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Research paper

The Capability of Multi-Layer Material of A Pitched Roof in Reducing Noises

Ernaning Setiyowati1*, Hanif Alfanani1, Enita C. Nisa1, Siti Aisyah1

1Department of Architecture, Universitas Islam Negeri Maulana Malik Ibrahim Malang, Indonesia
**Corresponding author E-mail: ernaning@arch.uin-malang.ac.id*

Abstract

Noise is an annoying sound that should be avoided from entering a building. Therefore, A building should have a well-insulating material to prevent noises. The roof is one part of the building that should be covered by the material. One alternative way to build an insulating material is to compile the roof by some layered material. This research aims to discover a compatible tiered roof to be composed in a pitched roof to decrease noises from outside the building. The layered material applied in this research are wire, aluminum foil, white fiber met, and ijuk. This research is an experimental study using a model that was measured straight in the field using an SLM appliance. The result of this study indicates that the multi-layered pitched roof can decrease noises more than a general roof tile. It can lower noise by about 11 dB.

Keywords: *layered pitched roof, room acoustic, noise, sound*

1. Introduction

A reasonable settlement is the one that can provide a comforting environment for the people. It is including the comfort of noise. Some of the housing areas can offer the convenience of noise, and some can not. The maximum noise rating (NR) that is allowed to be in a dwelling area is 25-35 dB, depending on the room. It is 25 dB for bedrooms and 35 dB for the living area (Szokolay, 2004).
Another source mentions that the noise level allowed in a house is 45-55 dBA (Mediastika, 2005). But the interference caused by external noise depends on the condition of the source (frequency, intensity, intermittency, duration, etc.) and the exposure level (propagation, isolation, and reverberation); and the occupant's sensitivity (Duarte & Tamez, 2009). Furthermore, the time and the activities of the residents are also influence the annoyance level. Therefore, although the exposure level is maintained throughout the day, people feel more annoyed during relaxing times, particularly at night if sleep disruptions take place and at weekends (Bristow & Wardman, 2006). Moreover, lifestyle and dependency on sound sources, also affect the sounds that are defined as noise (Kuno et al., 1993).
In the housing in Indonesia, especially in kampong area, noises usually come from motorcycles or cars, and the children that play on the road. Furthermore, people used to celebrate some special occasion by making a party, such a wedding party, by using some electronic speakers that can be heard by the entire people in a kampong. People in kampong plays on the road and celebrate their occasion on their house because of the lack of public spaces. Kampong does not provide comfortable public areas for their people that cause more noises around the house (Widaningsih, Busono, & Krisnanto, n.d.). Furthermore, there is also no spaces between houses, that sometimes cause people in some homes can hear the activities in the other houses. That is why the houses in kampong need some treatments at the buildings to reduce noises. The procedures used in this research is on the roof covering.
The good absorbent materials in medium frequency is a perforated material (Tizianel, 2005) and porous materials (Setiyowati & Nasrullah, 2015). Moreover, some layers should be added to create a sound insulation material (Doelle, 1986), and the acoustic permeation of multi-layer materials is preferable with perforated plate backed with airspaces (LEE & CHEN, 2001). Furthermore, the reflected sound wave inside the sound absorber can be absorbed again and again through the multilayer structure (Zulkifli, Nor, Tahir, Ismail, & Nuawi, 2008). That is why the treatment used in the roof covering of this research is to change it with some perforated and layered materials. Considering that the material will be used in kampong houses to reduce noises, so it should be cheap or can afford by the people. So the materials chosen are wire, aluminum foil, white fiber met, and ijuk. Ijuk in the height of 2 cm and the 150 kg/m3 of density mass volume has 0,23 absorption coefficient in the frequency of 500 Hz, 0,86 absorption coefficient in the frequency of 1000 Hz, 0,97 absorption coefficient in the frequency of 2000 Hz, and 0,81 absorption coefficient in the frequency of 4000 Hz (Zulfian & Sajidin, 2009). This capability of ijuk is the reason why this material is chosen to replace the roof tile in this research, besides its low price.
Meanwhile, aluminum foil should also be installed in the roof construction because of its capability of thermal insulation(Sudarmadji, 2014). However, the acoustic value is not the only reason to choose the building materials for the roof. This research aims to discover the ability of multi-layer material of a pitched roof in minimizing noises. To find the answer, the multi-layer material will also be compared to a standard roof material, i.e., tile roof. The comparison is to find out which material is better to be used in a building, especially in a kampong house

2. Methodology

The strategy of this research is a measurement in the field by using building models and SLM Rion NL-31 analog as the measurement instrument. It also uses a calculation by using the formula of NR (noise criteria). The dependent variable of this research is the roof covering material. Meanwhile, the independent variable is Noise Reduction (NR) of a layered pitched roof.

