engineering proceedings

MDPI

Proceeding Paper

Evaluation of Church Audial Quality on Cross-City Routes: The Java Christian Church in Bandung, Indonesia †

Syahla Salsabila and Beta Paramita *

Faculty of Technology and Vocational Education, Universitas Pendidikan Indonesia, Bandung 40154, West Java, Indonesia; syahlasalsabila@upi.edu

* Correspondence: betaparamita@upi.edu

† Presented at the 1st International Online Conference on Buildings, 24–26 October 2023; Available online: https://iocbd2023.sciforum.net/.

Abstract: The Church is a place of worship for Christians; to ensure the smooth and solemn implementation of worship activities, many factors that affect their overall effectiveness must be considered, and one of the conditions that must be met in the worship room is audial comfort. Certain churches are situated in noisy surroundings, which may impact the comfort and auditory experience of worshippers during prayer. This research examines the issue of audial comfort in a church positioned at the periphery of a cross-town road. The main goal of this research was to determine the audial quality deemed comfortable in the Java Christian Church in Bandung from the noise impact caused by high vehicle traffic. The prominent noise that arises from the highway is mostly caused by motorized vehicles. The methodology employed in this study involves a case study approach using quantitative descriptive analysis to evaluate the audial quality of the church. This study uses the Decibel X Sound Meter application to collect data through field measurements. The measured data were analyzed using NoiseTools and IBANA-Calc software was used to analyze the level of noise around the outer church buildings, which are directly adjacent to the main road. The standards used as research references are based on the Decree of the State Minister for the Environment, Number KEP-48/MENLH/11/1996, concerning environmental noise, and the US Department of Housing and Urban Development guidelines regarding spatial noise. Based on the observations made in this research, the noise level within the premises of the Java Christian Church in Bandung is fairly good, so the only addition needed is a barrier that can reduce environmental noise in the Java Christian Church in Bandung.

Keywords: church; Decibel X; IBANA-Calc; noise; NoiseTools

Citation: Salsabila, S.; Paramita, B. Evaluation of Church Audial Quality on Cross-City Routes: The Java Christian Church in Bandung, Indonesia. *Eng. Proc.* **2023**, *53*, 39. https://doi.org/10.3390/IOCBD2023-15182

Academic Editor: Alessandro Cannavale

Published: 24 October 2023

1. Introduction

Noise is sound pollution, namely the introduction of unwanted sound sources (noise) that do not meet standards, disturbing the environment, disturb the sense of hearing, and affecting health; it can even affect the psychology of the user [1]. In Indonesia, the main source of noise is noise that occurs on roads due to motorized vehicles, whether they are two-wheeled, four-wheeled, or so on. Noise levels on highways are influenced by vehicle intensity [2].

According to White and Walker (1982), motorized vehicles generally have a frequency between 100 Hz and 7000 Hz, with the source of motor vehicle noise coming from the horn, engine, exhaust, brake transmission, and friction that occurs between the tires and the road [3]. Because the friction that occurs between the tire and the road is friction between hard and soft objects, the noise caused by the road is generally in the form of sound and only a small amount is in the form of sound and vibration [2]. Therefore, ideally, buildings on the side of the road must be designed to minimize the entry of sound into them [4].

In general, churches in Indonesia are built in quite noisy areas, namely in busy environments and close to highways with high noise intensity [5]. Vehicle intensity generally

has a big influence on noise in the church environment [6]. Churches that are located in environments with conditions of high noise are a source of problems considering that the function of a church is as a place of worship; of course, the place of worship must provide peace to its users [7]. Therefore, audial comfort in churches is something that must be considered, so churches located in high-noise locations need to be studied in more depth [8]. A church is a building that functions as a place of worship; considering its important function, a church must fulfill the elements of comfort to support all the activities of the congregation within it [7]. The comfort of the prayer room is greatly influenced by the room's acoustics, which are related to noise or audial comfort [9].

