TO EVALUATE THE LEVEL OF SERVICE BASED ON PASSENGER BEHAVIOUR: CASE STUDY OF CHARBAGH RAILWAY STATION, LUCKNOW

A Project Submitted

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by

SHREYA GAUR

(University roll No. 1200106018)

Under the Guidance of

PROF. MOHIT K. AGARWAL

AND

AR. SAURABH VERMA

BABU BANARASI DAS UNIVERSITY

LUCKNOW

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DECLARATION

I, **SHREYA GAUR,** Scholar No. **1200106018** hereby declare that the thesis titled **"TO EVALUATE THE LEVEL OF SERVICE BASED ON PASSENGER BEHAVIOUR: CASE STUDY OF CHARBAGH RAILWAY STATION, LUCKNOW",** submitted by me in partial fulfilment for the award of **Masters in Urban and Regional Planning,** at School of Planning and Architecture, Bhopal, India, is a record of bonafide work carried out by me. The matter/result embodied inthis thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

Signature of the Student

Date: 3 MAY ,2022

Certificate

This is to certify that the declaration of SHREYA GAUR is true to the best of my knowledge and that the student has worked under my guidance for one semester in preparing this thesis.

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Signature of the Guide

(Mr. Saurabh Verma) (Mr. Mohit Kumar Agarwal)

ACCEPTED

Signature of Signature of	Signature of Signature of
Head, Department of Planning	Dean (Academic Affairs)
Date:__________ Place:________	Date:_______ Place:______

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ABSTRACT

A public transport interchange is one of the most important system in urban transport. An Interchange is defined as the node where different transport modes cumulate. On the onset of the 21st century, the travel behavior of the passengers changes a lot, as we saw massive migration from smaller urban regions to larger one as well as when urban cities merge together, the distance of travel increases,and thus cities need more efficient and optimal modes of travel to connect. The concept of transport interchange thus play a very decisive role in making these systems work in proficient manner, by reducing the travel time and distance. This thesis will endeavor through this system and its service levels impact based on thepassengers behavior. Passengers behave differently based on the type of luggage they are carrying, their age, and gender. Passenger behavior is one of the most imperative component of this study. For evaluating behavior, level of service for passengers with different parameters were studied. Site was selected based on the availability of different modes and passenger footfall. the sites is Lucknow Charbagh .A system of surveys were set and deployment schedule was created to record data for interchange system during peak hour for the locations. The data is then further organized and analyzed based on passenger behavior at different travel modes and Interchange and Level of services are set up, which willhelp in evaluating the service levels on 7 parameters and 6 levels. These 7 parameters are Age, Gender, Luggage, speed, Density, Flow, and Space. A methodology is developed to unify the passenger behavior in one and termed as PEF (Passenger Equivalent Factor) which is then used in evaluating the Level of service. While levels are basically categorized in A, B, C, D, E, F; where A, B are overdesigned, C is optimally designed, D is Sub-Optimally designed and E, F are Under-designed. The Interchange pathway will then be tested on these and inferences will be carved out. The inference will guide us to understand the currentstate of interchange and the need to intervene and to optimize its operations. Apartfrom understanding Level of service a Benz model theory is also studied which relates the space and time. Space and time is one of the most important output of this study which actually gives us the need of space during peak and will also helpin identifying whether the interchange system is operating on the optimize space.

Thus two theories are used in a way to make double check on the optimal space requirement of the interchange. Walkability index is also evaluated and based on the inferences, the quality of the system walkable areas are identified. The proposals are based on the credible analysis and the inferences which are jotted from the above said study. These proposals will enhance the operational capabilityof the whole system at both the study sites. The main objective of this study to device a methodology which can be incorporated for the upcoming Greenfield interchange systems around the country and also in retrofitting already existing interchange system.

Keywords: Interchange, Level of Service, Passenger Behavior Parameters, PEF (Passenger Equivalent Factor)

सारांश

सार्वजनिक परिवहन इंटरचेंज शहरी परिवहन में सबसे महत्वपूर्ण प्रणालियों में से एक है। एक इंटरचेंज को नोड के रूप में परिभाषित किया जाता है जहां विभिन्न परिवहन मोड संचयित होते हैं। 21वीं सदी की शुरुआत में, यात्रियों का यात्रा व्यवहार बहुत बदल जाता है, क्योंकि हमने छोटे शहरी क्षेत्रों से बड़े पैमाने पर प्रवासन देखा और साथ ही जब शहरी शहर एक साथ विलय हो जाते हैं, तो यात्रा की दूरी बढ़ जाती है, और इस प्रकार शहरों को और अधिक की आवश्यकता होती है। कनेक्ट करने के लिए यात्रा के कुशल और इष्टतम तरीके। परिवहन इंटरचेंज की अवधारणा इस प्रकार यात्रा के समय और दूरी को कम करके इन प्रणालियों को कुशल तरीके से काम करने में एक बहुत ही निर्णायक भूमिका निभाती है। यह थीसिस इस प्रणाली के माध्यम से प्रयास करेगी और इसके सेवा स्तर यात्रियों के व्यवहार के आधार पर प्रभाव डालेंगे। यात्री जिस प्रकार का सामान ले जा रहे हैं, उनकी उम्र और लिंग के आधार पर अलग-अलग व्यवहार करते हैं। यात्री व्यवहार इस अध्ययन के सबसे अनिवार्य घटकों में से एक है। व्यवहार के मूल्यांकन के लिए, विभिन्न मानकों वाले यात्रियों के लिए सेवा के स्तर का अध्ययन किया गया। विभिन्न साधनों की उपलब्धता और यात्रियों की संख्या के आधार पर दो स्थलों का चयन किया गया। दोनों स्थल दिल्ली में हैं, पहला दक्षिणी दिल्ली में सराय कालेन खान है और दूसरा पूर्वी दिल्ली में आनंद विहार है। सर्वेक्षण

की एक प्रणाली निर्धारित की गई थी और दोनों स्थानों के लिए व्यस्त समय के दौरान इंटरचेंज सिस्टम के लिए डेटा रिकॉर्ड करने के लिए परिनियोजन अनुसूची बनाई गई थी। फिर डेटा को अलग-अलग यात्रा मोड में यात्री व्यवहार के आधार पर व्यवस्थित और विश्लेषण किया जाता है और इंटरचेंज और सेवाओं के स्तर की स्थापना की जाती है, जो 7 मानकों और 6 स्तरों पर सेवा स्तरों का मूल्यांकन करने में मदद करेगी। ये 7 पैरामीटर आयु, लिंग, सामान, गति, घनत्व, प्रवाह और स्थान हैं। एक में यात्री व्यवहार को एकीकृत करने के लिए एक पद्धति विकसित की जाती है और इसे पीईएफ (यात्री समकक्ष कारक) कहा जाता है जिसे तब सेवा के स्तर के मूल्यांकन में उपयोग किया जाता है। जबकि स्तरों को मूल रूप से ए, बी, सी, डी, ई, एफ में वर्गीकृत किया जाता है; जहां ए, बी को ओवरडिजाइन किया गया है, सी को बेहतर तरीके से डिजाइन किया गया है, डी को सब-ऑप्टिमली डिजाइन किया गया है और ई, एफ को अंडर-डिजाइन किया गया है। फिर इन पर इंटरचेंज पाथवे का परीक्षण किया जाएगा और निष्कर्ष निकाले जाएंगे। निष्कर्ष हमें इंटरचेंज की वर्तमान स्थिति और हस्तक्षेप करने और इसके संचालन को अनुकूलित करने की आवश्यकता को समझने के लिए मार्गदर्शन करेगा। सेवा के स्तर को समझने के अलावा एक बेंज मॉडल सिद्धांत का भी अध्ययन किया जाता है जो स्थान और समय से संबंधित है। अंतरिक्ष और समय इस अध्ययन के सबसे महत्वपूर्ण परिणामों में से एक है जो वास्तव में हमें चरम के दौरान स्थान की आवश्यकता देता है और यह पहचानने

में भी मदद करेगा कि इंटरचेंज सिस्टम इष्टतम स्थान पर काम कर रहा है या नहीं।
इस प्रकार दो सिद्धांतों का उपयोग इंटरचेंज की इष्टतम स्थान आवश्यकता पर दोबारा जांच करने के लिए किया जाता है। चलने योग्यता सूचकांक का भी मूल्यांकन किया जाता है और अनुमानों के आधार पर, सिस्टम चलने योग्य क्षेत्रों की गुणवत्ता की पहचान की जाती है। प्रस्ताव विश्वसनीय विश्लेषण और उपरोक्त अध्ययन से निकाले गए अनुमानों पर आधारित हैं। इन प्रस्तावों से दोनों अध्ययन स्थलों पर पूरी प्रणाली की परिचालन क्षमता में वृद्धि होगी। इस अध्ययन का मुख्य उद्देश्य एक ऐसी कार्यप्रणाली तैयार करना है जिसे देश भर में आगामी ग्रीनफील्ड इंटरचेंज सिस्टम के लिए शामिल किया जा सके और पहले से मौजूद इंटरचेंज सिस्टम को फिर से तैयार किया जा सके।

कीवर्ड: इंटरचेंज, सेवा का स्तर, यात्री व्यवहार पैरामीटर, पीईएफ (यात्री समतुल्य कारक)

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CHAPTER - 1: **INTRODUCTION**

1.1 Background

Intermodality is an integral part of the sustainable mobility, and its enhancement is of vital importance mainly, in high congested transit hubs as their efficient design could lead not only to the increase in the share of commuters who use urban public transport but also to the consolidation of the overall public transport system. Each terminal should meet specific design standards according to its type since inadequate planning and design and inefficient way of operational management can cause long delays and malfunctions in travelling.

Inter-Modal Stations: Inter-modal stations deliver connections from one transit station to other modes of public transportation, including bus, rail transit, and metro transit systems.

In interchange, there are multiple public transport systems merging. Each interchange between two have passengers of different characters and parameters. For example, an interchange between a regional system and city transit system is different from systems that are intra city only, therefore, representing multiple options and combinations of transit systems with different characteristics. It will help in developing a model that will help further for future multimodal transit hub planning.

1.2 Need for the Study

Passengers are one of the essential constituents of the transport system, in a multimodal transit system, different modes were interconnected through an interchange. These interchanges are designed to handle specific capacity, which eventually impacts the utility of the whole system. Here the efficiency counts for time and distance. Seamless travel can be achieved only when facilities provide efficient space to the passengers, which are rarely observed in the Indian context.

The interchange is an essential interconnection within a system. In India, there are no planning norms that govern the space and mobility of passengers. As of now, the manual for railway station still follows J. J. Fruin's level of service space norms, which do not account for passenger behavior in a specific space. There is a need to find the parameters which will impact passenger behavior in different situations as it varies accordaing to their character, dimension, etc. These parameters are then analyzed to see the impact on passenger behavior and which all parameters have a significant impact on the interchange. The study will help to evaluate the passenger behavior model and space planning norms, which can be used for the Greenfield development of the interchanges.

1.3 Research Question

1. Whether the followed Level of service guidelines is ideal for passenger flow?
2. If not, which attributes of the passenger behavior impact their flow?
3. What should be the New Level of service of an interchange according to passenger parameters?

1.4 Aim

To evaluate the level of service based on passenger behaviour parameters at an interchange.

1.5 Objective

1. To study the attributes of passenger behaviour.
2. To assess the parameters impacting the interchange.
3. To assess the current structure of interchange and interconnectivity within all the system
4. To evaluate the current level of services for the existing interchange
5. To develop the capacity norms for the passengers at the interchange in terms of new level of service

1.6 Scope

- To determine the Level of Service for evaluating the pedestrian connectivity in an interchange, which will result in enhancing passenger accessibility.

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1.7 Limitations

- The research is limited to passenger behaviour study of transfer zone only.
- Vehicular movement is not taken into consideration.

1.8 Methodology

In order to examine and understand the approach and passenger behaviour impact on interchanges several methods will be used which will help further to evaluate and formalize the level of service at multimodal transit interchange.

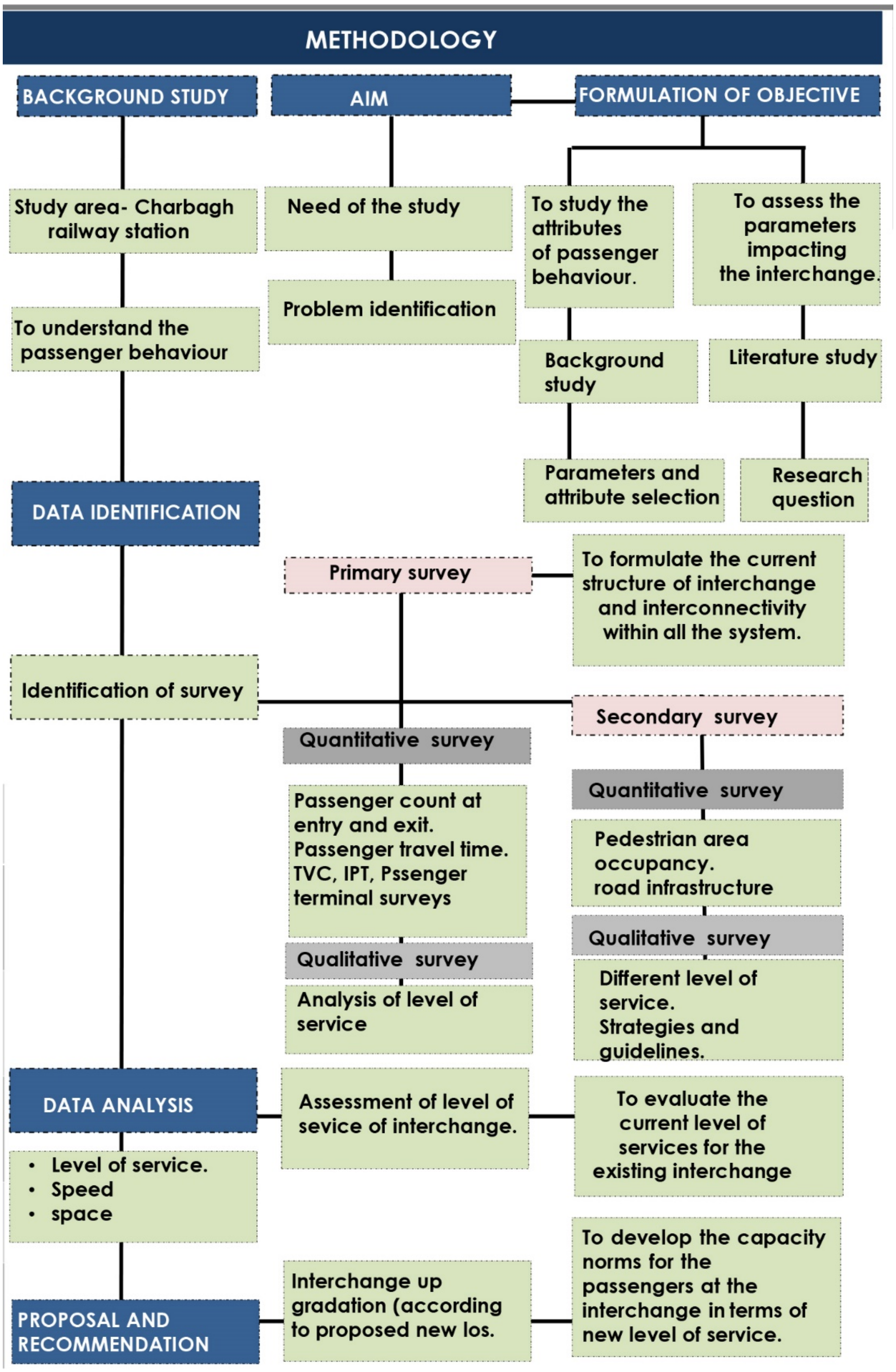


Figure 1. 1 methodology

The research framework has been divided into 3 stages in which first stage consistof background of the study which focuses on the introduction to the topic, problemstatement, aim, objective, scope, limitation and literature review. Literature review

is further divided into two parts consisting of background study and best practices. Best practices are taken for selection of parameters which affects the pedestrian behaviour.

Second stage focuses on data identification / data collection which consist of primary and secondary survey. Primary data consist of reconnaissance survey, passenger count at entry & exit gates/ points of different modes, passenger travel time, commuter's origin & destination survey. Secondary data collection consist of commuter's ticket sale data for each entry/ exit gate for all terminals within an interchange.

Third stage consist of data analysis of data collected from various survey according to passenger speed, pedestrian flow rate, pedestrian space and density according to passenger type. These factors will help to assess the existing level of service within an interchange and further develop planning capacity norms.

Fourth and last stage is to propose new level of service according to newly defined PEF (Passenger equivalent factor) and give required proposal for interchange up gradation.

1.9 Thesis Outline

Study conducted on Evaluation of Passenger Behaviour Parameters at an Interchange is undertaken in this thesis through 6 chapters. The initial chapter give an overview of the research followed by the case study information and data analysis. The later chapters explain the analysis and the results followed by conclusions and scope for future work.

Chapter One - This chapter forms the research background and set the objective of this research.

Chapter Two - Presents a review of the past literature related to studies on Level of Service and passenger behavior parameters. The review of literature mainly gives an overview and discusses different case studies conducted for the evaluation and implementation of Level of service and passenger affecting parameters.

Chapter Three – This Chapter reflects about the city profile of the study area. Itdiscusses various physical characteristics of the city.

Chapter Four - Provides details of the data collection process followed for conducting the primary and secondary survey.

Chapter Five – This chapter highlights the data analysis process for various surveys and discusses the key issues that are observed in the study area.

Chapter Six - Discusses the results obtained from the case study and presents various design interventions to resolve the major issues in the study area as well as a model for the successful implementation of newly defined Level of Service forGreenfield and Brownfield Projects.

Therefore we conclude this chapter with a clear vision of the framework and methodology of the study. This chapter establishes the need for the study which was based on an extensive research into various case studies and literature available and projects associated with in. In Chapter 2 we shall further discuss more about literature and different case studies to obtain a thorough knowledge and understanding of the same.

CHAPTER - 2: **LITERATURE STUDY**

Since the study is based on the evaluation of passenger behavior parameters to assess the level of service at an interchange, therefore different definitions, accessibility and capacity parameters are studied.

2.1 Multi-modal Interchange

A Multimodal Interchange hub is one in which co-ordination and integration of different modes of transport take place to decongest road, reduce journey time, enhance the environment, and provide greater convenience for commuters, efficiency and cost-effectiveness.

The act of changing between modes - **Interchange**
The place where one changes the modes - **Interchange Zone**
A purpose-built facility to improve interchange quality - **Interchange facility**

When more than one mode is involved, each mode provides “access” to the next in a chain, the term ‘multimodal’ is used to represent the system with more than one mode, and the term ‘intermodal’ to represent the connection between any two of these elements i.e., transfer from railway station to metro station, bus terminal to auto/cab etc.

2.1.1 Benefits of Multi-modal Interchange are as follows:

- It creates better connections between available modes of transportation.
- Creates a balance between all forms of alternative transportation
- Avoid mass transit interruptions, by allowing easy transfer between modes
- Allow expansion for new forms of transportation and other revenue-generating opportunities
- Remove people’s dependence on automobiles, thereby alleviating theinterstate system

2.1.2 Components of Multi-modal Interchange are as follows:

Waiting time: This is defined as the duration between the user's arrival to a transport terminal and the actual entry into the vehicle of the mode in question.

In-vehicle travel time: This is the duration of time on the vehicle.