2.1. Building Model

The dimension of the building model used as the measurement object is 1x1x0,6 m3. The measurement has been done in two models. The first model has wire, aluminum foil, white fiber met, and ijuk as the roof covering material. The second model, as the control variable used tile as a roof covering. Both models have the same dimension and the same material for the other building elements. The other materials are brick wall plastered and ceramic tiles. The detail of the layered roof covering materials can be seen in Figure 1, and the list of building materials used in the models are shown in Table 1.

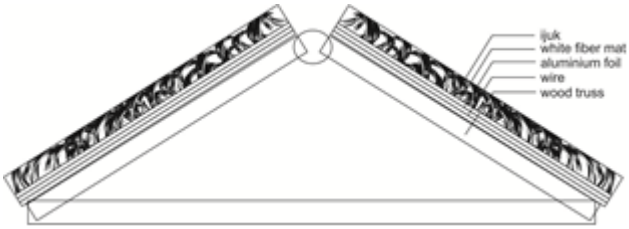

Fig 1. Detail of the Multi-Layer Roof Material

Table 1: List of Building Materials Used in the Models

	Model 1	**Model 2**
Floor	Ceramic tile	Ceramic tile
Wall	brick	Brick
Door	wood	wood
Window	Single glass	Single glass
Roof Truss	wood	wood
Roof Covering	Roof tile	Multi layer

2.2. The Tools and the Procedure of Measurement

The sound accepted by the model should be solely the sound through the wall. Therefore, all of the openings must be closed during the measurement. Sound Level Meter (SLM) analog is applied to be the instrument to measure the noise inside the room. The other device is a speaker to generate the sound outside the place that is regarded as the source of the noise. It is located in five meters away from the measured models. The sound data from outside and from the inside room were needed to discover the ability of the wall in reducing the noise.

3. Discussion

The data collected from the measurements will be analyzed and discussed. The measurement results are shown in Table 1 and 2.

Table 2: First Measurement of Noise Reduction

	Tile roof	**Multi-layer roof**
Noise source	94 dB	94 dB
Sound received in the room	86 dB	83 dB
NR (noise reduction)	**8 dB**	**11 dB**

Table 3: Second Measurement of Noise Reduction

	Tile roof	**Multi-layer roof**
Noise source	94 dB	94 dB
Sound received outside the room	80 dB	84 dB
NR (noise reduction)	**14 dB**	**10 dB**

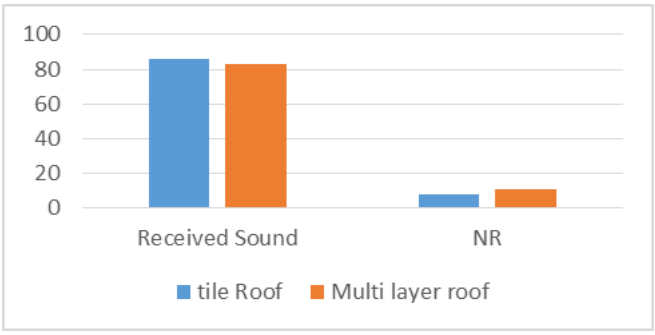

Fig 2. First Measurement: Sound Receive Inside the Room

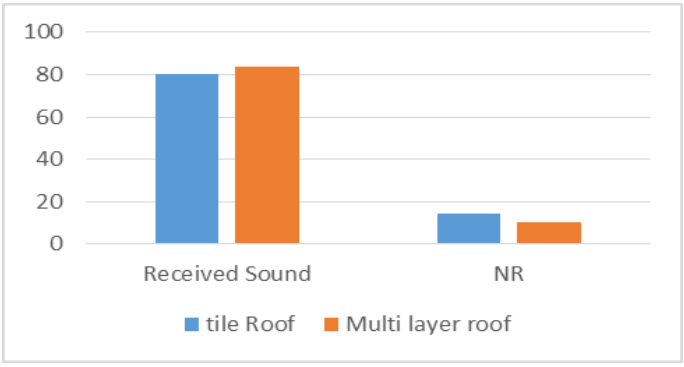

Fig 3. Second Measurement: Sound Receive Outside the Room

In the first measurement, the sound source was placed outside the model, and the sound level meter was inside. The result of this measurement is that the NR of roof tile is 8 dB, and the NR of layered roof is 11 dB. This indicate that the multi-layer roof can reduce more noise from outside than a roof tile.

