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Statistical Evaluation of Ingress and Egress Motion of Users for CTU Buses

Aman Kaushik[1], Parveen Kalra[2], Jagjit Singh[3], Suman Kant[4]
[1,2,3,4]*Production Engineering Department, PEC University of Technology Chandigarh*

***Abstract:** During Ingress and Egress Motion of Users in CTU Buses, there is awkward posture, lifting awkward items of passengers during Ingress and Egress Motion. And due to this awkward posture, passengers face various type of problem like low back pain, painful disorders of muscles, tendons, and nerves. Awkward posture of passenger can be due to improper step height of bus entrance, width of footstep, improper height of handrails, driver skills, other passenger attitude etc. The aim of this study was to study the ingress motion of passengers with respect to the existing design of CTU buses with collecting data through questionnaires, video recording etc., Analysis of ingress/egress is done using questionnaires collected from 130 passenger at 10 different location in Chandigarh and design for ingress is to be evaluated and identifying the difficulties people may encounter when they are using public bus service in Chandigarh in particular issues related to ingress and egress. Data has been analyzed to see the major effected passenger through statistical technique paired t-distribution. Paired t-distribution is conducted on two age group on each and every question of questionnaire and based of deviation of mean final result is obtain. Through a review of ingress/egress motion in buses and alighting questionnaire filled by passenger are documented in Google form and paired t-distribution is applied in statistica analysis software.*
***Keywords:** Kerb, Handrails, Ingress and Egress Motion of Users for CTU Buses, awkward posture, paired t-distribution.*

I. INTRODUCTION

The ease of getting in and out of a vehicle (or ingress/egress) is one of the most important ergonomic issues for automotive manufacturers. It represents the first physical contact of a customer with a vehicle. Urban transport is quintessential to the usability of urbanites**;** enabling the carrying out of activities in their daily lives. Due to its public nature, it should be inclusive enough to cater to all the members in society of diverse ages, abilities and sizes. With special concerns on embarkation and disembarkation of bus, this research paper attempts to identify physical attributes of settings and devices that would not merely make provisions for access by the older persons who need facilitations but for other passengers as well. Entrances and exits are key elements that the evaluators generally consider for making bus trips taken by the people with limited capability such as the older persons as easily and comfortably as others. The speed of embarkation and disembarkation is one of primary contributive factors to the efficiency of bus service, which influences passengers' subjective feelings on the use of buses. (Glumac et al, 2000) Recent studies indicated that, other than potential improvements of physical features associated to the design of buses, such elements also included the layout of bus stops, drivers' skills, as well as drivers' embarking and disembarking. (Caiaffaet al, 2001).Drivers will manipulate the bus more steadily if their skills are improved, which is beneficial to people with ambulant disablements such as the older persons. Moreover, relative study conducted by Caiaffa & Tyler (2000) in England indicated that, in local environment, passengers with physical limitations had more comfortable embarkation and disembarkation when the bus was embarked from or disembarked to the street kerb edge. In particular, to bring buses close to the kerb edge helped assure persons with fears or worries about falls of feeling able to use it**.**

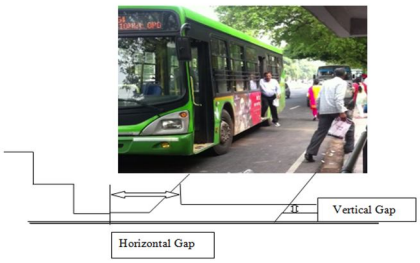

Figure 1: Bus Manipulated Towards the Kerb Edge of the Bus Shelter, And the Horizontal and Vertical Gaps

II. LITERATURE BACKGROUND

Many researchers have focused on solving the design issues related to the ergonomic issues related to vehicle. One of such issues is the "Ergonomics of Ingress/Egress design", which is the key area of discussion and analysis in the current work. Ingress and Egress research area is not very much explored however continued efforts of some researchers since last 3 decades have made this area interesting to explore. All below Researchers did commendable job in reducing the risk of injury by providing various ergonomics issues in the field of ingress/egress motion in the car, buses and truck and try to eliminate various key ergonomic issue to minimize the risk of injury. But there are very few studies about the an ergonomic evaluation of ingress/egress motion of users for buses in Indian context so we focused in how the ingress/egress motion of users is affected by various variable like door width, step height, kerb height, handrail height, bus driver attitude toward passengers. Singh et al (2014) said that ergonomic features are needed to be introduced into the design of buses to make them highly comfortable for the driver and passengers. Constantin et al (2014) aims to study the perception of young drivers over the elements of discomfort that occur while driving a vehicle. 40 subjects, young drivers (technical university students) participated in the study and were investigated in connection with the main elements of discomfort experienced in the car. Valuation of discomfort was based on descriptions of study participants, descriptions in which they were asked to specify what they perceive as discomfort in the car. Causse et al (2012) experimentally investigating the influence of roof height and sill width on car ingress/egress movements. The first uncomfortable (Ht1) and the lowest acceptable (Ht2) roof heights were obtained from 26 participants of three different stature groups thanks to a multi-adjustable vehicle mock-up. Both Ht1 and Ht2 were affected neither by stature nor by vehicle type. Chateouroux et al (2010) was focused on the analysis of truck cabin egress motions. An experiment was set-up to investigate the influence of COE truck architectural parameters on motion strategy and the discomfort associated. This analysis of Chateauroux gave us a better understanding about the way handles are used.

