

Challenges of implementing the green building concept in Mosques

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ARTICLE INFO	ABSTRACT
<p><i>Article history:</i> Received December 12, 2023 Received in revised form Feb. 08, 2024 Accepted March 18, 2024 Available online April 01, 2024</p> <p><i>Keywords:</i> Green building Mosque Rahmatan lil Alamin</p> <p>*Corresponding author: Sahid Department of Architecture, Faculty of Engineering, Universitas Katolik Parahyangan, Indonesia Email: sahid@unpar.ac.id ORCID: https://orcid.org/0000-0002-2249-078X</p>	<p>The Republic of Indonesia's Ministry of Religion reports more than 700,000 mosques in the country. Insufficient research has been conducted concerning this mosque-turned-building, particularly regarding how it may help the country accomplish its environmental commitments. The Istiqlal mosque received a green building assessment certificate (Excellence in Design for Greater Efficiency) from the International Finance Corporation in April 2022. This certificate should serve as a foundation for future research into the distinctive features of mosque building designs in Indonesia and their potential to contribute to accomplishing national environmental targets. Mosque buildings as an embodiment of the concept of Rahmatan Lil Alamin or mercy for all of nature should be in line with the concept of green buildings which strive to preserve nature. This research aims to determine the challenges of implementing the green building concept in mosque buildings with a case study of two mosques in the city of Bandung. To identify their traits, this study employed observational methods, case studies, and interviews with mosque managers. The Minister of Public Works Regulation Number 21 of 2021 about Green Building Performance Assessment will be employed to examine and assess the gathered data. The outcomes demonstrate that the low-performance value persists. Considerable work is required to achieve the desired results. In-depth talks with stakeholders are also required to map the distinctive qualities of mosque structures and identify methods in which they can support the realization of national environmental preservation objectives while also exemplifying the principles of Rahmatan lil Alamin.</p>

Introduction

The Government of the Republic of Indonesia has committed to reducing greenhouse gas (GHG) by its efforts by 26% by 2020 (Bakar 2021). Furthermore, this commitment was stated in the Nationally Determined Contribution document at the end of 2016 (Bakar 2021). The document sets a target of 29% (unconditional) or an emissions reduction target of 834 million tons of CO_{2e}

compared to business-as-usual conditions. The Republic of Indonesia government anticipates contributions from all parties involved to reach this objective.

The property industry may contribute to reaching the NDC target by implementing the Green Building idea into practice. The Green Building Council Indonesia was established in 2009 by several practitioners and academics, and the GreenShip Rating Tools were first introduced



in 2010 (GBCI 2010). These actions represented the beginning of the concept's application. Governments at the federal, provincial, and local levels are also working to achieve the NDC targets by enacting laws about green buildings. Governor regulations were initially approved by DKI Jakarta Province in 2012. The Bandung City Government passed Mayor regulations in 2016, and the Semarang City Government established Mayor regulations in 2019. The Central Republic of Indonesia Government has also contributed by enacting Regulations on Green Buildings in 2015 and 2021. Apart from that, other parties have also introduced green performance assessment, for example, the International Finance Corporation with EDGE (Excellence in Design for Greater Efficiencies) software, then the University of Indonesia with Green Metric and Semarang State University with UNNES Green School Ranking.

The idea of a green building is essential not only for design but also for construction, use, and demolition. According to Williams (2007), careful considerations need to be generated, including the production process for the elements. Understanding the local climate and conditions, conserving energy, employing the right technology, and utilizing renewable energy sources must all be incorporated into the green building idea (McLennan 2004). In addition, according to Bougdah and Sharples (2010), the green building idea requires to reduction of negative environmental effects, promotes comfort and health, and is cost-effective throughout the building's life cycle (Bauer et al. 2007).

Green buildings concept aim to reduce the harmful effects of a building from the planning stage until demolition (Zainul Abidin 2010; Nugroho 2020). Investment costs for green buildings should not be significantly different from those of conventional (Kats 2003) in fact, they may be negligible when weighed against the advantages they provide (Morris 2007). According to Addis and Talbot (2001), green buildings aim to use as few resources as feasible, which includes consuming only a minimum energy as possible (Hegger et al. 2012).

Minister of Public Works Regulation Number 21 Year 2021 concerning green building performance assessment has attempted to accommodate the various criteria mentioned above. The criteria include site, water energy, air quality, materials, waste, and waste. The assessment also covers the entire life cycle of the building from planning to demolition.

