A Study on Design Interventions for Long Distance Buses with Reference to Elderly Pilgrims in India

A thesis submitted

in partial fulfilment of the requirement for the award of the Degree of

DOCTOR OF PHILOSOPHY

by

Chinmaya Krishnan G

Department of Design

Indian Institute of Technology Guwahati

Assam, India – 781039

January, 2022

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DECLARATION

January, 2022

It is certified that, the work contained in this thesis titled "**A study on design interventions for long distance buses with reference to elderly pilgrims in India**" has been carried out by me, a doctoral student in the department of Design, Indian Institute of Technology Guwahati, under the guidance of Professor Debkumar Chakrabarti, for the award of Doctor of Philosophy, and this work has not been submitted elsewhere for a degree.

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CERTIFICATE

The thesis presented titled "**A study on design interventions for long distance buses with reference to elderly pilgrims in India**", by Shri. Chinmaya Krishnan G, was undertaken under my supervision and is a bona fide work. The volume of presented herein for the Degree of Doctor of Philosophy of Indian Institute of Technology Guwahati was not submitted by him earlier for any other degree or diploma. He has fulfilled all the requirements as mentioned in the rules and regulations for submitting the thesis for the Degree of Doctor of Philosophy of Indian Institute of Technology Guwahati.

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Chinmaya Krishnan G

PREFACE

Travelling has always fascinated mankind. Be it short trips to nearby places or very long trips that can run for several days. It always brings happiness and a new ray of hope into our life. Countries like India which have economies in their stages of development, primarily uses buses and other large transport facilities for very long group travels such as conducted tours or pilgrimages. This points towards the importance of proper design of facilities inside the vehicle where the occupants spend for long.

There are many modes of transport such as personalised mobility solutions like cars or mass transport systems like buses. A great amount of research work has been carried out in the former sector, but unfortunately, the amount of work done on the latter that is the bus, is much lesser, if the Indian scenario is considered particularly.

The mass transport systems are fundamentally used for two broad applications. As a fixed destination public transport carrier, and to serve as a platform to carry a group of people for activities such as conducted tours or travels. Now, in India, which holds the distinction of having the most vibrant culture on earth and a philosophy that is extremely inclined towards spirituality, one of the major reasons for long journeys are pilgrimages.

Now, this gets more interesting, if we consider the fact that, majority of pilgrims are elders. In India, the custom is that people gets more religious with age. Specially post retirement, they start pilgrimage-oriented travels. The perception of comfort for elders are much more pronounced and deeper due to the deteriorating physical wellbeing with rise in age.

This work tries to do a qualitative assessment of the requirement, needs and expectations of these fellow passengers while doing long distance journeys, because the aspect of comfort gets dominant in long distance travel. If we consider a personalised mobility solution like car, all the manufacturers have proper research wings for the ergonomic comfort of the users / passengers. Hence their products are designed with proper knowledge background. So, if an original automobile manufacturer is making the vehicle, there will be proper designing of interiors, facilities like seats and other amenities etc. But unfortunately, when we examine the bus building in India, there are

some disturbing notes. Only a handful of companies come with factory fitted bodies. All others supply vehicles as cowl and chassis only. This opens a huge market for the bus body builders in the country. But these coach manufactures lack sound knowledge about ergonomical aspects like the comfort, or they purposefully neglect it as they are primarily concerned with costs and profits only. And their customers too are concerned with price benefit, as almost all of the products run in the commercial market are with an aim of profit generation alone. It is also pronounced by the fact that in the commercial sector the customer may not be the user as in the case with non-commercial vehicle market like cars where the customer who buys the product is also travels in it.

This study aims to bring light on the factors contributing to the physical comfort for a pilgrim (especially elder traveller) with a qualitative assessment only. The study primarily done with a group of surveys with elderly pilgrims and also using direct observation studies, as comfort being a subjective factor, and the best way to asses one's comfort is to take direct feedback from them.

ABSTRACT

The systematic development of our society has introduced major changes, as well as formed new and wide-ranging opportunities. One substantial factor for the progress of any society is the establishment of a good transport system. India, in spite of showing good development for the past one decade, still has some key shortcomings in this segment. For any developing economy and especially with the second largest population in the whole world, the need for a strong transport system is inevitable. This is an attempt to throw some light towards the areas which still remains hidden, related with one of the most important arms of a transport system – the "Bus".

The mass transport system like bus is primarily used as a public transport system as well as group transport system in which a similarly interested group is transported, like conducted tours. In India, pilgrimage is seemed to be one of the most important reasons for conducted tours.

People after attaining certain ages tend to be inclined towards spirituality in India, as India roots deeply in spirituality. These people tend to do a lot of travel for this purpose (pilgrimage) specifically post retirement. And these group is also seemed to be interested in group travel as such travels are more enjoyed in groups – this brings the transport medium "bus" in to picture. The issue with such group is that though they are able to afford more than regular, we couldn't find any studies which specifically addresses such travellers' concerns. It also adds to the importance of such studies that as majority of such travellers are elders, for which the concept of comfort is more prominent. So, if a study is done on pilgrims, the outcomes can also be used for any mass transport system using buses, specifically addressing elders.

Although there are some studies which are carried out to identify the major ergonomical problems faced by the passengers utilising the mass transportation facility, especially in foreign countries, studies which are specifically applied to Indian context is seems to be missing. The long duration journeys utilising buses impose some serious issues because, being inside a bus for a prolonged journey affects physical as well as his/her mental comfort. Comfort is a very complex and subjective concept that is difficult to understand,

measure or quantify, and specifically define due to its cognitive as well as physical nature.

This work is an attempt to do a qualitative assessment of the needs and requirements of elderly pilgrims for their comfort, as the aspect of comfort is a subjective one, with a very complex nature. There are many external factors to the feeling of comfort or discomfort, such as visual input, smell, noise, temperature, humidity, vibration, pressure/ touch, posture and movement. They best way to assess one's comfort is to ask themselves about it.

Hence, in this work, to get an idea regarding the comfort aspect, as well as the needs and requirements of our subjects, that is elderly pilgrims, the tool we used was surveys. We have done extensive surveys with travellers while undergoing conducted tours especially pilgrimages. There were four different surveys to assess the existing issues which served as a platform for existing system feedback.

The survey one consisting of feedback about different aspects like seat system, different pain regions after a long travel, other factors contributing to the aspect of perceived comfort like interior colour theme and convenience amenities needed etc. The feedback was taken from subjects who are kept in airconditioned buses so as to keep the other contributing factors of comfort such as temperature, humidity and smell at bay.

One of the interesting factors came out of survey 1 was the influence of driver behaviour in perceived comfort of passengers. This triggered another study which investigated the same, with the survey two.

Also, it is noticed that the fellow passengers were finding it difficult to use the controls like that of seats, as their hand grip strength is deteriorating with age. But a study on the hand grip strength was not found and as a solution we did a study on the same too as survey three.

Now we have done a study on the existing bus platforms to assess the suitability of them for serving elders. This investigated aspects of entry/exit, in- vehicle movement, and other comfort and safety features. This is an observational study done as survey 4.

After all these studies, we found some serious issues with the present system designs and we tried to find some solutions to some of these issues in the form of design

interventions. Then we took some feedback about those design interventions proposed from some of the manufacturers and the main feedback we got was the varying demand of comfort by the buyers. To address this issue, we finally proposed a modular design concept. This proposal is accepted by the manufacturers and they opined that the complete feasibility will be available only after a prototype manufacturing.

The overall approach of the thesis is basically qualitative assessment of the needs of the elderly pilgrims and to support the ideas, few specific interventions are also made. This work is desired to be served as a platform for further design thoughts which would be able to comprehensively address all the problems and issues faced by elderly travellers utilising bus as a mode of transport.

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Chapter – 1

Introduction

This chapter consists of two sperate sections. In the first section a brief introduction to road-based mass transport system using buses, its origins, history, and classifications are included. The Indian scenario too is taken a look at. It also contains a note on the bus manufacturing process in India. In the second section, the detailed report of review of literature is provided. Then, research gaps, research questions, research hypothesis, aim and objectives are also given. The research design is also provided towards the end of this chapter. This chapter concludes with the thesis structure.

Chapter - I

Introduction: Road Based Public Transport System Using Buses

1.1 Overview of the research area

The technological growth in our society has initiated many changes, as well as created fresh and wide-ranging opportunities- facilitating communication and social wellbeing. One significant factor for the progress of any society is the establishment of a good transport system. In a country like India which has rural roots, mass transportation has a vital role to play. Also, as a developing country, many of its people still are under-privileged and gets only minimum income to sustain their life, a well-designed robust public transport system is extremely important. India, despite showing good growth for the past two decades, still has some key shortcomings in this (public transport) segment. This is an effort to throw some light into the areas which still remain unseen, related with one of the most important arms of any mass transport system – the "Bus".

For a country like India, the surface transport systems play the crucial role, mainly due to accessibility and economy (cost). The government is making huge investments in road infrastructure and it wouldn't be wrong if we consider these roads as the life flowing veins of any economy. Although there are many governing laws regarding the design, manufacture and operation of mass transport systems like buses, the society is facing some important problems also, to which a proper study is needed to get a solution to.

The Figure below (Figure 1.1) is a simple depiction of public transportation system and its classes, independent or in continuation, made from time to time is attempted to develop / suit appropriate need has been carried out - where bus has become a common mode of transport and is plying in almost all terrains.

The road-based transportation system is classified in to two. The individualistic transportation system and mass transportation system. The key focus of much of the ergonomics researchers is on individualistic transportation vehicles such as two wheelers, Cars, SUVs etc. A large number of researchers are working on that sector. But mass transportation systems like buses are getting less consideration from researchers especially if applied to Indian context.

The long distances buses used not only for transport people from one point to other (fixed destination - line buses), but also used as mass transportation medium such as conducted tours and pilgrimages. The pilgrimage is needed to become a thrust area because of the fact that most of the pilgrims are elders. People reaching certain age becomes more spiritually inclined, and would like to travel for it, especially after retirement. These travellers are expecting more comfort than a regular bus offers, because they are used to the comfort levels of personal mobility solutions like cars. As a good amount of them, were experiencing weakening of their reflexes due to age related problems, driving becomes gradually difficult and one of the solutions that they are looking for is the usage of mass transportation system. So, there is a need to consider such expectations from the senior travellers.

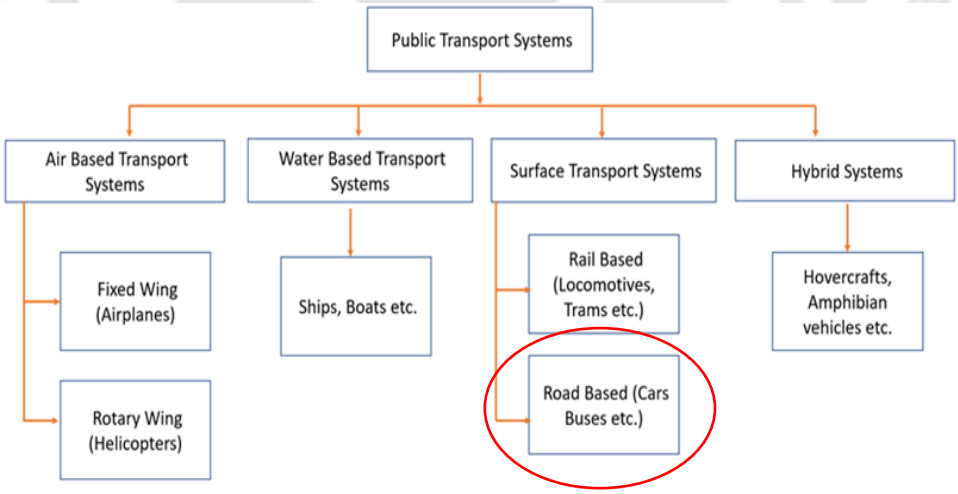

Figure 1.1: Types of Public Transport Systems: the existing classification

By definition, a “Bus” is a road vehicle designed to transport many passengers in a single stretch. The word bus comes from the Latin word Omnibus meaning “for all”. The capacity of buses can vary from 12 to as high as 175 as shown in Figure 1.2 (Neoplan

Jumbocruiser by German manufacturer Neoplan Bus GmbH holder of Guinness Book of world records as largest bus – Although non verifiable, China is said to have made bus with a capacity of 300 in 2007). Buses are of various types and application though the most common kind is the single-deck rigid bus. For carrying larger loads there are many design iterations like double-decker and articulated buses which will be discussed briefly as this report progresses. Also, for long distance travelling, coaches are being used.

Figure 1.2: Neoplan Jumbo Cruiser Bus: *This articulated double deck bus is made by German company Neoplan GmbH and holder of Guinness Book of World Records as the bus with highest number of seats at 170 seats with a length of 18 m; Picture courtesy: Neoplan official FB page*

Buses are fundamentally used for scheduled and non-scheduled passenger transport, though, there exists typical designs such as Bruck (Bus plus Truck -See Figure 1.3) which fits the role of both bus and a goods carrier.

Figure 1.3: A Mercedes Benz Bruck: *Bruck is combination of both bus and truck. It can carry a number of passengers and a significant amount of cargo at the same time thereby saving fuel and time; Picture courtesy: wikimedia commons*

The history of buses: innovation and needs

The following is the timeline of evolution of bus types. Figure 1.4 shows the history of bus transportation; can be used to generate the feeling of amusement and timeline factor to be used in today's context- for some specific experiences that we have erased in the developmental progress.

- It all started in early 1800s. Horse-driven buses were used from the 1820s, replaced by steam buses in the 1830s, and electric trolleybuses in 1882 (Berlin).
- Walter Hancock introduced steam powered buses in England on 22 April 1833 and was named as "Enterprise". It is known to be the first regular steam carriage service, and also claimed to be the the first mechanically propelled vehicle particularly intended with Bus transport characteristics.
- The first IC engine-based buses (later known as motor buses and now simply as bus), were used in 1895. Nowadays buses are rapidly advancing towards electric propulsion (like electric hybrid buses and fuel cell buses).
- Even for ICE based systems there are much lesser polluting options such as CNG. It is widely believed that bus manufacturing nowadays is increasingly globalised, with the identical designs can be seen around the world. A brief description about ICE based buses will follow.
- Siemens brothers introduced trolley buses in Berlin which was operated through trolley poles through overhead wires. Trolley buses are primarily electric buses that gets electric power for propulsion from two overhead wires (usually suspended from roadside posts) using spring-loaded trolley poles.
- The trolley buses have the inherent advantages such as better gradeability, better NVH properties, less prone to maintenance and above all lesser pollution. Specialists are of the opinion that trolleybus are better option when being compared with traditional trams, and has numerous advantages compared to conventional electric buses. For example, a regular battery-operated electric bus would cost anything around Rs 80 – 200 lakhs for a passenger capacity 32+1 to 49+1. And a greater share of this cost is going for the battery system. Also, the battery is considered to be among one of the least dependable (read as reliable)

component too. Again, a network of charging facilities is also needed. Couple this with the environmental hazard created by batteries which completed its lifetime, and after all these, an electric bus's endurance or range is severely limited. And also, there is a risk of battery exhaustion while travelling.

- Long distance travel started much earlier than expected. Figure 1.5 C shows one of the longest traveling buses that used to connect between Kolkata and London. The bus was having a sleeper area for passengers to take rest. Nowadays too such buses are coming back as two decker sleeper coaches and other associated designs.

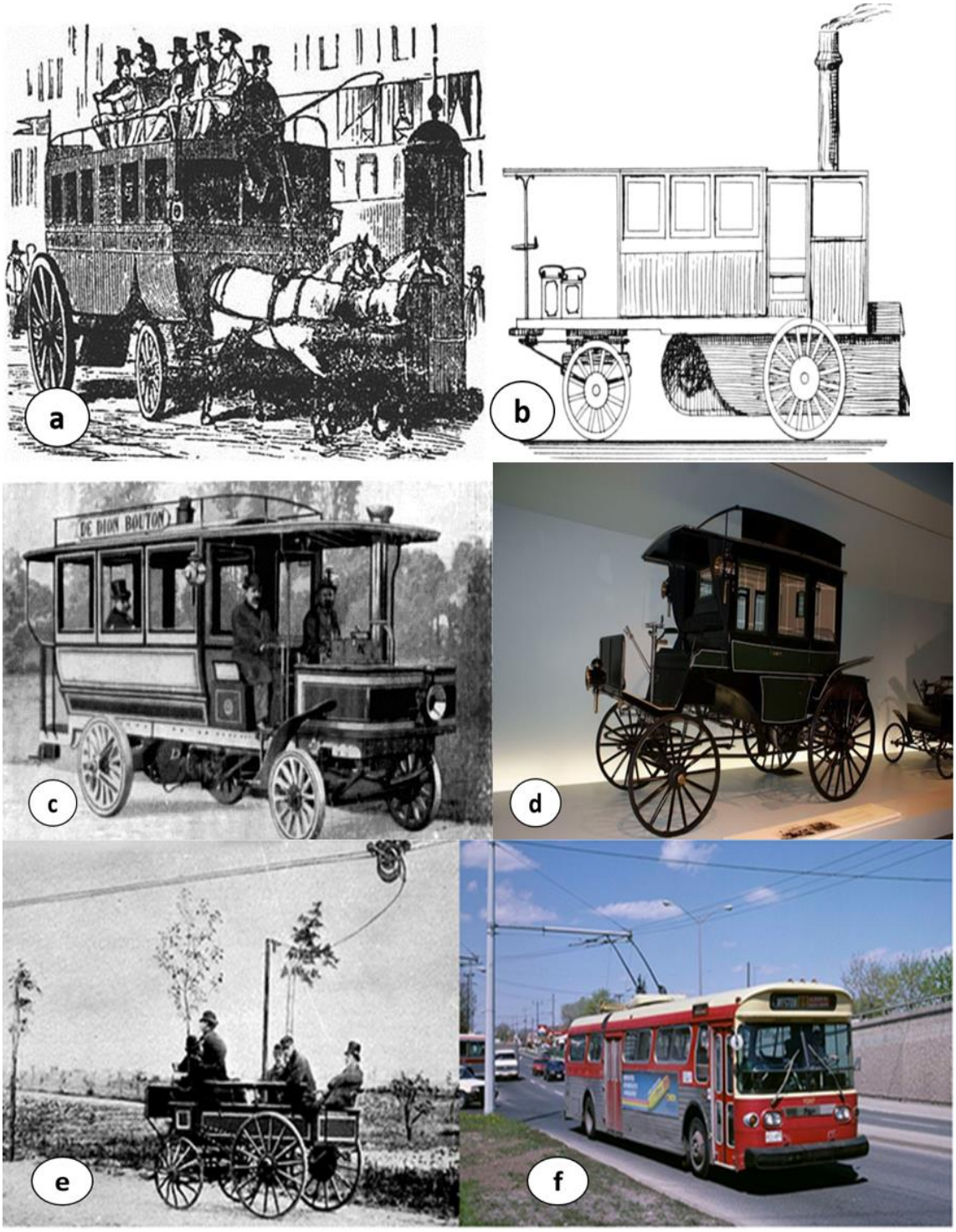

Figure 1.4: The history of bus transport: *An early horse driven bus* ***b)*** *An early steam bus design by Walter Hancock* ***c)*** *An early French steam bus* ***d)*** *The first internal combustion bus of 1895 (Made by Benz & Cie, the creator of Mercedes-Benz; Image courtesy: somagnews.com)* ***e)*** *Worlds First trolley bus – Siemens in Berlin (1882) and* ***f)*** *A modern day trolley bus operating in Toronto (Trolley buses are primarily electric buses that gets electric power for propulsion from two overhead wires;(Picture courtesy: Wikimedia commons and the transporters history)*

- The world's first internal combustion engine bus was made by Benz & Cie, the creator of Mercedes-Benz, and started to manufacture on March 12, 1895. Developed by Benz & Cie, Benz "Landauer" was developed with a capacity of 8 travellers. The Benz "Landauer" was powered by a 2.9-liter single-cylinder, four-stroke engine that produced 5 horsepower.
- The first mass-produced transport bus entered service in 1910. Designed by Frank Searle, it was the B-type double-decker bus and was operated by the London General Omnibus Company. It is estimated that well over 3000 buses of these types have been made.
- In India, the first motor bus route started on July 15, 1926, and ran between Afghan Church and Crawford Market, Mumbai (See Figure 1.5). The ticket cost was 25 paisa then (1/4th of INR).

Figure 1.5: Bus transport history in India: *From clockwise from top left: a) India's first bus service (This happened in present day Mumbai; Image courtesy: indiabookofrecords.in); b) Travancore bus stand in Kerala in 1950; c) One of the longest bus travels in history; Calcutta to London; d) A double decker bus operated by KSRTC, Kerala.*

Some Special types of buses

Although there exist many types of custom-made bus designs to cater the needs of different customers, some of them are eligible for a brief discussion.

- Articulated trailer bus - A trailer bus or articulated trailer bus is a bus designed in such a way that a bus bodied semi-trailer is connected to tractor unit in a similar fashion like an articulated semi-trailer truck. They are extended buses connecting together two (single articulation) or more (bi-articulation) sections with pivoting joints for higher passenger capacities particularly in intercity application connected by reasonably sized highways (See the Figure 1.6 below). The limiting factor is the huge space need and higher turning radius needed.

Figure 1.6: A biarticulated bus: *It is a bi-articulated bus made by Volvo, Sweden. Picture courtesy: Volvo bus official site.*

- The Bi- articulated bus - is typical bus design in which three rigid sections of passenger compartments are connected with the help of a pivot (hence the name articulated), shown in Figure 1.6.
- The Double decker bus – is a bus design that has two decks or two levels of passenger sitting floor, Figure 1.5 (d). The general advantage is the availability of more passenger space per road area required.
- The low floor and low entry buses, Figure 1.7 below.

A low-floor bus is a bus design which has no steps (or probably no need of a step as the floor height is kept as low as possible) between the ground and the floor of the bus. It

can be accessed from the sidewalk by a single step due to the small difference in height, due to the level difference of the bus deck and sidewalk. A bus with a partial low floor may also be referred to as a low-entry bus. The below shown Figure 1.6 explains the difference between the two. On the other hand, high-floor bus design needs climbing one or more steps to enter the vehicle interior floor which is placed at an elevated level. A low-floor improves the accessibility of the bus for the passengers, especially for the elderly and people with disabilities, using wheelchairs, walkers etc. The driveline layout is rear-engine, rear-wheel-drive with no drive shaft (direct drive system).

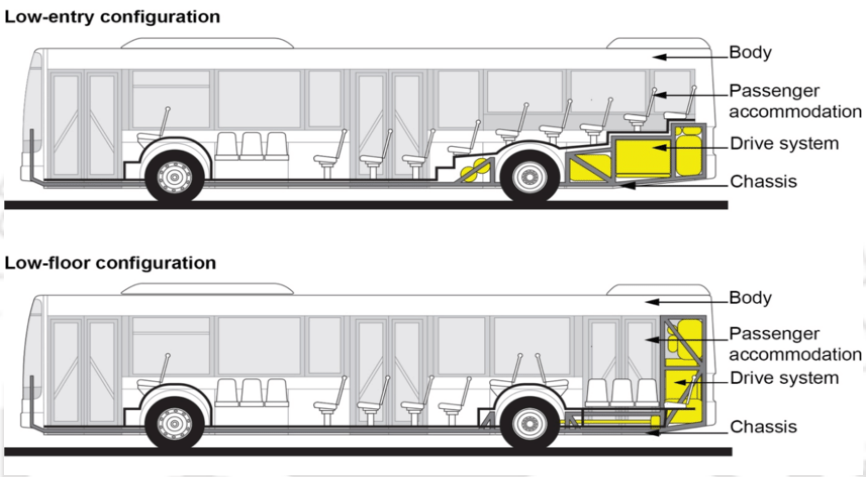

Figure 1.7: Low floor vs Low entry: Note the vertical powertrain system arrangement in the low floor arrangement. Both these configurations severely limits applicability for pilgrimages in Indian contexts as this configuration limits ground clearance which is a basic need for operating in Indian road conditions due to hilly areas like Himalaya ; *Photo credit: Australasian transport research forum.*

One of the limitations of low floor or low entry configuration is that, due to low available ground clearance. This severely limits the application or usage in rough terrains or roads like the ones in the so-called “Char Dham” pilgrimage. Generally, these types are suitable for well paved city roads or highways.

The Bus Manufacturing

The origins of bus manufacturing can be found in carriage building and probably in truck manufacturing. Generally, chassis designs were common for trucks and buses, but then as technology advanced, specific bus chassis started being developed. From the

beginning itself, bus manufacture constituted as chassis and body builds. Generally, it is considered that a bus body has lesser life than a chassis. So often a chassis can be fitted with more than one body in its lifetime. Then came the integral type bus designs combining the body and chassis. Figure 1.8 shows AEC route master bus which is among one of the earlier integral type body designs. After this, in the late 80's minibuses that are built on the van chassis were came. It was colloquially known as van derived buses. And still this method is followed for manufacturing minibuses.

Figure 1.8: AEC route master bus: One of the first integral bus designs; Such designs can be called back even now nowadays for particularly attracting tourists.*Photo coutesy: London Bus Museum website.*

In most parts of the world, bus has been designed as a basic chassis, front-engine, bonneted vehicle; But nowadays, due to stringent governmental norms coming, the external dimensions are limited. So, as a result, manufacturers tend to maximise the seating capacity within the above-mentioned constraints regarding external dimensions, making the design to tends towards rear- and mid-engine designs.

The early 90's saw the next major change in terms of bus design. Bus designers started shifting their focus from conventional setup towards low-floor designs, for better accessibility especially for elders and individuals with disabilities. Some designs achieved this by changing the door position to that behind the front wheels/axles, particularly for smaller buses. On the other hand, for the larger bus designs this was attained by several iterations of independent front suspension arrangements/designs, and also using kneeling technology (Kneeling means the driver can lower the bus height to

really lower levels by adjusting the pneumatic suspension and thus creating an unobstructed pathway into the entry and between the front wheel arches). But due to these arrangements one more problem came out. Now with this design it was difficult go with the conventional front engine set up. Hence as an answer to this, designers started to use a rear-engine setup. Some designs also incorporate extendable ramps for wheelchair access. Also, the accessibility enhancements can be achieved for high-floor coaches, by introducing built-in wheelchair lifts, Figure 1.9.

As regards to the propulsion, in the present day, although overwhelming majority of the bus designs depends upon IC engines, a rapid paradigm shift can be witnessed towards non-polluting alternatives like electric buses and hydrogen fuel cell systems.

Figure 1.9: Tata Motors electric bus with wheelchair lift: Electric buses can be designed easily with powered devices such as wheel chair lift which is conventionally powered by hydraulic mechanisms.

The bus manufacturers can be divided in to three classes:

1. Chassis manufacturer (Primary manufacturer) - builds the underframe for body-on-frame construction; also, the powertrain and other systems will be supplied by them.
2. Body manufacturer (Secondary manufacturer)- builds the coachwork for body-on-frame construction. Here the customization possibilities are endless often with lower cost at the cost of quality.

3. Integral manufacturer - builds the complete bus, often with no underframe. It should be noted that often Chassis manufacturer will also be the integral manufacturer. They will supply the product as according to the customer preferences whether as cowl and chassis type or complete factory-built unit.

The dividing of body and chassis building permits the manufacturing companies to specialise in two different arenas. Also, it permits the companies to offer product exactly as per customer requirements, so that the buyer is catered with different chassis/body combinations. Occasionally, a chassis and body builder will offer combination of one body and one chassis, as a 'semi-integral' unit. By this the buyer will get the benefits of two expert companies, and can also save some cost. The collaboration of Volvo with MG motors is an example.

The chassis of a bus is comprising of the following primary members:

1. A structural underframe
2. Engine and radiator
3. Gearbox and transmission
4. Wheels, axles, and suspension
5. Dashboard, steering wheel, and driver's seat

Figure 1.10: The Volvo B9L chassis: Rear engine vertical set up allowing for low floor configuration. *Image courtesy: Volvo official website*

Most of the times, chassis will be built as a complete unit, up to a point where it can be driven to on the highway or to a nearby bodybuilder. It can be front-engine, mid-engine, or rear-engine though in most of the cases the radiator is fitted at the front independent

of engine position, for more efficient cooling. The Figure 1.10 shows a Volvo B9L chassis with rear engine configuration which can be cited as an example.

Now the bus body/coach manufacturer builds the body onto the chassis. While designing the body the main considerations to consider are;

1. Usage
2. Number of seats
3. Staircase position/design (double-decker buses)
4. Number and position of doors
5. Entry design (Low floor/ Low entry/ High entry)

The general idea behind bus bodywork is the usage which may be categorised as ;

1. Bus (Short duration – Intra city operation)
2. Coach (Intercity long duration operation)
3. Dual Purpose

The Indian Scenario

The transportation segment is perceived as one of the key aspects of an economy's competitiveness. It is found that India's expenses for transportation account for close to 14 per cent of the GDP, and if comparing with developed nations (around 8-10 percent) it is reasonable. The bus industry is one of the most important unit of Indian automobile industry. The industry includes the buses that are used as school buses, mini buses, tourist buses, deluxe buses, commuter buses and others. Due to the growth of infrastructure and roads, linking the distant destinations has become much easier and hence more and more people are utilising bus services. This has significantly contributed to the growth of bus industry. The growth in this segment has made the manufacturers focussing more and more towards innovations and improvements.

Numerous new designs have been introduced and state of the art, comparable to the best in the industry technology has been demonstrated. Buses became well equipped with

advanced features and services which also includes passenger information system, HVAC systems, high quality propulsion systems (whether ICEs or Electric), extremely sophisticated suspensions systems (Pneumatic / MR Fluid based) and transmission systems etc. It is expected with this current or future generation technologically driven designs, the customer base may also increase at a high rate. Also, due to this ever-increasing consumer base, even the companies with foreign origin such as Mercedes, Scania and Volvo are making hefty investments in this, in India. It wouldn't be wrong if we state these companies has set new standards of luxury and comfort.

The key players in the Indian bus industry are Tata Motors, Ashok Leyland, Eicher - Volvo, Bharat Benz (also Mercedes Benz for high luxury segment), Swaraj Mazda, Mahindra and Mahindra Ltd, Bajaj Tempo Limited and others. Nowadays Indian born companies are also rapidly advancing towards electric / fuel cell propulsion.

Bus body manufacturing process in India

The Indian automobile industry particularly public transport systems such as buses creates an important seat for itself under Indian economy due to the huge employment opportunity potential it creates, reasonable investment sizes and also being among the largest number of customers or consumers depends on it for their transportation needs.

In the coach building process, the chassis is provided by original manufacturers, and body (coach) is built by bus body builders (popularly known as coach builders) in accordance with the requirements of the customer and specifications laid by different state government bodies and Union government. The process has a number of steps and is explained in Figure 1.11.

Design – in which a detailed body design is made consulting the prospective customer.
Selecting the Chassis – The appropriate company among OE manufacturers is selected as per the need of customer.
Frame building – A frame is built upon the chassis using C channels.
Side body building - Metal sheets are prepared and checked for grease/oil if any. Then sheets are cut to size for forming different parts, and these parts are formed on press brake. Now different parts and their subassemblies are fabricated as per their design

and size. These parts and subassemblies are fabricated– together to make them a complete bus body. In premium designs, side body panels are sandwiched using dampening materials for better sound absorption properties.

Painting - The complete body is painted as per the requirements of the customer. Shower test is carried out for leakage etc.

Figure 1.11: The bus manufacturing at coach building facility that shows the transformation of a chassis into a roadworthy bus; No considerations for ergonomics, value for money is the motto of majority of coach builders.

Appropriate body building on a given chassis has taken a customer need fulfilment trial in India, that leads us to think how specific needs are met.

1.2 Need of the study

There are two types of road-based transportation system. One is individualistic transportation and the other is mass transportation. The primary focus of much of the ergonomists is on individualistic transportation vehicles such as two wheelers, Cars, SUVs etc. A good number of researchers are working on that sector. But mass transportation systems like buses are getting less attention from researchers particularly in Indian context.

The mass transportation systems like buses find its many applications such as public transportation system (regularly plying between fixed destinations – line buses) and conducted tours or travels. Pilgrimage is one of the most important reasons for conducted tours in India. People attaining certain age becomes more spiritual, and would like to travel for the same, especially post retirement. Now the expectation of such travellers is that whatever comfort that they were getting while traveling/ driving by personal mobility vehicles like cars, should be there while using mass transportation vehicles too. As a good amount of them slowly deteriorating their reflexes, driving becomes increasingly difficult and one of the solutions that they are looking for, is the usage of mass transportation system. So, there is a need to consider such expectations from the fellow travellers. But it is a fact that in a country like India where majority of bus owners are depending on bus body building companies of varied levels of technical skills and capabilities, a proper design or study is evidently absent. The main considerations remain as the cost and easiness of maintenance. Proper designs with adequate attention to ergonomic aspect is still missing as majority of these third-party bus body manufacturers own only a bare basic team of fabricators and lacks designers with proper know-how of ergonomics. Hence this point towards a very serious issue and obviously a deeper study is the need of the hour.

