Reinterpreting Mosque Design with Basic Principle Rahmatan Lil'alamin

Andry Widyowijatnoko[1]

[1] School of Architecture, Planning and Policy Development, Institut Teknologi Bandung, Bandung 40132, Indonesia
andry@itb.ac.id

Abstract. Mosques in Indonesia are dominated by the use of domes, which are widely believed to be a representation of Islamic architecture. However, the history of dome use is inseparable from the reason of wide-span technology. Unfortunately, the tradition passed down from generation to generation is its form, not the essence of its wide-span technology. In fact, the inappropriate use of domes caused the destruction of many mosques during the earthquakes in Lombok and Palu in 2018. In designing mosques, architects should adhere to the basic principle of the descent of Islam, which is to provide mercy for the universe (rahmatan lil'alamin). This principle is translated in the design and construction of the Annur Aceh Mosque in Lombok and the Nurulhasanah Aceh Mosque in Palu in terms of wide-span technology to prevent interruptions in prayer lines, empower the local economy, and use natural materials to reduce emissions and even act as a carbon sink. This paper aims to reveal the design approach taken and explain the various challenges encountered during the construction of the two mosques..

Keywords: Mosque, Rahmatan lil'alamin, Timber, Bamboo.

1 Introduction

1.1 Mosque Design: Reinterpreting the Use of Dome

The prevailing notion that the dome is the quintessential architectural element of Islamic mosques is a misconception that requires deeper examination. This perception stems from the prominence of domed structures in iconic Islamic landmarks like the Dome of the Rock, but it fails to capture the true diversity and evolution of mosque design across the Muslim world. Please note that the first paragraph of a section or subsection is not indented.

Architects have often been asked to incorporate domes in the design of mosques, perpetuating the belief that this architectural feature is a mandatory component. However, a closer look at the rich tapestry of mosque architecture reveals that the dome is just one of many distinct styles that have emerged in response to local traditions, environmental factors, and the changing needs of Muslim communities [1]. Mosques have long been shaped by the complex interactions between religious, cultural, and environmental elements. As urbanization accelerates, the mosque's role has expanded beyond

S. Murtiyoso et al. (eds.), *Proceedings of the International Conference on Religious Architecture (ICRA 2024)*, Advances in Social Science, Education and Humanities Research 923,
https://doi.org/10.2991/978-2-38476-420-4_21

its traditional functions, becoming a vital hub for social, educational, and even political activities within modern cities. Consequently, as the Muslim population grows and becomes more urbanized, the design of mosques must evolve to address the changing needs and expectations of their congregations [2]. The evolution of mosque architecture has been shaped by a rich tapestry of cultural, religious, and technological influences. Globally, the use of domes in mosque design has historical significance, as these structures were often associated with grandeur, stability, and the celestial symbolism of the heavens. In Indonesia, the widespread adoption of dome-based mosque architecture can be traced back to the influence of Ottoman and Mughal architectural traditions, which were introduced during the colonial era. The technological advancements in dome construction, particularly the development of wide-span techniques, have been instrumental in the dominance of this design approach, as they have enabled the creation of expansive, uninterrupted prayer spaces. The use of domes in architecture has often been associated with the desire to achieve wide-spanning, column-free spaces, an aspiration that has driven the evolution of dome construction techniques [3].

While the dome-centric design of mosques in Indonesia has become a recognizable aesthetic, it has also posed significant challenges, especially in the context of natural disasters and environmental sustainability. The structural vulnerabilities of conventional dome structures have been exposed in earthquake-prone regions like Lombok and Palu, where these buildings have suffered extensive damage. One case occurred at the Nurulhasanah Mosque in Palu, where a single concrete column was installed in the center of the mosque to support the concrete dome. This column disrupted the prayer rows and obstructed the view of the Imam from several points within the mosque. When the earthquake struck in 2019, this column was severely damaged due to the pendulum effect.

Moreover, the heavy reliance on concrete and other energy-intensive materials in mosque construction has raised concerns about the environmental impact of these structures.

1.2 Rahmatan Lil'alamin in Mosque Design

Islam is a religion of *rahmatan lil'alamin*, meaning it brings grace and prosperity to all of creation, including animals, plants, jinn, and especially human beings. This concept is emphasized in the words of Allah SWT in the QS. Al-Anbiya: 107, “And We have not sent you (O Muhammad) except as a mercy to the worlds"[4].