The building functions that have been targeted to achieve the NDC have been extremely varied thus far. For instance, the DKI Jakarta Provincial Government is placing more emphasis on 'big' building such as offices, shopping malls, and residential buildings both new and old. The municipal governments of Bandung and Semarang are focusing on all building functions, including residential functions, within their administrative regions due to their recognition of the physical state of their cities. UNNES Green School, as the name implies, focuses on the operation of school buildings, whereas UI Green Metric concentrates on campus services.

The religious function of mosques is a building type that does not receive enough attention, despite being fairly popular in Indonesia. The Regional Office of the Ministry of Religion of the Republic of Indonesia stated that currently there are 741,991 places of worship for followers of Islam in Indonesia, with details of 296,797 mosques and 445,194 prayer rooms (kemenag.id). The government has started an initiative by promoting Eco Mosque through the Indonesian Ulama Council (MUI) and the Indonesian Mosque Council (DMI). However, until now the MUI and DMI have not provided adequate guidelines for mosque managers so that they can be certified green. Due to these limitations, the Istiqlal Mosque used the Edge-IFC assessment to obtain a green building certificate.

Green mosque initiatives have been attempted by many parties. Among these is the Green Mosque Initiative's campaign to install solar panels in several sizable mosques across the globe. Greenpeace, the Ummah for Earth Organization, the Lebanese Foundation for Renewable Energy, the National Council for Scientific Research, and the American University of Beirut all support this effort. Installing solar panels as a means of utilizing renewable energy has been done in some nations, including South Africa, Syria, Saudi Arabia, Pakistan, Scotland, Egypt, Morocco, and Algeria. The Istiqlal Mosque was selected for photovoltaic installation with 1306 kWh/kWp power output capacity (Greenpeace 2022).

In principle, Islam is on the side of the environment. Islam should be a blessing for the entire universe (Rahmatan Lil Alamin) according to what is stated in the Al-Qur'an, Surah Al-Anbiya' verse 107. According to Quraish Shihab, this verse can be interpreted as meaning that

Muslims should respect other people and respect the universe by preserving and protecting it from damage. This role is given to humans because humans have the task of being God's representatives to lead and manage this universe (Anshori 2016).

If the concept of Rahmatan Lil Alamin is also extended to mosque as places of worship for muslims, then the mosque should not only be beneficial for muslims but can also be beneficial for the whole of nature. When mosques have a role to contribute to all of nature, then the mosque should be in accordance with green building concept or should become an environmentally friendly building.

For mosque, efforts to be pro-environment can be translated into site design concepts (Fikriarini, Larasati, and S. 2021) and building design. (Nurjayanti and Nugrahaini 2023). Environmental support in building design can be exhibited by using eco-friendly materials (Nurjayanti and Nugrahaini 2023) and making effective use of water and energy (Fikriarini, Larasati, and S. 2021). It is possible to use passive or active energy-saving techniques in mosque buildings (Harsritanto et al. 2021).

While passive methods can be implemented through the implementation of air conditioning, lighting, and water management installations, passive strategies may additionally be utilized through the use of natural lighting and ventilation (Bakri 2018; Sobri et al. 2021). Furthermore, passive techniques have been utilized through the orientation of buildings and the elaboration of the building envelope with the use of innovative facade designs and flora on roofs (Danish, Shukri, and Taib 2023). Energy-saving efforts can also be made by arranging the layout and interior elements as well as regulating occupant behavior that supports the implementation of energy-saving principles (Adi 2016).

Furthermore, environmentally friendly efforts in mosque buildings can also be implemented through waste management (Ramadhan et al. 2019) and the use of local architectural features that take into account local climate conditions and utilize local materials (Omar et al. 2018). Decision-makers can choose other implementation options which are quite numerous and varied (Hidayat, Danuri, and Purwanto 2018). The obstacles encountered are increasing construction prices and a lack of understanding and willingness to implement green building concepts (Mat Yamin 2021).

The large amount of Mosque in Indonesia offers exceptional opportunities to apply the green building approach. Since the numbers are so substantial, the impact must be significant, regardless of the size of the accomplishment. This necessitates a more thorough analysis of its physical attributes, particularly those connected to the green construction idea.

Methods

Data was collected through observation and interviews. Observation of research objects by taking photos, measuring and describing. This observation is used to find out in detail the design of the mosque building. The daily activities that take place at the research object are also ascertained through observations. Lux meters, thermometers, anemometers, and hygrometers were additionally employed to assess the comfort performance of existing buildings. When assessing mosque administrators' green performance, observation data is completed through interviews.