III. RESEARCH OBJECTIVE

To study the Ingress/Egress motion of passengers with respect to the existing design of CTU buses with collecting data through Questionnaires, video recording etc.
To identifying the difficulties people may encounter when they are using public bus service in Chandigarh in particular issues related to ingress and egress.

IV. RESEARCH METHODOLOGY

A. Phase I- Collection Of Data

Questionnaires has been used to collect the following information from user population (i) Basic information (ii) Travelling mode and frequency (iii) Bus shelter design (iv) Ingress and egress issues (v) Handrail size and placement. Appropriate usability rating scale would be used to record the responses.

B. Phase II - Analysis Of Data

Data obtained in Phase1 has been suitably analyzed to draw inferences regarding difficulties encountered by public bus users during ingress and egress and the impact of age-related changes on the same. Statistical techniques paired t-distribution has been utilized to quantify the comparison of different comparison of different age group as follows,

1) Below 30
2) Between 30-40

3) Between 40-50
4) Between 50-60
5) Between 60-70
6) Above 70

Based on the many no of age group, we take data only two sample of size 20 and the data between different age group are selected randomly. The new sample are taken as

1) Below 40,Above 40 2) Male and Female

The two sample of size 20 namely as Male and Female also taken into consideration to find out the significant difference between gender. The structured interview schedule administered to the respondents contained 20 Statements/Questions covering every aspect of different ergonomic issues faced by passengers in CTU Buses. The respondents were asked to rate each Statement according to their level of agreement with it by using a 5-point Like-type scale (1: Strongly Agree, 2: Mildly Agree, 3: Neither Disagree nor Agree, 4: Mildly Disagree, 5: Strongly Disagree). A mean score was worked out for each of this statement. This has helped in finding a comprehensive picture of the agreement level for the content of that particular Statement among the respondents, as a group.

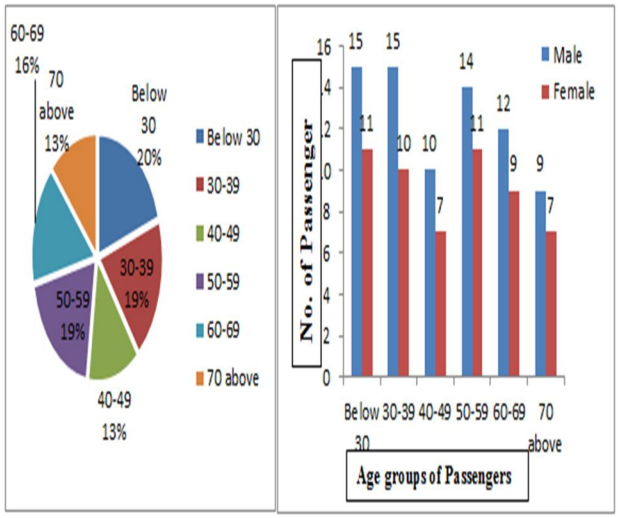

Figure 1.2: Age Group and their no. of passenger in different Age Group

It may thus be observed that in the Geographical in and around Chandigarh City, as a whole, managerial employees largely belong to the age group of Above 40 years. Among employees, as a whole, majority belong to the middle age below40 years.

V. SURVEY DATA ANALYSIS

The questionnaire related to further ingress/egress study has been attached in annexure A1. There is different part of questionnaire which is explained separately.

A. Profile of Participants

A total of 140 passengers are present during interviews and during the intervals of recording, with 130 passengers successfully interviewed. It was observed that many older passengers basically above 40 year age group actively participated in usual conversations when being interviewed. Basically there were total 60 passenger has pains in many part of body. Out of 42 passenger, 15 had feet problem 13 had legs problem, 6 had hand problems, 20 passengers had knuckle and back problem. There were 72 passengers had no physical problem, out of which mostly were below 40 age group.

Volume 3 Issue VII, July 2015
ISSN: 2321-9653
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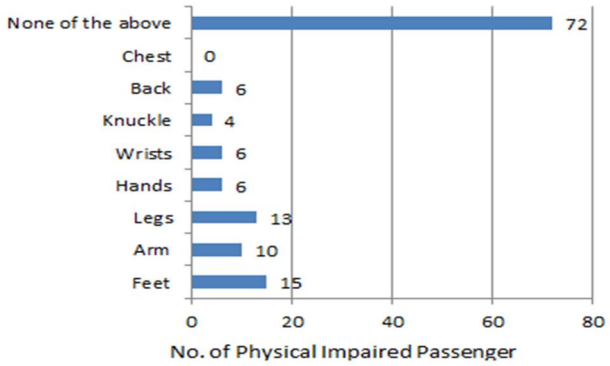

Figure 2: No. of Physical Impaired passenger

B. The Survey Questionnaire Results

1) The Degree of Difficulties In Ingress And Egress Motion Of Passengers:

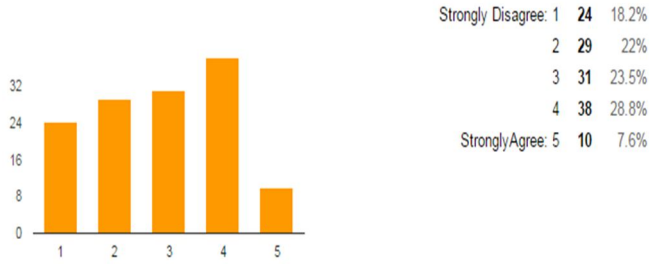

Figure 3: Issues between kerb and bus gap

Practically all the passengers were interviewed throughout swapping buses. This phenomenon demonstrates that the almost 36 % passenger strongly and mildly agree that there is too wide gap between bus and kerb as well as almost 40% passengers strongly and mildly disagree that kerb is not too wide to walk across.

