Ergonomic Assessment of the Point-to-point (P2P) Buses: Case of Passengers

Jeric B. Bonostro (jbbonostro@up.edu.ph), Andre A. Borromeo (aaborromeo@up.edu.ph), Carmela Gabrielle D. De Jesus (cddejesus@up.edu.ph), Danielle Jessa A. Trinidad (datrinidad1@up.edu.ph), Benette P. Custodio (bpcustodio@up.edu.ph)

1Department of Industrial Engineering and Operations Research, University of the Philippines, Diliman, Quezon City, Philippines

ABSTRACT

Metro Manila has the worst traffic situation in the world, according to the GPS-based application Waze. Moreover, three out of ten Filipinos say that commuting is the worst part of their day, citing traffic congestion and crowded transportation as their top reasons. One of the solutions introduced by the Department of Transportation (DoTr) to decongest traffic congestion is the point-to-point (P2P) bus service. Using the P2P bus allows shorter travel time due to fixed schedule of departure and absence of intermediate stops between two terminals. The service claims a more convenient travel with enhanced passenger experience to attract private-vehicle owners to use public transportation. Although travel time is shortened, average commute time of P2P buses still takes up to two hours. Sitting for a long period of time has an adverse effect in the health. Hence, there is a need to evaluate whether P2P bus seats fit the Filipino anthropometry and assess if these buses conform to standards of environmental conditions as they were manufactured in other countries. The ergonomic evaluation of P2P buses was conducted through quantitative and qualitative assessments: (1) measuring bus seat dimensions and comparing them with the corresponding adult Filipino anthropometric measurements, and (2) measuring environmental factors: temperature, illumination, and sound level and comparing them with standards (3) conducting surveys among passengers regarding their personal experience and preference of P2P buses. The P2P Bus service operators currently utilize a total of eleven (11) bus models; all of which were evaluated in the study. None of the bus models completely conform to all of the critical Filipino anthropometric measurements. Only four buses have collected illumination level within the acceptable values of greater than 107.6 lux. The collected mean sound levels on all buses conform to the standards of less than 100 to 110 dB. Seven (7) out of the eleven (11) buses, have temperatures that conform to the allowable range of 19°C to 26°C. A total of two hundred nine (209) P2P bus passengers, 19 samples for each of the 11 buses, were asked to participate in the survey. Results of the survey were consistent with the quantitative assessment; non-conformance to anthropometric measurements was reflected on the problems identified by the passengers. One hundred thirteen (113) out of the 209 passengers said that they are fully satisfied with the overall comfort of the buses. Overall rating of the bus models revealed that only three (3) bus designs were rated ‘good’. This shows that the buses currently being used have much to improve. This study can be used by bus manufacturers to improve design for buses and provide bus operators significant guidance in ensuring the P2P system’s safety, comfort, and convenience that Filipino commuters deserve.

Keywords: Point-to-point Buses · Filipino Anthropometry · Environmental Conditions · ESK-JES Joint Session

1. Introduction

Metro Manila has the worst traffic situation in the world, according to the GPS-based application Waze (Tan, 2015). Moreover, three out of ten Filipinos say that commuting is the worst part of their day, citing traffic congestion and crowded transportation as their top reasons (Tordecilla, 2016). The Department of Transportation (DoTr) is finding various ways to decongest traffic, and one of their solutions is the introduction of the point-to-point (P2P) bus service.
numbers and degrees of subjective health complaints compared with their peers with short commute (Urkonen, 2016). In the long run, these adverse effects are worsened by poorly-designed seats since majority of the commute time is spent for sitting. Seats should enable the user to periodically change position, support various muscle groups and not allow the other muscle groups to get tired (Gyi, 2016). Along with this, the environmental factors, such as temperature, illumination, vibration and sound level, should be considered in user-experience. The criteria for designing seats can be based on the ergonomics of seats and sitting. The height of the backrest should be high enough to support the trunk of a person. Seat height should not be too short as this will make the sitting bone suffer; however, it should not be too high as this may restrict blood flow on the popliteal fold. Meanwhile, seat depth must not be too long as this will prevent short people from reaching the backrest. The angle of the seat pan to the backrest should be greater than 90 degrees to prevent musculoskeletal disorders. Optimal angle is from 100 to 110 degrees and is preferably adjustable. Seat width must be able to accommodate larger people based on shoulder width. This measurement is based on the distance between armrests (if this exists) or the width of the seat pan. Armrests should only touch the fleshy part of the arms and should not touch the elbow (Stensland, 2016). The height of the armrest should not be too high such that short people will not be able to reach them, but this should not be too low such that tall people are forced into an awkward posture (Karwowski & Marras, 2003). The temperature, illumination, sound levels and vibration of an environment have certain standards or limits that are deemed fit for human comfort. Temperature for sedentary or low level activities is preferably between 19 degrees to 26 degrees (Freivalds, 2009). Meanwhile, the recommended illumination for visual tasks that are occasionally performed (e.g. selection of bus seats) is 107.5 lux (Lighting Design, 2011). Sound levels should not exceed 110 decibels for thirty minutes of exposure to 100 decibels for two hours of exposure (OSH). Vibration should be as minimal as possible as any increase of exposure decreases a person’s tolerance to it (Freivalds, 2009).