Data that will be used in the evaluation process later on are analyzed and grouped during the analysis process. To conduct the evaluation, the gathered data was compared to the green construction standards specified in Minister of Public Works Regulation number 21 Year 2021. Conclusions regarding the performance of the green buildings in the two case studies can be generated based on the evaluation data. The Al Ukhuwah and Istiqamah Mosques were chosen as samples in this research because they meet several criteria, including, the buildings were designed by architects, having land more than 4000 m², and being easy to reach by the congregations. These criteria mean that the mosque was deliberately designed with certain concepts; land area is not a limitation in the design process; the mosque has enough resources to implement the green building concept; and the mosque is known to many people and is used by congregations with varied backgrounds.

Results and discussion

Description



Figure 1. Front view of the Istiqamah Mosque in Bandung

The Istiqamah Mosque ([figure 1](#)) is located at Jalan Taman Citarum, Bandung City, West Java. This building was built in 1969 and designed by Ir. Achmad Noe'man and Ir. Gustaf Abbas. This mosque occupies an area of 5.200m² and a building area of 4.300m². The mosque is located on the ground and mezzanine floors, while the school is located on the semi-basement floor and the mosque management is located next to the mosque.

Al Ukhuwah Mosque ([figure 2](#)) is located on Jalan Wastu Kencana No. 27 Bandung City, West Java. This mosque was designed by H Keulman and built in 1998. This building stands on an area of 4.400m² and has a building area of almost 4.000m².



Figure 2. Front view of the Al Ukhuwah Mosque in Bandung

Site Management

According to [Permen PU 21 of 2021](#), Site Management criteria include:

- Building orientation
- Site development includes accessibility or circulation

- Development of land contaminated with hazardous and toxic waste (B3)
- Private green open space (RTH) plan
- Provision of pedestrian paths
- Basement design
- Provision of parking space
- Outdoor lighting system
- Construction of buildings above/underground, water/infrastructure/public facilities

Both mosques can meet all of the requirements for this criterion, except for C and I. Mosque structures are frequently designed so that the main prayer chamber is square and has a terrace, porch, or other supporting elements on the north, east, and west sides. In addition to serving as a conduit, the porch prevents heat from directly entering the main portion. The western wall of mosques regularly becomes closed off because it serves as a Mihrab. Preventing heat from entering the building during the day and night is an additional advantage of this. The two mosques cannot fully meet the criteria for a maximum orientation angle of 15 degrees because the mosque building is directed towards the Qibla whose angle exceeds this requirement.

From the criteria for roof covering and pavement, the two mosques have not considered the albedo factor or the value of sunlight reflection. When the mosque was designed and built, this factor was not widely discussed among planners. The building also has not prepared itself to harvest the rain water. This is proven by the unavailability of reservoirs or infiltration wells for rainwater at the two mosques.

Both structures have less space for greenery and more pavement than soil. Mosques are considered to benefit from having pavement because it may hold worshippers who cannot fit inside the main building. Vegetation inside the mosque area was not selected by its ability to give shade to surrounding area. Mosque The mosque actually uses the shade obtained from large trees planted on the side of the road by the government.

Both mosques are easily accessible from different areas of the city. Congregants have many mass-transportation options to get to both mosques. There are also sufficient pedestrians to reach the mosque location the mosque area is also very open for use by the community, including non-Muslims.

Both buildings have basements and their uses vary from being used only for education

(Istiqamah) to being used for management offices, meeting rooms, and vehicle parking (Al Ukhuwah). Parking allocation for both two- and four-wheeled vehicles is still very limited for the two mosques. Parking is forced to overflow onto the streets around the building during Friday prayers, Eid prayers, or when there are other large activities. This of course causes traffic jams and disrupts people's activities. The following tables are the points obtained by each mosque for site development criteria.

