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Structural Damages Identification and Maintenance Design of Sports Facilities for Improving Performance and Infrastructure Resilience

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Abstract

Building maintenance is vital to ensure facility reliability, security, and investment value, as neglect can lead to structural decay and safety hazards. This study aims to assess the deterioration level of sports facilities at PT SIER and devise an efficient maintenance plan. The process involves identifying structural damages, evaluating deterioration following guidelines, and planning maintenance actions. Subsequent steps include budgeting, creating Work Plans and Specifications, estimating Domestic Component Levels, and scheduling using the S-Curve. Analysis reveals varying degrees of architectural degradation, ranging from 1 to 3, signifying serious damage. The estimated total cost for upkeep and development is Rp 255,718,000, with a projected minimum Duty and Customs Levies value of 30.43%. Maintenance duration is estimated at 45 days, managed using the S-Curve method.

INTRODUCTION

The occurrence of building degradation due to insufficient maintenance is observed across various building types in Indonesia, spanning from residential dwellings to commercial edifices and educational infrastructure. According to the report by the Central Statistics Agency in 2023, the most substantial degradation is noted in educational facilities, particularly at the Elementary School (SD) level, where 44.74% of school classrooms experience mild to moderate damage, and 8.70% suffer severe damage during the academic year 2022-2023. Additionally, previous researchers elucidate that approximately 89% of structural degradation at the school building is attributed to the lack of regular maintenance (Gemilang et al., 2023).

Maintenance is essential for preserving the functionality, safety, and value of a facility (Astuti et al., 2019, 2022; Poupard et al., 2006; Zhao et al., 2011). Buildings, being important assets, need careful maintenance to guarantee they can withstand and function at their best throughout their intended duration (Polder et al., 2014; Van Belleghem et al., 2021). Building maintenance encompasses physical features and requires strategic planning to detect, avoid, and resolve possible concerns.

The Minister of Public Works Regulation Number 16/PRT/M/2010 outlines the Technical Guidelines for Periodic Inspection of Building Structures, which state that building maintenance involves activities focused on preserving the integrity of the building structure, its facilities, and equipment to guarantee the building's continued functionality. Building maintenance includes the repair or replacement of building structures, components, materials, amenities, and equipment to ensure the facility remains operable.

One of the primary challenges in building maintenance management is efficiency. This arises from ineffective systems, improper maintenance actions, insufficient guidelines, excessive use of public properties, and dissatisfaction with service quality (Chua et al., 2018). Building efficiency is essential for avoiding building failures during maintenance intervals (Azmy et al., 2023). Developing and maintaining building services are critical for assuring functionality (Dzulkifli et al., 2021; Hauashdh et al., 2021, 2022; Lai & Lu, 2024; Mahpour, 2023). Another researcher also has experience that government hospitals have limitations due to inadequate structures(M. Kadhim & R. Altaie, 2023). They pinpoint twelve factors that impact hospital maintenance, such

as design flaws (0.889), inadequate funding (0.874), insufficient training (0.871), misuse of building facilities (0.866), construction errors (0.863), lack of work experience (0.858), building age (0.826), individual modifications by hospital staff (0.826), insufficient maintenance staff (0.824), administrative corruption (0.821), selection of unqualified maintenance contractors (0.816), and unavailability of skilled maintenance Comprehending these aspects is essential for formulating plans, pinpointing issues, and discovering suitable remedies in hospital building upkeep. Improving the maintenance and management of buildings has the potential to significantly reduce carbon emissions, energy consumption, and environmental challenges, therefore promoting sustainability (Dzulkifli et al., 2021; Hauashdh et al., 2022). Prior studies focus mostly on traditional building care methods and overlook the need of integrating sustainability principles, climate change concerns, environmental variables, and new technology breakthroughs (Hauashdh et al., 2024).

According to prior studies, the maintenance and upkeep of a structure are crucial variables in determining its longevity. This research focuses on the upkeep of the sports facility building of PT Surabaya Industrial Estate Rungkut (SIER), notably the badminton hall and multipurpose field sections. The research evaluates the state of building components based on the 2017 Building Condition Assessment criteria provided by the Queensland Department of Housing and Public Works, which are used to develop maintenance plans. Cost estimate, Work Plans and Specifications (WPS), TKDN identification, and project scheduling utilising the S-Curve are all included in the compilation.