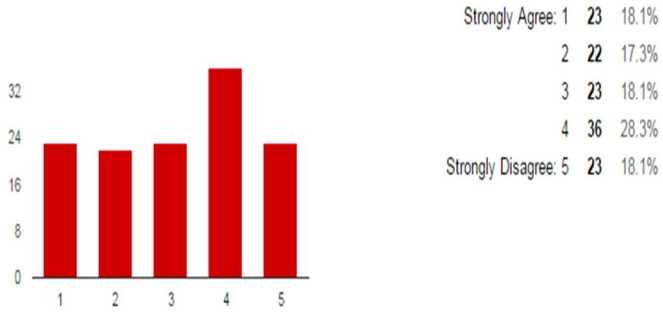

Figure 4: Responses to steps are too high or not

From the figure 4, in relation to problem at entrance that make it difficult for passenger to board buses, passenger were asked to rate about steps, are they too high. Out of 130 passenger, 35% passenger are strongly and mildly agree that find the steps are too high and they face problem when boarding to buses. 46% passenger observed that find the steps are too high.

Volume 3 Issue VII, July 2015
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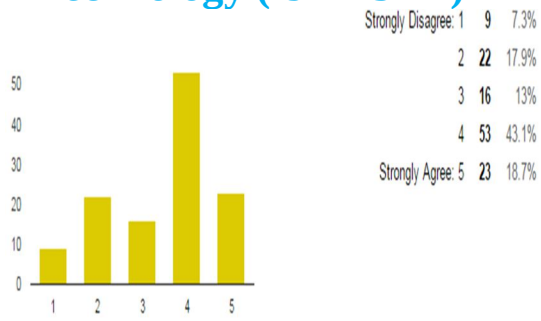

Figure 5: Comfort levels of handrails

From the figure 5, passengers were asked to rate that they cannot use the handrails safely and comfortably. 61% passengers are strongly agree that they facing problem while using handrails and only 25% passenger feels that no problem with handrails. When the passengers were asked about no of times they fallen while ingress/egress, it observed that 98 times passenger was fallen while Ingres sing or egressing in last six month. Out of 98, only 62 times passenger above 40 age group fallen 64 times. It should be noted that no. of times of fallen may be one, two or three times per passenger and out of 62, age group of 60 and above was fallen 50 times. So overall result says that only old aged person is strongly affected while Ingres sing or egressing.

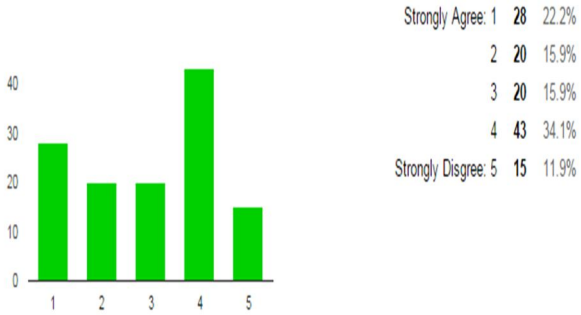

Figure 6: Difficulty in using Stature

In figure 6 passengers were asked to rate difficulties in using stature. From the survey result, it is observed that 130 passenger, 38% passenger are strongly agree and mildly agree that there is difficulty to use stature only 11% passenger observed that there is not difficulty to use stature.

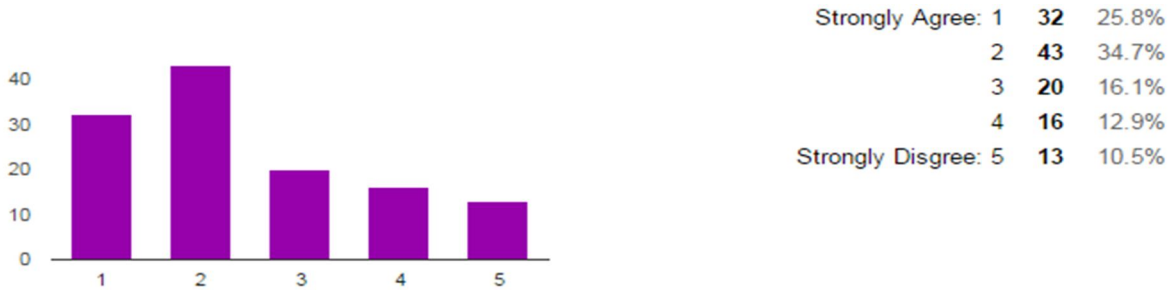

Figure 7: Handrail Access during Ingress/Egress

Figure 7 shows that when the passengers were asked to review about the accessibility of using handrails during ingress/egress. It is clearly shown from graph that handrail assessing is not special concerned for passenger. Almost 61% passenger are strongly agreed and mildly agreed that they are using handrail during ingress/egress motion.

