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Original Article

Implementing Green Building Principles for Interior Spaces: A Case Study of an Office Building in Manado, Indonesia

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Abstract *- Many nations use passive design techniques to reduce energy, water, and material consumption, particularly in the building sector, in an effort to fight global warming. Since buildings account for 40% of world energy use, 25% of greenhouse gas emissions, and 20% of global water use, eco-friendly construction techniques are crucial for energy conservation. Research findings evaluating the real performance of recently constructed buildings that claim to adhere to green building standards are scarce in Indonesia. Techniques concentrating on lighting, air conditioning, noise reduction, indoor air quality, clean water management, waste management, efficient use of electrical devices, and other sustainable practices can help buildings become more energy efficient. According to the Indonesian Ministry of Public Works and Public Housing, green building principles must be included in all construction projects. The Green Building Council of Indonesia (GBCI) created the Greenship grading system to assess and certify sustainable practices in interior spaces. The important issue of performance discrepancies in recently constructed facilities meant to meet international standards is examined in this research. The Dean's Office at Sam Ratulangi University's Faculty of Engineering performs poorly in key environmental metrics like temperature, humidity, noise levels, and lighting despite Indonesia's efforts to promote green building practices through the GBCI's Greenship rating system. The facility's total performance was below the minimum requirements, highlighting the opportunity to apply sustainable building practices and enhance the environmental performance of Sam Ratulangi University's structures.*

Keywords *- Technical evaluation, Office building, Interior space, Green building, Greenship criteria.*

1. Introduction

Global warming has prompted several nations to implement measures to cut back on fossil fuel-based energy use, especially in the building industry. The use of green building systems is a successful strategy for energy conservation. Optimising lighting systems, improving air conditioning, improving noise insulation, preserving indoor air quality, controlling clean water usage, lowering dependency on electronics, and implementing efficient waste management techniques are just a few ways to make buildings more energy efficient.

Through Regulation Number 02/PRT/M/2015 [1], which describes green building standards, and Regulation Number 21 of 2021 [2], which deals with green building performance assessment, the Ministry of Public Works and Housing in Indonesia requires adopting green construction techniques. Buildings are assessed using the Greenship Rating Tools by the Green Building Council of Indonesia (GBCI) [3], a registered member of the World Green Building Council.

Among these, Greenship Interior Space [4] evaluates elements including waste management, water use, energy efficiency, thermal comfort, lighting, noise levels, and air quality.With an emphasis on compliance with green building principles, this study evaluates the Dean's Building of the Faculty of Engineering at Sam Ratulangi University (FE USR) using the Greenship Interior Space assessment standards. The Dean's Building, which was built in 2020, is essential to overseeing budgets, governance, and educational administration. Sustainable construction methods are anticipated to be further advanced at Sam Ratulangi University by using this building evaluation as a model for incorporating green building concepts into other constructions. Dewa et al. [5], Buyang & Sangadji [6], and Irwan et al. [7] are among the researchers who have used green rating criteria in their studies, mostly evaluating existing buildings. These studies, however, have not expanded their analyses to include interior areas. The Indonesian Green Building Council has created certain standards and criteria for evaluating interior settings to recognise this gap.

This study is unique since it introduces a new methodology and focuses specifically on evaluating interior spaces using these particular criteria. By taking this method, the research is positioned as a noteworthy and inventive addition to the discipline.

2. Materials and Methods

This study uses a descriptive quantitative research method, a methodical way to examine an issue by examining how influencing elements relate to one another and assessing occurrences. Direct observation, interviews, and document analysis are some methods of gathering data. Both direct and indirect techniques are employed throughout the observation process. While direct observations occur on-site, indirect methods-such as mechanical, photographic, or electronic devices-systematically gather the necessary data [8, 9]. Concurrently, interviews are carried out to supplement the observations, giving researchers the opportunity to pose focused queries and acquire a more profound understanding of the information.

Details regarding participants' backgrounds, attitudes, and viewpoints are intended to be gathered through the interview procedure. Focused conversations on crucial subjects are made possible by employing a closed, structured interview style that guarantees that important response components are predetermined. This study includes measurements of the room volume, temperature, humidity, noise levels, and illumination quality. Documentation analysis is a methodical process that involves gathering information from written documents and visual assets, including letters, reports, regulations, diaries, photographs, and sketches. The collected data provides a significant reference for identifying and addressing potential site issues.

The study uses methodical processes, data analysis techniques, and quantitative evaluations to guarantee alignment with the research objectives. The Dean Building at Sam Ratulangi University's Faculty of Engineering is thoroughly inspected to determine whether it satisfies Greenship standards for indoor spaces. The Indicative Post-Occupancy Evaluation analysis approach is applied using the GBCI Greenship Space Version 1.0 [4] as the framework, which identifies important aspects affecting the building's technical parts' efficacy.