As the governmental regulations are there exists in the form of bus code, it mainly concerns with other design factors such as safety, body dimensions, entry / exit points etc. Also, we should consider the fact that in a country like India, where majority of public still uses bus travel even for longer duration, a properly designed ergonomic study is inevitable. Also, it is noted that in contrast from the developed nations, we lack a

proper concern over the usability of public transport systems for elders. There are many limitations when we try to evaluate the inclusive design philosophy of such public transport systems.

The existing systems needed be evaluated for the suitability for elders, and we need a deeper insight of the same. This point also magnifies itself by the fact that especially for elders the concept of comfort and fatigue are pronounced. So, we believe that by this study, we would give some light towards a problem that was long pending for address.

In view of the above discussed points, a comprehensive literature review was carried out to get a deeper insight about the current status of research regarding the comfort issues faced by the users (passengers), utilising the public transport systems particularly buses (doing long distance journeys).

1.3 Status Background

In order to see the attempts undertaken so far, a thorough literature review is needed. A comprehensive review about the various aspects of passenger public transport system design and inclusive design principles as applicable to such systems are studied here. The entire literature was taxonomically categorised first and later analysed further to identify the research gaps which in turn will give research questions. The study can be broadly stated as an attempt to get deep insight in to the bus design and manufacturing process in India inclusive of the limitations of the same, the comfort issues faced by the users or passengers by those limitations especially fellow passengers when they are using the buses for long distance travel purpose. A comprehensive search in electronic databases which included Scopus, Web of Science, PubMed, ScienceDirect and Google Scholar. The search was conducted with several keywords. The output was divided into five major categories based on the subject area of research and was further classified as per the three different research approaches. In the final stage, an integrated framework is proposed with an emphasis on the issues faced by long distance fellow travellers particularly pilgrims and possible ways to find solutions of the same.

India is one of the fastest growing economies in the world. It is estimated to achieve a growth rate of 7 – 8 % annually. With a comparable growth rate in population too, India is trying all the means to provide the basic facilities for its people. A good public transport system is considered to be the backbone of any developing country. As to own a personal vehicle, remains a dream for majority of its population, the dependency on public transport system is inevitable.

One of the major arms of the public transport systems in India is the buse. People use buses for both short term commute and long-term travel. There are numerous large players in the market to provide these customers with the state-of-the-art solutions in terms of mobility. But still there are some missing links. All over the world the bus is being manufactured in two fundamental ways. One is complete bus manufacturing by the parent company (the company itself manufactures both chassis as well as body) and the other is utilising the coach or body manufacturers for integrating the factory-built chassis to coach builder-built body. In India, the second type has most significant

contribution and it can be estimated from the fact that nearly 20,000 bus coach builders are operating there in this country, with varying capacities. The most important consideration while making / designing such a body is the cost associated with the it and maintenance. Majority of the customers of these companies are really inclined towards the cost rather than proper design considerations.

Buses are used generally for two purposes. One is to serve as the primary arm of public transport system for general public and other is to serve as a platform for private travel like conducted large group tours and pilgrimages. In latter often the travel duration is much more and as a result human factor issues play an influential role. Also, it should be considered that for this private travel like pilgrimages, majority of the travellers fall under the category of elders or senior citizens.

Now comes the million-dollar question. Are these coach builders following proper design procedures or philosophies? Are they designing their vehicles with proper features related with ergonomics? Are these products come with proper ergonomics for elders? Are they have sufficient attention for long distance travel comfort? And finally, are they designed with inclusive design principles in mind? Are our elder travellers getting all their needs and requirements attended?

It is extremely important to find out answers to the above-mentioned questions. Because we are no longer remains as an undeveloped country with moderate resources. In fact, our country is now considered among the best in the world when infrastructure and technical resources are concerned.

1.3.1 Review Methodology

We know that a systematic, structured, well designed and organised literature review is one of the most important steps of any research activity. A well-executed literature review will help to identify the relevant literature and to proceed towards the possible research gaps. As opined by K M Atkinson in the year 2015, the most important step to the process of scientific research is the critical assessment of available research methods and results and the ability of others to conduct reliable replications of the same. According to them, literature review is step by step iterative process including suitable keyword search, finding relevant articles and a systematic analysis of the same. This

study is following the similar approach. For this review of literature, the relevant sources of publication were identified based on the long-distance bus travel fatigue for elders. And for that purpose, we searched Scopus and Web of Science. The procedure and structure adopted for review methodology in this work is presented below in Figure 1.12.

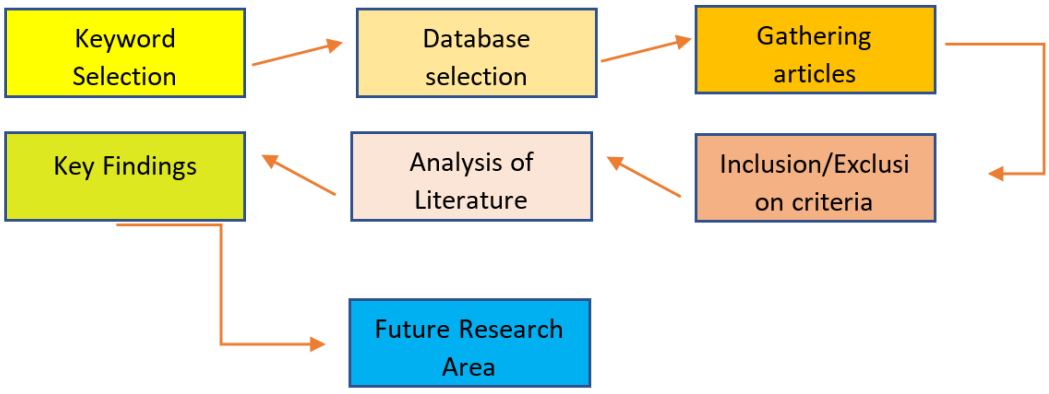

Figure 1.12: Review design methodology followed

1.3.2 Keyword Selection

The applicable keywords were used to find suitable articles/research papers from various above-mentioned sources. Here we followed a broad to particular approach in which a relatively large number of keywords was selected initially and brought down small number via an iterative process. The initial keywords used were long distance travel, passenger comfort, MSD and travel fatigue, Bus interiors, Seat design, Inclusive bus design and driver behaviour. Then it finalised to the following keywords; long distance travel induced fatigue, passenger fatigue, seat design, inclusive travel and driver behaviour and travel comfort. We used SAR (Search-Analyse-Refine) methodology for keywords shortlisting.

1.3.3 Selection of Database

Out of various resources available to us Scopus, Web of Science as well as PubMed databases were used to get relevant articles, research papers, book chapters and short articles. For thesis reports “Shodhganga” was also used.

1.3.4 Collection of Articles

Research articles were collected from various sources as mentioned above. The initial selection was done through relevance of the titles and keywords. The validity further confirmed by going through the abstracts, results and conclusion of the selected articles. Thesis reports and book chapters were selected based on the relevance to the proposed research activity.

1.3.5 Inclusion and Exclusion Criteria (Filtering)

The abstract level segregation was done and the database was further classified to several groups. The inclusion criterion was journal papers and other research articles with complete bibliographic data points and related to various categories related to passenger bus design and inclusive design based on age groups as concerned with public transport systems. The book chapters, thesis reports, mathematical modelling related articles, articles related to other modes of transport and driver fatigue were excluded. Duplicate articles, papers with incomplete bibliographic information and papers with non – relevant areas were also excluded. Although we generally took papers post 2000, some cardinal papers were included even if was published in late 1960s or 70s.

1.3.6 Analysis of Articles

Articles were grouped with respect to the area of research and were analysed through the outcomes of the study. The tabulation was done in order to extract the most important findings from those articles.

1.3.7 Key Findings

The findings from research articles were mapped to get the overview of the studies that were carried in the respective areas and understand the gap areas in accordance with the proposed research area.

1.3.8 Future Perspective of Research

After analysing the gap areas, the problem statement was finalized and research questions were generated. An integrated framework is proposed based on the extensive literature review.

1.3.9 Synthesis of Articles

To understand the relevant work carried out and emphasises given, a search on different search engines and indexes were initiated. After collecting 211 plus literatures which included journal papers, book chapters and theses, appropriate filtration was done. A total of 104 resources were short listed. After applying exclusion criteria, total of 37 book chapters and theses were excluded and a total of 67 articles were shortlisted for further analysis. And these shortlisted literatures were classified into 5 sections, based on category of research namely, long distance travel induced fatigue and elders, passenger comfort issues in long distance travel, seat design and seat comfort in automobiles, inclusive bus travel and driver behaviour. Figure 1.13 shows the categorisation of literature.

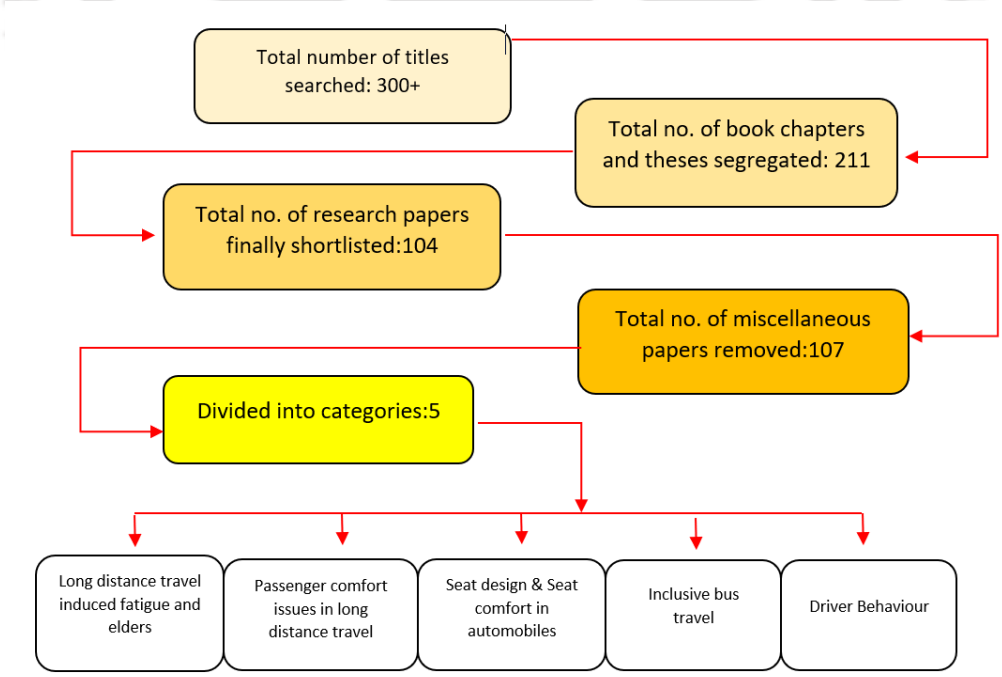

Figure 1.13: Categorisation of literature

The categories generated were, comfort or discomfort issues in long distance bus travel, Inclusive bus travel, long distance travel and fatigue, seat design and seat comfort. The final 67 articles were tabulated and an extensive review of each one of them were done. Out of these 67 articles, 60 articles were taken from journals and remaining numbers fell under the category of theses and book chapters. A consolidated data of research category and research approaches is given in the following Table 1.1. Long distance travel induced fatigue and elders included 7 papers, passenger comfort issues in long distance travel included 27 papers, seat design and seat comfort included 12 papers, inclusive bus travel included 8 papers and finally driver behaviour and comfort included 6 papers.

Table 1-1: Consolidated table of research approaches with shortlisted keywords under area of research

Literature Descriptive				
Sl.	**Authors**	**Year**	**Type of Research**	**Area of Research**
A1	Jairo Jose D C et al	2010	Exploratory	Ergonomics in design
A2	Smulders, M. et al	2016	Experimental	Seat design
A3	Denis Alves Coelho et al	2012	Experimental	Seat design
A4	Megan Romelfanger, et al	2019	Descriptive	Seat design
A5	Joshua P. Drost et al	2020	Experimental	Seat design
B1	Sukru Karali et al	2017	Descriptive	Comfort and Seat design
B2	M Kolich et al	2007	Exploratory	Comfort and Seat design
B3	Peter Vink et al	2017	Experimental	Comfort and Seat design
B4	R. Zenk ,Peter Vink	2012	Exploratory	Comfort and Seat design
B5	Matthias Franz, Peter Vink	2010	Experimental	Comfort and Seat design
B6	Vink, P., Lips, D.,	2017	Exploratory	Comfort and Seat design
B7	Sophia Tetteha et al	2017	Experimental	Comfort and Seat design
C1	Stefan Arnau et al	2017	Experimental	Fatigue and Age
C2	T Reilly et al	2008	Descriptive	Long distance journey fatigue issues
C3	Thomas Reilly et al	2009	Descriptive	Long distance journey fatigue issues

C4	J Waterhouse et al	2004	Experimental	Long distance journey fatigue issues
C5	Biggs et al	2009	Exploratory	Long distance journey fatigue issues
C6	Peter T. F et al	2010	Exploratory	Long distance journey fatigue issues
C7	Hoda M. Abd-Elfattah et al	2014	Descriptive	Fatigue and Age
D1	Broome, K., et al.	2009	Descriptive	Inclusive bus travel and journey comfort
D2	Carlos Aceves et al	2015	Descriptive	Inclusive bus travel, driver behaviour
D3	Nickpour, F.,et al	2012	Descriptive	Inclusive bus travel
D4	Miranda A. et al	2012	Experimental	Inclusive bus travel
D5	Victor Ei-Wen Lo ,et al	2019	Exploratory	Inclusive bus travel
D6	Nicola M Massy et al	2011	Experimental	Inclusive bus travel
D7	Kun-Hsi Liao	2016	Experimental	Inclusive bus travel
D8	Judith A. Davey	2007	Descriptive	Inclusive bus travel
E1	Lizandra da Silva Peter Vink	2019	Descriptive	Seat discomfort
E2	M. Wegner a, P. Vink	2020	Experimental	Seat comfort
E3	Vink, P., Lips, D	2017	Experimental	Seat comfort
E4	Huang, M et al	2016	Experimental	Seat comfort
E5	Neil Mansfield et al	2015	Experimental	Comfort issues
E6	K Kogi	1979	Descriptive	Comfort issues
E7	Sukru Karali et al	2017	Descriptive	Comfort issues
E8	Vincenzo Cascioli et al	2016	Experimental	Comfort issues
E9	Joyce M.A. Peter Vink	2018	Experimental	Comfort issues
E10	Liesbeth Groenesteijn, Peter Vink et al	2009	Experimental	Comfort issues
E11	Martin G. H et al	1997	Exploratory	Comfort and discomfort in travel

E12	Neil Mansfield, Peter Vink	2020	Exploratory	Comfort and discomfort in travel
E13	Peter Vink et al	2006	Exploratory	Comfort and discomfort in travel
E14	Vincenzo Cascioli et al	2011	Exploratory	Comfort and discomfort I n travel
E15	Michiel p. De looze et al	2003	Exploratory	Comfort and discomfort in travel
E16	Peter Vink,S. Hallbeck	2012	Descriptive	Comfort and discomfort in travel
E17	Neil J. Mansfield et al	2014	Exploratory	Comfort and discomfort in travel
E18	Peter Vink et al	2012	Exploratory	Comfort and discomfort in travel
E19	S. Hiemstra-van Mastrigt, Peter Vink et al	2015	Exploratory	Comfort and discomfort in travel
E20	M. Wegner, Peter Vink	2020	Exploratory	Comfort and discomfort in travel
E21	Peter Vink et al	2014	Exploratory	Comfort and discomfort in travel
E22	Kolich, M	2003	Exploratory	Comfort and discomfort in travel
E23	Peter Vink et al	2014	Experimental	Comfort and discomfort in travel
E24	Bazil Basri et al	2014	Exploratory	Comfort and discomfort in travel
E25	Peter Vink et al	2017	Exploratory	Comfort and discomfort in travel
E26	D J Oborne	1978	Descriptive	Comfort and discomfort in travel
E27	Branton P et al	1967	Descriptive	Comfort and discomfort in travel

F1	af Wahlberg et al	2003	Experimental	Driver behaviour, Comfort
F2	af Wahlberg et al	2007	Experimental	Driver behaviour, Comfort
F3	Yi HE	2013	Descriptive	Driver behaviour, Comfort
F4	Oborne D J	1977	Descriptive	Driver behaviour, Comfort
F5	Oborne D J	1978	Experimental	Driver behaviour, Comfort
F6	Jiang Z	2001	Experimental	Driver behaviour, Comfort

The above table expressed a consolidated status of the work carried out from time to time.

Research category wise numbers

As shown in the Figure 1.14 below, the maximum number of papers were found under the domain Comfort / Discomfort issues in long distance bus travel and it was almost 50% of the total papers shortlisted for this study. It was followed by inclusive bus travel at 15% of the total papers. The seat comfort and long-distance travel fatigue were equal in percentage at 13%. The least number of papers were found in seat design of buses at 9%. It suggests a need to study in Indian context.

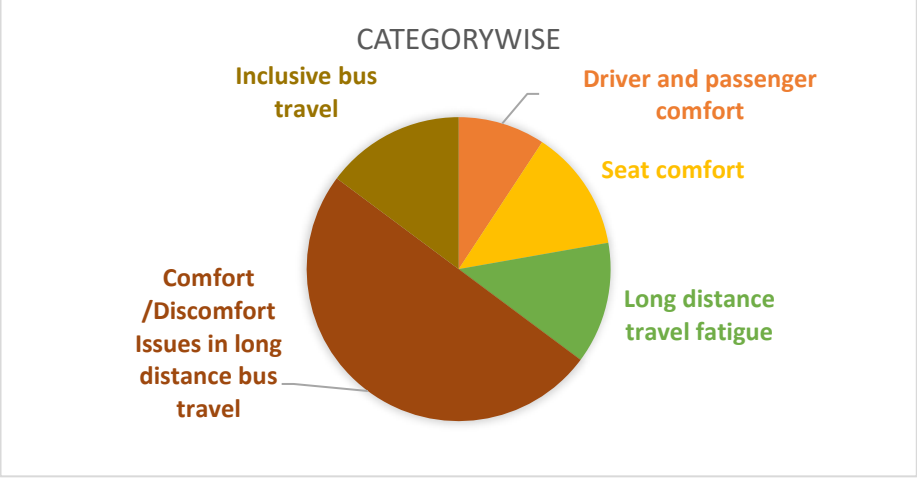

Figure 1.14: Research category wise numbers; comfort was the area preferred by many researchers.

Types of research wise numbers

When we consider the types of research wise numbers, the domain "comfort and discomfort in travel" recorded maximum number of papers in exploratory research category, whereas the domain "seat comfort" recorded greatest number of papers in experimental research category. "Inclusive bus travel and journey comfort" found the greatest number of papers in descriptive research category. The "long distance travel and fatigue issues" found equal number of papers in exploratory and descriptive research categories. Also, in "comfort and seat design" category found the greatest number of papers in both experimental and exploratory research categories. And lastly,31sb the area of seat design recoded largest number of papers in experimental research category. Figure 1.15 represents types of research wise numbers resulted from the search / survey.

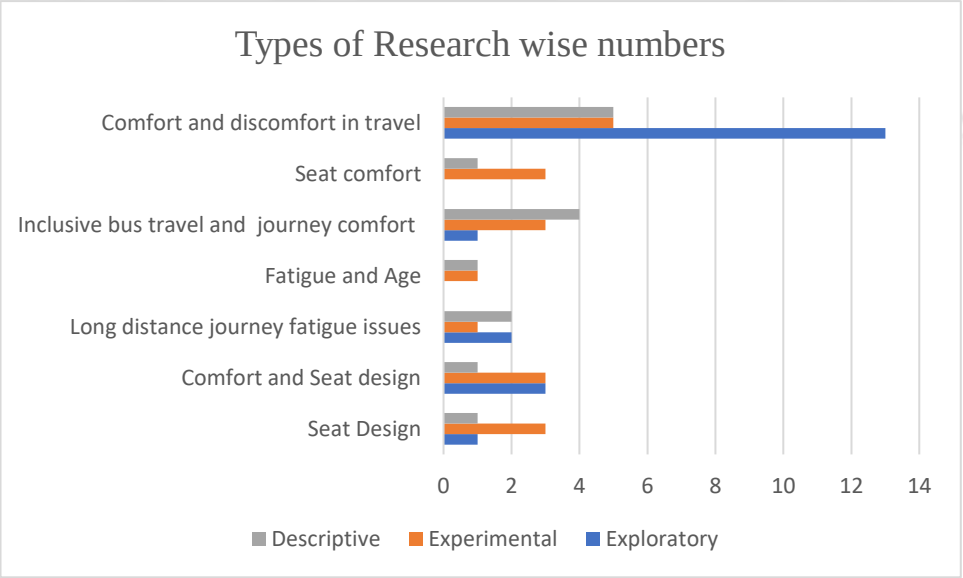

Figure 1.15: Types of research wise numbers

Country of Research wise numbers

When we consider the country wise research numbers, it is seen that Netherlands produced highest number of research works as per the afore mentioned research areas. It is interesting to note that the researcher from Netherlands Prof. Peter Vink is credited with highest number of papers in this regard. Netherlands is followed by UK, USA and

Australia respectively. Figure 1.16 shown below depicts the country wise contributions, where Indian contributions were not noticed.

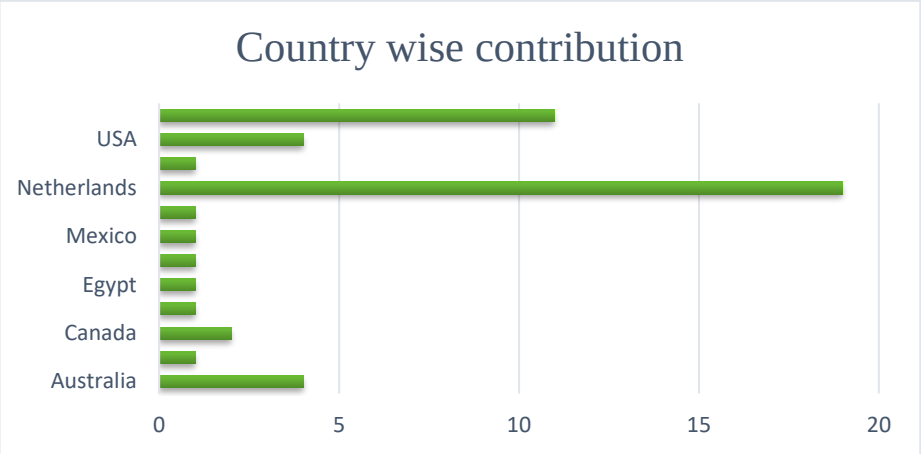

Figure 1.16: Country of research wise numbers; Netherlands was found to be the largest contributor and it was also noted that India particularly lacks considerable amount of research

Year of Research wise report

In recent years, 2017 witnessed highest number of papers as per this literature survey filtering criteria. It is followed by 2012,2014, 2009 and 2020. The detailed list of year wise contribution is depicted in the Figure 1.17, which shows almost gradual increase in interest.

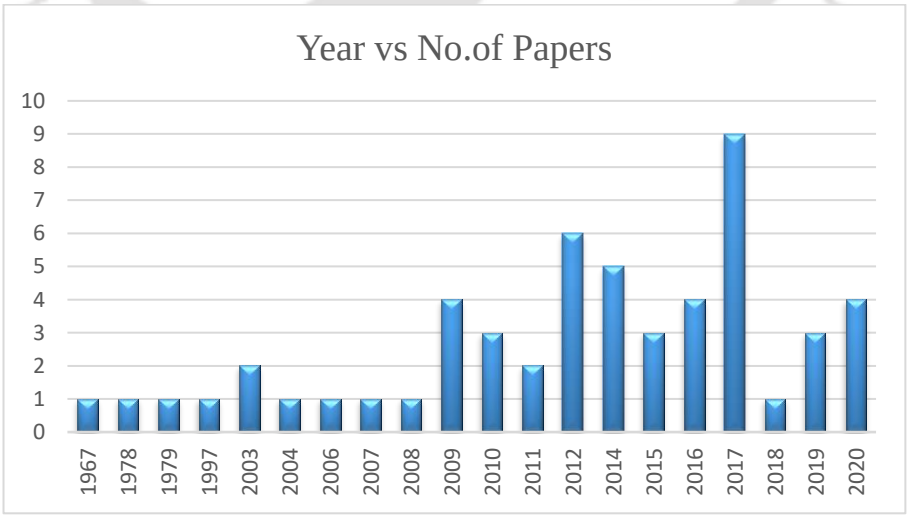

Figure 1.17: Research papers and publication year; the trend is increasing which shows that the interest of researchers in these areas is rising.

Publisher wise contribution

Elsevier as a publisher was found to be with largest number of publications in the concerned domain in three journals. It was followed by Taylor and Francis. Figure 1.18 below shows the publisher wise contribution.

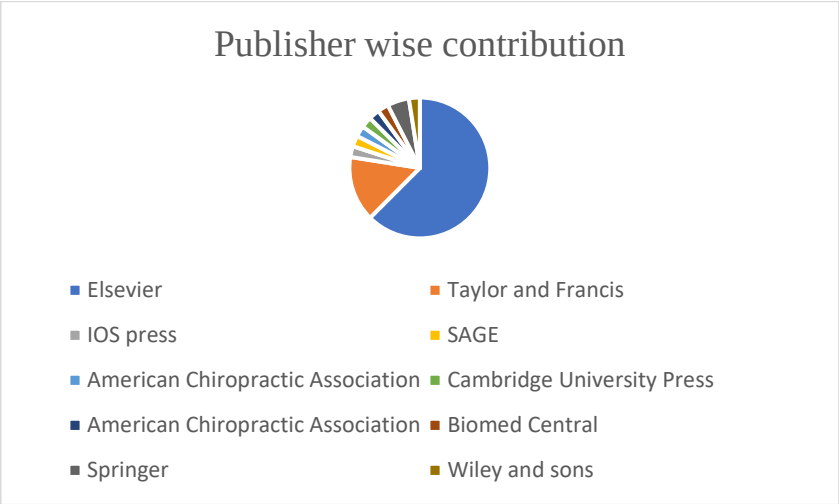

Figure 1.18: Publisher wise research numbers; Elsevier published largest number of papers in these areas.

Journal wise contribution

It is interesting to see that the maximum number of papers concerned with the above-mentioned domains were found in the journal "Applied Ergonomics". Almost 55% of the total papers were found from this single journal. The journal "Ergonomics" contributed nearly 14% followed by "Work" at 10%. The remaining journals shared almost equal shares. The Figure 1.19 shows the journal wise contribution.

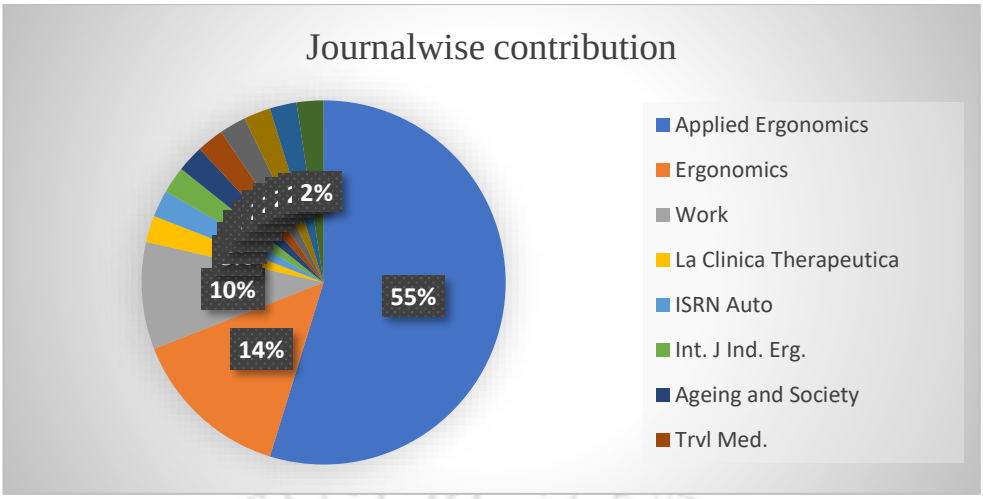

Figure 1.19: Journal wise research numbers; Applied ergonomics published largest number of papers in the selected domain.

First author wise contribution

The researcher from Netherlands, Prof. Peter Vink has the highest number of contributions in the aforementioned areas as per the applied filtering criteria of this literature survey. He has almost 18 papers in a variety of inter related domains as demanded by this survey. He is followed by Neil Mansfled. The Figure 1.21 shows the author wise contributions. It is also worth to mention that Prof. Peter Vink and Hallbeck reports 104794 double reviewed papers were generated from 1980 to 2010 (Vink and Hallbeck, 2012).

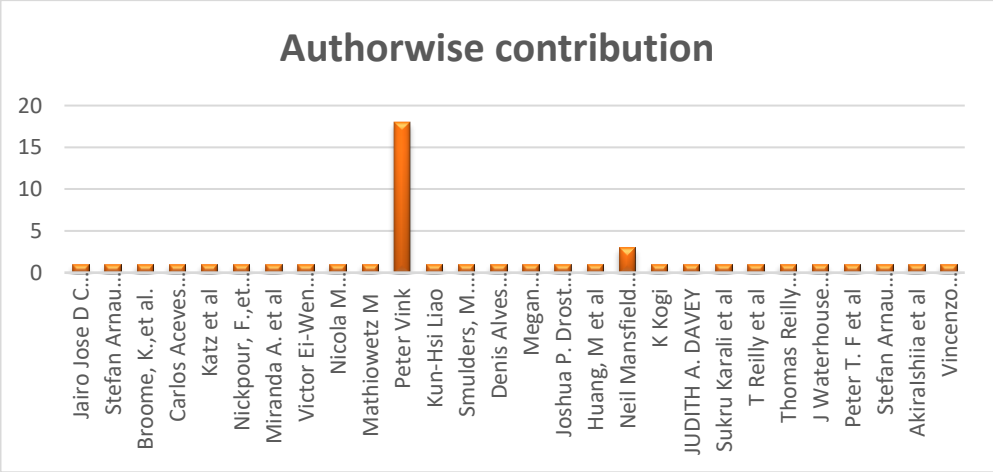

Figure 1.20: Author wise research numbers; Peter Vink from Netherlands contributed maximum number of papers.

1.3.10 Discussion

The entire literature review was categorised into five major categories namely “Long distance travel induced fatigue and elders”, “Passenger comfort issues in long distance travel”, “Seat design & Seat comfort in automobiles”, “Inclusive bus travel” and finally “Driver Behaviour”.

The detailed discussion is as follows:

Ergonomics as applied to public transport system

Improvement in “Ergonomic” aspects of public resources has been encouraged by day-to-day requirements of the general public. Throughout the past years, ergonomics based designing practices for the public systems has developed fairly quickly, but its growth appears to be hampered by an absence of constancy in the design principles as well as by the difficulty in defining and validating suitable methods and its outcomes. So, there is an urgency to establish and model an integrated approach which should be based on the actual feedback from the public. This approach is also applicable to the public passenger transport arena where the aspect of passenger comfort and safety is increasingly being focused together with traditional aspects like efficiency and productivity. Nowadays passengers are increasingly made aware of the concepts of comfort and fatigue, mainly due to the ever-increasing explosion of knowledge horizon. The biggest difficulty for applying ergonomics in public transport is that it should cater the needs of an extremely wide range of individuals with varying age groups, varying body dimensions (particularly in India), engaged in a number of non – vocational activities. The requirements are inclusive of those connected to both short and long journeys and effects of crowding. If we consider the instances of ergonomic enhancements already made in the area, it can be safely assumed that the attempts begin with the design of system of elements of newer transport facilities, while information related with dynamic characteristics of user (passenger) behaviour is not readily obtainable.

Hence it can be safely expected that, methods or tools to define the necessities of passengers from an integrated point of view may be established so as to serve as the basis of ergonomic considerations on non-vocational activities of the users.

The public transport system can be grouped into different sub systems on the basis of the means of travelling; as,

1. Railroads (including trains, trams and various types of metro systems),
2. Bus lines (includes micro, mini and small buses regular type buses etc.),
3. Ships (includes short distance boats, big end cruise ships etc.) and,
4. Air transport.

Hence the requirements of the passengers should be defined on the basis of different phases of the given mode of transport. Although it should also be noted that, the primary features of the passenger's real-world requirements are comparable and irrespective of the modes of transport, (here the process of "travel" is assumed as a system of activities in which starts when the passengers proceed towards their preferred means of travel and ends when they arrive at their destination). In 1977, Sakai *et al*., conducted a survey of public transport users (bus services) in Japan, which can be termed as a clear indicator about the different priorities in fundamental requirements of many passenger populations, and also that, these requirements are inclusive of both the primary service requirements and associated comfort. This survey had been conducted in collaboration with the metropolitan transport workers of Tokyo, in order to get a clear picture of what were the service functions required to increase the bus usage.

Researchers working under transport ergonomics regime worldwide pays primary attention for comfort within the vehicle and ergonomical design of ingress and exit.

As underlined by Oborne (1978) the most important role is of passengers for avoiding uncomfortable situations and defining their own level of comfort. Discomfort experienced by the passengers is a direct result of interactions existing among the vehicle conditions and the passengers' travelling behaviour. The most significant point to be noted here is the fact that users (passengers) are restricted inside the vehicle for the given period of time, and they have no choice but to accept the continuing influence of their environment. Hence, it can be safely assumed that the physical, mental, as well as environmental factors will have a cumulative effect on the user and it mostly influences their comfort. Therefore, it is said that, the ergonomic design procedures should be

different and it should be in accordance with the modes, the length and purpose of travelling together with passenger density.

