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Controlling Indoor Noise Annoyance Through Building Design - Indoor Motorsport Facility

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Abstract

Noise can be describe as an unwanted or disturbing sound and one of the inevitable environmental types of pollution especially in densely populated area. Loss of hearing is just one of the effect as noise also can interfere with sleep and speech, cause discomfort and other non-auditory effects. (Sprague, 2001). Nowadays, a lots of indoor motorsport facilities are being constructed either for recreational of for competitions. The sound from the revving engine and exhaust can produces a high level of noise that could be really disturbing and harmful to the occupants hearing health. Thus, the objective of this research is to introduce a noise controlling set for a better quality or safer hearing level for the occupants in an indoor motorsport facility. A study through various sources discussed on how to control the noise emissions and factors that will effects the levels of sound. A site visit to one of the largest indoor karting facility available in Southeast Asia were conducted and measurements taken during the activities being held. As a conclusion, it can be said that the sound emissions produced by the indoor karting activities does reach to the level non-safe hearing to occupants which could lead to a Noise Induced Hearing Loss (NIHL) if being exposed for a long period of time. Therefore, an approach towards better and safer quality sound should be introduce from the initial stages to achieve a safe hearing level in indoor motorsport facilities.

1 Introduction

Noise can be describe as an unwanted or disturbing sound and one of the inevitable environmental types of pollution especially in densely populated area. The importance of reducing the excessive noise annoyance in a building as loss of hearing is just only one of the effects. Noise also can interfere with sleep and speech, cause discomfort and other non-auditory effects. Too much exposure to the high-level noise and vibration could lead to structural failures as well as reduction in life span. (Sprague, 2001).

Noise controlling is a set of strategies required to reduce noise pollution or to reduce impact whether in an outdoor environments or indoors. When it comes to motorsports industries, the sound from the revving engine and exhaust can produces a high level of noise. Most sport supporters do love to hear the loudness and the roar of the crowds but in an indoor motorsport activities involving such as motorbike engines, the level of noise could be really disturbing and harmful to the occupants hearing.

In this paper discussed about the factors that need to considerer while designing a building to facilitate such activities. As consideration to the (IEQ) Indoor Environmental Quality, it is important to control the noise in an indoor area for the comfort, health and the well-being of users in the building. When ignored, it could lead to one of the factors that contribute to the negative effect in the productivity of the occupants.

2 Problem Statement

In these types of indoor facilities, the sound level produces by the motorsport exhaust can reach a high level of noise annoyance that could be disturbing and harmful to the users hearing health. In an indoor building, the sound reverberation from the original sources can increased the level of the sound in which could double up the damages to the occupants. Considering towards the occupants and environmental health, the building itself need to be design adequately to facilitate such activities.

3 Research Questions

1. What are the design factors that can reduce the sound annoyance in an enclosed building for motorsport involving activities?

2. What is the sound level produced from indoor motorsport activities and how does it effects human hearing range?

4 Purpose of the Study

In this study, intended to establish an architecture where capable of putting sports arena in better way. When it comes to indoor motorsport arena, in the aspect of acoustic quality of a space often neglected. Thus, it cause noise annoyance where could reach to a level that lead to a hearing damages to the occupants in the building. The aim of this research conducted is to provide a better building construction method or technique to control or reduce the noise level and to provide a safe sound quality to the users in an indoor motorsport facility. The methodology of providing a good design factors to reduce the sound annoyance will be identify and analysed through various sources available.

5 Research Methods

The research mainly will focused on the design factors in building construction that can be implement to achieve a safe hearing level for the users in indoor motorsport facilities including riders as well. The methodology of the studies conducted via both qualitative and quantitative methods.

The research primary data obtained through qualitative data such as content analysis and case study. As for the content analysis, information from various sources gathered and identified. For the secondary data the research conducted via quantitative method. A field experiment and interviews conducted at one of the largest indoor karting facility available in Southeast Asia, which is Traxtion Karting @ X-Park located in Petaling Jaya, Selangor. Level of noise emissions produced in this facility measured by considering several factors to cater with the objective of the research. The research framework overview illustrated in the figure 1.