Table 1. Criteria points for Istiqamah Mosque site

SITE MANAGEMENT				
No	Aspects and Criteria	Max Value	Value	%
1	Building orientation	2	1	50
2	Accessibility	6	1	16,67
3	Ex-B3 land	3	0	0
4	Green open space	6	1	16,67
5	Pedestrian path	4	4	100
6	Basement site	1	1	100
7	Parking lot	10	2	20
8	Outdoor light	1	0	0
9	Building above and /or underground, water, infrastructure	5	0	0
Point Total		38	10	26,32

Table 2. Criteria point for Al-Ukhuwah Mosque site

SITE MANAGEMENT				
No	Aspects and Criteria	Max Value	Value	%
1	Building orientation	2	1	50
2	Accessibility	6	3	50
3	Ex-B3 land	3	0	0
4	Green open space	6	4	66,67
5	Pedestrian path	4	4	100
6	Basement site	1	1	100
7	Parking lot	10	1	10
8	Outdoor light	1	0	0
9	Building above and/or underground, water, infrastructure	5	0	0
Point Total		38	14	36,84

Energy efficiency

According to Minister of Public Works Regulation 21 of 2021, energy efficiency criteria include:

- a. Building Envelope
- b. Ventilation System
- c. Air Conditioning System
- d. Lighting System
- e. Transportation Systems inside Buildings
- f. Energy Efficiency Calculations
- g. Electricity system

In the energy section, both mosques are designed with many openings and/or transparent walls. This allows for savings because mosque can take advantage of natural lighting and ventilation. However, at the same time, this can result in the heating of the building.

Based on the data, the temperature and humidity levels within the building are generally still within comfortable area. The wind blows extremely slowly, and it occasionally seems to not exist at all in other areas. When the mosque is completely crowded the staf will turn on the fans positioned throughout the building to ensure that the congregation feels comfortable. In the future, the management consider replacing the fan with air conditioning (AC). For now, only the management and education rooms of both mosques have utilized air conditioning.

Both mosques have not used energy-saving lamps to reduce energy consumption; have not used additional meters to record energy consumption for each building function; have not used light sensors or user sensors for savings; and have not used renewable energy sources. The following tables are the points each mosque received for energy efficiency.

Table 3. Istiqamah Mosque energy criteria points

EFFICIENCY USE OF ENERGY				
No	Aspects and Criteria	Max Value	Value	%
1	Building envelope	9	9	100
2	Ventilation	3	3	100
3	Air conditioning	7	7	100
4	Lighting	12	0	0
5	Transportation	3	3	100
6	Energy efficiency	5	0	0
7	Electricity	7	0	0
Total		46	22	47,83

Table 4. Al-Ukhuwah Mosque energy criteria points

EFFICIENCY USE OF ENERGY				
No	Aspects and Criteria	Max Value	Value	%
1	Building envelope	9	9	100
2	Ventilation	3	3	100
3	Air conditioning	7	7	100
4	Lighting	12	4	33,33
5	Transportation	3	2	66,67
6	Energy efficiency	5	0	0
7	Electricity	7	0	0
Total		46	25	54,35

Water efficiency

According to Minister of Public Works Regulation 21 Year 2021, water efficiency criteria include:

- a. Water sources
- b. Water usage
- c. Use of water saving sanitary equipment

The Regional Drinking Water Company (PDAM) provides the water used by Al-Ukhuwah Mosque. However, as the requirements of the congregation developed, the mosque management decided to add water sources from deep wells because of the finite availability of clean water and the inconsistent quality of water supplied by PDAM. On the other side, the Istiqamah mosque has not made use of PDAM facilities and has instead relied on deep wells since its founding. The two mosques have not yet employed water meters to record how much groundwater they consume daily.

Until now, the two mosques have not utilized rainwater as an alternative water source, even though the potential for utilizing rainwater is quite large in the city of Bandung. The two mosques also have not utilized recycled water as an alternative water source even though the Indonesian Ulama Council since 2010 has encouraged the use of recycled water for worship.

On the water usage side, the two mosques do not use water-saving sanitary equipment and do not utilize water meters to measure water needs in various spaces. The ablution water faucets and bathroom faucets still use ordinary water faucets so water savings still depend on the behavior of the mosque congregation. The following tables are the points each mosque received for water efficiency criteria.

Table 5. Istiqamah Mosque water criteria points

EFFICIENCY USE OF WATER				
No	Aspects and Criteria	Max Value	Value	%
1	Water sources	13	1	7,69
2	Water usage	4	0	0
3	Economical sanitary ware	5	0	0
Total		22	1	4,55

Table 6. Al-Ukhuwah Mosque water criteria points

EFFICIENCY USE OF WATER				
No	Aspects and Criteria	Max Value	Value	%
1	Water sources	13	1	7,69
2	Water usage	4	0	0
3	Economical sanitary ware	5	0	0
Total		22	1	4,55

Indoor air quality

According to Minister of Public Works Regulation 21 of 2021, indoor air quality criteria include:

- a. Smoking ban
- b. Control of carbon dioxide and carbon monoxide
- c. Refrigerant control

Neither mosque has any signage prohibiting cigarette smoking, it is unusual to see members of the congregation smoking. Although there are no designated smoking areas, it is occasionally seen that some worshippers smoke in the mosque courtyard. Smoking congregations are becoming less common at these two mosques without prohibition notice, perhaps due to increased awareness of the dangers of smoking in public places, especially mosques.