Volume 3 Issue VII, July 2015
ISSN: 2321-9653
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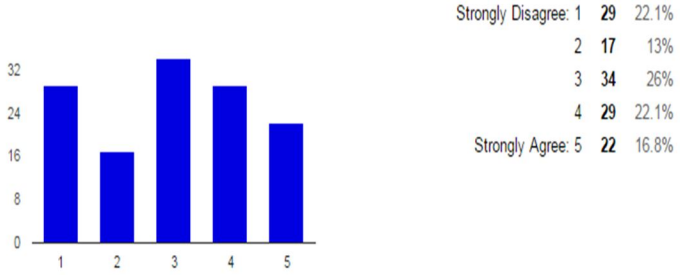

Figure 8: Difficulties in Ingress/Egress

Passenger were asked to rate the difficulties of ingress/egress. In this study, 35% passenger are strongly and mildly disagree that its difficult to egress than ingress and 39% passenger are strongly and mildly agree difficult to egress than ingress as shown in figure8.

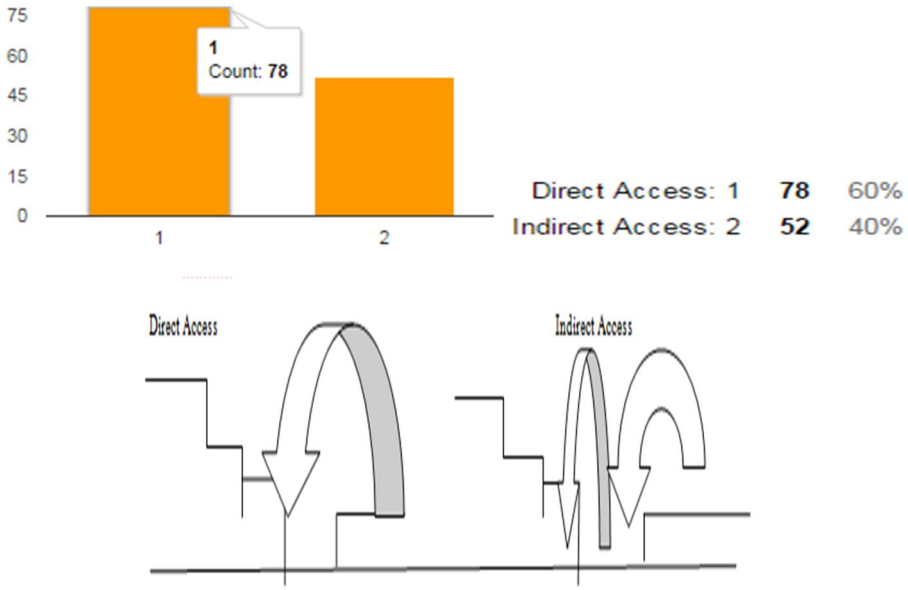

Figure 9: Percentage of preference of mode of ingress/egress

Figure 9 shows the preference of using ingress/egress by passenger. 60% passengers were reported that they prefer direct access where as 40% passengers reported that they would like to indirect access during ingress/egress from bus.

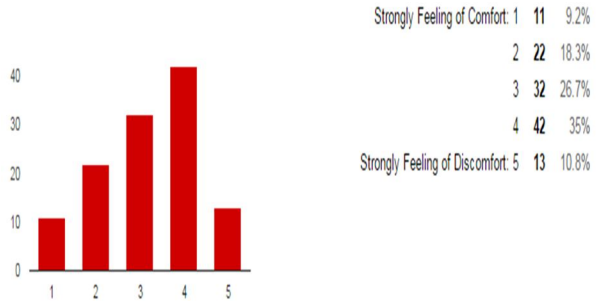

Figure 10: Difficulty in carrying bags while ingress /egress

In relation to difficulties in carrying bag while Ingres sing or egressing 47% reported that passenger are strongly and mildly feeling of

Volume 3 Issue VII, July 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

discomfort 46% are feeling of comfort as shown in figure 10.

Figure 11: Responses about gap near the door to place stature

Physically handicapped passengers were asked about that is there is sufficient gap near the door place stature. The figure 5.11 shows that 55% passenger think that bus having sufficient gap near the door to place statures and 45% think that there is bus having no sufficient gap near the door to place statures.

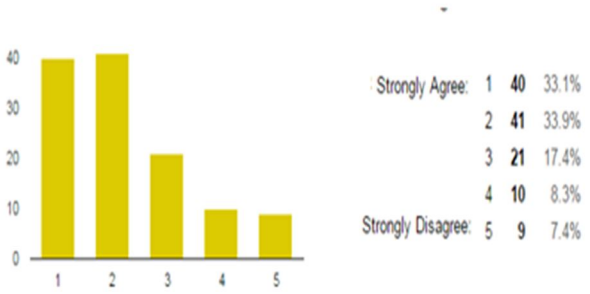

Figure 12: Afraid of Stumbling on moving buses

When the passenger were asked that they don't stand up until the bus stops due to afraid stumbling on moving buses, about 67% agree which is quite largely in figure 12 and should be taken into account and some suggestion should be implemented such as driver attitude and spring handrails.

