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

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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, one of the comforts 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 the worshippers during prayer. This research examines the issue of comfortable audial in a church positioned at the periphery of a cross-town road. The main goal of this research was to determine the comfortable audial's quality in the Java Christian Church in Bandung from the noise pact due to 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 church noise's quality. 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 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 it only needs to be added a barrier that can reduce environmental noise in the Java Christian Church in Bandung.

Keywords: Church; Decibel X; IBANA-Calc; Noise; NoiseTools

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1. Introduction

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

According to White and Walker (1982), motorized vehicles generally have a frequency between 100 Hz to 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 sound and vibration [2]. Therefore, ideally, buildings on the side of the road must be designed to minimize the entry of sound into the building [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 the noise in the church environment [6]. Churches that are located in environments with high noise conditions are a source of problems considering that the function of the 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]. The church is a building that functions as a place of worship, considering its important function, the 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 against 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, sound is said to be noisy because 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, room noise standards that have a value of less than 58 dBA have acceptable criteria, then noise between 58–74 dBA has acceptable criteria, while for values more than that the noise level is no longer acceptable (US Department of Housing and Urban Development). To achieve audial comfort in church buildings, architects must think about designs to create church buildings that have 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 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 the 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 it can disturb the congregation when 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 with numbers. In the 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 room noise by the US Department of Housing and Urban Development is 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, which has acceptable criteria, then noise between 58–74 dBA has acceptable criteria. acceptable, 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 comfort. This analysis aims to find out whether the Bandung Javanese Christian Church has 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. Analysis of the measurement data is processed through

software simulation with Noisetools.net and IBANA-Calc software to identify the noise level received by the Java Bandung Christian Church building.

This research framework has the following stages:

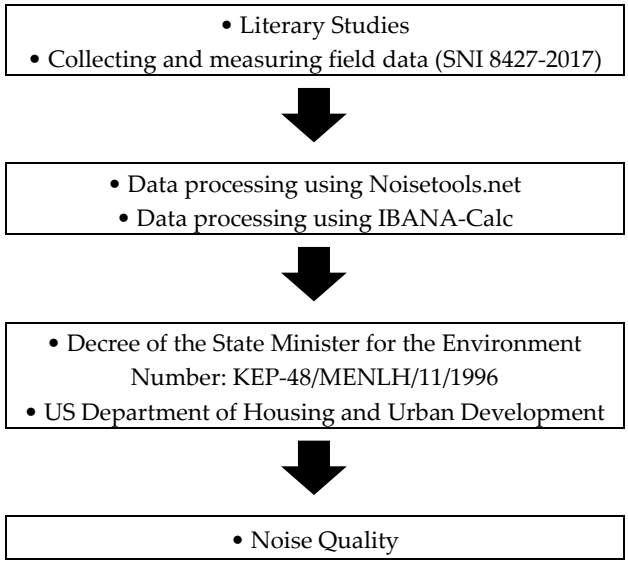


Figure 1. Stages of the research framework.

3. Results and Discussion

3.1. Building Specifications

Bandung Javanese Christian Church is located on Jl. Merdeka No. 28, Bandung, West Java with coordinates −6.911836″ S and 107.610834″ E. The building orientation faces west with the following boundaries:

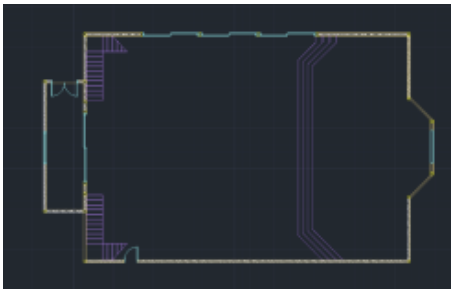
Figure 2. Location of the Javanese Christian Church in Bandung.

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

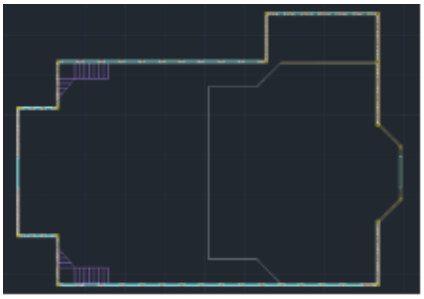
The Bandung Javanese Christian Church was chosen because it is in accordance with the problems in this research, a building for worship located on the side of a highway which has noise problems that exceed normal limits. Uniquely, this church is designed with an opening position that does not directly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

(**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.

