The Assessment of Aural Disturbances Experienced by A Church Located in Housing District of Bandung
Case Study: GKII Pniel Bandung

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Abstract. Church as a sacred building is best situated in a surrounding which has an ideal aural environmental quality to enhance its acoustic performance as well as to enrich aural experiences of the worshippers. However, due to the lack of suitable site in urban context, in many cases church has to be located in the housing district with all its demerit factors, among others are aural disturbances which emanated from different sources. This study will assess the aural disturbances experienced by a church located in housing district of Bandung. The assessment will include major sources of aural disturbances, its intensity, and level of concern of the worshippers, using direct field measurement method and interview. Results of this study will display level of aural quality attained by this church, and appropriately propose relevant strategies to overcome the aural disturbances being faced.

1. Introduction
Aural architecture is known as a science that combines architecture, acoustics, sound, perception, and anthropology in one perspective in view of human experience of sound and space. Aural architecture encourages emotional and behavioral responses in both real and virtual environments [1]. The aural environment is the space where the sense of hearing becomes the main tool in feeling the sound space. Architecture, sound, perception, and anthropology become a perspective in looking at human experience of sound and space. A room with a good aural can provide an experience of intimacy, anxiety, connectedness, alienation, warmth, and an atmosphere of spirituality [1]. This experience can be felt anywhere as long as the sound plays an important role in it.

The worship space has a complex acoustic environment that requires hearing sound clarity and aesthetic sound experience. This experience can create emotions through perception of sound [2]. The Church as a sacred building must be located in an area of ideal environmental quality to enhance its acoustic performance while enriching the aural experience of its congregations. Creating a worship space is not just about creating space inside, but also about how the environment can support the procession and atmosphere while worshiping. Quiet and away from noise sources is the ideal aural environment for the church.

However, because of the urban planning in Indonesia that places churches into residential areas, many churches must be in the residential district with all the demerit factors, including aural disturbances derived from vehicles, private activities, and neighborhood activities. Aural comfort depends on the noise level of the environment. Noise, defined as an unwanted noise, can interfere and cause attention to become distracted or unfocused.
2. Selected Church
The church is a Protestant church located in Bandung City. This church is located on Cimanuk Street with a land area of about 500 m². This one-story church building was built in 1990 by a local congregation who wanted a place of worship with a strategic location but also quite calm.

![Figure 1. GKII Pniel Bandung](maps.google.com)

Based on Regional Spatial Plan of Bandung, the location of this church stands in the residential area. The rules of the church building functions set into the zone of residential areas and arranged in accordance with the needs of the region. In addition there is also the educational function of SMP N 44 Bandung right next to the church.

![Figure 2. GKII Pniel Bandung](maps.google.com)

The development of the economy and the rapid growth of the culinary industry in Bandung has had an impact on the area around the church. Housing that was quite quiet, now turned into a row of restaurants that every day is always crowded by visitors. As a result the church atmosphere is not the same as before. If the church was once considered a building of concern to the environment and sacred, then due to increased activity around it the church began to lose its sanctity and slowly barely visible again. The intensity of the vehicle is increasing and the sounds of music from the restaurant add to the hustle and bustle of the environment.

3. Methodologies
The assessment will include major sources of aural disturbances, their intensity, and level of concern of the worshippers.

The method in this research is direct field measurement and auralization [2]. Direct field measurement is one of the methods used to measure the physical aspects of the aural conditions from the location. Direct field measurements were made at the time of non-church worship activities to
measure noise levels using a Sound Level Meter around the church environment when the church was empty.

Auralization is a method to assess aspects of aural perception. Auralization can also be called by observation or feeling directly. Observations were carried out to assess the level of aural disturbances from various sources and intensity.

4. Observation and Measurements
This observation is to observe field conditions, noting any sounds or audible sound disturbances, and also including their intensity.

The first observations and measurements were made at 6 am before the First Sunday Service. At this morning the church environment was quite calm. There is almost no activity going on around the church. Lack of activity at this hour makes the smallest sound can be heard. Some of the voices heard include: the sound of birds, the sound of the door open, and the sound of falling leaves.

