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# Optimizing Noise Levels in the Inpatient Room at Bumi Panua Pohuwato Hospital

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**Abstract**

Bumi Panua Hospital is the only hospital in Marisa District, Pohuwato Regency. In each building, there is a lot of activity going on between patients, nurses, doctors, and visitors who arrive. In addition, the vehicle parking location which is right in front of the hospital inpatient room can cause noise which can reduce patient comfort. The noise level of the hospital must be in accordance with its function and meet health requirements, especially in inpatient rooms. The aim of this research is to carry out measurements to optimize noise levels in patient inpatient rooms at Bumi Panua Pohuwato Hospital. The method used in this research is a descriptive analysis method with a quantitative approach and acoustic simulation using the I-SIMPA application. From the results of Background Noise and Reverberation Time research on class III and II inpatient rooms at Bumi Panua District Hospital. Pohuwato. The condition of background noise in class III and II inpatient rooms is not good because the (dB) produced by background noise in the room is quite high, above 66 dB and exceeds the recommended standard regarding (dB) background noise in patient rooms. It should be below 40 - 45 dB. Based on the simulation results, the reverberation time in class III and class II inpatient rooms produces reverberation time that exceeds the recommended standard due to not using acoustic materials and the shape and volume of the room which causes sound reflection to occur for longer. Optimization is carried out to reduce the reverberation time so that the sound intensity in the room is not too long and can reduce background noise in the patient room.

**Keywords:** *Background Noise; Hospital; Reverberation Time (RT30),*

## Introduction

The global era has had a very rapid impact on the development of cutting-edge health science and technology (Santosa and Budi W 2012). A hospital is a building that needs to be designed so that it can provide comfort and good psychological effects for patients. The comfort in question is providing comfort both psychologically and physically. In general, psychological factors can help to heal and recover patients, especially patients who are hospitalized. Noise is a sound or sound that is unwanted or that can interfere with activities (Imran, Program, and Arsitektur n.d.)

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High noise causes acoustic defects in the room. Noise is closely related to the health of a person's sense of hearing and body and soul (Siska 2015). As a function of the hospital, it is a place of treatment and a period of healing for patients. One factor that can influence the level of comfort is sound or sound. (Dewi and Syamsiyah 2020).

Acoustics is something related to sounds or voices (Hakim, Rulia, and Fahlafi 2021). The presence of excessive noise can disrupt health, namely calm which refers to anger, insomnia, and disturbances in the sense of hearing, so hospitals need to provide comfort for patients. However,some rooms in hospitals have very high noise levels, one of which is the inpatient room. where the standard for conversation is

60 dB and sound above 60 dB is included in the noise category which can interfere with listening comfort.

Bumi Panua Hospital is the only hospital in Marisa District, Pohuwato Regency. This hospital is on Jl. Dr. Herizal Umar, Botubilotahu Village, subdistrict. Marisa. This hospital building has one floor and activity inside and outside the building is very busy. where we know that a hospital is a place that requires 3 extra calms for doctors, nurses, and most importantly for patients who are inpatient or outpatient.

Based on the results of observations made by researchers of the buildings and inpatient rooms of Bumi Panua Pohuwato Hospital, information was obtained that in each building there was a lot of activity taking place between patients, nurses, doctors, and visitors who came, especially in class III and class II inpatient rooms. This is a public treatment room that can be accessed by all lower and upper middle classes and indirectly results in many visits from various groups which can cause noise. Apart from that, the vehicle parking location which is right in front of the hospital inpatient room can cause noise which can reduce patient comfort.

Hospital comfort needs to be improved to prioritize patient calm to help their recovery. Therefore, the noise level of the hospital must be in accordance with its function and meet health requirements, especially in inpatient rooms. Based on this description, it is necessary to carry out measurements to optimize the noise level at Bumi Panua Pohuwato Hospital, especially in inpatient rooms, because the recommendations are aimed at patients who are in the recovery period. The aim of this research is to carry out measurements to optimize the noise level in the inpatient room at Bumi Panua Pohuwato Hospital.

This research focuses on acoustic systems in the form of Background Noise and reverberation time in inpatient rooms because they are the main parameters in measuring room acoustics. It is hoped that this research will be able to analyze the noise levels that occur in hospital inpatient rooms so that better improvements can be made in the future to make this hospital maintain and pay attention to the comfort level of its users.

