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Sustainable building material for noisy urban residential space

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Abstract

Researches on noise control have been conducting until now. Eventhough correlation model of housing orientation to airport's runway was found out, it would be better if housings are equipped by materials which can absorb noise. This paper will refresh the housing master plan design near airport continued with the possibility of housing on controlling noise disturbance. Method used is descriptive analysis on reviewing sustainable materials for low cost housings. Results of researches show that wood sawdust and coconut fibre panel have quite good acoustical performances and could be used to be wall layering in noisy urban housings.

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Keywords: acoustical theory; housing master plan design; absorber materials.

1. Introduction

The number of houses in Indonesia always increases. City noise problems will always be associated with the three main sources of noise, such as transport, heavy equipment and factory activity (Setyowati, E & Sadwikasari, A.F., 2013). Airport is one of many urban transportation which causes urban noise. To clarify the discussion it would have taken the case of noise on residential areas near the airport.

Furthermore, noisy urban areas such as the airport area, highways are surrounded by a densely populated residential area (Setyowati, E & Sadwikasari, A.F., 2013). In the previous research, housing facing to airport's runway will have high intensity noise, while housing opposite toward the runway will receive less in noise

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intensity(Setyowati, E & Trilistyo, H., 2013). Eventhough model correlation between angle of orientation and noise intensity received by inhabitant has been determined, it would be better if housing equipped by absorber however. If housing are added by absorber they will much more comfortable from noise diturbance. Materials having high absorption coefficient > 0.2 are arguably as absorbers (Ermann, M, 2015). Sawdust generated by certain woods will have different properties. Meanwhile, according to *Bucur* (2006) acoustic properties of wood will be affected by noise emission characteristics of the specific wood material.

Nomenclature

L	: Noise intensity level (dB)
A	: Amplitudo
π/ω	: constant
α	: Angle of orientation (°)
$\frac{\pi}{\omega} \alpha_c$: Phase

1. Low cost Housing near noisy Airport

The population of the world continues to increase. As a result, the number of housing is also increasing day by day. With increasing urban population in the world, the urban sprawl is not inevitable. Transportation is an area that has never deserted the consumer in the condition as described above. Intensity of transportations by land, sea and air will always increase. To clarify the discussion, so in this article is taken case studies that have been done before, which is about the noise on the housing around the airport.

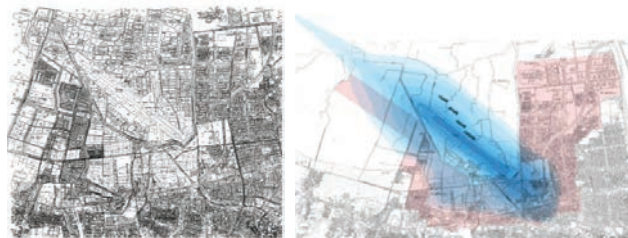


Fig.1.Noise maps in Region ofAchmadYani International Airport in Semarang, Indonesia (Setyowati, E.,2013)

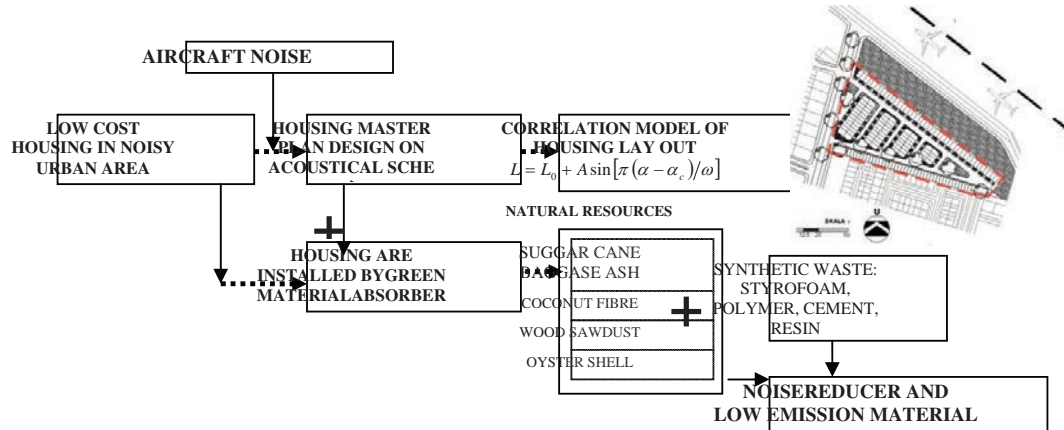


Fig.2. Low emission Comfortable Low Cost Housing in Noisy Urban Residential Space Mapping Research

Housing around the airport has a different orientation angles vary the sound source the airport. Therefore, the patterns of the received sound levels were also different (see fig.01). Previous research has found a correlation model between the angle of orientation of housing and the intensity level of noise received by inhabitant in housings area. This study create mapping on how the housing master plan design more effective through extensive research of green material which can reduce noise, especially in noisy urban housings (see. Fig.2).