The translation of "*rahmatan lil'alamin*" or "mercy to the worlds" can also be applied to mosque architectural design that upholds effectiveness and efficiency [5], as well as building safety and security [6]. The use of a specific structural system or building form that ultimately becomes inefficient and even jeopardizes the safety and security of mosque congregants also violates these principles. The use of dome structures to achieve wide spans without obstructing the prayer rows is one form of implementing the principle of rahmatan lil'alamin. However, if one insists on using a dome solely for the sake of aesthetics and it requires columns that disrupt prayer rows or even pose a danger because they are not constructed properly, then this goes against that principle.

Furthermore, the principle of rahmatan lil'alamin should also serve as a foundation for environmentally conscious and sustainable design. This means that mosque architecture should not only focus on aesthetics and functionality but also on its impact on the environment and long-term sustainability. This principle not only underscores the need for functional and aesthetically pleasing worship spaces but also demands that mosque architecture be environmentally conscious and sustainable [1].

Environmentally conscious design involves the use of eco-friendly and renewable materials, wise management of natural resources, and minimizing the carbon footprint [7]. For instance, using building materials with low environmental impact, such as sustainably managed bamboo or wood, can reduce deforestation and environmental degradation [8]. Islamic architecture is architecture that embodies the qualities of Islam. It is possible for architecture that did not originate from Islam to be considered Islamic if it aligns with the concepts of Islam as outlined in the Quran and Hadith. Even though it is not originally from Islam, green building can be classified as Islamic architecture because it aligns with the Islamic concept that encourages humans to care for the Earth [5] [9]. Architecture is one of the human activities that is also framed within the scope of worship to Allah SWT. Therefore, in practicing architecture, we should always be guided by the Qur'an and the Sunnah. One key understanding is that Islam is a religion of *rahmatan lil'alamin*, meaning it brings mercy, blessings, welfare, and benefits to the entire universe. Hence, in practicing architecture, we should strive to make our designs reflect this principle, creating architecture that is *rahmatan lil'alamin* for the environment in which the building stands, ensuring that it does not cause negative impacts (*mudharat*) on the environment or lead to the destruction of the ecosystem in that area [6]. Therefore, the use of organic materials aimed at reducing carbon emissions, or even serving as carbon storage, and possessing low embodied energy can be considered as part of the application of the *rahmatan lil 'alamin* principle. Of course, the use of these organic materials does not negate the principles of ensuring that functions operate well and that safety and security standards for the congregation are met.

By integrating the principle of *rahmatan lil'alamin* into environmentally conscious and sustainable design, mosques can not only become comfortable and safe places of worship but also contribute positively to environmental preservation and the well-being of the surrounding community.

Based on various reviews of mosque manifestations that adhere to the principle of *rahmatan lil'alamin*, this paper focuses on discussing the design approaches of mosques in addressing wide span issues for the perfection of prayer rows and the use of natural materials to reduce carbon emissions and as carbon sink.

1.3 Materiality: Bamboo and Timber

The conversion of bamboo and timber into a carbon sink is a crucial consideration in the pursuit of sustainable building practices and mitigating the effects of climate change. Bamboo, in particular, has garnered significant attention due to its rapid growth, high strength-to-weight ratio, and remarkable carbon sequestration capabilities [10] [11] [12]. Bamboo, a versatile and resilient grass, has been utilized in construction around the world, particularly in regions where it is indigenous [11] [13]. Its exceptional properties, including high tensile, bending, and buckling strength, make it an attractive alternative to traditional construction materials such as concrete and steel, which have a considerable carbon footprint [11] [14]. Edrees (2016) even advocates for the use of renewable materials that are rapidly produced, affordable, and conducive to innovation, like bamboo, as an element of the *rahmatan lil'alamin* concept [5].

Moreover, bamboo's ability to absorb and store large amounts of carbon dioxide from the atmosphere is a significant advantage in the fight against climate change [12] [15]. Studies have reported that the biomass accumulation potential of bamboo is much greater than that of many fast-growing exotic tree species, making it a priority species for carbon storage and sequestration [15]. Similarly, timber, derived from various tree species, has the potential to serve as a carbon sink. The construction industry's transition towards more sustainable materials, such as bamboo and timber, can contribute to the overall reduction of carbon emissions and the mitigation of climate change [11] [12].

