PROCEEDINGS of the
23rd International Congress on Acoustics

9 to 13 September 2019 in Aachen, Germany

Passenger's Train Soundscape: Identification of Activities

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ABSTRACT

Passenger's train is an environment where people are exposed by mechanical sound and the sound of human activity. The passengers need to be in the same acoustic environment for a period of time, so a comfortable environment is a necessity. Soundscape intervention can be applied in this case with the consideration of passenger's activity. This study tries to identify the activities in a passenger's train with 9 hours (07:20-16:20) journey.

There are several activities identified in the train: sleeping, eating, going to the toilet, and using mobile phone. In general, when the passengers are not sleeping, they are using mobile phone. The passenger tends to sleep during three periods of time. The eating activity happens once after the first sleeping period. The passenger's going to the toilet twice during the journey. First, after two hours of journey and after 5 hours of journey. The study has identified the passenger's activity during nine hours train journey. The result of this study can be beneficial to design acoustic environment scenario which considers the different activity.

Keywords: Sound, Insulation, Transmission

1. INTRODUCTION

Since becoming one of the most advanced and developed transportation [1], many people choose the train as their transportation. As train's passengers, they are exposed by mechanical sound and human activity sound during the journey [2]. Train's passengers have to stay on the train and perceive same acoustic environment for a period of time during the journey. Since they cannot change the acoustic environment when it feels uncomfortable, acoustic comfort became one of the important aspects to be considered.

Train in Indonesia classified into two different groups, local train and inter-city train. Most of inter-city trains have more than 8 hours of travel time [3]. The object of this study is long journey train with 9 hours (07:20 – 16:20) travel time. There are several activities on the train during the travel time and every activity needs different acoustic environment. The aim of this study is identifying the dominant activity per period of time during the journey. Different activities also give different perception to the acoustic environment. The results from identification can be used to determine the suitable soundscape intervention will be applied.

Previous study had been done on the train with 3 of hours travel time [2]. The result of the study showed monotonous activities from the departure until the arrival so the same acoustical environment could be applied during the travel time.

2. LODAYA TRAIN

The train will be identified in this study is Lodaya train which classified as inter-city train with 8 hours and 41 minutes travel time. Lodaya train has average velocity at 60-100 kilometers per hour. Lodaya train is mass railway transportation provided by Indonesian Railways Company (PT KAI)

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purposely serving passengers from Bandung to Solo, and vice versa.

The train usually leaves Bandung Hall Station at 07:20 in the morning and at 18:55 at night. Meanwhile, the train leaves from Solo Balapan Station at 07:10 in the morning and at 19:10 at night. It provides 2 classes of train, executive class and economy class. This study is focused on economy class of Lodaya train with departure time 07:20 from Bandung Station and have 80 seat capacity [2].


Figure 1 – Economy Class Passenger Train of Lodaya [4]

3. METHODS

The analysis was conducted by in-situ measurement. In-situ measurement was performed by direct observing on the train and writing down passenger's activities every 30 minutes during the journey. The data of observing on the train provided information about dominant passenger's activities every 30 minutes.

Besides observing, an objective measurement was also done to get objectives parameter. The objective evaluation was done by sound recording inside the train during the journey. Thus, the data represent whole condition of the journey. The measurement was done in the passenger's train using binaural recording during the journey. In addition to binaural recording, the devices used to obtain objective parameters are Zoom H2n Handy Recorder and Zoom H3-VR Handy Recorder. This measurement takes place in the middle seat of the train's cart that could represent the whole acoustic environment on the passenger train.

Objective measurement would provide several parameters such as sound pressure level, L_{eq}, L_{10}, L_{90}, and L_{50}. Background noise on the train is represented by L_{90} and eventual sound is represented by L_{10}. This eventual sound is mostly caused by passenger activities. Thus, there was a correlation between passenger's activities and sound pressure level on the train.

The result from objective measurement will be compared with the result of observing passenger's activities every 30 minutes during the journey. From these measurements, the basic for designing suitable acoustic environment on the long-distance train can be obtained. The proper acoustic design based on the passenger's activities will help passengers feel comfort although it's a long journey.

4. RESULT

4.1 Sound Pressure Level Analysis

Objective measurement was performed to collect sound level data during the journey. In this study, sound level data was collected for 8 hours and 41 minutes and calculated for every 30 minutes to get L_{eq}, L_{10}, L_{50}, and L_{90} data as shown in Figure 2.