## Literature Review

Sound can literally be interpreted as something that we hear. Sound is the result of vibrations of particles in the air and the energy contained in sound can increase rapidly and can travel very long distances. (Nasution, Wahab, and Nuari 2018). According to Sasongko (2000) noise is sound that is undesirable because it is not appropriate to the context of space and time so that it can cause disturbances to human comfort and health (Rusmayanti, Nurhasanah 2021).

In a closed room, background noise is produced by mechanical or electrical equipment in the room such as air conditioners, fans and so on. Likewise, noise comes from outside, such as traffic noise on the highway, noise in vehicle parking areas and so on. Background noise cannot be completely eliminated, but can be reduced or reduced and optimized through a series of acoustic treatments for the room (Savitri and Syafei 2018).

Acoustics is defined as something related to sound or sounds, as Shadily, 1987 argued, acoustics comes from the English word: acoustics, which means the science of sound or the science of sound. (Khairunnisa 2019). Acoustics is the science of sound systems and the overall effects that sound has on the audience (Sutanto 2015). The goal in acoustic solutions is to address desired sounds and noise control regarding undesirable sounds. The equipment used in the fields of information and communication, transportation and entertainment generally produces unwanted sounds or is often called noise (Wahyu Anggraeni, Rachmad Zahrial Amin, and Winda Artha Mustika 2022).

The principle in interior acoustics is to strengthen or direct useful sounds and eliminate or weaken sounds that are not useful for human hearing. Thus, designing the interior of a particular room must be adjusted to the acoustic needs of the activities taking place in it (Hakim, Rulia, and Fahlafi 2021). Generally, sound systems in buildings have two purposes, namely for human physical and psychological health and audial comfort. By architects as building planners, sound planning cannot be separated from four elements, namely sound sources, sound receivers, sound propagation media and sound waves (Gharata, Satria, and Arminda 2023).

Noise level standards are the maximum permitted noise levels from business activities so that they do not cause harm to human health and environmental comfort (KepMenLH No 48:1996) (Yoyon efendi, Rometdo Muzawi, Lusiana 2020). Apart from that, a parameter that is very influential in room acoustic design is reverberation time. Until now, reverberation time is still considered the most important criterion in determining the acoustic quality of a room.

## Methodology

The method used in this research is a descriptive analysis method with a quantitative approach. According to Arikunto (2006:12) with quantitative research, many are required to use numbers, starting from data collection, interpretation of the data, as well as the appearance of the results. So it can be concluded that quantitative descriptive research in this research is to see, review and describe with numbers the object being studied as it is and draw conclusions about this according to the phenomena that were visible at the time the research was carried out (Putra 2015).

This research carried out noise measurements using a sound level meter (SLM) and the I-SIMPA application. The sound level meter is used to measure background noise and the I-SIMPA application is used to simulate Reverberation Time to analyze the acoustic properties of buildings. Research begins with conducting surveys/observations, documentation, taking measurements, and continues with data analysis, conclusions and recommendations.

Technological developments provide new opportunities for acoustic design. Space acoustic assessment at the design stage is usually carried out with scale models, which is time consuming and impractical. It is now possible to use computer simulations to analyze acoustic properties before the actual construction of a building and acoustic design can become an integral part of the architectural design process (Alzoubi and Attia 2019).

The research used by researchers regarding background noise uses the ISO 3382-1 standard and refers to the recommendations of KepMenLH No. 48:1996. It can be seen from tables 1 and 2 below:

Table 1. Standard noise level in the environment

| No | Activity environment | Noise level DB (A) |
|---|---|---|
| 1 | Hospital | 55 |
| 2 | School | 55 |
| 3 | Place of worship | 55 |

Source: KepMenLH No 48:1996

Table 2. Noise index per room or hospital unit

| **No** | **Activity environment** | Noise level **DB(A)** |
|---|---|---|
| 1 | Patient room<br>- When not sleeping<br>- Sleeping time | <br>45<br>40 |
| 2 | Operating room, general | 45 |
| 3 | Anesthesia, Recovery | 45 |
| 4 | Endoskopi, Laboratorium | 65 |
| 5 | Office/lobby | 45 |

Source: KepMenLH No 48:1996

The reverberation time standard used by researchers is based on the ISO 3382-1 standard as in table 3.