As reported by K.Kogi in the year 1979, when a questionnaire survey was done with train passengers based on a 5-point ratings system, passenger discomfort is found to be comprising of the following factors:

(i) Physical or Postural factor: The discomfort felt physically as a result of inappropriate sitting postures. It primarily discusses the postural pain as a result of limited leg room, hard and narrow seats, unfitted backrests together with tiredness of the legs, and pains at the back and lower back.

(ii) Mental factor: This discomfort can be termed as associated with psychological factors of the journey and can be attributed to the factors such as,

(a) anxiety about destination or luggage,

(b) disturbances caused by the other passengers (such as smoking, drinking and high volume talking etc.),

(c) becoming bored,

(d) having a headache, as well as

(e) feeling irritated.

(iii) Environmental factors: This includes both annoying environmental factors such as,

(a) vibration,

(b) noise,

(c) insufficient illumination,

(d) conflict with co-passengers,

(e) deriving from unfitted elbow-rests,

(f) narrow aisles, and finally

(g) other spatial restrictions.

The differences in travelling class, type of vehicle, duration of journey, and purpose of travelling, had remarkable impacts on all three comfort factors.

The contribution of various journey factors to each of these discomfort areas was further examined by Wakamatsu et al. in 1970, based on a regression analysis of the above-mentioned questionnaire results (Wakamatsu *et al.* 1970). The most important factor for overall comfort was the physical or postural component, for which the class difference,

the purpose of travel, and the carriage type related with seat comfort, contributed the most. It was then postulated that the need for enhancement of seat comfort and leg room was crucial.

Influence of Journey Length

The influence of journey purpose and of journey length on passenger comfort command special mentioning, especially for longer journeys, where physical and psychological displeasure play crucial roles in developing discomfort. It is normally believed that a journey of three hours or longer would create substantial fatigue among passengers; the degree of fatigue depending significantly on journey conditions. It should also be noted that (as per Wakamatsu et al) not all effects of applicable factors have noteworthy correlations with the length of journey. The progressive development of discomfort is said to be multidimensionally organized, as in the case of progress of overfatigue (Kogi 1970), and the structure may change at around three hours from the journey start.

A deeper study comprising of outward and inward trips of four hours each by high-speed trains, reveals that collective effects are more pronounced on the inward trip (Endo *et al.* 1974). Such properties were noted with respect to general fatigue, aches in the back, buttock, shoulders, and legs, as well as sitting discomfort. Passenger seats and vehicle interiors which are designed for short trips never seem to be appropriate for passengers doing longer journeys.

A suitable way of learning the effects of the environment on travellers would be to compare their behavioural output, by which the prescriptive and evaluative approaches to passenger comfort may create effectiveness and validity (Branton and Grayson 1967). Nevertheless, it is vital in all types of methods to re-assess the outcomes of previous studies by further investigating the long-term and cumulative effects on travellers after any suggested enhancements have been implemented. It is also noted that the more significant factors are the effects of crowding, since intolerance of overcrowding, which is so specific to public transportation, very seriously affects travellers. Overcrowding may happen in various stages of the daily, weekly, and seasonal cycles of transport, though the daily' rush-hour' problem is actually the utmost important. The solutions are many, from a rise of traffic and vehicle capacity to specific design of the interior space

of vehicles, but it should also be noted that there do not seem to be exact end solutions to the problem. It is also claimed that the problem is closely related to city planning and demographic factors. From physiological points of view, there seems to be a tolerance limit regarding the extend of crowding.

The length of the journey is also associated with this intolerance; a journey of even 30-60 min in a physiologically overcrowded' vehicle causing discomfort (Kogi et al.). Therefore, it can be safely assumed that there would be more than one limit of discomfort in crowded transport conditions, since psychological intolerance can be occurred within the' physiological' limit. Inter-vehicle environmental factors, such as ventilation, temperature, and polluted air, also play a prominent role.

Ergonomic Design and Human Requirements

Mechanization and automatization are playing a significant part in changing public transport systems. It can be assumed safely that; they are accelerated by growing demands on public transport and by the manpower issues. Ergonomic considerations have to be applied in dealing with the interaction between traveller characteristics and the newer systems.

Hence it is found that, it is essential to meet the dynamic requirements of travellers in view of fundamental incompatibility existing between normal human requirements and prescribed mechanized standards.

In a nutshell it can be said that specifically applied ergonomics knowledge on newer systems does not necessarily validate the suitability of the solution employed. It may regularly create new types of discomfort. In that regard, the condition is comparable to industrial mechanized systems, where the difference between designed and real behaviour levies unusual workload on the workers.

Although cost-benefit associations establish a significant limiting factor for any ergonomic improvement, this should not mean that frequent investigation of the effectiveness of the solution is needless. It would be always better to learn by re-assessment of the original design, however ergonomical it may seem to be. This is specifically true for public transport systems.

Colour and Its effect on mental or cognitive comfort

Application of colours are everywhere around us (Samad et al). Various researches are of the opinion that the colour has a deep effect on our mood and on our behaviour (Rui et al, Fuxing Huang et al, Cecilia et al). Be it in building interiors, automotive interiors, or even natural environment a colour can change an individual's mood from gloomy to joyful, from confusion to clarity, from anxiety to stability. The colour can productively be used to create various moods and to increase or decrease emotion levels (Babin et al.). The creation of an atmosphere by variety of means such as temperature, sounds, layout, ambient lighting, and colours can inspire perceptual and emotional responses and affect the behaviour of consumers (Kwallek et al 1988 and 1997). Therefore, it is evident that if we analyse it, we might get an insight as to how an individual's mood differs when subjected to an enclosed space. It is also evident that the ambiance of the interior space such as a vehicle interior affects the passenger's behaviours and perception of that place by affecting their cognitive comfort. So, it can safely be assumed that the various physical factors such as light and colour have a paramount influence on the environmental characteristics of space particularly in confined spaces like bus interiors.

1.3.11 Critical Appraisal

Helander and Zhang (1997), stated that comfort and discomfort are clearly different things. According to them comfort and discomfort and two mutually exclusive factors with different fundamental influences. The term comfort is related with an experience of relaxation and wellbeing. Comfort can be changed by changing emotions, historical experiences and environments. For example, interior colour of a vehicle certainly uplifts the perception of comfort for an individual.

But discomfort can be influenced more by the physical exposure to a particular condition. It can be associated with the feeling of simple or complex pain, soreness, inflammation, general feeling of loss of wellbeing etc.

Comfort is very subjective in nature as identified by Eikhout et al. (2005). The most reliable way of evaluating the perception of comfort is by directly asking the subjects

about their feeling. The feedback of subjects is the most important factor for measuring comfort. We cannot say that increasing comfort levels may decrease the discomfort or decreasing the discomfort levels may not necessarily increase the perception of comfort (S. Hiemstra et al.,2017). A designer should give proper weightage to both comfort and discomfort.

In 2003, De Looze et al., suggested a model for comfort with three different levels. The levels are human, seat, and context. This work was originally based on Helander and Zhang. For example, if you consider the sitting comfort, at the context level, the subject's physical environment has a greater influence. But at the seat level, the physical features of the seats like contour, aesthetics etc. defines comfort.

If you consider the discomfort in long distance travel, Vergara suggests that low back pain is the most influential factor (Vergara and Page, 2002). This is found to be because of direct dependency between articular loads and sense of discomfort (Vergara et al.,2002; De Looze et al.,2003; Karwowski et al.,1999; A Rhimi, 2017).

It is also shown that the discomfort originated due to low back pain rises with rise in time (Vergara and Page, 2002; Na et al.,2005; Dunk and Callaghan, 2010). It is also important to mention that the human body itself responds to feeling of this discomfort naturally, by creating postural changes or movements (Vergara and Page, 2002; Na et al.,2005; Vergara,1998). Hence by allowing passengers to move inside the vehicle (such as in a bus) may reduce the feeling of discomfort due to long and constrained sitting.

While designing any product like vehicle, chairs, tools etc., designers are trying to minimise the feeling of discomfort and increase the perception of comfort (Peter Vink et al.,2012). The study about comfort or discomfort becomes increasingly difficult due to the fact that a product in itself can never be comfortable (Peter Vink, 2005). It is the user who is going to define whether a particular to product is comfortable to him or not (Neil Mansfeild and Peter Vink et al., 2020). The main difficulty being faced by designers is the lack of a reliable instrument or method or experience that can be consistently applied to create enhanced comfort or reduced discomfort (Neil Mansfeild and P Vink, 2020; Capetti et al., 2016; Peter Vink, 2017).

The Indian bus manufacturing is yet to get focussed and research work carried out in India are also not much highlighted in various reports published, apart from a few attempts in styling. This raises concerns of long-distance bus journeys and design interventions with appropriate effects.

1.4 Research Gaps

The above-mentioned studies focus on the below lacunae.

1. Although numerous studies are found about the concept of comfort and discomfort, devoted studies particularly applied to public transport systems using buses is scarce.
2. A proper study about the ergonomical evaluation of long-distance travel using buses as applied to Indian context is lacking
3. An investigation about the suitability of long-distance buses for elders as applied to Indian context is missing.
4. Though there are many factors for the perception of travel comfort or discomfort, the role of driver behaviour in it, was not found as applied to Indian context.
5. As the concept of comfort is purely subjective, a study based on the feedback of fellow travellers during long distance bus travel is not reported to act upon.
6. Although many literatures are available for colour psychology, the effect of interior colour theme of buses and its influences on elder travellers is an open area to work further.

The research gaps lead to the following research questions.

1.5 Research questions

The issues made questions specifically viewing elders (pilgrims) doing long distance bus travel in India.

1. What are the factors contributing to the perception of discomfort for passengers especially elders doing long distance journeys such as pilgrimages in India?
2. Does interior colour theme have any effect on the mental comfort of elder travellers and if yes what could be the preferred colour for them?
3. Does driver behaviour affect the long-distance travel comfort mind set for elders? If yes, do our drivers need to be trained for handling specifically elders to take care with special attention.
4. Are our long-distance journey buses user friendly, especially for elders? Do the coach manufacturers give proper attention towards ergonomical aspects and inclusive design?
5. What aspects be considered as design interventions to such needs?

The study tries to light on the above.

1.6 Research Hypothesis

If we understood the elderly pilgrim's needs through a qualitative assessment and if these are used while designing the bus infrastructure, it would be well accepted as one of the ways for appropriate design intervention.

1.7 Aim and Objectives of the study

The study aims at understanding the contributing factors for the perception of comfort especially elders as target customers, while undergoing long distance journeys such as conducted tours or pilgrimages in India.

1. To identify the factors contributing to the feeling of comfort or discomfort for fellow passengers using buses for long duration journeys.

2. To identify the influence and preferred colour for interior of the buses doing long distance travel especially with elders.
3. To determine whether our drivers need to be trained for handling our fellow passengers while doing long distance journeys.
4. To investigate the suitability of our coach builders-built body buses, for using as long-distance travel particularly elders.

Research objectives and Research questions mapping

The following Figure 1.21 shows the mapping of research objectives and research questions with adopted methodology for each step.

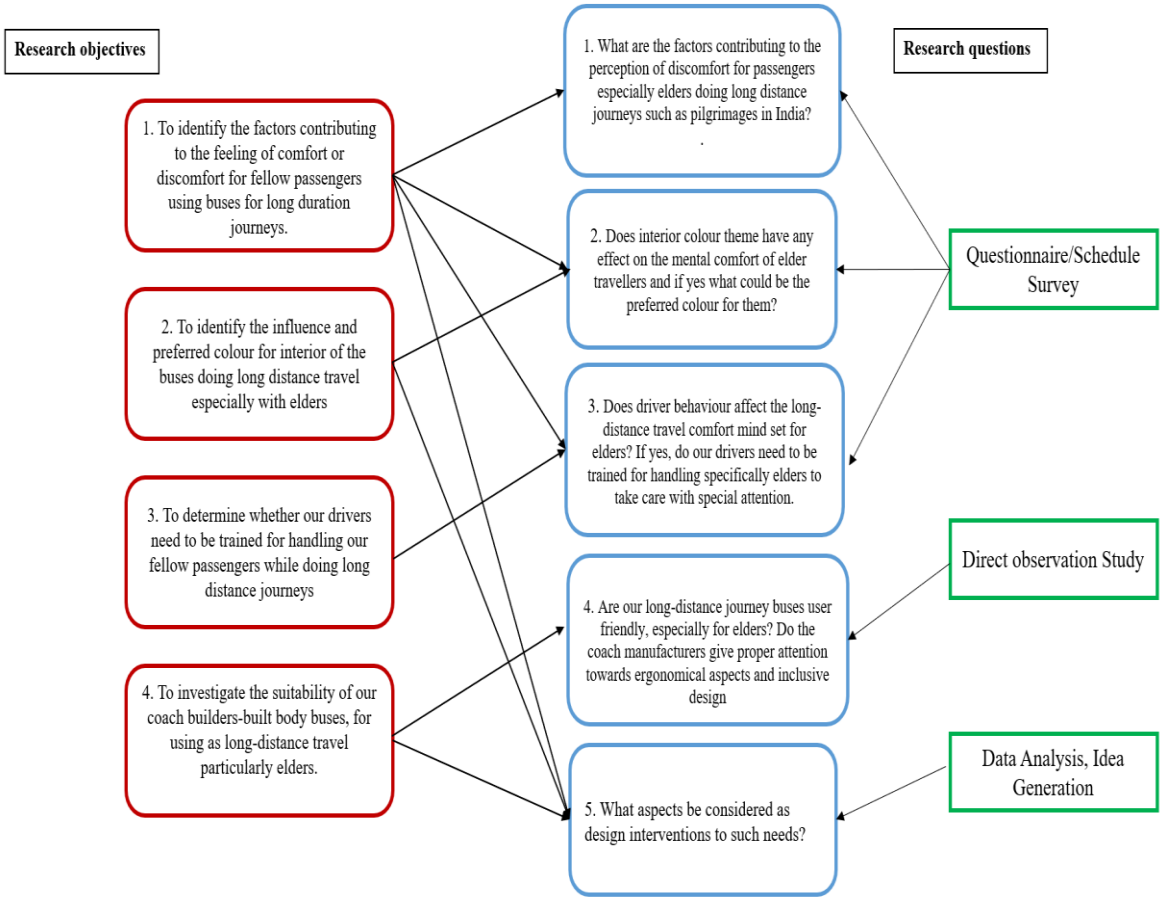

Figure 1.21: Research objectives and Research questions mapping

1.8 The study framework

The study is based on extensive surveys. For this study,work is divided in to 3 phases.

After a thorough literature review there was a contrasting lack of proper research addressing the travelling elders particularly doing long distance journey travels like pilgrimages or conducted tours, in which they have to spent many hours or even days continuously with short brakes or mere night halts inside the bus. Apparently, the bus becomes their second home. Hence it is vital to know whether a so-called deluxe class bus cater to the needs of such passengers or is there any human factor issues leading to spoilage of the entire trip spirit? We hope to find out answers to such question through our study.

Figure 1.22 gives the structure of research design. The back bone of this work is field surveys as comfort is a subjective aspect and the best way to get an idea is to ask the stakeholder directly about their feedback.

- Phase 1 is conducted to get a comprehensive idea of the prevailing situation.
- Phase II is for the study to know whether the present system is inclusive of our target subjects.
- And in phase III, detailed study is conducted to identify the existing human factor issues as applied to our focussed subjects.

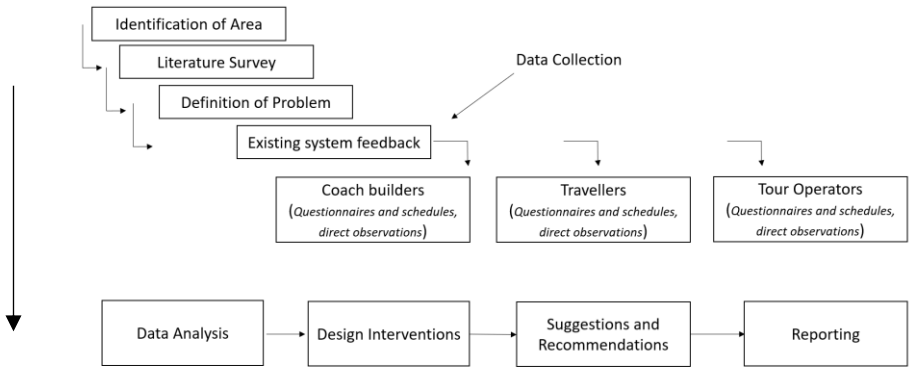

Figure 1.22: The Framework

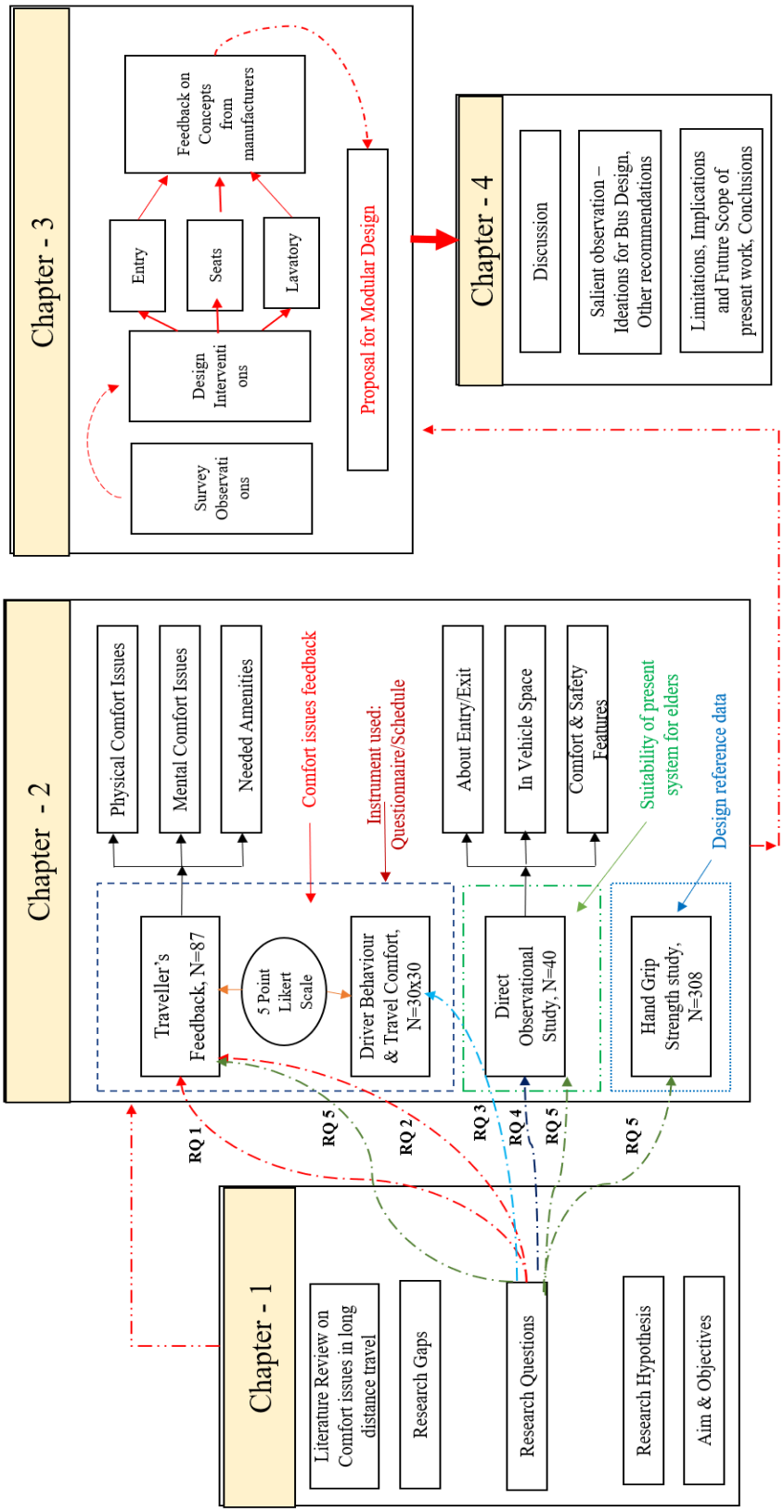

Figure 1.23: Thesis work flow and contents of various chapters; RQ – Research question

For the first phase, direct observational study was preferred as it gives a deeper insight in to the existing system. And for other phases the following tools were used.

1. Direct observations – by going with the subjects for multi day duration journeys.
2. Feedback from the travellers who fall under the definition of our subjects in the form of an extensive survey. For this too a lot of travel may be required with the subjects.
3. Feedback from the conducted tour operators, coach builders and some carefully selected common people.

All these subjects for responses will be selected with purposive and random sampling.

For taking feedback surveys, instrument such as schedules as well as questionnaires will be used.

After identifying the prevalent issues, the suggestions and recommendations will be furnished based on the proposed design interventions.

1.9 Conclusion

At this moment design development is looking for improvement in quality of life and social interaction specifically for growing aged population, as they will need a specific look in to their issues. Pilgrimage in a group appears to be one of the areas affected with some issues. Any design intervention for a long-distance bus travel may add to a solution for this issue. This work aims at an elevation of the quality-of-life experience of elders particularly pilgrims, while travelling through mass transportation options such as buses. This thesis concerns with design- intervention possibilities towards a schematic development with ergonomic issues in mind through a qualitative assessment of the needs of elder travellers and possible ways to address these needs.

1.9 Thesis layout: Chapter Scheme

This thesis consists of four chapters. A brief description of each chapter is given below.

- Chapter 1: - **Introduction:** This chapter begins with the introduction to road based public transport systems using buses. It gives classification of public transport systems and then moves towards history of buses, different types of buses etc. It also covers an elementary idea of bus manufacturing in Indian scenario. The need of the study is also covered in this chapter. Also, this chapter covers the backbone of any research; the literature review. It covers the review and detailed analysis of literature. The literature is organized in to five areas namely, Comfort / discomfort issues of long-distance bus travel, Fatigue and related factors, Seat design, Seat comfort and contributing factors and finally inclusive bus travel. After a comprehensive analysis of literature, the research gaps are identified and research questions were also generated. The chapter also proposes a framework for the study.

- Chapter 2: - **Expressions and Perceptions of Travellers and Service Providers**: This chapter provides a deep insight to the existing features of long-distance bus travel in India. It also serves the results of four broad and extensive fact-finding surveys done on a pan India basis. It depicts the long-distance travel comfort issues faced by the elders (here subjects were taken from pilgrims), their needs etc. A second and broader survey gives ideas about various issues regarding the problems existing with bus design and manufacturing in India, issues faced by travellers inclusive of driver behaviour as a factor of long-distance travel comfort. A proof of deteriorating hand grip strength is also presented, with a relationship with BMI and hand grip strength.

- Chapter 3: - **Design Interventions and Feedback on Concepts**:
  This chapter gives some possible design interventions based on the user survey performed. The entire chapter is divided in to three sections. The first section lists the needed improvements in the existing systems in accessibility, seats,

creature comfort and other needed amenities etc. Then the second section of the chapter try to provide some design interventions for the problems we identified. And finally in third section 3, with a very limited scope, we tried to take the feedback of the recommended design interventions. A schematic diagram with these concepts is also furnished.

- Chapter 4: - **Discussion, Salient Features and Conclusion:**

  This chapter is concerned with the discussion about the concluded work, suggestions and recommendations made as per this work. The thesis key contributions, scope for future work and limitations are furnished afterwards. The work is concluded with a mapping of objectives and accomplishments.

  In the end, general details like references, list of publications based on this work is also furnished.

Chapter – 2

Experiences and Perceptions of Travellers and Service Providers

In this chapter, the detailed report of direct observations, feedback or survey done among the stakeholders (the travellers, the tour operators and selected respondents from the common class) are furnished. All the findings of the questionnaires and schedules are explained in detail. The problems and issues existing with the current coaches, being used as tourist buses, are explored. This chapter serves as a qualitative assessment report of the issues and problems as experienced by elderly pilgrims with the current mass transport systems using bus specifically applied to Indian context.

Chapter 2

Experiences and Perceptions of Travellers and Service Providers

2.1 Introduction

For any research conducted on ergonomic aspects of a product, a detailed user feedback on the actual experiences is the most important one. Also, there would be different opinions and perceptions from the end users (here travellers) and service providers (here manufacturers and operators) regarding various aspects.

Here for this research, we have conducted a concept development survey as a first step. After analysing the feedback we got, and personal experiences of the researcher, it is further decided to conduct an extensive field study and survey divided mainly into four broad classes.

I. Bus user (traveller) feedback,
II. Driver behaviour and travel comfort
III. Study on existing bus platforms (Observational study)
IV. A devoted study to analyse the hand grip strength of passengers which will be further explained as this report progresses.

The Figure 2.1 shown below, is the exact structure of organisation of these surveys and studies. In order to avoid confusion of the readers, for each survey, the methodology and literature support is provided separately. The initial plan was to do two studies which are bus user or traveller feedback and an observational study about existing bus platforms, but later, after getting the feedback from the stakeholders, it is further decided to add two more studies namely, study on driver behaviour and perceived comfort and study on hand grip strength.

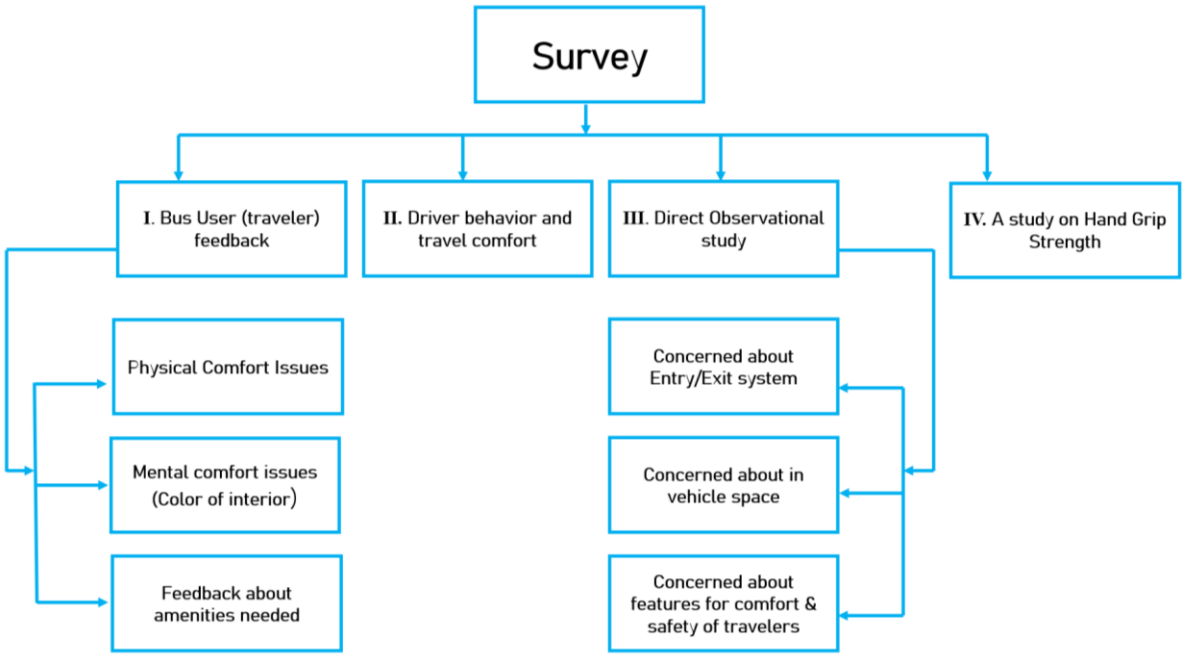

Figure 2.1: Structure of Surveys*:* The study is divided into four sections namely, bus user feedback, driver behaviour feedback, bus system feedback (direct observation) and study on hand grip strength.

2.2 Surveys

As mentioned above, this study is divided in to four major surveys namely, bus user feedback, driver behaviour feedback, bus system feedback (direct observation) and study on hand grip strength. The Bus user feedback is again classified in to three classes which concerned with physical comfort issues, mental comfort issues and amenities and facilities needed. The third study which is based on the existing bus platforms is also divided in to three viz., concerned about entry system, concerned about in vehicle space and finally concerned about features for comfort and safety of travellers. Now we are moving to the first study, that is bus user feedback.

2.2.1 Study – I Bus User Feedback

The long-distance travel, either for official purpose or pleasure (read as pilgrimage - especially applied to Indian context), is becoming more and more common in these days. Although long distance public travels primarily have many modes like road (primarily bus), rail, air, and sea; any long duration trip, whether by sea, air, road or rail, is

associated with travel fatigue, T Reilly et al., the collective influences of a altered routine (especially loss of sleep and mis scheduled meals) and also the overall disturbances caused by travel. Although planning any travel well in advance may minimise various problems, but some factors are so complex that it is very difficult to escape from these problems such as sitting in cramped or constrained and uncomfortable conditions or postures.

Long-distance travel is often originated with a cluster of transient negative effects, jointly stated as 'travel fatigue', which result from anxiety about the journey, the change to an individual's daily routine, and many other complex factors. Biggs et al. (2009), opines that fatigue is tough to observe and leaves no physical indication in the short term, making it a factor which is very complex to measure or quantify objectively and that is analytically underestimated in studies.

This survey is fundamentally categorised in to three aspects.

A. Feedback about physical ergonomic aspects
B. Feedback about interior colour theme of bus
C. Feedback about facilities and amenities needed

1(A): The physical ergonomics aspects

If we consider about a car or an MUV or SUV or any personal transport vehicles, all the manufacturers have proper research wings for the ergonomic comfort of the users / passengers. Hence their products are designed with a comprehensive knowledge background. But sadly, if we consider the bus manufacturing scenario, especially in India, this is not the case. If an original automobile manufacturer is making it, there will be proper designing of interiors, facilities like seats etc. with proper attention to ergonomics. But unfortunately, when we observe the bus building in India, there are some disturbing notes. Only a handful of companies come with factory fitted bodies. The choice is of the buyer to either go for an OE manufactured complete bus or to buy only chassis and then getting the body built from bus body manufacturers. This opens a huge market for the bus body builders in the country. But these coach manufactures lack sound knowledge about ergonomical aspects like the comfort, or they purposefully neglect it

as they are primarily concerned with costs and profits only. And their customers too are concerned with price only, as almost all of the products run in the commercial market with an aim of profit generation alone. It is also pronounced by the fact that the commercial sector the customer may not be the consumer (user) as in the case with non-commercial vehicle market like cars where the customer who buys the product is also travels in it.

This triggers many health issues for the passengers as continued sitting in a forced or static posture such as in a bus, causes an individual to long term static loading of the body which is usually seen as a risk factor for the development of musculoskeletal discomfort, Aldington et al. (2009), Cascioli et al. (2011), Fazlollahtabar et al. (2010), Healey et al. (2010), Luttmann et al. (2010). It has been also claimed that prolonged sitting opens a potential risk to spinal and paraspinal discomfort and disorders, Aldington et al (2009) and Healey et al. (2010). Confined seating limits physical activity and makes it difficult to leave the seat or do any stretching exercise. It is claimed that this physical inactivity causes physiological problems, such as swell, pain and ischemia of the lower limbs, Luttmann et al (2010), or any other body parts.

So, this survey aims to bring light on the factors contributing to the physical comfort for a traveller inside a bus for a very long journey. Comfort is a very complex and subjective concept that is difficult to understand, measure or quantify, and specifically define due to its cognitive as well as physical nature, Shen et al (1997). There are many external factors to the feeling of comfort or discomfort, such as visual input, smell, noise, temperature, humidity, vibration, pressure/ touch, posture and movement. Here we are concerned only with seat system feedback and amenities needed, neglecting the temperature and humidity as all the buses in which this study is performed were air conditioned. There are some scales and other methods available for measuring the aspect of comfort. Also, there are some objective tools developed for measuring seat comfort, Wegner et al. (2020). The objective comfort evaluation is somewhat highly complex, for, the aspect of comfort is more subjective in nature, Peter Vink el al (2006).

Scope of the study

The scope of the study is limited only to the buses operating under pilgrimage activities.

Methodology

In this study, a group of surveys have been performed to find out the most problematic areas as concerned with long distance bus travel especially with pilgrims. As it was a preliminary survey, it particularly aimed at finding out the basic amenities needed by the users (passengers), feedback on seats, and feedback on various pain regions after long distance travel to find out the key problematic areas. As it is a practice to consider long term comfort after the first 30 minutes of travel, Mergl 2006, we focussed on very long journeys that can take up to several days. We took pilgrims as the target audience because of two reasons. First, in India, the long-distance bus travel with duration of more than one complete day is opted mainly by the pilgrims (specially conducted tours or pilgrimages). Second reason is that, if the target respondents are pilgrims, they mostly included elderly individuals, for whom the concept of comfort and fatigue are noticeable and pronounced, and if you are selecting them, it would be easier to include the subjects in large numbers as needed for the study. The survey was done to find out those factors and the subjects were taken from pilgrims travelling to "Nishkalankeshwar", "Dwaraka" and "Somanatham". All of the above destinations were situated in Gujarat.

