STRUCTURAL MODEL OF NOISE, VIBRATION AND VENTILATION TOWARD TEMPORARY PASSENGER HEALTH IN THE MOVING TRAIN

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DOCTOR OF PHILOSOPHY

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Faculty of Manufacturing Engineering

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2023

DECLARATION

I declare that this thesis entitled “Structural Model of Noise, Vibration and Ventilation Toward Temporary Passenger Health in The Moving Train” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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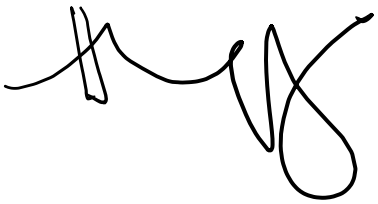
APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Doctor of Philosophy.



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Date : 21 July 2023

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DEDICATION

For my beloved husband:

Mr. Mohd Fauzzi bin Mohd Kassim

For my beloved children:

Nurfatihah

Muhammad Firdaus Izwan

Nurfaiqah

Muhammad Faiz Isyraf

Nurfalisha

Nurfahmida

Muhammad Fayyadh Firaz

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An my treasured colleagues:

UTeM's lecturers, staff and students

KKTM's colleagues

ABSTRACT

Rail transport is one of the alternative modes of transportation that has become a priority for developing countries to promote environmental, economic, and social well-being in upgrading the quality of urban life. As such, the study that considers the ergonomic risks experienced by passengers while boarding the train is very important to allow passengers to be in a healthy train cabin and not cause temporary unhealthy environment to train passengers. This research examined passenger satisfaction and comfort towards KTM Komuter based on the Ergonomic Risk Factor (ERF) and the health symptoms experienced by train passengers while using this public vehicle. Five dimensions were being investigated; Ergonomic Risk Factor, Musculoskeletal Disorder symptoms, Health symptoms, Passenger Comfort and Passenger Satisfaction. Structured self-administered questionnaires were distributed to the KTM Komuter passengers using the random sampling technique. A quantitative research method, with a questionnaire as an instrument for this research. Usable responses were received from 361 passengers giving a response rate of 90.25 percent. The structural Equation Model (SEM) investigated the relationship between the ERF, health symptoms, passenger comfort, and passenger satisfaction through IBM-SPSS-AMOS version 25.0 software. Apart from that, data collection using a measurement tool was also done to enable data collection for vibration values (the Dytran Model 5313A), noise (Sound Level Meter), and ventilation (Air Quality Meter) in the train cabin. This is to obtain results that are equivalent to the evaluation of the survey questions that have been answered by train passengers based on their own experiences while boarding this train to their destination. Ergonomic risk factors have a significant effect on Musculoskeletal Disorder symptoms, ergonomic risk factors have a significant effect on health symptoms, ergonomic risk factors have a significant indirect effect on passenger comfort, musculoskeletal disorder has a significant effect on passenger comfort, and lastly, health symptom has a significant effect on passenger comfort. Based on the measurement tool result that has been compared with the standard for each ergonomic risk factor, the noise in the train cabin has reached a value of 82.2 dBA while in the gangway from the journey of UKM to Kajang. As for the vibration value, the measurement tool has recorded the highest vibration value reading of 2,2182 m/s2 in the z-direction in the gangway area along the journey from Kajang to Tiroi. Meanwhile, the ventilation value that has been recorded has also exceeded the allowable standard level that is for the value of CO_2 concentration (ppm) is 1589.72 during the morning hour, relative humidity has an average value of 68.11 and the average temperature value that has been recorded is 23.72^0C. The results obtained from the user's answers to the questionnaires that have been distributed that revolve around ergonomic risk factors that affect health symptoms as well as comfort and user satisfaction are in line with the reading results recorded from the measurement tool that records the value of vibration, noise and ventilation risk. This study model can be used to develop and build a public transport system that considers ergonomic risk factors to enable this vehicle to provide a healthy train cabin for the passengers. By taking separate data by gender, it can also be done by comparing other railway companies to enable validity to be done better by comparing the results obtained from two different railway transport companies.