Audial comfort can be seen based on comfort in the presence of noise both in the environment and inside the building (PU Ministerial Decree No. 28 of 2002). The audial comfort of a building is influenced by sound pressure, and sound is said to be noisy when it exceeds the noise threshold value. The acceptable noise requirement for environments in places of worship such as churches is 55 dBA (Decree of the State Minister for the Environment Number: KEP-48/MENLH/11/1996). Apart from that, standard room disturbances which have a value of less than 58 dBA have acceptable criteria, then disturbances between 58–74 dBA also meet acceptable criteria, while for values more than that the level of disturbance is no longer acceptable (US Department of Housing and Housing and Urban Development). To achieve audial comfort in church buildings, architects must think about designs to create church buildings that allow all kinds of comfort so that the congregation can worship solemnly and comfortably [10].

One of the churches that will be discussed in this article is the Bandung Java Christian Church, which is located in an environment that has a high noise intensity. This research aims to identify the quality of noise in the Bandung Javanese Christian Church environment. Apart from that, an in-depth study of the Javanese Christian Church building in Bandung will determine the quality of noise that occurs so that if there is a discrepancy, repair options will be provided that can be carried out to reduce the noise through simulation using Noisetools.net and IBANA-Calc software [11].

This church was originally a house on stilts which was then converted into a church and inaugurated in 1992. This church is located right on the edge of a main road which is quite busy with vehicles so it is quite noisy and can disturb the congregation when they are carrying out their worship. Javanese Christian Church (GKJ) Bandung is located on Jl. Merdeka No. 28, Bandung.

2. Research Methods

Based on the phenomena that occur, this research uses a descriptive quantitative approach. This approach aims to explain the data through numbers. In this case study, the evaluation of audial comfort in the Javanese Bandung Christian church building aims to determine the noise level that occurs in the Bandung Javanese Christian Church environment. The standard used is the Decree of the Minister of the Environment, Number KEP-48/MENLH/11/1996, and the guidelines for room noise provided by the US Department of Housing and Urban Development are used as a parameter to measure noise levels in the Javanese Christian Church in Bandung. The Church is a place of worship used by Christians, the environmental noise level standard that applies to places of worship is 55 dB, and the acceptable room noise standard is less than 58 dBA, then noise between 58 and 74 dBA also meet acceptable criteria, whereas for values greater than that the noise level is no longer acceptable. This noise value limit aims to overcome all disturbances to achieve the desired level of comfort. This analysis aims to find out whether the Bandung Javanese Christian Church experiences normal or abnormal noise (noisy).

Data collection was carried out through observations based on the SNI 8427-2017 standard, namely the procedure for measuring noise levels in the field using the Decibel X Pro Sound Meter application. The analysis of the measurement data is processed through software simulation with Noisetools.net and IBANA-Calc software to identify the noise level experienced in the Java Bandung Christian Church building.

This research framework contains the stages shown in Figure 1.

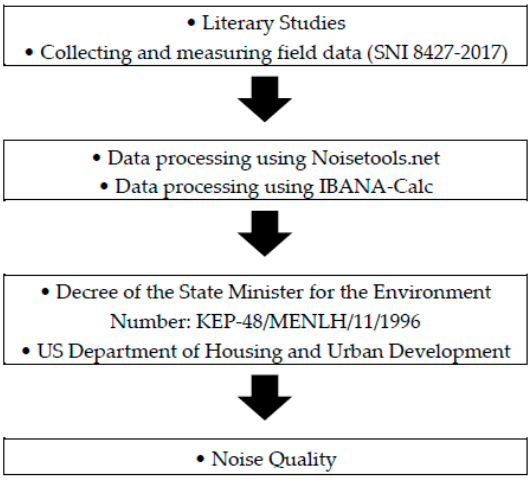


Figure 1. Stages of the research framework.

3. Results and Discussion

3.1. Building Specifications

The Bandung Javanese Christian Church is located on Jl. Merdeka No. 28, Bandung, West Java, with the coordinates −6.911836″ S and 107.610834″ E. The building orientation faces westward with the boundaries as shown in Figure 2.

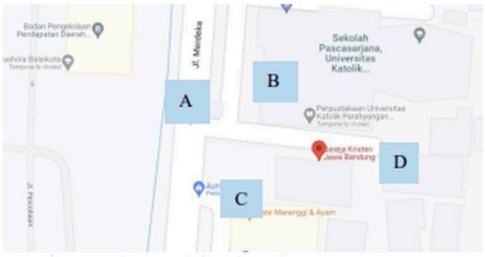


Figure 2. Location of the Javanese Christian Church in Bandung.