RESEARCH METHODS

The stages in the research on the maintenance of the badminton hall and multipurpose field area at PT SIER are explained and depicted in Figure 1.

Preparation

The preparation stage involves a literature review comprising journals related to the research topic on the fundamentals of building maintenance, classification of building deterioration, Minister of Public Works Regulation No. 24/PRT/M/2008 concerning Guidelines for Building Maintenance and Upkeep, and Minister of Public Works Regulation No. 16/PRT/M/2010 concerning Technical Guidelines for Periodic Inspection of Building Structures.

Data collection

The data collection stage commences with field surveys and documentation to record all building components, along with inspections of the building component condition assessment forms.

Maintenance analysis and development planning

a. Classifying damages
   All data on damages to the aspects of outdoor spatial planning and architecture are categorized based on items within the scope of the badminton hall and multipurpose field areas.
b. Identifying the level of damage
   The existing damage items are identified based on the Building Condition Assessment Guidelines issued by the Queensland Department of Housing and Public Works in 2017, which subsequently serve as a reference for determining the technical proposals for building maintenance implementation as presented in Table 1.

Table 1. Damage condition score based on the guidelines by the Queensland Department of Housing and Public Works in 2017

Damage Score	Description	Building Condition
5	Excellent	No damage, condition and appearance like new
4	Good	Minor damage present Damage to exterior layers, decrease in quality in finishing parts, no major maintenance or upkeep required
3	Moderate	In average or fair condition, damage is visible clearly, finishing parts require maintenance, the building still functional but needs repairs, and maintenance activities can be postponed
2	Poor	Severe damage, potential structural issues, poor appearance, major damage present, components prone to failure
1	Severe	The building does not meet standards, is not fit for operation and use, is unable to function as intended, can cause environmental issues and pollution

c. Calculation of damage volume
The calculation of the volume of damage serves as the basis for the Budget Plan (RAB) calculation.

Repair and development design

Creation of repair and development designs using AutoCAD and Sketchup software.

Budget Plan Calculation

Cost estimation is based on the existing volume of damage. f. Preparation of Work Plans and Specifications (WPS). Preparation of WPS as guidelines for project implementation.

Identification of Domestic Component Levels (DCL)

Calculation of Domestic Component Levels as a benchmark for achieving the minimum IDCL realization required by the Ministry of Industry.

Project scheduling with S-Curve

Project scheduling to obtain an overview of the project activities sequence and the dependency relationships between activities.

