical rationale for why certain building elements should be

addressed earlier than others. At the academic level, the framework can be developed into thesis instruments, applied research, teaching materials, and an initial model for educational building asset management.

This framework also supports the sustainability agenda. Safe and well-functioning educational buildings contribute to SDG 4 on quality education. Priority-based maintenance can also reduce resource waste because repairs are carried out based on the level of urgency and risk, rather than merely on user complaints or subjective perceptions.

## CONCLUSION

Write a conclusion based on your interpretation of the findings and discussion. The conclusion presents critical points that explain the answers to research questions. In this section, the author can provide input and recommendations. Suggestions present advanced ideas to be developed in subsequent research or practical improvement.

This article produces a conceptual framework of condition and maintenance risk indicators for educational buildings. The framework is built upon two main constructs: building condition and maintenance risk. Condition indicators include structural elements, architectural elements, roofs, drainage, mechanical, electrical, and plumbing (MEP), sanitation, safety, and space function. Risk indicators include safety, educational function, cost, comfort/health, operations, and reputation or accreditation.

The integration of condition and risk indicators results in a conceptual matrix that can be used as a basis for determining maintenance priorities. This framework indicates that maintenance decisions should not be based solely on the level of physical deterioration, but should also consider the consequences that may arise if intervention is delayed. Thus, building elements with poor condition and high risk can be placed as the main priorities.

The framework can be easily translated into a visual inspection instrument and is aligned with the needs of educational building management. Its limitation is that the framework remains conceptual and does not yet include empirical validation results. Further research should conduct expert validation, limited trials in educational buildings, inter-rater consistency analysis, and development toward multi-case studies on campuses or schools in tropical regions.

## REFERENCES

- BegiĆ, H., and KrstiĆ, H., (2024), Comprehensive review and comparative analysis of building condition assessment models, *Results in Engineering*, Vol. 22, 102176. <https://doi.org/10.1016/j.rineng.2024.102176>
- Besiktepe, D., Ozbek, M. E., and Atadero, R. A., (2021), Condition assessment framework for facility management based on fuzzy sets theory, *Buildings*, Vol. 11, No. 4, 156. <https://doi.org/10.3390/buildings11040156>
- Ilter, D., and Ergen, E., (2015), BIM for building refurbishment and maintenance: Current status and research directions, *Structural Survey*, Vol. 33, No. 3, pp. 228-256.
- International Organization for Standardization, (2018), ISO 41001:2018 Facility management - Management systems - Requirements with guidance for use, International Organization for Standardization, Geneva.
- International Organization for Standardization, (2024), ISO 55000:2024 Asset management - Overview, principles and terminology, International Organization for Standardization, Geneva.
- Ismanto, (2018), Penentuan prioritas kegiatan perawatan bangunan gedung sekolah negeri di Kota Blitar, Tesis Magister, Universitas Brawijaya, Malang.
- Kandiyoh, G. E., Sengkey, S. L., Tampi, R., and Mantiri, N., (2025), Optimizing building maintenance strategies using visual evaluation and life cycle cost analysis, *Jurnal Multidisiplin Madani*, Vol. 5, No. 11, pp. 1209-1216.
- Khalil, N., Kamaruzzaman, S. N., and Baharum, M. R., (2016), Ranking the indicators of building performance and the users risk via Analytical Hierarchy Process (AHP): Case of Malaysia, *Ecological Indicators*, Vol. 71, pp. 567-576.
- Liu, S. S., and Arifin, M. F. A., (2021), Preventive maintenance model for national school buildings in Indonesia using a constraint programming approach, *Sustainability*, Vol. 13, No. 4, 1874. <https://doi.org/10.3390/su13041874>
- Mostafa, S., Dumrak, J., and Soltan, H., (2015), Lean maintenance roadmap, *Procedia Manufacturing*, Vol. 2, pp. 434-444.
- Pärn, E. A., Edwards, D. J., and Sing, M. C. P., (2017), The building information modelling

- trajectory in facilities management: A review, *Automation in Construction*, Vol. 75, pp. 45-55.
- Peraturan Menteri Pekerjaan Umum Nomor 24/PRT/M/2008, (2008), *Pedoman Pemeliharaan dan Perawatan Bangunan Gedung*, Kementerian Pekerjaan Umum, Jakarta.
- Putra, M. R. N., and Beatrix, M., (2024), Analisis penentuan prioritas pemeliharaan bangunan dengan metode Analytical Hierarchy Process pada bangunan gedung Creative Space Unicorn - Surabaya, *Jurnal RAB Construction Research*, Vol. 9, No. 1, pp. 183-194.
- Re Cecconi, F., Moretti, N., and DeJaco, M. C., (2019), Measuring the performance of assets: A review of the Facility Condition Index, *International Journal of Strategic Property Management*, Vol. 23, No. 3, pp. 187-196. <https://doi.org/10.3846/ijspm.2019.7955>
- Santosa, S., Rochadi, M. T., Suroso, Suwanto, and Mawardi, (2019), Penentuan prioritas perbaikan gedung menggunakan metode AHP dari sudut pandang tenant, *Wahana Teknik Sipil*, Vol. 24, No. 2, pp. 89-103.
- Wang, K. C., Almassy, R., Wei, H. H., and Shohet, I. M., (2022), Integrated building maintenance and safety framework: Educational and public facilities case study, *Buildings*, Vol. 12, No. 6, 770. <https://doi.org/10.3390/buildings12060770>
- West, J., Siddhpura, M., Evangelista, A., and Haddad, A., (2024), Building Condition Auditing (BCA): Improving auditability and reducing ambiguity, *Buildings*, Vol. 14, No. 11, 3645. <https://doi.org/10.3390/buildings14113645>