The quantification of the carbon sequestration potential of bamboo and timber is crucial in order to understand the significance of building with these biomass materials as carbon sinks. By understanding the amount of carbon dioxide that can be absorbed and stored in every ton or cubic meter of bamboo and timber, researchers and policymakers can better evaluate the impact of using these materials in construction and develop strategies to maximize their carbon sequest ration capabilities [11] [12] [15].

2 Design Approach

2.1 Annur Aceh Bamboo Mosque, Lombok: A Fusion of Architectural Traditions and Structural Innovations

The 2018 Lombok earthquake caused the destruction of many buildings and resulted in numerous casualties. One of the buildings that collapsed was the Annur Mosque in North Lombok. The community was traumatized by brick and concrete construction because many buildings made from these materials collapsed. Meanwhile, many traditional buildings made of wood remained standing.

The Provincial Government and the people of Aceh raised funds to help rebuild the mosque and appointed the author as the architect and leader of the mosque reconstruction team. A lesson from this incident is that the community tends to be resigned and gives the architect and the Aceh Provincial Government considerable freedom regarding the mosque's design.

Although there was a proposal to build the mosque in the style of the Baiturrahman Mosque in Aceh, Nova Iriansyah, the Governor of Aceh at that time, rejected it and instead approved the architect's suggestion to build the mosque using bamboo. The first step taken was to convince stakeholders that a mosque does not necessarily need a dome and should instead have broader benefits as part of the *rahmatan lil'alamin* concept.

The choice of bamboo use has several reasons. First, bamboo is one of the most sustainable materials and has numerous ecological benefits when grown and acts as a carbon sink when used. Therefore, this material is highly suitable in relation to the *rahmatan lil'alamin* concept. Second, the potential of bamboo is significant in Lombok, as can be seen in various places throughout Lombok and as stated by Darmayanto et al. [16]. The use of local materials, which also means boosting the local economy in the post-disaster region, aligns well with the *rahmatan lil'alamin* concept. The third reason is the trauma experienced by the community due to brick and concrete structures that have caused many casualties, making bamboo a more acceptable choice in terms of earthquake resistance. The fourth reason is the architect's effort to make this mosque a means of education and promotion for the use of bamboo among the community. Although the potential of bamboo is significant in Lombok, its use is still limited to temporary buildings or tools like scaffolding. Additionally, bamboo is still perceived as the poor men's timber. Therefore, this example of a wide-span building can serve as a good promotion for the future use of bamboo. The final reason is the desire of the Aceh provincial government to contribute the best and most unique mosque, which can symbolize the care of the Aceh community for others.

After receiving a positive signal from stakeholders regarding the use of bamboo, the next step is to design the building with this material to ensure it is convincing enough to be built. The three design challenges for this mosque are as follows:

First, the architectural style of the mosque must reflect the local identity while also embodying a modern design aesthetic. Bamboo, as a traditional building material in many regions, can be leveraged to create a design that seamlessly blends the old and the new [17].

Fig. 1. A Fusion of architectural traditions (rice-barnshape) and structural innovations (reciprocal frame + vector-active structure).

Secondly, the design must ensure that the use of bamboo does not hinder the achievement of a wide-span structure to accommodate uninterrupted prayer rows within the mosque.

Finally, the challenge of ensuring a long service life for the bamboo structure must be addressed through the principle of "preservation by design". This involves protecting the bamboo from direct sunlight and rain exposure, as well as avoiding high humidity levels that can accelerate deterioration.

The design approach for Annur Mosque in Lombok, Indonesia, represents a unique blend of form analogy and exploration of vector-active and bulk-active structure-based systems (see Fig. 1). The shape idea widely used in modern architecture in Lombok is the analogy of a traditional rice barn, a common structure found in the settlements of the Sasak tribe. This architectural analogy has been incorporated into the design of various government buildings, often in a more simplistic manner.

The rice barn roof shape resembles a tunnel, similar to the reciprocal frame shape based on the da Vinci Bridge concept. Traditional timber mosque architecture, which can be found throughout the Malay Peninsula, Sumatra, Java, Kalimantan, Brunei, the southern Philippines, and the former kingdom of Champa in Cambodia, is characterized by its small size, the use of timber as the primary building material, post and beam method of construction, and decorated carved components [18]. The Annur Mosque, however, departs from this traditional timber construction approach, instead embracing a more contemporary design that incorporates bamboo as the primary structural material.

Starting from the shape analogy of a rice barn, the bamboo structure exploration for the Annur Mosque was generated from the author's extensive experience conducting workshops on reciprocal frames using bamboo. This extensive experience has even led to the discovery of a new structural system based on reciprocal frames that intersects with tensegrity, called reciprocal tension or rection [19].