Transfer time: This is defined as the duration between one getting out of the previous mode and arriving at the entrance point of the following mode.

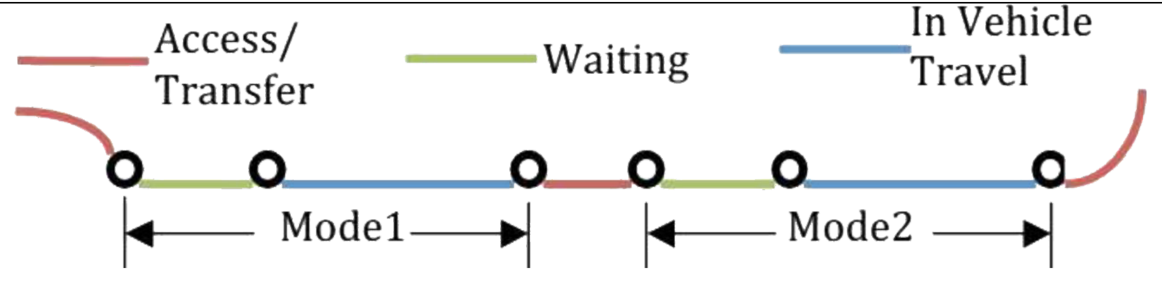


Figure 2 Components of Multi-modal Interchange

Figure 2. 1 components of multi modal interchange

Multi-modal interchange delivers connections from one terminal to other modes ofpublic transportation including bus, light rail transit, people movers, and metro transit systems. Design considerations may include: (India, 2009)

Accommodation of large numbers of passengers with baggage

Accommodation of large peak passenger movements associated with othermodes

Moving walkways (travelators) to assist customers and reduce travel time overlong (i.e., > 153 m) distances

Connections that may require extensive renovation to existing facilities

Connections that may require extensive renovation to existing intermodalfacilities.

2.2 Pedestrian level of service

A transit station's important objective is to provide adequate space and adequate facilities to meet projected peak pedestrian demands while ensuring pedestrian safety and convenience. It has been observed in early studies transit stations were designed on the maximum passenger capacity and not based on comfort. Some research has shown that capacity is reached when there are very dense crowding and passengers causing congestion and lead to the system failure (Kittelson & Associates, Transit Cooperative Research Program, & Transit Development Corporation., 2003)

The capacity estimation procedures presented are based on a relative scale of comfort and convenience for pedestrians. Pedestrian capacity and service level.

The level of service under different operating characteristics and volumes of traffic can be derived from a road & structure. It is possible to list the factors affecting the service level (LOS) as follows:

- Speed and travel time
- Traffic interruptions/restrictions
- Freedom to travel with the desired speed

Pedestrian service levels offer useful means of assessing the performance and comfort of an active pedestrian area. Pedestrian LOS walking thresholds are based on the freedom to choose the desired moving speeds and the ability to circumvent slow-moving paths.

Other considerations concerning pedestrian flow include the ability to cross a footpath, walk the other way round a large footpath and maneuver without conflicts with other feet or changes in walking speed. Service levels for queuing areas rely on standing space available, perceived comfort and safety and the ability to handle between locations.

Since the pedestrian LOS is based on the number of available pedestrian areas, LOS thresholds can be used to indicate desired design functions such as platform size, step count and width, corridor width, etc.

(Fruin, 1971) Pedestrian facilities should be designed on the basis of qualitative as well as quantitative factors. The capacity of a pedestrian traffic stream invariably occurs at the heaviest concentrations combined with restricted walking speeds. The level-of-service concept for highway design contained in the Highway Capacity Manual (2) offers a model approach to the design of pedestrian ways as well. The manual describes six levels of design ranging from A to F based on service volumes, volume/capacity ratio, and a qualitative evaluation of driver convenience. Pedestrian level-of-service standards similarly should be based on the freedom to select desired walking speed, the ability to bypass slower-moving pedestrians, the ease of crossing, and the presence of reverse flow at various traffic concentrations.

The Traffic Engineering Handbook makes use of a 2-ft wide pedestrian lane for design purposes. On the basis of human shoulder breadths, this might be considered a valid assumption. In free-flow conditions, most pedestrians prefer to avoid contact with others and therefore adopt larger inter-person spacing. Natural spacing in the traffic stream also determines the ease of overtaking and passing other pedestrians. To determine these natural spacing under different traffic concentrations, inter-person distances were measured. Level-of-service standards for walkways are described.

Table 1 Level of service for pedestrians	
Level of Service defined by J.J.Fruin (1971)	
Level of Service A	Equivalent to an average pedestrian area occupancy of 35 sq. ft. per person or greater
Level of Service B	Equivalent to an average area occupancy in the range of 25 to 35 sq. ft. per person
Level of Service C	Equivalent to an average area occupancy in the range of 15 to 25 sq. ft. per person
Level of Service D	Equivalent to an average occupancy in the range of 10 to 15 sq. ft. per person
Level of Service E	Equivalent to an average area occupancy in the range of 10 sq. ft. per person
Level of Service F	Equivalent to an average area occupancy of 5 sq. ft. or less per person
Source: J.J.Fruin's PLOS	

Figure 2. 2 level of service pedestrain

(Ashford, 1988) The concept of level of service has been developed by planners and designers to provide some degree of sensitivity in the processes of design and capacity analysis for transport facilities. The level of service analysis provides, to some degree, a measure of the comfort and convenience experienced when operating at the various levels of design and service volumes which could be experienced at any particular facility.

The earliest forms of highway capacity analysis defined capacity in three ways. Basic capacity was the maximum number of passenger cars that could pass a given point on a roadway in one hour under ideal road and traffic conditions. Possible capacity was denned as the maximum number of vehicles that could pass a given point during one hour under prevailing road and traffic conditions. Practical capacity was the maximum number of vehicles that could pass a given point. without the traffic density being so great as to cause unreasonable delay, hazard or restriction to the driver's freedom to manoeuvre under the prevailing road

The level of service is dependent on ease of flow and freedom of movement. The criteria on which these could be evaluated were:

The ability of an individual driver to choose his speed.

Ability to overtake.

Ability to manoeuvre in the traffic stream.

Tools and techniques including planning balance sheets (Paquette, Ashford and Wright, 1982), decision effects matrices as used for the Atlanta Hartsfield design, matrix evaluation sheets (Baltimore Washington BWI) and the Emphasis Curve Technique (Hong Kong Airport), mainly deal with overall design evaluations. Threedifferent classes of passenger activity are considered: processing, holding and circulation/mode transfer.

Level of service standards have been set but these are essentially straightforwarddesign and operational criteria which give no indication of sensitivity to overload conditions

Most airports that have set performance standards (such as queuing time, bag delivery time, etc.) have some form of performance monitoring procedures. Theseprocedures if pooled and linked to passenger perception of service can form the basis of a much more comprehensive level of service construct developed on bothnational and international data.

(Magda Pitsiava-Latinopoulou, 2012) Talks about how the provided level of service of Intermodal passenger facilities affects the commuter's behaviour regarding the modal choice. To achieve the objective categorization of the variousterminals is done, considering their specific characteristics in terms of the means that they serve as well as the commuters that use them, in order to establish general design rules for each category. In this categorization, all urban and suburban Intermodal public transport Terminals, as well as Intermodal Terminals between means of public transport and private cars (Park and Ride facilities), were considered. After that a case study was executed based on a kind of a Revealed Preference Survey for the Intermodal Terminals of the city of Athens, in order to examine the impact of their operation on the number of interchanges between thevarious transport modes.

In case study various categories of terminals were examined through a questionnaire survey and site observations. The survey shows that the majority ofpassenger transfers takes place among the most collective means of transport

(metro, suburban rail, tram and urban buses), with the number of transfers between public transport modes decreasing in accordance with their interoperability. The results of the study show that the location of a terminal in a central area with the appropriate adjacent environment results in increased local access by foot.

2.3 Pedestrian capacity terminologies

Terms used in this chapter for evaluating pedestrian circulation are defined as follows: (Kittelson & Associates, Transit Cooperative Research Program, & TransitDevelopment Corporation., 2003)

2.3.1 Pedestrian capacity:

The maximum number of persons that may occupy or pass through a footpath ora feature, expressed as persons per area unit or persons per time unit. Both a maximum capacity that reflects as many people as possible that can pass throughand a "design" capacity that represents the maximum desirable number of pedestrians are applied in inappropriate ways.

2.3.2 Pedestrian Speed

Average walking speed for pedestrians, usually expressed in units of feet or metersper second.

2.3.3 Pedestrian flow

The number of pedestrians passing a point per unit of time, expressed as personsper minute, 15 minutes, or another period of time; ' point ' refers to a line across the width of a walkway, stairway, or doorway, or through a pedestrian element suchas an escalator or gateway.

2.3.4 Pedestrian flow per unit width

Pedestrian average flow per unit of effective walkway width, expressed as passenger per inch, foot or meter per minute.

2.3.5 Pedestrian density

The average number of passengers per area unit within a walkway or queuing area, expressed as passengers per square foot or meter.

2.3.6 Pedestrian space

The average area used by or provided for each pedestrian in a walkway or queuing area, expressed in terms of square feet or meters per pedestrian; this is the inverse of density, but is a more practical unit for the analysis of pedestrian facilities.

The space required for the passenger is normally differentiated according to the activity and the speed at which they walk. Consideration of the type and characteristics of pedestrians is important. For example, the area required by a person using a wheelchair or carrying luggage or packages is greater than that required by a person standing without items.

2.3.7 Pedestrian time-space

Space normally required by pedestrians for different activities (walking, queuing, chatting, shopping, etc.) multiplied by the amount of time spent doing the activity in a specific area.

2.3.8 Effective width or area

The area of the space normally utilized by pedestrians, or the width of a walkway or stairway. The effective width or area excludes areas occupied by physical obstructions and buffer spaces adjacent to walls and obstructions.

2.4 Passenger Behaviour

The different influence factors for passenger behaviour. These factors have been clustered into 3 main groups:

- Socio-economic aspects: population and economic growth
- Internal system aspects: travel time, comfort service levels, and capacity constraints
- Other systems' aspects: congestion, and other public and private transport's service levels.

Choice users are more receptive to time and comfort, while captives are more costly. However, the response of the Captives to changes is quite inelastic due to a lack of alternatives. In any terminal, environment passengers have different needs and they behave differently as they walk at different speeds on flat and stepped surfaces.

2.4.1 Passenger demand classification

- Commuters: Travellers usually travel to and from work or study and know the layout and train services of the station. At most stations, regular passengers are a large proportion of passengers during peak times.
- Leisure Travellers: Infrequent railway users; could require help in finding and providing information on the train. They generally arrive at the stations earlier

and therefore stay longer compared to regular travellers. A large number of users can use these services during special events at certain stations. They may carry different types of luggage.

- Passengers in wheelchairs: Need step-free access and may require assistance in accessing train services or other facilities at a station.
- Passengers with reduced mobility: It can be physical or cognitive that affects your ability to navigate within a station. Passengers' personal attributes are some of the key factors affecting travel mode choice behaviour. Age groups are different from travel behaviours and activity patterns.
- Passenger incomes and levels of education on demand for public transport, both of which have been positive in the sharing pattern of transport modes.
- The impacts of journey attributes such as time of departure and distance on choice behaviour.
- Passenger satisfaction with the performance attributes of various travel modes (performance satisfaction attributes) has a significant influence on the choice of mode.
- Passenger attributes can be classified by — (Reliability, Frequency, Speed, Accessibility, Distance, Time)

2.5 Walkability Parameters

Walkability is the measure of effectiveness of the designs in promoting walking. It helps in evaluating the quality of walkway/ sidewalk/ foot over bridge to help to improve it and to freshly design it according to standards. There are several methods to evaluate the walkability like GMI (global walkability index), walkability index (Indian Highway Capacity Manual (Indo-HCM), 2017) and audit tool for walkability assessing pedestrian infrastructure (method was developed by Clean Air Asia in the year 2016) but it has been found that walkability index is the most suitable according to Indian context.

2.5.1 Walkability Index

Walkability Index (Indian Highway Capacity Manual (Indo-HCM), 2017) is a qualitative assessment for the evaluation of pedestrian facility comprises of quality assessment of the characteristics of the Footpaths. This method uses the perception of the pedestrians and attempts to quantify the comfort level of pedestrians while encountering certain roadway characteristics. Quality of Service

(QOS) indicates the environmental qualities of pedestrian space and serves as a guide for the development of standards for pedestrian facilities. Pedestrian spaces should be designed considering human convenience and should be suitable to the needs of pedestrians.

Walkability Index is used for evaluating pedestrian infrastructure performance considering the following factors:

- Physical and user characteristics/parameter
- Importance weight and satisfaction rating of individual parameter (0-5rating)

To determine the Walkability Index, the perception of the pedestrians on the quality of Footpaths available and needs of the pedestrians has been captured to build the Walkability Index. Thus, the Walkability Index is calculated.

Table 2 Walkability index Physical and User Characteristics/ parameters

Parameters /Score	0	1 (Satisfactory)	2 (Good)	3 (Very Good)	4 (Excellent)
Footpath Surface	No raised footpath	Bad condition. Lots of bumps and cracks.	Moderate quality with few bumps and cracks	Reasonable quality. Walking is comfortable	Even surface with no cracks or bumps, tactile flooring
Footpath Width	No footpath	< 1.5 m	1.5 m to 2 m	2 m to 3 m	3 m + wide
Obstructions	cannot walk on the footpath	Many. Some difficulty in walking	Few. Slight difficulty in walking	Very few, but no problem in walking	No obstruction (trees, hoardings, poles, parked vehicle)
Vehicular Conflict	Unsafe	Footpath not sufficiently raised and no guard rails	Raised footpath but no guard rails	Raised footpath, guard rails but not continuous	Well protected, raised footpath, continuous guard rails. motorized two-wheeler cannot move
Longitudinal Continuity	Long stretches of discontinuity. Non existent	Frequent ups and downs, kerb height difficult in mounting.	Few ups and downs, mountable kerb	1-2 ups and downs, kerb cuts provided	Continuous
Encroachment	Cannot walk	Very difficult to walk	Slightly difficult to walk because of encroachment	Hawking on footpath but no problem in walking	Separate hawkers zone provided
Availability of crossing Facilities	Unsignalised at grade crossing	Unsignalised at grade zebra crossing	FOB without lift and escalator	Signalized at grade without median refuge / FOB with lift/escalator	Signalized at grade crossing with median refuge/ FOB with lift
Security	None of the parameters in favor of pedestrians. Unsafe during day also.	Any one parameter in favor of pedestrians. Can walk only during daytime	Any two parameters in favor of pedestrians. Can walk only till late evening.	Any three parameters in favor of pedestrians. Can walk till late night.	Well illuminated, good visibility, police patrolling during day and night time. CCTV cameras. Can walk during any time of day

Comfort	None of the parameters in favor of pedestrians	Any one parameter in favor of pedestrians (other than dustbins)	Any two parameters in favor of pedestrians but trees are essential.	Any three parameters in favor of pedestrians, but trees are essential.	Very comfortable (trees, public toilets, benches, dustbins)
Walking Environment	None of the parameters in favor of pedestrians	Any one parameter in favor of Pedestrians	Any two parameters in favor of pedestrians	Any three parameters in favor of pedestrians	Very pleasant, plantation, no garbage, no bad smell
Source: Indo-HCM 2017					

Figure 2. 3 wallability index

Quality of service will be further determine according to the below mentioned walkability index score table to understand in which category it falls.

Table 3 Quality of Service for Footpaths					
QOS (Quality of Service)	**A**	**B**	**C**	**D**	**E**
Walkability Index / Score	≥124	<124- 106	<106- 70	<70- 52	<52
Source: Indo-HCM 2017					

Figure 2. 4 quality of service for footpath

Walkability index has to be calculated to assess the condition of walking environment i.e. interchange area from one terminal entry/ exit to another. Walkability index of routes were evaluated depending upon above mentioned parameters and score has been given to respective route based on currentcondition.

2.6- Standards, Codes & Guidelines

2.6.1 Highway Capacity Manual

The concept of LOS was firstly originated in 1965 for vehicular LOS. Later HCM 2000 (Highway Capacity Manual) was further developed for pedestrian facilities. Itis based on the speed and space requirements of pedestrian walking. It consist ofsix LOS categories from A-F. This range is used to determine the LOS that is provided for a given direction (Highway Capacity Manual , 2000).

2.6.2 IRC (103-2012)

IRC 103-1988 talked about guidelines for pedestrian facilities which were further evaluated upon time (irc-103-1988-guidelines-for-pedestrian-facilities) and in (IRC

2012 (Guidelines For Pedestrian Facilities)) pedestrian level of service were introduced based on average pedestrian space available. Since pedestrian and passenger share have similar characteristics, this manual can be used as a reference to compare existing PLOS standards and newly defined PLOS standards for interchange.

2.6.3 NUTP 2014

(Ministry of Urban Development Government of India, 2014) states that Walking is the universal form of traveling. Every trips starts and end with a walk. For achieving success of public transport walking is essential. Since several factors affect walkers such as age, gender, type of luggage, disabilities, etc. Therefore, it is essential to plan and design passenger facilities keeping people with reduced mobility into consideration.

2.6.4 Indo HCM 2017

(Indian Highway Capacity Manual (Indo-HCM), 2017), consist of methodology for determining PLOS (pedestrian level of service). It also consist of PLOS ranges for different types of pedestrian facilities i.e. stairways, foot over bridge, crosswalks, footpaths.

2.7 Pedestrian Flow Models

2.7.1 Greenshield's Model

The fundamental relationship between speed, density, and volume for passenger flow is analogous to vehicular flow. As the volume and density increase, passenger speed declines. As density increases and passenger space decreases, the degreeof manoeuvrability of an individual passenger declines so does the average speedof the passenger stream.

Macroscopic stream models represent how the behavior of one parameter of traffic flow changes with respect to another.

Greenshield assumed a linear speed-density relationship to derive the model. The equation for the relationship is:

$$v = vf – \{(vf / kj)*k2\}$$

Where v is the mean speed at density k, vf is the free speed, and kj is the jam density. It indicates that when density becomes zero, speed approaches free-flowspeed. Once the relation between speed and density is established, the relation with the flow can be derived.

The relation between speed and flow, flow, and density are parabolic, as shown inthe figures.

Once the relationship between the fundamental variables of traffic flow is established, the boundary conditions can be derived. Similarly, we can find the relation between speed and flow (q) using the formula below:

q = kj*v- {(kj / vf)*k2)}

Where q is the flow, kj is the jam density, vf is the free speed, v is the mean speedat density k, v0 is the speed at maximum flow, qmax is the maximum flow, k0 is the density at maximum flow.