The church that was used as the object of research was a two-story church located on a cross-city route where noise problems were high. Initially this church was a house on stilts which was later converted into a church. The inside of the church has a mezzanine concept.

Table 1. Construction Data and Building Specifications.

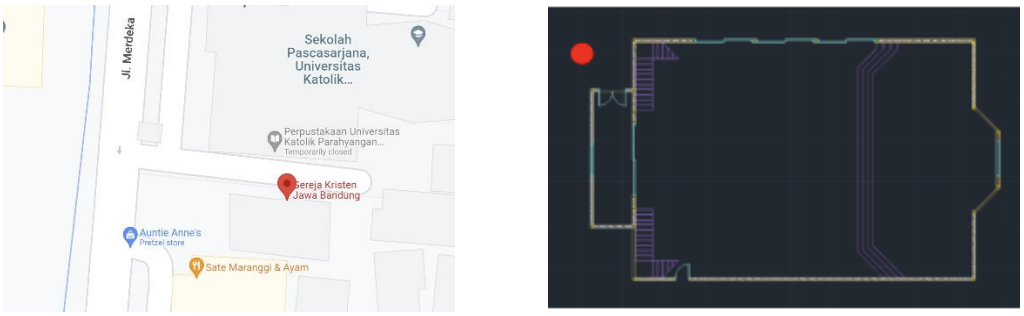
No.	Name of Constructions	Specifications
1	Building area	340 m^2
2	Wall Specifications	Red plastered eye stone, white paint finish
3	Aperture Specifications	Glass Block
4	Fence	Wrought iron finished with black paint

3.2. Field Measurements

Measurement of the noise level of the Javanese Christian Church in Bandung was carried out by measuring 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. 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 generally vehicles passing at 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 is 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° equipped with pedestrian access that is 2 m wide on each side of the road, 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, precisely

under a tree. Noise level measurements were carried out using the Decibel X—Pro Sound Meter application made by SkyPaw Co., Ltd. via the Redmi 9T device. On December 28, 2022, this application has a rating of 3.6 on the Play Store and has 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.



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

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

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

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 shows humidity of 89% and 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, machine height ranges from 50–80 cm [3]. On 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's place of worship has a barrier 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 is then analyzed by NoiseTools.net software with a single frequency, see Figure 5.

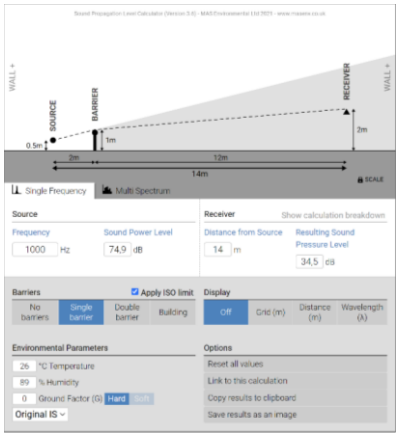


Figure 5. Noisetools single frequency simulation.

The data shows 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 noise standards on the premises. worship of 55 dB.

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

From the research results table, it is known that the Bandung Javanese Christian Church has a fairly high noise level for a place of worship. The data above shows that the noise level at the Bandung Javanese Christian Church is around 67.1–100 dB. This data is used for Noisetools.net multi-spectrum simulations. Data from multi-spectrum analysis are as follows, see Figure 6.

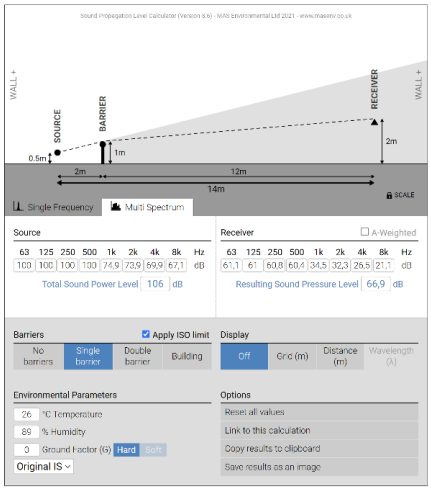


Figure 6. Noisetools multi frequency simulation.

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 that engineering is needed in the 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 by the outside of the Javanese Bandung Christian church building.

Table 4. Noise Measurement Data Received by 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

Data from the multi-frequency Noisetools.net experiment was entered into IBANA-Calc, see Figure 7.