The assessment focuses on specific technical components and standards, including:

1. Appropriate Site Development
2. Energy Efficiency and Conservation
3. Water Conservation
4. Material Resources and Cycle
5. Indoor Health and Comfort
6. Building Environment Management

The study results should verify that the structure satisfies the requirements and standards needed for interior spaces to be certified by Greenship. Verification of adherence to established guidelines for project feasibility studies, institutional backing, and financial permission from organisations like the Islamic Development Bank (IDB) and pertinent regional organisations would be done by this conclusion.

The precondition criteria for each category must be met before moving forward with assessments based on credit and bonus criteria. The study shows that these essential conditions have been satisfied, enabling the research and assessment procedures to proceed. Inconsistencies in the area, however, with regard to necessary requirements suggest that the difficulty goes beyond merely earning certification points. Resolving these disparities requires a thorough assessment of the alignment between globally acceptable buildings and the principles of green architecture.

3. Results and Discussion

3.1. Appropriate Site Development

The building manager's explicit implementation of a motor vehicle reduction policy has not met this condition. In assessing Greenship-certified buildings, this non-compliance has been disregarded when evaluating other criteria.

The dean's office of the Faculty of Engineering is situated on campus, providing easy access to associated departments. The ground-floor area of the building is 780 m², with a total surface area of 3,705 m², yielding a Building Coverage Ratio (BCR) of 21%. This ratio indicates considerable potential for the utilisation of the remaining land in accordance with GBCI criteria.

Significantly, 79% of the site area is designated for a parking lot, primarily composed of paving blocks. Only the periphery contains medium to large trees that offer shade. The present site management does not prioritise reducing space designated for motor vehicles, instead indicating a trend towards enlarging parking facilities. The utilisation of paving blocks permits a degree of rainwater infiltration but in a restricted capacity, as illustrated in Figure 1(a).

(a)

(b)
Fig. 1 Block plan and Dean Building of Faculty of Engineering University of Sam Ratulangi (Source: Google Maps, 2024)

To increase user accessibility between the building on the southwest side and the building block on the southeast side, a link has been created. Figure 1a illustrates that the remaining building blocks are isolated and can only be accessed via the paved road. The existing social conditions among stakeholders typically obstruct the advancement of bicycle infrastructure, leading to a dependence on either bicycles or motor vehicles.

The restricted land availability for vegetation poses challenges; nonetheless, the planted trees exhibit a medium to dense canopy, attaining heights of approximately 4-5 meters. These trees are species recognised for attracting various birds, thereby enhancing the area's natural ambience. Only the vicinity of the official parking lot benefits from tree shade.

The building lacks a rainwater harvesting design. Rainwater collected on the roof is directed through pipes that function as closed ditches, channelling it to the city's drainage system. The paving blocks in the parking lot significantly contribute to heat accumulation by absorbing and radiating heat, particularly during daylight hours under intense sunlight exposure.

Upon examination of the GBCI Greenship space version 1.0 requirements, it is evident that the dean's building fails to meet the standard, satisfying only approximately 50% of the criteria, weighing 11.65%.

3.2. Energy Efficiency and Conservation

Establishing an energy conservation campaign and ensuring that all energy-related motions or activities within the facility are stopped is the first step in meeting this criterion. At the moment, metering is the main technique for increasing energy conservation and efficiency. This procedure facilitates energy usage assessment, recognises conservation opportunities, and aids fundamental commissioning tasks. The electrical meter panel of the building is collectively utilised by almost all adjacent structures, leading to an absence of separate metering for each edifice.

In version 1.0 of the GBCI Greenship space calculation, this criterion has a weight of 13.59%, contributing to the Overall Thermal Transfer Value (OTTV) for the dean's building. The building's OTTV was determined to be 38 W/m². Although this result is beyond the SNI 6389:2020 range, it yet signifies a remarkable performance level. The building's façade comprises a greater number of walls than glass windows, resulting in a Wall-to-Window Ratio (WWR) of roughly 30%, especially evident in the southwest and northeast façades. The window-to-wall ratio for the northwest and southeast walls is merely 5%. The air conditioning system is installed throughout the building, excluding designated sections such as restrooms and corridors, which get air from the mezzanine level corridor, as illustrated in Figure 2.

Fig. 2 Hall of Dean Building of FE University of Sam Ratulangi

The central air conditioning system in this building is the theatre room, which has a capacity of 60 PK. A 60 PK system may suffice for common applications; nevertheless, depending on the dimensions and utilisation of the theatre space, it is advisable to verify whether the system is appropriately scaled. Theatre rooms frequently produce excess heat from lighting and audience presence; supplementary cooling or enhanced zoning may be beneficial.