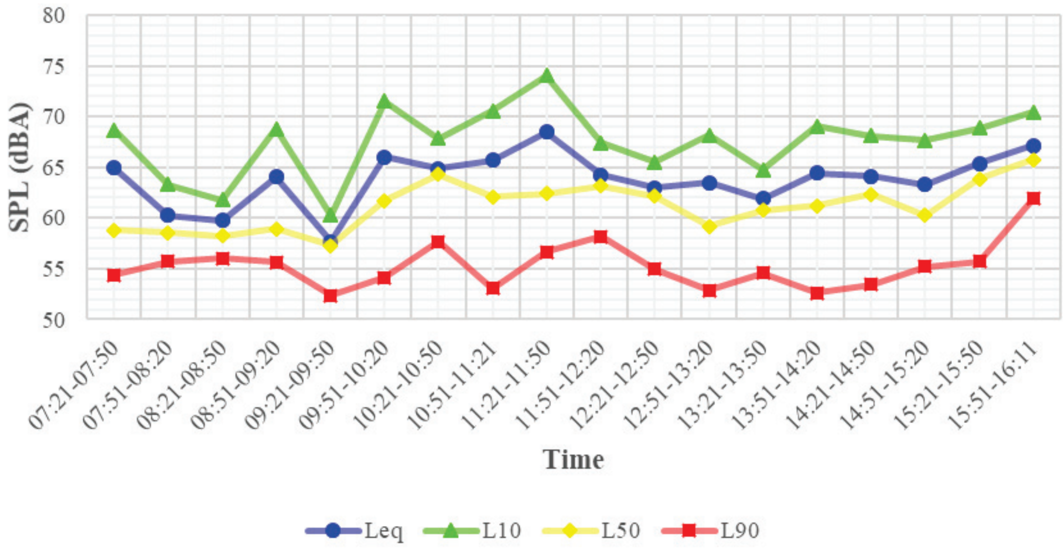

Figure 2 – Sound Pressure Level in the Lodaya Train

Figure 2 shows the value of L_{eq}, L_{10}, L_{50}, and L_{90} are fluctuating during the journey. Generally, the value of LA_{eq} in this train is around 64.5 dBA. L_{90} value indicates background noise level in the passenger's train which comes from train movement. L_{90} value decreases at 09:21 – 10:20, 10:51 – 11:21, 12:51 – 13:20, and 13:51 – 13:50 because of the train stopped at several stations. Nonetheless, L_{90} value increases at last 11 minutes of the journey because of the other sound sources beside noise from train movement as background noise.

Table 1 – Range Value of Sound Pressure Level

	Maximum Value, dBA	Minimum Value, dBA	Range, dBA
L_{eq}	68.4	57.6	10.8
L_{10}	74.0	60.3	13.7
L_{50}	65.7	57.3	8.4
L_{90}	61.9	52.4	9.5

L_{10} value indicates incidental sound level in the passenger's train and it increases at 08:51 – 09:20, 09:51 – 10:20, 11:21 – 11:50, 12:51 – 13:20, and 13:51 – 14:20. Table 1 shows the value of L_{10} has the highest range than the other value. It indicates there are variated incidental sound with variated level during the journey. Most of incidental sounds came from passenger's activities in the train. There are a wide difference between L_{10} and L_{90} at 07:21 – 07:50, 09:51 – 10:20, 10:51 – 11:21, 11:21 – 11:50, 12:51 – 13:20, and 14:21 – 14:50 more than the average difference. Incidental sounds with high sound pressure level appeared at those time.

The value of L_{eq} has similar fluctuation with the value of L_{10} and increases at the same time. The trend of the value could be seen in Figure 2 but the sound sources could not be identified. Consequently, further analysis must be done to identify dominant sound sources related to the sound level measurement. Dominant sound sources could be identified by analyzing spectral sound level measurement.

4.2 Spectral Sound Level Analysis

Figure 3 showed the correlation between sound pressure level, frequency and measurement time. Dominant frequency of measured sound inside the train is low frequency between 100 Hz – 315 Hz and constantly measured during the journey The result of sound pressure level measurement showed fluctuated value but still stable because the increment and decrement were not too high. The increasing sound pressure level appeared at 09:51 – 12:20. The increment occurred at higher frequency up to 1000 Hz. The increasing sound pressure level also occurred at lower frequency at 09:51 – 12:20 and 11:51 – 12:50. The increment occurred at 63 Hz. The increasing sound pressure level at several range frequency was caused by incidental sound sources. Otherwise, there was a decreasing sound pressure level occurred at 09:21 – 09:50.