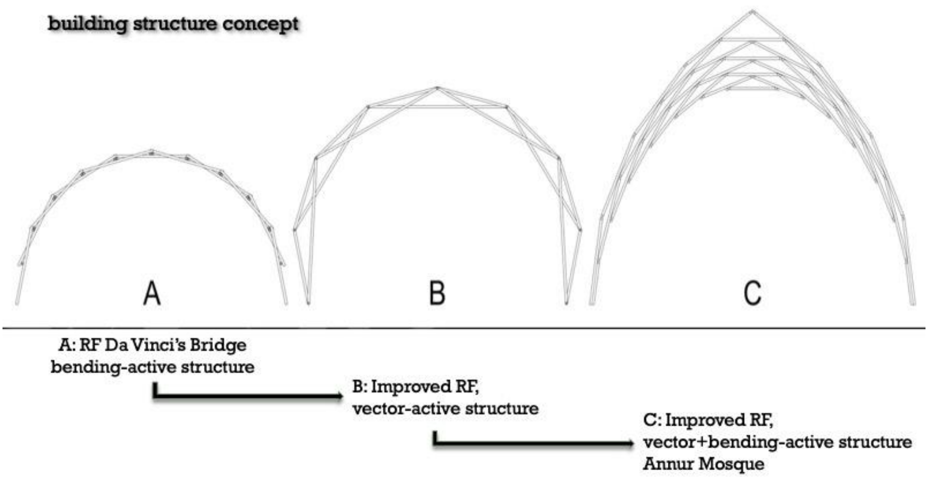

Fig. 2. The evolution of Annur Mosque structure

Fig. 3. The interior of the mosque showcases the grandeur of the layered bamboo structure

However, the development of the mosque's design from the conventional reciprocal frame did not lead to rection but rather towards a structural system that, according to Engel's categorization [20], falls under vector-active structures. The Annur Mosque's structure is a combination of both types of structures, creating roof rigidity with a layered structure. Ultimately, the Annur Mosque structure can be categorized as a two-hinged arch structure (see Fig. 2 and Fig. 3).

2.2 Nurulhasanah Aceh Timber Mosque, Palu: Where Timber Technology Inspires Awe

Not long after the earthquake hit Lombok, another earthquake, tsunami, and liquefaction struck Central Sulawesi on September 28, 2018. The provincial government and the people of Aceh once again managed to collect donations to rebuild one of the damaged mosques in Palu. The success of the previous humanitarian project to design and build a mosque in Lombok led to the author being entrusted with managing the donation funds for the design and construction of another mosque in Palu. The Nurulhasanah Mosque stands relatively close to the Palu Koro fault line. The main cause of damage to this mosque was the concrete dome in the center of the mosque, which was supported by a single column that was not strong enough to withstand the earthquake forces.

As part of the implementation of the concept of *rahmatan lil'alamin*, the choice of using natural materials becomes the first option. The initial concept of this mosque uses a bamboo or wooden structure with the application of a combination of hypar and folded plate structures as shown in Fig. 4 and Fig. 5.

The hyperbolic paraboloid, commonly referred to as the "hypar," is a fascinating and versatile geometric structure that has captured the attention of architects, engineers, and mathematicians alike. This unique three-dimensional shape is characterized by a saddle-like form, where the surface curves in one direction and simultaneously curves in the opposite direction, creating a delicate balance and a visually striking appearance.