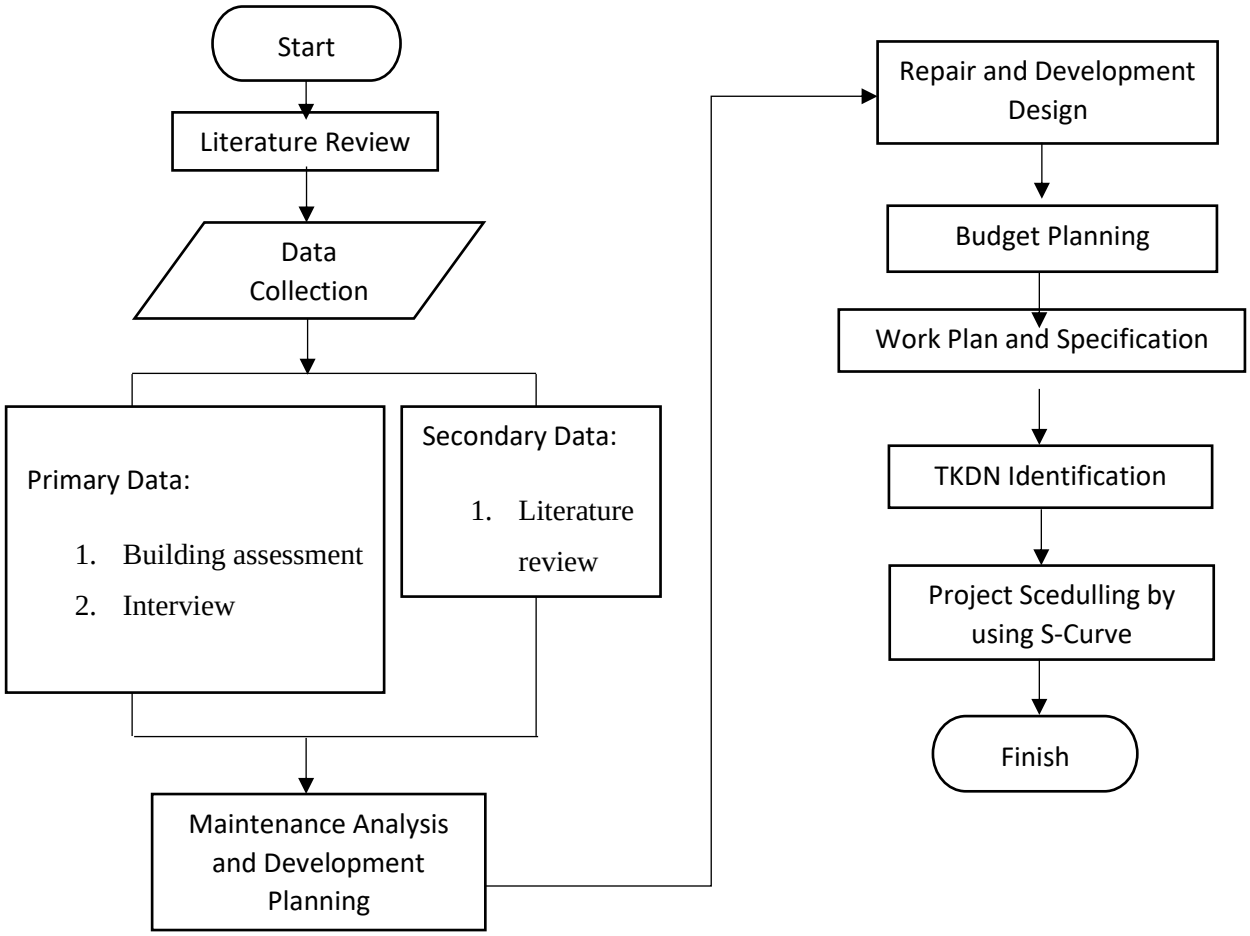


Figure 1. Diagram of research methods

RESULTS AND DISCUSSION

Inspection of architectural component damages in the sports facility at the badminton hall area

The condition of the badminton hall area was assessed and displayed in Figure 2. The inner walls of the badminton hall exhibit peeling in specific areas with varying degrees of severity. This affects the aesthetic appearance of the room and also reduces the wall's protection against moisture and dust. Damage to the inner walls is illustrated in Figure 2 (a). The kalsiboard walls exhibit fractures in certain areas, especially those directly exposed to the weather. Extreme temperatures are the cause of these fractures in the kalsiboard. Damage to the kalsiboard can be observed in Figure 2 (b).

(a) (b) (c)

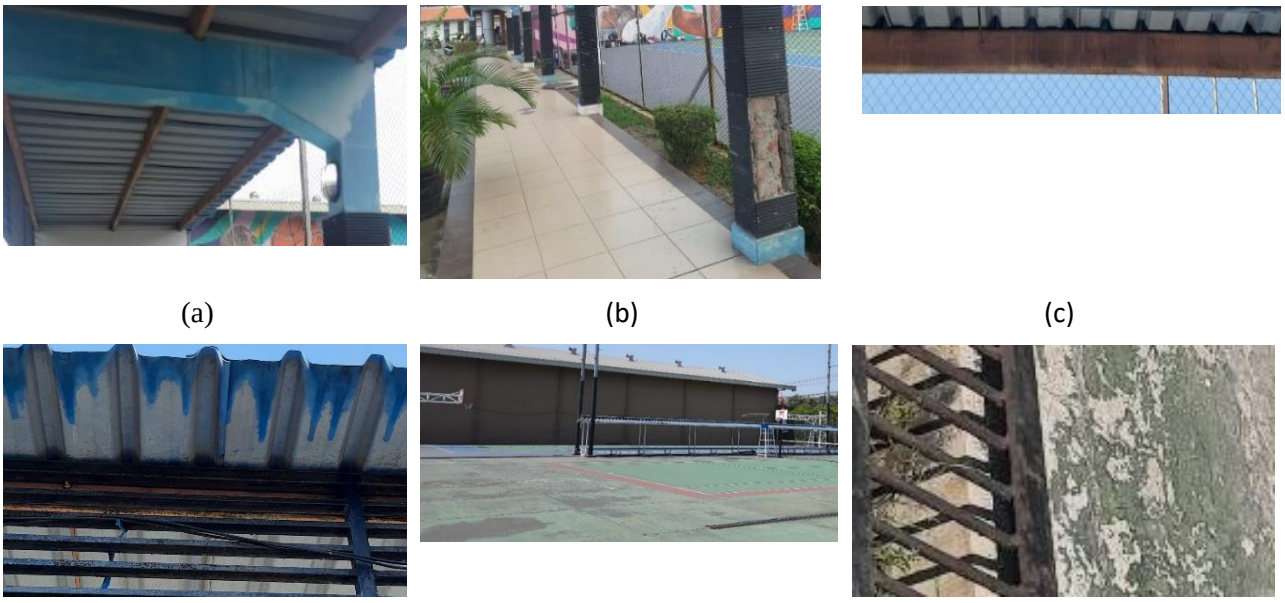
(d) (e) (f)

