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Study of the application green construction in testing the functional feasibility of main praja office the regional secretariat of Denpasar city

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ABSTRACT

The functional feasibility and green construction application in the retrofitting of the Praja Utama office building of the Denpasar City regional secretariat was investigated based on Indonesian regulations PUPR Ministerial Regulation No.21 of 2021 concerning Green Buildings and PP No. 16 of 2021 concerning building functional feasibility testing. Visual observations and structural analysis using SAP2000 software revealed significant damage to structural elements, compromising the building's safety and functionality. A retrofitting plan was developed using Fiber Reinforced Polymer (FRP) to strengthen and repair the damaged components. The green construction assessment showed a high level of compliance, with 12 out of 13 required categories fulfilled in the retrofitting process. The findings highlight the importance of regular structural assessments, timely retrofitting interventions, and the feasibility of incorporating sustainable practices in building rehabilitation projects. The successful application of FRP and green construction principles demonstrates the potential for restoring structural integrity while minimizing environmental impact. Future research could explore the broader application of these methods and develop standardized guidelines for functional feasibility assessments and green construction in retrofitting projects.

Keywords: FRP; green construction; worthy of function

1 Introduction

Green construction is an approach to planning, design and development that aims at effectiveness, efficiency and quality along with paying attention to environmental aspects. This places greater emphasis on environmental awareness and efficient use of resources, as well as providing a positive impact on the local ecosystem [1]. Green construction is very necessary to ensure that development remains efficient and durable. This helps to reduce the negative impacts of sustainable development and protect the assets that have been built. Research [2] on the planning of the Tanjungpura University central library building resulted in a percentage of green construction implementation achievement of 53.52%. The environmental impact that occurs is very clear that the green construction concept is superior in preserving the environment. Apart from that, [3] also stated that green construction does not increase implementation costs in design and build project work contracts but provides good benefits for reducing environmental impacts due to construction activities and is more economical to apply to building construction projects.

Ratification of Law Number 11 of 2020 concerning Job Creation as a substitute for several articles of Law Number 28 of 2002 concerning Buildings, Government Regulation Number 16 of 2021 concerning Implementing Regulations of Law Number 28 of 2002 concerning Buildings as a substitute for Government Regulation Number 36 of 2005 concerning Implementing Regulations of Law Number 28 of 2002 concerning Buildings, and Minister of Public Works and Public Housing Republic of Indonesia Regulation number 27/PRT/M/2018 concerning Building Functional Worthiness Certificates in order to fulfill building requirements, and the management of buildings in an orderly manner, both administratively and technical, to produce functional, reliable buildings that guarantee safety, health, comfort and convenience for users, and are in harmony with their environment [4]. Buildings must always function well, reliably, guarantee safety, health, comfort and

convenience for users, and be in accordance with the environment [5]. The research carried out by the next researcher was entitled Study of structural aspects of the SLF of the Majapahit Transmart Building, Semarang using descriptive methods with qualitative and quantitative data approaches [6] . The physical inspection method for the building is carried out by: visual inspection, non-destructive testing and/or destructive testing, analysis with the help of the SAP 2000 program resulting in data on the quality of the concrete in the beams and columns which is quite good and the building structure is still declared fit for function. Technical Study of the Functionality of Garment Buildings 1 and 2 PT. Eratex Djaya, Tbk [7] using the physical inspection method of the building is carried out by: visual inspection (contained in a checklist), non-destructive testing and/or destructive testing. And from the results of the structural analysis using the SAP2000 program, the results obtained were that the calculation of axial load and shear load on each type of structural column under the existing loading conditions was still within safe limit conditions for axial and shear loads. Meanwhile, the structural beam is stated to still be within safe limits against bending and shearing.