Table 3. Optimum Values of Objective Space Acoustic Parameters

| Accoustical | Conference | Music |
|---|---|---|
| Reverberation Time (RTmid,s) | 0.85<Rtmid<1.30 | 1.30<RT-mid<1.83 |
| Early Decay Time (EDT,s) | 0.648<EDTmid≤0,81 | 1.04<EDT-mid≤1.76 |
| Definition (D,%) | ≥65 | - |
| Clarity (C50, C80, db) | C50>6 | -2<C80<4 |
| Centre Time (TS, ms) | <80 | <80 |

Source: Hedy C. Indrani, Sri Nastiti N. Ekasiwi 2007

## Result and Discussion

### A. Location of Bumi Panua Pohuwato Hospital

Figure 1. Site Plan for Bumi Panua Pohuwato Hospital


Figure 2. Class III inpatient buildings (a) and class II inpatient buildings (b)

(a)

(b)

Based on figure 1. The position of the class III inpatient room building is in the middle of other buildings. while the class II inpatient room building is in the northern part of the hospital. The total area of the class III building is 300 m2 with a height of 4 m and a total of 5 patient rooms. The patient room area is 32 m2 which is used by 3-4 patients. Class II inpatient rooms have a total area of 360 m² with a building height of 4 m, the number of patient rooms is 10 rooms. The patient room area measures 20 m2 and is occupied by 2 patients.

Materials used in buildings:

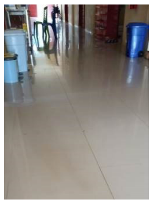
1. Wall = Plaster Brick

Figure 3. Material and absorbent
(Source: Odeon)

| 63 Hz | 125 Hz | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz | 4000 Hz | 8000 Hz | α(w) |
|---|---|---|---|---|---|---|---|---|
| 0,01000 | 0,01000 | 0,02000 | 0,02000 | 0,03000 | 0,03000 | 0,04000 | 0,04000 | 0,05000 |

2. Floor = ceramic

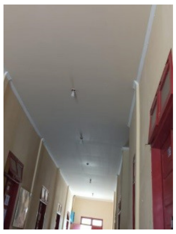
Figure 4. Material and absorbent
(Source: Odeon)



| 63 Hz | 125 Hz | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz | 4000 Hz | 8000 Hz | α(w) |
|---|---|---|---|---|---|---|---|---|
| 0,01000 | 0,01000 | 0,01000 | 0,01000 | 0,02000 | 0,02000 | 0,02000 | 0,02000 | 0,05000 |

3. Ceiling = Gypsum

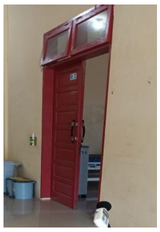
Figure 5. Material and absorbent
(Source: Odeon)



| 63 Hz | 125 Hz | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz | 4000 Hz | 8000 Hz | α(w) |
|---|---|---|---|---|---|---|---|---|
| 0,14000 | 0,14000 | 0,10000 | 0,06000 | 0,05000 | 0,04000 | 0,03000 | 0,03000 | 0,05(L) |

4. Door = Wood

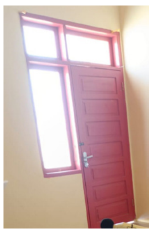
Figure 6. Material and absorbent
(Source: Odeon)



| 63 Hz | 125 Hz | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz | 4000 Hz | 8000 Hz | α(w) |
|---|---|---|---|---|---|---|---|---|
| 0,20000 | 0,20000 | 0,05000 | 0,03000 | 0,01000 | 0,01000 | 0,01000 | 0,01000 | 0,05000 |

5. Window = Glass

Figure 7. Material and absorbent
(Source: Odeon)



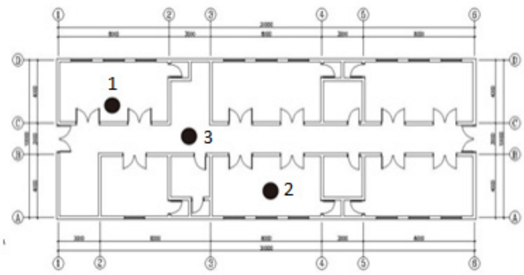
| 63 Hz | 125 Hz | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz | 4000 Hz | 8000 Hz | α(w) |
|---|---|---|---|---|---|---|---|---|
| 0,18000 | 0,18000 | 0,06000 | 0,04000 | 0,03000 | 0,02000 | 0,02000 | 0,02000 | 0,05000 |