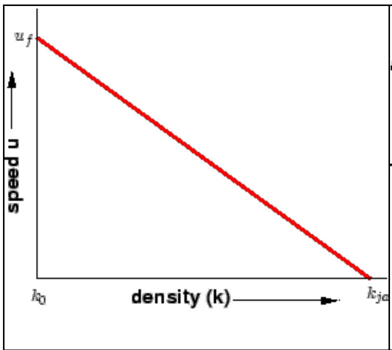


Figure 3 Speed vs. Density Graph

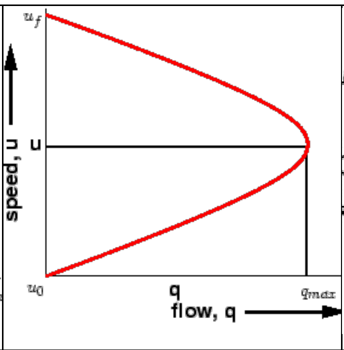


Figure 4 Speed vs. Flow Graph

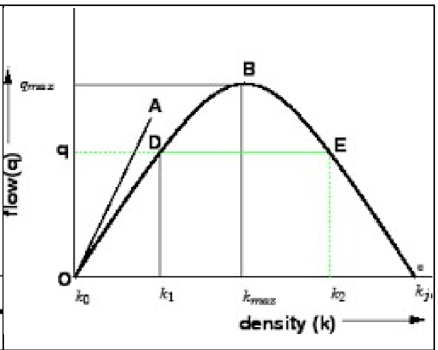


Figure 5 Flow vs. Density Graph

2.7.1 Benz Model

Gregory Benz has a slightly different way of determining pedestrian LOS than using Fruin's flow rate method as mentioned in (Benz, Application of the Time-Space Concept To a Transportation Terminal Waiting and Circulation Area., 1985) and (Benz, Transit Platform Analysis Using the Time-Space Concept., 1987). Benz's method is probably best suited for transportation terminals and other complex pedestrian spaces, which could be applied to sidewalks, as well. His methodology is called the time-space approach.

In the time-space approach, pedestrian activities generate time-space needs. The areas where these activities take place are time-space zones. They have a limited capacity to meet pedestrian time-space needs. The time-space concept can be described as:

$$\text{T-S req.} = \Sigma\ P_i\ M_i\ T_i$$

Where,

T-S req. = time-space required

Pi = number of people involved in activity i

Mi = space required per person for activity i

Ti = time required for activity i

$$\text{And, T-S req.} = \text{T-S avail}$$

$$\text{T-S avail} = \text{A avail} \times \text{T avail}$$

Benz's approach focuses on the area (sq. ft.) and not simply the effective width at an imaginary point. In calculating the A avail, Benz also recommends taking into account "cushions" around obstacles that represent unused space. But, he doesn't clearly identify how big those cushions will be.

2.7.1 Walk area Width-Volume (WWV)

(Mozer) Introduces a measurement called the "walk area width volume" (WWV) for pedestrians. The WWV is determined using an equation which includes measures of peak hour pedestrian volumes, mode split that is not pedestrian (wheelchairs, bicyclists, skaters, runners, etc.), usable width of the walk area, and a "travel pattern factor" representing the one way or bi-directional nature of the facility's pedestrian traffic.

$$WWV = PHV \times (1 + NPM) / (WWA / (TP \times FD))$$

Where,

PHV=Peak hour pedestrian volume

NPM=Mode split

WWA=Width of the walk area (mt)

TP=Travel Pattern Factor

FD=Facility Design Factor

2.7.2 Chandra and Kumar's Method

(Mardani, Chandra, & Ghosh, 2015) formula states that { (An / Ap)*(Vp / Vn) }, here An is the area of passenger with no luggage , Ap is the area of passenger with attributed luggage, Vp is the speed of passenger with attributed luggage and Vn is the Speed of passenger with no luggage. It is being used further to calculate the passenger equivalent profile.

2.7.3 Anova Testing

The Anova test has been used to conduct the significance of the recorded data set for the particular category based on different parameters. The test proves the significance of the data set and it should be lesser than 0.05, if it's not significant then the data set is rejected and if it's in the range then the data set is accepted for further analysis as stated by (Sullivan Lisa, n.d.) And (SINGH GURCHETAN, 2018).

2.7.4 K-mean clustering technique

In k-mean clustering is one of the clustering technique which is used to cluster same set of values in a parameter in different clusters based on the difference of center to center equivalent distance. K-mean clustering is one of the fastest and easier technique among other types as mentioned by (Kanungo, et al.) And (Dabbura Imad, 2018).

2.8 Case Studies

To understand which parameters affect the pedestrian flow several case studies are taken into consideration i.e., (WHYTE H WILLIAM, 1988); (Morrall, Ratnayake, & Seneviratne); (YOUNG-IN KWON, SHIGERU MORICHI); (Stucki Pascal, 2003); (Daamen & Hoogendoorn, 2003) conducted over different parts of the world. These are primarily studies that do not use the traditional HCM pedestrian LOS analysis methodology. They provide an insight into the ways pedestrian studies can be undertaken without following a pre-existing set of guidelines.

These primarily studies used different parameters like age, gender, groups, luggage, health, trip length, trip purpose, obstacles, infrastructure and environment. Parameters impact have been seen in case studies on a larger group and then they were considered further for the research and used further in primary surveys as shown in table below.

Table 4 Parameters Identified for Pedestrian flow characteristics

S.No	Pedestrian Case Studies	Passenger Behaviour								Infrastructure	
		Age	**Gender**	**Groups**	**Luggage**	**Health**	**Trip Length**	**Trip Purpose**	**Environment**	**Infra-Structure**	**Obstacles**
1	City. Rediscovering the Center - William H. Whyte										
2	Field Studies of Pedestrian Walking Speed and Start-Up Time - Richard L. Knoblauch										
3	Comparison of CBD pedestrian characteristics in Canada and Sri Lanka - John F. Morrall										

4	Analysis of Pedestrian Behavior and Planning Guidelines with Mixed Traffic for Narrow Urban Streets - Young-In Kwon										
5	Obstacles in Pedestrian Simulations - Pascal Stucki										
6	Experimental Research of Pedestrian Walking Behavior - Winnie Daamen										

Figure 2. 5 case study

From the case studies age, gender, groups, luggage, trip length, trip purpose, obstacles and extras (phones, drinks, old person, and kids) were considered for Commuter's origin and destination survey and further analysis.

2.9 Conclusion

From the literature review it has been concluded that passenger speed is hampered by different parameters like age, gender, groups and luggage. These parameters should be considered further while data collection and analysis. To understand the how PCU (passenger car unit) can be formulated, several researches are studied like (Raj, Sivagnanasundaram, Asaithambi, & Ravi Shankar, 2019), (Mardani, Chandra, & Ghosh, 2015), (Srikanth, 2019). These researches give idea that Chandra's model is best suited for my study. In similar way to understand the pedestrian level of service several researches are concluded like (Marisamynathan & Lakshmi, 2018), (Zhao, Bian, Lu, & Rong, 2014), to determine how pedestrian level of service can be formulated.

CHAPTER - 3: **STUDY AREA PROFILE**

3.1 Background

Lucknow is the capital city of Uttar Pradesh, the most populous state of India. Lucknow had a population of 3,647,834 in 2001.The estimated population of Lucknow in 2010 is more than 50 lakh. Lucknow is also the administrative headquarters of Lucknow District and Lucknow Division. According to Government of India, the Lucknow district is one of the ninety Minority Concentrated Districts in India, shown by 2001 census data on population, socio-economic indicators and basic amenities indicators.

The City covers an area of 980 sq.km bounded by 26.30 degree & 27.10 degree North Latitude and 80.30 degree & 81.13 degree East Longitude. Today, Lucknow is a vibrant city that is witnessing an economic boom and is among the top ten fastest growing m (Road traffic injury prevention , 2004) (Mobility and transport, 2015) metropolitan cities of India. Located in what was historically known as the Awadh region, Lucknow has always been a multicultural city. It is also known as the Golden City of the East, Shiraz-i-Hind and the Constantinople of India. Lucknow is popularly known as the the City of Nawabs. The Gomti River, meanders through the city, dividing it into the Trans-Gomti and Cis-Gomti regions. It is the second largest city in Uttar Pradesh state. Courtly manners, beautiful gardens, poetry, music, and fine cuisine patronized by the Persian-loving Shia Nawabs of the city are well known amongst Indians and students of South Asian culture and history.

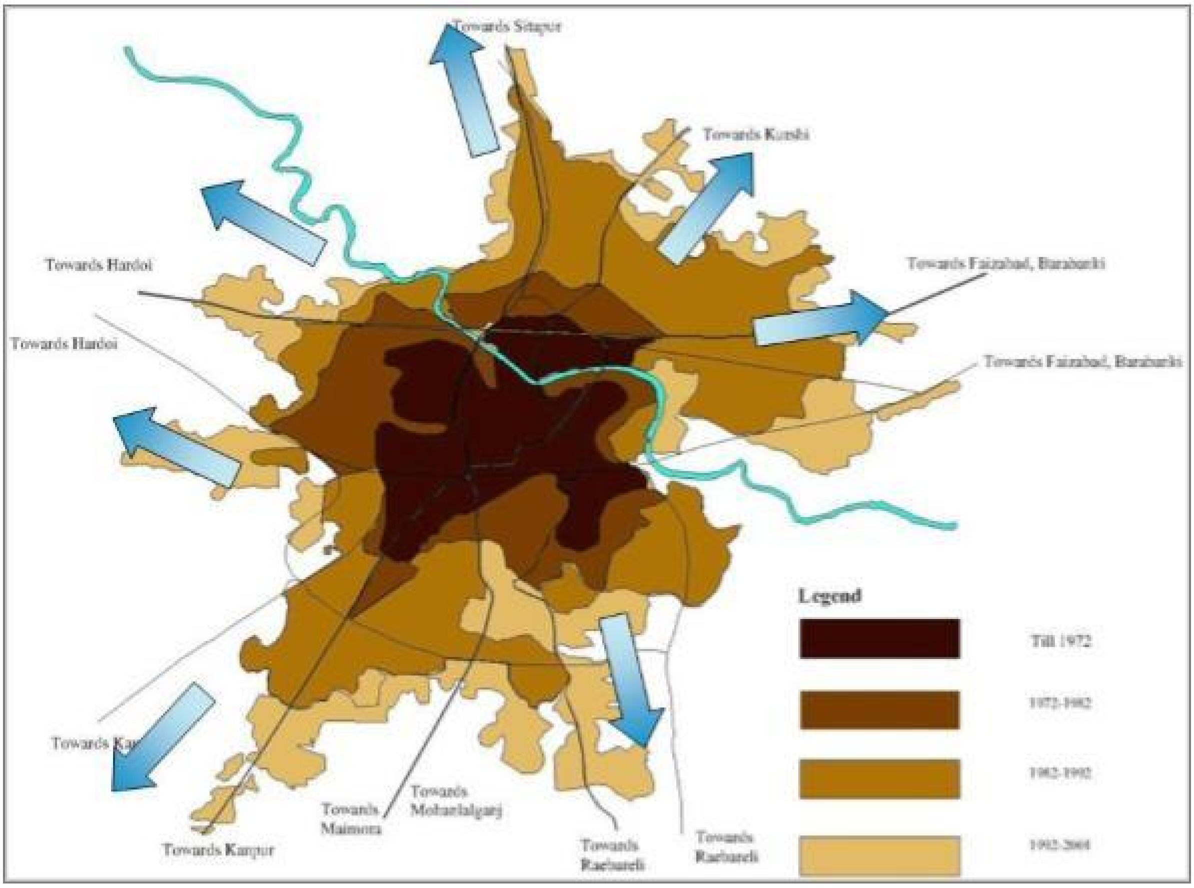


Figure 3. 1 evolution of Lucknow city

3.2 Land Use Distribution:

The municipal area was 92 Sq Km in 1987 and increased to 163 Sq Km in 2005. The Lucknow Master Plan prepared during 2004-05 for the year 2021 covers an area of 980 Sq Km. Residential use has grown dramatically in comparison to all other uses, although there has also been notable growth in commercial, industrial and public service land use. The percentage of area under traffic and transportation use has decreased from 10.38% in 1987 to 7.62% in 2004-05. However, a provision of 16% of total land use has been made under traffic and transportation in Lucknow Master Plan 2021. (Authority)

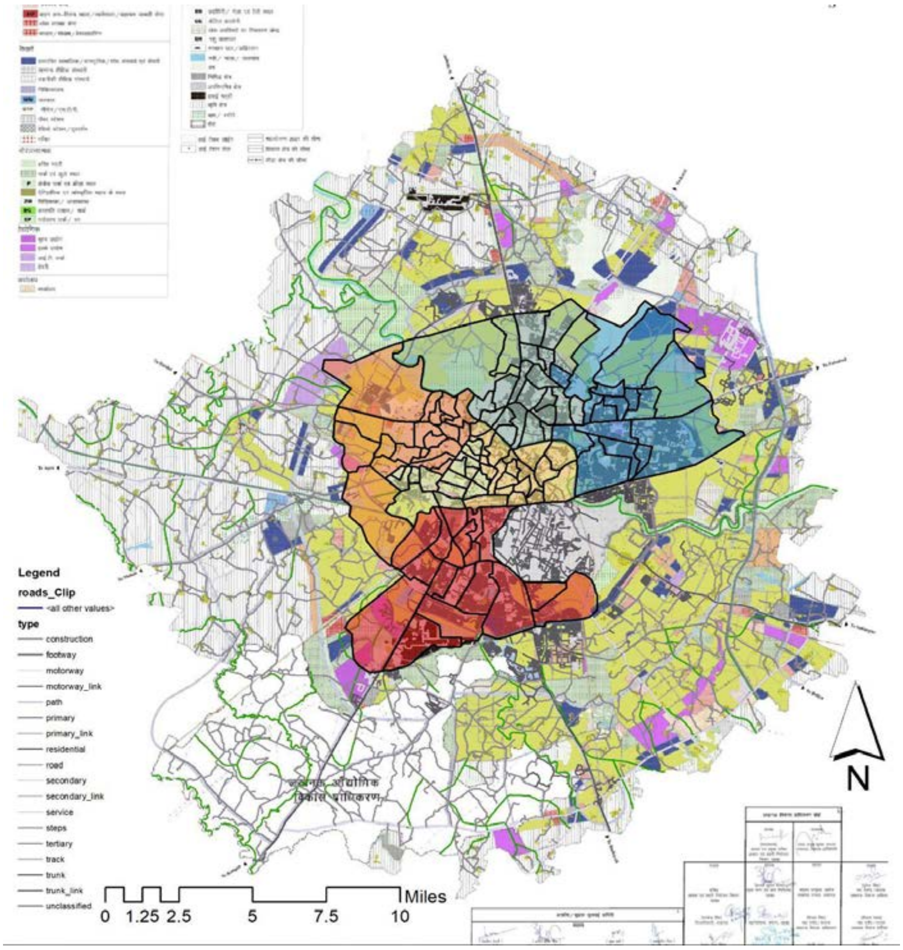


Figure 3.2.Lucknow Master plan 2031

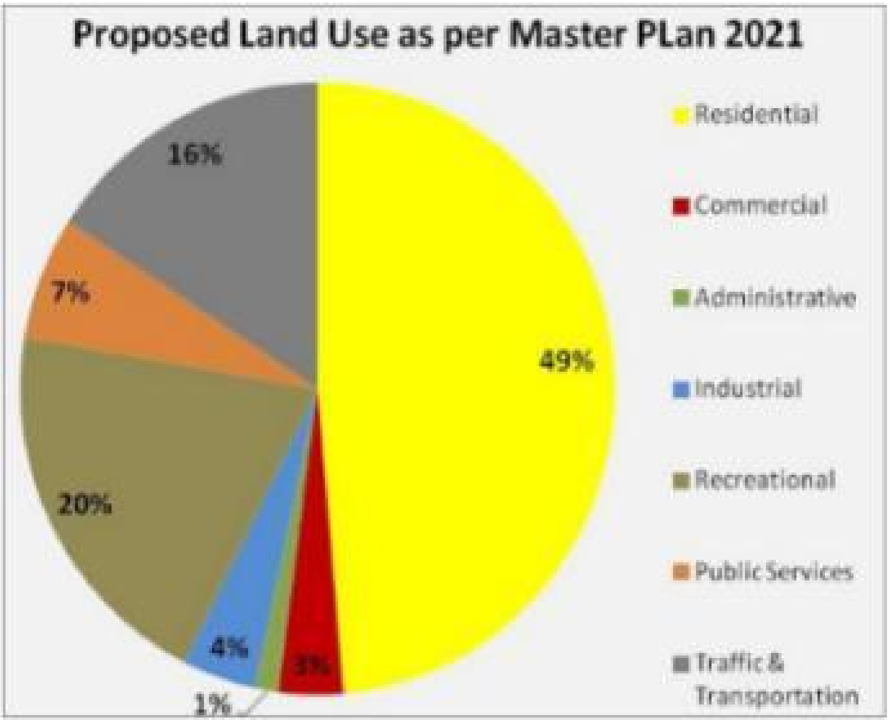


Figure 3.3 Proposed land use

The proposed master plan shows that the residential use is going to contribute around 49% 0f the land use and the recreational landuse is given second most importance with 20% of the area under it. Then the transportation carries out 16% of the landuse in the proposal. Public services landuse has 7% contribution, industrial landuse has 4% and commercial landuse has 3% of the contribution.

Be it the cultural charm or the monumental, all are well conserved here to make Lucknow "The city of many splendors". Lucknow - The upcoming METRO is a hallmark of cultural extravaganza, known all over the world for its many splendors. The unique combination of its cultured grace and newly acquired pace is its most promising feature that augurs well for the future. A city that has a magical charm, a charm that's forever and a charm that's apart.

3.3 Historicity of the study area:

Lucknow city has the following distinct centers, which attract people and traffic:

Heritage Centers or Tourist Centers: The main tourist attraction centers of Lucknow city are: Bara Imamabad, Chita Imamabad, Rum Darwaza -located on the Northwest of the Bara Imambara and Sikandar Bagh.

Commercial Centers: Lucknow has seen a radial growth but the city centre continues to remain the hub of commercial activities. Old City areas of Aminabad, Chowk, Hazratganj, Kapurthala-Bhootnath Chowk, Aminabad-Latouche Road (Gautam Buddha Marg) etc. are the main commercial areas of Lucknow city.

Industrial Centers – Although Lucknow is primarily an administrative city, it also has an industrial base, which includes industries relating to aeronautics, machine tools, distillery chemicals, furniture and chikan embroidery etc. Lucknow city is traditionally associated with chikan embroidery work on readymade garments, sarees, etc. with most units being small-scale and household-based and are located in the old city area.

The state Government, which it is fulfilling very actively, and enthusiastically have entrusted Lucknow Development Authority (LDA) with the responsibility of planning and development of Lucknow. The Authority (LDA) has prepared "Lucknow Master Plan-2021" for guided and planned development of the city in future by taking into consideration the requirements for overall development and is planning and developing the envisaged infrastructure.

Educational Centers: Lucknow is a hub of education and research and many premier institutions are located in and around the city. The Indian Institute of Management (IIM-Lucknow), Chhatrapati Shahuji.