To control CO₂ (carbon dioxide) and CO (carbon monoxide), the two mosques have not installed sensors. The area that accommodates the most worshipers is the prayer area. In this section, both mosques have fairly high ceilings (figures 3 and 4) and have sufficient ventilation openings so that the congregation still does not feel stuffy even though the room is fully occupied. Meanwhile, the room that has the potential for CO to arise is in the semi-basement, namely the car and motorbike parking area. At the Al-Ukhuwah mosque, the semi-basement floor is a semi-open area. Natural ventilation or fresh air input is very possible, thus, the potential for high CO levels appears to be very minimal.

Air conditioning (AC) equipment is only used in a small part of the space, namely the management room and meeting room or conference room. The AC system used is a split AC with R-32 refrigerant type. This type of refrigerant meets the ODP (Ozone Depletion Potential) value = 0, but the GWP (Global Warming Potential) value is still <700 so it does not meet the specified criteria.



Figure 3. Interior view of the Istiqamah Mosque in Bandung



Figure 4. Interior view of the Al Ukhuwah Mosque in Bandung

The following tables are the points each mosque received for indoor air quality criteria.

Table 7. Istiqomah Mosque air quality criteria

INDOOR AIR QUALITY				
No	Aspects and Criteria	Max Value	Value	%
1	Smoking prohibition	5	0	0
2	CO ₂ and CO	9	0	0
3	Refrigerant	10	0	0
Total		24	0	0

Table 8. Al-Ukhuwah Mosque air quality criteria points

INDOOR AIR QUALITY				
No	Aspects and Criteria	Max Value	Value	%
1	Smoking prohibition	5	0	0
2	CO ₂ and CO	9	0	0
3	Refrigerant	10	5	50
Total		24	5	20,83

Use of environmentally friendly materials

According to Minister of Public Works Regulation 21 Year 2021, the criteria for environmentally friendly materials include:

- Controlling the use of hazardous materials
- Use of environmentally friendly certified materials

Although both mosques have been operational for almost 30 years, no particular documentation about their usage of eco-friendly materials could be located. However, it was discovered through interviews with the two mosques' administrators that the construction materials came from the surrounding Bandung area. No materials are imported from overseas or from other parts of the island.

There is insufficient information in the comprehensive material specifications for materials that present a health risk to building

occupants or certified ecologically friendly materials. The points that each mosque earned for fulfilling the requirements for utilizing eco-friendly materials are provided below.

Table 9. Istiqomah Mosque material criteria points

ENVIRONMENTAL FRIENDLY MATERIAL				
No	Aspects and Criteria	Max Value	Value	%
1	Hazardous	6	0	0
2	Friendly materials	15	0	0
Total		21	0	0

Table 10. Material criteria points for the Al-Ukhuwah Mosque

ENVIRONMENTAL FRIENDLY MATERIAL				
No	Aspects and Criteria	Max Value	Value	%
1	Hazardous	6	2	0
2	Friendly materials	15	0	0
Total		21	2	9,52

Waste management

According to [Permen. PU. 21 of 2021](#), waste management criteria include:

- Application of the principle of reduce, reuse, recycle
- Implementation of a waste handling system
- Implementation of a waste generation recording system



Figure 5. Waste sorting program at the Al Ukhuwah Mosque in Bandung

Both mosques have attempted to implement the principle of waste segregation, although the management is not yet strict. Garbage is collected in a certain place and then taken regularly by waste officers. Waste has also not been recorded and weighed so the daily volume of waste is not yet known with certainty. The following tables are the points obtained by each mosque for waste management criteria.