The buses currently being used in the Point-to-point (P2P) buses were manufactured in other countries. Hence, there is a need to evaluate whether P2P bus seats fit the Filipino anthropometry and if these buses conform to standards of environmental conditions.

2. Method

The ergonomic evaluation of P2P buses was conducted through quantitative and qualitative assessments.

Quantitative assessment comprised of (1) measuring bus seat dimensions and comparing them with the corresponding adult Filipino anthropometric measurements, and (2) measuring environmental factors: temperature, illumination, and sound level and comparing them with standards. Seat dimensions measured include backrest height, seat height, seat width, seat depth, backrest-to-backrest distance, armrest length, armrest height, armrest-to-backrest distance, and seat pan-to-backrest angle. Temperature, illumination, and sound level were measured through the use of devices such as Logger Pro with light sensor, temperature probe, and sound level meter. The measurements were collected on six locations of the bus, for about 200 seconds at each location. On the other hand, the evaluation of the bus vibration was only based on the subjective perception of the passengers based on the survey due to lack of available laboratory devices.

Qualitative assessment to support the quantitative assessment involves conducting surveys among passengers regarding their personal experience and preference of P2P buses. From a population of around 11.9 million in Metro Manila, the computed sample size for the study is 196. This was calculated using Cochran’s Formula with a 95% confidence interval and a 7% margin of error. The test subjects were the commuters who use the P2P buses as a mode of transportation. Convenience sampling was used to gather the test subjects of the study.

Overall rating of the buses was also computed; 50% of the overall rating was based from the assessment of the environmental conditions while the other 50% from the bus seat area assessment. The rating for environmental conditions was calculated by getting the number of factors that a bus was able to conform to and dividing this number by four. Meanwhile, the rating for the bus seat area was calculated by determining how many of the bus seat components of each bus were able to meet the specifications and dividing this number by nine. The average of the two ratings was taken and was compared to a range of values to get the overall rating. If the rating was from [80 to 100], the bus was said to be excellent, and if the rating was from [60 to 80], it was said to be good. From [40 to 60], the bus is only
considered fair, while from [20 to 40] it was marginal. Lastly, if the rating was from [0 to 20], the bus is considered inadequate.

3. Results

Acceptable ranges of measurements of bus seat dimensions (see Table 1) were calculated based on the corresponding anthropometric measurement of Filipino Manufacturing Workers (Del Prado-Lu, 2007).

<table>
<thead>
<tr>
<th>Table 1. Acceptable Bus Seat Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bus Measurements</strong></td>
</tr>
<tr>
<td><strong>Backrest height (cm)</strong></td>
</tr>
<tr>
<td><strong>座 height (cm)</strong></td>
</tr>
<tr>
<td><strong>Seat Width (cm)</strong></td>
</tr>
<tr>
<td><strong>Seat depth (cm)</strong></td>
</tr>
<tr>
<td><strong>Backrest-to-Backrest distance (cm)</strong></td>
</tr>
<tr>
<td><strong>Armrest length (cm)</strong></td>
</tr>
<tr>
<td><strong>Armrest height (cm)</strong></td>
</tr>
<tr>
<td><strong>Armrest-to-Backrest Distance (cm)</strong></td>
</tr>
<tr>
<td><strong>Seat pan to backrest angle (°)</strong></td>
</tr>
</tbody>
</table>

The P2P Bus service operators currently utilize a total of eleven (11) bus models: Man-Almazora, Man-Gemilang, Ankai AK7556 (Ankai), Higer-Double-deck, Man Lion’s City VIP, Volvo B7RLE Euro5 (Volvo 1), Volvo 2, Daewoo LGLFD5A49GR200164 (Daewoo 1), Daewoo LGLD5A47GK200132 (Daewoo 2), Daewoo LGLFD5A43DK200219 (Daewoo 3), and Higer KLO6129G (Higer-Single-deck); all of which were evaluated in the study. Measurements of these buses were gathered and compared to their respective acceptable ranges which were set by the proponents based on Filipino anthropometry.