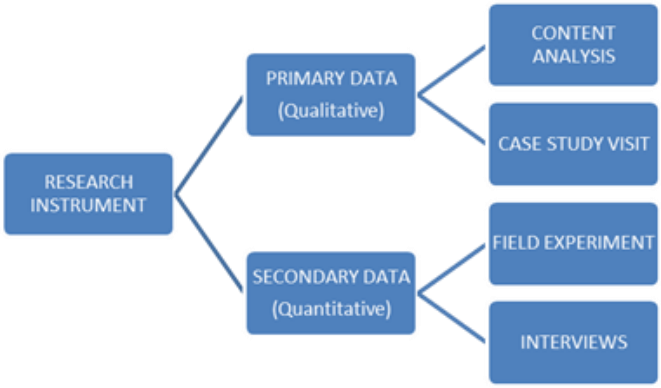

Figure 1: Research Framework Overview

6 Findings

For primary data, the investigation on various sources focused on the construction or design elements that will effect as sound reducing agents to achieve a better acoustic quality for the occupants and the neighbouring context of indoor motorsport facilities investigated. A case study also conducted at one of the indoor motorsport facility and the existing construction method applied to the building analysed. From the analysis, several technique been identified as can be used to control the level of noise emissions produced in the building. The sound level can be affected by the design factors with the manipulation of volume of the spaces, shape of the spaces and the type of materials being used. These design factors will results in a different sounds characteristic in an enclosed area. The quality of sound is depends on the reverberation time for the spaces.

6.1 By Manipulation of volume of spaces

In an architectural spaces, cubic volume, which is calculated equivalent to the ceiling height times floor area. By reducing the volume of the space and lower the ceiling height, it will effects the space to produce an excessive amount of reverberation due to the tight reflection and can cause increase of sound annoyance.

6.2 By Manipulation of Shapes of spaces

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increase of sound annoyance.

6.3 By Manipulation of Shapes of spaces

When designing a building to contains high level of sound annoyance, it is important the design materials considered to achieve safe level of noise emissions to the users in the indoor motorsport building. There are three type of materials can be applied that can help in controlling the sound pressure such as absorptive, reflective and diffusive materials.

- **Absorptive materials** - Sound absorbing materials classified on the ability of the material to absorb as much as sound wave and reflect as minimal as it could and at the same times transmit more sound waves. Materials that could absorb and transmit more sound waves than the reflections considered good sound absorbing materials
- **Reflective materials** - When sound waves hit surfaces, the reflections of sound is varies depends on dissimilarity of the surfaces contacted. Softer surfaces will produces lower amount of reflections compared to the harder surfaces such as concrete floor.
- **Diffusive materials** - An acoustic diffuser can be used to deflect certain amount sound wave from the unwanted places. Reflections from a hard surfaces often gives problematic echoes, an acoustic diffuser may be used or applied to the surfaces and the sound will be scattered in all directions. The use of sound diffusers is effective to eliminate pockets of noise annoyance in a space or area.

6.4 Via Site Planning

Acoustical site design uses the arrangement of buildings on a piece of land to minimize noise impact by capitalizing on the site's contour and natural shape. Barrier buildings, open space, non-residential, land uses can be arranged during the early stage of designing to shield the nearby residential areas or other noise sensitive activities from the noise sources. Acoustical site design can be categorized into 3 groups.

- **Distance -** Noise can be reduce by increasing the distance between the sound sensitive activities and the noise. Distances can reduced sound level which mean by doubling the distance of the noise source can reduced its intensity.
- **Building as noise shield** - Another additional noise protection can be achieved simply

by arranging the site plan to use building as a sound barriers. A long building, or a row of buildings parallel to the noise source can protect other more distant structures or open area from excessive noise pollutions.

- **Orientation** - The orientation of activities or building on a site has a quite significant impact to reduce the noise emissions. Noise impacts can be severe for rooms facing the sound sources since they are the closest to it.

6.5 Via Acoustical Architectural Design

Noise also can be controlled in a building with proper architectural design. Start by giving attention to acoustical consideration in the planning of placement of windows, building height, courtyards, room arrangements, and balconies the architect or the designers may achieve a significant noise impact reduction even without the need for costly acoustical construction.

- **Room Arrangements** - Noise impacts can be reduced by separating more noise sensitive rooms from less noise sensitive rooms; the less sensitive room or area should be placed closest to the noise source and placing the more sensitive rooms in the part of the building which is furthest away from the noise source.
- **Solid Walls** - By eliminating windows and other openings from the walls of a room or spaces close to the noise sources, the noise can be reduced. The solid walls can then have the effect as a sound barrier for the rest of the building. Walls that are directly adjacent and those perpendicular to the noise source can be the most severe impacted.
- **Balconies** - If balconies needed in a building, they should be given acoustical consideration as it may reflect the noise directly into the interior of the building.
- **Courtyards** - In a proper architectural design may also provide for noise reduction in an area outside or inside of the building. The patio houses and court garden can provide outdoor acoustical privacy which as can be seen at schools, rest homes, and hotels.

