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INFLUENCE OF PASSENGER CHARACTERISTICS AND BEHAVIOUR ON RAILWAY STATION DESIGN: REVIEW PAPER

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ABSTRACT

This research paper summarizes published research work on how the passenger behaviour and characteristics influences the railway station design. Due to the growing population in cities and increased intercity trips, efficient public transportation is becoming an essential need. One of the best options for this problem is use of mass transit which accommodates transportation of people in high numbers per single trip. As a way of making Mass transit attractive to passengers, the utter most important objective of station design is to satisfy the various demands of passengers, translating to a people-oriented design. Public transportation systems such as rail transport pay dividends in key areas which include less traffic congestion, less pollution, safer travels, lower expenditures, less effort and better predictability. Passengers in railway transport exhibit different requirements during travel, which are reflected in terms of requirements regarding wished for offers and in specific behaviour patterns hence proper investigation on passenger characteristics and behavior mapping will aid station operators to offer services which are in sync with user requirements in a cost effective manner.

Keywords: Passenger Behaviour • Passenger Characteristics • Mass Transit • Railway Station

1.0 INTRODUCTION

Due to the growing population in cities and increased intercity trips, efficient public transportation is becoming an essential need. One of the best options for this problem is use of mass transit which accommodates transportation of people in high numbers per single trip [1]. Railway transportation is one of the most popular methods of mass transit transportation, allowing large numbers of passengers to travel in an efficient and cost-effective way. Reports from several institutions show a continuous growth trend in recent years, in line with government policies to use mass transit in order to promote energy efficiency and reduce pollution and congestion within cities, as information from research indicate that train operating companies are providing more than double the number of journeys by rail in comparison to two decades ago [2]. As a way of making Mass transit attractive to passengers, the utter most important objective of station design is to satisfy the various demands of passengers, translating to a people-oriented design [3]. Railway stations are mainly designed to shelter people whilst waiting for the train, along with retail opportunities for the operator. Whilst all these are important for the success of the station it sometimes feels that the individual needs of the passenger are further down the list of priorities [4]. Thus, it is sacrosanct to conduct detailed studies on the characteristics and behaviors of passengers in stations, which are highly dependent on their psychology [3]. The goal must be in line with carrying out thorough investigations related to passenger movement and waiting areas which will have an influence on design of station facilities which are attractive and at the same promoting time efficiency, enabling travelers to feel comfortable as well as ensuring smooth operation [4].

2.0 LITERATURE REVIEW ON STATION DESIGN

Public transportation systems such as rail transport pay dividends in key areas which include less traffic congestion, less pollution, safer travels, lower expenditures, less effort and better predictability [2]. Mass transit users are likely to experience the most negative emotions in comparison with other transportation

modes such as private cars, walking and cycling [5]. Public transport use has a negative effect on travel satisfaction if not delivered to the user's expectations, hence it is necessary to turn public transport to an attractive alternative which is capable of improving the passenger's wellbeing. Passengers in railway transport exhibit different requirements during travel, which are reflected in terms of requirements regarding wished for offers and in specific behaviour patterns [6]. The requirements depend on possible personal limitations and travel purpose and hence this will have an influence on the chosen means of transport. Significant influencing variables on the behaviour of travellers are possible mobility limitations, whereby these to some extent can be broadly defined [4].

Cost-effective ways to improve the quality of public transport and increase ridership which should be sought for may involve comfort and convenience improvements, which are relatively cheaper. Encouraging society to use railway transport more often requires the implementation of measures to make the journey more pleasurable. Key solutions include strategies to increase information provision, enhance convenience, improve control and facilitate journey planning which are based on the analysis of passenger preferences [2]. Travel is largely a derived demand. Usually, people do not travel for the sake of it, but because they need to do something at the destination e.g. to work, to shop, to visit friends and family, or leisure activities [5]. However, the underpinning reasons for travel, such as the need for company, are not generally discernible. Instead, only the passenger's actual travel behaviour is noted. This behaviour is shaped and constrained by many factors which include location, connectivity, costs, age, congestion, ability to travel and available transport options. Past experiences and social norms also influence people's mobility behaviour [6]. One of the key infrastructure of rail transportation is the station. Proper design and analysis of stations for improving station capacity and customer satisfaction, will ultimately lead to improved performance of the overall network. The capacity of a station is the ability of the station and its associated spaces to create safety and comfort for passengers expected to use the station. [7]. According to Ruger (2015) the expected passenger movement, from passenger behaviour analysis, during station design is as follows;

- Entering the station
- Stay in the station
- Move in the station
- Walk to the platform and wait on the platform
- Board the train

2.1 Customer Needs and Preferences

People in transit from one location to another often opt for the path of least resistance, i.e. the least cost, fastest and most reliable way to travel. Having opted for the train, passengers are subjected to a set of chain experiences in the course of the journey. The ultimate goal is to provide services enabling passengers to experience their transit time in a relaxed and pleasant way. [8]. It is a general requirement in railway design processes related to passengers, that they must be in forefront and the focus of all investigations. Existing railway projects have made it possible for operators, to assess the behavior and needs of passengers during their stay in the railway stations, in many different phases [9].