## B. Background Noise Measurement

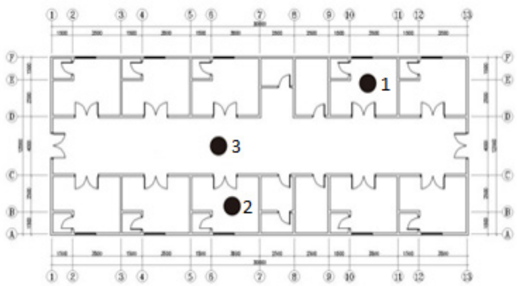
Background measurements were carried

out directly using a sound level meter. Measurements were carried out in two inpatient rooms, namely class III and class II inpatient rooms on three days and three different times, namely Monday, Thursday and Sunday at 11.00 AM, 17.00 PM and 19.00 PM. Measurements are carried out at three measuring points as shown in the following inpatient room plan:

Figure 8. Plan of measuring points for Class III Inpatient Room (a) and Class II Inpatient Room (b)




(a)




(b)

## C. Measurement Process

Figure 9. The process of measuring class III inpatient rooms

Figure 10. The process of measuring class II inpatient rooms

## D. Measurement Results

- Background Noise Measurement in Class III Inpatient Rooms

Table 4. Results of Monday's background noise measurement

| Unit of measure (dB) | MONDAY | | |
|---|---|---|---|
| | TIME | | |
| | 11.00 | 17.00 | 19.00 |
| POINT 1 | 68.21 | 66.35 | 67.29 |
| POINT 2 | 66.58 | 67.14 | 68.67 |
| POINT 3 | 71.24 | 74.23 | 72.46 |

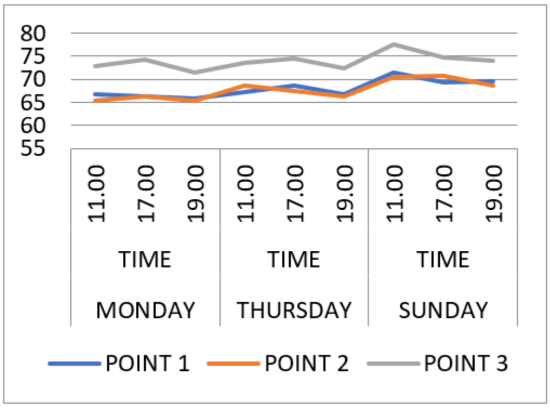
Table 5. Results of Thursday's background noise measurement

| Unit of measure (dB) | THURSDAY | | |
|---|---|---|---|
| | TIME | | |
| | 11.00 | 17.00 | 19.00 |
| POINT 1 | 67.57 | 67.73 | 66.24 |
| POINT 2 | 68.37 | 66.83 | 68.36 |
| POINT 3 | 74.23 | 73.78 | 72.58 |

Table 6. Sunday background noise measurement results

| Unit of measure (dB) | SUNDAY | | |
|---|---|---|---|
| | TIME | | |
| | 11.00 | 17.00 | 19.00 |
| POINT 1 | 71.46 | 69.27 | 69.64 |
| POINT 2 | 70.63 | 70.84 | 68.75 |
| POINT 3 | 77.48 | 74.76 | 73.96 |

Figure 11. Graph for measuring background noise in class III hospital rooms
Source: Author




- Background Noise Measurement in Class II Inpatient Rooms

Table 7. Results of Monday's background noise measurement

| Unit of measure (dB) | MONDAY | | |
|---|---|---|---|
| | TIME | | |
| | 11.00 | 17.00 | 19.00 |
| POINT 1 | 66.76 | 66.29 | 65.87 |
| POINT 2 | 65.34 | 66.43 | 65.36 |
| POINT 3 | 72.86 | 74.39 | 71.53 |

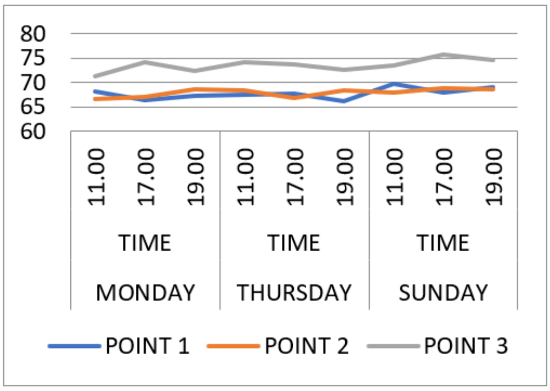
Table 8. Results of Thursday's background noise measurement

| Unit of measure (dB) | THURSDAY | | |
|---|---|---|---|
| | TIME | | |
| | 11.00 | 17.00 | 19.00 |
| POINT 1 | 67.25 | 68.63 | 66.87 |
| POINT 2 | 68.76 | 67.38 | 66.29 |
| POINT 3 | 73.49 | 74.48 | 72.36 |