6.6 Via Acoustical Construction

As noises can passes through walls, floors, windows, ceilings, and door of a building, acoustical construction can be implement. In order to choose right materials for such as walls,

floors or ceiling, the insulation performance of the materials measured. To compare the insulation performance, the Sound Transmission Class (STC) are used to measure a materials ability to resist the sound wave penetration. A high STC rating shows good insulating materials.

6.7 Via Acoustical Barriers

Generally, a noise barrier is an object placed as an obstacle between the receiver and sound source where it interrupts the path of the sound travel. Noise barriers can be made out of various different substances such:

- Sloping piece mounds of earth or called berms
- Walls and fences
- Planting regionally or dense of shrubs
- Or by the combinations of all above

The choices of alternative depends upon space, cost aesthetics and safety as well as the desired level of sound reduction. The effectiveness of the barrier as sound reducing agents depends on the mass and high of the barrier. Besides that, it is also dependent by the distance from noise source and the receiver.

6.8 Finding From Case Study Building Visited

For this experiment, a site visit conducted to one of the largest indoor karting facilities available in Southeast Asia where it is located at Petaling Jaya, Selangor. This indoor karting building refurbished from a factory to indoor motorsport facility. In this facility, it is also equipped with other sections rather than just a racing track such as cafeteria, services workshops, and management offices. The illustrated layout plan shown in figure 2, it show the entrance towards the facility located in industrial area as shown in figure 3, but on the other side of the road, it is a residential area. As the site situated in the urban context, it is important to achieve a safe level of noise emissions for such activities.

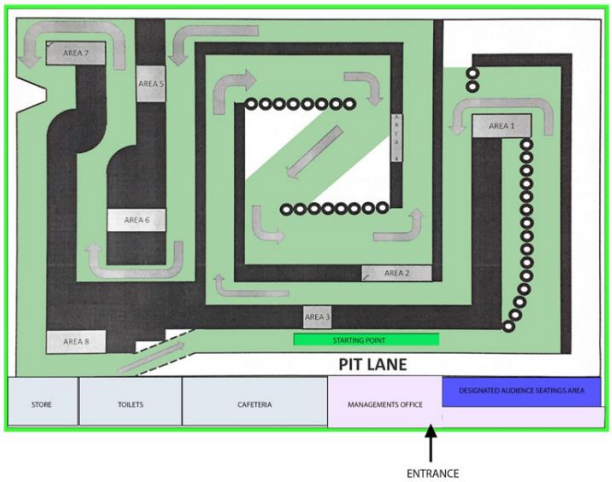

Figure 2: Illustrated Layout Plan of the indoor karting

Figure 3: View towards the entrance of the building

An investigation at the selected conducted to study the materials used as finishes. Mainly focused on wall, flooring and roof materials. By the observation, as for the track flooring, normal industrial cement rendered with epoxy protective layers used. For the walls, cement rendered brick wall with dark grey paint and as for the roof, metal deck roof with insulation installed as shown in figure 4. Identified that no approach towards better sound quality considered in building construction as to reduce the level of noise emissions produced. The highest and the lowest clear headroom also measured using Laser Meter Distance where the measurement shows that the highest clear headroom for this facility is at 23ft high and the lowest one is at 15ft high. Distance between the audience seating and the track also measured as shown in figure 5. The designated

seating situated just 2.5m from the nearest track. Without any barrier or sound reduction agents provided, the level of noise can be heard from this area are pretty high as the noise level measured.

Figure 4: Materials used in the building

As the building observed, a field experiment test to measure the sound level produced by the activities also conducted by using a sound level meter. The measurement taken during a normal weekdays which on Tuesday 30 June 2020 at 5.00 pm as four riders compete with each other in this 570m long in overall track. The measurement taken at the point 1, where the longest straight line available as illustrated in figure 5. Point 2 taken place at the most steepest cornering in the track as the sound produced by the tire friction also recorded. The yellow line show the enclosed perimeter wall where most of the opening just provided at wall B and wall C as wall D and wall A equipped with rooms.