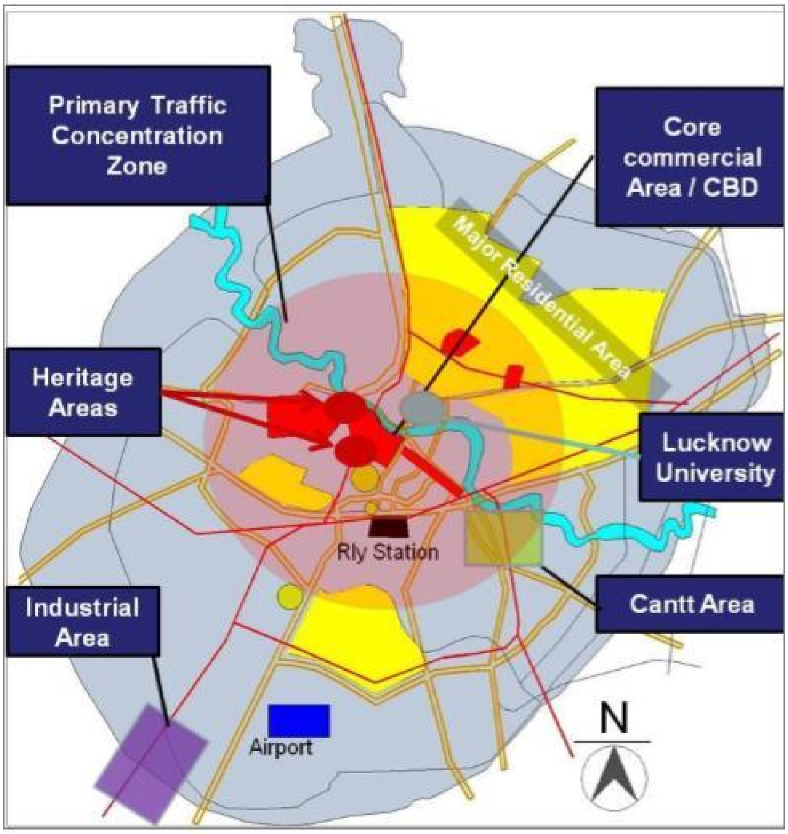


Figure 3.4 Development centres in Lucknow

Forty-one percent (Walk-17%, Bycycle-16%, Cycle Rickshaw-8%) of trips in Lucknow are made by nonnotarized transport (NMT); but the facilities available are grossly inadequate. The objective should be to provide continuous, encroachment free pedestrian and NMT facilities across the city.

In Lucknow, the road network is found devoid of foot-paths. This makes the pedestrians use carriageway for walking. Many a time it has been observed that the pedestrians use the road without least concern for the vehicular traffic. This leads to accidents. Hence, it is necessary that foot-paths should be provided along the main roads.

A significant amount of pedestrian traffic was Figure 18: Congested Nodes, CMP observed at various intersections in the city. In order to have safe movement of pedestrians at the intersections, it is necessary to include a separate “Pedestrian Phase” or “All Red” phase in the cycle of the traffic lights. This will ensure safe crossing of pedestrian at signalized junctions.

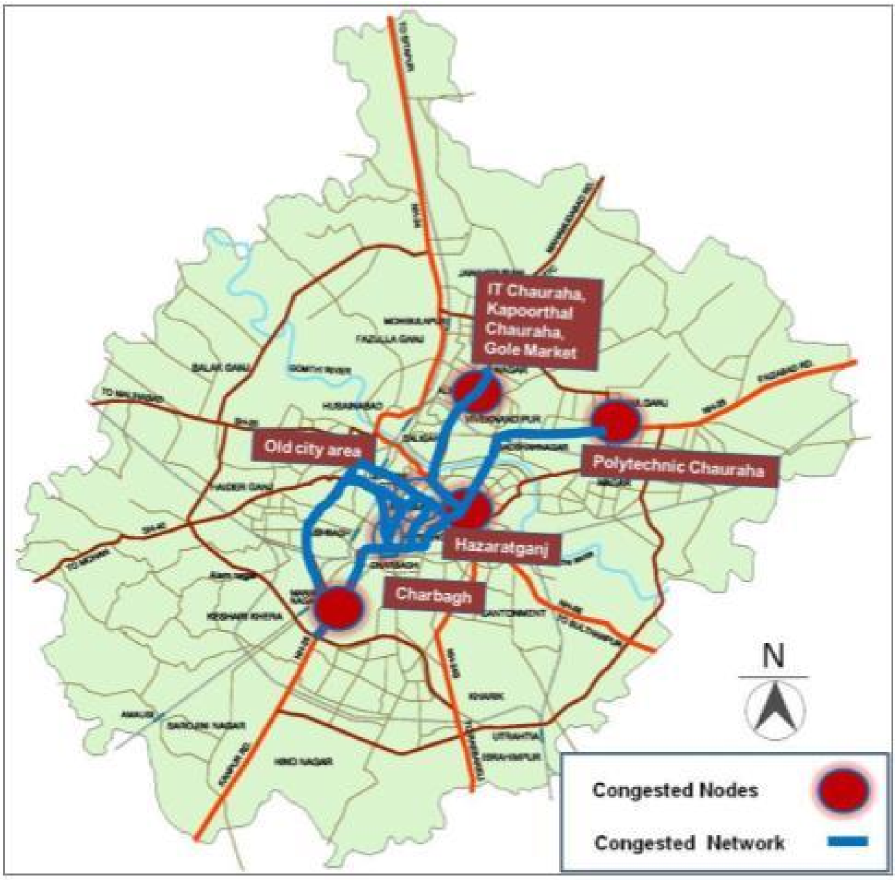


Figure 3.5 Development centers in Lucknow

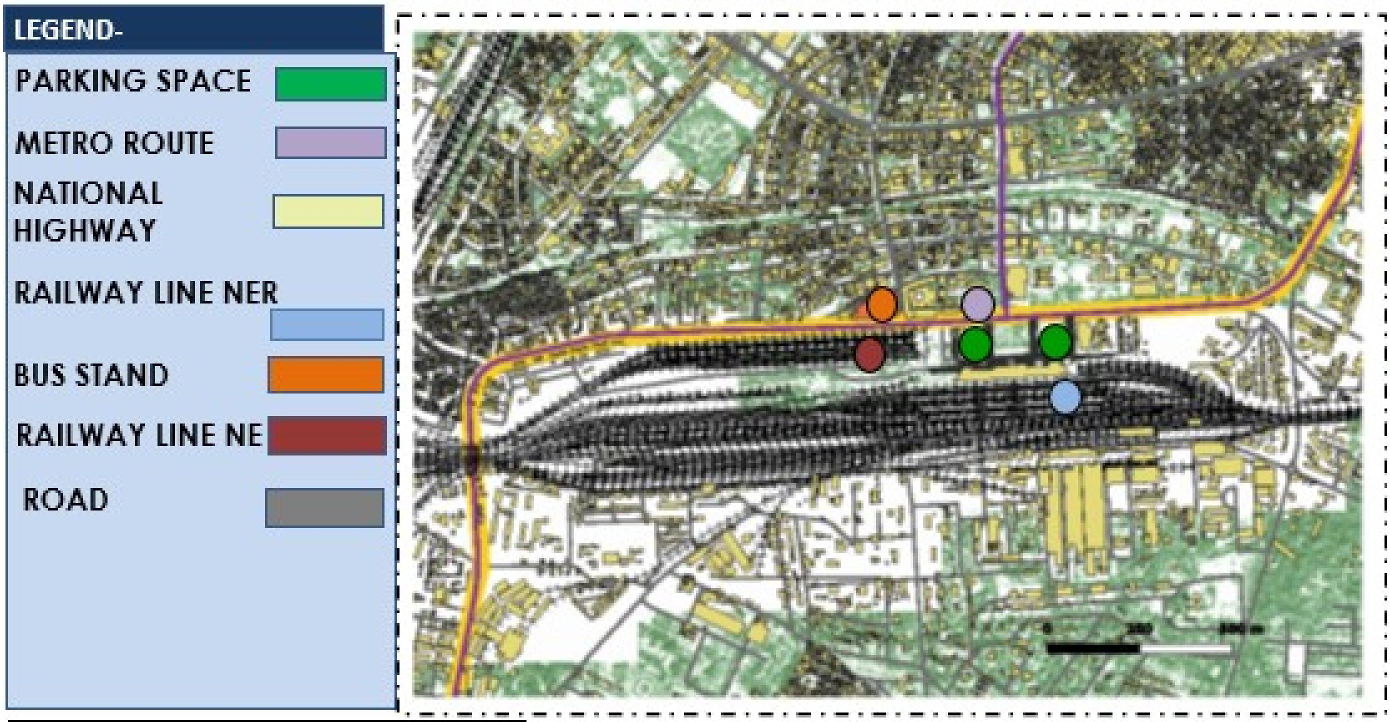


Figure 3.6 map of charbagh Lucknow

	Charbagh		
	Railway Station	Bus Stand	Metro
Daily capacity	372	100	105
Ave Daily Passenger	120000	50000	15000
Mode of Public Transport	Auto, Cab, Bus, Rent Bike, Metro	Auto, Cab, Bus, Rent Bike, Metro	Auto, Cab, Bus, Rent Bike

Figure 3.7 daily footfall

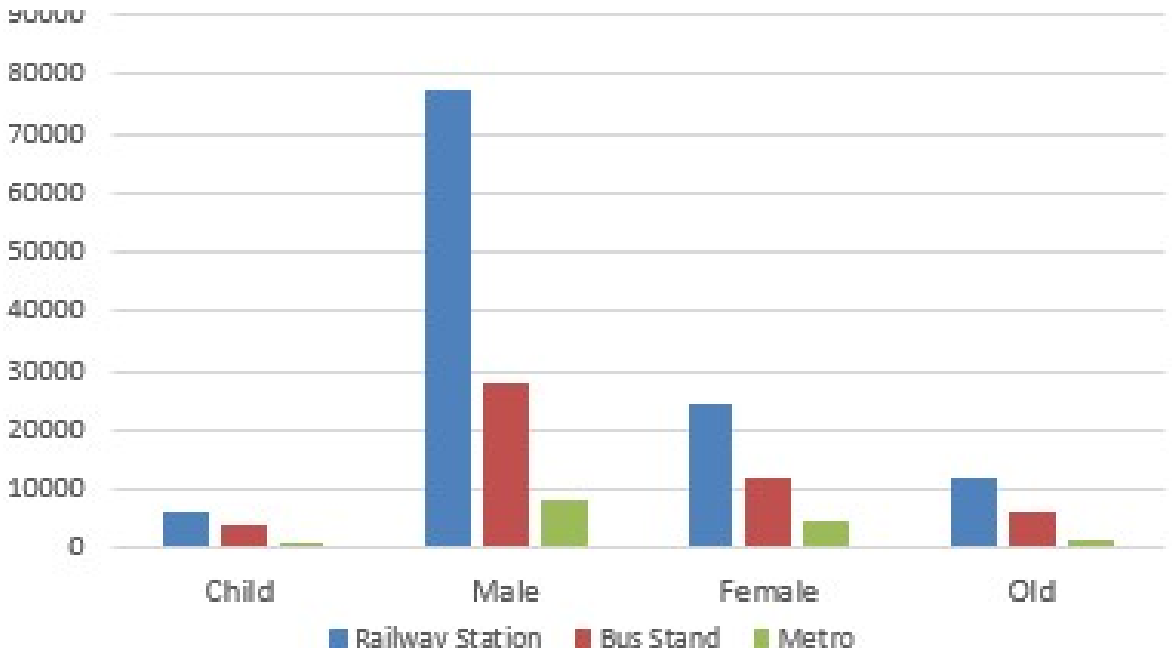


Figure 3.8 bar graph daily footfall

CHAPTER - 4: DATA COLLECTION

4.1 Background

Series of surveys have been conducted around the premises of the interchange.

The surveys have been divided into three types depending upon usercharacteristics as

Reconnaissance Survey

User Perception (Primary Survey):

It further consists of

Passenger travel time survey

Commuter's origin and destination survey.

User Behaviour (Primary/ Secondary Survey):

It consists of Passengervolume count survey at entry & exit gates of different modes.

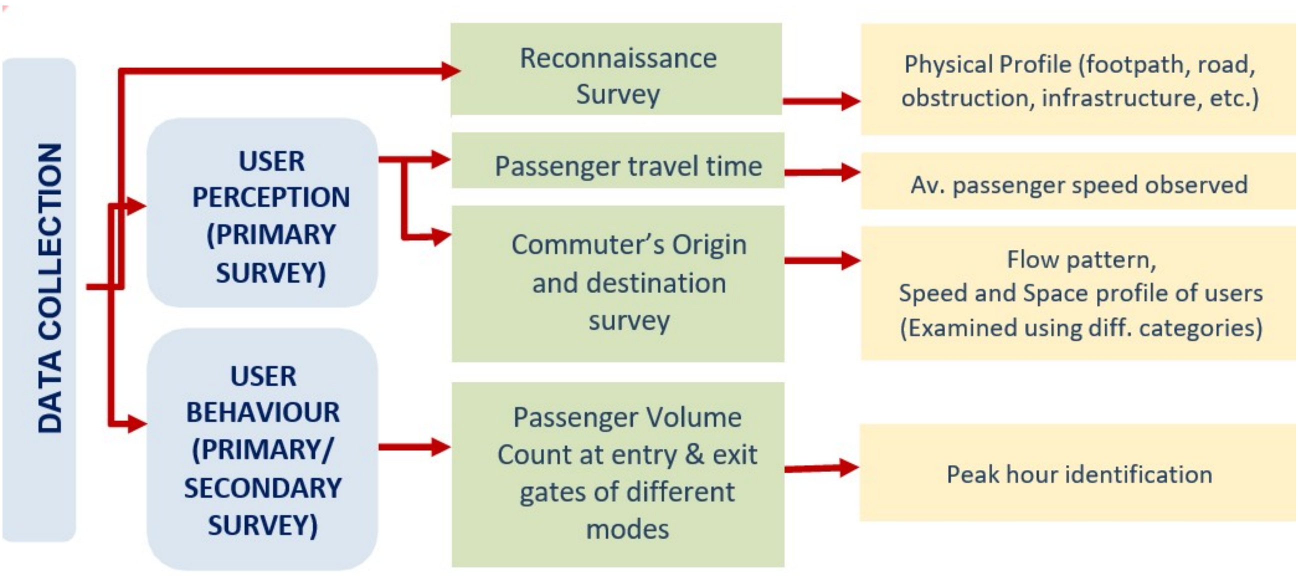


Figure 4. 1 data collection survey

CHAPTER - 5: **DATA ANALYSIS**

5.1 Data Analysis Methodology

In order to understand the approach and passenger behaviour impact on interchanges the methodology for data analysis is being detailed.

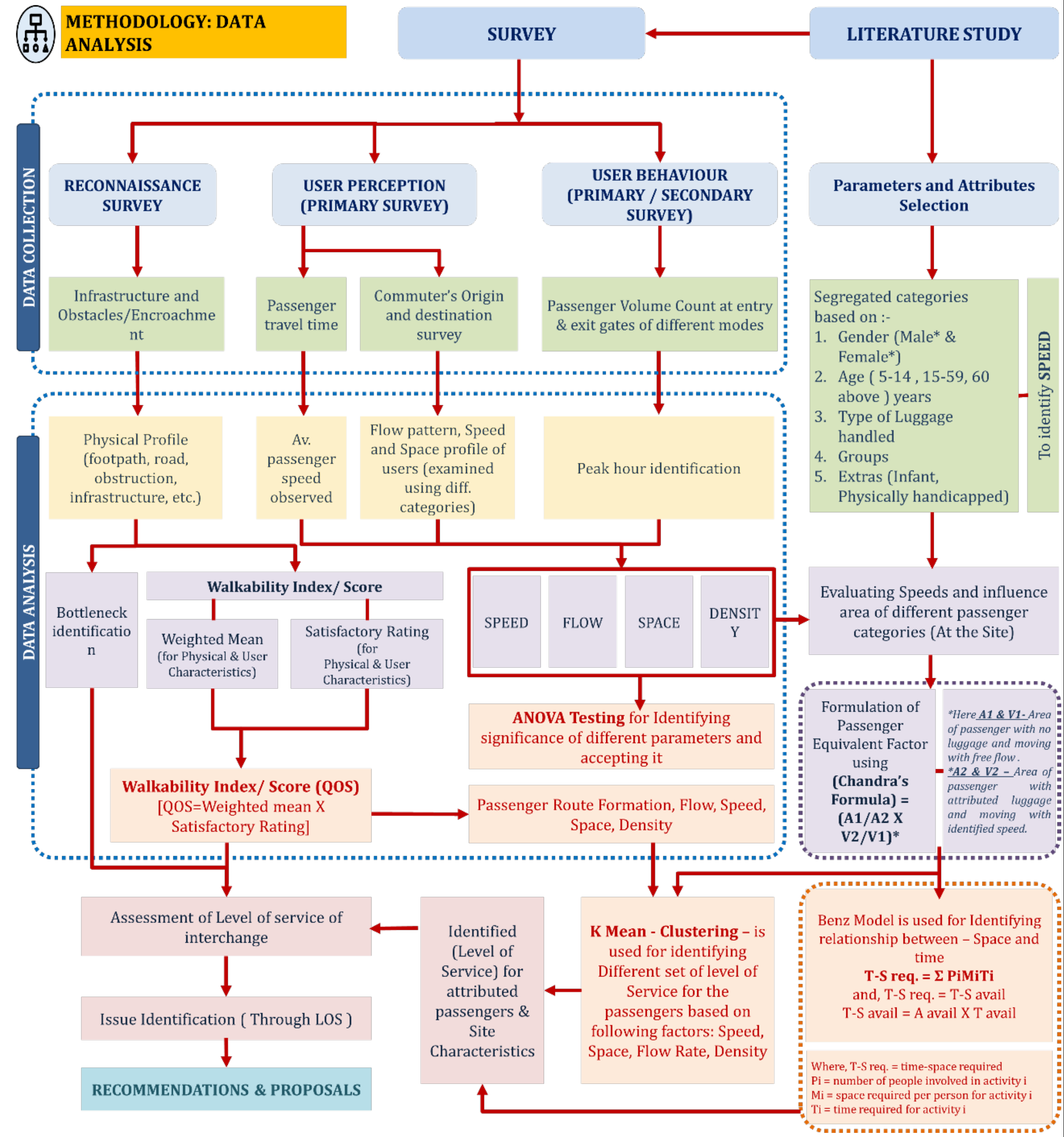


Figure 10 Data Analysis Methodology

Figure 5.1 data analysis

The methodology is categorised in four major sections, first one is to conduct a literature study which help in creating understanding for the study and also guide in designing methodology for the project, after this the 3 major categories are Data collection, Data analysis and Recommendations under which all study objectives are achieved. In data collection the surveys are divided in three sections

TERMINAL	PEAK HOUR TIME
METRO STATION	6:30 TO 7:30 PM
NER RAILWAY STATION	6:00 TO 7:00 PM
NR RAILWAY STATION	6:00 TO 7:00 PM
BUS STAND	6:30 TO 7:30 PM

Figure 5. 2 peak hour time

TERMINAL	15 MIN COUNT	PEAK HOUR	METRO	BUS	RAILWAY	AUTO	TOTAL
METRO STATION	294	1176	-	158	72	64	294
RAILWAY STATION	570	2280	149	131	-	290	570
BUS	160	2640	232	-	148	280	660
AUTO	427	1708	182	98	147	-	427

Figure . 5.3 passenger count

Reconnaissance survey, User Survey, User perception. Reconnaissance survey was conducted on both the sites to identify infrastructure loopholes and encroachment which make a strong point for this study. Under User perception survey passenger travel time, and Origin & destinations were conducted to understand the situation, interconnection and the behavioural patterns. While the

User behaviour was conducted to identify the volume count at various terminals and interchange during peak hour. The literature study help in building a strong case for identifying parameters and attributes for the passengers and under this the passengers are categorised under gender, age, type of luggage handled, these different parameters help in identifying speed.

The second category is Data analysis, under this the data which is collected and observed at the site is organised and analysed to identify bottlenecks. Walkability index is identified which indicate the quality of the walkable areas. The final goal of this study to identify and evaluate the service levels of passengers with different parameters, for this process the terminology is created called PEF, which is used to unify passengers in one unit. This PEF is further used to create LOS through K-Mean Clustering. The LOS will help in identifying the impact of the passengers on the interchange. Another analysis is conducted using Benz model theory. The Benz model theory will help in identifying the relation between Space and time. These two level will provide us the service levels and proposals are created on these.