Figure 2. The architectural component damage in badminton hall area

The natural stone coating layer experiences peeling due to extreme weather conditions, affecting the coating's quality and making it brittle and prone to peeling. This damage falls into the category of moderate damage, requiring maintenance. Damage to the natural stone coating can be seen in Figure 2 (c). The cock replica has experienced corrosion and rust across its entire area. Galvanized pipes placed in outdoor areas are directly exposed to sunlight, rain, and extreme weather, causing corrosion and rust. This damage has the potential to reduce the durability and strength of the pipes in bearing loads. Damage to the cock replica can be seen in Figure 2 (d). The pipes on the facade of the badminton building experience rust in certain areas. Corrosion of galvanized pipes is caused by direct exposure to sunlight and temperature fluctuations. Damage to the facade pipes can be observed in Figure 2 (e). The lettering exhibits rust in certain areas due to direct exposure to temperature changes and weather conditions. The condition of the lettering is shown in Figure 2 (f).

Inspection of architectural component damages in the sports facility at the multipurpose field area

The damage that occurred in the multipurpose field area was depicted in Figure 3 (a)-(i).



(a) (b) (c)

(d) (e) (f)

(g) (h) (i)

Figure 3. The architectural component damage in the multipurpose field area

The kalsiboard experiences color fading of paint (Figure 3 (a)). Damage to the natural stone includes the detachment of some stones from the pillars, posing aesthetic and safety concerns for users (Figure 3 (b)). Poor installation and inadequate mortar or plastering that fails to meet standards are among the causes of stone detachment. Additionally, the coating layer on all natural stones peels off. Girders exhibit rust across their entire area (Figure 3 (c)). Hollow sunscreens experience erosion at specific points and rust along the entire hollow area. The outer play area of the tennis court experiences color fading of the paint. This area is commercially used for tennis court rental, so aesthetic aspects are crucial. Drainage grills experience rust throughout their area (Figure 3 (d)). The drainage on the multipurpose field is covered by iron grills. There are benches missing wood on one side (Figure 3 (f)). The wood has dimensions of 3.8 x 0.2 m and 2.8 x 0.2 m. Additionally, all benches experience paint peeling (Figure 3 (g)). Damage to these benches results in suboptimal load-bearing capacity and the potential for more severe damage, necessitating replacement and maintenance (Figure 3 (h)). Bench posts made of iron experience paint peeling in certain areas. Bench roofs are broken in several areas, causing leaks and rendering the roof ineffective as protection (Figure 3 (i)).

Based on the survey conducted, data on the level of damage were obtained as shown in Table 2.