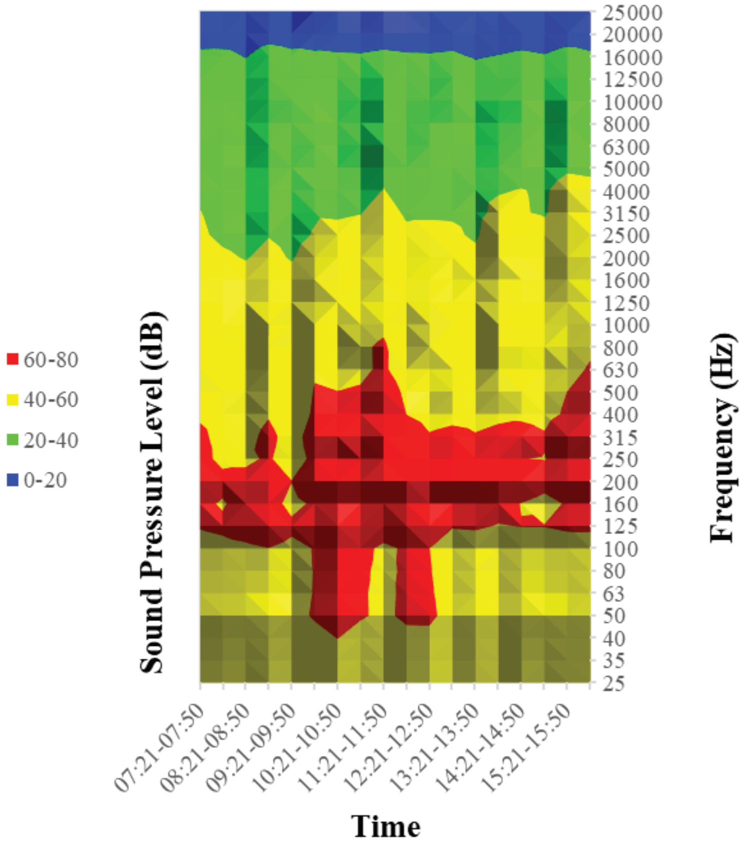

Figure 3 – Spectral Sound Level of Lodaya Train

Dominant frequency values can be used to identify dominant sound sources in the train. The low frequency as dominant frequency explained that the dominant sound source is mechanical sound. Mechanical sound could come from friction between the wheel and the rail causing vibration that propagates through the structure of the train [5]. Mechanical sound would appear along the journey.

The decreasing sound pressure level at 09:21 – 09:50 indicates mechanical sound from train movement disappeared due to train stopped at the station for a long time. On the other hand, the increasing sound pressure level at several periods of time indicates occurrance incidental sound from passenger’s activity. The sound from activities has frequency characteristic up to 1000 Hz. Passenger’s activities with frequency up to 1000 Hz is conversation. The result of objective measurement must be validated by in-situ measurement of activities.

In-situ measurement of activities was done by writing down passenger’s activities every 30 minutes during the journey. The data shows there were four dominant passenger’s activities on the train. The dominant passenger’s activities were conversation, eating, sleeping, and using mobile phone.

4.3 Identification of Passengers Activities

There were different dominant activities for every period. There were conversation, eating, sleeping, and using mobile phone. Conversation activities occurred 5 periods during the journey. Eating activities also occurred 5 periods during the journey but at different periods. Sleeping and Using mobile phone occurred at 4 periods of time.

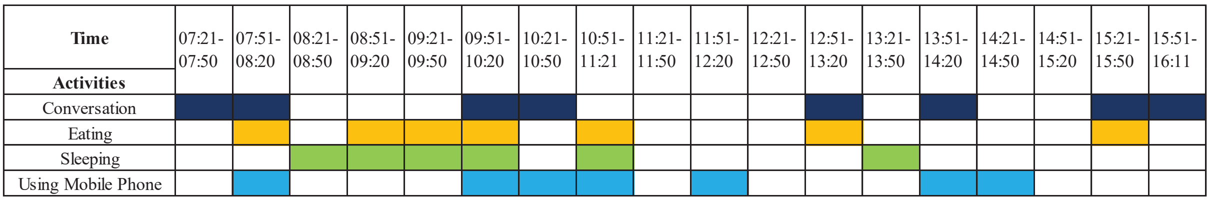

Figure 4 - Dominant Passenger Activities

The dominant activities are divided into two different groups of activities with different appearance period. As shown in figure 4 conversation and using mobile phone appeared as dominant activities at most of the same period. Those activities appeared at the beginning of the journey, in the middle of the journey and the end of the journey. Eating and sleeping as the other dominant activities also appeared at the same period. The figure 4 showed the passengers tend to eat or sleep when they are not chatting or using mobile phone.

4.4 Correlation between Objective Measurement and Identification of Passenger Activities

Sound pressure level measurement result is consistent with the identification of passenger's activity result. Sound pressure level measurement result showed L_{eq} value is fluctuating and increasing at 09:51 and identification of passenger's activity result showed conversation activity showed at the same period. The data was also strengthened by spectral sound level analysis result. The sound pressure level increased at mid and high frequency up to 1000 Hz at those periods. Conversation has a frequency characteristic between 250 Hz – 4000 Hz [6]. Accordingly, conversation is correlated to L_{eq} with correlation coefficient 0.3.

Some improvements would be necessary to achieve acoustic comfort in the passenger's train. Due to different dominant activities for every period during the journey, it needs different acoustic environment. Thus, suitable soundscape intervention could be applied differently for every period during the journey.

5. CONCLUSIONS

The value of L_{eq} L_{10}, L_{50}, and L_{90} were fluctuating during the journey and the value of LA_{eq} in this train during the journey is around 64.5 dBA. Fluctuation of L_{eq}'s value same as fluctuation of L_{10}'s value because of incidental sounds. The increasing sound pressure level was caused by passenger's conversation. It is shown by the value of the correlation coefficient between L_{eq} and conversation appearance frequency. It is also strengthened by spectral analysis result that shows increment sound pressure level at high frequency up to 1000 Hz. Identification of passenger's activity result explains there were four dominant passenger's activities. There were conversation, eating, sleeping, and using mobile phone. Those dominant activities appeared at different periods of time. Thus, soundscape intervention should be applied differently for every period during the journey.

ACKNOWLEDGEMENT

This research was supported by a grant from National Center for Sustainable Transportation Technology and funded by the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia.

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