2. Absorber material made of waste

Research on green materials are continuously carried out by researchers in the framework of the discovery of new material innovations for Noise Control and the concept of Green Design of housing in noisy urban area. Starting from research on middle-low income housings near the airport which were suffered by airport noise (Setyowati, E & Sadwikasari, A.F., 2013; Setyowati, E., & Trilistyo, H., 2013; Setyowati, E., 2013).

Forests and plantations resources of Indonesia can produce a variety of materials, for example acoustical material made of sawdust and coconut fiber (Setyowati, E, Hardiman, G., Atmadja, S.T., 2015). While in the previous research on sustainable housing, that prototype of housing in Indonesia is low cost housing with lower to middle income community. The number of houses in Indonesia always increases. Furthermore, noisy urban areas such as the airport area, highways are surrounded by a densely populated residential area (Setyowati, E & Trilistyo, H., 2013). Thus, those housings should be equipped by absorber on their walls. According to Leslie, D, 1993, materials having absorption coefficient higher than 0.2 are arguably as absorbers. Sawdust generated by certain woods will have different properties.

2. Methodes

1. All Correlation model between angle of orientation and noise intensity

This study uses a quantitative approach to polynomial regression method. Regression method used was polynomial regression of goneometry. Because the orientation angle which can be observed in a preliminary study on the existing cluster is limited to only 3 certain angles, it needs building modelling in order to study a lot of orientation angles. In order to examine the relationship between sound levels with varying orientation angles, then building models created can be rotated on its axis. While to examine aspects of configuration, the three combined building models coupled with the front wall of the building elements, as the embodiment of configuration patterns that are linear rectangular housing.

2.2. Research on green material with Acoustical performance

Refer to Valerie, S, and Tegguer, A.D, 2013, rresearch on concrete material which seeks to reduce the use of cement materials, which accounted for *carbon dioxide* emissions (CO_2). Those researches concern on concrete material trying to reduce the use of cement materials which contributed to *carbon dioxide* (CO_2) emissions. In the research conducted by Setyowati, E., and Purwanto, 2015, the fine aggregate in cement was substituted by bagasse ash, while coarse aggregate was replaced by the industrial waste such as: *Styrofoam* and *polymer* waste wrapping snacks, foods and some kind of goods produced by industry. The results obtained from these studies are that the density of polymer mortar is $1,73 \text{ kg/cm}^3$, while foam mortar has density of 1.86 kg/m^3 . The compressive strength of polymer mortar is $133,33 \text{ kg/cm}^2$, while Styrofoam's is $60,24 \text{ kg/cm}^2$.

Moreover, the acoustical characteristics of polymer mortar are better than Styrofoam's on its absorption coefficient and Sound Transmission Loss (STL). Moreover, since several volcanoes erupted simultaneously in year 2013 in Indonesia, research concerning volcanic ash as cement substitution has been conducted mutually. In that research, the mix-concrete used is volcanic ash+cement:sand: Recycled Concrete Aggregate (polymer or Styrofoam waste):water with a ratio of 1,000:1,600:2,220:0,635. On the other hand, several concrete material which use bagasse ash as cement substitution have unattractive visualization due to the darker color of the materials.

In this research, we replace the fine aggregate and coarse aggregate with oyster shells which have beautiful color depend on the oyster species. Our previous researches in 2013 to 2014 studied materials made of forest and plantation waste such as: wood sawdust and coconut fibre. On the first year, the hot press machine was assembled and patent registered to government cq. Ministry of Law and Human Right of republic of Indonesia. Wood sawdust and Coconut fiber were used as acoustical waffle panels which have absorption coefficient between 0,432-0,529 and Sound Transmission Loss between 46,134 – 62,688 dB (Setyowati, E., Hardiman, G., Atmadja, S.T, 2015).