Table 9 . Sunday background noise measurement results

| Unit of measure (dB) | SUNDAY | | |
|---|---|---|---|
| | TIME | | |
| | 11.00 | 17.00 | 19.00 |
| POINT 1 | 69.73 | 67.88 | 69.14 |
| POINT 2 | 67.86 | 68.86 | 68.64 |
| POINT 3 | 73.48 | 75.74 | 74.64 |

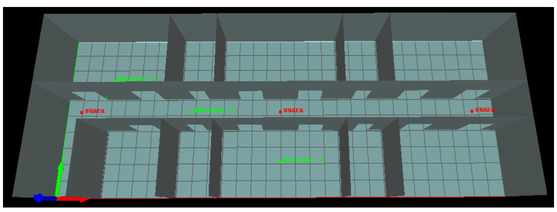
Figure 12. Graph for measuring background noise in class II hospital rooms
(Source: Author)



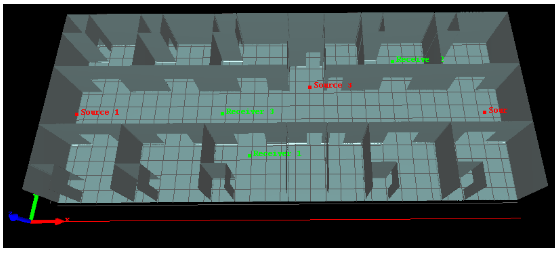

From the results of Background Noise research on class III and II inpatient rooms at Bumi Panua District Hospital. Pohuwato obtained the Background Noise intensity value in class III inpatient rooms in the range of 66 - 75 dB while in class II it was in the range of 66 - 77 dB. The condition of Background Noise in class III and II inpatient rooms is not good because (dB) is quite high, above 66 dB and exceeds the recommended standard regarding (dB) Background Noise in patient rooms which should be below 40 - 45 dB. This is caused by the activities of patient visitors and the parking lot which is right next to the building so that a lot of unwanted sound enters the building, where the elongated, linear shape of the building with the use of materials that are not good for acoustics causes a lot of sound reflections and buzzing for too long. the room becomes Background Noise sound.

## E. Modeling Process Using the I-Simpa Application

Figure 13. Class III (a) and class II (b) inpatient rooms
(Source: Author)



(a)



(b)

Reverberation time uses three sound sources placed in the building corridor. The reverberation time measurement point is carried out at the same time as background noise.

## F. Reverberation Time Simulation Using The I-Simpa Application

### 1. Sound distribution in class III inpatient rooms

Figure 14. Sound distribution in class III inpatient rooms (Source: I – Simpa)