Fig. 4. Image of the initial design

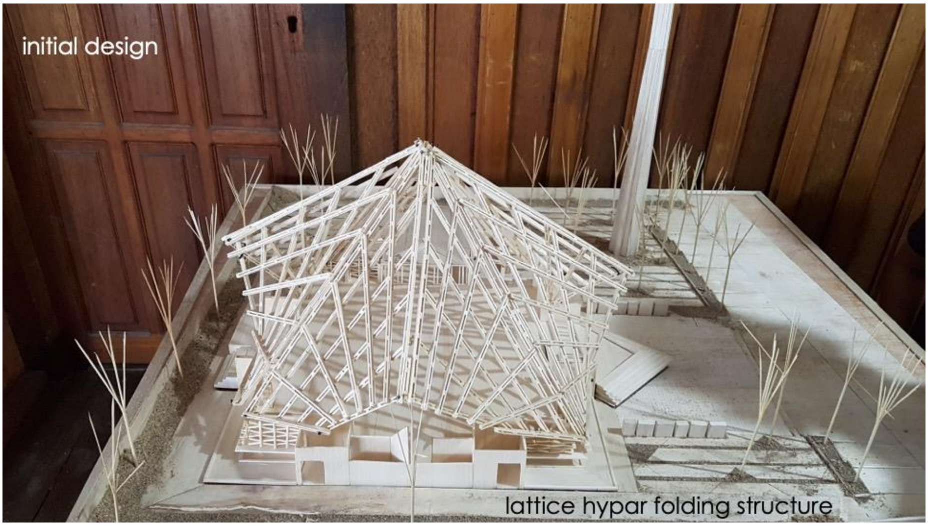

Fig. 5. Physical model of the mosque using hypar + folding structure

The idea of using hypar structures combined with folded plate structures has been studied for quite some time. This structure is easier to construct with round cross-section bamboo because the orientation of the bamboo as beams does not matter. An assessment of bamboo's availability was also conducted with a field survey, but the results were not as expected. The bamboo potential in Central Sulawesi is not sufficient to meet the needs. Moreover, the quality of the available bamboo was also not up to expectations. Assessments for procuring bamboo from outside the province but still within Sulawesi, as well as from outside the island of Sulawesi, were also conducted, but they were not feasible from a cost perspective.

The exploration to realize the idea of this structural system continued with a focus on using wood. The rectangular cross-section of wood posed a challenge because if the rectangular wooden beams were installed as usual, there would be sharp edges facing the roof surface or resting on the main beams. The solution to mitigate this issue was to use two boards joined together as shown in Figure 5. The subsequent challenge was the roof covering. When it was decided to use asphalt sheets for the roof covering due to their climate resistance, aesthetics, and the undulating shape of the roof, this roof construction required plywood sheets as a base for attaching the asphalt sheets. The question arose as to how much plywood available in the market with a thickness of at least 18mm could be twisted to conform to the geometry of the hypar surface.

In the end, changes to the roof structure design had to be made after failing to find a team of craftsmen willing to work on the design with the hypar and folding frames. Simplification was done by eliminating the hypar surfaces and focusing solely on the folded plate structure (Fig. 6). Generally, the rigidity of the roof shape was achieved through the folds of rigid planes. The rigidity of each plane itself was achieved with a lattice or grid system. These changes were then simulated in 3D images and also in scale models (Fig. 7) to assess the constructability and the complexity of the joints involved.

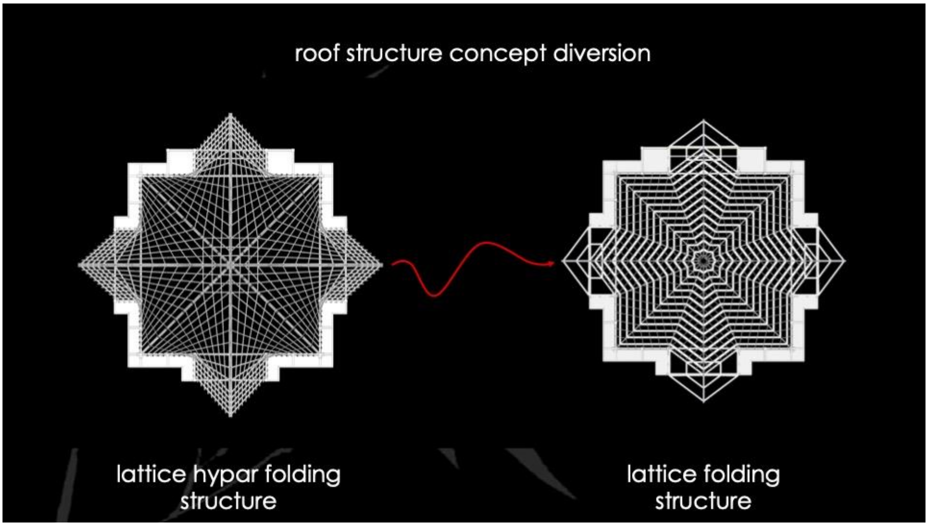

Fig. 6. The change of the roof structural system

Although simplification had been carried out, the design challenges for the mosque remained significant because there was no precedent for a building of this size in Indonesia. With a span of 20m x 20m, the dimensions of the beams used to form the grid could not rely on standard market sizes. Therefore, a simple wood lamination system needed to be introduced to create beams according to the required dimensions. Field surveys were conducted to map the dimensions of beams or boards available in the market. After considering various wood sizes available in the market and taking into account the availability of materials, 30/300 mm boards with a length of 4 meters were chosen as the primary raw material for the roof construction. These raw materials were then used to create laminated wood beams with dimensions of 90/600 mm and 60/300 mm, with varying lengths.

