Composing the noise space: Musical architecture of urban culture

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Abstract. In the recent climate change era of several tropical urban living and cultures, many slums are built on the railroad tracks accompanying the overheating environment. The people in that area can receive the noise radiation that was made from the railroad and the train wheels friction. The design research aims to manage noise with high intensity into the white noise, which was fit and valuable to increasing human life performance in daily life. It enhances through designing the attractive area at Malang urban area as the site and analyzing the environmental psychology approach according to adaptable barriers. This study uses audio editing and music notation software, Adobe Audition and Cubase, to capture the sound to support the design. The results highlighted that musical architecture could bridge the needs of the various people's living space and noise that cannot be moved and deleted. The play of materials, order, and composition of time that pay attention to the intensity and frequency of noise design project compose the rhythm of formal and spatial settlement design.

Keywords: architecture design, dynamic noise, railway, sound frequency, urban environment

1. Introduction
In the tropical urban environment, several settlements have been built along the railroad tracks and have become one of the destinations for the community to access creative industry services. The condition of the dwelling, which is on the side of the railroad tracks, needs special handling so that the building can respond to noise and accommodate user activities optimally. Noise waves are identical to disturbing sounds because they have different waves from human speech waves and musical sound waves. Noise is unwanted because it is unsuitable for time and space, affecting human comfort and health integrating with an urban heat environment [1]. It can affect human comfort and health due to three factors: frequency, consideration, and control. Noise depends on the sound source and the receiver which is described as urban activity and culture [2]. So it can be concluded that noise is a sound wave formed from various waves that do not go in rhythm so that noise can reduce the hearing intensity and interfere with the activities of the surrounding environment.

Noise on a moving train in the range of 85-100 dB depends on the train's speed. This noise comes from several things, including friction and vibration between the wheels of the train and the rail. The movement of the engine in the train and the concrete bearing vibration also have contributions [3]. These aspects produce internal noise emissions (in the train) and external noise or are exposed and accepted
by the environment. In response to this, the Indonesian Ministry of Health divides several noise zones that are allowed to be in a city, namely zone A (35-45dB), which is designated for research, treatment, and hospital areas, Zone B (45-55 dB) for housing, education, and recreation. Zone C (50-70 dB) for offices, commerce, and markets, and Zone D (70-90) for industry, factories, railway stations, bus terminals, and the like [4].

In the context of the study being taken, Malang is selected for study location (Figure 1). In addition to the previous studies [1], [2], [5]–[7], the railroad area is located between the residential area where the noise threshold that humans can accept is 80 dB with an exposure of 8 hours per day, while 100 dB with time exposure to 15 minutes per day. It can be seen that the condition of the community on the site is very unhealthy because they get exposed to noise throughout the day. So that to deal with this, it is necessary to make a design that can bridge the site conditions without disturbing existing activities on the site. So that the invention is carried out so that the dwelling and shop areas along the site are not disturbed, but the building can still be responsive to noise and user comfort. Moreover, this research aims to respond to this noise; the musical architecture method is applied and used to translate, play, and regulate noise from the ground so that new experiences can occur and get activities that can run optimally on the site.

![Figure 1. Condition of the site.](image)

**2. Methodology**

This study conducts the site analysis to understand site conditions associated with noise and user activity. It is carried out by considering climate, culture, time, user activity, and movement of noise sources [8]. The method could be explained by research phases as follows:

1. **Site analysis.** It can be seen the influence of location and climate responding the climate change, zoning of buildings based on utility, zoning of buildings based on users, zoning of vehicle movements and noise sources, time-based noise points, and the intensity of noise exposure given by noise sources to site users. Intervention on the design result is adjusted to the synthesis of scores and the intensity of noise exposure, the function of the building, the users, and their needs. All are the illustration of urban culture.

2. **Field observation and measurement** use sound recording and sound level meter.
3. Audio program and music note analysis are analyzed by Adobe Audition and Cubase. It will be translated to the frequency analysis and site barrier control and architectural design based on the following domain to domain transfer analysis (Figure 2).