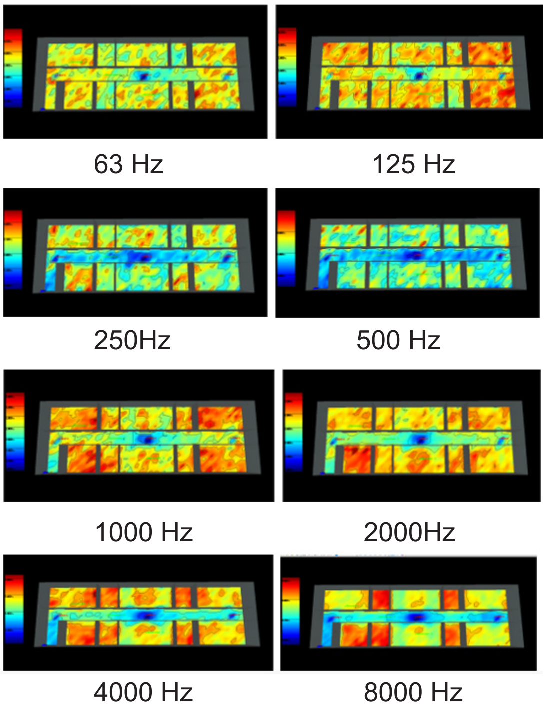



Table 10. Reverberation Time (T30) Class III Inpatient Room

| Hz | POINT 1 (S) | POINT 2 (S) | POINT 3 (S) |
|---|---|---|---|
| 63 | 4,2 | 4,23 | 4,43 |
| 125 | 4,21 | 4,02 | 4,38 |
| 250 | 4 | 3,86 | 4,01 |
| 500 | 4,19 | 3,9 | 3,99 |
| 1000 | 3,45 | 3,71 | 3,54 |
| 2000 | 3,29 | 3,29 | 3,33 |
| 4000 | 1,95 | 2,08 | 2,04 |
| 8000 | 0,98 | 0,98 | 0,95 |

### 2. Sound distribution in class II inpatient rooms

Figure 15. Sound distribution in class II inpatient rooms (Source: I – Simpa)

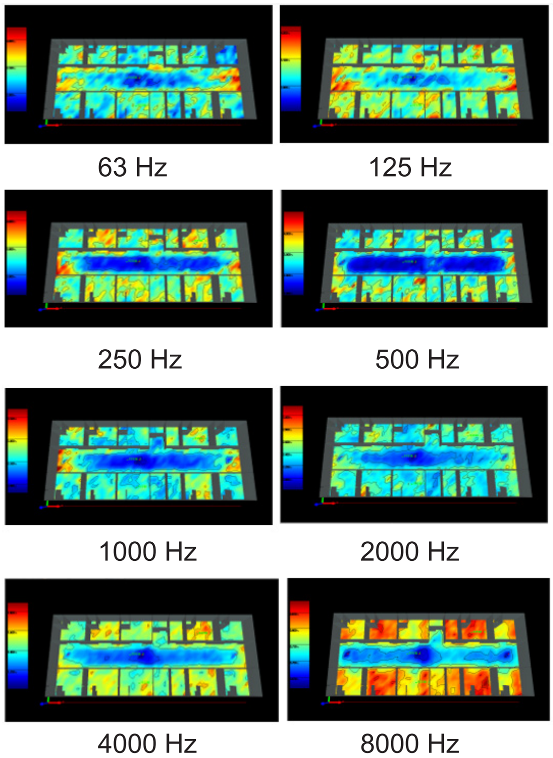



Table 11. Reverberation Time (T30) Class II Inpatient Room

| Hz | POINT 1 (S) | POINT 2 (S) | POINT 3 (S) |
|---|---|---|---|
| 63 | 4,41 | 4.18 | 4.23 |
| 125 | 4.00 | 4.62 | 4.06 |
| 250 | 3.83 | 3.94 | 3.99 |
| 500 | 3.75 | 3.94 | 3.80 |
| 1000 | 3.34 | 3.21 | 3.47 |
| 2000 | 2.93 | 2.95 | 3.13 |
| 4000 | 1.90 | 1.73 | 1.85 |
| 8000 | 0.92 | 0.89 | 0.90 |

Based on the simulation results, the Reverberation Time (RT30) in class III inpatient rooms is in the range of 0.95 seconds at 8000 Hz and 4.43 seconds at 63 Hz. The simulation results for Reverberation Time (RT30) in class II inpatient rooms are in the range of 0.90 seconds at 8000 Hz and 4.62 seconds at 125 Hz. If you look at the image of the sound distribution pattern entering the patient's room, there are more and longer sound reflections, resulting in a long reverberation time.

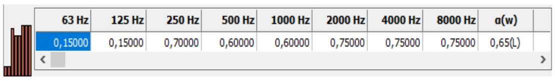
## G. Optimization of The Use Of Acoustic Materials

Optimization aims to improve the acoustic performance of inpatient rooms and the optimization carried out is a simulation using acoustic materials that can optimize the sound in the room. Optimization was carried out as a recommendation from researchers for hospital buildings to optimize noise intensity and reverberation time which refers to patient comfort.