3. Result and Discussions

There is a control method of noise in noisy settings, i.e. housing orientation and configuration of residential building in a residential area near the airport. Research results related to the purpose of the research is the development of models and mapping of the Airport Noise zone with regards to the direction of the orientation of the housing against the runway. A series of studies were done to get model correlation between noise level received in the building (L) with the orientation angle of configurations (α), as follows (Setyowati, E & Sadwikasari, A.F., 2013; Setyowati, E., & Trilistyo, H, 2013):

$$L = L_0 + A \sin[\pi(\alpha - \alpha_c)/\omega] \quad (1)$$

whereas A is amplitudo, π/ω is constant, α is angle of orientation ($^\circ$) and $\frac{\pi}{\omega}\alpha_c$ is phase.

The correlation model can be generalized for several reasons:

1. Results from empirical testing in the field of environmental acoustic was using a model of replica of the building that could represent the existing buildings on a residential area of the airport, in terms of the ability of the Sound Transmission Loss (STL)
2. The correlation model is the ratio of the relative noise level reduction, not the absolute value of it.

The pattern of sound levels that occur are caused by a very dominant configuration patterns affect sound levels received. Aspects of reflection and absorption causes noise was increasing significantly. To be able to map out the lay out of housing based on sound levels received, then the resulting theory of orientation direction housing mapping zone near the airport is as follows:

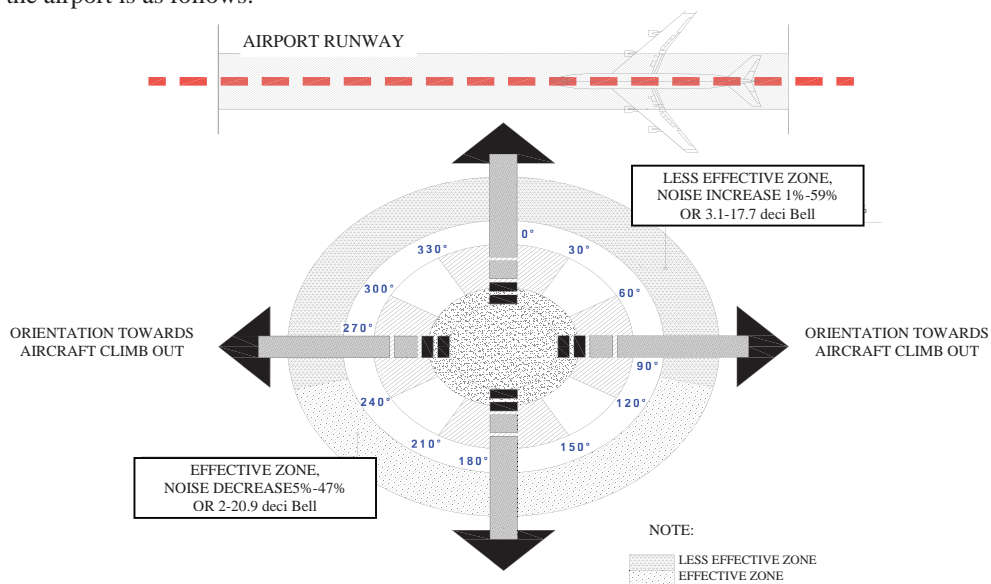


Fig. 3: Angle of Orientation of Housing Zone Mapping of Noise (Setyowati, E, 2013)

Zone with dark grey in color is zone less effective on term of orientation angle of housing. This zone causes noise

increase between 1-59% or 3.1-17.7 deci Bell. Meanwhile, zone with light grey in color is effective zone, because it can reduce noise up to 5-47% or 2-20.9 deci Bell (see figure 03). The housing orientation angle of 90° and 270° are orientation of housing towards the aircraft climbs out either when take off or landing. The mapping zone is very usefull for creating lay out of housing near airport.