The closer to the hour of worship will begin, the congregations have begun to visit the church. The sound of the piano from the church marks the activity of worship in the neighborhood. Until the beginning of worship activity, the piano sound has become the main voice is heard. In addition, occasionally heard the sound of traffic, either crossing the road environment and the vehicle of congregation who came to the church. The noise is described in Table 1.

| No. | Location     | Kinds          |
|-----|--------------|----------------|
| 1   | Bird         | High pitch     |
|     |              | Quite          |
|     |              | Clear          |
|     |              | Non vocal      |
|     |              | Natural        |
|     |              | Decay          |
| 2   | Opened door  | Low pitch      |
|     |              | Quite          |
|     |              | Clear          |
|     |              | Non vocal      |
|     |              | Artificial     |
|     |              | Attack         |
| 3   | Falling leaves | Low pitch | Quite |
Measurements were made outside the church with a specified measurement point from across the road (MP1), from inside the church fence (MP2), and from the church's closest wall to the street (MP3). This measurement will be done a few minutes before the worship starts.

**Table 2.** Description of sound noise observation 1

| No. | Measurement Point | 0   | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | Average |
|-----|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|
| 1   | MP1 (Street)      | 70.9| 70.3| 66.7| 72.1| 67.2| 68.7| 70.9| 74.2| 68.7| 73.5| 72.4| 70.5   |
| 2   | MP2               | 70.4| 66  | 66.6| 69.2| 64.7| 66.1| 67.2| 72.1| 67.3| 70.9| 70.7| 68.2   |
| 3   | MP3 (Wall)        | 67.2| 65  | 64.9| 67.2| 62.9| 64.6| 65.3| 69  | 69.5| 67.1| 68.4| 66.4   |

The first measurement is done during Sunday Service 1 at 6 to 6.30 am. Measurements were made for 10 minutes.

**Figure 4.** Measurement points

The measuring point 1 (MP1) shows a relatively higher intensity compared to the MP2 and the MP3. It is because this measuring point closer to the sound of traffic. The average value on MP1 is 70.5 dB, MP2 68.2 dB, and MP3 66.1 dB. The peak point on the 3rd and 7th minutes indicates the sound of traffic recorded through the measuring point.
Observation and Measurements 2

The second observation was made at the time of the Second Sunday Service at 9 am. At this time activity in the church environment has started crowded. The aftermath of the first worship service at 8 am was the first observation.

Noise at this service is more varied due to activity in residential and commercial environments around. The aural disturbances observed include: the sound of birds, the sound of high traffic, children playing, music from neighbors, singing, and street vendors.

| No. | Location | Kinds          |
|-----|----------|----------------|
| 1   | Bird     | High pitch     |
|     |          | Quite          |
|     |          | Clear          |
|     |          | Non vocal      |
|     |          | Natural        |
|     |          | Decay          |
| 2   | Traffic  | Low pitch      |
|     |          | Loud           |
|     |          | Clear          |
|     |          | Non vocal      |
|     |          | Artificial     |
|     |          | Attack         |
| 3   | Children | Low-High pitch |
|     |          | Loud           |
|     |          | Clear          |
|     |          | Vocal          |
|     |          | Attack         |
| 4   | Music    | Low pitch      |
|     |          | Quite          |
|     |          | Clear          |
|     |          | Non Vocal      |
|     |          | Artificial     |
|     |          | Decay          |
| 5   | Man singing | High pitch   |
|     |          | Quite          |
Reveberant
Vocal
Artificial
Attack
6 Street vendors
High pitch
Loud
Clear
Non vocal
Artificial
Attack

Table 4. Description of sound noise observation 1

| No. | Measurement Point | 0  | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 |
|-----|-------------------|----|----|----|----|----|----|----|----|----|----|----|
| 1   | MP1 (Street)      | 75 | 71.2 | 79.7 | 72.3 | 77.4 | 72.9 | 71.6 | 82 | 73 | 76.6 | 83.3 | 75.9 |
| 2   | MP2               | 71.8 | 66.1 | 73.7 | 68.3 | 75.8 | 71.9 | 68.9 | 78.8 | 68 | 70.4 | 73.1 | 71.5 |
| 3   | MP3 (Wall)        | 69.7 | 63.5 | 65 | 66.6 | 71.2 | 68.1 | 68.5 | 69 | 64.3 | 70 | 68.8 | 67.7 |

The second measurement is done during the Second Sunday Service at 8 to 9 am. Measurements are also done for 10 minutes.

Figure 6. Measurement 2 Chart

The diagram shows the fluctuation of the sound intensity. This is enough to describe the atmosphere and sound disturbances that exist in the church environment. The lowest intensity at MP1 is at 71.2 dB (minute 2) and the average value is 75.9 dB. The average value in MP2 is 71.5 dB while the MP3 is 67.7 dB. This average value is higher than the measurements of First Sunday Service.