2) The Degree Of Difficulties In Traveling Mode And Frequency Of Passengers:

Figure 13: Frequency to go on foot

When the passenger were asked that how many times they go on foot, 45% passengers go on foot 2-3 times every day and 43% passengers go on foot one time a day and 11% passengers go on foot 2-3 times every week as shown in figure 13. Only 1% passengers go on foot one times in a week.

Volume 3 Issue VII, July 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Figure 14: Frequency to go on bus

When the passenger were asked that how many times they commute by bus, 37% passengers go with bus 2-3 times every day and 49% passengers go with bus one time a day and 11% passengers go with bus 2-3 times every week as shown in figure 14.. Only 3 % 45% passengers go with bus one times in a week and 1 % passengers go with bus one times in a month.

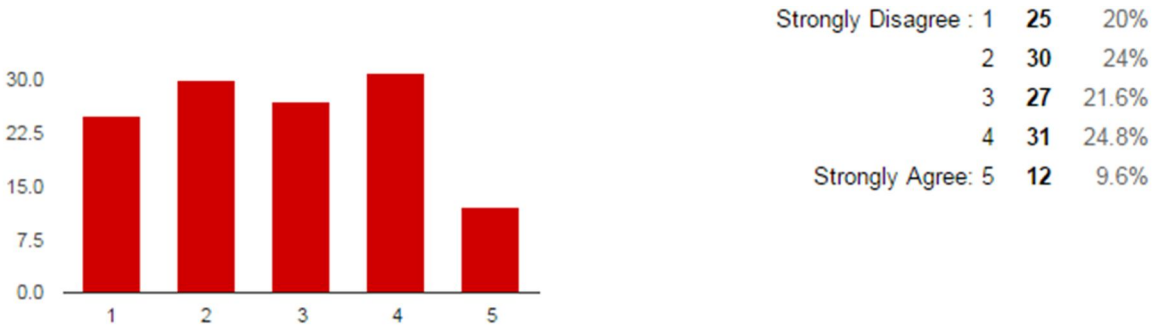

Figure 15: Transport difficulties faced by passengers

When the passenger were asked that passenger that they are not able to many places because of transport difficulties, 44% passenger are strongly and mildly agree that they are not been able to because of transport difficulties and 35% are strongly and mildly disagree that they are not been able to because of transport difficulties as shown in figure 15. Only 21 % passengers are either agree nor disagree.

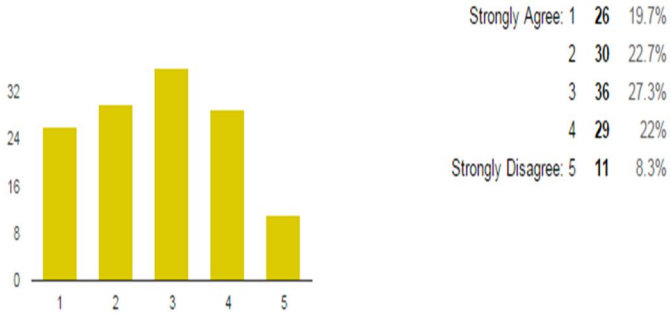

Figure 16: Passengers not able to go due to personal problems

In relation to passengers not able to go due to personal problems, 43% passenger are strongly and mildly agree that they are not able to go anywhere because of personal problems and 30% are strongly and mildly disagree that they are not able to go anywhere because of personal problems as shown in figure 16.

Volume 3 Issue VII, July 2015
ISSN: 2321-9653
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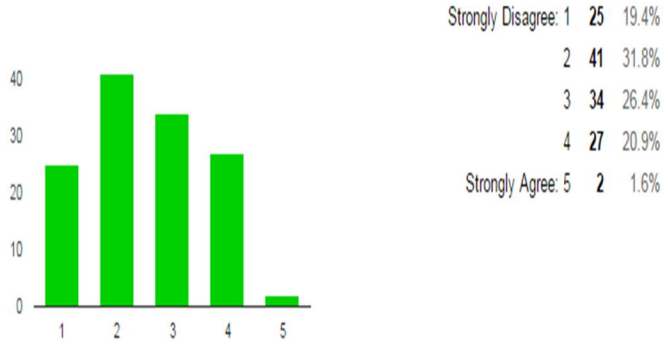

Figure 17: Difficulties in using public bus service

When the passenger were asked that decreased frequency is greatly caused by the difficulties and inconvenience when you use public bus service, 51% passenger are strongly and mildly agree that the decreased frequency is greatly caused by the difficulties and inconvenience when you use public bus service and 23% are strongly and mildly disagree that the decreased frequency is greatly caused by the difficulties and inconvenience when you use public bus service as shown in figure 17. Only 26 % passengers are either agree nor disagree.