5.2 Passenger Equivalent Factor (PEF) Profile

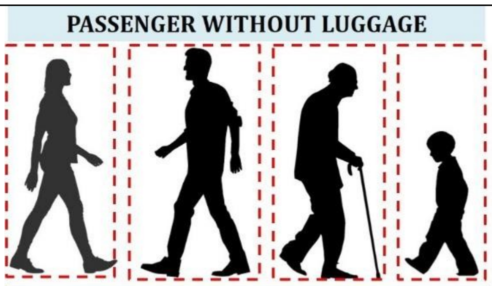
Passenger equivalent factor (PEF) have been formulated to define different attributes of passengers in one unit. Chandra's method has been used to formulate PEF. Chandra's formula states that {(An/Ap)*(Vp/Vn)}, where An is the area of passenger with no luggage, Ap is the area of passenger with attributed luggage, Vp is the speed of passenger with attributed luggage and Vn is the Speed of passenger with no luggage. PEF have been formulated for different categories of passenger with attributed luggage with differing speed based upon their age, gender and groups.

Speed based PEF's have been formulated for this study. For evaluating the passenger profile passengers have been categorised and area of influence is taken through anthropometry study. Twelve categories have been formulated depending upon their luggage which are — passenger without luggage, passengers with polybag/ lunch bag, passengers with bag pack, passengers with duffle bag, passengers with 2 duffle bag, passenger with duffle & bag pack, passenger with trolley bag, passengers with trolley & bag pack, passenger with trolley & duffle bag, passenger with trolley duffle n bag pack, passenger with infant, passenger with disability. These 12 categories are further divided depending upon age and gender.

For age it is divided into 4 subcategories which are infant below 4 yrs., child age varying from 5-14yrs, adult age varying from 14-59yrs and lastly old age above 60yrs. For gender categories are subdivided into 2 male and female.

5.2.1 -Passenger without luggage:

Passenger without luggage in adult male category is taken as the base for the assessment to define the passenger equivalent factor for different categories. Sample at different locations has been taken for each attribute to find the speed of that particular passenger, which is moving in a free flow condition. The area of influence has been taken in X and Y axis to identify their length and width while walking. The area of the passenger without luggage comes out to be 0.47sqm for male adult category and 0.38sqm for female adult category and with average speed of 52 m/min and 49m/min respectively whereas for child area of influence is 0.22sqm and speed is 40m/min.



PASSENGER WITHOUT LUGGAGE				
	X(m)	Y(m)	Area(sqm)	Speed(m/min)
5-14 YRS	0.45	0.48	0.22	40
M (15-59yr)	0.63	0.75	0.47	52
F (15-59yr)	0.55	0.70	0.38	49
>60 YRS	0.63	0.75	0.47	45

Figure 11 Passengers without Luggage

PASSENGER WITH POLYBAG/ LUNCHBAG				
	X(m)	Y(m)	Area(sqm)	Speed(m/min)
5-14YRS	NA	NA	NA	NA
M (15-59yr)	0.75	0.75	0.56	41.6
F (15-59yr)	0.67	0.70	0.47	39.2
>60 YRS	0.75	0.75	0.56	35.4

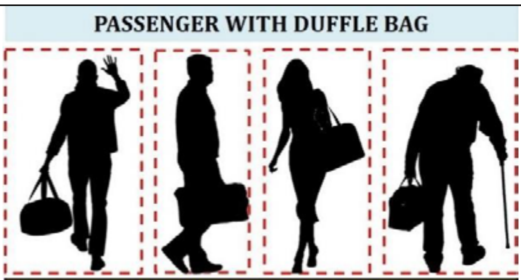
Figure 12 Passengers with poly/ lunch bag

5.2.2- Passenger with polybag/ lunch bag:

Area and speed differ from passenger to passenger, gender & age and the type of luggage they are carrying with them. For passengers with polybag/ lunch bag area of influence comes out to be 0.56sqm for male adult and 0.47sqm for female adult with average speeds reduced to 41.6 m/min and 39.2m/min respectively.

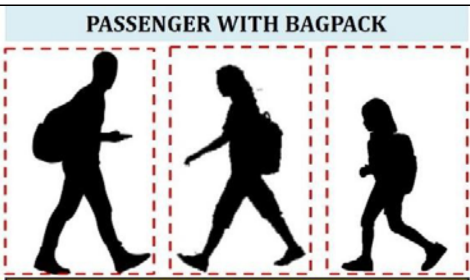
5.2.3- Passenger with duffle bag:

Passengers with Duffle bag are subcategorised into male adult, female adult and old category having influencer area of 0.65sqm, 0.55sqm and 0.65sqm while the average speed of the passengers 34.36 m/min, 32.28m/min and 28.7m.min respectively.



PASSENGER WITH DUFFLE BAG				
	X(m)	Y(m)	Area(sqm)	Speed(m/min)
5-14 Yrs	NA	NA	NA	NA
M (15-59yr)	0.87	0.75	0.65	34.36
F (15-59yr)	0.79	0.70	0.55	32.28
>60 YRS	0.87	0.75	0.65	28.7

Figure 13 Passengers with duffle bag



PASSENGER WITH BAGPACK				
	X(m)	Y(m)	Area(sqm)	Speed(m/min)
5-14YRS	0.45	0.53	0.24	32.87
M (15-59yr)	0.63	1.03	0.64	38.1
F (15-59yr)	0.53	0.98	0.52	37.64
>60 YRS	NA	NA	NA	NA

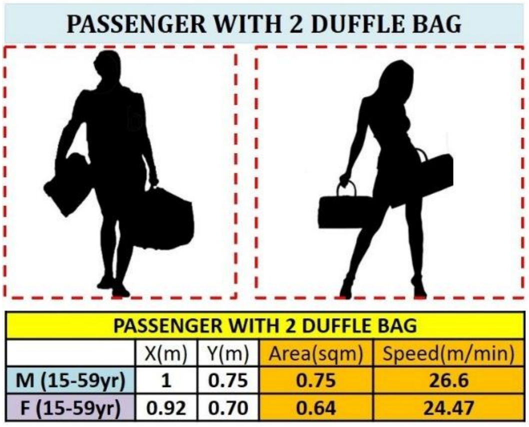
Figure 14 Passengers with bag pack

5.2.4.-Passenger with Bag pack:

Passengers with Bag pack are subcategorised into child, male adult and female adult category. It usually take more space in Y-axis so the new area comes out to be 0.24sqm, 0.64sqm, 0.52sqm with speeds reduced to 32.47m/min, 38.1m/min , 37.64m/min child, male adult and female adult respectively. The speeds and area changes according to the type of bag pack passengers are carrying and the area of the bag differentiates according to its carrying capacity, thus the area of the semi-large bag is taken for the study.

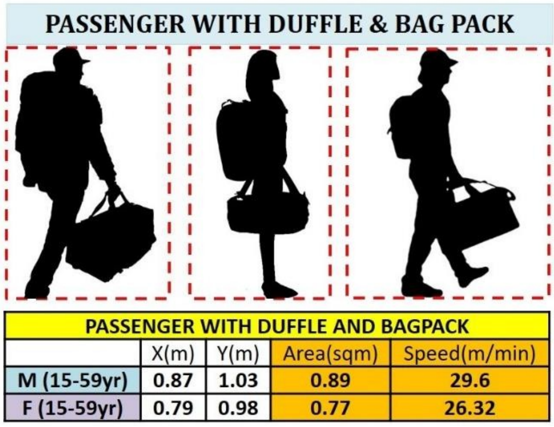
5.2.5 - passenger with 2 duffle bag:

Passengers with 2 duffle bag is subcategorised into male adult and female adult as could not find any passenger of 2 duffle bag in child and old category. It coversan influence area of 0.75sqm and 0.70sqm with average speed of 26.6 m/min and24.47m/min in male adult and female adult category respectively. The speeds of the passengers drastically reduces with the increase in weight and the number of luggage carrying in both hands. The X-axis of the passenger with 2 duffle bag hasincreased compared to Y-axis.



PASSENGER WITH 2 DUFFLE BAG				
	X(m)	Y(m)	Area(sqm)	Speed(m/min)
M (15-59yr)	1	0.75	0.75	26.6
F (15-59yr)	0.92	0.70	0.64	24.47

Figure 15 Passengers with 2 duffle bag



PASSENGER WITH DUFFLE AND BAGPACK				
	X(m)	Y(m)	Area(sqm)	Speed(m/min)
M (15-59yr)	0.87	1.03	0.89	29.6
F (15-59yr)	0.79	0.98	0.77	26.32

Figure 16 Passengers with duffle & bag pack

5.2.6- Passenger with duffle & Bag pack:

Passengers with duffle bag are divided into male adult and female adult category.It covers an influence area of 0.89sqm and 0.77sqm with average speed of 29.6m/min and 26.32 m/min for male adult and female adult respectively. Both X- axis and Y-axis length increases in this category.

5.2.7- Passenger with trolley bag:

Passengers with trolley bag covers a large influence area, there is a major increasein the length both in X axis and Y axis. The total influence area comes out to be 1.96sqm and 1.52sqm with the average speed of 28.56 m/min and 26.30 m/min inmale adult and female adult category respectively. The speed of the passenger isreduced drastically.

PASSENGER WITH TROLLEY BAG	X(m)	Y(m)	Area(sqm)	Speed(m/min)
M (15-59yr)	1.11	1.77	1.96	28.56
F (15-59yr)	1.05	1.45	1.52	26.30

Figure 17 Passengers with trolley bag

PASSENGER WITH TROLLEY AND BAGPACK	X(m)	Y(m)	Area(sqm)	Speed(m/min)
M (15-59yr)	1.21	1.77	2.14	27.46
F (15-59yr)	1.11	1.45	1.61	25.12

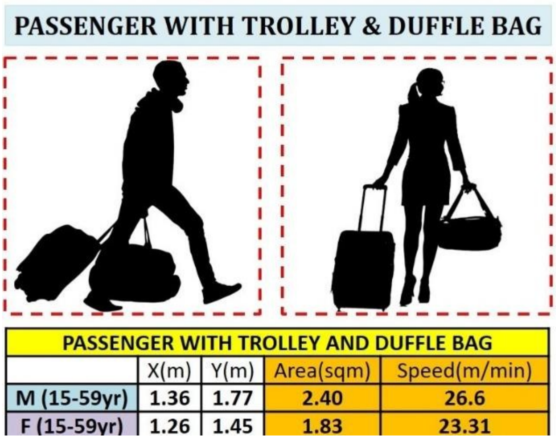
Figure 18 Passengers with trolley & bag pack

5.2.8- Passenger with trolley & Bag pack:

Passengers with trolley & bag pack covers a magnificent large area in both X-axisand Y-axis and is divided into male adult and female adult category. It covers an influence area of 2.14sqm and 1.61sqm with average speed of 27.46m/min and 25.12m/min for male adult and female adult respectively. Speed is reduced due toweight on back and in hands covering a larger area.

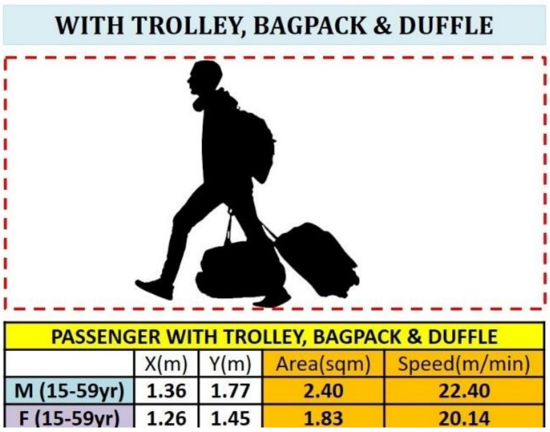
5.2.9- Passenger with trolley & duffle bag:

Passengers with both trolley bag & duffle bag covers a large influence area of 2.40sqm and 1.83sqm with the average speed of 26.6 m/min and 23.31 m/min of male adult and female adult category respectively. Speed of the passenger reduces drastically due to heavy weight.



PASSENGER WITH TROLLEY AND DUFFLE BAG	X(m)	Y(m)	Area(sqm)	Speed(m/min)
M (15-59yr)	1.36	1.77	2.40	26.6
F (15-59yr)	1.26	1.45	1.83	23.31

Figure 19 Passengers with trolley & duffle bag



PASSENGER WITH TROLLEY, BAGPACK & DUFFLE	X(m)	Y(m)	Area(sqm)	Speed(m/min)
M (15-59yr)	1.36	1.77	2.40	22.40
F (15-59yr)	1.26	1.45	1.83	20.14

Figure 20 Passengers with trolley, duffle & bag pack

5.2.10-Passenger with trolley, duffle bag & Bag pack:

Passengers with trolley, duffle bag & bag pack is subcategorised into male adult and female adult category with not any presence of child and old age group. It covers a large influence area of 2.40sqm and 1.83sqm with average speed of 22.40m/min and 20.14m/min for male adult and female adult respectively. Speed is reduced due to heavy weight on back and both hands.

5.2.11- Passenger with infant (0-4yrs):

Passengers with infant (0-4yrs) comprises of common gender and age group category for all. It covers an influence area of 0.51sqm with the average speed of
34.36 m/min.

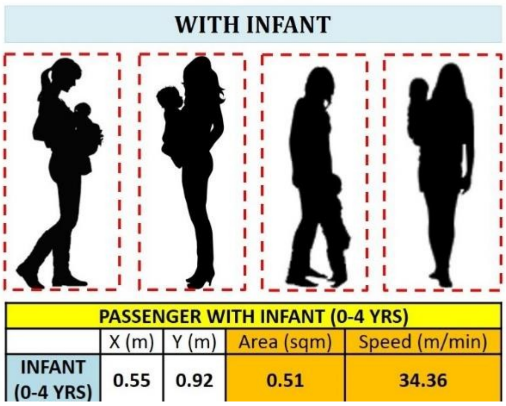


Figure 21 Passengers with infant

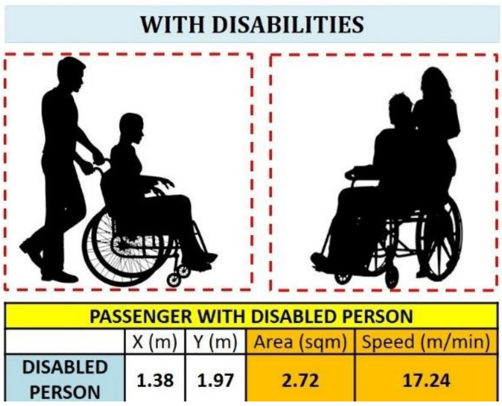


Figure 22 Passengers carrying disabled

5.2.12- Passenger with disabled person:

Passengers carrying a disabled person comprises of wheel chaired person as it carries the maximum area. It covers an influence area of 2.72sqm with the averagespeed of 17.24 m/min.

Table 6 PEF for different passenger categories

PEF (Passenger Equivalent Factor)				
Types of Passengers	**Age & Gender**	**Area (sqm)**	**Average Speed (m/ min)**	**PEF**
Without Luggage	5-14 YRS	0.22	40	**0.6**
	Male (15-59yr)	0.47	52	**1.0**
	Female (15-59yr)	0.39	49	**0.9**
	>60 YRS	0.47	45	**1.2**
With polybag/ lunch bag	Male (15-59yr)	0.56	41.6	**1.5**
	Female (15-59yr)	0.47	39.2	**1.3**
With bag pack	5-14 YRS	0.24	32.87	**0.8**
	Male (15-59yr)	0.65	38.1	**1.9**
	Female (15-59yr)	0.52	37.64	**1.5**
	Male (15-59yr)	0.65	34.36	**2.1**

With Duffle Bag	Female (15-59yr)	0.55	32.28	**1.9**
	>60 YRS	0.65	28.7	**2.5**
With 2 Duffle Bag	Male (15-59yr)	0.75	26.6	**3.1**
	Female (15-59yr)	0.64	24.47	**2.9**
With Duffle & Bag pack	Male (15-59yr)	0.90	29.6	**3.3**
	Female (15-59yr)	0.77	26.32	**3.2**
With Trolley Bag	Male (15-59yr)	1.96	28.56	**7.6**
	Female (15-59yr)	1.52	26.3	**6.4**
With Trolley & Bag pack	Male (15-59yr)	2.14	27.46	**8.6**
	Female (15-59yr)	1.61	25.12	**7.1**
With Trolley & Duffle Bag	Male (15-59yr)	2.41	26.6	**10.0**
	Female (15-59yr)	1.83	23.31	**8.6**
With Trolley & Bag pack & Duffle Bag	Male (15-59yr)	2.41	22.4	**11.8**
	Female (15-59yr)	1.83	20.14	**10.0**
With Infant (0-4 Yr)		0.51	34.36	**1.6**
With Physically Disabled Person		2.72	17.24	**17.4**

Figure 5. 4 passenger equivalent factor

After evaluating the area and speed (m/min) of different category for peak hour at different survey locations based on the parameters (luggage, gender, age, groups)PEF (Passenger Equivalent Factor) has been formulated using CHANDRA'SMETHOD as shown in above.

It is clearly visible that PEF of the passenger carrying trolley and duffle bag is 10 times that of passenger without luggage due to increase in area and weight of theluggage speed reduces drastically from 52m/min to 26.6m/min.

5.3 Evolution of Pedestrian Level of Service (PLOS) forInterchange

The evolution of PLOS consists of 6 steps starting from defining the level of service and then assessing it for pedestrians. Following steps as detailed below have beenused to evaluate the assessment of level of service for the passengers of differentattributes.

Step 1: Primary survey data is collected from peak hour period OD survey and pedestrian volume count of different survey locations to formulate PEF considering speed (m/min) and area (sqm) of passenger's with different attribute. Effective width has been recorded from reconnaissance survey. Chandra's formula is used to find PEF.

Step 2: Second step is to calculate Average Weighted Speed for all terminals (Metro Station, ISBT, Railway station, Local Bus Stand) of both interchanges. Speeds of different passenger types have been evaluated for each minute depending on the passenger count at that particular minute as shown below.