A. Western limit: Jalan Merdeka
B. North boundary: Parahyangan Catholic University Graduate School
C. Eastern boundary: Javanese Christian Church Sunday School
D. South boundary: Pretzel Store

The Bandung Javanese Christian Church was chosen because it represents the problems in this research, as a building for worship located on the side of a highway which has noise problems that exceed normal limits. Uniquely, this church is designed with an opening position that does not directly face the road. The front facade of this church is a large window made up of a glass box; see Figure 3.

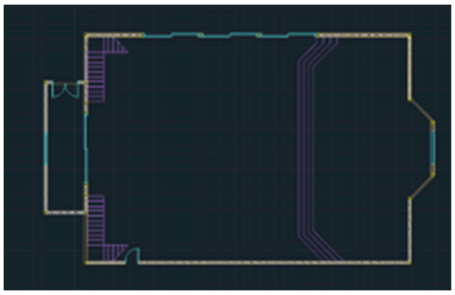
The church that was used as the object of research was a two-story church located on a cross-city route where noise problems are high. Initially, this church was a house on stilts which was later converted into a church. The inside of the church employs a mezzanine concept. According to Table 1, the construction specifications are as follows:

Table 1. Construction data and building specifications.

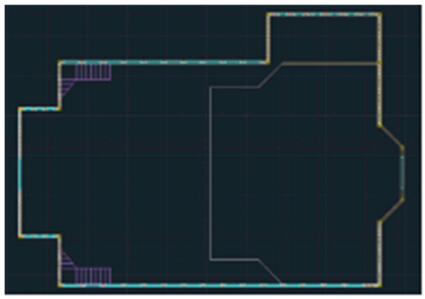
No.	Name of Constructions	Specifications
1	Building area	340 m^2
2	Wall specifications	Red plastered eye stone, white paint finish
3	Aperture specifications	Glass block
4	Fence	Wrought iron finished with black paint

(**a**) Javanese Christian Church exterior

(**b**) Interior of Javanese Christian Church



(**c**) 1st floor plan



(**d**) 2nd floor plan

Figure 3. Specifications of the Bandung Javanese Christian Church.

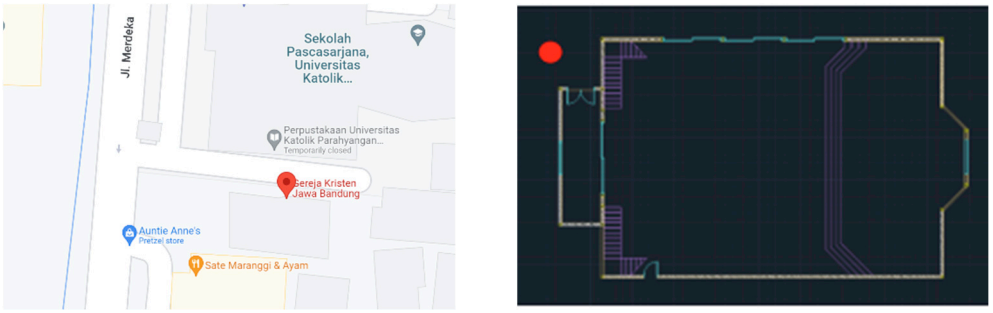
3.2. Field Measurements

The measurement of the noise level of the Javanese Christian Church in Bandung was carried out by taking measurements in the church environment, which is directly adjacent to the main road, because the main road is the biggest source of noise in the Javanese Christian Church in Bandung, most of which is caused by motorized vehicles. The Bandung Javanese Christian Church is located right next to Jl. Merdeka No. 28, Bandung. Jalan Merdeka No. 28, Bandung, is included in the type 2 arterial road class with specifications for serving public transportation and general vehicles passing at a high speed. When the measurements were carried out, road conditions were quite quiet because they were carried out at 09.46–09.48 WIB, which are office hours, so traffic conditions were not too busy. Apart from that, the width of the arterial road, Jl. Merdeka No. 28, Bandung, has a road width of 11 m with a slope of 0° and equipped with pedestrian access that is 2 m wide on each side of the road, while the distance from the fence to the front of the church building is 12 m. The area of the frontmost building facing the main road is 55 m^2.