3) The Degree Of Difficulties In Bus Shelter & Bus Driver Attitude

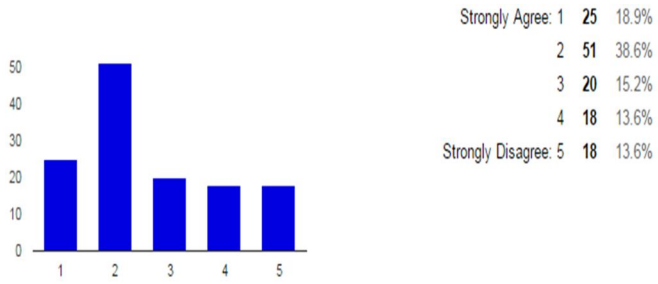

Figure 18: Improper bus parking

In relation to bus stops since there is no particular point where the bus would stop, 58% passenger are strongly and mildly agree that there is no particular point where the bus would stop and 27% are strongly and mildly disagree that there is no particular point where the bus would stop as shown in figure 18. Only 15 % passengers are either agree nor disagree.

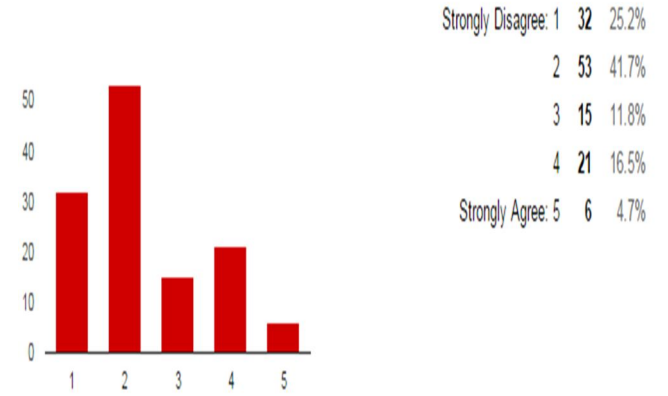

Figure 19: Do bus drivers usually park bus properly at Bus stop

Figure 19 shows that 21% passenger are strongly and mildly agree that drivers usually park bus properly at Bus stop and 67% are

Volume 3 Issue VII, July 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

strongly and mildly disagree that drivers usually park bus properly at Bus stop. Only 12% passengers are either agree nor disagree. So proper training should be provided for drivers.

4) The Degree Of Difficulties From Uses Of Handrails

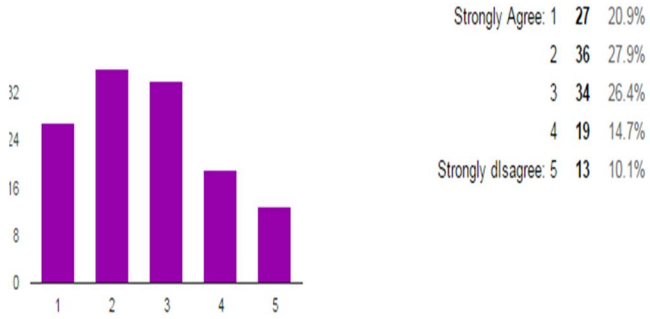

Figure 20: Handrails to keep balance and posture

In relation to hand rails for keep balance, 49% passenger are strongly and mildly agree that handrails are they are a good support to keep balance and 25% are strongly and mildly disagree that handrails are they are a good support to keep balance as shown in figure 20. Only 26 % passengers are either agree nor disagree.

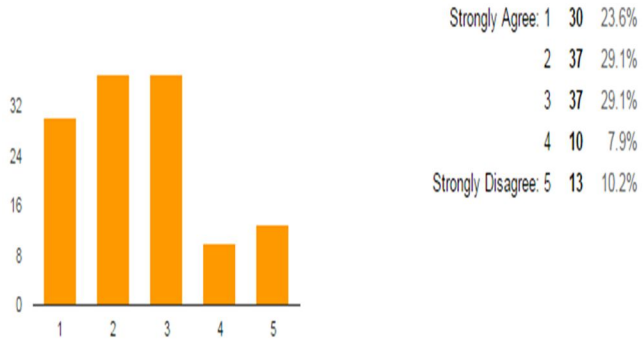

Figure 21: Shape or diameter of handrails

In relation to hand rail usability for keep balance, 53% passenger are strongly and mildly agree that shape or diameter of handrails is not suitable for holding and 18% are strongly and mildly disagree that shape or diameter of handrails is not suitable for holding as shown in the figure 22. Only 29 % passengers are either agree nor disagree.

Figure 23: No. of passengers injured due to the handrails

Figure 23 shows that 25% passenger think that been hurt before due to the handrails and 75% think that they have been hurt before due to the handrails.

5) Overall Assessment

Volume 3 Issue VII, July 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

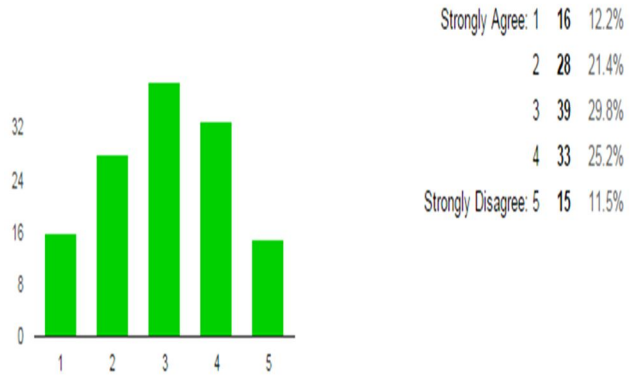

Figure 24: Overall Passenger Satisfaction

In relation to overall satisfaction about CTU services, 34% passenger are strongly and mildly satisfy from CTU bus service and 36% are not satisfy from given bus service. Only 30 % passengers are either agree nor disagree about overall satisfaction.