The inaccessibility of the refrigeration unit may provide a substantial limitation in diagnosing issues or enhancing efficiency. Inaccessibility of the unit for maintenance may adversely impact the system's overall energy consumption or performance. Establishing regular maintenance plans may be advantageous, or the refrigeration unit might be relocated if practicable.

Building managers have not met this criterion by explicitly implementing a motor vehicle reduction policy. In the assessment of Greenship-certified buildings, this non-compliance was disregarded when evaluating other criteria. Inadequate control measures may result in inefficiencies. Contemporary systems provide intelligent controls enabling zonal temperature regulation, timers, and integration with occupancy sensors to prevent energy wastage. Upgrading the control systems to more automated and flexible models, potentially incorporating building management systems (BMS) for centralised monitoring and adjustment, may prove advantageous.

LED technology is used to design artificial lighting with energy-saving features, a clear way to improve energy efficiency. In comparison to conventional lighting alternatives, LEDs exhibit reduced power consumption and an extended lifespan. The room designs could additionally integrate enhanced task lighting or daylight harvesting systems that modulate artificial illumination according to the availability of natural light. The lighting control system has a deficiency in its self-regulation mechanism, resulting in suboptimal energy use. Integrating occupancy sensors, daylight sensors, and adjustable lighting may mitigate superfluous energy consumption, especially in areas that are not consistently occupied. Furthermore, centralising control via a smart lighting system or combining it with the MVAC could enhance overall building efficiency.

Under clear-sky circumstances, the rooms benefit from natural light. Integrating automated shade systems could enhance daylight utilisation, especially in tropical or humid settings where sunshine intensity varies. This method can sustain a uniform indoor lighting ambience without reliance on artificial sources. Furthermore, employing smart glass or adjustable blinds may effectively control the influx of natural light into the area.

Table 1. Lighting in buildings (lux)

Room	Hour		
	10.00	13.00	15.00
Lobby	560	190	60
Library	365	285	362
Vice Dean room	524	525	510
Hall	130	135	103
Lecturers room	572	378	365
Dean Room	104	168	120

Table 1 demonstrates that, during the measuring period, specific lights met the standard, particularly those surpassing 350 lux and marked in light green, while others did not comply. The low WWR number suggests that the design probably did not integrate enough lighting combinations from the beginning despite some lights being on during measurements.

The electrical equipment employed is generally traditional, indicating a deficiency in understanding green building concepts. Of the energy efficiency and conservation requirements, almost 40% match the GBCI Greenship standards in version 1.0.

3.3. Water Conservation

Campaigns to conserve water have not been carried out with any discernible indication of thorough effort. Standards have not been followed when evaluating the building's facilities and conditions. Under the specified conditions, the building is strategically elevated approximately 70 cm above the road, guaranteeing that the structure stays unscathed even during recurrent flooding-when the nearby street becomes a tiny waterway. This environmental issue profoundly affects the entire campus vicinity, chiefly because of the absence of a functional drainage system.

The building's design did not include a rainwater gathering reservoir. A deep well functions as the water supply, with the pump elevating water to the top tank situated on the fifth level of the building. Nonetheless, the pump often experiences difficulties while functioning over its capacity, leading to its inability to elevate water.

The main water use strategy is choosing washbasin faucets, kitchen faucets, valve tanks, and flush valves that use less water and comply with standard water consumption guidelines, as illustrated in Figure 3 and Table 2.

Fig. 3 Toilet and washroom conditions

The GBCI of the interior space gives this water conservation criterion a weight of 7.77%, which indicates that it is important. The water output devices utilised in the restrooms and restrooms are the source of the information supplied here.

Table 2. Water usage data and a list of lavatory and WC equipment

Types	Brand/Type	Water amount
WC flush valve	Toto/CW705ELNJ	6 l/flush
WC flash tank	Toto/CW637J	3,3 l/flush
Closet flush valve	Toto/U57K	0,5 l/flush
Sink faucet	Toto/LW587J	4 l/mnt
Wall faucets	Toto/ TX133L	5 l/mnt

The water provided to each washbasin tap is non-potable. Upon initial consideration, with a roof area of around 780 m² and maximum rainfall reaching 129 mm, typically occurring in January, the average number of wet days is 17.8 [11]. Leveraging this potential can diminish rainfall flow from the roof to the garden or urban areas, thereby alleviating the strain on infrastructure.

3.4. Material Resources and Cycle

The building's structural system is primarily made of reinforced concrete, according to the available documents. It is important to note that there are no prefabricated components present on the site, most likely because there is an abundant supply of construction materials such as sand and stone. The funder is the one who determines the policy for the procurement of materials, and USR must then give their consent. For reinforcement, the island of Java is usually the supplier of steel and cement. The local cement industry, especially Conch, had not reached mass production levels at that time.