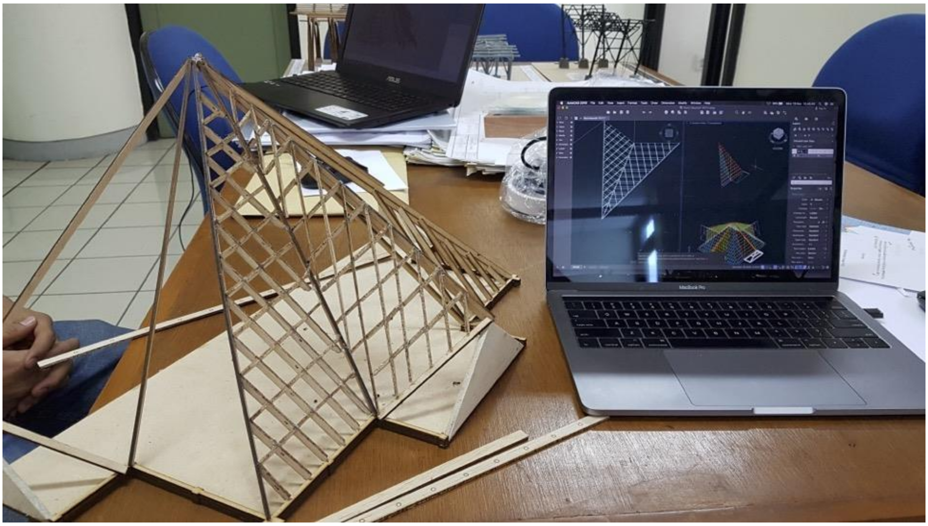

Fig. 7. 3D model in computer and physical

3 Results and Discussions

3.1 Annur Aceh Bamboo Mosque, Lombok

Annur Mosque was successfully completed in 2019 after overcoming various challenges. The author, as the architect and the leader of the construction team, was fully assisted by undergraduate and graduate architecture students from ITB in terms of design and construction supervision.

This mosque adopts a form similar to the rice barns of the Sasak tribe, using a semi-prefabricated construction method. Unlike planar construction systems that create 2D frames, the mosque's structure is divided into 2D frame modules (Fig. 8) that are then assembled layer by layer. These layers form a two-hinged arch structure, which is a combination of a reciprocal frame construction and a truss structure.

The bamboo structure used for this mosque is capable of spanning 14 meters with a length of 18 meters. At the front of the building, a two-story concrete structure was built to serve as the entrance and to provide protection for the bamboo structure facing east from direct sunlight and rain water. Visitors will experience a surprising effect when entering the mosque, as the beauty of the structure can only be fully appreciated from inside the building, after entering the ’concrete gate’ (Fig. 9 and Fig. 10). This ‘gate' also functions as restrooms and ablution facilities for the congregants, in addition to providing additional prayer space on the upper floor.

Fig. 8. Erection of the first prefabricated planar module

Fig. 9. Front elevation of the Annur Aceh Mosque

The foundation and concrete work were carried out by local contractors and workers. Most of the bamboo was sourced from Yogyakarta, with only a small portion obtained locally from Lombok. The reason for this was the short timeframe for the need for a large quantity of preserved bamboo and the still limited bamboo preservation facilities in Lombok. Workers were also brought in from Yogyakarta, not only because of the differing skill levels of bamboo workers but also because almost no local workers were available due to the numerous construction projects following the 2018 earthquake. From the perspective of applying the principles of *rahmatan lil-alamin* related to local economic circulation, this is certainly not ideal. However, when viewed from the perspective of the mosque's overall budget, most of it was still absorbed in non-bamboo work that involved the local community. In terms of CO2 absorption, the use of bamboo for this mosque is equivalent to a saving of 3.2 tons of CO2.

Fig. 10. Interior of the mosque, showing the structural layers of bamboos

3.2 Nurulhasanah Aceh Timber Mosque, Palu

The construction of Nurulhasanah Mosque took 21 months, with 4 months of delays due to administrative issues, making the net construction time 17 months.