Recommended materials for inpatient rooms:

1. Wall = mineral wool board

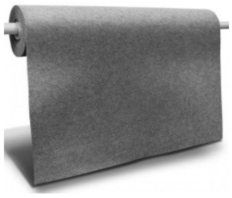
Figure 16. Material and absorbent
(Source: Odeon)

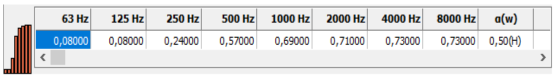


| 63 Hz | 125 Hz | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz | 4000 Hz | 8000 Hz | α(w) |
|---|---|---|---|---|---|---|---|---|
| 0,15000 | 0,15000 | 0,70000 | 0,60000 | 0,60000 | 0,75000 | 0,75000 | 0,75000 | 0,65(L) |

2. Floor = Carpet Heavy

Figure 17. Material and absorbent
(Source: Odeon)

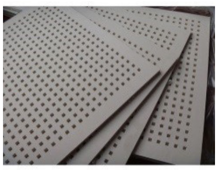


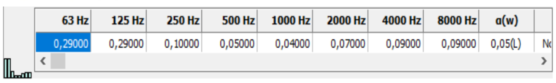


| 63 Hz | 125 Hz | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz | 4000 Hz | 8000 Hz | α(w) |
|---|---|---|---|---|---|---|---|---|
| 0,08000 | 0,08000 | 0,24000 | 0,57000 | 0,69000 | 0,71000 | 0,73000 | 0,73000 | 0,50(H) |

3. Ceiling = Gypsum Perforated

Figure 18. Material and absorbent
(Source: Odeon)





| 63 Hz | 125 Hz | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz | 4000 Hz | 8000 Hz | α(w) |
|---|---|---|---|---|---|---|---|---|
| 0,29000 | 0,29000 | 0,10000 | 0,05000 | 0,04000 | 0,07000 | 0,09000 | 0,09000 | 0,05(L) |

### 1. RT30 optimization simulation for Class III Inpatient Rooms

**Sound distribution pattern**

Figure 19. Sound distribution in class III inpatient rooms
(Source: I – Simpa)

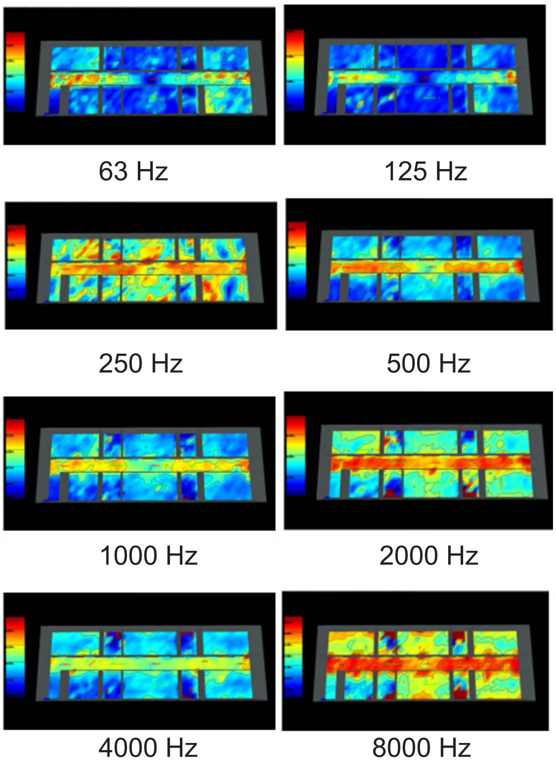



Table 12. RT30 optimization simulation for Class III Inpatient Rooms

| Hz | POINT 1 (S) | POINT 2 (S) | POINT 3 (S) |
|---|---|---|---|
| 63 | 1,26 | 1,54 | 2,38 |
| 125 | 1,24 | 1,36 | 2,57 |
| 250 | 0,42 | 0,41 | 0,58 |
| 500 | 0,30 | 0,31 | 0,66 |
| 1000 | 0,25 | 0,31 | 0,57 |
| 2000 | 0,22 | 0,23 | 0,45 |
| 4000 | 0,20 | 0,23 | 0,42 |
| 8000 | 0,18 | 0,22 | 0,33 |

### 2. RT30 optimization simulation for Class II Inpatient Rooms

**Sound distribution pattern**

Figure 20. Sound distribution in class II inpatient rooms (Source: I – Simpa)