In Figure 4, you can see the measurement points marked with red circles; data collection was carried out at the front of the Bandung Javanese Christian Church, under a tree, precisely. Noise level measurements were carried out using the Decibel X - Pro Sound Meter application made by SkyPaw Co., Ltd., based in Hanoi, Vietnam, via the Redmi 9T device. On December 28, 2022, this application had a rating of 3.6 on the Play Store and had been downloaded more than 1 million times with a preview of 66,9000 accounts. Despite the limitations of the equipment, researchers used this application to take measurements to determine the noise that occurs due to motorized vehicle traffic at the Javanese Christian Church in Bandung. Measurements were carried out on 18 November 2022 at 09.54 WIB to 09.58 WIB with a time span of 2 min per session; see Table 2.

Table 2. Noise measurement data.

No.	Time (WIB)	Noise (dBA)
1	09.54	74.3
2	09.56	74.3
3	09.58	74.9



(**a**) Location (**b**) Floor Plan

Figure 4. Measurement point for the Javanese Christian Church in Bandung.

3.3. Analysis Using NoiseTools.net Software

At this stage, the data from measurements in the field will be analyzed in more depth using the NoiseTools.net application to calculate the sound pressure level from one noise source by considering sound attenuation to determine the distribution of sound reaching the building. In addition to sound pressure level data, there needs to be input regarding humidity and temperature. Data regarding humidity and temperature in the Bandung area on 28 December 2022 at 10.00 WIB show a humidity of 89% and a temperature of 26 °C (wheater.com).

In addition, specifications for distance and noise source must also be included in this analysis because this will influence the sound pressure level results. There are actually many motor vehicle noise points, but generally, the source of noise comes from the vehicle engine, measured at the distance between the engine height and the road surface. In general, the machine height ranges from 50 to 80 cm [3]. Jalan Merdeka No. 28 Bandung is generally dominated by private vehicles, so roads that are usually used by vehicles other than heavy vehicles generally have an average height of 50 cm [2].

In this further analysis, the Javanese Christian Church as a place of worship has a barrier measuring 1 m high. The barrier is a fence made of iron and coated with black paint. The distance from the receiver to the barrier is 10 m, with a receiver height of 4 m. For analysis, the middle value of the receiver height taken is 2 m, while the distance from the barrier to the road is 2 m. After obtaining the required data, the data are then analyzed using NoiseTools.net software with a single frequency; see Figure 5.

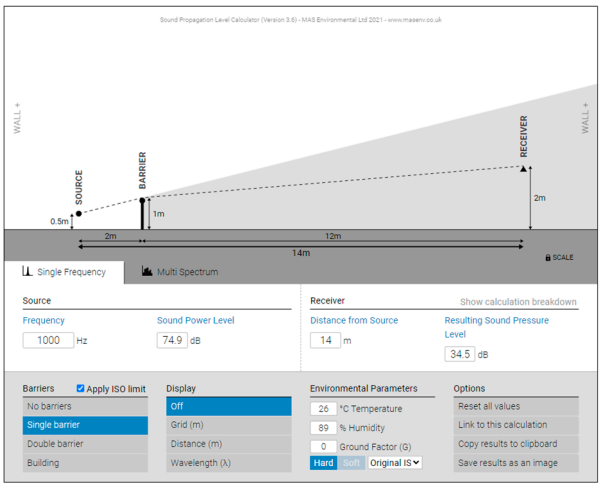


Figure 5. NoiseTools single-frequency simulation.

The data show that the resulting sound pressure level at a distance of 14 m is 34.5 dB. These results indicate that the noise that occurs in the church environment is in the very

good category because it is based on the KEP-48/MENLH/11/1196 standard which requires a noise standard on the premises of worship of 55 dB.

From the research results (Table 3), it is known that the Bandung Javanese Christian Church has a fairly high noise level for a place of worship. The data above show that the noise level at the Bandung Javanese Christian Church is around 67.1–100 dB. These data are used for NoiseTools.net multi-spectrum simulations. Data from the multi-spectrum analysis are below; see Figure 6.