Method of the housing master plan design in noisy cities, housing will become more effective if the housing is equipped with material which can reduce noise. On the research of green materials some of the materials that can be used in the reduction of noise have been mentioned in the mapping on the figure 02. However, to further clarify the discussion, then the acoustic performance of some material can be seen in the following figure (Setyowati,E and Sadwikasari, A.F., 2013; Setyowati,E., Hardiman, G., Purwanto., 2015):

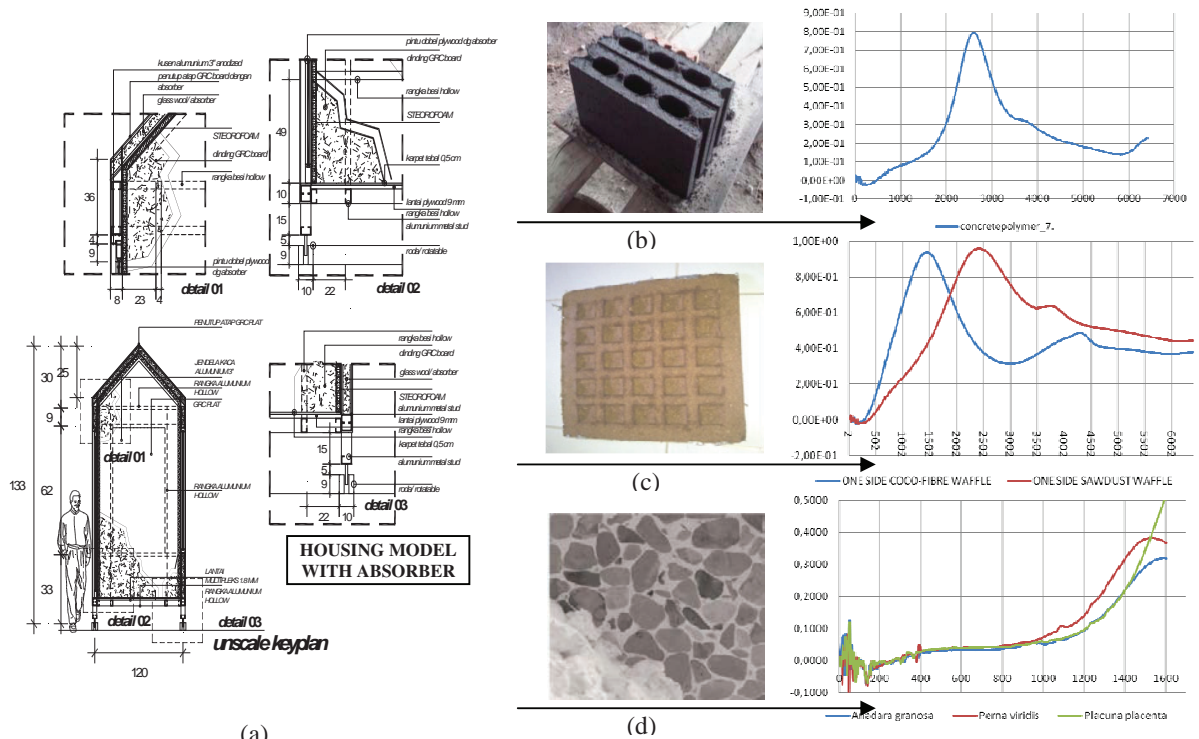


Fig. 4: (a) Housing Construction to reduce Noise; Acoustic characteristics of polymer brick (b), coconut fibre and sawdust panel (c) and oyster shell concrete material (d)

In the picture, it can be seen that the polymer concrete material has a good acoustic performance as wall panel, because it has absorption coefficient at about 0.2-0.8 on the frequencies of 1,700-1,800 Hz. Oyster shell waste concrete material has lower acoustic performance than the polymer concrete. For the material finishing the walls, coconut fibre and wood sawdust acoustic panel also has a good acoustic performance. The material has a range of absorption coefficient at between 0.43-0.53 on the frequencies of 1.0 – 6.4 k and STL at about 46-62 deci Bell.

4. Conclusions

Housing near the airport are disturbed by noise everyday. It is needed some methods to reduce noise received by inhabitants of housing. Previous researches conducted by Setyowati,E and Trilistyo, H, 2013, found out the correlationship model between orientation angle of housing and noise intensity received by inhabitants. The correlation model is:

$$L = L_0 + A \sin[\pi(\alpha - \alpha_c) / \omega] \tag{1}$$

whereas A is amplitudo, $\frac{\pi}{\omega}$ is constant, α is angle of orientation ($^{\circ}$) and $\frac{\pi}{\omega}\alpha_c$ is phase.

Eventhough the correlation model has been found out, but it would be better if housings are equipped by material which can absorb the noise quite well. Then, next researches are trying to create green materials which are not only sustainable but also have good abilities on term of reducing noise. Green materials such as polymer brick, foam brick, coconut fibre panel and sawdust panel can absorb noise very well, so they can be fitted into housings on term of noise control, especially for housings in noisy urban spaces.

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