The subjects were selected based on purposive and random sampling methods. Questionnaires and meetings observations were used to have their views on various aspects like the ones mentioned above. A total 87 subjects have been studied travelling in 3 different buses with three different type seat systems and interiors, in three different trips, covering a total of 1474 Kms in 9 days consecutively. The route map considered for the study is provided in Figure 2.2.

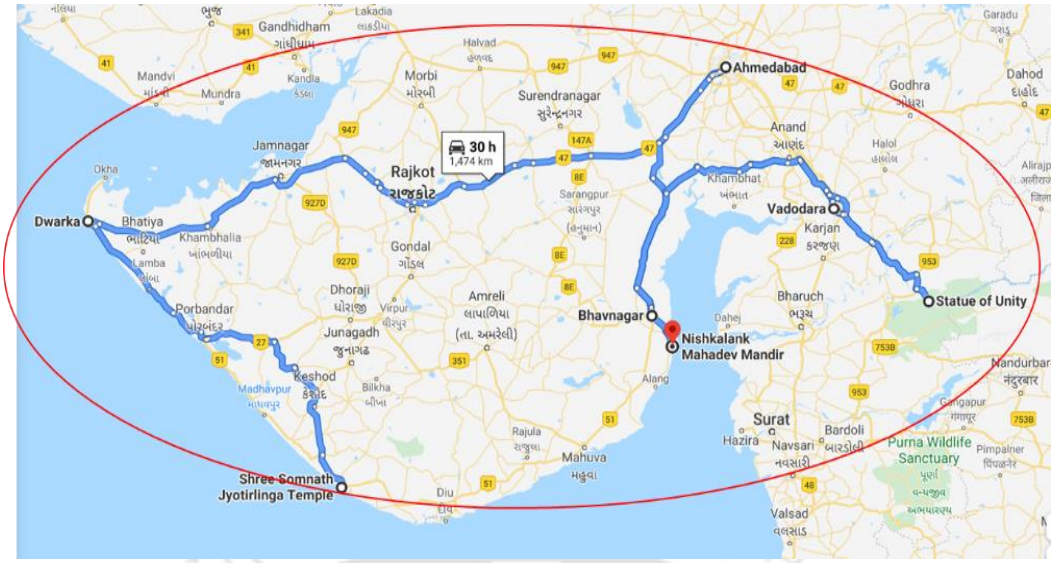

Figure 2.2: Route travelled for survey, through Gujarat, India

The researcher travelled in the same buses for the entire period and taken feedback just after each day's journey personally. The buses were deemed to be of deluxe type, with air conditioning. One was having adjustable back rest only (Figure 2.3 - A). One was not having any of the features (Figure 2.3 - B). One bus was having adjustable back rest as well as adjustable hand rest (Figure 2.3- C).

Figure 2.3: Random snaps about interior types of three buses selected for the study: Bus in A and C were having hand rests and bus B didn't have it.

Out of these 87 subjects, responses of 3 were excluded in the seat system feedback and pain regions feedback as they were having surgical or accidents history, for, the pain they are feeling could not attributed to travelling alone. There were 42 men as well as 41

ladies. Regarding the age, the mean age of the group is 57.15 years with a standard deviation ±12.024.

Apart from personal details which included name, gender, age, details about current medications if any, history of any psychological and physiological problems, some thirty open ended questions were asked and responses were recorded. The questionnaire was categorized in to six parts as follows: -

1. Personal details of the respondents as quoted above.
2. Travel details
3. The Seat feedback – In this section passengers were asked to give feedback on the seat they are travelling on, with an emphasis on comfort of seat. A five-point Likert scale was used. As the objective was to measure the comfort, highest rank was given to comfort and least rank was given to Troublesome. The scale was;

Table 2.1: Scale used for measuring comfort: Here we used a scale which gives maximum value (5) for absolute comfort and minimum value (1) for absolute troublesome.

Aspect	Score
Troublesome	1
Not Okay	2
Neutral	3
Okay	4
Comfortable.	5

The seat system was grouped in to seven categories as to get precise feedback of the same. The categories were,

(a) Back support
(b) Lumbar Support
(c) Neck Support
(d) Head restraints
(e) Thigh support
(f) Leg Support and finally,
(g) Hand rests.

In the part 3 itself, questions regarding needed improvements were also asked. It included questions regarding a (proposed) split leg support with independent movement, Cushioning, types of hand rest as well as leg cum foot rest were also asked.

4. In part 4, feedback was taken about the pain as experienced by the subjects after each day's travel. Here too, a 5-point Likert scale was used as shown by **table 2.2;**

Table 2.2: Pain scale used: Here we used a reverse scale which gives maximum value (5) for extreme pain and minimum value (1) for absolute comfort

Aspect	Score
Extreme Pain	5
Moderate Pain	4
Low Pain	3
Slight discomfort	2
Absolute Comfort	1

Also, questions were asked about the pain experienced at,

(a) Upper Back
(b) Lower back
(c) Neck
(d) Head
(e) Thigh / Hip
(f) Ankles
(g) Elbow
(h) Shoulder
(i) Any other (open ended)

Figure 2.4 shown below demonstrates the pain regions asked about.

The part 6 was actually an extension of part 4, so as to get more clarity about the pain regions. Figure 2.5 gives the anatomical diagram used for the study. In this section a

diagram was shown to the participants marking different regions of the body so that precise feedback about the region of pain is got.

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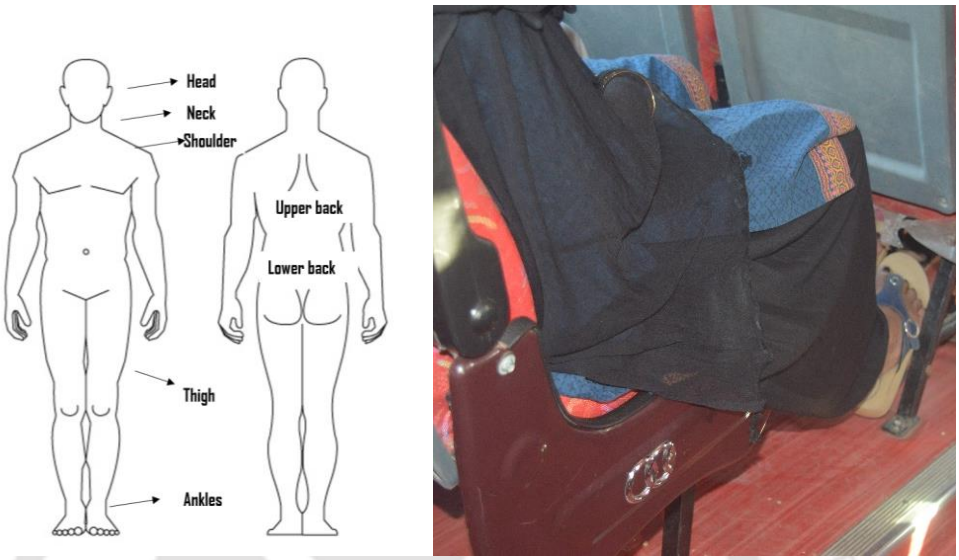

Figure 2.4**:** Pain feedback regions: Figure shows the seven pain feedback regions as asked by the survey. A subject while being seated for long time in a bus may develop pains in their body.

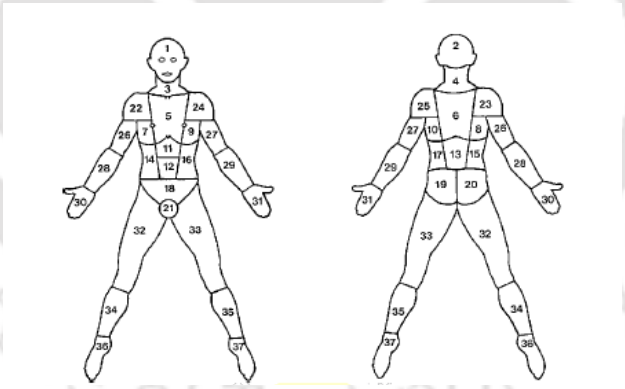

Figure 2.5: Anatomical pain regions diagram used for survey: Taken from reference Luci Mara et al.,2015.

Now as already mentioned we used a 5-point Likert scale. For that, the Range = (5-1) / 5 = 0.80

Table 2.3: Range of the scale used for seat feedback and meaning

Scale	Range	Response	Interpretation
5	4.21-5	Comfortable	No Problems
4	3.41-4.20	Okay	No complaints
3	2.61-3.40	Neutral	No opinion
2	1.81-2.60	Not okay	Problematic
1	1- 1.80	Troublesome	Problematic

Table 2.4: Range of the scale used for pain feedback and meaning

Scale	Range	Response	Interpretation
5	4.21-5	Extreme Pain	Problematic
4	3.41-4.20	Significant Pain	Problematic
3	2.61-3.40	Moderate Pain	Slightly Problematic
2	1.81-2.60	Slight discomfort	Negligible
1	1- 1.80	Absolute Comfort	No Pain

The questionnaire reliability was calculated using SPSS software and found out to be 0.848 (Refer **Appendix II**). As per Robert A Peterson (1994) any value which is greater than 0.8 is deemed to be good, though greater values than 0.9 may indicate redundancy.

Results and discussion

Seat system feedback

As per the seat feedback, the major problematic area was neck support or probably the lack of it. In a comfort scale, it scored the least marks at 1.578, followed by lumbar (1.65), leg (1.759), and back (1.78). Figure 2.6 below shows the various regions and the

comfort score gained by these regions. It can be easily understood that the head support scored highest among the group, but still under the needed comfort range.

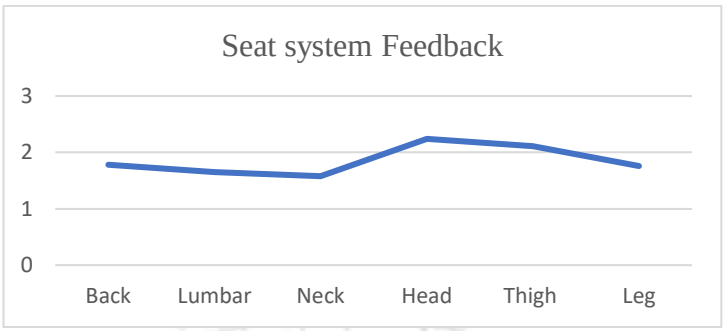

Figure 2.6: Response about Seat system: The least score was for neck - means it was the biggest problematic area. Next comes upper and lower back regions and leg specifically ankle region.

Pain regions after travel

When asked about the pain regions, again neck area holds the highest pain region at 3.489 on a scale of 5, followed by upper back (3.012), lower back (3), elbow (1.9), ankles (1.3), head (1.22), thigh (1.2) and shoulder (1.07). Also, it is interesting to note that a significant portion of the population has three major pain regions namely, Neck (85.54 %) followed by upper back (78.3%) and lower back (77.11%). Figure 2.7 furnished below shows the pain regions and associated pain scores. Here again neck region was the most problematic one. It indicates that a properly designed neck rest should be provided. Figure 2.8 shows the various pain regions and is coloured according to the severity of pain associated with that area.

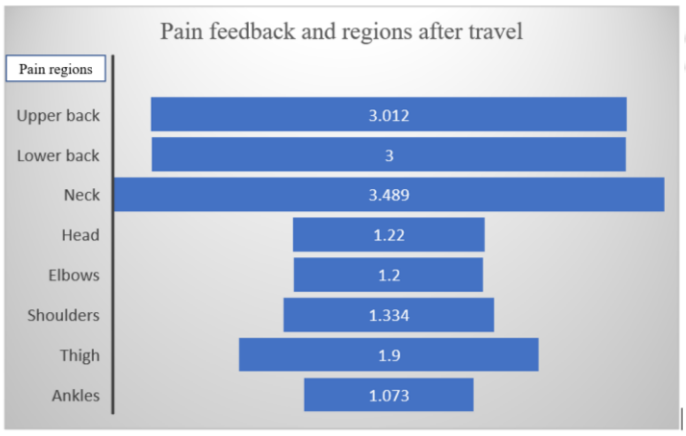

Figure 2.7**:** Responses about pain and its regions: Note that again neck scored highest score for severity of pain – at significant level, closely followed by upper back and lower back.

The neck region recorded highest pain which fell under the significant pain category as per table 2.3. Upper back and lower back regions score were 3.012 and 3 respectively which falls under moderate pain category.

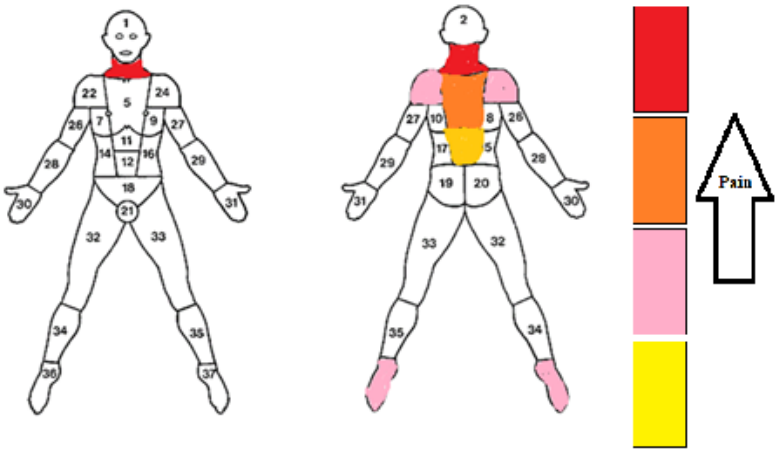

Figure 2.8: Pain regions with respect to severity of pain: Figure shows the severity of pain with respect to the regions of the body

1(B): Feedback about interior colour theme of bus

Colour and its effects on human mind have always been a fascinating area of research for decades. Plenty of research outputs are available in these areas too. There are a number of articles and research papers available worldwide about colours and its intriguing nature. This was known to mankind centuries ago, and India was no exception. A country with a vibrant culture was always known to be using the colours in the most effective way and texts like "Chitrasutra" (web reference) proves it. The colours and its effects on human psychology is of paramount importance to designers too. In what way colours have an effect on the mental comfort of individuals is a major concern of designers; be it the architects, interior designers, or automobile designers. Automobile designers while designing the vehicle interior design gives paramount importance to colours and its selection. As majority of the time, the traveller spends inside the vehicle, the selection of interior colour is of great priority. All the major automobile manufacturers have proper research wings for the cognitive comfort of the users /

passengers. Hence their product's interiors are designed with proper knowledge background.

While vehicles such as cars and all, are designed with these factors in mind. Large commercial vehicles such as buses may not have considered these aspects. This study aims to find out the most preferable colour system by fellow passengers particularly pilgrims, the perception of mental comfort. It tries to find the preferable colour for seats, ceiling, floor and window glasses.

There are many theories and concepts available about visual or cognitive comfort of interiors, mostly on the application of colour and its influences on people. So far, most people are accustomed with the common theories about the relationship between colour and attitude or feelings, such as red makes active feelings, blue has a tranquilising effect, and yellow gives people feel uplifted, Chung et al (2020). However, it is said that little experimental research has been conducted and most of the findings are questionable or obsolete. While colour is an integral part of design, little empirical evidence exists to support some of the commonly held ideas about the effects of colour human cognitive well-being or perceived mental comfort.

Methodology

The general methodology adopted in this study is already discussed in detail in the section 1A. Pilgrims were selected as subjects because in India, the long-distance bus travel is opted majorly by the pilgrims. The pilgrims were selected based on purposive and random sampling and the target respondents were mostly senior citizens for whom the concept of comfort and fatigue are pronounced. Questionnaires and meetings observations were used to have their views on interior colour theme. A total 87 subjects have been studied travelling in 3 buses. Out of these 87 subjects, responses of 4 were not considered as they were having problems related with thyroid which may affect the mental comfort and may trigger mood swings etc. Apart from personal details which included name, gender, age, any current medications, history of any psychological and physiological problems, some ten open ended questions were used to assess the preferred colour theme. The questions started with the concept of respondents with the fact that

colour has an effect on the mental comfort of the individual. Then the colour preferences of seats, ceiling of the vehicle, running board and window glasses have been asked.

Also, a colour wheel was presented to the respondents are asked to identity the preferred colour.

Results and discussion

i. Effect of Colour on the Perceived mental comfort: Out of 83 selected targets, 75 people (90.36 %) were of the opinion that the colour of the interior of the bus have an effect on their cognitive comfort. Figure 2.9 shows the responses of the subjects.

ii. Gender wise response about colour*:* When we try to look in to the gender wise response pattern, all the female respondents confirmed that the interior colour influences their mind. But when we look in to the men, only 34 out of 42 (roughly 81%) responded that interior colour of the bus has an effect on their mind. Figure 2.10 below shows the pattern of gender wise response.

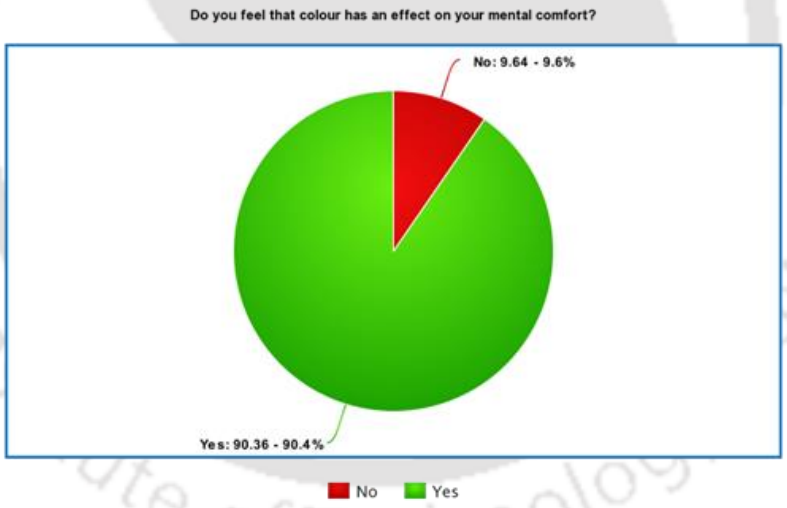

Figure 2.9: Response about effect of interior colour theme on mental comfort: Majority of people said that colour affects their comfort

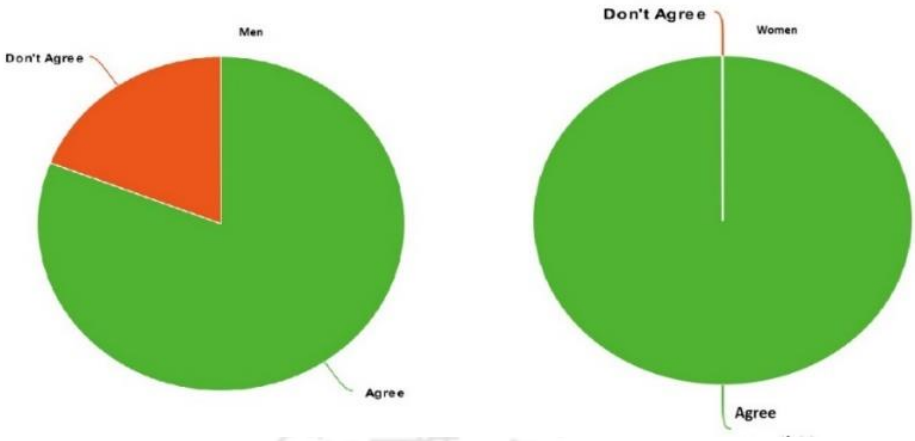

Figure 2.10: Gender wise response pattern about colour influence on mood: See that all women agreed that colour affects their comfort whereas 34 out of 42 men were of the same opinion

iii. Age wise response for colour effects on mind: Also, when we analyse the age wise response pattern, given in the Figure 2.11, we can see that in the age group of 20-30 years, 75% people agrees that colour of the interior in general influences them. Similarly, for age group 31-40 it is 71%, for 41-50 it is 89.47%, 51-60 it is 85% and finally for above 60 years of age, 97% agrees the same.

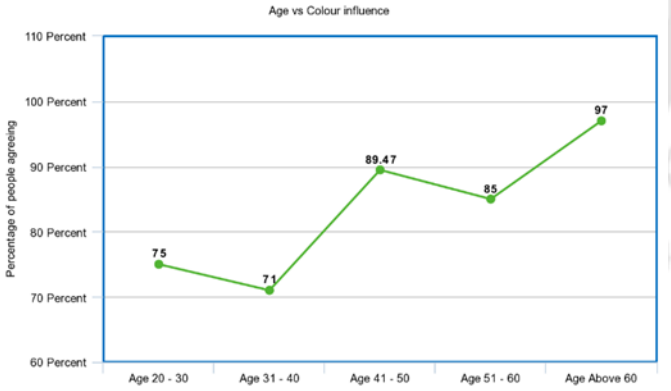

Figure 2.11: Age wise response about colour influences: Figure shows age wise response of the people regarding the effect of interior colour of the bus affects their perceived comfort; it should be noted that respondents above age 60 agreed fully that colour affects their cognitive comfort while travelling.

iv. Preferred Colour Temperature: When asked about the colour theme preference based on the colour temperature, 76 people selected cool colours, 5 selected warm colours, and only 2 selected neutral colour as shown by Figure 2.12.

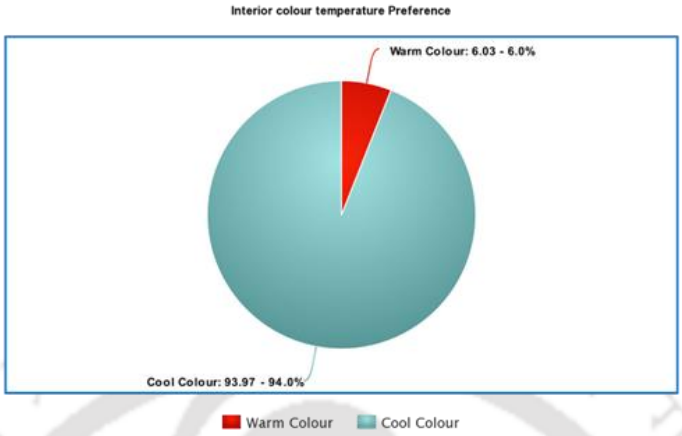

Figure 2.12: Response about preferred colour temperature: 76 out of 83 (91.56%) of people selected cool colours.

v. Seat colour preference: Asked about seat colour depicted in Figure 2.13, out of 83 individuals, 77 selected light colours and out of them 53 selected ivory colour, 10 selected light pink (all of them were women), 9 persons selected light blue and remaining 5 people selected white colour. Out of 6 people who selected dark colours 4 selected brown, 1 selected maroon and 1 selected black.

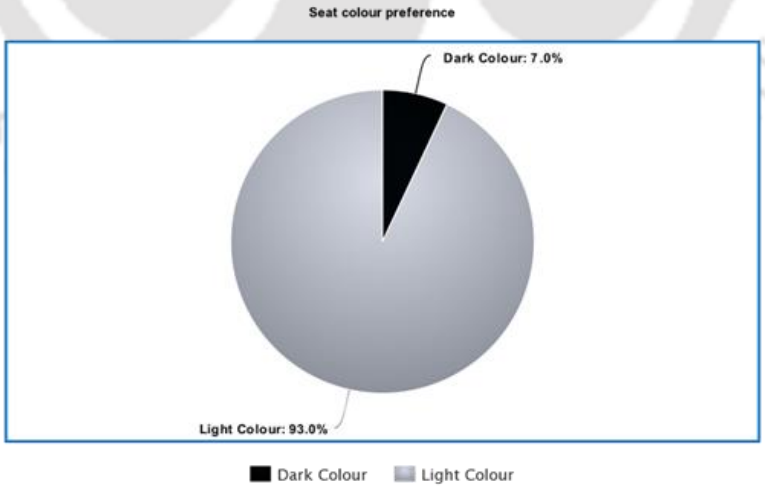

Figure 2.13: Response about seat colour preference: 92.77% selected light colours for seats out of which 68.8 % voted for ivory colour

vi. Preferred ceiling colour*:* As far as ceiling colour is concerned, depicted in the Figure 2.14, a whopping 98.79 % (82 out of 83) selected light colours especially pure white (65), Ivory (12) and light blue (5).

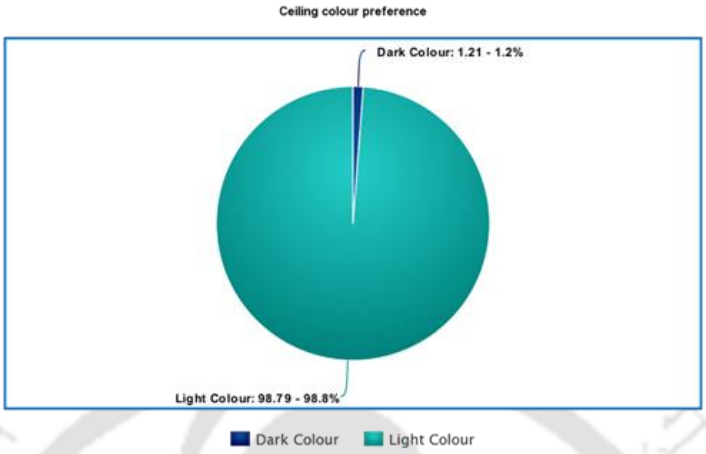

Figure 2.14: Response about ceiling colour preference: 98.9 % selected light colours; out of which 79.26% voted for white colour.

vii. Preferred floor colour*:* When asked about the floor colour 70 people selected light colours (84.33 %) in which 59 selected marble white colour, 7 people selected ivory colour and remaining 4 selected light pink colours. Out of those who selected dark colours (13 People), 11 selected dark maroon and 2 selected black. Figure 2.15 shows the response pattern. Here a point to be noted is that the operators strongly opposed light colours for floor as it would be difficult to maintain clean.

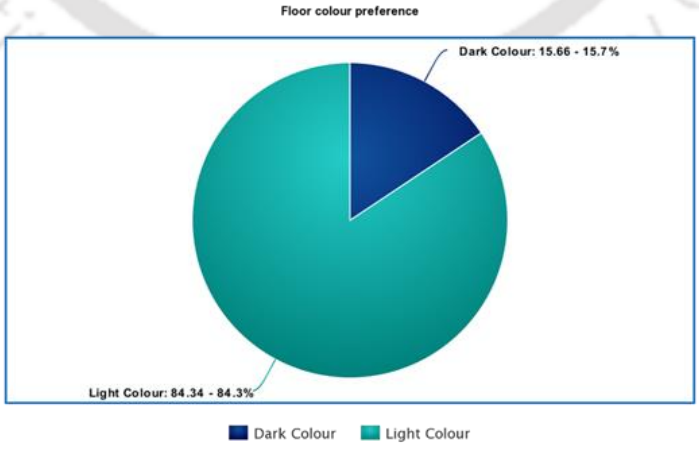

Figure 2.15: Response about floor colour preference: 84.33% people selected light colours for floor.

Also, regarding the tint film colour 65 persons liked it plain and only 18 liked tinted glass. The ones who preferred tinted glasses selected light brown as the colour of choice.

Finally, when the preferred colour is asked as a whole, majority of the group voted for ivory colour (63.85%) followed by light pink (12.14%), light blue (10.8%), and white (6%). Dark colours are preferred as brown (4.81%), Maroon and black – 1.2% each as shown in Figure 2.16.

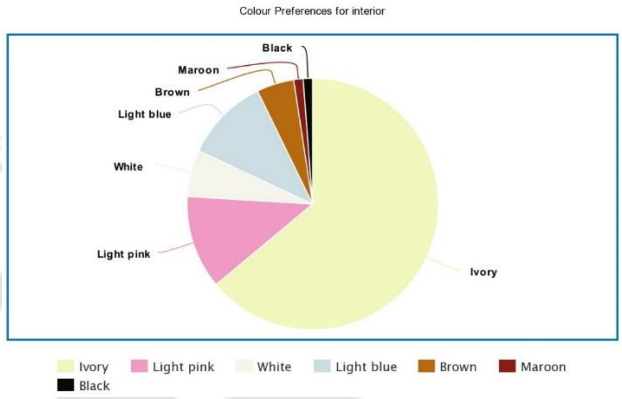

Figure 2.16: Preferred colour for interiors in general: Ivory was selected as the preferred colour in general by approximately 64% of people followed by pink. Also, pink was selected only by women.

viii. Gender and age vs preference for light colours: The following Figure 2.17 is the response based on gender and age band, who voted for light colours for interiors.

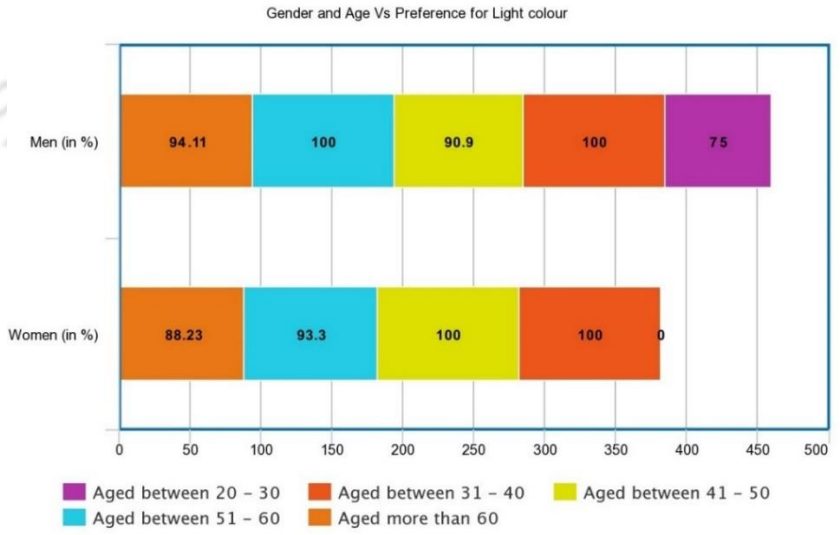

Figure 2.17: Age and Gender of respondents and preference of light colours; After attaining the age of 50 or above, both men and women prefers light colours.

All men, when aged between 31-40 and 51-60, selected light colours. And for women, when aged between 31-40 and 41-50, all of them selected light colours.

The study shows that majority of people prefers light colours for the interiors, seats, bus floor as well as ceiling. People also felt that the interior colour theme of the vehicle in which they are travelling affects their mental or perceived comfort as a whole. The study reveals that almost 94 % of the people selected light colours for the interiors such as ivory. This shows the demand of tranquillity rather than energetic travels as demanded by a general tourist. Blue boosts intellectual activity, reasoning, and logical thought. It is the colour of the intelligence. Blue is also known to lower the blood pressure. Surely, it is a calming, tranquilising colour, aiding reflection. Strong blues stimulate clear thought and lighter, soft blues calm the mind and aid concentration (Rosenstein 1985). Also, we found that the fleet operators are using dark colours for the interiors as it is easy to clean and it can mask the stains and age. Hence little or no concern is there for the cognitive comfort of the occupants in buses especially the ones which are being used for pilgrimages. As this is only a preliminary study, a further in-depth study is needed to analyse the choices made by the passengers, the relationship between choice of colours and gender (pink seat colour was selected only by women) etc.

1 (C): Feedback about facilities and amenities needed

The features and amenities provided by the vehicle in which you are travelling greatly enhances your perception of comfort. Hence to get a complete understanding of the factors influencing comfort or discomfort in long distance travel, questions regarding the features and amenities needed is inevitable. So, we put a separate section for these set of questions.

Methodology

The general methodology adopted in this study is already discussed in detail in the section 1A. We selected pilgrims as our subjects because in India, the long-distance bus travel is opted mainly by the pilgrims or conducted tours. The subjects were selected based on purposive and random sampling and the target respondents were mostly senior

citizens as the concept of comfort and fatigue are more noticeable for them. Questionnaires and meetings observations were used to have their views on needed amenities and features. A total 87 subjects have been studied travelling in 3 buses. They have been asked about the amenities they needed. The questionnaire already had a list of amenities and feature. We asked about amenities needed. After conducting preliminary survey, we zeroed in on 11 items namely, place for water bottle, Medicine pouch, coat hanger, foot wear storage, mobile charging points, split curtain, walking ramp, seat belt, floor lights, toilet and trays. Subjects were asked to rank them on a 5-point Likert scale. The scores were,

Table 2.5: Amenities feedback score

Description	Score
Extremely needed,	5
Needed,	4
Good, if it is there,	3
Not Sure	2
Not needed.	1

Also, apart from this, an open-ended question was also there, if the subject wanted to demand a feature or amenity which was not on the list provided. In addition to this, feedback on video screens (whether they like to watch video while travelling) and if they do, whether they like individual screens or general screens and a question about tinted glass were also asked.

Results and discussion

As far as the amenities needed are concerned, almost everybody in the target group voted for walking ramp inside the bus as very long duration confined posture is leading to many pain regions. Also, almost all demanded for an attachment by which they can apply leg movements freely. Apart from this the highest priority was of toilets. Figure 2.18 shows the response pattern.