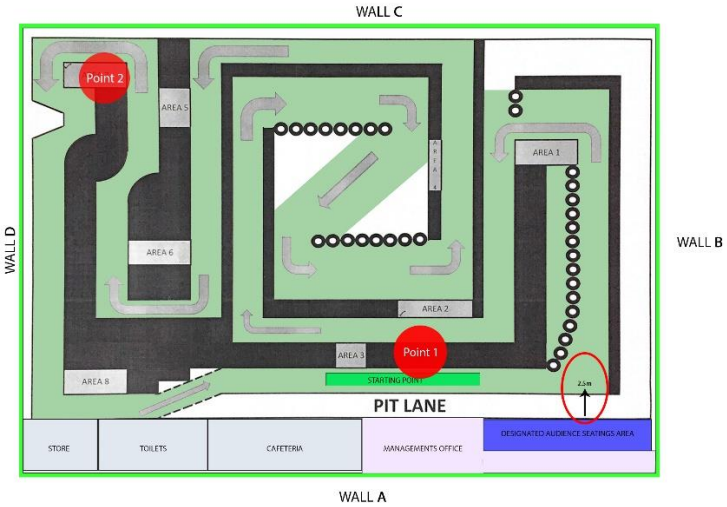

Figure 5: Points where the measurement taken

The test were conducted three times in each spot to measure the average sound level produced. Table 1 shows the measurements taken at Point 1. At this point the cart accelerate at the highest speed achievable. Table 2 shows the data measured at the point 2.

Table 1: Data Recorded at the Point 1

Test Session	Sound Level (dBA)
1st Lap	95.3
2nd Lap	95.2
3rd Lap	96.4

Table 2: Data Recorded at the Point 2

Test Session	Sound Level (dBA)
1st Lap	99.1
2nd Lap	100.2
3rd Lap	99.2

Aside from that, the sound level produced by the cart also measured using Static Noise Test method regulated by Italian Motorcycle Federation sports regulation where the static limit at the exhaust were fixed not to exceed 94 dBA. The Static Noise Test method are tested by placing the sound level meter placed 0.5 meter away and with 45° angle from the tips of the exhaust as shown in figure 6. (Giancarlo, S., 2008). Table 3 shows the noise level produced. By analysing the data taken, can conclude that the cart static noise does exceed as regulated by the regulations. But yet the sound of noise emissions created by the cart during test run indicates that the constructions method implemented in the building need to be improved.

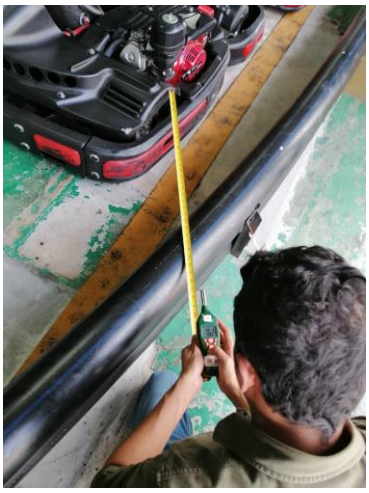

Figure 6: Measurement Taken Using Static Noise Test

Table 3: Data Recorded for static Honda GX270 cart sound test

Test Session	Sound Level (dBA)
1st Test	77.6
2nd Test	86.2
3rd Test	78.5

7 Conclusion

As conclusions, this research on controlling noise annoyance in indoor motorsport facility is rethinking on to develop a better experience to the users and at the same time for the health and safety measurements. It been proven that the existing indoor motorsport facilities often neglected the constructions method when it comes to indoor environmental qualities. As the noise induced hearing loss may not cause much effect on the users that not often visited the facilities, but yet the health on the crew members of the facilities as well should be taken care of as they do exposed to the noise emissions for much more longer period of time. There is many methods available to be implemented as noise reducing technique. Some of the method that can be implemented for this building by installing sound absorptive materials on the enclosed interior wall to reduce the sound reverberation process and as for the roof, an opening can be introduced and the track can be installed with noise barrier to reflect the sound to the outside of the building. Furthermore, by applying all those requirements needed to achieve a good sounds quality, the industry can also spared a room for further improvisation such as in this case, the cart can be upgraded from Four-

stroke to Two-stroke cart. The main reason for the delayed upgrading the carts is due to the sound level produced by more powerful cart is much higher thus afraid it will cause disturbance to the nearby buildings. Thus, by implementing all requirements needed to improve the sound quality, the benefits will not only to the occupants of the building and nearby area but together towards the growth of the industry as well.

Lastly, it can be said that the sound emissions produced by the indoor karting activities does reach to the level non-safe hearing to occupants which could lead to a Noise Induced Hearing Loss (NIHL) if being exposed for a long period of time. Therefore, an approach towards better and safer quality sound should be introduce from the initial stages to achieve a safe hearing level in indoor motorsport facilities.

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