Table 7 Passenger attribute table for evaluating the average weighted speed of terminals

ggag e	without Luggage				with polybag/ Lunchbag		with Bagpack			with duffle Bag			with 2 duffle Bag	
ender	Child	Male	Female	Old	Male	Female	Child	Male	Female	Male	Female	Old	Male	Female
ge rs)	5-14 yr	15-59	15-59	60+	15-59	15-59	5-14 yr	15-59	15-59	15-59	15-59	60+	15-59	15-59
Count	18	69	15	15	16	18	24	112	32	22	7	3	19	6
PEF Value	0.6	1	0.9	1.2	1.5	1.3	0.8	1.9	1.5	2.1	1.9	2.5	3.1	2.9
Total	10.8	69	13.5	18	24	23.4	19.2	212.8	48	46.2	13.3	7.5	58.9	17.4
peed	28.80	40.80	37.62	35.4	29.58	27.96	15	27.12	26.7	25.56	23.52	22.68	23.52	25.2
v.Weighted	0.29													
Av. peed	[illegible]													

ggag e	with duffle Bag + Bagpack		with Trolley bag		with Trolley bag + Bagpack		with Trolley + Duffle Bag		with Trolley + Bagpack + Duffle Bag		Passenger with		Total Passengers	Total PEF Value	Tota PEF
ender	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Infant	Physically handicapped			
ge rs)	15-59	15-59	15-59	15-59	15-59	15-59	15-59	15-59	15-59	15-59	(0-4 Yr)				
Count	27	12	48	32	22	12	18	6	12	3	1	1	570	118.8	1975
PEF Value	3.3	3.2	7.6	6.4	8.6	7.1	10	8.6	11.8	10	1.6	17.4			
Total	89.1	38.4	364.8	204.8	189.2	85.2	180	51.6	141.6	30	1.6	17.4			
peed	22.92	21.6	21.54	20.34	26.4	19.74	23.4	18.3	17.7	14.4	8.4	0.3			

Figure 5. 5 passenger attribute table

Table 8 Compiled 15min set table of data of Charbagh metro station

Charbagh METRO STATION							
S.No	**Width (m)**	**Av. Speed (m/min)**	**Av. Speed (m/sec)**	**PEF**	**Flow Rate (PEF/m)**	**Av. Space (Sqm/PEF)**	**Density**
1 Min	3	32.6	0.544	183	60.9	0.54	1.87
2 Min	3	39.4	0.656	96	32.0	1.23	0.81
3 Min	3	25.9	0.432	210	70.0	0.37	2.70
4 Min	3	25.5	0.425	227	75.8	0.34	2.97
5 Min	3	23.6	0.393	268	89.2	0.26	3.78
6 Min	3	33.7	0.562	170	56.7	0.59	1.68
7 Min	3	42.4	0.706	83	27.7	1.53	0.65
8 Min	3	42.8	0.714	91	30.4	1.41	0.71
9 Min	3	41.2	0.686	89	29.5	1.39	0.72
10 Min	3	27.4	0.456	179	59.5	0.46	2.18
11 Min	3	41.2	0.686	121	40.5	1.02	0.98
12 Min	3	40.1	0.669	148	49.4	0.81	1.23
13 Min	3	40.9	0.681	56	18.5	2.20	0.45
14 Min	3	43.0	0.716	105	35.0	1.23	0.82
15 Min	3	25.1	0.419	297	98.9	0.25	3.94
		Total PEF		**2323**			

Figure 5. 6 compiled 15 min table

Step 3: From the compiled 15 min set the Average flow rate (PEF/Min) has been calculated for each time frame for all 3 terminals through Vp=PEF/Width. Similarly, **Average Space** has been calculated through **Sp=Vp/Average Weighted Speed** and **density** through **density=1/average space.**

Step 4: K-Mean Clustering has been conducted by using SPSS, to form differentclusters using data set. K-Mean Clustering is used for identifying different set of level of Service for the passengers based on following factors: Speed, Space, FlowRate and Density. Clustered units are used to find the PLOS (Pedestrian Level of service) for an interchange.

Step 5: Pedestrian traffic flow diagram:

Pedestrian flow diagram have been formulated to identify the behavior of one factorwith respect to another. Greenshield logarithmic model is used for finding the relationship between Speed vs. Flow, Space vs. Density and Flow vs. Space as

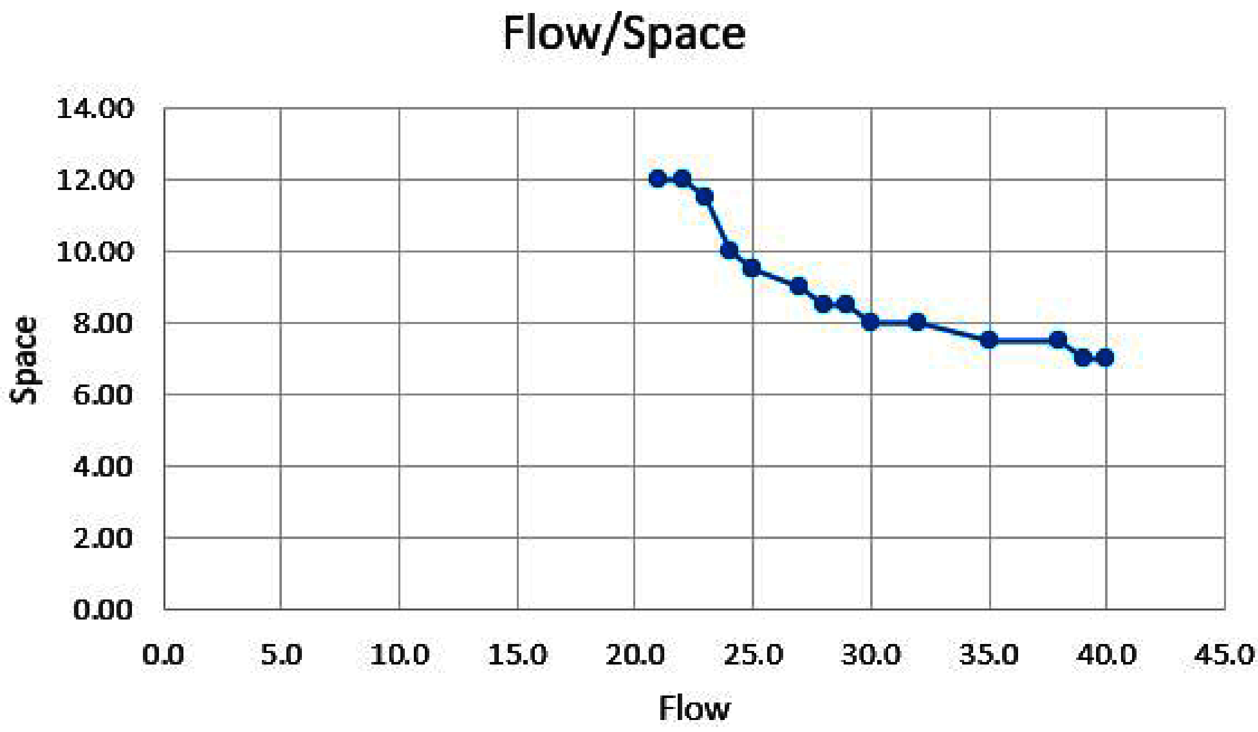


Figure 5. 7 flow/space

It has been observed from flow vs. space relationship graph that as the flow increases space per person decreases.

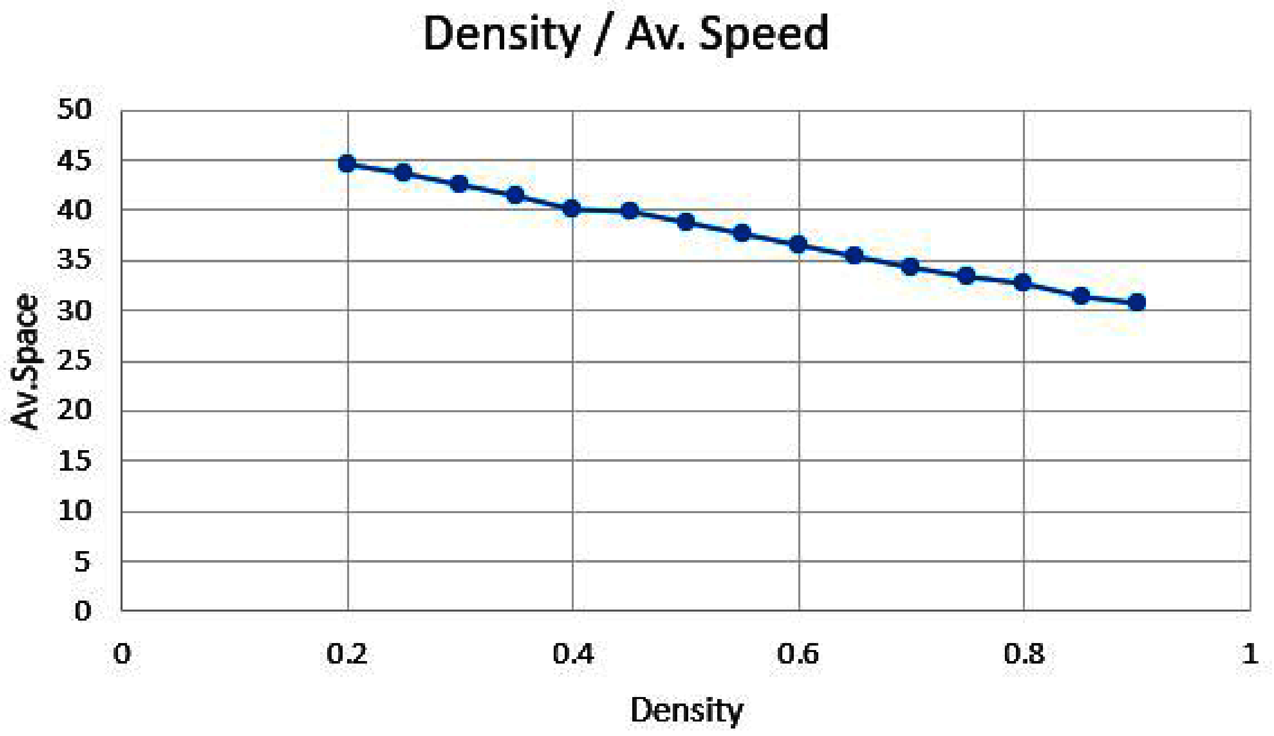


Figure 5. 8 density/average speed

As observed from the density vs. speed relationship graph that with the increase in average speed per person, density also decreases. Therefore when speed is zero, jam density (K) is equal to 10 (approx.) which means there is lot of congestion on pathway.

In space vs. speed relationship graph it has been observed that with the increase in average speed per person, average space also increases.

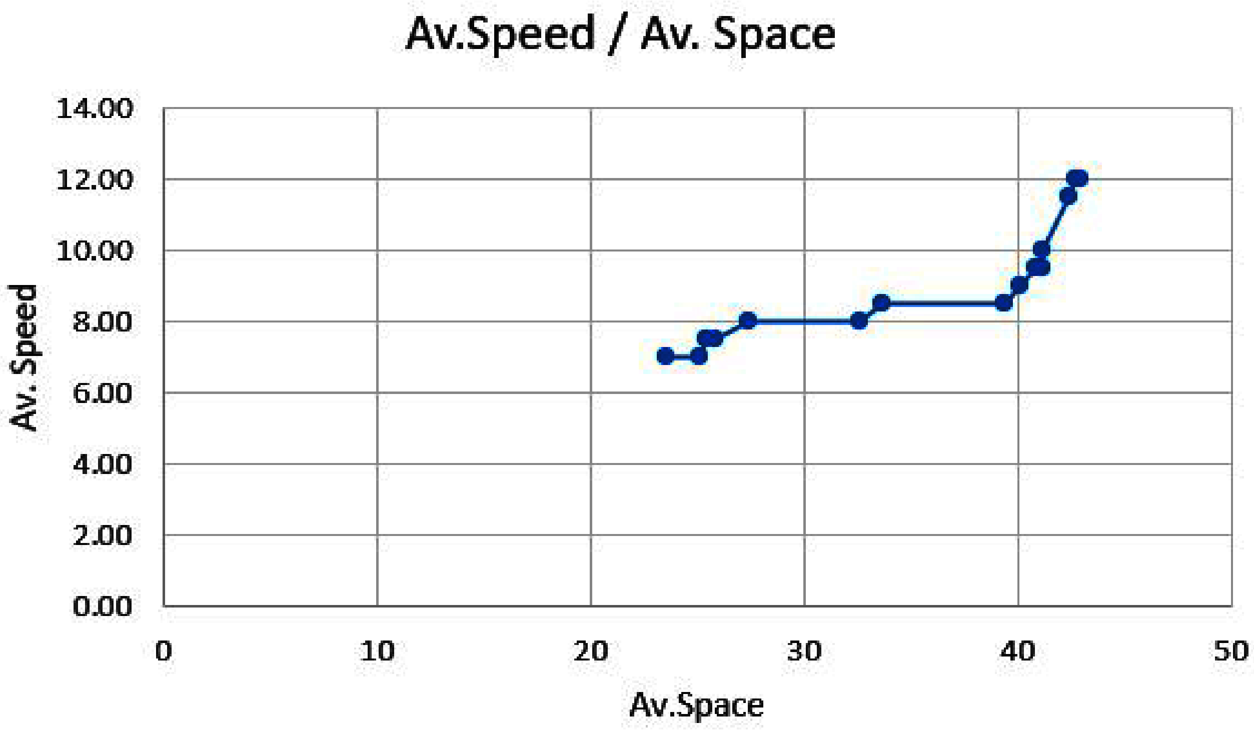


Figure 5. 8 average speed/ average space

Step 6: Pedestrian level of service (PLOS) have been formulated using above steps and is further used to evaluate existing LOS for the interchanges.

Table 10 PLOS for an interchange formed

PLOS	Average Space (Sqm / PEF)	Related Measure		
		Flow Rate (PEF / Min)	Average Speed (m / Min)	Density (PEF / Sqm)
A	14.40 - 12.68	17-66	50.70 - 48.41	> 0.91
B	12.68 - 9.26	67-114	48.41 - 43.80	0.92 - 1.87
C	9.26 - 6.94	115-170	43.81 - 37.70	1.88 - 2.97
D	6.94 - 4.17	171-227	37.71 - 30.30	2.98 - 5.12
E	4.17 - 1.88	228-231	30.31 - 25.10	5.13 - 6.72
F	1.88 - 0.15	232-419	25.11 - 21.60	6.73 - 10.42

Figure 5. 9 PLOS for interchange

5.4 Charbagh Physical & User Characteristics

Passengers travel characteristics is different from both interchanges, these user characteristics helps in deciding the travel pattern of the passenger, for example the number of luggage, type of luggage which play major role in deciding the existing situation.

5.4.1 Physical Characteristics

Charbagh interchange consists of 4 terminals Charbagh railway station, swami vivekanand ISBT, Charbagh metro station and kaushambi bus terminal. These all terminals are well connected via foot-over-bridge for passengers to walk freely free from vehicular conflict. These terminals are also well connected via main road.Data has been collected according to peak hour for particular terminals to analysethe passenger distribution flow along different modes within an interchange

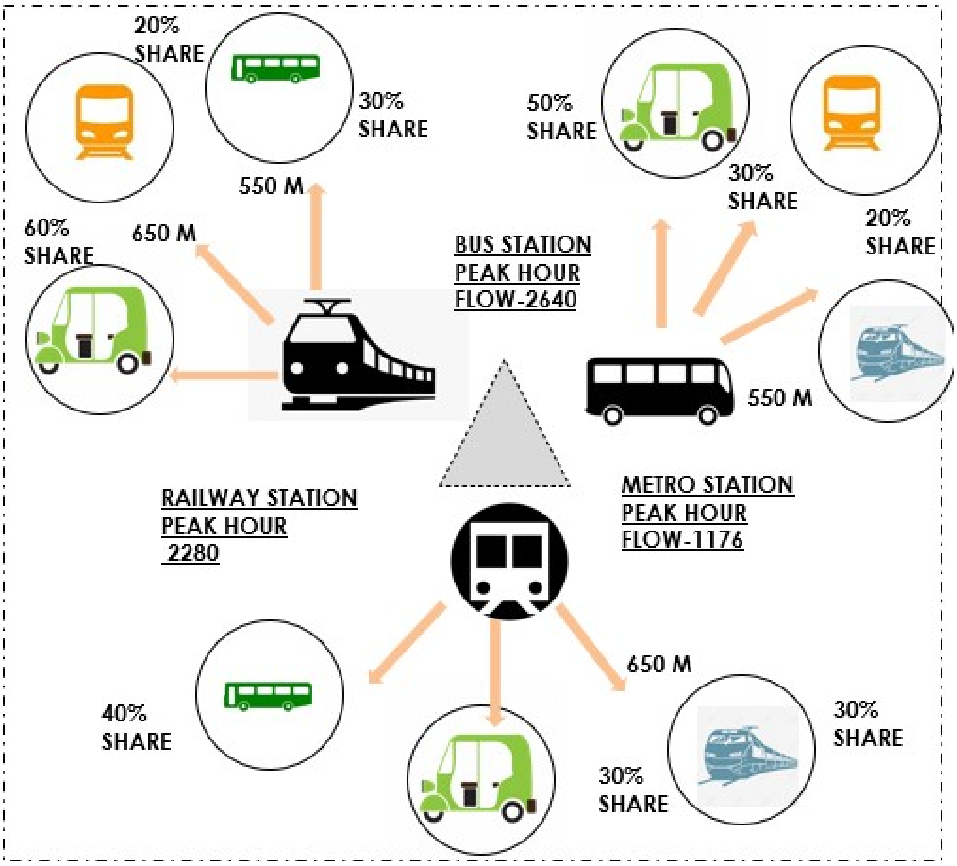


Figure 5. 10 trip share percentage

As shown above, percentage modal share has been segregated depending upon passenger flow as identified during survey. For different type of terminals passenger flow is different for e.g. maximum percentage share of passengers in case of metro station is to ISBT that is 33% share followed by kaushambi bus terminal 30% and further railway station of 28% whereas in terms of railway stationmaximum percentage share is 35% to metro station followed by 30% to kaushambibus terminal and 28% share of ISBT. In the same way ISBT has maximum share of 40% passengers to metro station followed by 27% share to railway station, 20%share of kaushambi bus terminal and 13% share of local passengers whereas in case of kaushambi bus terminal maximum share of 35% is of metro passenger and 27% share of railway station passengers with only 15% share of local travellers.

As shown below in Table 12, the number of passenger movement through different travel modes is shown which helps in analysing the flow pattern and type of luggage a particular category passenger carries. This will help further in evaluatingthe current level of service of these particular pathways in an interchange.

5.4.2 USER CHARACTERISTIC

AS DUE TO PRESENCE OF HIGHER TRAIN PASSENGER THE PIE CHART IS DIVIDED INTO 4 CATEGORY THAT IS AGE GROUP. PASSENGER GROUP, NUMBER OF LUGGAGE AND GENDER.

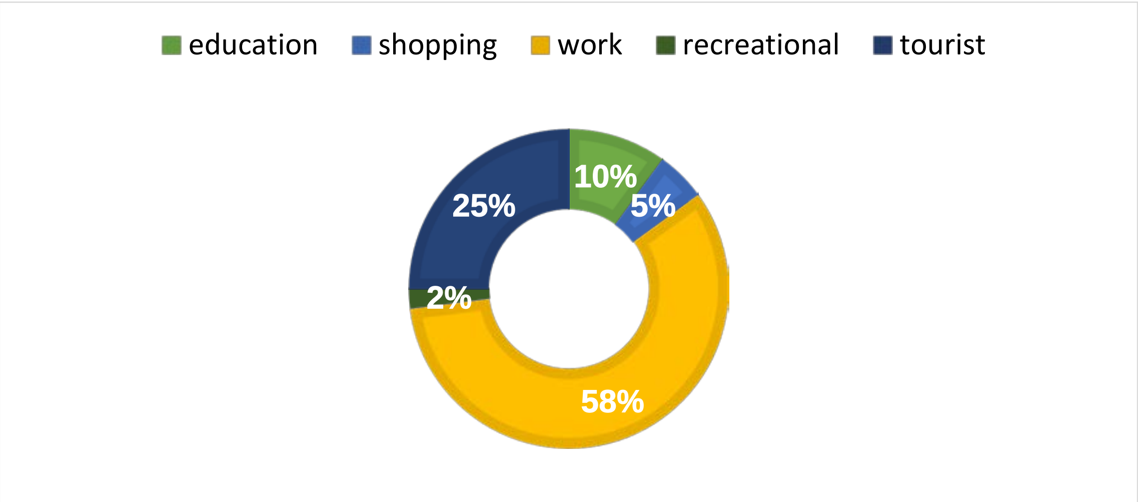


Figure 5. 11.TRIP PURPOSE

Work Purposeconsist of highest share of 58%, followed by 17% of transit trips, while there is only2% of shopping trips.