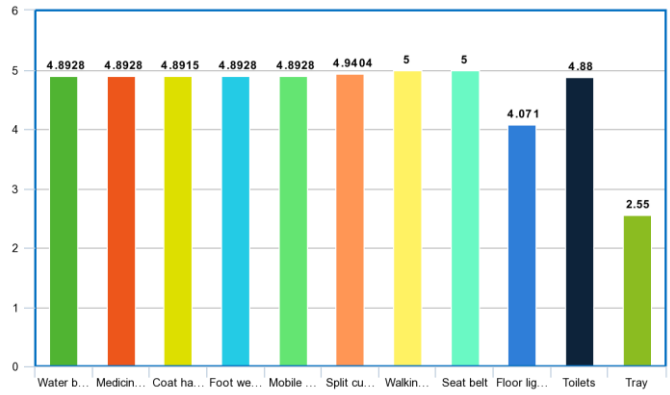

Figure 2.18: Response about amenities needed: All women voted for toilets with highest score; walking ramp is another most needed one

It was also interesting to note that, all women voted for toilets inside bus and also, they have given highest mark (5) for toilet. Facilities for keeping water bottles, medicine pouches, coat / secondary cloth hanger, individual mobile charging points as well as place to keep footwears without slipping was almost equally important.

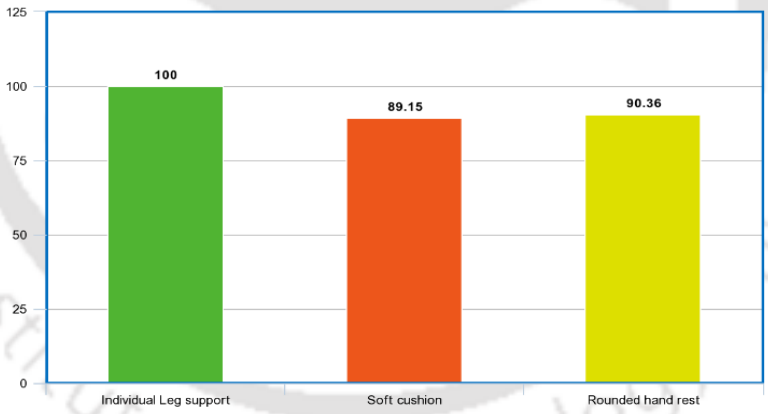

Figure 2.19: Response about leg rest cushioning and hand rest.

Regarding the question about individual leg support, cent per cent voted for it. And 89.15 per cent people voted for soft cushioning together with 90.36 per cent voting for rounded hand rest which can be used as a support for palms too.

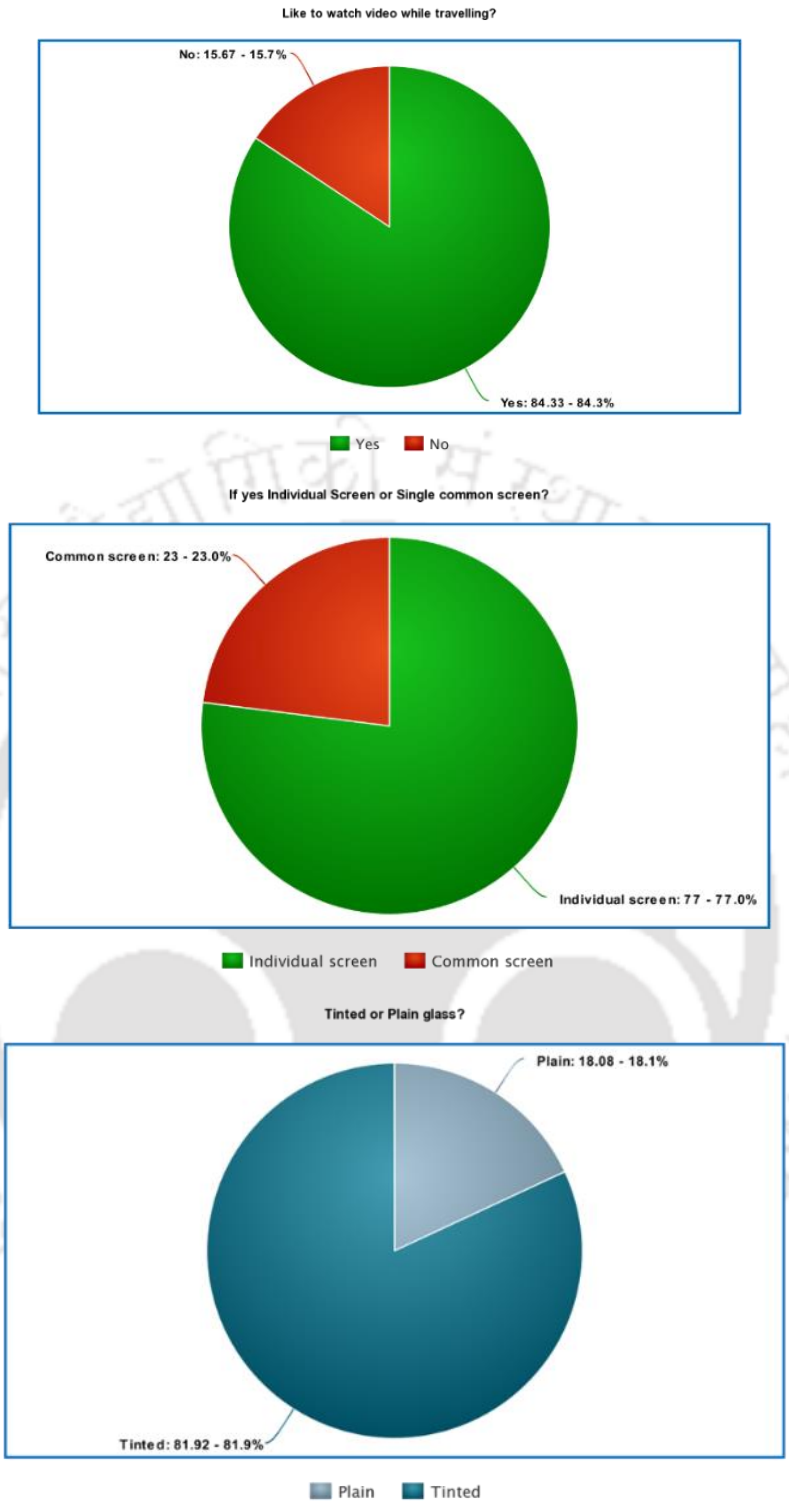

Figure 2.20: Response about some general questions: Most of the people likes to watch video while travelling and majority among them prefers individual screens; regarding tinted film -majority selected it

When asked some general questions like option about video screens and tinted glass, the response was as follows (refer Figure 2.20). The response to a question whether they like to watch video while travelling, 84.34% voted positively and 77% preferred individual screens for the same. And finally, when asked about the tinted glass, roughly 92% reinstated the need for it.

In the open-ended survey when asked about any other factor that they wanted to furnish, many said about driver behaviour. This triggered another brief study to investigate whether the driver behaviour affects the perceived comfort of travellers. Therefore, we conducted the following study to have an idea about the extent to which the driver behaviour affects comfort of the passengers.

2.2.2 Study – II Driver Behaviour and Travel Comfort

The comfort as experienced by the passenger is of paramount importance while designing a public transport system. Every company, every designer must try to ensure the travel comfort of its passengers who are utilising the facility. It is a well-established fact that travel comfort or rather the comfort itself is subjective in nature. Worldwide many researches have been done under the head "comfort". But almost all of them were focussed on variables such as noise, vibrations, seat design, passenger's posture, body dynamics etc. (Osborne et al.,1973). There have been other attempts available for comfort research such as road surface or road undulations and conditions etc. and its effects on comfort (Yi H et al.,2013). But are there other factors too which can influence travel comfort in long distance travel and that too if the travellers are elders? And if particularly applied to Indian scenario? Is the driver behaviour having any impact on the perceived comfort on passengers? Do our drivers need a special training to deal with passengers especially fellow passengers? This study tries to find out an answer.

Passenger comfort is influenced by many factors, such as seat design, vibration, ambient noise, odour, temperature, humidity, and even interior colour theme (Zhaohui Wu et al,2009; Chinmaya et al,2020). Even if numerous researchers around the globe, devoted their time and resources for nearly half a century, a single traveller comfort standard which manufacturers can use with full rely upon is still missing. Due to the complex

characteristics of the concept of comfort and to make it more difficult, the subjective nature of the same, getting a consensus among researchers is far from realisation.

When we consider the driver behaviour and its influence on passengers, many revelations can be had. Driving is the most influential factor for motion sickness in fellow passengers (Mark Turner et al.,1999).

Kottenhoff et al., in the year 2011, suggested that, the following driving behaviour may affect the overall perceived comfort of a passenger.

1. Sudden braking
2. Sudden acceleration or deceleration
3. Sharp cornering creating excessive body rolls (note that buses are known to have higher body rolls than other passenger vehicles due to relatively higher positioning of centre of gravity.)
4. Jerks while travelling. It is particularly problematic with elders as they find it difficult to balance when jerks are happening.
5. Bumpy driving (also called pumping or uneven driving – the most influential reason behind motion sickness).

Based on the literature we formed a questionnaire for the study. This study was particularly addressing the issues with fellow passengers doing conducted tours or pilgrimages in India. As a normal conducted tour or pilgrimage may last up to several days and hence passengers will spend a majority of time inside the bus. So, whatever be the effect, it would be pronounced for the passengers.

There are many factors concerning with the behaviour of driver of the vehicle and the comfort of passengers. The traveller comfort criteria is the most important and most necessary one to explain the association between acceleration behaviours and travellers comfort. (Griffin M J, 1990; M.M. ElMadany, Z,1990; Robertson, D.I,1992; Demic, M,2002).

The standards related with assessing the comfort while travelling inside a vehicle is governed by the ones issued by ISO, and is widely considered to be one of the most popular group criteria applied (ISO-2631(1978); ISO-2631(1997) for assessing the ride comfort due to vibrations created by travelling. One of the most important aspect about

passenger comfort is the pattern of acceleration due behaviours of the drivers, such as hard acceleration and deceleration.

It is found that subtle and less frequent speed changes (acceleration and deceleration) would generate greater values of comfort ratings. As there are a band of driving behaviours from subtle to strong and rapid change in speed (accelerations and decelerations) by drivers (af Wa hlberg,2003;2004;2007), correlations between these factors and traveller comfort are established (Yi He et al. 2013).

It is evident that, most of the research on passenger comfort appears to be focused on environmental conditions such as vibration, noise, temperature and traveling postures (Oborne and Clarke, 1973;1977; Jiang, 2001). According to Yi He et al. (2013), researchers mostly debated the aspects of vehicle and road condition to analyse how the vibration affects the passenger's body while travelling. Considerable research is also done in separating the relationship between road surface styles and passenger comfort. All these appears to be focussing on the technical side of comfort but unfortunately the behaviour of the driver and its influence on passengers' comfort especially elder passengers is not at all concerned of (Oborne,1978; Leatherwood et al.,1980; Parsons et al.,1979; Demic et al., 2002). There is a contrasting absence of research about how the driver's behaviours such as aggressive acceleration and deceleration (Robertson et al., 1992) and willingness to help fellow passengers influence the perception of comfort among passengers.

To improve the bus drivers' procedures of operation and to enhance safety, numerous bus operators are willing to train the drivers, but focusses mainly on the fuel economy and safety, but passengers' comfort is comfortably ignored. On a contrary note, some research such as A.E.af Wahlberg, 2007 and Z. Y. Jiang, 2001, claims that the training of bus driver behaviours may cause a bad experience for passengers. But it is a still debated topic and as comfort is a purely subjective aspect, it would be better to gain information directly from stakeholders ie. passengers themselves. And for that purpose, majority of researchers use questionnaire survey as the most sought-after tool.

Methodology

For this survey, we developed a questionnaire with four different sections.

1. Feedback about smoothness of acceleration / deceleration *(Comfortable and smooth drives without jerks)*
2. Was the driver informative about destination? *(Drivers are well versed about the journey details and destinations)*
3. Was the driver helpful? *(Willingness to help on various issues as and when required)*
4. Are you satisfied with the overall behaviour of the driver? *(Cordial and interactive*)

The questions were asked to travellers just after a long duration journey. Survey was done on 30 different drivers of 30 different buses doing multi day duration travel (doing pilgrimages and conducted tours). The journey took a minimum of 2 days and up to 7 days maximum. The buses were taken from 6 different Indian states (Kerala -16; Karnataka – 3; Tamil Nadu -3; Andhra Pradesh – 6; Uttarakhand -7 and Rajasthan- 5) and for each driver 30 passengers were selected and taken feedback from. The least duration journey was the Dwaraka trip in Gujarat, whereas the longest duration journey was done in Uttarakhand - a conducted pilgrimage for the famous "Char Dham (Gangotri – Yamunotri - Kedarnath – Badrinath)". The "char dham" trip took 9 days to complete from Rishikesh, Uttarakhand. Each day's travel took around 5-10 hours of duration with mini breaks in between. The buses were having seating capacity ranging from 32 seats to 49 seats. A set of questions was floated to find answers related to four different aspects viz. 1) satisfactory driver behaviour (cordial and interactive), 2) Do the drivers are well versed about the journey details and destinations. 3) Willingness to help on various issues as and when required and, 4) Comfortable and smooth drives without jerks while accelerating and decelerating. The respondents from each bus (samples) were selected with purposive random sampling. Responses were noted down against a five-point Likert scale towards framing a possible behaviour guideline see **table 2.6** below. Regarding the age of drivers, the mean was 34.18 with standard deviation 7.54.

We used a 5-point Likert scale for the survey. The range and response set are as given in the below shown table.

Table 2.6: Scale and range used for the survey on driver behaviour

Scale	Range	Response	Interpretation
5	4.21-5	Absolutely Agree	Extremely Positive
4	3.41-4.20	Agree	Positive
3	2.61-3.40	Neutral	Neutral
2	1.81-2.60	Disagree	Negative
1	1- 1.80	Absolutely Disagree	Extremely Negative

A reliability analysis was also done on the questionnaire and the Cronbach's Alpha was found out to be 0.803 which is sufficient as stated by Robert A Peterson (1994).

Results and discussion

Question 1: Feedback about smoothness of acceleration / deceleration.

For the first question which was "was the acceleration and deceleration smooth and comfortable and without any jerks?", the score was 2.16, which represents "disagree". This actually shows the disagreement of the travellers. The Figure shown below (Figure 2.21) represents the pattern of responses. It can be seen that majority of the answers lie in the region below 2.6 which represents negative response (disagree). Only 2 drivers got their score about 3.41 which shows the agreement.

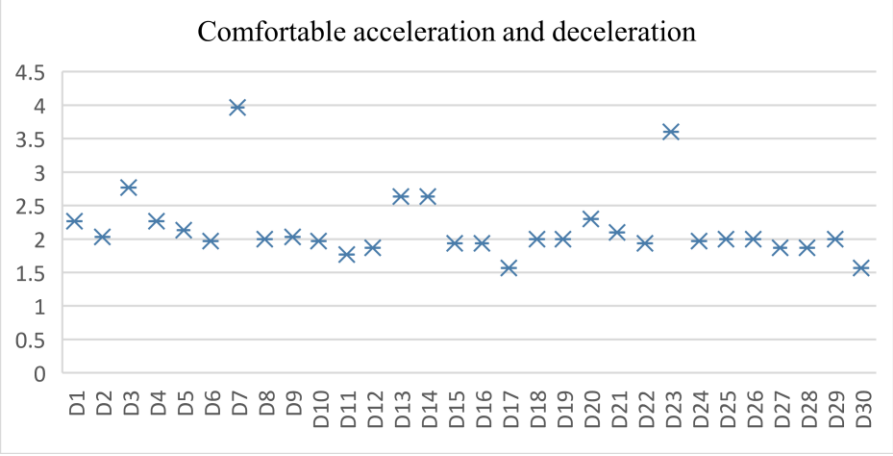

Figure 2.21: Response pattern for the question "comfortable acceleration and deceleration"

Question 2: Was the driver informative?

Similarly, for the second question “Was the driver informative and cooperative?”, the score was 2.36 which also falls under the category “disagree”. The Figure shown below (Figure 2.22) represents the pattern of responses. It can be seen that majority of the answers lie in the region below 2.6 which represents negative response (disagree). Here, a point to be noted that in the previous concept development survey, many people complained about the driver’s attitude, and that comment triggered this question. Only 3 drivers got their score about 3.41 which shows the agreement.

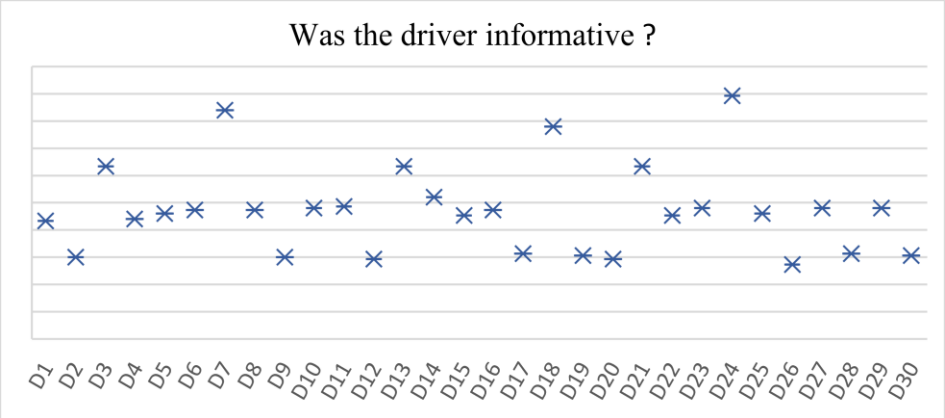

Figure 2.22: Response pattern for the question “was the driver informative”; the respondents were of the opinion that driver was not informative or willing to communicate.

Question 3: Do you feel that the driver in your vehicle was helpful?

For the question “Do you feel that the driver was helpful”, the average score was 2.46 which represents “Disagree”. The Figure shown below (Figure 2.23) represents the pattern of responses. It can be seen that majority of the answers lie in the region below 2.6 which represents negative response (disagree). Only 4 drivers got their score about 3.41 which shows the agreement.

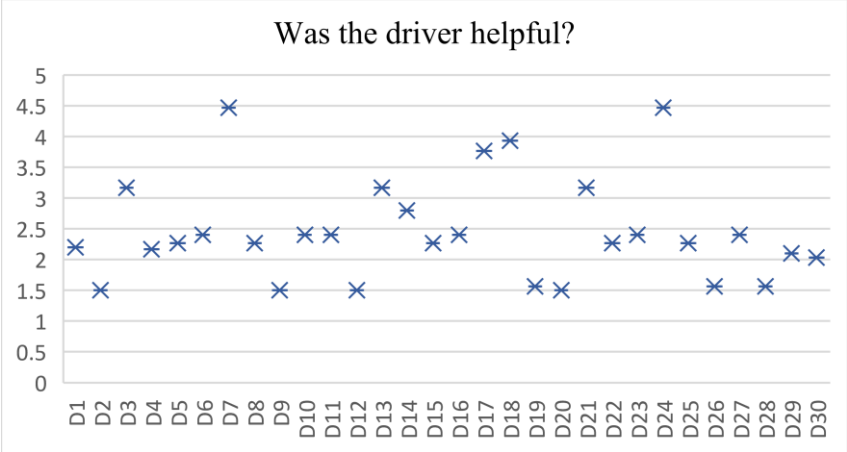

Figure 2.23: Response pattern for the question "was the driver helpful"; the respondents were of the opinion that driver was not helpful.

Question 4: Are you satisfied with the overall behaviour of the driver?

Now for the question "Are you satisfied with the overall behaviour of the driver?" the average score was 2.37 which is again "Disagree". The Figure shown below (Figure 2.4) represents the pattern of responses. It can be seen that majority of the answers lie in the region below 2.6 which represents negative response (disagree). Only 4 drivers got their score about 3.41 which shows the agreement.

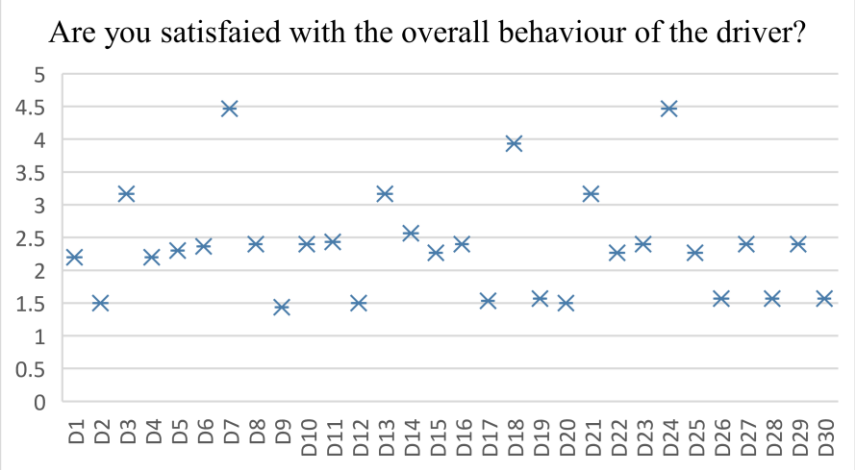

Figure 2.24: Response pattern for the question "are you satisfied with the overall behaviour of the driver"; the respondents were of the opinion that they are not satisfied with the driver.

Now if we consider the age of the driver and the scores they got, there are some interesting takeaways. We can see a general trend that if age is higher, so is the score they got. In the Figure 2.25 Shows this trend. Here in the x-axis driver score and on y-axis age is shown.

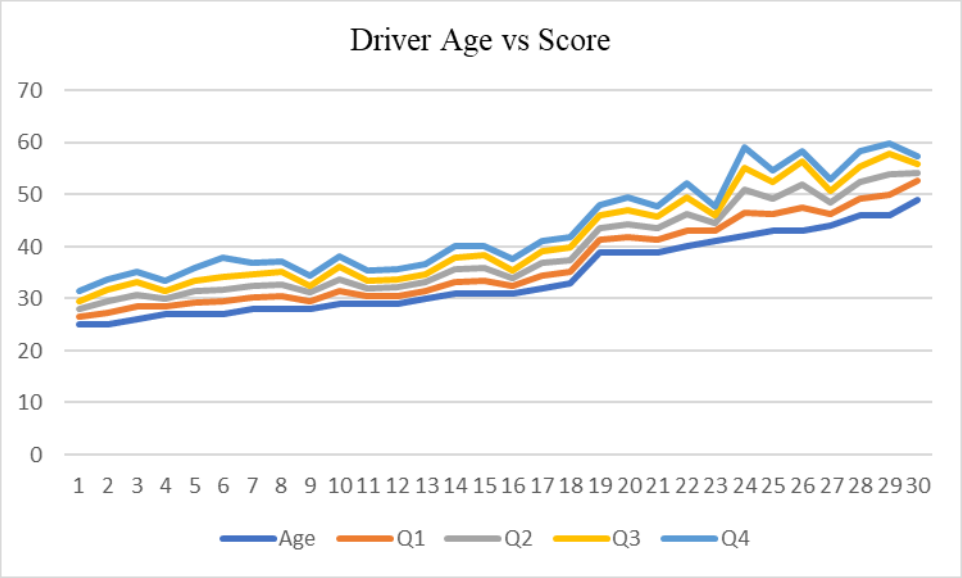

Figure 2.25: Age vs Score. Age is shown on the y axis. Trend is that as age rises score is also rising.

Also, Figure 2.26 reiterates this fact. Point to be noted here is that, all the drivers who got the score of 3.4 or higher, falls under the age category of 40 and above.

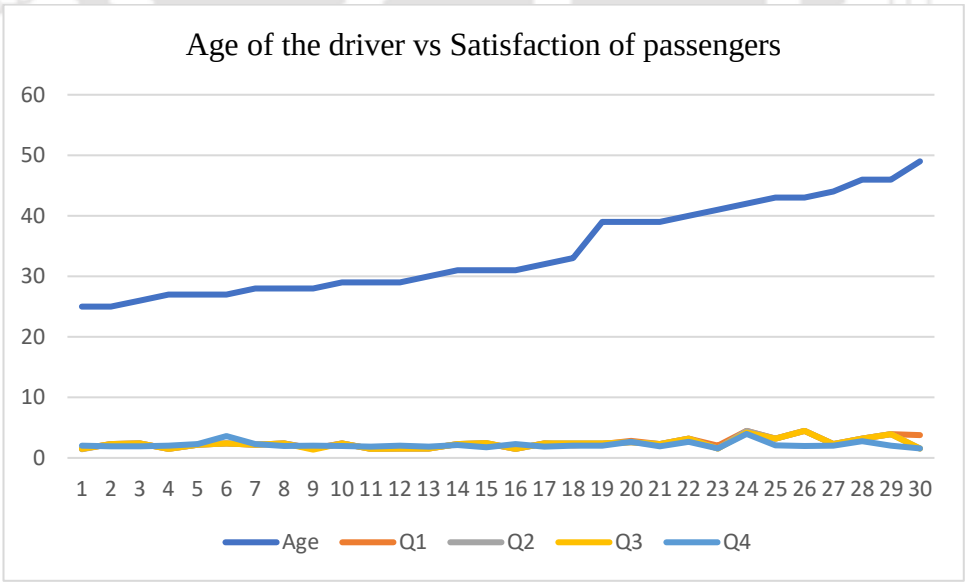

Figure 2.26: Age of the driver vs satisfaction of passenger: Note that as the age of the driver rises the satisfaction is also on the rise

The average score attained by the drivers for all the four questions were in the range 2.16 – 2.46, showing “disagree”. It points towards the pronounced dissatisfaction existing among long distance bus travellers due to driver behaviour. Hence it can be safely assumed that the driver behaviour affects the aspect of perceived comfort of passengers.

Also, it is very interesting to see the relationship between age of the driver and score. As the age rises score also rises. It might be due to the gained maturity of the driver with rise in age. Also, all the drivers who got scores above 4 for all the questions were have their age greater than 40.

In conclusion it is evident that our long-distance drivers definitely need to be trained specially to handle elder passengers. People who are spending many days for activities like conducted tours and pilgrimages, will definitely expect more polished and comfortable behaviour from their drivers. And the driver behaviour definitely affects the perceived comfort of fellow passengers.

2.2.3 Study III Bus System Feedback (Observational Study)

The public transport system using buses advanced significantly in India especially after the governments liberalisation policies. The focus area now shifted to passenger comfort and reduction of fatigue while travelling. Gone are the days which witnessed buses as a coach structure mounted on a chassis, with bare basic features for passengers.

The passengers using a bus for long distance travel, falls under many categories like physiological dimensions including weight, age, gender etc. with considerable differences in their requirements. So, for a design to be truly inclusive, it should consider all of these factors in to consideration.

This study aims at a simple investigation in to the existing buses used for long distance travel and its applicability as a people mover suited for elderly citizens.

Methodology

For this study, both questionnaire related surveys and direct investigation are used. In the first place this study is divided in to three categories, namely;

A. Entry / Exit system - focussing on the entry system components like doors, assistive lamps, steps etc. and easiness with which a passenger can use those systems.
B. In vehicle movement – focussing on the interior design features aisle, assistive grab rails etc.
C. In vehicle feature for easiness / safety / comfort of passengers.

The entire study 21 different points and is given below.

A. Concerned with Entry Exit system

1. Puddle lamp
2. Floor type
3. Kneeling facility
4. Hand rail for entry
5. Wheel chair access
6. Sufficient luminous contrast at step edge
7. Step slip resisting
8. Step side lighting
9. Step rise from ground
10. Step track homogenous or not
11. Door type (PA/Auto/Manual)
12. Max rise of step

B. Concerned with in vehicle movement

1. Floor unevenness
2. Well-lit gangways
3. Sufficient luminous contrast for gangways
4. Seat floor elevation
5. Foot rest
6. Individual reading lamp
7. Grab rails

C. Concerned with in vehicle feature for easiness/Safety/Comfort of passengers

1. Easy seat adjustments:

2. Emergency bell switch:

We took 40 buses from across 6 Indian states namely Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Uttarakhand and Rajasthan. We used random and purposive sampling and 4 states were covered by the author himself and remaining two states covered by deputed fellows.

For the first two sections, researcher inspected the bus in person and in detail, and for the last section concerning seat adjustment easiness and signage a three-point Likert scale was used.

Results and discussion

The following are the results we got with the study.

A. Concerned with Entry Exit system

Figure 2.30 shows the observation for this section.

1. Puddle Lamps – The puddle lamps on the steps makes the entry and exit in low or no light condition (night) easier. In this study, out of 40 buses, only 13 buses had puddle lamps (32.5%).
2. Floor type – Whether low floor / low entry or high floor.
3. Kneeling facility – By kneeling facility, the entry and exit process becomes easier and also wheelchair access would also doable. This facility actually needs air suspension system. In our study, only one bus had this facility.
4. Hand rail for entry – All the buses had hand rails for entry/exit.
5. Wheel chair access – Only one bus had the wheel chair access facility.

Figure 2.27: Wheelchair access of a low entry bus: needs smooth transition and it is easier to design wheel chair access to low entry/low floor configuration.

6. Sufficient luminous contrast for steps – there should be sufficient luminous contrast for steps in order to avoid confusion between two consecutive steps specially in low light conditions. This scope of confusion among passengers may increase if the age of passenger is more. In this study we found only 8 buses were having this feature. That is only 20%.

Figure 2.28: Non homogenous step track: Figure shows a non-homogenous step track but with sufficient contrast between two consecutive steps

7. Slip resistant steps – Although step should be slip resistant for legal compliance, we found only 10 buses having this feature.
8. Step side lighting – Only 1 bus had the step side lighting.

9. Homogenous step track – This feature too is helpful in avoiding the confusion among passengers. The chances of a fall are more when there is non-homogenous step track. We found only 6 buses (15%) with homogenous step track.
10. Door type – In this, 2 buses were using pneumatically assisted door closing, only bus had fully auto door closure, and remaining 37 buses had manual door closure.

11. Maximum rise of step – Here as per the rules and regulations prevailing, for a type 3 deluxe or AC deluxe bus, which are considered here for the study, the maximum permissible rise of step from ground is 40 cms and for remaining steps it is 25cm. But in our study, we found that the maximum rise of steps from ground, (ie 40 cm) is not comfortable for fellow passengers.

Figure 2.29: Step size of a typical bus under study: Note that for fellow passengers such a height is not comfortable

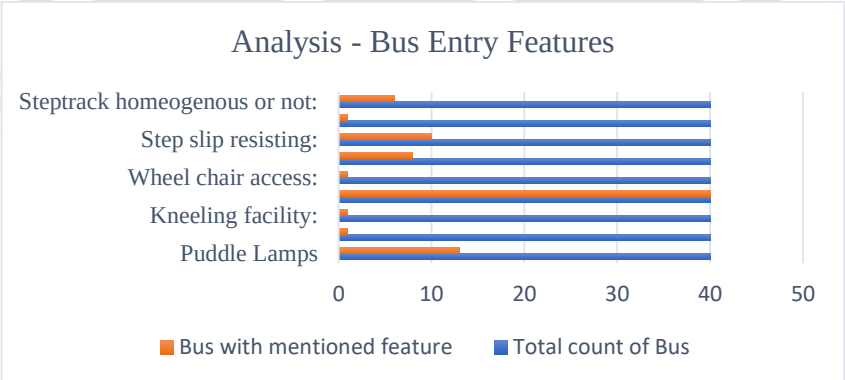

Figure 2.30: Graphical representation of buses with mentioned features

B. Concerned with in vehicle movement

1. Floor unevenness – Out of 40, 34 buses had uneven floor due seat floor elevation.
2. Well-lit gangways – In order to make the in-vehicle movement easier, well-lit gangways are necessary. We found only 8 buses having well-lit gangways.

Figure 2.31: Well-lit gangway: Figure shows a well-lit gangway - see the bluish light strip. It is essential for fellow passenger especially while travelling through night and in airconditioned buses it is needed even in night.

3. Sufficient luminous contrast for gangways – we found no bus sufficient luminous contrast for gangways.
4. Foot rest – We found 27 out of 40 buses with foot rest.
5. Individual reading lamp – Out of 40 buses, 50% of buses had individual reading lamp.
6. Grab rail – 4 out of 40 buses had this feature.

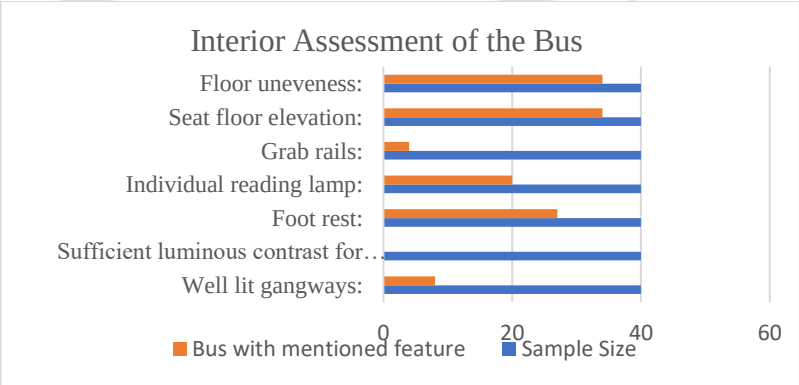

Figure 2.32: Graphical representation of buses interior features

C. **Concerned with in vehicle feature for easiness / safety / comfort of passengers**

1. Easy seat adjustments – The seat adjustments were very hard in 23 buses whereas in 11 buses it was moderately hard.
2. Emergency bell switch – We found no buses with individual bell switch for emergency.

When we investigated about the easiness with which the seat controls are operated, most of the elder passengers found it difficult to use them. It is an established fact that as age increases, the physical ability decreases. Here we felt the need of a devoted study to find out the hand grip strength values of Indian individuals and its relation with rise in age, as such a study was absent with regard to Indian context. This triggered to another study which is following.