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In the second measurement, the sound source was placed inside the model, and the sound level meter was outside. The result of this measurement is that the NR of roof tile is 14 dB, and the NR of the layered roof is 10 dB. It indicates that the tile roof can reduce more noise from inside than a multi-layer roof.

The first and the second measurement shows a different result. It shows that it is not only the material type, but it is also the arrangement of the material that gives an influence to the noise reduction. The tile roof is good at reducing noises from inside building, while the multi-layer roof is vice versa. This analysis is shown in figure 4 and 5.

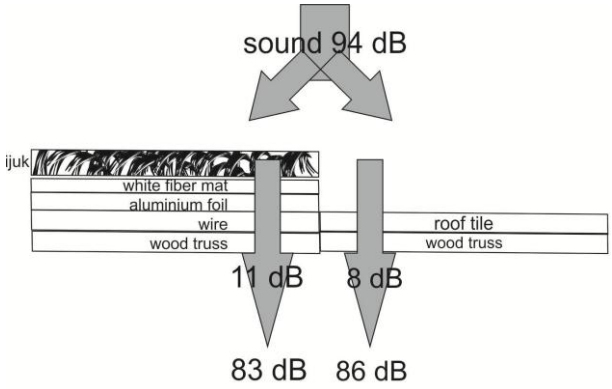

Fig 4. First Measurement

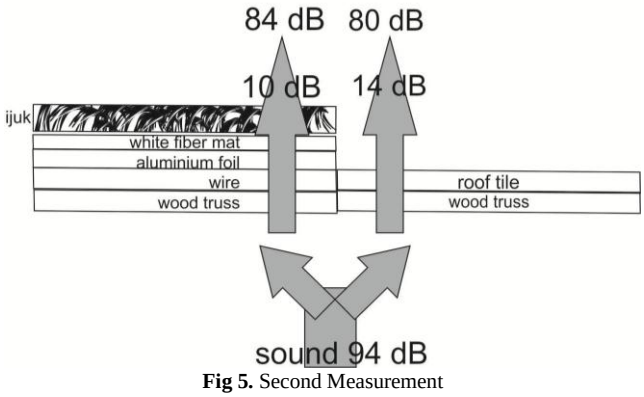

Fig 5. Second Measurement

Figure 4 and 5 shows the detail of the noise reduction. In the first measurement, the sound is received by ijuk first; then it is transmitted to the next layer, which are white fiber mat, aluminum foil, wire, and wood truss. Compare to the other layer material, ijuk has the most significant coefficient of sound absorption because of its porous characteristic. Because ijuk receives the sound first, it has the first opportunity to absorb the sound, then transmit the remaining sound to the next layer. It causes the noise reduction in the first measurement is bigger than the second one. In the second measurement, the sound receives in a wood truss first, then transmitted to the wire and aluminum foil that has a small coefficient absorption. This cause the sound is reflected first before it is absorbed in the ijuk. The reflection made the noises louder. It causes the noise reduction is less than the first measurement.

Meanwhile, the tile roof shows a different result. The sound from inside is easy to be absorbed in the roof and get out of the room because the inside material does not have a reflection characteristic. While the sound from outside is reflected by the tile characteristic from the outside, that causes the noise reduction in the first measurement is less than in the second measurement.

4. Conclusion

This research aims to discover the ability of multi-layer material of a pitched roof in reducing noises, compare to the tile as a conventional roof material. The measurement shows a different result and different capability of these materials. The tile roof is good at reducing noises from inside of a building, and the multi-layer roof is good at lowering noises that come from outside. This different capability makes both materials are suitable to be used in a house, but with a different treatment and placement, depends on the requirement of a room. For example, the place that needs to be quiet, like a bedroom, need to use a multi-layer roof to reduce noises from outside. Meanwhile, the area that might cause noises like a living room needs to use a tile roof so the noises will not disturb the neighbors.

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