The flooring features ceramic tiles, and the paint used is environmentally friendly typically free from ammonia and other harmful substances. Nonetheless, the process does not include recycled or previously utilised materials. Equipment and supporting materials are sourced solely from Java, highlighting the necessity of assessing carbon emissions and embodied energy linked to these materials. Currently, no thorough evaluations of carbon emissions or embodied energy are being carried out. Furthermore, legally certified sales outlets provide wood that is frequently utilised without the necessary certification.

To conform to the work plan and conditions, a consistent waste management strategy is implemented during the development and operationalisation phases. This policy incorporates a waste segregation system, which remains an ongoing practice. Refrigeration systems, especially those utilising refrigerants with zero ozone depletion potential, have become vital elements in industrial and building operations. Notwithstanding the building's endeavours, it has not completely satisfied the GBCI Greenship Interior Space standards in version 1.0, despite this criterion holding a substantial assessment weight of 27.18%, the second highest among all criteria.

3.5. Indoor Health and Comfort

According to the interior GBCI standard, indoor comfort and health are the most important factors, making up 28.16% of the total score. This criterion encompasses numerous essential elements, including:

Notwithstanding the extensive acknowledgement of the smoke-free initiative by all building residents, a minority persists in smoking indoors. The structure is devoid of conspicuous signage pertaining to the smoking prohibition and fails to offer designated smoking zones externally.

The integration of outdoor air is contingent upon the design of the air conditioning system, necessitating the strategic placement of clean air entrance points away from sources of pollution. This requires a comprehensive examination, especially about the predominant indoor activity.

CO_2 sensors, essential for tracking and controlling CO_2 concentrations and air quality in compliance with health regulations, are absent from rooms with manufactured air conditioning systems. Management of pollution sources in the region, encompassing chemical and biological contaminants, is achieved by situating garbage receptacles in less conspicuous locations.

Nevertheless, existing waste sources, excluding food waste, do not substantially affect the ecosystem. No precise methods or strategies exist for regulating sources of chemical and biological contaminants.

The correlation between visual comfort and lighting levels, as previously delineated, is substantial. Certain rooms remain inadequate in meeting lighting regulations, resulting in visual discomfort, particularly during indoor activities. The presence of external vistas and natural illumination significantly contributes to increased productivity. Most rooms surrounding the dean's building are externally viewable and enjoy natural illumination. Although the glass partition in the corridor diminishes light intensity, some still manage to permeate. Thermal and acoustic comfort levels were methodically assessed in several rooms, with the findings presented in Table 3.

Table 3. Measurement of air temperature (°C)

Room	Hour		
	10.00	**13.00**	**15.00**
Lobby	28	28,5	27,6
Library	25,7	26	27
Vice Dean room	26,6	26,7	27,5
Hall	na	27,9	27,8
Lecturers room	26,7	27,6	27,8
Dean Room	27,6	26,4	25,2

na: not available

The average air temperature in the room surpasses the established standard, as shown in Table 4 and measured with the instrument depicted in Figure 4, even though all interviewees reported feeling comfortable in these conditions. The comfort declaration encompasses the entire room, likely attributable to the functioning of the air conditioning system and the regulated air humidity levels.

Fig. 4 Instruments used

Table 4. Noise Level (dB)

Room	Hour		
	10.00	13.00	15.00
Lobby	57	58	53
Library	53	50	53
Vice Dean room	59	53	54
Hall	na	64	63
Lecturers room	49	62	65
Dean Room	48	51	54

In light of the fact that the room was located in a public building subject to a significant amount of foot traffic, the findings of the complete assessment revealed that it did not meet the requirements for noise levels. Even though it was at a low level, the hissing sound was caused by the air conditioning system that previously existed.

3.6. Building Environment Management

Adopting green innovations and initiatives, environmentally friendly fit-out activities, including a Greenship Associate or Greenship Professional as a team member, and green concept training are all requirements for establishing environmental management. Since the opening of the dean's building, there has not been a single activity that has satisfied these requirements.

Other ancillary events occur on historic occasions, such as the faculty's anniversary, including environmentally orientated projects like tree planting. This criterion fails to satisfy the 11.65% weight requirement. The demand can be met through operational automation and efficient building management.

4. Conclusion

Although it complied with international building standards during auctions or international bidding, the Dean's Building at Sam Ratulangi University (FE USR) did not fully fulfil the green building principles for interior spaces. This was the case despite the fact that it complied with international building standards. Due to the fact that only a small number of the requirements have been satisfied, the GBCI standards cannot be used as a valid benchmark for the design or administration of this building. Even those requirements do not meet the expectations that were set for them. Enhancing stakeholder awareness is crucial for attaining compliance with sustainable construction requirements. The tenets of sustainable development, which correspond with green construction methods, must be well embedded. This procedure necessitates considerable work, particularly through additional research into green construction components specifically adapted to the local context and environment.

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