None of the bus models completely conform to all of the critical Filipino anthropometric measurements. 67% (6 out of 9) bus dimensions of Man-Almazora and Daewoo 1, 44% bus dimensions of Man-Gemilang and Volvo 1, 33% bus dimensions of Ankai, Higer-Double-deck, Daewoo 2, and Man Lion’s City VIP, 22% bus dimensions of Volvo 2 and Daewoo 3, and 11% bus dimensions of Higer-Single-deck match the considered Filipino anthropometric measurement.

The measurements of the environmental factors of the buses were compared to the standards of illumination, temperature, and sound level for a person sitting without doing any work. The acceptable illumination must be greater than 107.6 lux or 10 foot candles. For the temperature, the recorded values must lie between 19 to 26 °C. And the collected sound levels must be less than 100 to 110 dB which is the acceptable amount of noise exposure for about 30 minutes to 2 hours. There were only four buses whose collected illumination was greater than 107.6 lux namely Man Gemilang, Volvo 1, Volvo 2, and Daewoo 1. The illumination recorded on Man Gemilang and Volvo 1 was caused by the natural and artificial lighting since both source of light were being used during the collection. Both buses do not have curtains and freely allow natural lighting to enter. However, Daewoo 1 and Volvo 2 only used the natural lighting as a source of light yet both still met the acceptable illumination. The buses can be mostly affected by the natural light because the artificial lighting is usually used during the evening trips. Ankai, Man-Almazora, and Man Lion’s City VIP buses did not conform to the allowable range because of tinted windows. Also, curtains may have prevented or lessen the natural lighting present inside the bus. Since weather is also uncontrollable, darker natural lighting was collected in the Higer-Double-deck resulting to a nonconforming illumination. The illumination collected in Higer-Single-deck, Daewoo 2, and Daewoo 3 is relatively low since they are collected when natural light is low (i.e. either during early morning or in the evening). The collected mean sound or noise level on all buses conformed to the standards of less than 100 to 110 dB. The volume of the televisions, stereo, and sound systems installed in all buses are controlled at sufficient levels since it does not create sound level hazardous to its passengers. The buses Ankai, Higer-Double-deck, Man-Gemilang, Higer-Single-deck, Daewoo 1, Daewoo 2 and Daewoo 3 have temperature on six locations of the bus that conform to the allowable range of 19 °C to 26 °C. Except for Man-Gemilang and Higer-Single-deck, these buses have adjustable air conditioners that allow
the passengers are to easily adjust the temperature depending on their preference. On the other hand, some collected temperature on six locations of Man-Almazora, Volvo 1, Volvo 2, and Man Lion’s City VIP did not meet the requirements. These buses have air conditioners that cannot be controlled by the passengers.

A total of 209 commuters were asked to answer the survey forms, 19 test subjects for each of the 11 buses. Results of the survey were consistent with the quantitative assessment; non-conformance to anthropometric measurements was reflected on the problems identified by the passengers. All buses except Daewoo 3 received a high illumination rating. Rating of the amount of noise people was low. All buses received a temperature rating of greater than 3. Commuters had a fair opinion regarding the vibration. One hundred thirteen (113) out of the 209 passengers said that they are fully satisfied with the overall comfort of the buses.

4. Conclusion

Results of the study revealed that none of the bus models completely conform to all of the critical Filipino anthropometric measurements and environmental standards. Overall rating of the bus models revealed that only three bus designs were rated ‘good’, six were rated ‘fair’, and two were rated ‘marginal’. This shows that there is much room to improve the buses currently being used. Immediate actions can be recommended to DoTr and the P2P bus operators. Since the seat height of most bus seats in the study were not within acceptable range, the operators may choose to install foot rests on their buses. Operators may also opt to make the lights and air-conditioning adjustable. Curtains will be useful early in the day so that passengers have a choice to reduce illumination. Meanwhile, for buses whose air-conditioning cannot be adjusted by passengers, the bus drivers should be specified to control the temperature inside the bus. This study can be used by bus manufacturers to improve design for buses and provide bus operators significant guidance in ensuring the P2P system’s safety, comfort, and convenience that Filipino commuters deserve.

References