Figure 7. Decrease in the mean value of the measuring point

Based on the graph, the distribution of sound in the church environment can be understood with reasonable. The MP1 taken from the curb across the church has a higher average value than the other measurements point. Noise from the traffic and neighbors activity are the cause. While the comparison
between measuring results service at 6 am with the service at 9 am shows a clear difference about the higher environmental noise during the day.

6. Analysis
Aural architecture can explain how sound and space can affect emotions, behavior, and experiences. If current research focuses only on architectural acoustics, aural architecture involves aspects of perception and culture that can provide a more comprehensive understanding of aural experience [2]. Physical aspects of aural architecture relate to measurable technical elements. Observations and measurements carried out provide an overview of the physical content of aural disorders in the church environment. Aspects of perception are related to the responses and perceptions of each individual. While the cultural aspects explain the aural experience of the environmental culture side that affect other aspects. Analysis of aural experiences and their disturbances based on physical, perceptual and cultural aspects are described simultaneously as a unity of understanding.

6.1 Components of Bahareque
Church surrounded by other buildings with a relatively close distance. The boundaries of the church site are:

- North: Residence
- East: Road, office, restaurant
- South: School
- West: Residence

At Sunday Services, the neighbors does not cause disturbing sounds. For example, the schools and offices that do not operate on Sundays, as well as restaurants that have not been operating in the morning. But it would be very disturbing if the worship took place on another day. Both school and restaurants have a peek time resulting in noise. One way to keep the sound from being heard is to keep the sound source away. If the point distance to the source of the sound multiplies 10 times, the intensity level is reduced by 20 dB. The distance between adjacent buildings precisely leads to the opposite.

![Figure 8. Decrease in the mean value of the measuring point](image)

Ideally, the church should have enough courtyard and not only on the front but also on the left and right even behind it. In addition to the sound mileage factor, the presence of this yard will create a comfortable environment and enhance the impression of spirituality as a place of worship.

6.2 Sound Barrier
The condition of the land in contact with the road requires a barrier element so that the sounds that reach the building do not cause discomfort or disruption to the activity inside. According to Koenigsberger in Satwiko [3] states that the allowed noise level in the church is 35-40 dB. Trees and
wall fence can be an option as a barrier of noise from the street. Vegetation can muffle sound up to 95% by absorbing sound waves by leaves, branches and twigs.

The church environment is pretty much overgrown with trees and other. At the front of the church there are trees with a height of approximately 10 m with canopy and wide leaves. In principle, trees with characters like this fit into a common barrier of sound that intersect with the road. However, based on the observation it is seen that these trees do not cover the bottom that can still be penetrated by the noise from the road.

![Figure 9. A church still visible to be recognized from the street](image)

There are elements of the church fence to help in dispelling the sound that comes with covering the bottom of the tree. The front fence of the church has a height of 2 m with a combination of stone materials and iron arrangement. A solid field is effective in reflecting sound. While the transparent field is not very effective. View and aesthetic considerations are the reasons for the design of this fence.

![Figure 10. Street section](image)

In Indonesia the fence has become a complement of buildings to boundary the area. Few people have reason to present the fence as a barrier of sound, but rather to give a boundary of land, privacy, or security considerations. But in this discussion the fence serves as a barrier of sound that unwittingly reduces the intensity of noise from the street.
Figure 11. Street section

The combination of trees and fences is a design strategy in controlling noise from the road. Design options can vary. However it is advisable in the selection of vegetation should be of various height. Short plants such as teh-tehan or soka flowers can be used as a sound barrier while beautifying the church environment. In addition to the transparent part of the fence can be modified by providing a place to be overgrown with plants.

7. Conclusions

Coming to a house of worship is an experience that is different from other places because it relates to the sanctity of the environment. A worship environment that requires sound aesthetics cannot be separated from the approach to the sound space in it. Experience involving aural and visual can determine the atmosphere built during worship. This experience can affect the emotions through perception of the sound.

To establish the sanctity of a place of worship should consider a good environment as it affects the atmosphere formed from its surroundings. There are voices that are allowed to be present in the church environment, some are not. Birds' voices are natural voices permitted to be present in the church environment.

Most of the sound is not recorded by the Sound Level Meter due to the small intensity of sound that only records the sound intensity above 30 dB. The observed sounds are not necessarily sound interference. If it sounds vague then it is not a sound interruption.

Sound barriers with vegetation need to be carefully considered so that other aspects such as the view towards the church are not blocked.

References

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The research about the assessment of aural disturbances experienced by a church located in housing district still need to be developed. The obstacles that exist in this research in terms of data collection and the results may be refined in further research. The hope of this study can contribute to the development of science.