C. Paired T-Distribution Test

Paired T-distribution has been used on the basis of age group and gender (male/female) of sample size n=20.

In the Questioners mentioned in Annexure 1.1, the few important questions (20 in number) are selected only, after that paired t test was performed on the basis of age group of below40 and above 40.These few important questions are mentioned in Table 1 has the mean data of 20 random samples for 20 important questions for age groups of above 40 and below 40. A separate study has also been performed for male and female and has the data in table 2.

It can clearly be seen through table 1 that so many questions have difference among two categorized age group i.e. above 40 and below 40. However almost no difference was observed among gender. Hence this t-test suggested that focus has to be on two categorized age group i.e. above 40 and below 40.

Table 1: Randomized Data mean according to their age-group:

Question ns	Below40 Mean	Above 40 Mean	MALE	FEMALE	Significant Effect for Age Group	Significant Effect for Male/Female
Q:1	3.2	3.9	3.2	3.6	YES	NO
Q:2	2.15	2.85	3.65	3.9	YES	NO
Q:3	3.7	3.6	3.1	3.45	YES	NO
Q:4	3	3.65	2.75	3.55	YES	YES
Q:5	2.15	2.25	2.3	2.33	NO	NO
Q:6	2.6	2.75	2.85	3.1	YES	NO
Q:7	1.75	1.44	1.5	1.7	NO	NO
Q:8	2.5	3.33	2.45	2.85	YES	NO
Q:9	2.5	3	2.6	3.4	NO	NO
Q:10	3.1	3.2	2.9	3.33	NO	NO
Q:11	3.1	3	2.7	2.76	YES	NO
Q:12	2.3	2.65	2.3	2.7	YES	NO
Q:13	1.8	2.8	2	2.222	YES	NO
Q:14	3.35	3.75	3.7	4	NO	NO
Q:15	1.5	1.44	1.55	1.88	NO	NO

Q:16	2.85	3.6	3.15	3.33	YES	NO
Q:17	1.45	1.6	1.4	1.55	NO	NO
Q:18	2.8	3.5	3.45	3.45	YES	NO
Q:19	2.45	3.1	2.25	2.6	NO	NO
Q20	2.1	2.65	2.1	2.65	NO	NO

Table 1 shows the paired- t test produced on the selected question of questioner with sample size 20 on two age group namely as below40 and above 40. If there is significant difference between age group and gender, its means higher age group facing the problem according to question. The significant difference is shown in the form of Yes and No.

VI. CONCLUSIONS

The following are the conclusions described below,

This present study mainly focused on exploring the effects of key problems faced by passengers while Ingress/Egress motion such as handrail height, bus driver attitude, step height, door width etc. on the human body.

Paired T-distribution suggested that there is significant difference during ingress -egress between the two age group namely as below40 and above 40 for convenience and comfort for majority of the questions.

It was found that, 67% passengers afraid of stumbling on moving buses. Further it was also observed that, 67% passengers feel that drivers usually do not park bus properly. In addition it was analyzed that old age persons also faces problem of improper bus parking at bus stop.

54% passengers think that bus drivers give proper time for Ingressing or Egressing however 46% think that bus drivers do not give proper time for Ingressing or Egressing. It should be noted that old age persons have same experience as with 46 % of the people. From the survey result, it has been observed that out of 130 passengers, 48 passengers are facing difficulty to use stature.

Paired t-distribution results suggested that above 40 age group feel that gaps between the bus and the kerb is too wide to walk across. So proper training should be provided for drivers to park buses near the kerb.

The study demonstrates that the almost 36 % passenger agree that there is too wide gap between bus and kerb as well as almost 40% passengers disagree that kerb is not too wide to walk across. The remaining passengers have neutral view over it. So we should train driver that he/she must park the bus near the kerb.

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APPENDIX1: QUESTIONNAIRE FOR PAIRED T-DISTRIBUTION

Q1.Do you think the pain doesn't impact you at all in your everyday life?

Strongly Agree Strongly Disagree

Q.2 Do you find there are many places you would like to go but have not been able to because of transport difficulties?

Strongly Agree Strongly Disagree

Q3. Do you find there are many places you could not go as frequently as you would like to because of personal problems?

Strongly Agree Strongly Disagree

Q4. Do you think the decreased frequency is greatly caused by the difficulties and inconvenience when you use public bus service?

Strongly Agree Strongly Disagree

Q5. You judge where the bus since there is no particular point where the bus would stop this cause great inconvenience?

Strongly Agree Strongly Disagree

Q6. Do bus drivers usually park bus properly at Bus stop?

Yes No

Q7- Do bus drivers gives proper time for Ingressing or Egressing?

Yes No

Q8-Do bus drivers often start bus before the passengers gets seated?

Agree Disagree

Q9. Do you feel the rapid acceleration and deceleration while ingressing/egressing?

Strongly Agree Strongly disagree

10. Do you find that the entrance/exit gate of bus is not properly opened while ingressing/egressing?

Strongly Agree Strongly Disagree

Q11. Do often find that the gap between the bus and the kerb is too wide to walk across for you?

Strongly Agree Strongly Disagree

Q.12.You cannot use the handrails safely and comfortably.