Building structural repair planning is a very vital thing carried out by building owners to produce strength, stiffness, capacity and restore it according to its function and fulfill the planned life of the building in accordance with regulations regarding building structural concrete requirements [8] , minimum building design loads [9] , Procedures for earthquake resistance planning [10] . Evaluation of damage to the existing structure of the building begins with a field survey and testing on the KPKNL Bontang building to obtain the actual compressive strength of the concrete and the number of reinforcements installed in the structural elements in the field, then 3-dimensional modeling is carried out using SAP V.14 software and structural analysis to determine the level of security of the building and determine the repair methods that will be used. In this assessment, the building is evaluated based on the special moment resisting frame structure requirements (SRPMK) [11] . Research on the structural reliability of several reinforced concrete buildings in the Jabodetabek area against earthquake loads based on SNI 1726:2019 shows that the column, beam and plate elements are unable to withstand the forces of moment, shear and inter-story drift. Arising from earthquake loads in accordance with earthquake requirements in SNI 1726:2019, so it is necessary to strengthen the structure of the three structural elements, so that the capacity of the structural elements is able to withstand the loads acting on the building structure [12].

The increasing demand for sustainable and energy-efficient buildings has led to a growing interest in green construction practices worldwide [13]. Governments and regulatory bodies have recognized the importance of promoting green construction to mitigate the environmental impact of the building sector [14]. In Indonesia, the adoption of green construction principles is gaining momentum, with various regulations and guidelines being implemented to encourage sustainable building practices [15].

The Praja Utama office building of the Denpasar City Regional Secretariat, located on Jalan Gajah Mada No.1 Dauh Puri Kangin, West Denpasar District, Denpasar City, was built in 1992 with an area of 1350 m^2 consisting of three floors. On the third floor of the building which functions as a meeting room, the floor plate experienced vibrations so that this room could not be used according to its function. Several structural elements such as beams and floor plates were damaged (porous concrete and corrosion of the reinforcement). Based on this, research was carried out on the functional feasibility of the building and the repair methods that will be carried out so that the building can function again according to the plan and the level of application of green construction can be assessed by taking the title "Identification of the Application of Green Construction in Testing the Functionality of Buildings and Repairing the Structure of Public Office Buildings. Main Regional Secretariat of Denpasar City.

2 Data and Methods

2.1 Study Area

This research is located in the Praja Utama office building of the Denpasar City Regional Secretariat which is located on Jalan Gajah Mada no.1 Dauh Puri Kangin, West Denpasar District, Denpasar City, built in 1992 with an area of 1350 m^2 consisting of three floors.

2.2 Dataset

This research uses primary data sources, where researchers carry out direct observations and testing in the field. The following data is used:

1. Surveys, interviews and visual observations
2. Testing of building structural elements
3. Depiction of as built drawings
4. Land Data (Sondir)

2.3 Methods

The method used in this research is a quantitative method. In this research, direct data was collected on the building structure of the main regional secretariat office building for the city of Denpasar to be able to plan and create

implementation methods according to green construction.

In general, the flow of this research study can be explained as follows:

1. Government Regulation No.16 of 2021 concerning existing buildings must be functionally fit to obtain a functionally fit certificate.
2. PUPR Ministerial Regulation No.21 of 2021 requires the implementation of green construction.
3. Building structures that are damaged or cannot function in accordance with the initial planning must undergo a functional fitness test so that they can function according to plan and meet regulatory standards regarding building structures.
4. The next stage is the planning process for modifying/Retrofitting the existing building structure.
5. Buildings that will be built or repaired during the construction process must comply with green construction.
6. Finally, there is a conclusion on the level of application of green construction in testing the suitability of building functions and retrofitting.

Specific analysis techniques employed in this study include:

1. Visual inspections and condition assessments of structural elements.
2. Non-destructive testing (NDT) methods such as ultrasonic testing, rebound hammer testing, or cover meter surveys to evaluate concrete quality and reinforcement conditions.
3. Destructive testing methods such as core drilling or pull-out tests to obtain actual material properties.
4. Structural modeling and analysis using SAP2000 software to assess the building's performance under various loading scenarios and identify deficiencies.
5. Evaluation of structural capacity based on relevant design codes and standards.
6. Quantitative assessment of green construction application using a checklist or scoring system based on PUPR Ministerial Regulation No.21 of 2021.