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MODEL STRUKTUR HINGAR, GETARAN DAN PENGUDARAAN TERHADAP KESIHATAN SEMENTARA PENUMPANG DALAM KERETA API BERGERAK

ABSTRAK

Pengangkutan rel merupakan salah satu kaedah pengangkutan alternatif yang menjadi keutamaan negara membangun untuk menggalakkan kesejahteraan alam sekitar, ekonomi dan sosial dalam meningkatkan kualiti kehidupan bandar. Justeru, kajian yang mengambil kira risiko ergonomik yang dialami penumpang semasa menaiki tren adalah amat penting bagi membolehkan penumpang berada dalam kabin tren yang sihat dan tidak mendatangkan persekitaran yang tidak sihat secara sementara kepada penumpang kereta api. Penyelidikan ini mengkaji kepuasan dan keselesaan penumpang terhadap KTM Komuter berdasarkan Faktor Risiko Ergonomik (ERF) dan gejala kesihatan yang dialami oleh penumpang tren semasa menggunakan kenderaan awam ini. Lima dimensi sedang disiasat; Faktor Risiko Ergonomik, Gangguan Muskuloskeletal (MsDS), Gejala Kesihatan (HS), Keselesaan Penumpang (PC) dan Kepuasan Penumpang (PS). Soal selidik terurus sendiri berstruktur telah diedarkan kepada penumpang KTM Komuter menggunakan teknik persampelan rawak. Kaedah kajian kuantitatif, dengan soal selidik sebagai instrumen untuk penyelidikan ini. Maklum balas boleh guna diterima daripada 361 penumpang memberikan kadar tindak balas 90.25 peratus. Model Persamaan struktur (SEM) mengkaji hubungan antara ERF, HS, PC dan PS melalui perisian IBM-SPSS-AMOS versi 25.0. Selain itu, pengumpulan data menggunakan alat ukuran juga dilakukan bagi membolehkan pengumpulan data bagi nilai getaran (Model Dytran 5313A), bunyi hingar (Meter Aras Bunyi), dan pengudaraan (Meter Kualiti Udara) dalam kabin kereta api. Ini bagi mendapatkan keputusan yang setara dengan penilaian soalan tinjauan yang telah dijawab oleh penumpang tren berdasarkan pengalaman sendiri semasa menaiki tren ini ke destinasi mereka. ERF memberi kesan yang signifikan terhadap simptom MsDS, ERF memberi kesan yang signifikan terhadap HS, ERF memberi kesan tidak langsung yang signifikan terhadap PC, simptom MsDS memberi kesan yang signifikan terhadap PC, dan akhir sekali, HS mempunyai kesan yang ketara terhadap PC. Berdasarkan keputusan alat ukuran yang telah dibandingkan dengan piawaian bagi setiap ERF, bunyi hingar di dalam kabin tren telah mencapai nilai 82.2 dBA semasa berada di lorong dari perjalanan UKM ke Kajang. Bagi nilai getaran pula, alat pengukur telah mencatatkan bacaan nilai getaran tertinggi iaitu 2,2182 m/s2 dalam arah z di kawasan laluan sepanjang perjalanan dari Kajang ke Tiroi. Manakala nilai pengudaraan yang telah direkodkan juga telah melebihi paras piawai yang dibenarkan iaitu bagi nilai kepekatan CO_2 (ppm) ialah 1589.72 pada waktu pagi, kelembapan bandingan mempunyai nilai purata 68.11 dan nilai suhu purata yang telah direkodkan ialah 23.72^{0}C. Keputusan yang diperolehi daripada jawapan pengguna terhadap borang soal selidik yang telah diedarkan yang berkisarkan ERF yang mempengaruhi HS serta PC dan PS adalah selaras dengan hasil bacaan yang direkodkan daripada alat ukuran yang merekodkan nilai risiko getaran, bunyi dan pengudaraan. Model kajian ini boleh digunakan untuk membangun dan membina sistem pengangkutan awam yang mengambil kira ERF bagi membolehkan kenderaan ini menyediakan kabin tren yang sihat untuk penumpang. Dengan mengambil data berasingan mengikut jantina, ia juga boleh dilakukan dengan membandingkan syarikat kereta api lain untuk membolehkan kesahan dilakukan dengan lebih baik dengan membandingkan keputusan yang diperoleh daripada dua syarikat pengangkutan kereta api yang berbeza.

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LIST OF SYMBOLS AND ABBREVIATIONS

CO_2	-	Carbon Dioxide
dBA	-	Decibels A
Leq	-	Equivalent Continuos Sound Level
EFA	-	Exploratory Factor Analysis
ERF	-	Ergonomic Risk Factor
GIF	-	Goodness-of-fit
HS	-	Health Symptoms
HSN	-	Health Symptom from Noise Effect
HSVB	-	Health Symptom from Vibration Effect
HSVT	-	Health Symptom from Ventilation Effect
KLS	-	KL Sentral
KTM	-	Keretapi Tanah Melayu
MSD	-	Musculoskeletal Disorder
OSHA	-	Occupational Safety and Health Administration
PC	-	Passenger Comfort
PS	-	Passenger Satisfaction
PS	-	Pulau Sebang
RMSEA	-	Root Mean Square Error of Approximation

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