2.2.4 Study IV. A Study on Hand Grip Strength of Adults

Introduction

The hand grip strength is the static force that an individual's hand can exert when he or she squeeze around the device. The device used to measure the hand grip strength is known as a hand grip dynamometer. Many studies have been performed worldwide as hand grip strength has its own role in Work Related Upper Limb Musculo Skeletal Disorders (WRULD), Victor et al. This WRULDs are the single most problematic factor prevails among workers (especially working with manufacturing industries). In European Union alone the self-reported WRULD cases 14% -46 % (Buckle P et al) whereas in USA 21.7% - 33.9 % (Ma et al).

The other side of hand grip strength is the estimation of it while designing controls. In the bus transport systems, there are some controls that must be activated by passengers such as seat fore and aft adjustment, back support angle etc.

Methodology

For this study 9 Indian states were selected randomly (Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Uttarakhand, Rajasthan, Assam, Gujarat and West Bengal) and hand grip strength of subjects who were selected on the basis of random and purposive sampling were recorded using Jamar Hydraulic Dynamometer. The subjects were taken by two methods. In the first method, the samples were taken by researcher while travelling. In the second method, some institutions in Kerala were identified like Amrita School of Ayurveda were students and staff from across India is working / studying. Hence it was easier for getting the subjects for the intended study.

The study took a total 308 eligible participants out of 411 primary participants. Those who were having any types of pain, surgical procedures done on their hands were not included. Also, those who do regular exercise enhancing hand strength were not included so as to maintain natural or spontaneous values as far as possible.

Out of the selected 308 subjects 168 were men and 140 were women. The average age of men was 47.35 with the standard deviation of 15.21, whereas the average age of women was 45.41 with a standard deviation of 14.9. The study took a total of 97 days. The age group wise mean and SD is furnished in **table 2.7** below. The subjects were categorized into six groups viz. 20-29; 30-39; 40-49; 50-59; 60-69 and above 70.

Table 2.7: Age details of respondents

Age	Mean	Standard Deviation
20 - 29	27.10	2.20
30 - 39	35.17	2.46
40 - 49	44.30	2.45
50 - 59	55.22	2.43
60 - 69	65.00	2.35
70 & Above	74.59	3.96

Personal details like name, gender, age, medical history, height, weight were collected. The hand grip strength is taken in to two categories i.e., Comfortable (that value for which the persons were comfortable) and Maximum value (the maximum value that can be exercised by the individual). These values are collected for both the hands. The hand grip strength is taken in *three* trials for each category, and the average is calculated. The BMI is calculated from the primary data collected.

Results - Men

Comfortable values

The comfortable values are the average of three consecutive reading taken without exerting much force and extent of force was deemed to be “comfortable”. Figure 2.33 shows the comfortable values of left hand and right hand for men. The age group and average values are also shown in **table 2.7**. The table shows the total result of men as average. The value begins to dip once the age gets to the range 40-49. After 40-49, it dips sharply till end is reached, clearly showing the trend.

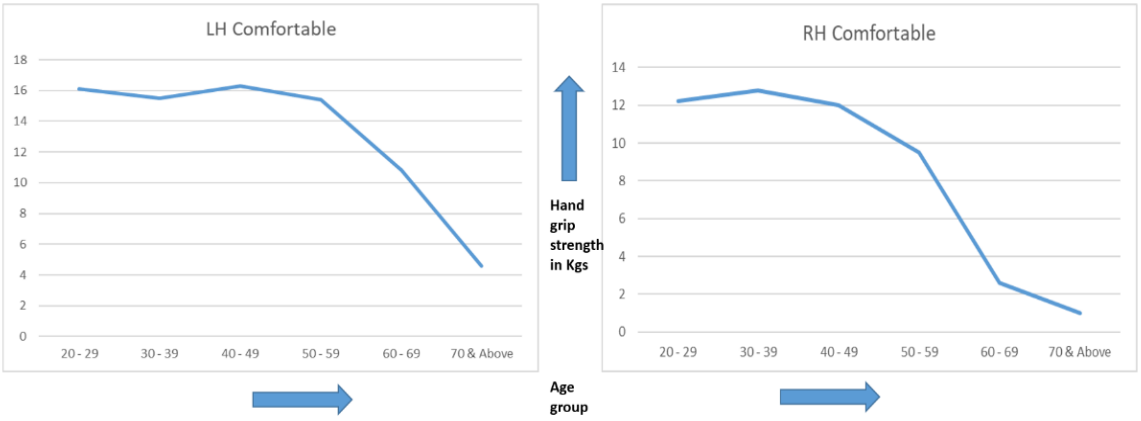

Figure 2.33: Comfortable values of hand strength - men

Maximum values

The maximum values are the average of three consecutive reading taken with exerting maximum forces. Figure 3.34 shows the maximum values of left hand and right hand for men. The age group and average values are also shown in **table 2.8**. The table shows the total result of men in average. Here too the trend is similar. The hand grip strength is declining as the age is increasing.

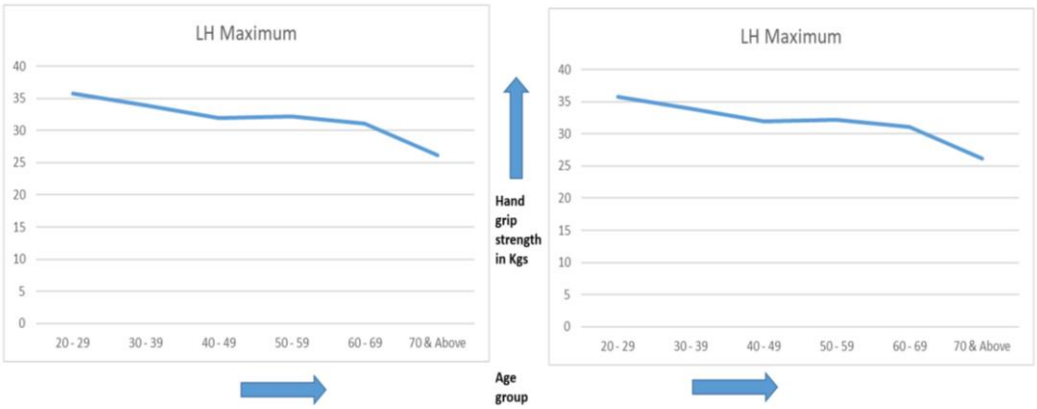

Figure 2.34: Age vs maximum values of hand strength - men

The average of comfortable values as well as maximum values are given in the **table 2.8**, for all the age groups for men and women

Table 2.8: Average values of Hand grip strength

Age ⟶	**20 - 29**	**30 - 39**	**40 - 49**	**50 - 59**	**60 - 69**	**70 & Above**
Average LH Comf	16.07937	15.49524	16.3404255	15.42029	10.8125	3.84848485
Average RH Comf	12.1619	12.80857	11.9680851	9.521739	2.565278	1.03030303
Average LH Max	35.7619	33.86667	32.0496454	32.23188	31.0625	26.0909091
Average RH Max	38.03175	36.84762	35.3404255	34.48485	34.3125	28.469697
LH max Highest	79.3	62.7	41.3	41.3	57.7	75.3
RH Max Highest	76.3	73.3	44.7	42	58	69.3

Results - Women

Comfortable values

The comfortable values are taken as the average of three consecutive readings without exerting much force and extent of force was deemed to be “comfortable”. Figure 2.35 shows the comfortable values of left hand and right hand for women. The age group and average values are also shown in **table 2.8**. The table shows the total result of women in average.

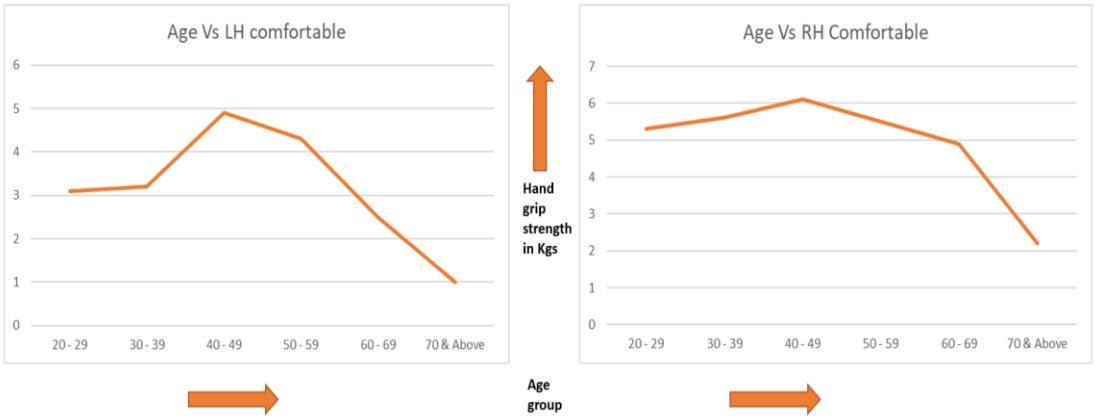

Figure 2.35: Age vs Comfortable values of hand strength - Women

Here it is to be noted that at first the hand grip strength is increasing till 40-49 group and then suddenly, a sharp decrease is observed.

Maximum values

The maximum values are the average of three consecutive reading taken with exerting maximum forces. Figure 2.36 shows the maximum values of left hand and right hand for women. The age group and average values are also shown in **table 2.8**. The table shows the total result of women in average.

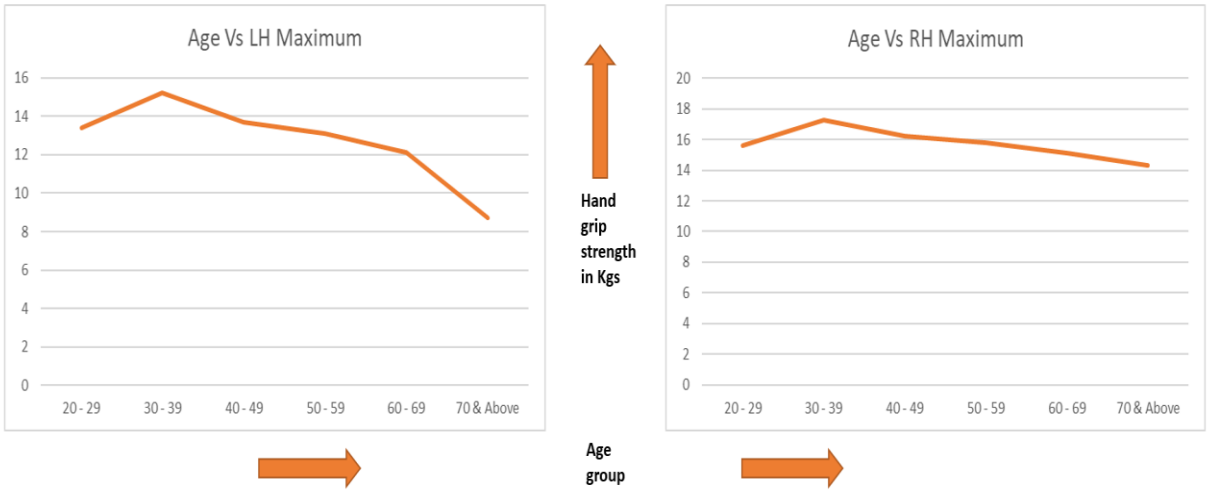

Figure 2.36: Age vs Maximum values of hand strength - Women

Here too the trend is clear. The hand grip strength is declining as the age is increasing. The interesting thing is that in the first phase the hand grip strength is increasing till 30-39 age group is reached. Post to then, the decline starts.

Results - Combined

The hand grip strength of both men and women are compared in the Figure 2.37 below. It can be clearly stated that the hand grip strength is decreasing as the age increases. And also, the hand grip strength of men is found to be more than that of women. In addition to that, if we consider the maximum value of hand grip strength, right hand is seemed to be more strength than left hand. But if we consider the comfortable values, the left hand is showing better strength. It is actually an area for further exploration.

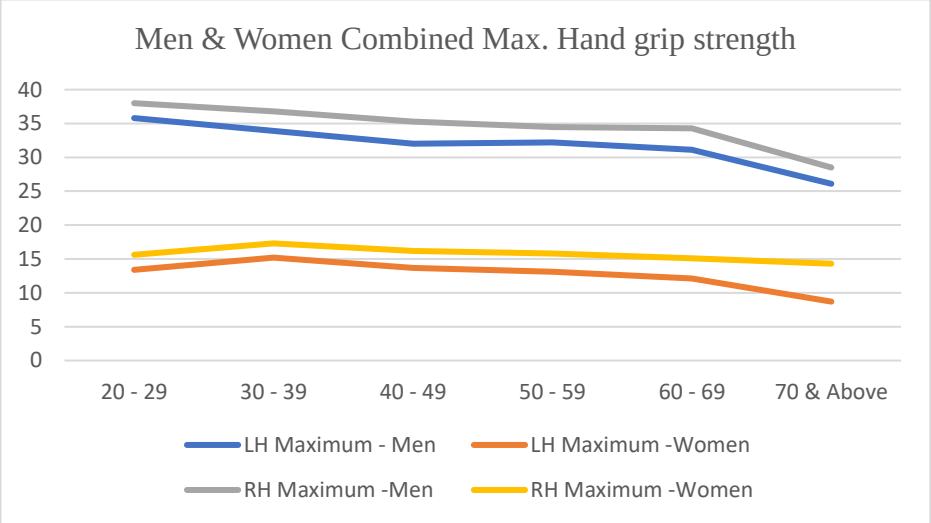

Figure 2.37: maximum values of hand strength - men and women

Inference

Generally, it can be stated that the hand grip strength of an individual deteriorates with age. As a result, if a product is designed, special care must be given to make it inclusive for elders. In the example we considered here, if a seat is designed for general target customers with control levers, it may not be comfortable for elder passengers. Hence, we must design controls with this in mind. Also, as far as hand grip strength is concerned women seem to have much lesser strength than men of the same age.

2.3 Discussion

After conducting the above studies, we found that there exist some serious issues for the comfort of long-distance bus travellers particularly elders like pilgrims. Starting from the seat available for such buses, to the facilities and amenities provided/needed for the passengers need to be addressed. It is observed that the studied buses did not have proper neck support, lumbar support, leg support as well as space for palm rest. As regarding to the interior colours, it is found that most of the pilgrims opted for lighter colours which creates peace and tranquillity rather than flashy energetic colours. Interior colour theme of long-distance buses greatly affects the perceived comfort of the passenger. Regarding the features and amenities needed by the passengers, there were a long list of demands from the passenger side. But among them, on board lavatories was the most important. Regarding the entry features, almost all the buses we studied, was found to be not so elder friendly as the step size was prohibitively high. Also, the in-vehicle space was also not enough for free movement which is a need for bringing down some of the long-distance travel fatigue symptoms.

In addition to this, we found that the behaviour of the driver plays an important role in the perceived comfort of the passengers while doing long duration travel. Drivers with matured and cordial behaviour were found to be enhancing the perceived comfort of the passengers.

Finally, a limited study to quantify the hand grip strength of individuals found that the hand grip strength of men and women has a decreasing trend when they reached the age of 50 and above. Also, the strength of men found to be more compared to women.

As a result of these studies, we found that, there needs to be some design interventions in terms of bus interiors, seats, entry/exit system, as well as facilities and features needed. In addition to this there is a need for training of our long-distance drivers to specifically handle the elders.

Chapter – 3

Design Interventions and Feedback on Concepts

In this chapter, the detailed discussion about the already performed surveys and studies in the second chapter is made. Also, we have tried to find solutions to some of the existing problems found by the surveys, or the features demanded by fellow passengers. Importance of driver orientation training is also provided. Apart from this, one of the most important features demanded by the fellow passengers, the washroom is discussed and tried to find a solution of.

Chapter - 3

Design Interventions and Feedback on Concepts

3.1 Introduction

This chapter is divided into three sections. The section 1 is concerned about the conclusive remarks of the studies done. The section 2 incorporates the proposed design interventions based on the study feedback we got. And finally, section 3 shows the feedback on some of the design interventions proposed.

3.1 Section I - Feedback of the studies

It is revealed in detail about the surveys that have been already performed. The results and a brief discussion are as follows. The results are discussed in three main groups for the easiness to understand and comprehend.

I. **Bus Travellers feedback** – In this the existing system is evaluated based on the preferences of pilgrims or elders. In this, the following aspects considered primarily;

A. *The physiological problems* associated long distance travel by elders or pilgrims.

B. *The Psychological aspects* – In this the psychological aspects like colour preferences for interiors and its effects on passenger's perception of comfort are focussed.

C. *Design related feedback* – In this the feedback is related with the design aspects like ingress, egress, seat system etc.

II. **Existing Bus system feedback -** This study aims at a simple investigation in to the existing buses used for long distance travel and conducted tours and its applicability as a people mover suited for elderly citizens.

III. **Driver Behaviour and Comfort** - In this it is investigated that whether the behaviour of the driver of long-distance bus affects the perception of comfort of passengers and whether our drivers need to be trained for handling long distance travellers like pilgrims or elders in general.

IV. **Hand Grip Strength** – In this, results of devoted study to quantify the hand grip strength of individuals has been carried out.

3.2.1 Feedback about travel comfort and interior features

In the bus system feedback as mentioned in the previous chapter, many factors creating fatigue inducing seat design, different pain regions, colour psychology, and needed amenities. The following were the findings;

1. When asked about the seat feedback neck support is found to be problematic (exact score is given in the previous chapter) and is closely followed by lumbar support, leg support, and general back support.
2. Regarding the pain regions neck became the area with highest pain feeling followed by Upper back and Lower back (lumbar).
3. Most of the respondents complained about the oedema in their ankle region too.
4. Now when we are concerning the colour psychology part, almost 90 % respondents agreed that the interior colour has an effect on the mental comfort while travelling. It can change the passenger mood while travelling.
5. It is also interesting to find out the fact that it was women respondents who felt the effect of colour more noticeably than men.
6. As the target respondents of this study were mainly pilgrims, they preferred light colures for interiors rather than flashy or dark colours.
7. People also liked cool colours rather than warm colours. Almost 94% people liked cool colours irrespective of gender.
8. For seat, 98.79% individuals selected light colours. But on the contrary, 82% of the operators selected dark colours for seats as it aids in masking the dirt and signs of wear and tear.

9. For floor colour too, 84.34% people selected light colours and remaining people selected dark colours.
10. Finally, when asked about the preferred colour for interiors in general almost 64% people voted for ivory followed by pink and light blue.
11. If we examine the gender wise preference of colours, when aged between 20 – 30, 75% men preferred light colours; When aged 31 – 40, almost 100% men preferred light colours; when aged between 41 and 50, 90.9% selected light colours; when age is between 51 and 60, 100% of men voted for light colours and finally, when age is above 60, 94% preferred light colours for interiors.
12. Now for women, when aged 31 – 40, almost 100% women preferred light colours; when aged between 41 and 50, 90.9% selected light colours; when age between 51 and 60, around 93% of women preferred light colours and finally when aged above 60, around 88% preferred light colours for interiors.

Observation:

The overall responses of the subjects' points towards that some attention is to be given while designing seats for long travel buses. It should be well supportive and not to be a trade-off for cost considerations. Also, majority of the respondents were favouring lighter shades (shades of blue, white or ivory). This points towards the demand of tranquillity rather than energetic travels as demanded by a general tourist. Blue is known to boost intellectual activity, reasoning, and logical thought. It is the colour of the intelligence. Blue is also known to lower the blood pressure. Surely, it is a calming, tranquilising colour, aiding reflection. Strong blues stimulate clear thought and lighter, soft blues calm the mind and aid concentration.

3.2.2 Feedback about facilities and amenities needed

1. After conducting preliminary survey (Open ended), we selected 11 items as amenities needed to be included in the study and they were, place for water bottle, Medicine pouch, coat hanger, foot wear storage, mobile charging points, split curtain, walking ramp, seat belt, floor lights, toilet and trays.

2. Everybody in the target group voted for walking ramp inside the bus, as very long duration confined posture is leading to many pain regions.
3. Almost all demanded for an attachment by which they can apply leg movements freely.
4. Apart from these the highest priority was for toilets.
5. It was interesting to note that, all women voted for toilets inside bus and also, they have given highest mark (5) for toilet.
6. When they are asked about the video players or screens almost 85% voted for video screens but they preferred the individual headrest mounted screens rather than common TV, which most of the tour operators are choosing.
7. People preferred tinted glasses rather than un-filmed glasses due to hot and sunny tropical conditions prevailing in India

3.2.3 Bus system Feedback

1. When inspected whether the step tracks are homogenous or not majority of the buses were not having homogeneous step tracks
2. Step side lighting which is another must have factor for buses used for long distance travel especially for elders, a very few buses were having it.
3. Only a few buses were having the slip resisted steps
4. Very small number of buses had the entry steps with sufficient luminous contrast.
5. Negligible number of buses had wheel chair access
6. Almost every bus had hand rails for entry
7. Only a handful of buses had kneeling facility for making entry easier
8. Only one bus had easy access entry point due to step size
9. Not enough number of buses were found out to be having puddle lamps
10. More than 90% of the buses had manually closed doors

Observation:

When the study finished, it was found that almost all the points using which this investigation is carried out, like, non – homogenous step tracks, step side lighting, slip resisted step tracks, well-lit gangways and easy entry / exit system were absent. Also, the step size too creates an issue. None of the buses were having emergency bell switch which is an absolute necessity in the case of separated cabin buses used for air conditioning. Hence, it is evident that almost all the buses not found to be elder friendly.

3.2.4 Driver Behaviour and Travel Comfort

1. For all the questions asked to rate the drivers the score was much below satisfactory levels. This actually pointed towards the need for diver training especially handle elder passengers.
2. It was very interesting to note that as the age of the driver increases, the satisfaction levels of the passengers are also increased
3. Highest satisfaction score was achieved by drivers with their age above 40.

Observation:

It was observed that people feel the driver behaviour to be surely affecting the passenger comfort. But it is evident that our drivers needed to be trained properly to handle the passengers especially long-distance travellers like pilgrims, because our drivers on whom this study was performed, was not found out to be having satisfactory behaviours. As the needs of fellow passengers differ, driver handling them for multi day long travel must be trained and made aware of the needs and requirement of the fellow passengers.

3.3 Section – 2 Design Interventions

3.3.1 A. Seats

A1. General Seats aspect: The seats should have sufficient neck support (almost all the buses lack this feature), lumbar support (standard deluxe bus seats do not have this feature) and enhanced thigh support. It should have hand support with an extension for palm support. Individual leg support is also preferred. Figure 3.1 shows the schematic of the proposed seat.

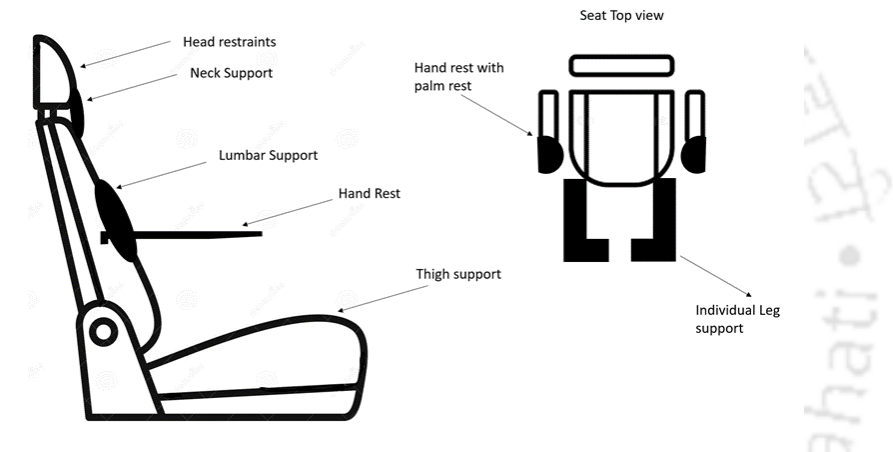

Figure 3.1: Schematic representation of recommended seat

A2. Addition of swivelling seats: As the travellers under consideration using their bus primarily for pilgrimage, (which is also leisurely in nature), sightseeing is an inevitable part of the travel. But looking sideways for prolonged time may induce pains for them. In order to overcome this, swivelling seats are proposed to be introduced. The Figure 3.2 below, shows the seat with proposed swivelling arrangements. Figure 3.2 (a) represents independent swivelling whereas Figure 3.2 (b) represents single unit swivelling to save comparatively more space.

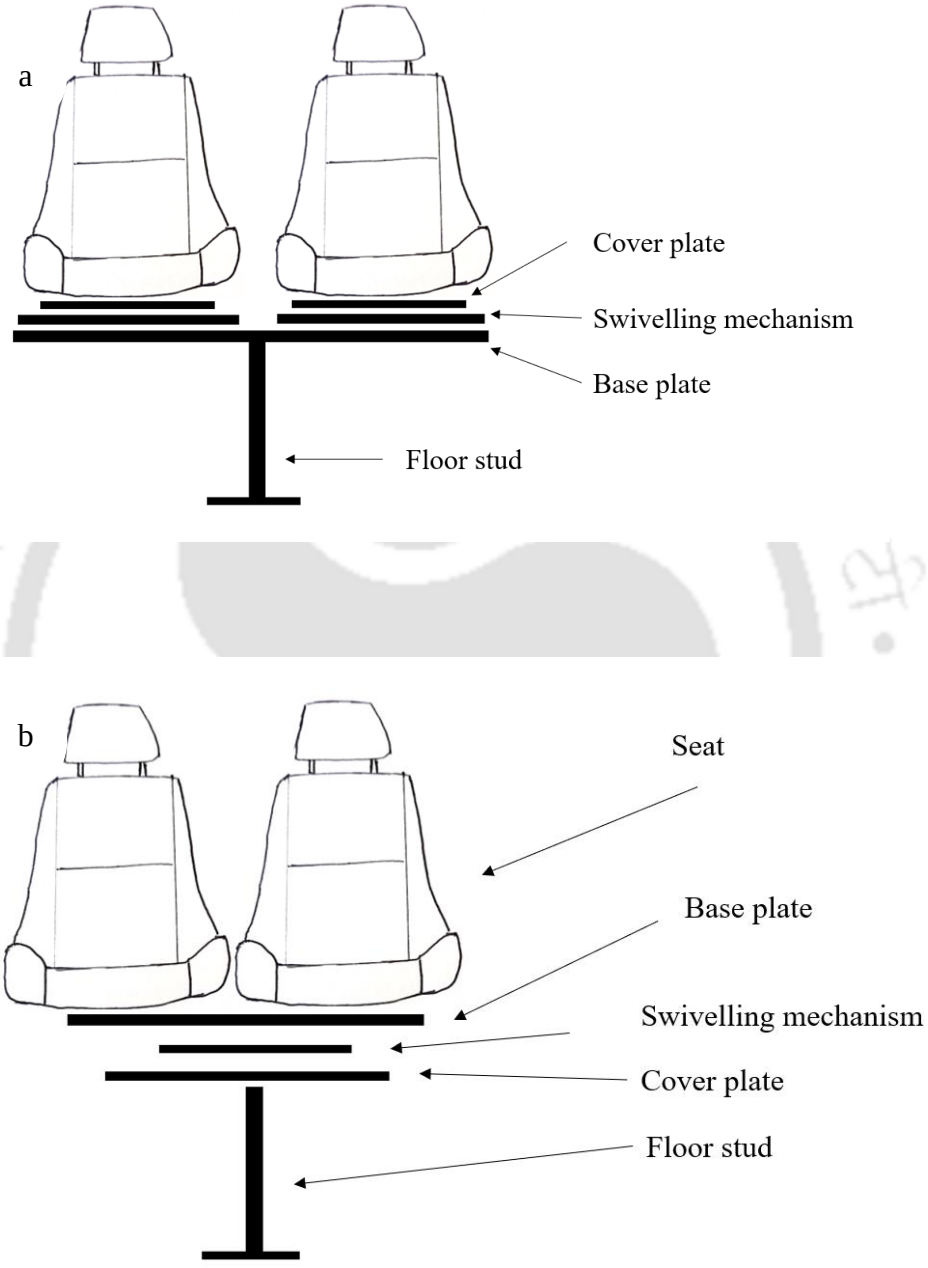

Figure 3.2 : Swivelling seats- a schematic representation, not to scale. Figure 3.2 a represents independent swivelling whereas Figure 3.2 b represents single unit swivelling to save comparatively more space.

Advantages and disadvantages of swivelling seats is depicted below.

Table 3.1: Merits and demerits of swivelling seats

Advantage	**Disadvantage**
1. Seat swivelling reduces the strain generated on neck while sightseeing inside moving bus	1. Space needed for the arrangement is more as when seats are turned it eats more area
2. Increased comfort	2. Mechanism is more complex
3. More freedom of movement to the passengers	3. Higher cost
4. Adds to the perceived luxury of the cabin and increased perception of more bang for the buck	4. Reduced number of seats due to more space requirement

Figure 3.3 shows the two options of swivelling seats. Option 1 is seat with a single base plate and option 2 is two independent seats. In the first option seat turns as a single unit and in the latter it turns independently. For independent seats, the space required is more. Hence as a cost trade off, single base seats can be preferred.

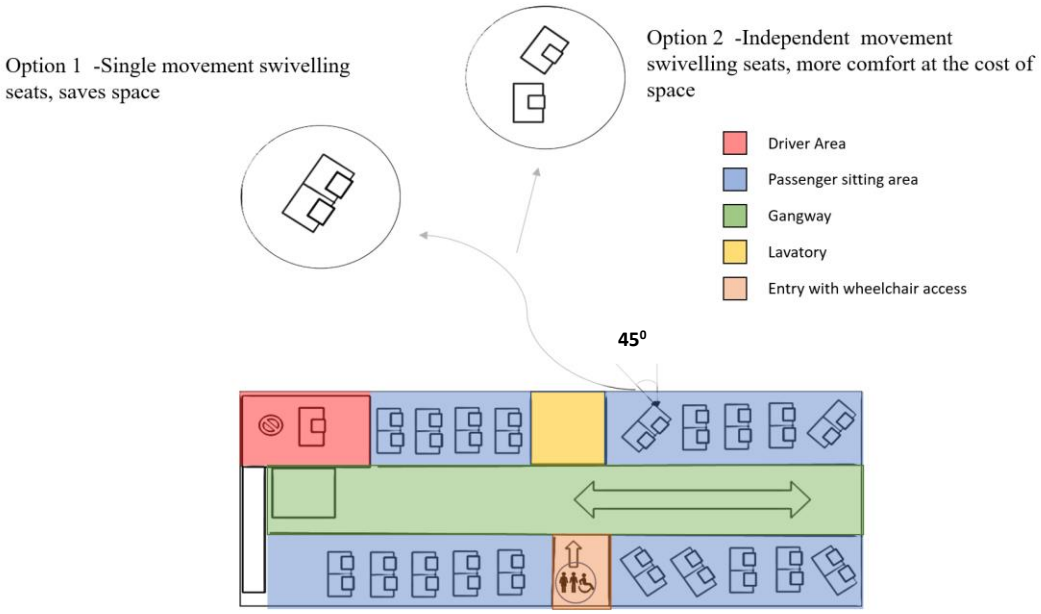

Figure 3.3: Schematic diagram of options of swivelling seats. Here option 1 needs less space, and option 2 offers more comfort. Not in Scale.

Now we will look in to the complete schematic diagram of seat system as shown in Figure 3.4. As per the studies we have undertaken so far, it is evident that proper support should be there for neck, upper and lower back, thigh as well as arm rest. Though much of these are already present in some seats, the real problem is not all seat design are satisfying these conditions. The Figure shows all the needed enhancements for the seats which should be made mandatory for buses used for long distance travel. Also, the arm rest should have a place for resting the palm of the traveller. In addition to this, when not in use, it is observed that, on many occasions, the arm rest collides with moving passengers. In order to avoid that rotating arm rest which can be safely kept under the seat is preferred.

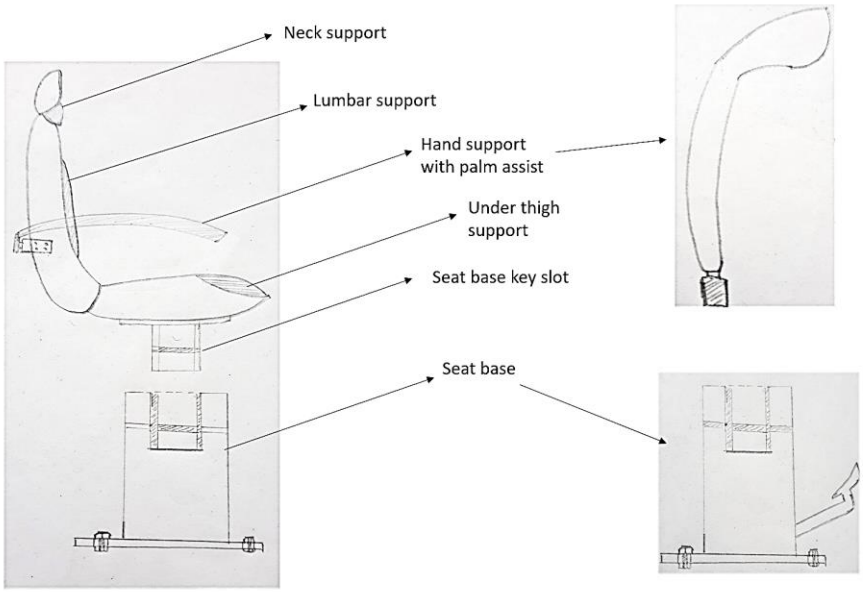

Figure 3.4: Schematic sketch of recommended seats with mentioned feature and palm rest incorporated hand rest

Observation:

Due to the immense risk of neck pain owing to prolonged looking at sideways, swivelling seats must be used. Also, it aids to the feeling of perceived luxury.