Despite the high level of difficulty and the large scale of the project, this mosque was built primarily using local human and natural resources. The wood was sourced from Palu and its surroundings, while the workers also came from the island of Sulawesi. The equipment used was simple, without heavy machinery such as mobile cranes. The lamination technique used was a combination of wood adhesive and screws, with the help of wood clamps as pressing tools. The four main beams that form the main pyramid of the roof structure measure 90x600 mm with a length of 18 meters and weigh nearly 1 ton (Fig. 11). These beams were lifted manually using tackle and pulley systems, without the aid of cranes (Fig. 12).

Although it has the same size as the previous mosque (20m x 20m), the new Nurulhasanah Mosque does not have a column in the middle of the space, so it does not disrupt the prayer rows. Given the mosque's relatively close proximity to the Palu Koro fault line, the mosque's wall structure is made of reinforced concrete that is not too tall and has many folds to strengthen the building horizontally (Fig. 13). The concrete structure is fully tied together by tie beams but is not unified by ring beams because there are three entrance openings and one mihrab, which would be compromised by ring beams. Instead, steel truss frames are installed in these areas, which will later support the wooden structure.

Fig. 11. Manual lamination technique to form main beams

Fig. 12. Erection of main beams using tackles and pulleys

The application of the principle of *rahmatan lil'alamin* in this project involved maximizing the use of local resources, thereby contributing to the growth of the local economy post-disaster. In addition to providing a better mosque space with improved aesthetics compared to the previous mosque (Fig. 14), another major achievement is the CO2 storage in the form of wood, equivalent to 77 metric tons.

This mosque serves as an example to the people of Palu, demonstrating the possibilities of their abundant wood resources. Currently, most timber is sold and shipped off the island, resulting in a scarcity of modern wooden structures locally.

Fig. 13. The appearance of the mosque building from a drone's perspective

Fig. 14. A Fusion of architectural traditions

An interesting point of discussion arises from the use of natural materials in both mosques. The bamboo and timber structures have attracted Eurasian Tree Sparrows (*Passer montanus*), which perch and nest within them. On one hand, this embodies the Islamic principle of *rahmatan lil'alamin* – mercy to all creation. On the other hand, it presents a practical challenge: how to maintain the mosque's purity for praying when bird droppings soil the floor.

4 Conclusions and Suggestions

In the author's opinion, mosque design should be rooted in the fundamental principle of Islam's purpose, which is to be a mercy to all creation (*rahmatan lil'alamin*). The interpretation of this principle can be broad, but it must always adhere to the primary principle of maximizing benefit and minimizing harm. If the use of a dome is intended for creating a wide span or easy identification, it can be justified. However, if it risks interrupting the prayer lines, which are of higher importance, or even poses a safety hazard, it should be avoided. The most crucial aspect lies in the wide-span technology itself, ensuring uninterrupted prayer lines and unobstructed views of the *Imam* or the pulpit, of course, with the guarantee of safety and security for the congregation below.

Furthermore, the principle of *rahmatan lil'alamin* in mosque design should also be seen as a means to empower the community surrounding the mosque by utilizing local resources. Principles of sustainable development, such as energy saving, reducing carbon emissions, and acting as a carbon sink through the use of biomass for the main building materials, are also very much aligned with this principle.

Acknowledgments. My deepest gratitude goes to Nova Iriansyah, the Governor of Aceh during the implementation of this project, along with his staff and the entire Acehnese people who have contributed funds for the construction of these two mosques. I would also like to extend my gratitude to Directorate of Research and Community Service (DRCS) ITB and School of Architecture, Planning and Policy Development (SAPPD) ITB for their support in becoming part of the ITB volunteer team for Lombok and Palu. Additionally, I would like to express my thanks to Imam Prasetyo, who assisted with the design of both mosques and the construction of the Nurulhasanah Palu Mosque, as well as to Gilang I. Noegraha, who assisted in the construction of the Annur Lombok Mosque. Furthermore, my appreciation goes to Rumah Amal Salman and the members of the Lombok and Palu volunteer teams, both from ITB and outside ITB, whom I cannot mention one by one, for their contributions up to the writing of this paper.

Disclosure of Interests. The author has no relevant competing interests to disclose concerning the content of this article.