Table 2. Damage level on the building components

No	Component	Damage Condition	Damage Level Score
Badminton hall area			
1	Interior wall paint	The paint on the interior walls of the badminton hall is peeling	3 (Moderate)
2	*Kalsiboard wall*	Kalsiboard is broken	1 (Severe)
3	Naturalstone coating	Coating on natural stone is peeling	3 (Moderate)
4	Floor hinge	The floor hinge is worn out, and unable to hold the door leaf swing	1 (Severe)
5	Cock replica	Galvanized pipe components of the cock replica are rusted and corroded	1 (Severe)
6	Galvanized pipe	Paint on galvanized pipes is peeling and rusting	3 (Moderate)
7	"GEDUNG BADMINTON SIER" sign	Paint on the sign is rusted	3 (Moderate)
Area Lapangan Multifungsi			
8	Kalsiboard wall	Kalsiboard is fading in color	3 (Moderate)
9	Natural stone	Some areas of the natural stone are detached from the pillar. Coating on natural stone is peeling	1 (Severe)

No	Component	Damage Condition	Damage Level Score
10	Gording	Gording is rusting	3 (Moderate)
11	Hollow sunscreen	Several hollow areas are corroded. Hollows are corroded	1 (Severe)
12	Outdoor tennis play area	The outdoor tennis play area is fading in color	3 (Moderate)
13	Drainage grill	Drainage grill is rusted	3 (Moderate)
14	Bench	Some benches lack seats. Wooden benches are peeling paint	1 (Severe)
15	Bench pole	Bench poles have peeling paint	3 (Moderate)
16	Bench roof	The asbestos bench roof is cracked, causing leaks	1 (Severe)

Budget for sports facility maintenance at PT SIER

In calculating the budget for the maintenance of sports facilities, Microsoft Excel was used as supporting software. The Activity-Based Costing (ABC) system used in the budget planning calculation is PT SIER's ABC system. The budget breakdown for maintenance work at PT SIER's sports facilities includes various tasks such as equipment procurement, site cleaning, rust removal, wall painting, and electrical installations. The total estimated cost amounts to Rp 255,718,786.80, including a 11% Value Added Tax (VAT) of Rp 25,341,501.39.

Maintenance Work Plan and Specifications (RKS) for Sports Facilities at PT SIER

The Maintenance Work Plan and Specifications (WPS) serves as a reference for vendors to meet job requirements. This document includes technical, administrative, and safety requirements. By adhering to this document, the project is expected to proceed according to the set targets.

The Domestic Component Level (DCL) for maintaining sports facilities at PT SIER

The calculation involves three identifications to determine the DCL value: identification of goods and combination of goods needs, identification of service needs, and the combined DCL value of goods and services needs. The summary of the combined DCL value of goods and services needs is presented in Table 3.

Table 3. Summary of DCL value of goods and services for the maintenance process

No	Item	Estimated Value	KDN Cost	Total TKDN
1	Goods Requirement	177,701,792	17,770,179	10.00%
2	Service Requirement	52,675,494	52,328,527	99.34%
	Total	**230,377,285**	**70,098,707**	
	Minimum Combined Goods and Services TKDN Value			**30.43%**

Planning time control with the S-curve

The time control for the maintenance work of the sports facilities at PT SIER is designed using Microsoft Excel. In this plan, the duration of the work has been set for 45 days. To ensure appropriate progress, daily targets have also been established for the workers. With these daily targets, it is hoped that the work progress can be effectively controlled, ensuring that the project is completed on time according to the established schedule.

CONCLUSION

The assessment of damage to the sports facilities at PT SIER reveals a range of scores from 1 to 3, indicating the presence of severe and moderate levels of damage throughout the infrastructure. Addressing these damages is imperative to ensure the structural integrity and operational efficiency of the facilities. Furthermore, based on the estimated budget for maintenance and development, amounting to Rp 255,718,000, it is evident that a substantial investment is required to undertake the necessary repairs and improvements. Allocating resources efficiently and effectively is crucial to maximize the impact of the maintenance efforts. In addition, considering the minimum Domestic Component Level (TKDN) value for combined goods and services, which stands at approximately 30.43%, it is essential to prioritize the utilization of locally sourced materials and services to meet regulatory requirements and promote economic sustainability within the region. The maintenance work is scheduled to span 45 days, with project control utilizing the S-Curve methodology. This approach allows for efficient monitoring and management of project progress, ensuring timely completion while optimizing resource utilization. In conclusion, addressing the identified structural damages, adhering to budgetary constraints, meeting regulatory standards, and employing effective project management techniques are essential steps in enhancing the performance and resilience of the sports facilities at PT SIER.

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