3.3.2 B. Interior features and amenities

B1 Toilet: The most important needed amenity was the addition of a toilet. Particularly women voted for it. As this study focussed specifically on elders, many of them were diabetic and needed frequent urination. This made them uncomfortable to tell the driver to stop the vehicle every now and then. This triggers the need of toilet inside coaches. In the following section we examine the optimum position of toilets inside the bus. Generally, there are three different configurations for toilets inside a coach, "Front, Rear and Middle" as shown by the Figure 3.5.

Optimum Position of coach toilet based on Score Based Comparison (SBC) Method

Here for finding out the optimum position of toilet in a coach, we developed a tool named SBC or score-based comparison method. The method is as follows;

Step 1: Identify various ranking constraints known as ranking agents. Here in this case the ranking agents were, ease of access, available space, ventilation issues, maintenance easiness, access for the disabled (divyangans), chance of interference with other passengers, usage comfort, space utilisation efficiency and feeling of privacy.

Step 2: For each ranking agents, the possible score values are ranging from -2 to +2. The scores values are +2 – highly favourable; +1 – favourable; 0 – neutral; -1 – moderately unfavourable; -2 – highly unfavourable.

Step 3: With the above values, assign suitable scores for every ranking agent.

Step 4: Take the total score and arrive at the conclusion.

The below Figure 3.5 shows the generally used lavatory positions in buses, though buses with this facility is itself scarce. Figure 3.5 A shows the lavatory placed at the friend portion, Figure 3.5 B shows the lavatory placed at middle section, and finally Figure 3.5 C shows the lavatory placed at the rear portion. If the lavatory is placed at the front area, the general practice is that the entry to the vehicle is also placed at the front. The biggest issue with the front entry is that, it limits the space available for designing a smooth entry as a good amount of available space is eaten up by front mounted engine and gearbox (in the case of front engine vehicle which is the most common practice in India)

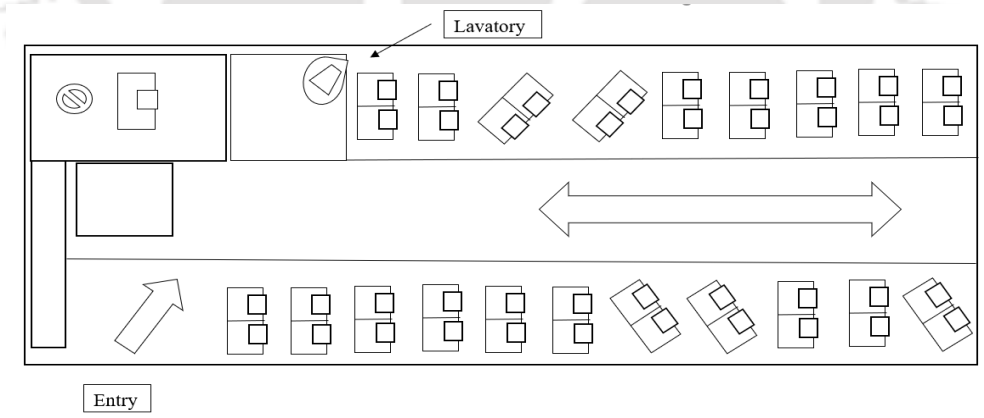

Figure 3.5 (A): Schematic diagram of generally used lavatory positions in buses – Front, Not to scale.

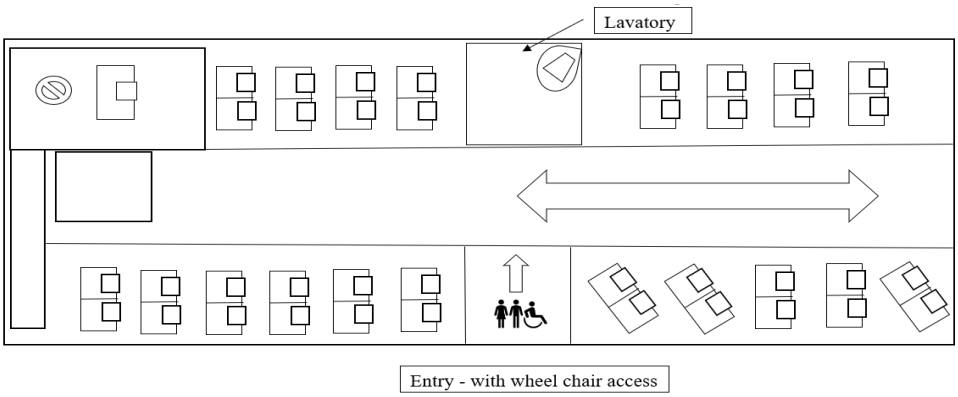

Figure 3.5 (B): Schematic diagram of generally used lavatory positions in buses – Middle, not to scale

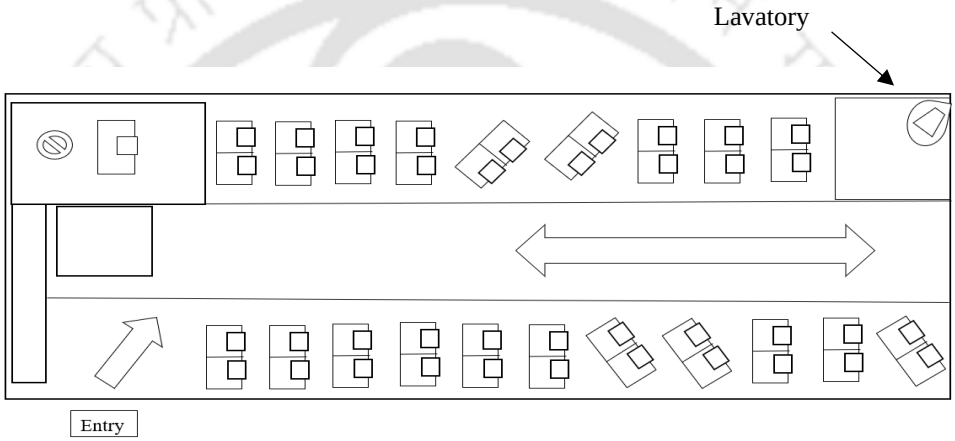

Figure 3.5 (C): Schematic diagram of generally used lavatory positions in buses – Rear, not to scale

The following is the SBC score table used for finding out the optimum position for lavatory in a bus.

Table 3.2: SBC table

Toilet Position ➡ / Criteria ⬇	Front	Middle	Rear	Remarks
Ease of access	-1	+2	-1	Can be easily accessed by any row passenger
Available space	-1	+2	0	No constraint for space at middle
Ventilation	-2	0	+2	As air moves backwards natural

				ventilation is more at rear
Maintenance easiness	0	+1	+1	Front space is cramped
Access for "divyangans"	0	+2	-1	Front is cramped. Rear is uncomfortable due to up and down motion
Interference of other passengers	-2	0	0	Going up to front end may create an interference to passengers
Comfort of usage (Without much pitching)	+1	+2	-2	Front end has least pitching
Space utilisation efficiency	+1	-2	+1	Middle is the most crucial space and if it is used for toilet, a greater number of seats may need to remove
Feeling of privacy	-1	-1	+1	Rear end adds to privacy feeling as everybody looks towards front
Total Score	**-5**	**+6**	**+1**	

Here we can find that if the toilet is at front the total score is "-5"; and for rear the total score is "+1". So here **middle** position emerges as the optimum position for toilet with the highest score of "+6". Note that this is only the optimum position and not the best.

Observation:

The position of toilet might be at the centre rather than at any extremities. It aids in avoidance of up and down movement (pitching) of rear position due to overhang apart from other benefits.

3.3.3 Step size for entry and exit.

Now it was the turn of the step size. The maximum step rise from ground is limited by central rules (AIS 052) to be 40 cm. But in practice it can go slightly higher. And even for that value, the elders needed assistance to climb to the bus. So, we wanted to suggest a step rise value that may suite elders. A devoted study for the same was beyond the scope of this work. So, we wanted a solution that may not need a lengthy study. We did some literature research and tried to get a value of maximum permissible rise of step from ground. We found that the mid patella height of 95 percentile of Indian population (combining male and female gender), to be 51.6 cm, as provided by Indian Anthropometric dimensions by Prof. D Chakrabarti. As a thumb rule we selected the 1/3rd of this mid patella height 51.6 cm. The one third of it is 17.2 cm. As our target customers found it difficult to enter the bus, we decreased the step size to 17.2 cm by providing an iron made step of size 17.2c m. Then we asked the fellow passengers to use it. As the maximum rise is 40 – 50 cm on the sampled buses, it was illogical to go for any value higher than the proposed value, with a full-scale experiment. All of our subjects found it to be comfortable to use the step with revised dimension. To sum it up, we feel that the entry step size should be limited to 20 cm (rounded to next 10th Figure with a negligible difference of 28 mm from experimented value.) for the step from earth's surface to vehicle.

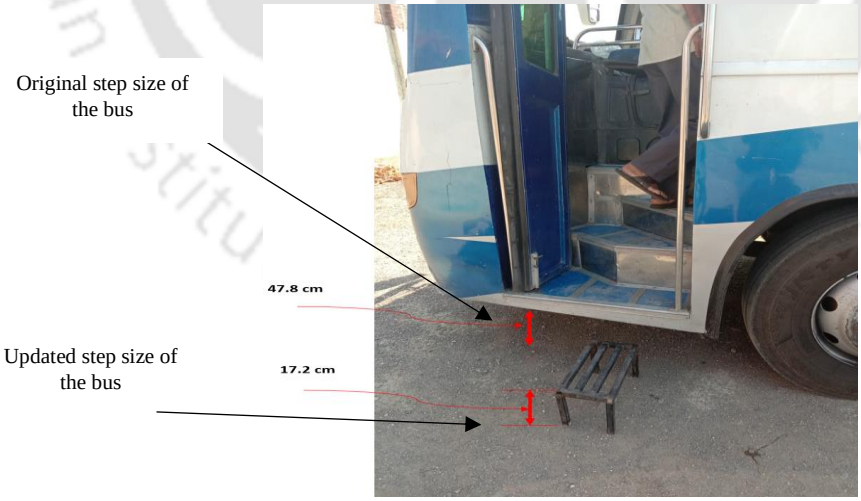

Figure 3.6: Dummy step used to decrease the effective step size for entry: It is used to find out the comfortable step size for elders

3.4 Section – 3 Feedback on concepts generated

Other than a detailed set of suggestions and recommendations which will be made available in the next chapter, we took preliminary feedback about some of the proposed solutions like the lavatory, swivelling seats and step size from the some of the manufacturers and tour operators. A very brief report on the feedback we got is furnished below.

A. Swivelling seats

The idea of swivelling seat, though welcomed generally by both tour operators and manufacturers, there was a significant concern of the number of seats that can be included in standard 12 m long bus. The maximum length of the bus with no articulation is limited to 12 m in India. Refer the **table 3** which shows the relative merits and demerits of swivelling seats. If the swivelling seat set is adopted, though possible to manufacture without much of a cost addition, the number of seats will be reduced significantly.

Due to decreased number of seats, for conducted tour operators, the cost incurred would be more. So, they have to charge more money in order to even break even a trip. One other reason is that, it is not economically viable to design, make and operate buses addressing only one group target customers like pilgrimage or any other conducted tours. Buses are of general purposes, if it can be used for pilgrimages or tours, the same vehicle is to be used for another trip like a rented marriage trip. So, making a dedicated platform is of no particular use.

B. Lavatory

For lavatory also, the response was similar. Almost all the coach manufacturers have the facility to add lavatories but the demand from their end customers (one who buys buses) is not there. Also, the demand of comfort varies from person to person. Some people may need more comfort and may be ready for paying more price for it. But this may not be case with other people.

For a design to termed to be useful, it should be inclusive of all the strata of the society. So, we tried to find a solution incorporating the best of both the worlds. In many

countries, there are many options in which travellers' comfort is given paramount importance. The cost is not at all a major concern and the people are paying the premium. Example include the recently started the "JET" bus service in the US connecting Washington DC and New York city via road, Figure 3.7.

Figure 3.7: The JET bus: Bus operating between DC and New York

The 50-seat capacity bus has only 12 seats with full luxury. They charge a premium from their customers. But for a society like us, need a financially viable as well as inclusive solution.

3.5 Proposal for modular design for the buses

Modular bus design is proposed as solution for the above dilemma. The recommended modular design is such that all seats can be removed or added very easily. Also, the lavatory too is removable. As Figure 3.6 depicts, which is a schematic diagram of the proposed design, the seats are placed on single pillar which is bolted on the floor with just two lock nut sets. For a complete comfort-oriented setup, the number of seats is to be decreased and all seats are allowed to swivel. Also, the lavatory is modular and can be removed as and when required. If the number of seats is to be increased, just lock all seats seizing swivel function and add all needed seats. Also, though there can many classes, here as an example, we consider, two classes which are as;

Class 1: For swivelling seats – low seat density

Class2: Non-swivelling – high density seats

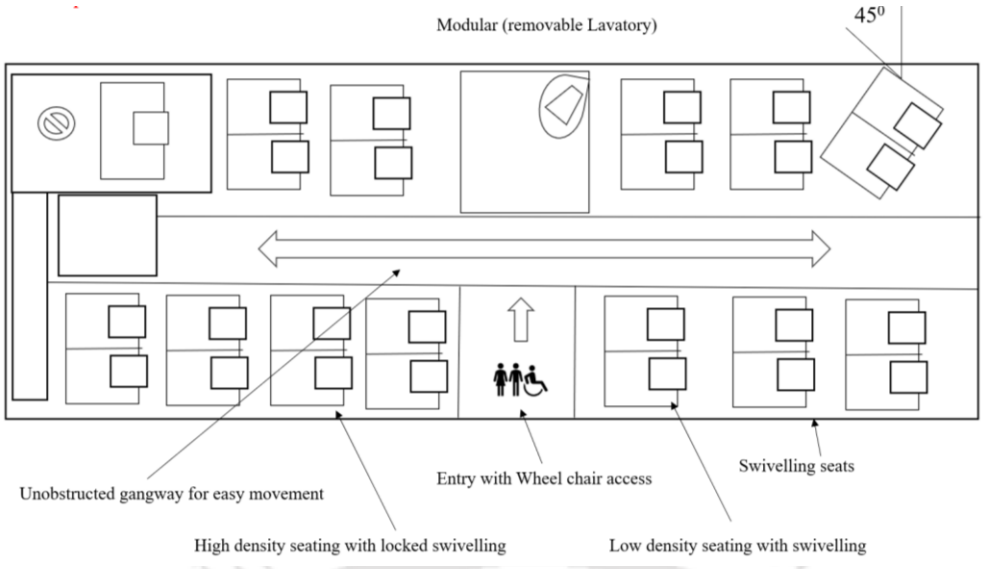

Figure 3.8: Proposed Schematic diagram of the modular concept of bus – Not to scale

The modular design of bus platforms can give many advantages. Seats can be arranged in high density (low comfort) style to low density (high comfort) mode and in between many options are there. Even for an extreme high number of seats for application such short trips, the toilets too can be removed and seats can be added in its place. So simply one bus can be operated for different roles and different comfort levels as demanded by the passengers. Below shown Figure s explores some of the options.

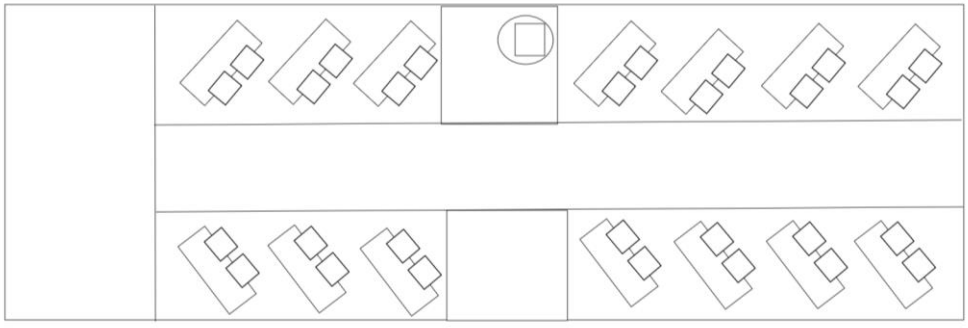

Figure 3.9: Option 1: Low density – high comfort seating, a schematic diagram – not to scale

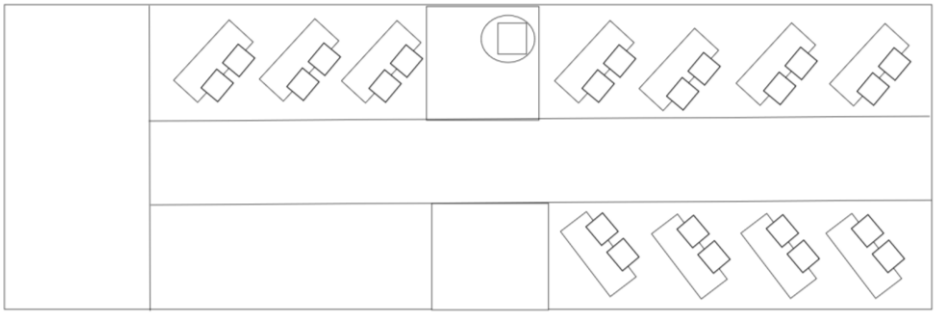

Figure 3.10: Option 2: Low density – high comfort seating with activity space, a schematic diagram - not to scale

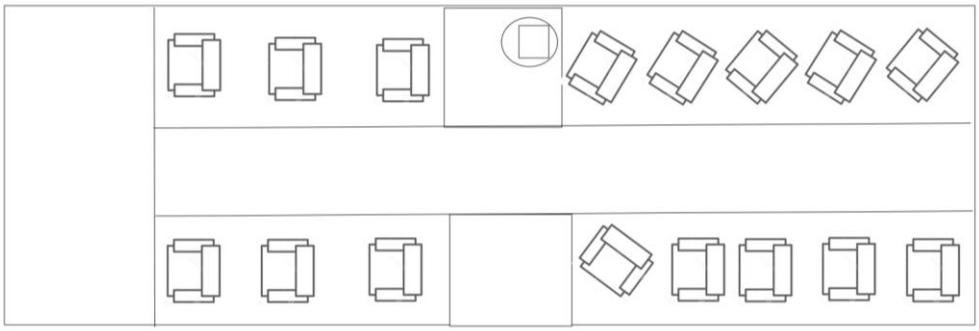

Figure 3.11: Option 3: Low density – Ultra high comfort single seating, a schematic diagram- not to scale

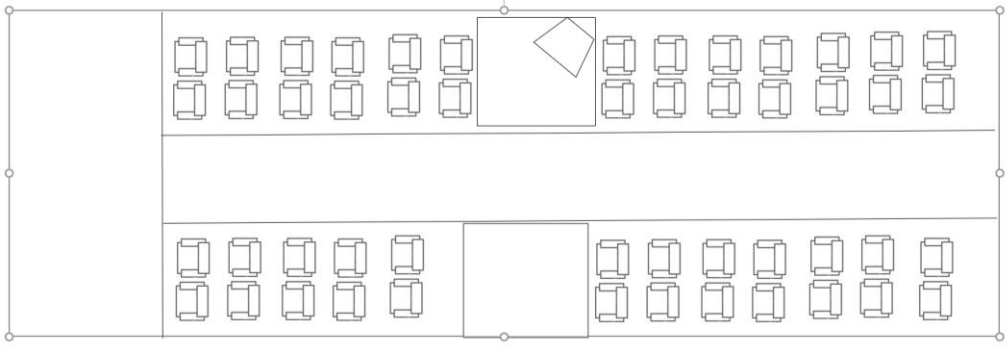

Figure 3.12: Option 4: High density – low comfort seating; suitable for short trips, a schematic diagram – not to scale

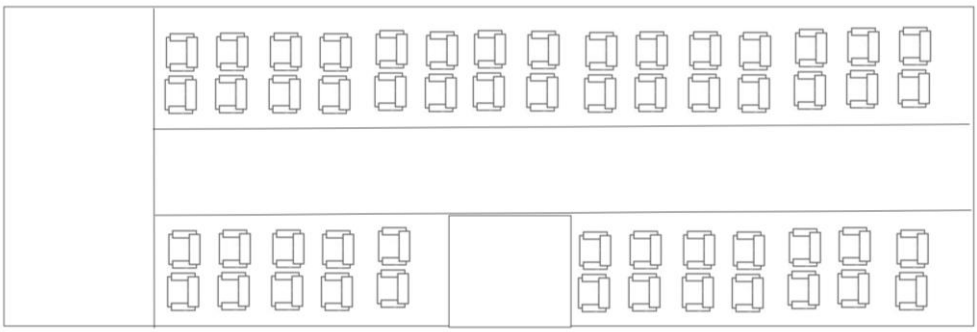

Figure 3.13: Option 4: Ultra High density – low comfort seating; suitable for short trips and without lavatory, a schematic diagram – not to scale

Advantages of Modular concept in bus design

1. Fully flexible – The same bus can be used for many roles such as for short trips, long duration trips, conducted tours etc.

2. Can be used in different seat capacities as demanded by the passengers – The bus can be used with any configuration like ultra-low density seating, low density seating, high density seating and ultra-high density seating.

3. For shorter duration trips even the lavatories can be removed.

4. Cleaning and maintaining the lavatories becomes easy.

5. Can be offered with various comfort levels – The comfort offered in ultra-low density and low-density seating is much more than other modes. This helps in catering the needs for travellers with both ideas, economical concerns, and comfort concerns.

6. Increased safety as number of sharper edges are less compared to conventional designs.

Disadvantages

1. Slight increase in perceived cost – As the model is not made, manufacturers are hinting a slight increase in the cost of making.

2. Elaborative design is needed – as a new concept, elaborative design is needed which can also add to some cost

3. Lack of familiarisation among buyer – a it is a newer idea, convincing the buyers to invest in such an idea may become harder.

4. Set up time is higher – As there need to be arranging and re-arranging of interior resources, time needed at the beginning is slightly higher, though not with all trips.

5. Swivel spring needs additional maintenance

6. Additional check-ups required before probable every travel

Feasibility of proposed interventions

Th feasibility of the proposed design interventions are given below;

1. Technical
- No additional design requirement for swivelling seats
- No additional tooling for manufacturing
- Easier to cater to the needs of customers as modular approach is taken
2. Economical
- Although slight increase in cost, flexibility is extremely high
- Ultra-high comfort and usability is ensured with a minimum cost increase
- With same investment many types of customers can be served
3. Legal (AIS 052, UBS GoI, AIS 023)
- Within the legal frame size of 12m, all these can be incorporated
- No upper storage as per legal conditions
- Due importance to safety
- All AIS standards has been kept intact.
4. Safety (AIS 052, UBS GoI, AIS 023) -For safety aspect all the GoI instructions are met.
- No sharp edges
- No upper storage spaces
- Personal storage space is under seat
- Completely retractable palm and arm rest
- Well-marked exit
- No rear lavatory to block emergency exit

3.6 Conclusion

After analysing the results of the surveys conducted for this study, we came to the conclusion that many ergonomical or comfort issues are existing there in the long-distance bus travel in India particularly with pilgrims or elders. The issues are listed and we proposed some design interventions as the solutions of those existing issues. The major issue with those interventions was the lack of agreement of between the passengers and operators or manufacturers. This was because of the fact that, the passenger requirements and considerations of operators vary to a greater extent. As a solution to this we proposed a modular approach to designing of the buses. This would easily cater the needs of both the stakeholders, the travellers as well as operators or manufacturers (Here it is worth noting that the manufacturers opinions are to a great extent influenced by buyers or operators, as for the manufacturers, the voice of their customers is of paramount importance).

The modular approach is a solution to all these issues. The same vehicle can be transformed in to a low number of seats ultra-comfortable long-distance coach or to a high number of seats, but with a lower comfort standard for short trip durations. Also, higher standards for safety are ensured too.

The feasibility analysis also pointed towards the importance of modular approach. Hence it is clear that modular approach to the design would be the single most solution for all of these issues. The entry system, seat system, in vehicle entertainment and movement, and interior colour theme, issues with all of these can be sorted out with the suggestions.

Chapter – 4

Discussions, Salient Features and Conclusion

In this chapter, after a brief introduction, and discussion about the studies done, all the salient observations are listed. Then it gives inferences together with suggestions / recommendations. Thesis significance too is furnished in this chapter which will conclude with the scope of the research to carry forward.

Chapter - 4

Discussions, Salient features and Conclusion

4.1 Discussion

The mass transportation systems like buses are used for a number of applications like public transportation system (fixed routes) and conducted tours. Pilgrimage is one of the most important reasons for conducted tours in India. People reaching certain age becomes more spiritual, and would like to travel a lot for the same, particularly after retirement. The expectation of such travellers is that the comfort that they are used to get while traveling by personal vehicles like cars, should be there while travelling in buses too. So, there was a need to study such expectations of the subject pilgrims.

Many tour organizers have come up with varieties of services and offers different levels of comfort while going from one destination to another. Here the specific need is that, these types of fellow passengers, majority of whom are enjoying their retirement life, are not poor and are willing to pay for the comfort that they are getting.

A good number of elders are preferring mass or group travel for trips such as pilgrimages is not without a reason. The interdependency among passengers and some of the reliable and comfortable services offered by the tour operator without the worries that you may face while using their own vehicle. The travelling can be done with free of mind as well as fuss free. In that case, it is needed to look in to how these long-distance buses behave, what are the requirements and expectations from the fellow passengers, and how those requirements and expectations can be fulfilled.

For this purpose we completed a qualitative study to find out and analyse the needs of the passengers and is furnished in chapter 2. A significant portion of this study was devoted to the suitability of existing bus transport system. This is somewhat in line with the philosophy of inclusive design. The idea behind this study is that, for conducted tours

and especially pilgrimages, majority of participants were elders. So, it should be evaluated on the basis of inclusive design ideas. One of the most important aspect of this study is that it actually tries to evaluate the suitability of existing buses used as long-distance tourers, with respect of elders.

After a devoted and extensive study which also included many field surveys, the following recommendations are formed. This set of recommendations are actually classified into two primary groups. One is applicable to the bus designers or coach builders (because in India coach builders are primarily responsible for bus building as discussed earlier in this report), the second one is applicable to the law makers as it is concerned with driver training.

4.2 Salient observations

After the comprehensive study, and from the personal observations of the researcher, we made some recommendations and ideas for addressing the comfort issues of the passenger. This is divided in to ideas for bus design and recommendations for bus driver training.

4.2.1 Ideation issues for bus design

Under these sections, there are ideations applicable to entry system, applicable to gangway, applicable to seat system, applicable to facilities and amenities, and applicable to interior colour theme.

1A: Applicable to Entry / Exit System

1A1: The maximum rise of step should be limited to 25cm if the bus is not a low floor / low entry bus. (The low floor or low entry buses are not a feasible solution as terrain such as Char Dham yatra demands high ground clearance).

1A2: There should be puddle lamps to give sufficient light while entry or exit is made during night time.

1A3: There should be homogenous step design due to the fact that elder people will tend to assume the step size to be homogenous and may fell.

1A4: Sufficient luminous contrast should be given for two consecutive steps.

1A5: Hand rails should be provided in both sides of the entry.

1A6: At the entry to cabin there should be at least 90 cm clear width without any hindrance like seats.

1A7: Steps should be slip resistant

1A8: Bus design should incorporate with a wheelchair access

1A9: All the controls that are applicable to passengers, such as seat arrangement should be designed in such a way that even the elder most individual find it easy to use, as the hand grip strength of individuals are deteriorating as age increases, as found by this thesis using the hand grip strength study.

1A10: It would be much easier to bring the entry gate to the middle of the bus because majority of Indian tourist buses uses front engine layout and steep steps would results for such a layout, if front entry is preferred.

1B: Applicable to Gangways

1B1: The gangways should be properly lit and should be with sufficient luminous contrast.

1B2: The seat platform should not be elevated, and if it is unavoidable the maximum elevation should not be greater than 10 cm.

1B3: Gangways should be slip resistant

1B4: Gangways should be in sufficient size and design to allow free movement of the passenger while travelling as it reduces chances of effects of long time sitting.

The gangways are serving also as a movement platform for passengers while doing long journeys. As long duration journeys with confined sitting creates many comfort issues such as Musculo skeletal problems, oedema etc. as suggested by the literatures given in chapter 1, it is important to consider these while designing gangways.

1C: Applicable to Seat System

1C1: The seat should be designed with proper support for neck, upper back, lumbar and legs.

1C2: Individual hand rest should be incorporated.

1C3: As far as hand rest is concerned, rather than the conventional design, a rounded one is preferred.

1C4: Each seat should be designed with water bottle, medicine pouch, pouch for storing spectacles, front trays and place for footwear storage.

1C5: Seats should be provided with seat belts as in long journeys, passengers tend to nap or sometimes even long sleep. But when the driver suddenly brakes, due to inertia and max weight transfer theorem, people may get a shock or may collide with the front seat.

1C6: The seats are to be provided with swivelling mechanisms

1C7: All seats should be provided with individual under the seat storage spaces for storing personal belongings for immediate usage.

The seats may have swivelling mechanism which can be locked at 45^0 angle to save the space. When swivelling mechanism is used, the number of seats would be decreased. It would be even further decreased if opted for 90^0. Also, fellow passengers might need immediate storage spaces to store medicine pouches, small hand bags with essentials etc. In addition to that safety is also enhanced as the upper storage compartment is omitted.

1D: Applicable to facilities and amenities needed to be incorporated

1D1: For long journey pilgrimage buses and conducted tour buses should mandatorily be provided with toilets. It was the most important need of the passengers. The optimum position of toilets found to be at the centre. Modular lavatories are proposed.

1D2: It is also needed to have sufficient width of the gangway as in long journeys to avoid boredom and oedema at the legs, people can move inside the bus.

1D3: People prefer individual screens for video play back. As it is a premium feature it can be limited to deluxe class buses.

1D4: Every passenger should be provided with mobile charging points and split curtains.

1E: Applicable to interior colour theme

1E1: As it was evident that the interior colour theme affects the perception of travel comfort among passengers, light colours should be used for bus interiors as far as possible

1E2: Bus ceiling should be applied with light colours so as to bring a sense of space and tranquillity. As the pilgrims seek peace of mind lighter shades would be more welcome.

1E3: Cool colours are the preferred colour of pilgrims. So, it would be a welcome gesture as far as possible cool colours or white shades such as ivory is used for interior colour theme.

The need from the pilgrims or fellow passengers are completely different if compared with youth passengers, as far as interior ambience is concerned. Youth seems to be preferring flashy colours but our subjects, pilgrims, are more inclined towards cool or light colours. This flashy, dark interior atmosphere definitely affects their mental comfort. So, it is good idea to stick on to the light colours.

4.2.2 Recommendations for Bus Drivers and their training

2A1: Drivers should be trained for specially handling elder passengers.

2A2: Drivers should be trained for providing information regarding the destinations.

2A3: Drivers should be trained for extending a helping hand as and when required for the passengers.

2A4: Drivers should also be trained for improving professional skills such as smooth driving styles.

2A5: Only drivers who are properly trained and skilled should be given the task of long-distance travel buses.

During the study many of the times it is observed that the behaviour of the driver discomforts the fellow passengers specially women. This triggered the need of further studies which is furnished as the second study in chapter 2.

4.3 Observations fulfilling Objectives

This section is intended to state whether the set objectives were met or not.

Objective 1: *To identify the factors contributing to the feeling of discomfort or fatigue for fellow passengers using buses for long duration journeys*.

With three extensive surveys done with subjects chosen from pan India basis, even the ongoing pandemic severely restricted tour or pilgrimage sector, we were able to identify some of the factors contributing to the perceived comfort. Starting from seat related issues to even the interior colour theme found to be affecting the feeling of comfort of fellow passengers specially in a long duration journeys like pilgrimages. Other factors found were lack of lavatory, space for movement, features and amenities and even driver behaviour as discussed in detail in chapter 2. **Thus objective 1 of the research was fulfilled.**

Objective 2: *To identify the influence and preferred colour for interior of the buses doing long distance travel especially with elders*.

The research found that the fellow passengers seek cool colours with an expectation of tranquillity and peace rather than any flashy energetic colours. Also, it is found that colour used for interior affects the perceived comfort of passengers. In addition to this it is also established that pilgrims especially elders prefer light colours for interior ambience. **Thus objective 2 of the research was fulfilled.** At the end of the research, it was found that coach manufacturers lack any proper knowledge about these facts and they simply select the colours according to the easiness of maintenance and sometimes according to customer(buyer) needs.

Objective 3: *To determine whether our drivers need to be trained for handling our fellow passengers while doing long distance journeys.*

This research found that the driver behaviour does affect the perceived comfort of the passengers while in a multi – day duration journey. And also, it is found that as the age of the driver increases, they succeeded to give the perception of feeling of comfort to their passengers. **Thus objective 3 of the research was fulfilled.** The details of the study are available in chapter 2.