Table 3. Multi-frequency noise measurement data.

Frequency (Hz)	Sound Pressure Level (dB)
63	100
125	100
250	100
500	100
1000	74.9
2000	73.9
4000	69.9
8000	67.1

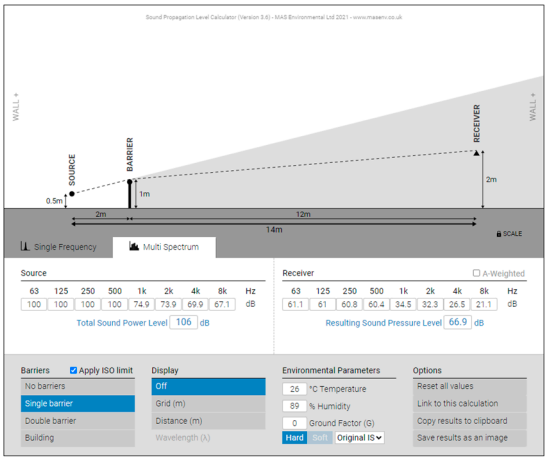


Figure 6. NoiseTools multi-frequency simulation.

Based on the results of analysis via NoiseTools.net, the sound pressure level (SPL) that reaches the building is 66.9 dB. When compared with the Environmental Noise Standard from KEP-48/MENLH/11/1196 which requires a noise standard in places of worship of 55 dB, from the results of this analysis it was found that the environmental noise of worship at the Javanese Christian Church in Bandung does not meet the requirements, so engineering is needed for its design to reduce noise levels in the Javanese Christian Church building in Bandung. Adding a barrier that can dampen sound will help reduce noise.

3.4. Analysis Using IBANA-Calc Software

The research continued with data analysis using IBANA-Calc software, and measurement data from NoiseTools.net, namely in the form of noise data received outside the Javanese Bandung Christian church building. See Table 4.

Data from the multi-frequency NoiseTools.net experiment were entered into IBANA-Calc; see Figure 7.

Figure 7 shows that the noise graph decreases as the noise frequency increases. In the IBANA-Calc experiment, you must include the frequency specifications of the field material that receives the noise. The wall material used was red brick with plaster finished with white paint. The wall coefficient was obtained from the *Building Physics* book [12]. See Figure 8.

Table 4. Noise measurement data received in buildings.

Frequency (Hz)	Sound Pressure Level (dB)
63	61.1
125	61
250	60.8
500	60.4
1000	34.5
2000	32.3
4000	26.5
8000	21.1

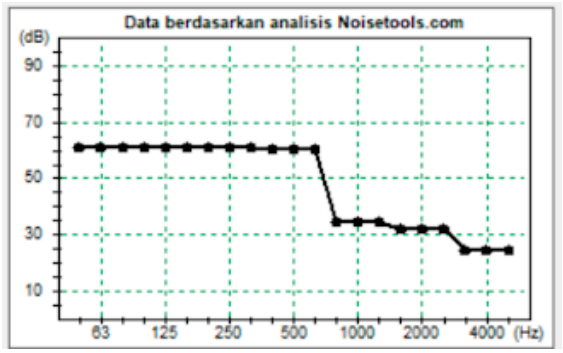


Figure 7. Noise source simulation with IBANA-Calc.

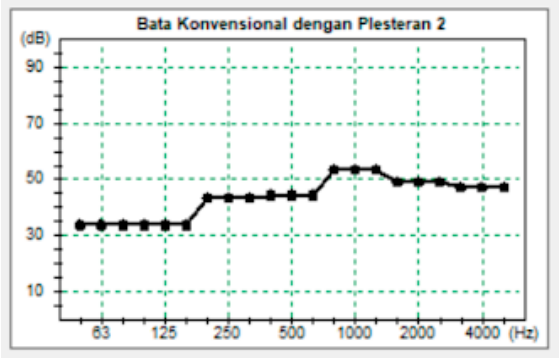


Figure 8. Wall coefficient simulation with IBANA-Calc.