Strongly Agree Strongly Disagree

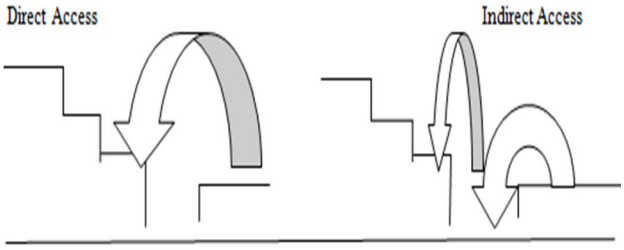
Q13. Do you find handrails are easily accessible during ingress/egress?

Agree Disagree

Q14. Do find it is more difficult to egress than ingress?

Strongly agree strongly disagree

Q15 While ingressing/egressing from bus which mode do you prefer?



Q16. Do you face difficulty carrying bags while Ingressing or Egressing?

Strong feeling of easy Strong feeling of difficulty

Q17. Do you find the bus having sufficient gap near the door to place statures?

Yes No

Q18. You won't stand up until the bus stops because you are afraid of stumbling on moving buses. Do you agree with this?

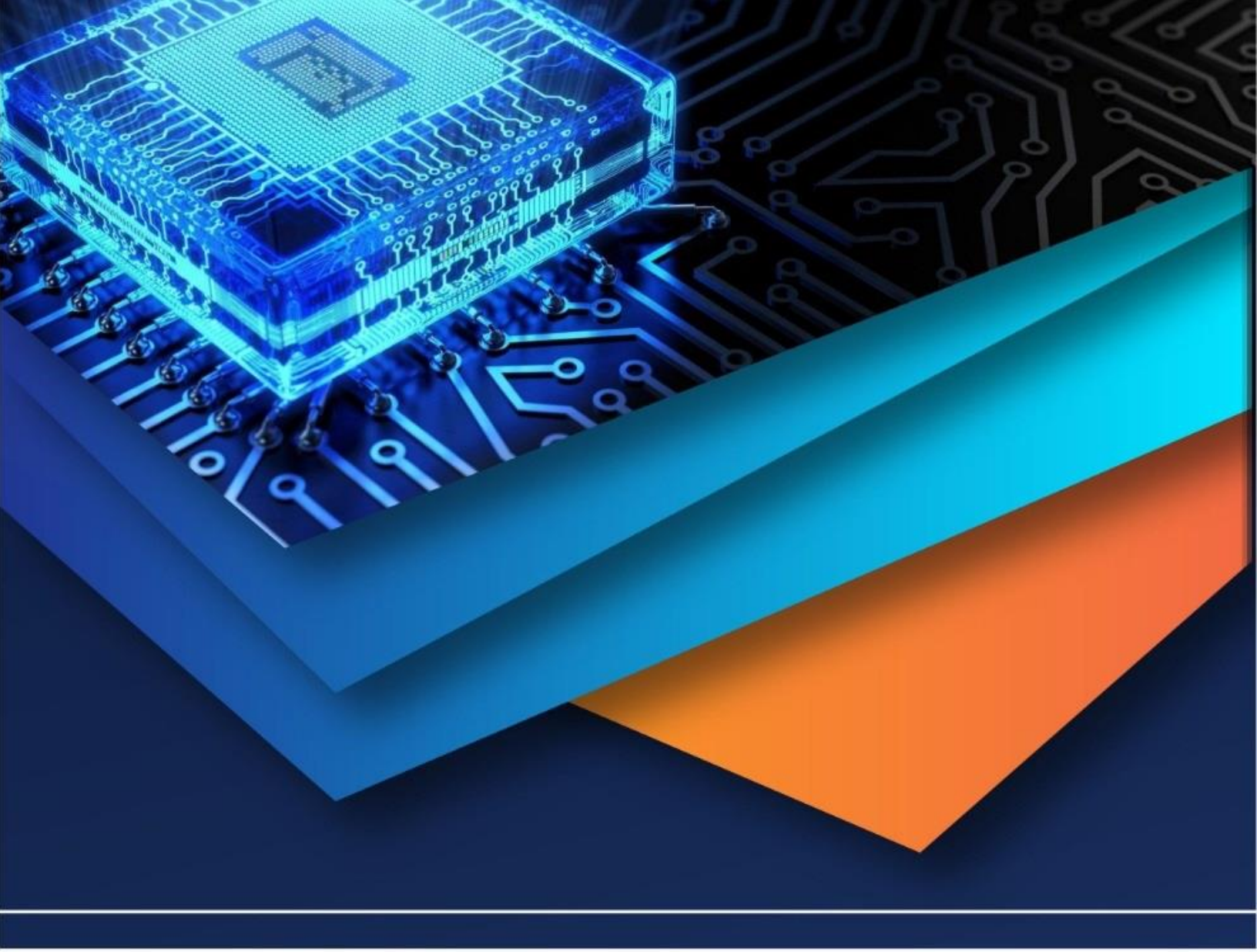
Strongly Agree Strongly Disagree

Q19. Do you often use handrails to keep balance, and you think they are a good support?

Strongly Agree Strongly Disagree

Q20.Do you find with current bus service satisfactory?

Strongly Agree Strongly Disagree



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