![Figure 2. Domain to Domain Transfer Method.](image)

3. Results and Discussion
3.1. Site analysis on environmental acoustics
The data inputted in the site analysis are area climate (radiation, temperature, rainfall, wind, topography, vegetation), site effects (site use and vehicles, user activity schedules, noise parameters, susceptible time to noise exposure, and building data around, traffic, and density), schedule of train movement of pedestrian movements. In addition to the previous findings [9], the results that occur are synthesized so that they are able to illustrate what will happen in the design (Figure 3).

Music is a tone or sound that is arranged to contain rhythm, song, and harmony. It can be defined as the essential power which is very effective to calm and bring inspiration to many people. Through this definition, it can be understood that music is a group of sounds arranged so that it becomes a harmonious rhythm and can influence human emotions and performance. Music can also be interpreted as a part of human life and development. So that concerning the architectural science clusters, sound design can enrich the building experience and research how buildings and spaces can become an instrument.

There are similarities in the two groups of knowledge above, both of which discuss rhythm and harmony. On the architectural side, the emphasis is on the physical form of rhythm and harmony. At the same time, musicals pay attention to things that are connected to the user experience of the space. One method that can become a bridge for the two families is musical architecture. Musical architecture is a method that can unify space and sound into an enjoyable instrument and optimize the usability of space. There are several ways to apply to the musical architecture method. ONL's acoustic barrier uses a musical architecture method by combining a folding architecture to support the design implementation according to the design site conditions [10]. Le Corbusier's The Philips Pavillon uses aural-visual experience to apply the musical architecture method, to adapt it to the occupants' requirements and occupations.
Meanwhile, in applying the musical architecture method, Joel Sanders Architect uses a shared soundscape method in designing a Sound Lounge by taking into account the location and activities of the user. From the precedent results above, it can be found that the application of the musical architecture method is highly dependent on the conditions of the site, the users, and the activities that will be accommodated on the site (Figure 4). In addition to the previous finding [11], the user response to the environment procedures follows the attributes of environmental psychology; Noise volume, estimation of the occurrence, and the capability for controlling the source.

Figure 3. Noise radiation in daytime and nighttime.
3.2. Experiment on acoustic simulation

On the shoulders of the site directly opposite the railroad tracks, initially, there are no significant restrictions. The site's safety against exposure to noise exposure, dust, and the movement of people and trains is not guaranteed (Figure 5). The design will apply a barrier capable of declining noise and increasing the security value for settlements. Barrier site scraping in response to noise is designed based on the analysis of scores and the level of intensity of noise exposure received on the site. The barrier's design also considers the function shaded on that part of the site so that the barrier along the site has various heights, and several sides expose the train's movement. The material applied to the barrier design is a gabion wall that contains tightly arranged boulders.

3.3. Dwelling concept translation from musical architecture

Reaching acoustical comfort is the same effort on integrating thermal in anticipating urban heat islands. The comfort shift will be predicted as a resilient idea [12]. It is a channel for airflow in and out and
reduces incoming noise energy in responding to climate change (Figure 6-7). On the part of the site with relatively high noise emission intensity, the design is supported by a barrier in an acoustic glass. This is designed according to the direction of the noise. It is used to absorb most of the noise that passes into the building so that only a tiny portion of the noise can penetrate into the building. A custom rooster is also carried out to handle noise, especially from the building area facing the street, apart from thickening the walls.

The relationship of controlling noise for every sound frequency has consequences in a contradictory way for absorbing the wavelength as its dimension. For example, for sound attenuation of the most critical frequency, 1000 Hz, the building material must provide around 0.4 m of the hole as a noise trap. The lower frequency gives the bigger absorber or cavity on the building material or façade for reducing the noise. The music note is an illustration of tone, low or high frequency, and its intensity. Therefore, it is essential in architecture design which is translated into all the building elements, especially the frontal direction to the noise source.