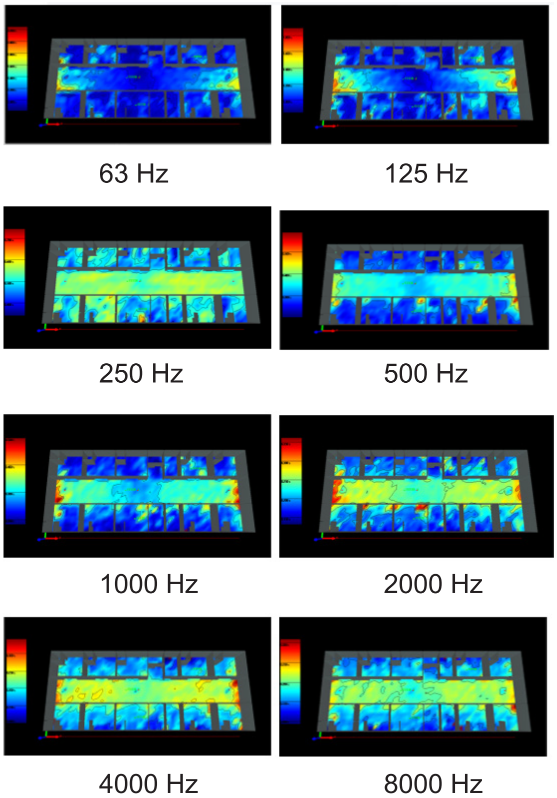



Table 13. RT30 optimization simulation for Class II Inpatient Rooms

| Hz | POINT 1 (S) | POINT 2 (S) | POINT 3 (S) |
|---|---|---|---|
| 63 | 1.50 | 1.15 | 2.35 |
| 125 | 1.53 | 1.20 | 2.12 |
| 250 | 0.43 | 0.40 | 0.57 |
| 500 | 0.47 | 0.29 | 0.53 |
| 1000 | 0.34 | 0.26 | 0.53 |
| 2000 | 0.27 | 0.20 | 0.39 |
| 4000 | 0.21 | 0.20 | 0.36 |
| 8000 | 0.28 | 0.18 | 0.28 |

Based on the simulation results, the Reverberation Time (RT30) in class III inpatient rooms is in the range of 0.20 seconds at 4000 Hz and 2.57 seconds at 125 Hz. The simulation results for Reverberation Time (RT30) in class II inpatient rooms are in the range of 0.20 seconds at 4000 Hz and 2.35 seconds at 63 Hz. This time meets the recommended standards, namely the reverberation time is lower than 1.30 seconds. Based on the simulation results of the sound distribution pattern, it shows that the reverberation time produced in the patient's room runs out faster than the sound in the corridor. These results are better than before optimization was carried out

## Conclusion

From the results of Background Noise research on class III and class II inpatient rooms at Bumi Panua District Hospital. Pohuwato. In class III rooms, the background noise intensity is in the range of 66-75 dB From the results of Background Noise research on class III and class II inpatient rooms at Bumi Panua District Hospital. Pohuwato. In class III rooms, the background noise intensity is in the range of 66-75 dB and in class II the background noise intensity is in the range of 66 - 77 dB. The condition of background noise in class III and II inpatient rooms is not good because the (dB) produced by background noise in the room is quite high, above 66 dB and exceeds the recommended standard regarding (dB) background noise in patient rooms. It should be below 40 – 45 dB according to the recommendations of KepMenLH No. 48:1996. Based on the simulation results, Reverberation Time in class III and class II inpatient rooms occurs longer.

The factor that influences the noise measurement results for class III inpatient rooms is that the location of the building is in the middle of other buildings, making the presence of a corridor on the side of the building which is frequently passed by patient visitors causing more sound to enter the inpatient room. and the dense activity of patient visitors also causes the buzzing time that occurs in the room to be longer, causing high noise.

In class II inpatient rooms, the factor that influences noise is because the parking lot is right next to the building so that a lot of unwanted sound enters the inpatient room, where the elongated, linear shape of the building and the use of materials that are not good for acoustics causes a lot of reflections. Sounds and buzzing in the room for too long become Background Noise.

After carrying out simulations as a form of recommendation for researchers to optimize noise and reverberation time in inpatient rooms, researchers recommend using the following materials: 1) Walls using Mineral Wool Board, 2) floors using Heavy Carpet and

3) Ceilings using Perforated Gypsum. From the simulation results, recommendations obtained good results regarding reverberation time. Low reverberation time can reduce the intensity of background noise that occurs in the room and make the building have better acoustic levels
When designing a building, you must pay attention to the conditions of the surrounding environment and designing a spatial layout in the building is expected to pay attention to important elements such as materials so that the desired room atmosphere can be created well.

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