References

1. Skinner, R.: Traditions, Paradigms and Basic Concepts in Islamic Psychology. Springer Science+Business Media, 58(4), 1087-1094. https://doi.org/10.1007/s10943-018-0595-1 (2018)
2. Mughal, M A Z.: An anthropological perspective on the mosque in Pakistan. Taylor & Francis, 14(2), 166-181. https://doi.org/10.1080/1683478x.2015.1055543 (2015)
3. Şahin, M., Mungan, I.: Dynamic Performance of the Roof of Hagia Sophia considering Cracking. SAGE Publishing, **20**(3), 135-141. https://doi.org/10.1260/026635105775213827 (2005)
4. Apriani, E., Fathurrochman, I., Harmi, H.: EAJIS: Academic Journal of Islamic Studies vol. 3, no. 2, December 2018 IAIN Curup – Bengkulu | p-ISSN 2580-3174, e-ISSN 2580-3190, 191-192 (2018)
5. Edrees, M.B.: Journal of Islam and Science, Volume 03 Number 01, June 2016, 85-103. https://doi.org/10.24252/jis.v3i1.4374 (2016)
6. Edrees, M.B.: Konsep Arsitektur Islami sebagai Solusi dalam Perancangan Arsitektur. Journal of Islamic Architecture, Volume 1 Issue 1, June 2010, 16-20 (2010)
7. Kula, E: Islam and environmental conservation. Cambridge University Press, 28(1), 1-9. https://doi.org/10.1017/s0376892901000017 (2001)
8. Bsoul, L., Omer, A., Kucukalic, L., Archbold, R H: Islam's Perspective on Environmental Sustainability: A Conceptual Analysis. Multidisciplinary Digital Publishing Institute, 11(6), 228-228. https://doi.org/10.3390/socsci11060228 (2022)
9. Riswanda, Muhammad R.: Sekolah Menengah Atas Thafidz Quran dengan Pendekatan Arsitektur Islam di Semarang. Universitas Katolik Soegijapranata Semarang (2022)
10. Bhagat, D., Bhalla, S., West, R.: Fabrication and structural evaluation of fibre reinforced bamboo composite beams as green structural elements. Elsevier BV, 5, 100150-100150. https://doi.org/10.1016/j.jcomc.2021.100150 (2021)
11. Mouka, T., Dimitrakopoulos, E G., Lorenzo, R.: Insight into the behaviour of bamboo culms subjected to bending. Royal Society, 19(189). https://doi.org/10.1098/rsif.2021.0913 (2022)
12. Yadav, M., Mathur, A.: Bamboo as a sustainable material in the construction industry: An overview. Elsevier BV, 43, 2872-2876. https://doi.org/10.1016/j.matpr.2021.01.125 (2021)
13. Widyowijatnoko, A.: Traditional and Innovative Joints in Bamboo Construction. ISBN: 978-3-86130438-4. Druck and Verlagshaus Mainz GmBH Aachen (2012)
14. Hebel, D E., Heisel, F.: Introduction. Cultivated Building Materials, De Gruyter, 46-57. https://doi.org/10.1515/9783035608922-006 (2017)
15. Devi, A S., Singh, K S.: Carbon storage and sequestration potential in aboveground biomass of bamboos in North East India. Nature Portfolio, 11(1). https://doi.org/10.1038/s41598-020-80887-w (2021)
16. Damayanto, I P G P., Rustiami, H., Miftahudin, M., Chikmawati, T.: A synopsis of Bambusoideae (Poaceae) in Lombok, Indonesia. MBI & UNS Solo, 21(10). https://doi.org/10.13057/biodiv/d211004 (2020)
17. Nurdiah, E A., Juniwati, A.: Bamboo architecture as a learning project for community development of rural area in Indonesia. IOP Publishing, 490(1), 012004-012004. https://doi.org/10.1088/1755-1315/490/1/012004 (2020)
18. Munir, F F A., Tharim, A H A., Ahmad, A C., Ismail, N., JAAFAR, N.: Association between Thermal Comfort Condition and Worshippers' Satisfaction in Timber and Concrete of Suburban Religious Buildings, 53-63. https://doi.org/10.21163/gt_2020.151.22 (2020)

19. Widyowijatnoko, A., Irwanuddin, I., Aditra, R.F.: Rection as a Synthesis of Reciprocal and Tensegrity Structure. Nexus Netw J 21, 465–478 https://doi.org/10.1007/s00004-019-00443-6 (2019)
20. Engel, H.: Structure Systems, 3rd Edition. ISBN-10: 3775718761. ISBN-13: 978-3775718769 (2007)