The window material is a glass block with a thickness of 11 cm. The glass block has the same STC value as that of a 150 mm thick concrete slab, namely 53 STC (sevesglassblockinc.com). Hence, to find out the acoustic coefficient of a glass block, you can use the concrete coefficient of 150 mm. The concrete coefficient was obtained from the *Building Physics* book [12]. The results of the analysis can be seen in Figure 9.

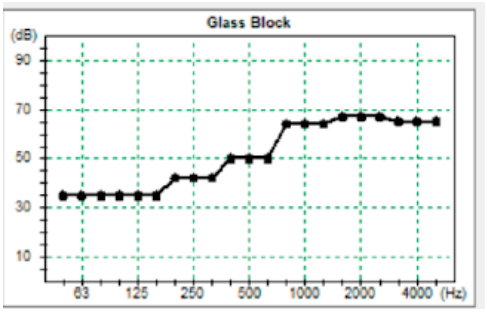


Figure 9. Window coefficient simulation with IBANA-Calc.

The first scenario was simulated by entering two materials in the IBANA-Calc simulation based on a total wall area of 55 m^2 and windows measuring 11.88 m^2. The room absorption value was assumed to be 50% with the assumption that there is only a small amount of absorbent material in the church. The input space measures 340 m^2. The simulation results graph is a comparison between indoor and outdoor sound levels. The results of the analysis can be seen in Figure 10.

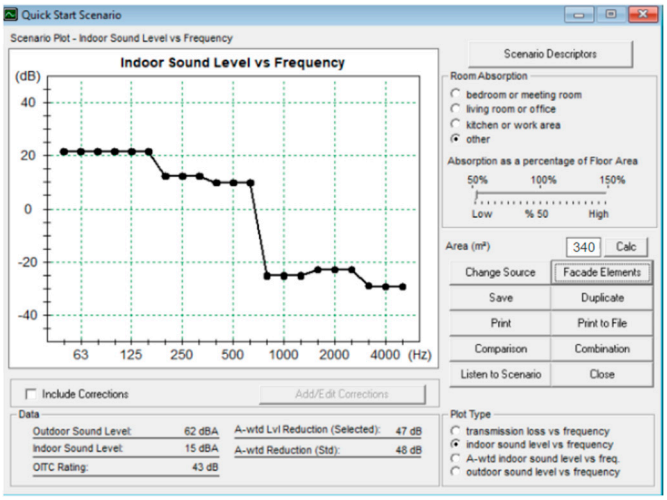


Figure 10. Noise simulation results with IBANA-Calc.

From the simulation using IBANA-Calc software, the following data were obtained on Table 5.

Table 5. IBANA-Calc simulation results data.

No.	Item Result	Noise (dBA)
1	Outdoor Sound Level	62
2	Indoor Sound Level	15
3	OITC Rating	43
4	A-wtd Lvl Reduction	47
5	A-wtd Reduction	48

The simulation data show that the outdoor noise level is 62 dB, which is not loud enough to measure sound outside a place of worship because it is based on the Decree of the State Minister for the Environment, Number KEP-48/MENLH/11/1996, on the environmental noise standard for places of worship, which is 55 dB. Furthermore, the sound level in the room is 15 dB. According to the US Department of Housing and Urban Development, a noise level of less than 58 dB fulfils community acceptance criteria.

Based on the results of data analysis using these two software, the church room still meets standards. However, in terms of barriers outside the room, an intervention should be carried out to reduce noise. This intervention takes the form of adding barriers in the form of vegetation and replacing building fence materials.

4. Conclusions

Audial comfort in places of worship is a complete element that must be fulfilled because it will support the activities of the congregation there. Audial comfort can be provided and is said to be good if it meets the standards.

Research on audial comfort regarding room noise in the Javanese Christian Church in Bandung reveals that it is of a very good quality because the church has an indoor sound level noise value of 15 dB. According to the US Department of Housing and Urban Development, a noise level of less than 58 dB meets acceptable community acceptance criteria.