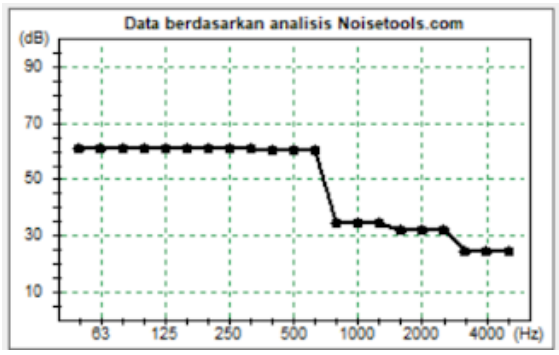


Figure 7. Noise Source Simulation with IBANA-Calc.

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 is red brick with plaster finished with white paint. The wall coefficient is obtained from the Building Physics book [12].

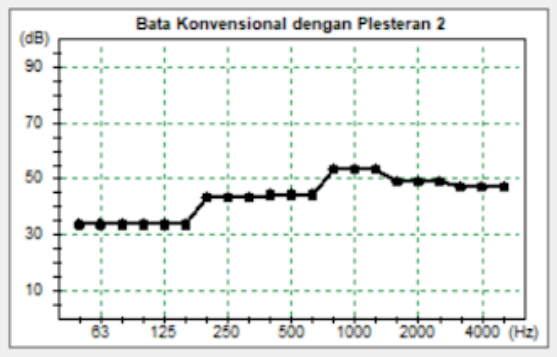


Figure 8. Wall Coefficient Simulation with IBANA-Calc.

The window material is a glass block with a thickness of 11 cm. The Glass Block has the same STC value as a 150 mm thick concrete slab, namely 53 STC (sevesglassblock-inc.com). So to find out the acoustic coefficient of a Glass Block, you can use the concrete coefficient of 150 mm. The concrete coefficient is obtained from the Building Physics book [12].

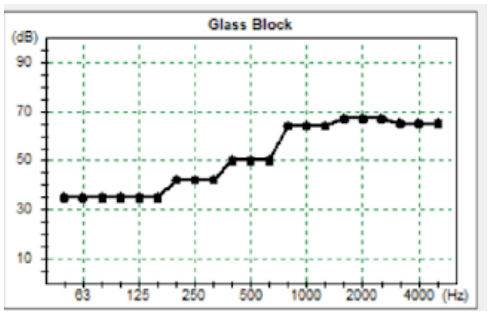


Figure 9. Window Coefficient Simulation with IBANA-Calc.

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 of 11.88 m^2. The room absorption value is assumed to be 50% with the assumption that there is only a small amount of absorbent material in the Church. The input space is 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.

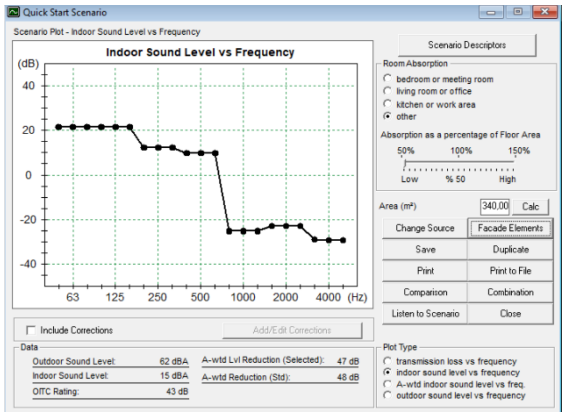


Figure 10. Noise Simulation Results with IBANA-Calc.

From the simulation using IBANA-Calc software, the following data was obtained:

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 shows 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 environmental noise standards for places of worship is 55 dB. Then, the sound level in the room is 15 dB. According to the US Department of Housing and Urban Development, noise of less than 58 dB has acceptable community acceptance criteria.

Based on the results of data analysis using these two software, the church room still meets standards. However, on barriers outside the room, 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 met and said to be good if it meets the standards.

Research on audial comfort regarding room noise at the Javanese Christian Church in Bandung is of very good quality because it has an Indoor Sound Level noise value of 15 dB. According to the US Department of Housing and Urban Development, noise of less than 58 dB has acceptable community acceptance criteria.

Noise in the environment of the Javanese Christian Church in Bandung has an Outdoor Sound Level value of 62 dB, 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. So 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 intensity of the vehicles increases and there are activities that create more noise such as the Drum Band parade, then the quality of the noise at the Javanese Christian Church in Bandung will get worse. There needs to be more analysis on this matter.

Recommendations for improvements that can be made are 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.

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