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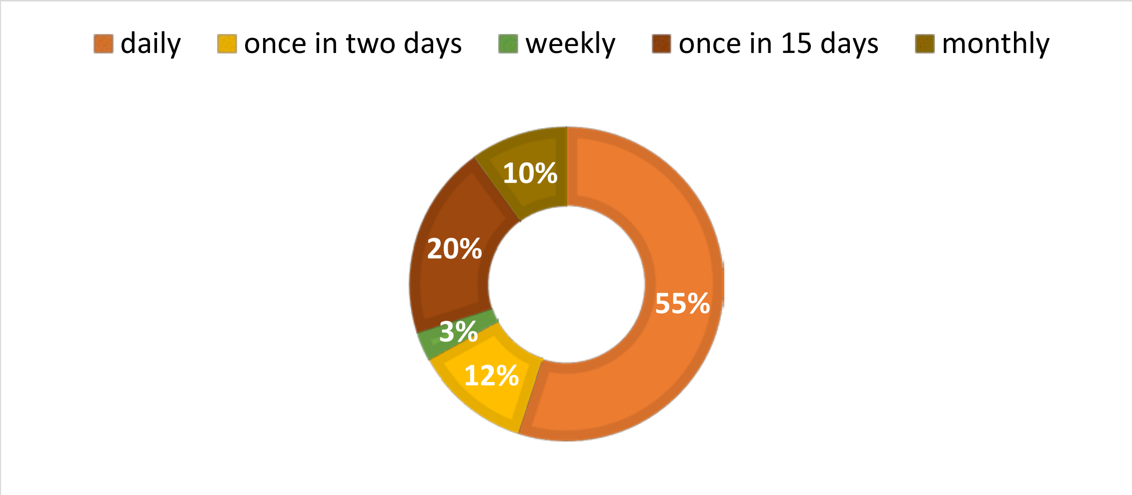


Figure 5. 12 TRAVEL FREQUENCY

It is observed trip frequency consist of highest share of daily travellers 55%, followed by 20% of monthly travellers and 12% of weekly travellers.

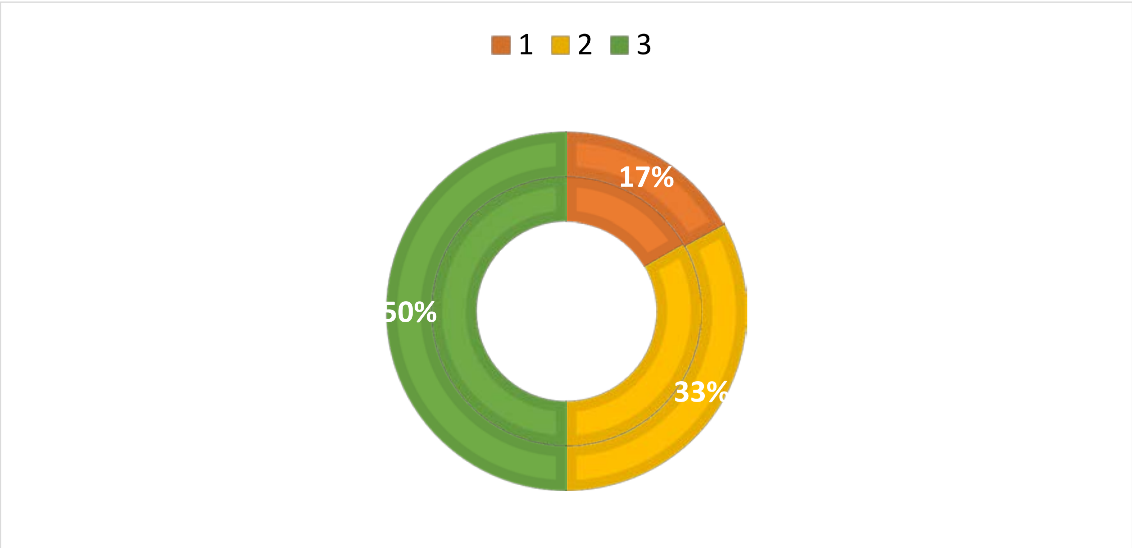


Figure 5. 13 NUMBER OF LUGGAGE

This pie chart shows the number of luggage with passenger for the interchange. Where 1 luggage is more than other.

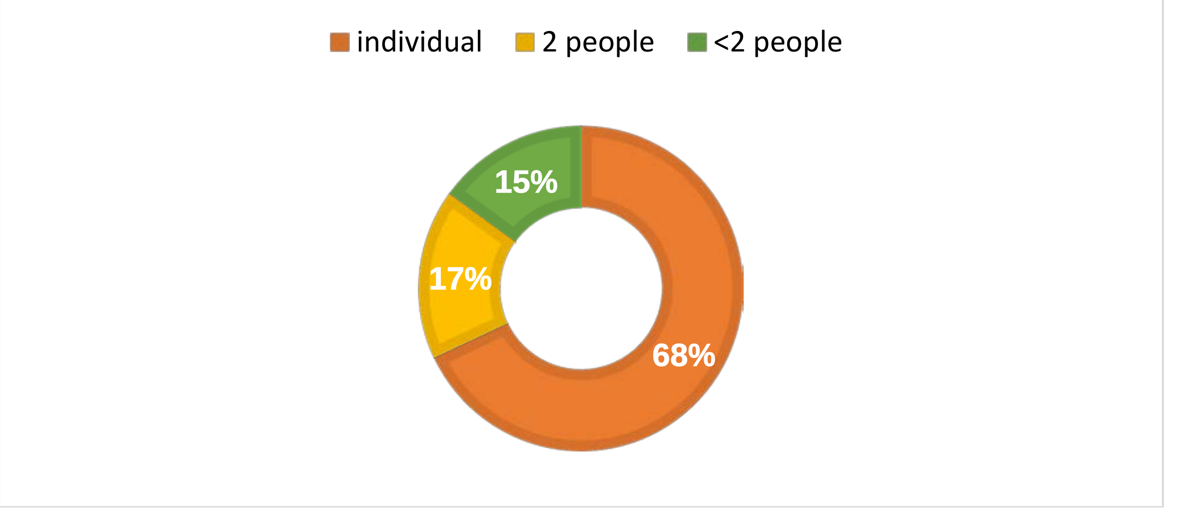


Figure 5.14 PASSENGER GROUP

This pie chart shows the passenger group travelling for the interchange. Where individual ratio is re than the other.

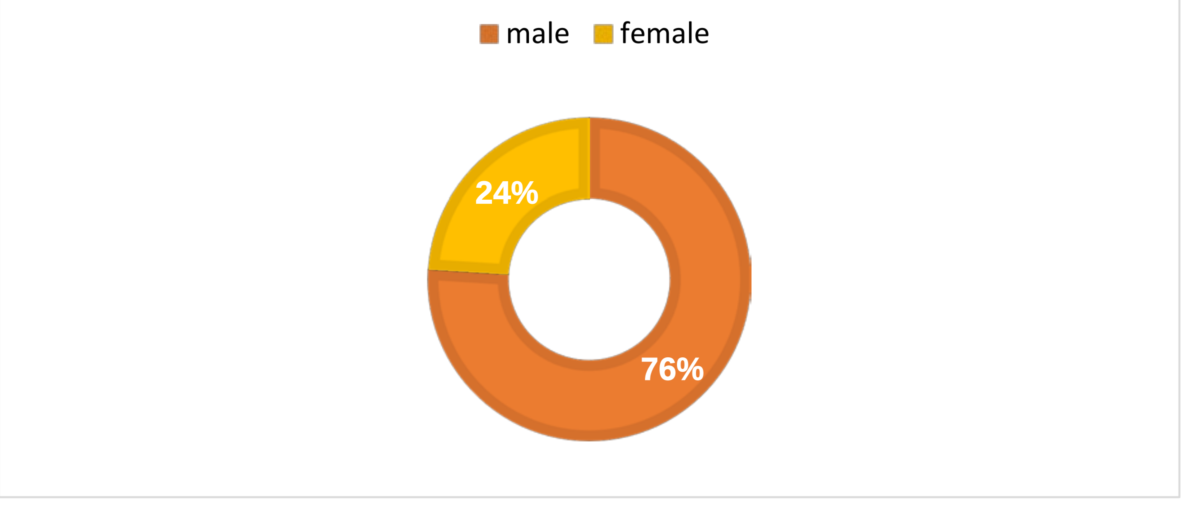


Figure 5. 15 **GENDER**

This pie chart shows the gender travelling for the interchange. And shows that the male gender is higher than the female.

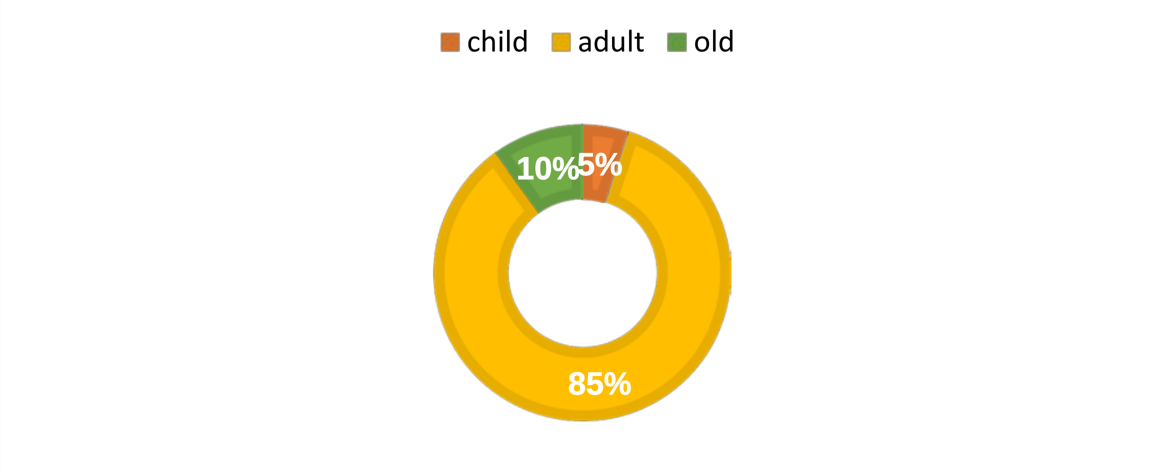


Figure 5.16 AGE GROUP

This pie chart shows the age group of passenger for the interchange. Where 1adult is travelling more than old and children.

5.4.1 Walkability Index/ Score

Walkability index has been evaluated based on parameters as discussed in 2.5.1 and score has been calculated as described in Table 3. Nine routes have been identified in Charbagh interchange and scores have been evaluated according to the respective routes based on their current condition of walkway as shown in table below. Major issues along route is that due to heavy passenger flow over terminals walkways effective width is less which caused discomfort while walking.Walkability Index in Charbagh interchange shows only three route with bad scorethat from Metro to Railway FOB lifts & escalator were not provided, from ISBT to Kaushambi Bus Terminal FOB encroachment by hawkers creating congestion, with no provision of street light and escalators were not in working condition. Other than that the walkability index score for Charbagh interchange is good.

Table 13 Charbagh Walkability Index

ROUTES	Footpath Surface	Footpath Width	Obstruct-ions	Vehicular Conflict	Longitudinal Continuity	Encroachment	Availability of crossing Facilities	Security	Comfort	Walking Environment
ISBT Entry Gate for interstate buses **(A)**	2	2	2	2	2	2	2	2	2	1
ISBT Entry Gate for DTC/Cluster buses **(B)**	2	2	2	2	2	2	2	2	1	1
ISBT to Metro station **(C)**	3	2	3	2	3	3	3	3	3	3

ISBT to railway station **(D)**	3	2	3	2	3	3	3	3	3	3
Metro to Railway station FOB **(E)**	3	2	1	2	2	1	1	1	2	1
Metro to kaushambi FOB **(F)**	3	2	1	2	2	1	2	1	1	1
Entry to Railway station **(G)**	2	1	2	2	2	2	2	2	1	1
Railway station exit **(H)**	2	1	2	2	2	2	2	2	1	1
Kaushambi Bus terminal to Bus stop **(I)**	2	3	1	2	2	1	2	1	1	1
WEIGHTED MEAN	**2.4**	**1.8**	**1.8**	**2**	**2.2**	**1.8**	**2.1**	**1.8**	**1.6**	**1.4**
SATISFACTORY RATING (0-5 Rating)	**4.5**	**2**	**2**	**3.5**	**4**	**2**	**4**	**2**	**1.5**	**1**
WALKABILITY INDEX/ SCORE	**10.8**	**3.6**	**3.6**	**6**	**8.8**	**3.6**	**8.4**	**3.6**	**2.4**	**1.4**
	Total= 53.2									
WALKABILITY INDEX/ SCORE lies under <70-52, so QOS is D										

Figure 5. 17 charbagh walkability index

Weighted mean as per ten parameters and satisfactory rating will be added as perpassenger’s response to calculate walkability index. Walkability index for Charbagh interchange is 53.2 with lies between <70-52 category, so QOS is D.

Chapter -6: PROPOSAL

6.1 - PROPOSAL 1-
To propose auto/taxi stand parking (eradicating encroachment)

While giving the auto/taxi stand parking the encroachment will be less and area which is covered by the street vendors and auto can be shifted under the parking so that the road will be more wide..

Figure 6.1 EXISTING PLAN OF CHARBAGH

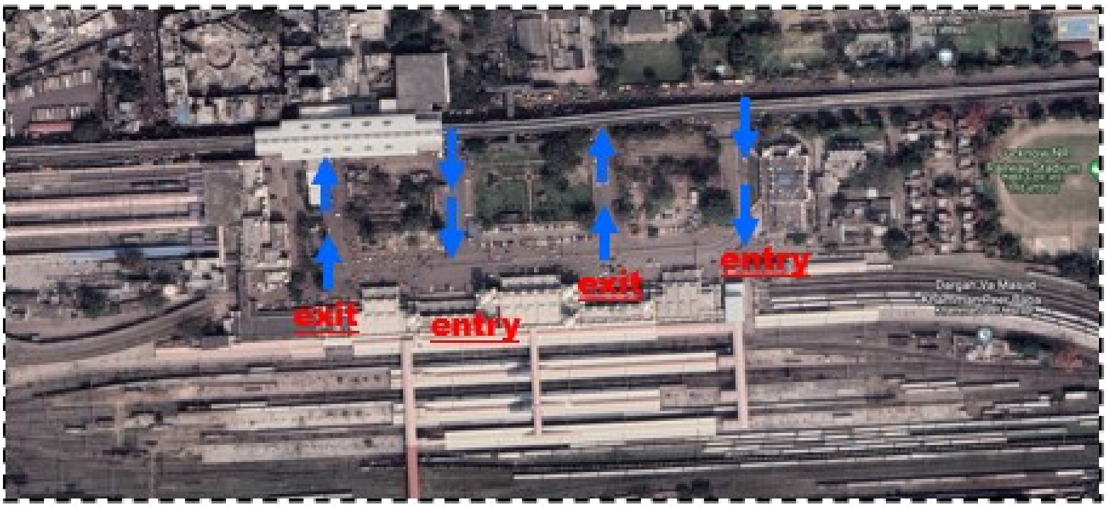
Figure 6.2 PROPOSED PLAN OF CHARBAGH

6.2 - PROPOSAL 2-
To create entry and exit

WHILE CREATING ENTRY AND EXIT THE PLOS WILL INCREASE AS THE MOVEMENT OF PEDESTRIAN WILL BE IN SPECIFIC MANNER. AND IT WILL NOT CREATE CONGESTION.

figure 6.3 EXISTING PLAN OF CHARBAGH

Figure 6.4 PROPOSED PLAN OF CHARBAGH



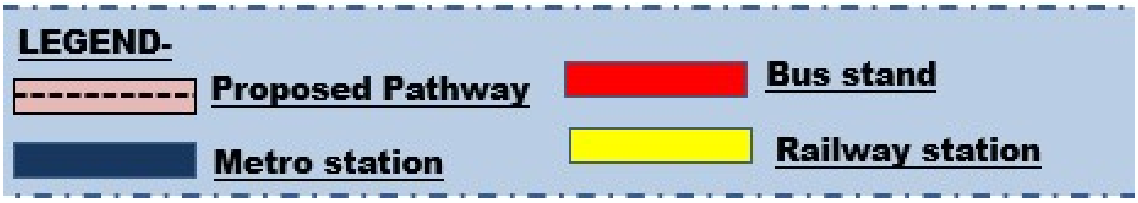
6.3- PROPOSAL 3-

To create the pathways for pedestrian (Capacity Enhancement of the Interchange walkways)

WHILE CREATING PATHWAY FOR THE PEDESTRIAN THE PLOS WILL INCREASE AS THE MOVEMENT OF PEDESTRIAN WILL BE IN SPECIFIC MANNER. AND IT WILL NOT CREATE CONGESTION.

Figure 6.5-EXISTING PLAN OF CHARBAGH

Figure 6.6 PROPOSED PLAN OF CHARBAGH



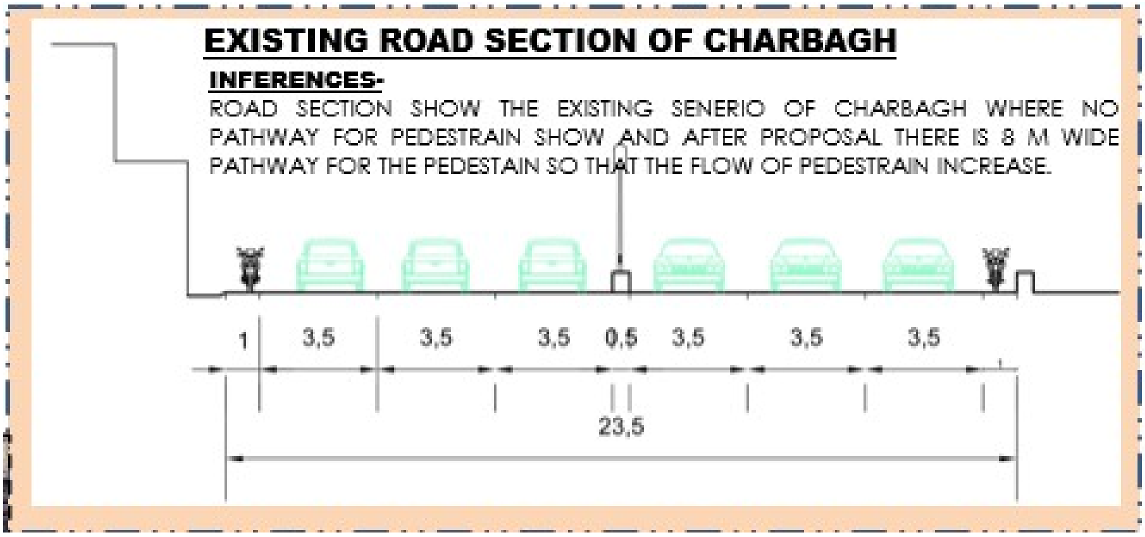


Figure 6. 7 existing road section

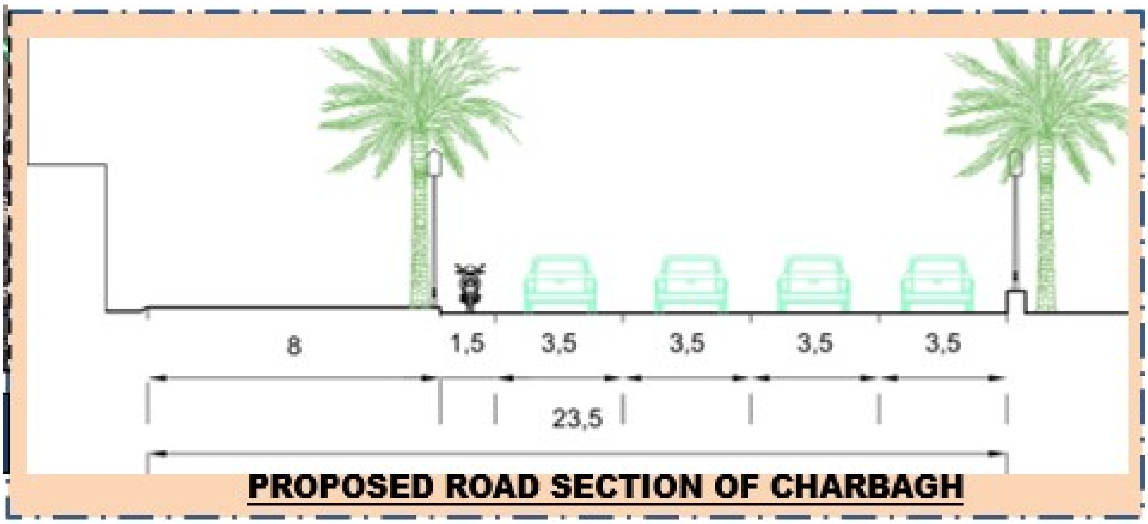


Figure 6. 8 proposed road section

6.4- PROPOSAL 4-

To create underground walkway instead of footbridge

WHILE CREATING UNDERGROUND WALKWAY INSTEAD OF FOOTBRIDGE IT WILL HELP IN LESS ENCHROCHMENT AND WILL BE HELPFUL FOR THE DISABLED AND OLD PERSON.