Objective 4: *To investigate the suitability of our coach builders-built body buses, for using as long-distance travel particularly elders*.

This was perhaps the most important study. We found that there are many ergonomical issues existing in the present system and there is a need of some improvements in the present system to make it elder friendly. Issues regarding the entry, interior features, colour theme, seats, lavatory (or probably the lack of it) all makes it uncomfortable for the elders. **Thus objective 4 of the research was fulfilled.** The details of the study are available in chapter 2.

4.4 Thesis Novelty, Significance and Contributions

Outcomes of this work are the significant addition to the knowledge domain and design-development of transportation system based on buses particularly applied to Indian context. The novel contributions of the thesis are furnished below, pointwise.

4.4.1 Contribution to knowledge database

Establishing influence of colour theme used in the interior of the bus and perceived comfort of long-distance travellers.

Colour and its effect on the mindset of people was always an established fact. But whether the colour has an influence on the perceived comfort of long-distance travellers was not established. This work proposed that colour has an influence in the perceived comfort of the passengers particularly if they are undergoing long distance travel of multi days duration. Hence coaches designed for long distance travel must take this in to account. The colour preference of people also tends to differ based on the age group. The elders seemed to be preferring light colours for the interiors of the vehicle in which they are travelling.

Exploring the suitability of present bus design norms laid by the governments, for elders.

Although there are certain guidelines set by central government as well as various state governments, for bus design, the suitability of such guidelines for elderly people was not established as applied to Indian context. This work found that there are some issues faced by our fellow passengers while utilising such guidelines. One example was the step size for entry. The government guidelines state that the step size to be 40 cm but this research found that the ideal step size for elders would be 20 cm maximum.

Establishing a national reference database for hand grip strength of Indians

The hand grip strength of Indians was seemingly lacking and while designing controls such as seat movement controls, it would be helpful to people if the hand grip strength is considered. This is particularly applicable to elderly travellers, as with the increase in age the physical ability deteriorates. This work tried to establish a reference data for hand grip strength for Indians.

4.4.2 Contribution to bus design

Identified major comfort issues with elders while undergoing long distance travel, which can be used while designing future mobility systems.

This work identified the major issues relating the perceived comfort of elders while undergoing long duration travel. The focus areas for bus interior feature design for enhancing the suitability for elders were identified. The significant issues with present day design are also identified. Also, appropriateness of the some of the government guidelines for design of buses, for elderly passengers is also examined and found some issues. The specifically important areas while designing busses for conducted tours and pilgrimages were also identified and reported. Also, to increase the flexibility of such bus designs, the proposal for modular design concept is also made.

4.4.3 Contribution to the society

For any developing or developed country, a good and robust public transport is the backbone. The transport system based on buses is one of the most important one. Buses, apart from being used as a public transport system, also serves as the medium for mass transportation such as pilgrimages and conducted tours. But a devoted study to know the problems faced by the pilgrims especially observing the fact that the greatest majority of pilgrims are elders, was absent. The ergonomical problems faced by the passengers during multi-days travels in which they spent most of the time inside the same bus are more pronounced due to the fact that almost all the passengers fall under the higher age group. This study tried to investigate the same and came up with some of the design ideations, which we believe, would enhance the quality of travel and perceived comfort of elderly travellers.

It is established that our drivers need to be trained for addressing the problems faced by fellow passengers.

4.5 Limitations of the study

Due to the fact that the entire work was done amidst the pandemic issues, the extend of surveys was limited. We could consider only a few states in India for the study. Also due to the same reason it was not possible to carry machineries for quantitative measurement of different aspects. Hence, we used only “Schedules” and “Questionnaires” for the study.

Due to heterogeneous nature of buses used in India, it was not possible to take samples from every stratum of bus sizes, hence we focussed only on standard sizes generally used for conducted tours and pilgrimages, particularly in large groups.

The limitations are as follows;

1. Controlled air temperature buses were used – All buses used for survey were air conditioned. Only for observation study about the existing platforms, we considered non-air-conditioned buses together with AC buses.
2. Only limited to elderly pilgrims.
3. The only instrument used was questionnaire / schedule
4. Limited number of participants were considered because of the pandemic
5. Considered design safety guidelines only and no accident safety was considered.

4.6 Scope for Further studies

The aim of this work is to do a qualitative study about the existing issues concerned with long distance travel comfort for elders particularly pilgrims. Hence this work heavily relied upon on-field surveys, as the term comfort itself is subjective in nature. The core idea of this work was to identify the ergonomical problems existing with current buses when used as a medium for pilgrimages. Hence no particular issues were investigated deeply.

Also, it is found that colour affects individual's mental comfort while travelling. But a deeper study which uses correlation techniques can also be performed to reinstate this study.

Apart from this, if there are particular issues faced by physically handicapped people is needed to be examined further, though our entry system did consider them too.

The following are some of the areas and ideas suggested for future work.

1. EMG studies for quantifying different issues.
2. Studies involving all age groups.
3. All kinds of conducted tours can be included rather than pilgrimages
4. More subjective and objective measurement techniques can be used.
5. More number of participants can be considered to increase validity of present study.
6. Controlled environment studies can be performed for comfort aspect.
7. VR based ambience theme vs mood studies – For interior related studies like colour.
8. Acceleration / deceleration can be measured using devices such as V-Box etc. and quantify it to find out the extend of influence on comfort
9. Issues of "Divyangans (differently abled individuals)" can be studied separately.

The main limitation for future research is the heterogeneous nature of bus types in India. Possibly every state has different types of buses operating. In addition to this every state generates its own motor vehicle rules which also affects size and comfort levels of buses.

4.7 Conclusion

This was the first work to get a qualitative assessment done on the comfort issues faced by elderly people undergoing the long-distance travel such as pilgrimages. In the beginning after the deep study of the current status of work done in the selected field, we found that not much work has been done in the area of long-distance bus travellers comfort issues specifically for growing aged population in India. Pilgrimage in a group appears to be one of the areas affected with these issues. Any design intervention for a long-distance bus travel may add to a solution for this issue. So, we decided to study the existing comfort issues faced by fellow passengers doing pilgrimages in India. For that we did four main survey-based studies to develop design- intervention possibilities towards a schematic development with ergonomic issues in mind through a qualitative assessment of the needs of elder travellers and possible ways to address these needs.

After conducting the above-mentioned studies, we found that there exist some serious issues for the comfort of long-distance bus travellers particularly elders like pilgrims. It was observed that the studied buses did not have proper neck support, lumbar support, leg support as well as space for palm rest. As regarding to the interior colours, it is found that most of the pilgrims opted for lighter colours which creates peace and tranquillity rather than flashy energetic colours. Interior colour theme of long-distance buses greatly affects the perceived comfort of the passenger. Regarding the features and amenities needed by the passengers, there were a long list of demands from the passenger side. But among them, on board lavatories was the most important. Regarding the entry features, almost all the buses we studied, was found to be not so elder friendly as the step size was prohibitively high. Also, the in-vehicle space was not enough for free movement which is a need for bringing down some of the long-distance travel fatigue symptoms.

In addition to this we found that the behaviour of the driver plays an important role in the perceived comfort of the passengers while doing long duration travel.

Finally, a limited study to quantify the hand grip strength of individuals found that the hand grip strength of men and women has a decreasing trend when they reached the age of 50 and above. Also, the strength of men found to be more compared to women.

As a result of these studies, we found that there needs to be some design interventions in terms of bus interiors, seats, entry/exit system, as well as facilities and features needed. And with the same in mind, we proposed some design interventions for long distance bus design. The first intervention was concerned about seat design and then interior colour theme of buses. The interior features of the buses were also considered for design interventions. The optimum position for lavatory is proposed. And in order to meet the demand of various customers, tour operators and travellers, we proposed a modular design approach. By adopting a modular approach in the design, we can ensure that the same vehicle can be utilised to cater the needs of various customers.

After suggesting these interventions, we approached the coach manufacturers, and they expressed their hope and willingness to implement the ideas, provided the customer needs are met. For a full idea about the scope, a model manufacturing in line with the mentioned interventions is to be done.

This work met all the objectives set at the beginning of this work. The qualitative assessment of the needs and requirements of the fellow passengers are identified and some proposals to meet them are also made. We firmly believe that by this work, and if the recommendations are accepted, the aspect of quality of life perception of our fellow travellers doing long distance travel in buses for pilgrimages will be elevated, at least to some extent, as the perceived comfort rises.

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Survey -1 Questionnaire

The Survey- questionnaire

Serial no : Travel code:

Indian Institute of Technology Guwahati
Department of Design

Personal Interview Questionnaire

Survey done by : Chinmaya Krishnan G, RS - DoD
Date: / / 2020

Part - I
Respondent Details

Name : Contact:
Age : Sex: M / F / TG Married : Yes / No
History of any physiological / psychological problems : Yes / No Ht: cm Wt: Kg
Under any Medications :
Continuously travelled for : hours / Kms
Is travelling a hobby :

Part – II
Travel Details

How often you travel in buses for long distances :
Any particular problems that you face regularly while travelling :

Part – III
Seats

Aspect	Troublesome	Not Okay	Neutral	Okay	Comfortable
A . Seat system feedback	1	2	3	4	5
Back Support					
Lumbar Support					
Neck Support					
Head Restraints					
Thigh support					
Leg support					
Individual Hand rest					
B. Needed Improvements	1	2	3	4	5
Split leg support with independent movement					
Split leg support with single stretch movement					
Prefer soft cushioning					
Prefer supportive firm cushioning					

Serial no : Travel code:

Prefer rounded hand rest or straight hand rest : Rounded / Straight / Neutral
Prefer single piece or two piece leg cum foot rest : Single / Two / Neutral

Part – IV
Physiological problems and Accessories needed

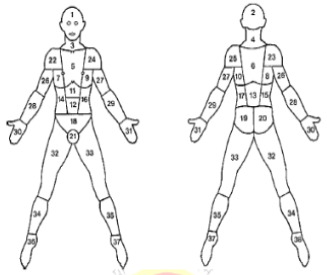
Aspect	Extreme Pain	Moderate Pain	Low pain	Slight discomfort	Absolute comfort
A . Pains	5	4	3	2	1
Upper Back					
Lower back					
Neck					
Head					
Thigh / hip					
Ankles / foot					
Elbow					
Shoulder					
Any other					
	Extremely needed	Needed	Good if it's there	Not sure	Not at all needed
B. Needed accessories / facilities					
Att. Water bottle					
Att. Medicine pouch /clutches					
Att. Coat hanger					
Att. Foot wear					
Att. Mobiles					
Split curtains					
Walking ramp					
Seat belt					
Floor lighting					

Part – V
Interior theme

1. Which type colour do you prefer for seats : light / dark / intermediate
2. Which type colour do you prefer for bus ceiling : light / dark / intermediate
3. Which type colour do you prefer for floor : light / dark / intermediate
4. Colour temperature preference for interior : Cool / Neutral / Warm
5. Do you believe that colour has an effect on your mental comfort : Yes / No
6. If yes what shade would you prefer :
7. Would you prefer playing any videos while travelling: Yes / No
8. What is your pick for video playback : Individual screens / One common Screen
9. Would you prefer a tinted window glass or plain glass: Tinted / Plain
10. Any other Information:

Serial no : Travel code:

Part VI
Pain Regions



Declaration

I, Mr./Ms./Mrs./Dr._____ from _____ have given the above data to the Department of Design, Indian Institute of Technology, Guwahati, for research purpose. I know that these data will be used for academic research purposes and the result of this study may be also used for commercial spinoffs. The data furnished above is true to the best of my knowledge, experience and belief. I know the institute will keep my personal details as a secret.

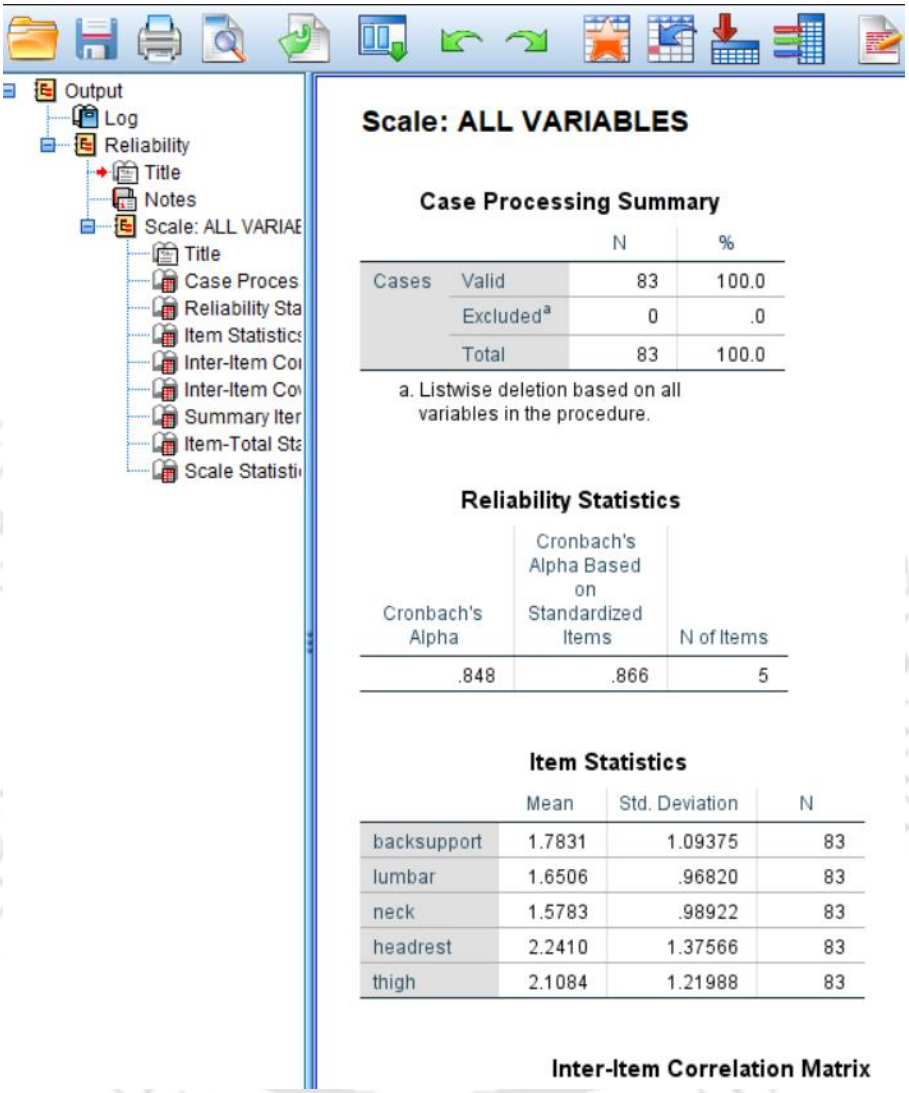
Date :
Place:

Signature:
Name:

Appendix - II

SPSS Results - A group of Screenshots

1. The reliability of questionnaire - Cronbach's Alpha for Study 1



Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	83	100.0
	Excluded[a]	0	.0
	Total	83	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

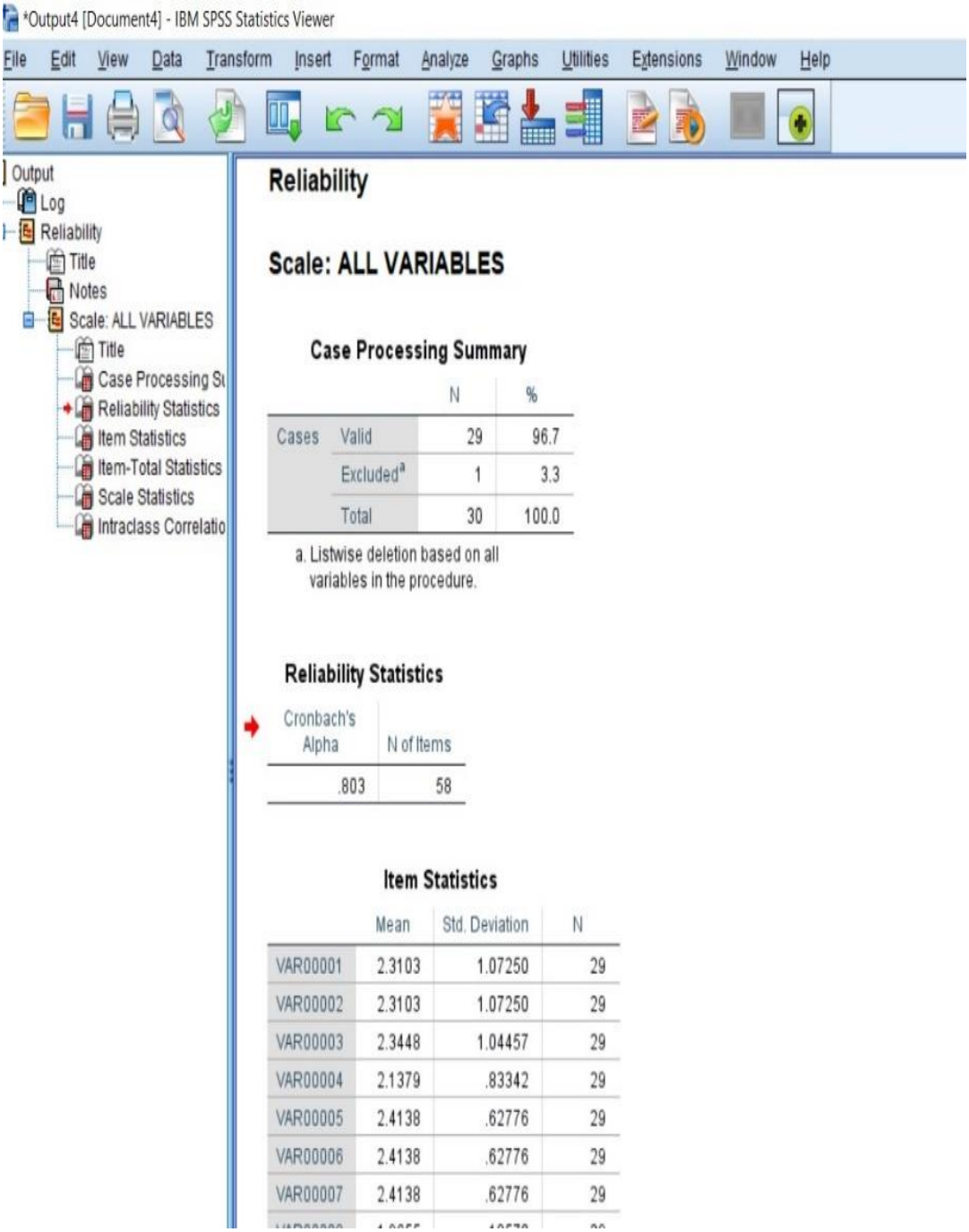
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.848	.866	5

Item Statistics

	Mean	Std. Deviation	N
backsupport	1.7831	1.09375	83
lumbar	1.6506	.96820	83
neck	1.5783	.98922	83
headrest	2.2410	1.37566	83
thigh	2.1084	1.21988	83

Inter-Item Correlation Matrix

2. The reliability of questionnaire - Cronbach's Alpha for Study 2 – Driver feedback

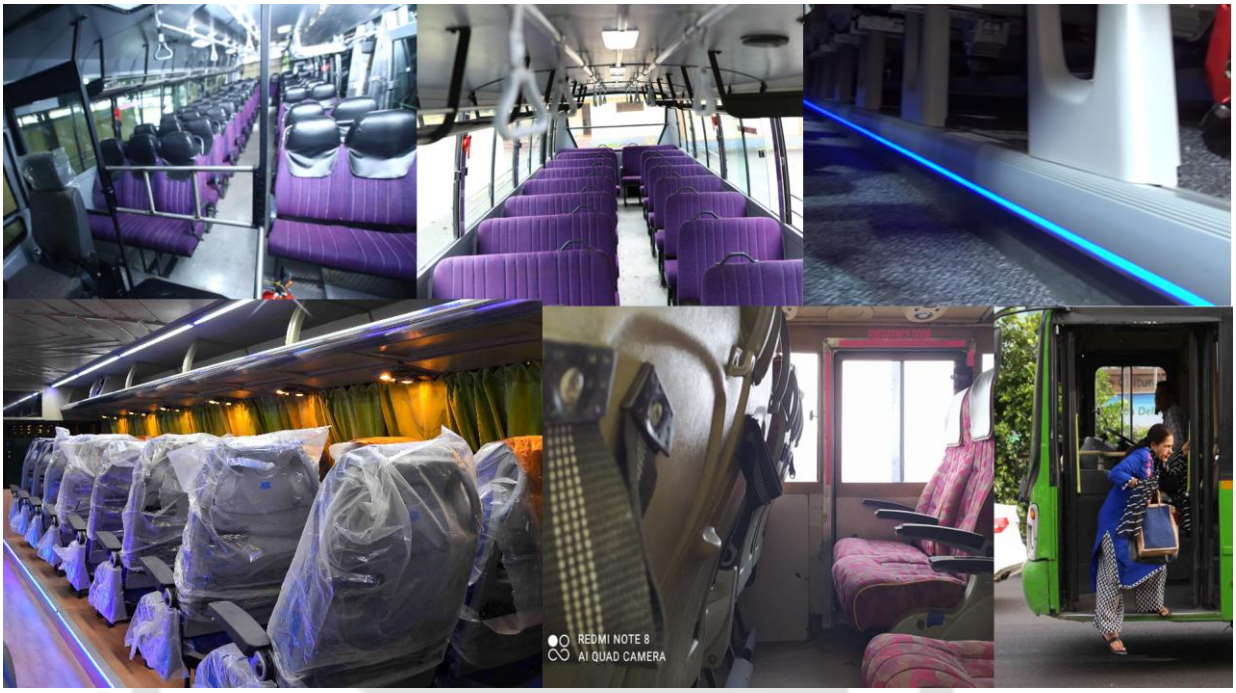


Appendix – III

Sample images of Survey-1

Appendix – IV

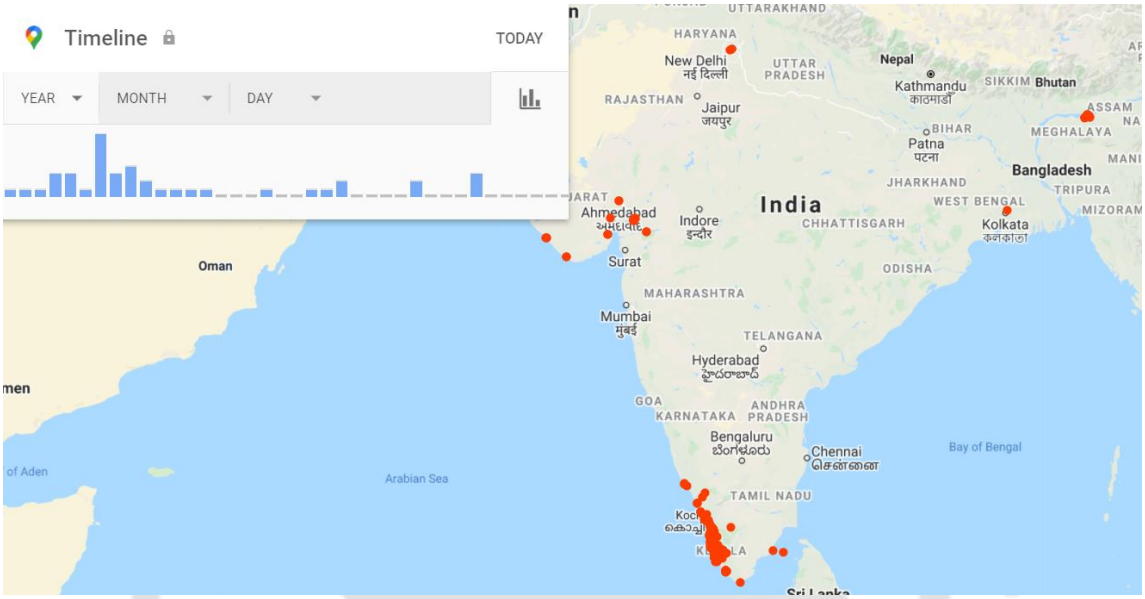
Sample images of Survey – 2, Bus interior.



Hand grip survey underway, Survey - 3

Appendix – V

Google timeline travelled (red dot areas covered) for the surveys



Chapter 2
Factors to Look into for Designing Interiors of Long-Distance Pilgrimage Buses in India: A Survey-Based Study

G. Chinmaya Krishnan and Debkumar Chakrabarti

Abstract There are not many differences in buses used for long journeys for pilgrimage purposes, with a common deluxe bus as regards to interiors. Passengers of different attitudes and comfort perceptions do differ. On inquiry to pilgrims and tour organizers in a preliminary investigation, it was noticed that sufficient attention is required to be given while designing the interiors of such public carriers but not much attention is paid so far, and no specific study was also carried out, and normal buses with need-based modifications are being used. This may be due to the lack of in-depth knowledge about vehicle design, vehicle ergonomics, etc. and the lack of sufficient financial strength of these body building companies to employ knowledgeable persons. This study aims at understanding the critical factors affecting passenger physical comfort as concerned with interior aspects of buses for long journeys. The scope of the study is limited only to the buses operating under pilgrimage activities. The survey was done to find out those factors, and the samples were taken from Vrindavan, Dwaraka and Somanatham. The pilgrims were selected based on purposive and random sampling as the target respondents were mostly senior citizens for whom the concept of comfort and fatigue is pronounced. Questionnaires and meeting observations were used to have their views on physical comfort, accessories and other facilities, seating considerations, the place for movements, etc. The study finds certain issues that appear to be vital for designing long-distance pilgrimage purpose buses.

2.1 Introduction

In a country like India, which holds the distinction of having the most vibrant culture on earth and a philosophy that is extremely inclined towards the spirituality, one of

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2021 HWWE
Humanizing Work and Work Environment
ABSTRACT BOOK
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Driver Behaviour as An Influential Factor for Enhanced Long Distance Bus Travel Experience as Applied to Elders Doing Pilgrimages – A Survey Based Study

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Abstract: One of the most influential factors for the overall satisfaction of long distance bus travellers is the interaction between passengers and drivers. This paper tries to find an answer whether our drivers really aware of the needs, apart from their professional (driving) training, on behavioural issues especially attitudes towards their passengers particularly elders' requirements. An ergonomic survey was conducted on 30 long journey pilgrim buses of different routes with a total journey duration of 2-7 days continuous with night halts en-route and per day travel time of 6-10 hours with mini breaks in between. A set of questions was floated to find answers related to four different aspects viz.1) satisfactory driver behaviour (cordial and interactive), 2) Do the drivers are well versed about the journey details and destinations. 3) Willingness to help on various issues as and when required and, 4) Comfortable and smooth drives without jerks while accelerating and decelerating, and was enquired on 30 passengers for each driver (selected with purposive random sampling). The number of drivers was also 30. Hence in total 900 respondents were surveyed. Responses were recorded with a five-point Likert scale towards framing a possible behaviour guideline. The results suggest that a set of remedial knowhow to handle psycho-social and physical issues relevant to elderly passengers can be framed out and drivers may be given refresher training on special care requirement; It is expected to enhance rejuvenation of travelling spirit in spite of the gradual deterioration of physical capability of senior pilgrims.

Keywords: Long distance bus travel, driver behaviour, elderly pilgrims, inclusive bus travel

Paper 3 Published as a book chapter in ACED SEANES 2020

Colour preference for bus interiors doing pilgrimages – A survey based study

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Abstract: Colour and its effects on human mind have always been a fascinating area of research for decades. Plenty of research outputs are available in these areas too. The colours and its effects on human psychology is of paramount importance to designers too. Especially in the case of automotive designers, the colour and its effects are of extreme importance while designing the interiors as users spent a considerable time inside the vehicles. While vehicles such as cars and all are designed with these factors in mind, large commercial vehicles such as buses may not have considered these aspects. This is primarily due to the fact that in India, majority of buses are not coming with factory fitted bodies but instead they use bodies built by coach builders. The problem with these body builders is that they are focussing more on low cost rather than any cognitive ergonomical aspects. This study aims to find out the most preferable colour system by fellow passengers particularly pilgrims, the perception of mental comfort. The study uses open ended questionnaire survey with around 83 respondents from all parts of India. It tries to find the preferable colour for seats, ceiling, floor and window glasses.

Keywords: Bus interior design, cognitive comfort, colour psychology

Introduction

Colour and its influence on the mental comfort of an individual or user is always been a research area for many. Colour has a very influential role in design. Be it product design scenario, or social media user interface design [1], or game design [2] or any modes of design the colour and the effects of it on the emotional responses of human [3] is a fascinating area. Even virtual reality based studies have been performed to analyse the colour and its effects on human mind [4]. There are a number of articles and research papers available worldwide about colours and its intriguing nature. This was known to mankind centuries ago, and India was no exception. A country with a vibrant culture was always known to be using the colours in the most effective way and texts like "chitrasutra" proves it. However, the complex nature of colures and its effect on human being is still a fascinating area of exploration. In what way colours have an effect on the mental comfort of individuals is a major concern of designers, be it the architects, interior designers, or automobile designers. Automobile designers while designing the vehicle interior design gives paramount importance to colours and its selection. As majority of the time, the traveller spends inside the vehicle, the selection of interior colour is of great priority. All the major automobile manufacturers have proper research

Paper 4 Published as a book chapter in ACED SEANES 2020

Cognition in Place: Dialogues of Architecture and Identity

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Abstract. A sense of place is seen as natural. Some consider the sense of place as a survival instinct, while others believe it to be a territorial instinct. Environmental psychologists argue that physical settings play a significant role in creating an image of a place in the minds of their users. The built environment of an area has a substantial impact on the creation of the identity of that place. In cities of architectural value, the built environment shapes an image of the city in the minds of residents and visitors. According to Kevin Lynch, a city can be imagined by its residents by five elements, namely, paths, edges, districts, nodes, and landmarks. The tourism business can extract the image created at these locations and market it to strengthen the identity. This paper summarises a study done in Bikaner, India, a city famous for its historic buildings and traditional food. Thirty- five people were enquired about the identity of the city and how they relate to it. The results show that the architecture of the city plays an essential role in creating a place identity.

Keywords: Architectural Identity, Cognition, Place Identity, Bikaner.

1 Introduction

Architecture is a medium for place identity creation. Places are doubly constructed: most are built or, in some way, physically carved out. They are also interpreted, narrated, perceived, felt, understood, and imagined. The relationship between people and the environment is a field of study for environmental psychologists. Place attachment is described as the feelings we acquire towards places with great familiarity, places we belong to and have an affinity with. When place attachment grows, we start to identify ourselves with the place, both on a larger scale (nationality, city, etc.) and at a smaller scale (neighborhood, homes, or rooms). This heightened attachment results in self-concepts based on places.

Paper 5 : Waiting for reply from journal “Ergonomics”

A population-based pilot study on the hand grip strength for an age and gender stratified data of Indians

Krishnan C & Chakrabarti D

Abstract: The purpose of this study is to collect the comfortable and maximum hand grip strength of bus travellers aged above 18 years, so as to serve as a reference while designing the various controls generally used by passengers such as seat movement controls, sliding of window glasses etc. The secondary purpose of the study is to cater as a national data of the same and to compare the Indian data with some of the other country data. We took 308 (n=308) eligible participants (purposive and random sampling) form 9 Indian states and took three measurements each for left and right hands and calculated the average. The BMI was also calculated. The subjects were divided based on the gender and age groups. The results of men were showing an initial rise of hand grip strength till the age rise to 30-39, for comfortable values, and then a decline of the same as the age progresses. The comfortable values show a sharp decline than maximum hand grip strength value. Also, women show comparatively lesser hand grip strength than men within the same age group.

Keywords: *Hand grip strength, age and gender stratified data, Bus design*

Paper 6: Waiting for reply from journal "Ethics, Medicine and Public Health "

Human Factor Issues of Long-Distance Bus Travel in India – A Study done on Pilgrims and Conducted Tour Travellers

Krishnan C & Chakrabarti D

Abstract: The systematic development of our society has introduced major changes, as well as formed new and wide-ranging opportunities. One substantial factor for the progress of any society is the establishment of good public transport system. research in the transportation arena has always been a fascinating area for researchers for decades. But the main considerations remain as the cost and easiness of maintenance. Proper designs with adequate attention to ergonomic aspect is still missing as majority of these third-party bus body manufacturers own only a bare basic team of fabricators and lacks designers with proper know-how of ergonomics. The primary idea behind this study is to throw some light in to the existing ergonomical issues or problems in the long-distance travel using buses, especially for elders. The principal tool used for this study is survey. Through a concept development survey, the basic ideas regarding the existing problems and issues with long distance travel comfort, is established. The study addresses physical ergonomical issues such as traveller physical fatigue and comfort issues, as well as mental comfort issues with respect to interior colour themes used in the buses and its effects on the mental or perceived comfort of the passengers. Apart from this the effect of driver behaviour on the perceived comfort of the fellow passengers is also considered. Based on these studies some suggestions and recommendation are also made with some possible design interventions such as optimum position of toilet in buses, proposal for a modular approach for bus interiors etc.

Keywords*: Bus design, Traveller's Comfort, long distance travel issues, Passenger fatigue*