3 Results and Discussion

The results of visual observations showed that several structural elements such as beams and floor plate columns experienced damage such as spaying, cracks and reinforcement experiencing corrosion/rust. From the results of the visual observations carried out, damage occurred to some structural components, namely several columns, beams, floor plates, steel hoods and non-structural ones, namely the ceiling, ceiling plaster, building envelope (plaster, plastering) so that it was categorized as seriously damaged and could be repaired using costs amounting to a maximum of 65% of the highest unit price of the new building.

3.1 Identify the Application of Green Construction

After carrying out a thorough visual observation, the application of green construction in the Denpasar City Regional Secretariat Main Office Building can be identified as shown in Table 1. Referring to the applicable standards, the achievement of green construction in testing the suitability of building functions and modifications with a total of 13 indicators reached 12 indicators, so it is categorized as good.

3.2 Customization Process for green construction

The identification carried out on the Denpasar City Regional Secretariat Main Office Building to achieve green construction in testing the suitability of the building's functions and modifications has reached the applicable standards, therefore the modification process for green construction is carried out, namely:

A. Green Construction Implementation Methods for Customization

1. Reliable Construction Planning & Evaluation Management.

Structured and comprehensive project work plan initiation document at the beginning of the construction period. This plan is equipped with work security and safety (K3) and construction safety documents which regulates:

a. K3 Socialization and Promotion;
b. Work protective equipment;
c. Personal protective equipment;
d. Insurance and licensing;
e. K3 Personnel;
f. Health Infrastructure Facilities;
g. Required signs;
h. Control of noise and vibrations resulting from work implementation

Document evaluation, monitoring and improvement mechanisms for improving project performance on a regular basis, especially for risk list priority work. In this case, daily, weekly and monthly report documents as well as meeting schedules between directors, supervisors and implementers have been scheduled to be achieved on time according to the predetermined time schedule, according to quality and in accordance with the budget set by the project owner.

2. Project Innovation towards 'Green' Improvement

The use of scaffolding no longer uses wood and bamboo but uses scaffolding so that it can be used continuously and from a safety perspective the

construction can be well maintained. Scaffolding maintenance including checking strength is a standard operational procedure before use. (attached to the technical specifications and work methods).

B. Optimization of equipment use

1. Efficient management of construction equipment

The mobilization plan document and monitoring of the realization of the mobilization of construction equipment in this customization process do not use heavy equipment, but must still be planned well for timely completion of this activity. The equipment needed such as concrete drills, meters for removing the remaining demolition can be mobilized at any time.

Efforts to utilize technology to optimize the use of construction equipment by carrying out tests on the equipment before use to ensure especially the vibrations and noise they cause.

2. Human and Environmental Safety regarding Tool Use

Construction safety documents related to building height against falling materials. Installation of safety nets is carried out during demolition work, installation of FRP and restoration of walls, to avoid environmental pollution and disturbance to residents.

The implementation of construction waste management can be seen in The Table 2.

Table 1. Identification of Green Construction Applications.