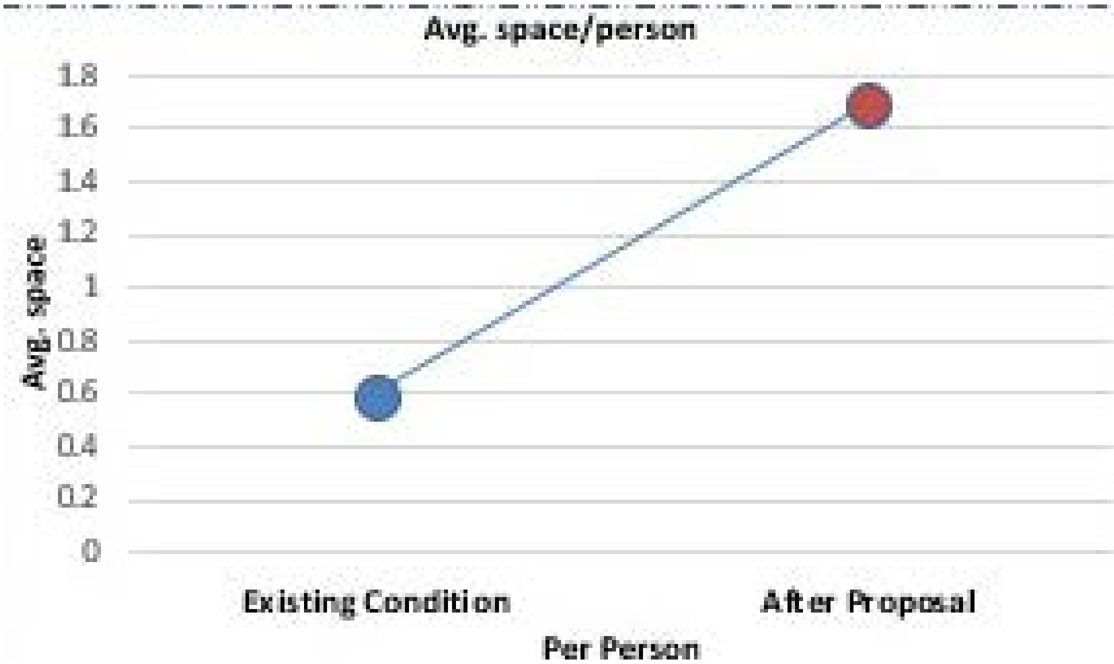
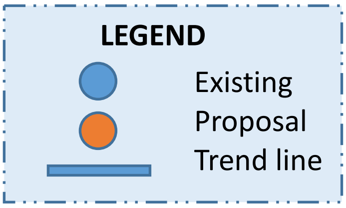


Figure 6. 9 average apace / person

According to standard and norms average space required per person is 0.64 sqm (without luggage) and 2.4 sqm (with luggage).

In this graph show the existing (0.6 sqm) and proposed avg. space per person (1.7 sqm)



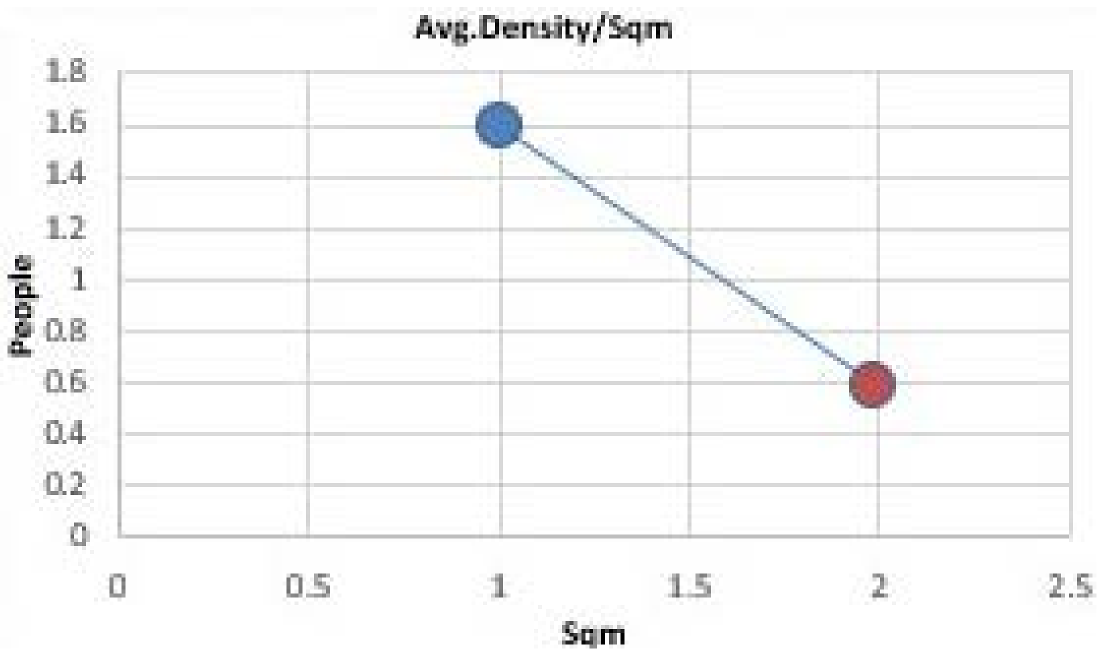


Figure 6. 10 average space / sqm

After proposing pathway od 8 Mtr. Wide avg density will decrease 1.6 person/sqm to 0.58 person/sqm. That create more space for each person to walk easily and huddle free.

It make ease in walkability and improve pedestrain level of services (PLOS).

6.5 – RECOMMENDATION

6.5.1 -SPACE ALLOWANCES FOR WHEELCHAIR

• the minimum clear floor or ground area required to accommodate a single, stationary wheel chair and occupant is 900mm x 1200mm as shown in the figure.

• a minimum clear floor ground area of 1200mm x 1200mm would allow access for•the minimum clear floor ground area for a wheelchair to turn is 1500mm whereas it may be ideal to provide 1800mm.

6.5.2 -TACTILE PAVING

Tactile paving is a textured bright coloured tile which can be detected by a visually impaired person and provide guidance in using pedestrian area. • Tactile paving should be provided in the line of travel avoiding obstructions such as manholes/tree guards/lamp posts etc. • Tile should have colours which contrasts with surrounding surface.

6.5.3 -DESIGN REQUIREMENTS FOR CURB RAMP

• Curb ramps are provided where the verticalrise is 150 mm or less.

• It should have a slip-resistant surface and should not allow water accumulation near where the ramp begins and ends.

• It should not project into the road surface and should be located or protected to prevent obstruction by parked vehicles

• It should be free from any obstruction such as signposts, traffic lights, etc.

• The gradient of a curb ramp should not be steeper than 1:10.

• The width should not be less than 900 mm.

• Warning blocks should be Installed at the end of the curb ramp to aid people with visual impairments.

• Curb ramps do not require handrails.

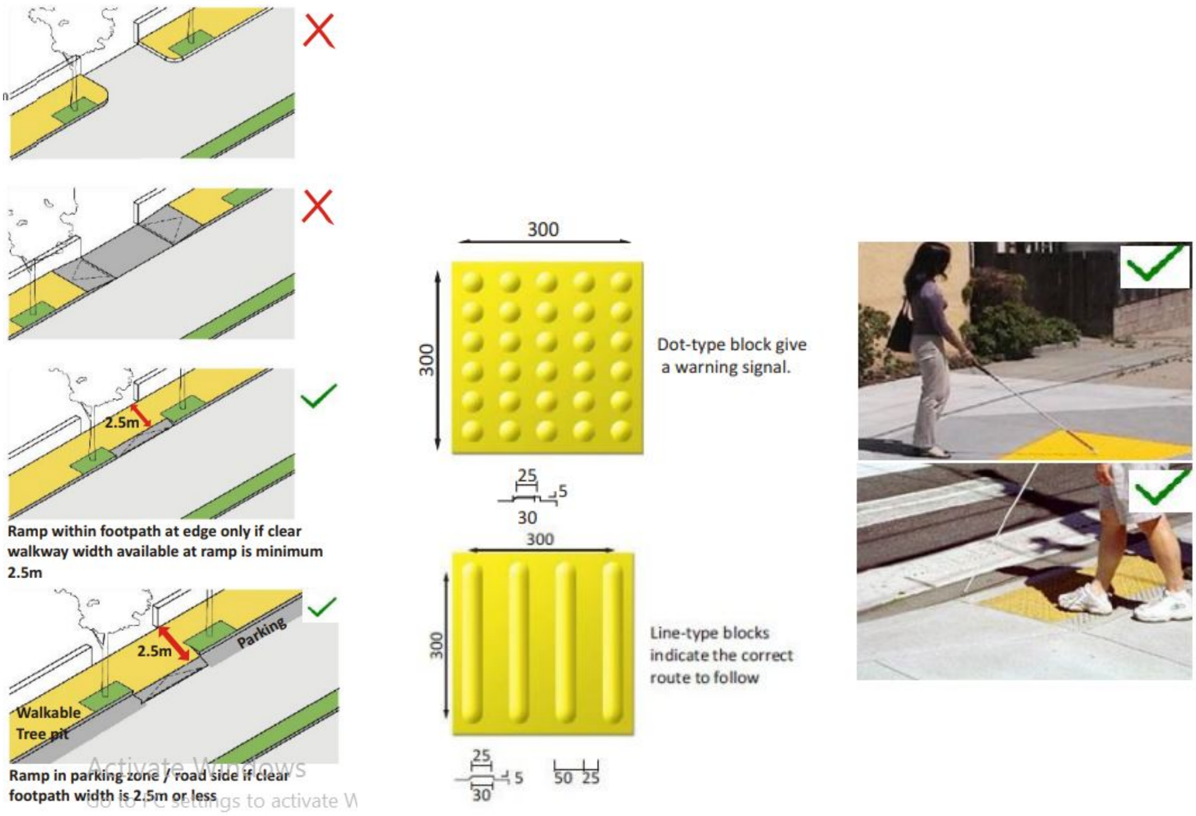


Figure 6. 11 tactile pavement

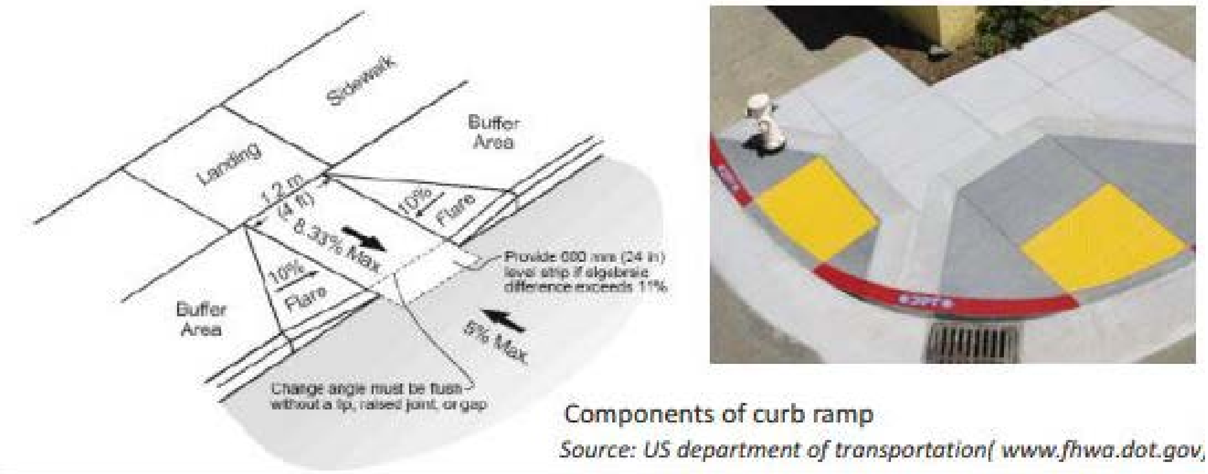
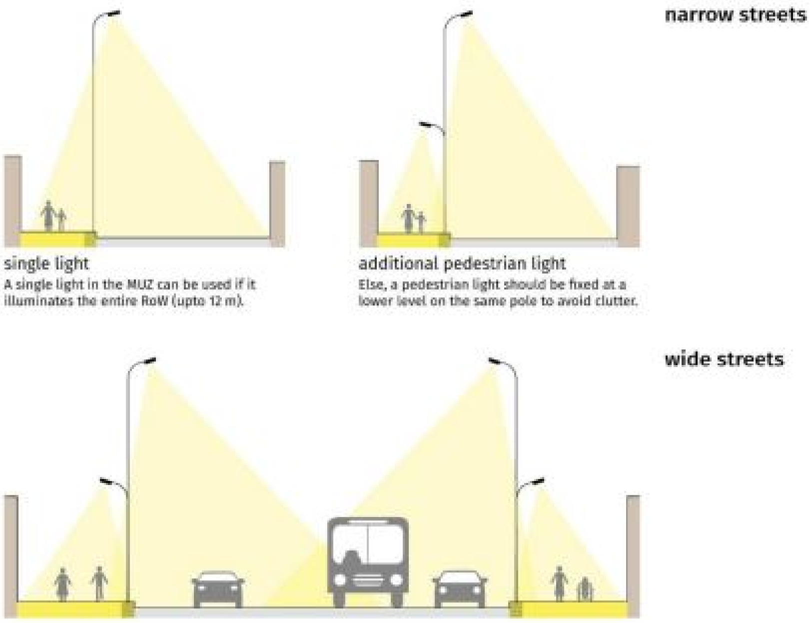


Figure 6. 12 component of curb ramp



Street type	Pole height (m)	Spacing* (m)
Footpath or cycle track (< 5 m width)	3–6	9–16
Local street (< 9 m width)	8–10	25–27
Arterial or collector (> 9 m width)	10–12	30–33

Figure 6. 13 street light type

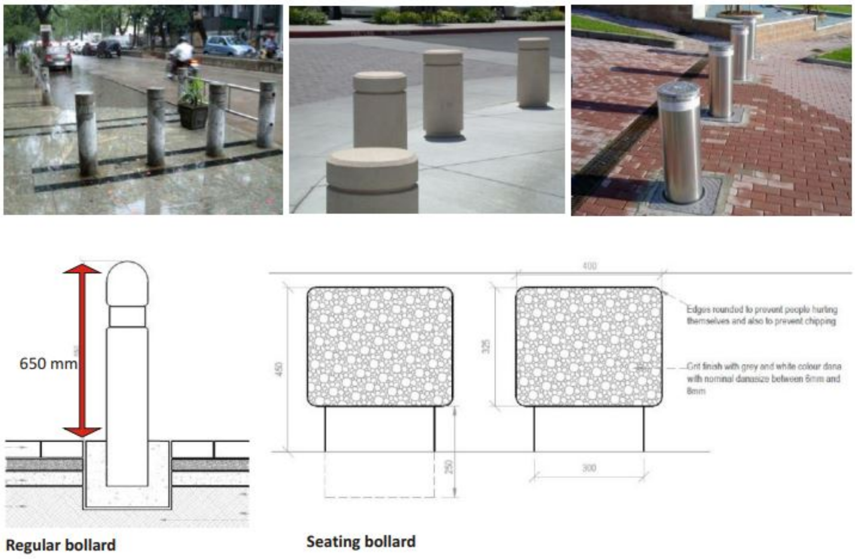


Figure 6. 14 seating

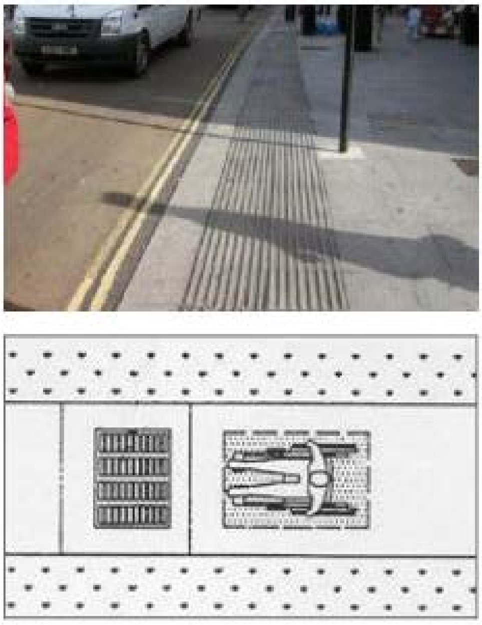
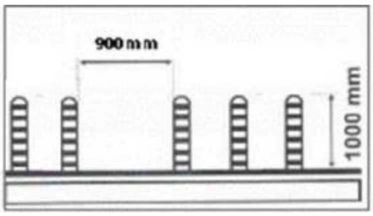
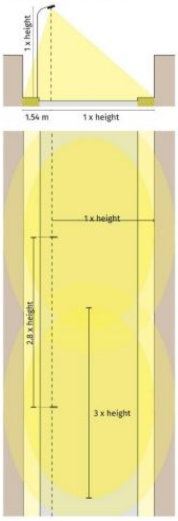


Figure 6. 15 pathway for wheel chair

Placement of grating



Street Lights



There are 3 types of speed breakers :

Type	Location	Remark
Speed BUMP	Local / Neighbor hood Streets	Speed Bumps to be moulded fibre type fixed properly and maintained.
Speed HUMP	Feeder Streets /Mobility Streets	Humps to be bitumen / concrete. Should be spaced at midblocks.
Speed TABLE	Mobility Streets	Tables to be bitumen / concrete. Should be spaced at midblocks.

Figure 6. 16 type of speed breaker

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