Table 11. Istiqomah Mosque garbage criteria points

GARBAGE MANAGEMENT				
No	Aspects and Criteria	Max Value	Value	%
1	Implementation of 3R	1	1	100
2	Waste system	5	2	40
3	Note the Occurrence	1	0	0
Total		7	3	42,86

Table 12. Al-Ukhuwah Mosque garbage points

GARBAGE MANAGEMENT				
No	Aspects and Criteria	Max Value	Value	%
1	Implementation of 3R	1	1	100
2	Waste system	5	2	40
3	Note the Occurrence	1	0	0
Total		7	3	42,86

Waste management

According to [Permen. PU. 21 of 2021](#), waste management criteria include:

- a. Provision of waste management facilities
- b. Recycle water from domestic waste

Without any pre-treatment, the gray water from the Istiqomah Mosque is directed straight into the heart of the city. First, the black water is gathered in a septic tank, where it is routinely emptied. The generated black and gray water at the Al-Ukhuwah Mosque, however, is currently directed straight into the city's river basin because septic tank installation is not currently possible there. The points that each mosque received for meeting the waste management criteria are listed below.

Table 13. Istiqomah Mosque waste criteria points

WASTE MANAGEMENT				
No	Aspects and Criteria	Max Value	Value	%
1	Processing waste	7	4	57,14
2	Recycled water	5	0	0,00
Total		12	4	33,33

Table 14. Al-Ukhuwah Mosque waste criteria points

WASTE MANAGEMENT				
No	Aspects and Criteria	Max Value	Value	%
1	Processing waste	7	1	14,29
2	Recycled water	5	0	0,00
Total		12	1	8,33

The following tables is a recapitulation of the points obtained by each mosque for all green building assessment criteria according to Minister of Public Works Regulation No. 21 Year 2021.

Table 15. Recap of Istiqomah Mosque points

No.	Aspects and criteria	Max value	value	%
1	Footprint	38	10	36,8
2	Energy	46	22	54,3
3	Water	22	1	4,5
4	Air quality	19	0	20,8
5	Material	21	0	9,5
6	Rubbish	7	3	42,8
7	Waste	12	4	8,3
Total points		165	51	30,9

Table 16. Recap of Al-Ukhuwah Mosque Points

No.	Aspects and criteria	Max value	value	%
1	Footprint	38	14	36,8
2	Energy	46	25	54,3
3	Water	22	1	4,5
4	Air quality	19	5	20,8
5	Material	21	2	9,5
6	Rubbish	7	3	42,8
7	Waste	12	1	8,3
Total points		165	51	30,9

The total points obtained by the two mosques were still relatively low, encompassing 40 and 51 out of the 165 points provided. The number of points still does not meet the minimum points that should be obtained to meet the criteria for a green building, which are 75 points.

Challenge

To fulfill the criteria of Minister of Public Works Regulation 21 of 2021, future mosque designs need to consider the following:

- a. On-site management criteria
To assess the exterior and determine the building's direction, mosque design must consider sun orientation. Green spaces are required to be preserved by mosques following laws, and trees with broad crowns are necessary to grow there. Mosques must restrict the amount of pavement to comply with laws and maintain albedo levels.
- b. On energy efficiency criteria
Mosques need to minimize energy use by using energy-saving equipment, sensors, and automatic switches. Mosques also need to accept the presence of renewable energy to replace some of the energy used in the mosque. Mosques are expected to avoid using air conditioning and continue to utilize natural ventilation. The presence of a porch is still needed as a buffer for heat entering the building.
- c. On water efficiency

Mosques need to avoid using water from deep wells by utilizing communal water supply facilities, rainwater and recycled water. Mosques also need to utilize water-saving sanitary ware and water meters to monitor water distribution.

- d. On indoor air quality criteria
Mosques need to maintain the air quality inside the mosque by minimizing or even eliminating cigarette smoke, carbon dioxide, and carbon monoxide through natural and artificial ventilation.
- e. On environmentally friendly material criteria
Mosques are encouraged to use local and certified environmentally friendly materials.
- f. On environmentally friendly material criteria
Mosques are encouraged to record waste generation while preparing efforts to reduce, reuse, and recycle the waste they produce.
- g. On waste management criteria
Mosques are encouraged to prepare simple waste processing facilities or utilize waste channels provided by the government. Mosques need to prepare recycling facilities so that waste can be reused.

Conclusions

In general, the achievement of green building performance under Minister of Public Works Regulation No. 21 Year 2021 for the two case studies is still relatively low. Future mosque architects and managers need to be encouraged to implement the various criteria stated in the regulation as part of efforts to embody the Rahmatan lil Alamin principles and help realize the government's targets in the environmental sector.

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Sahid contributed to the research concepts preparation, methodologies, investigations, data analysis, visualization, and revisions.

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