Noise in the environment of the Javanese Christian Church in Bandung has an outdoor sound Level value of 62 dB, and the environmental noise standard for places of worship is 55 dB based on the Decree of the State Minister for the Environment, Number KEP-48/MENLH/11/1996. Hence, it can be concluded that according to environmental noise standards, the Javanese Christian Church in Bandung has poor environmental noise. This will also have an effect if the volume of vehicles increases and there are activities that create more noise, such as the Drum Band parade, in which case the quality of the noise at the Javanese Christian Church in Bandung will become worse. There needs to be more analysis on this matter.

Recommendations for improvements that can be made include adding a barrier to the front of the church, either by adding vegetation that filters noise or by replacing the iron fence material with a fence made of plastered brick walls, but still using a design that has functional Javanese traditional elements, filters noise, and strengthens the design of the Javanese Christian Church.

Author Contributions: Conceptualization, S.S.; methodology, S.S.; software, S.S.; validation, S.S.; formal analysis, S.S.; investigation, S.S.; resources, S.S.; data curation, S.S.; writing—original draft preparation, S.S.; writing—review and editing, S.S. and B.P.; visualization, S.S.; supervision, B.P.; project administration, B.P.; funding acquisition, B.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by BeCool Indonesia.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data are obtained in the article.

Acknowledgments: This paper was supported by the Center of Excellence for Low Emission Building Materials and Energy and the Laboratory of Science, Technology and Building Materials of the Universitas Pendidikan Indonesia.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Sumardiyono, S.; Wijayanti, R.; Hartono, H.; Budiastuti, M.T.S. Pengaruh Kebisingan terhadap Tekanan Darah, dengan Stres Kerja sebagai Variabel Mediator. *J. Kesehat. Vokasional* **2020**, *5*, 124–131. [CrossRef]
2. Mediastika, C.E. *Akustika Bangunan: Prinsip-Prinsip dan Penerapannya di Indonesia*; Erlangga: Jakarta, Indonesia, 2005.
3. White, R.G.; Walker, J.G. *Noise and Vibration*; Ellis Horwood Ltd.: New York, NY, USA, 1982.
4. Siska, D. Analisa Kebisingan dan Studi Akustik dalam Tatanan Bangunan. *J. Arsitekno* **2015**, *6*, 33–38. [CrossRef]
5. Balirante, M.; Lefrandt, L.I.R.; Kumaat, M. Analisa Tingkat Kebisingan Lalu Lintas di Jalan Raya Ditinjau dari Tingkat Baku Mutu Kebisingan yang Diizinkan. *J. Sipil Statik* **2020**, *8*, 249–256.
6. Sangkertadi, S.; Manganguwi, R. Tingkat Kebisingan dan Perambatan Suara Akibat Bunyi Luar Pada Gereja Masehi Injili Minahasa (GMIM) Kampus Unsrat dan GMIM Bethesda Manado. *J. Ilm. Sains* **2021**, *21*, 130–136. [CrossRef]
7. Sulistyowati, D.R.; Kusno, A.; Ishak, M.T. Evaluasi Kenyamanan Audial Ruang Gereja Lanraki Biringkanaya Makassar. *J. Lingkung. Binaan Indones.* **2018**, *5*, 144–153. [CrossRef]
8. Suroto, W. Dampak Kebisingan Lalu Lintas terhadap Permukiman Kota (Kasus Kota). *J. Rural. Dev.* **2010**, *1*, 55–62.
9. Gumelar, R.; Ramadhan, T.; Maknun, J. Evaluation of the Audial Comfort of the Mosque on the Cross-City Route: Al-Ghani Mosque Ciamis. In Proceedings of the IOP Conference Series: Earth and Environmental Science, Bandung, Indonesia, 11 December 2021.
10. Sari, S.M. Wujud Budaya Jawa Sebagai Unsur Inkulturasi Interior Gereja Katolik. *J. Dimens. Inter.* **2007**, *5*, 44–53.
11. Sastika, A.; Febrina, S.E. Efektifitas Pemakaian Material Akustik pada Gereja Bethel Indonesia (GBI) Musi Palem Indah Palembang. *J. Arsit. Dan Perenc.* **2022**, *2*, 63–72. [CrossRef]
12. Satwiko, P. *Fisika Bangunan*; C.V Andi: Yogyakarta, Indonesia, 2009.