No	Aspect	Application	Points
CUSTOMIZATION CONSTRUCTION PROCESS			26
1.	Green Construction Process for customization		13
	a. Green Construction Implementation Methods for Customization		5
	1)	Reliable Construction Planning & Evaluation Management.	3
	2)	Project Innovation towards 'Green' Improvement	2
	b. Optimization of equipment use		3
	1)	Efficient management of construction equipment	2
	2)	Human and Environmental Safety in Using Tools	1
	c. Implementation of Construction Waste Management		5
	1)	Carry out calculations to reduce construction waste (concrete, iron, wood, glass, ceramics, gypsum ceiling waste, etc.). Includes estimated volumes of each type of construction waste.	1
	2)	Sorting construction waste according to type (wood, steel, concrete, glass, rubble, and so on).	1
	3)	Provision of special facilities for material locations containing B3 waste with optimal storage standards according to the calculated simulation volume (provision of absorbent media).	
	4)	Monitor waste output according to type, or collaborate with third parties in managing construction waste according to type.	1
	5)	Demonstrate 3R (reduce, reuse, recycle) construction waste efforts in the project and recap the volume of products produced. Example: Real use of waste from concrete, iron, wood, glass, ceramics, gypsum ceilings, etc. Used in small drainage concrete blocks, walkway blocks, vertical garden stands, flower pots, and other garden accessories.	1
2.	Customization Implementation Report		13
	a. Green construction process document		4
	1)	Submit a copy of shop drawings for the scope of work that requires testing and commissioning	1
	2)	Submit a copy of the material approval list, material specifications, owner performance criteria for the scope of work that requires testing and commissioning	1
	3)	Testing and commissioning documentation reports for work according to planning criteria	2
	b. Job handover documents		5
	1)	Training program documentation report for equipment system operation	1
	2)	Warranty certificate documents for major equipment from manufacturers	1
	3)	Operation and maintenance manual documents for equipment systems according to the criteria of each manufacturer	3
	c.	Submit as-built drawings that have been validated according to the installed condition	4

Table 2. Management of construction waste

No	Waste	vol.	sat.	transportation	Reuse	recycle	reduce
1.	brick wall demolition waste	235.2	m3	evening	for fixing Balinese ornaments	used for printed Balinese ornaments	
2.	demolition waste Brick Ornaments (Columns)	22.7	m3	evening	for fixing Balinese ornaments	used for printed Balinese ornaments	
3.	waste from dismantling ceiling frames	3.9	m3	evening	for reinstalling the ceiling		
4.	Ceiling demolition waste (gypsum)	64.4	m3	evening	disposed of at a waste processing site		
5.	Ceiling demolition waste (lumbersering)	13.3	m3	evening	disposed of at a waste processing site		
6.	Ceramic demolition waste	10.7	m3	evening	reused for footpath paving		

4 Conclusion

This study investigated the functional feasibility and green construction application in the retrofitting of the Denpasar City Regional Secretariat Main Office Building. The main conclusions drawn from the research are as follows:

1. The visual observations and damage assessment revealed that the building structure is not suitable for use in its current condition. Significant damage was observed in structural elements such as columns, beams, and floor plates, compromising the building's safety and functionality.
2. The structural analysis confirmed that the building does not meet the required strength, stiffness, and capacity standards in its present state. To restore the building's structural integrity and ensure its safe operation, a retrofitting plan was developed.
3. The proposed retrofitting method involves the use of FRP to strengthen and repair the damaged structural elements. FRP was selected for its high strength-to-weight ratio, durability, and corrosion resistance, making it an effective solution for structural retrofitting.
4. The green construction assessment, based on PUPR Ministerial Regulation No.21 of 2021, revealed that the retrofitting process of building achieved a high level of compliance with green construction principles. Out of the 13 required categories, 12 were fulfilled, indicating a strong commitment to sustainability & environmental responsibility.

The findings of this study have significant implications for the management and maintenance of public office buildings. The results highlight the importance of regular structural assessments and timely retrofitting interventions to ensure the safety and functionality of these facilities. The successful application of green construction principles in the retrofitting process demonstrates the feasibility of incorporating sustainable practices into building rehabilitation projects.

However, it is important to acknowledge the limitations of this study. The research focused on a single case study, and the findings may not be directly generalizable to other buildings with different structural characteristics or environmental contexts. Additionally, the long-term performance and durability of the FRP retrofitting solution should be monitored and evaluated over time to assess its effectiveness.

Future research could explore the application of the proposed retrofitting method and green construction principles to a broader range of public office buildings. Comparative studies could be conducted to evaluate the performance of different retrofitting techniques and materials. Furthermore, the development of standardized guidelines and best practices for the functional feasibility assessment and green construction application in building retrofitting projects would be valuable for practitioners and decision-makers.

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