![Music score design](http://www.sengpielaudio.com)

![Architectural translation](http://www.sengpielaudio.com)

**Figure 6.** Music score and architecture relationships.

The treatment of the dwelling roster design in the area is not jammed. The shape of the roster pattern depends on the point of road congestion. The roster is made of concrete. On the 1st floor, there is a vibrating panel to reduce noise emission energy that enters through vibrations. The concept of this vibratory panel adapts the idea of vehicle exhaust, where the gas boom that makes a loud sound is reflected at a certain angle and distance along the body of the exhaust until the sound that comes out is minimized. This panel is mainly placed in the area facing the highway, so that noise emissions from
road congestion can be minimized and do not interfere with activities on the first floor with an open concept (Figure 8).

Figure 7. Existing and the proposed model.

Figure 8. The existing and proposed model.

4. Conclusion

The musical architecture method is one method in identifying and changing the sound into an architectural masterpiece. In this design, the application of the musical architecture method is used to convert noise into architectural works by arranging and combining noise with other connected factors. The results of this method are syntheses that can be used as a reference in changing the design form. It lays out the design, makes patterns in the design, determines the design direction, and determines the materials and furniture in the design. So that the results of the building design can be responsive to noise emissions that occur, excess, and cannot be moved.
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References
[1] F. X. T. B. Samodra, "Analysis of resilient design by thermoacoustic adaptation of tropical urban model," Journal of Architecture and Urbanism, vol. 41, no. 4, pp. 305–315, 2017, doi: 10.3846/20297955.2017.1413960.
[2] J. Fallmann and S. Emeis, "How to bring urban and global climate studies together with urban planning and architecture?," Developments in the Built Environment, vol. 4, p. 100023, Nov. 2020, doi: 10.1016/j.dibe.2020.100023.
[3] F. X. Teddy Badai Samodra, "Soundscape elaboration from anthroponic adaptation of community noise," 2018. doi: 10.1088/1755-1315/126/1/012034.
[4] Regulation of the Minister of Health of the Republic of Indonesia, Industry Work Environment Health Standards and Requirements. 2016.
[5] D. Botteldooren, L. Dekkoninck, and D. Gillis, "The Influence of Traffic Noise on Appreciation of the Living Quality of a Neighborhood," OPEN ACCESS Int. J. Environ. Res. Public Health, vol. 8, pp. 777–798, 2011, doi: 10.3390/ijerph8030777.
[6] T. Münzel et al., "Environmental stressors and cardio-metabolic disease: part I—epidemiologic evidence supporting a role for noise and air pollution and effects of mitigation strategies," European Heart Journal, vol. 38, no. 8, pp. 550–556, Feb. 2017, doi: 10.1093/eurheartj/ehw269.
[7] M. M. Zefreh and A. Torok, "Theoretical Comparison of the Effects of Different Traffic Conditions on Urban Road Traffic Noise," 2018, doi: 10.1155/2018/7949574.
[8] R. M. Rehan, "HBRC Journal The phonic identity of the city urban soundscape for sustainable spaces The phonic identity of the city urban soundscape for sustainable spaces," 2019, doi: 10.1016/j.hbrcj.2014.12.005.
[9] P. Tassi, O. Rohmer, A. Bonnefond, F. Margiocchi, F. Poisson, and S. Schimchowitsch, "Long term exposure to nocturnal railway noise produces chronic signs of cognitive deficits and diurnal sleepiness," Journal of Environmental Psychology, vol. 33, pp. 45–52, Mar. 2013, doi: 10.1016/j.jenvp.2012.10.003.
[10] P. Parthenios, S. Petrovski, N. Chatzopoulou, and K. Mania, "Reciprocal transformations between music and architecture as a real-time supporting mechanism in urban design," International Journal of Architectural Computing, vol. 14, no. 4, pp. 349–357, Sep. 2016, doi: 10.1177/1478077116670743.
[11] F. X. T. B. Samodra, Irvansyah, and C. Erwindi, "Investigation on environmental adaptation of traditional lifestyle in the tropical city housing," AIP Conference Proceedings, vol. 2230, no. 1, p. 040008, May 2020, doi: 10.1063/5.0002374.
[12] F. X. T. B. Samodra, Irvansyah, and C. Erwindi, "Standard review and update for tropical comfort shift of the built environment," 2018. doi: 10.1051/e3sconf/20186704013.