According to Ruger (2016), rail passenger analysis is focused on;

- Behavior
- Needs and expectations

Travel time and reliability are important for customers when using the railway service. This includes dwell time at train stations where passengers will spend most of their time when waiting for the train or disembarking from it. It is important to know the level of quality customers expect and what they are prepared to offer to get the quality they want. This helps to define the quality of customer needs in different quality layers [10].

Although most operators have a sound knowledge on the basic qualities of the train station, such as safety, reliability, and cleanliness, research highlights that these are not enough to create happy customers. Once the basic facilities are addressed and put in order, the operator will get satisfied customers but when customers are allowed to experience pleasant and relaxing services the operator is guaranteed to get happy customers [11]. Various transport needs of passengers can be classified and ranked according to importance in the shape of a pyramid. The pyramid of passenger needs reflects the perception of the quality offered by the railway transportation service. Figure 1 shows the customer wish pyramid which is in line with passenger behaviour analysis in order to design railway stations which serve their purpose in a cost effective way to satisfy customers. [8]

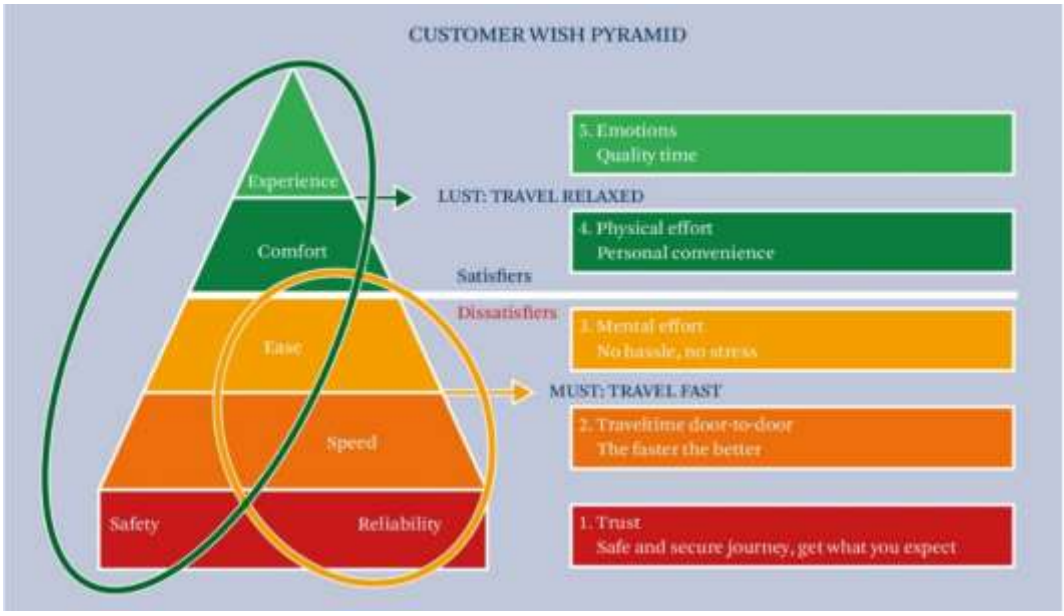

Figure 1: Customer Wish Pyramid [8]

The base of the pyramid is formed by the basic needs which include reliability and safety. For passengers, safety in particular means social safety and this is a prerequisite for consideration in the station premises and surroundings [8]. If potential customers perceive a service to be unsafe, they will avoid it. Reliability indicates the degree, to which passengers experience whilst receiving the quality they expect. If an expected service (train, information, seats, coffee, etc.) is not available when and where customers need it, dissatisfaction will be the norm of the day leading to commuters avoiding use of the train service [2] [8]. Good orientation, travel information and signposting are important aids and must be seen as logical solutions to providing key information to station users. Passengers expect a certain level of physical comfort at the station which harbors around the periphery of sheltered waiting, sitting areas, and food and refreshment facilities [4] [8]. Finally, the need of a pleasant experience must be satisfied and this is influenced by visual aspects such as architecture, design, cleanliness, interior finish materials and colours. Besides these, however, also less tangible environmental variables, such as lighting, smell and sound (noise or music) influence the quality of the experience. Offering facilities such as shops and cafés within the vicinity of the station and the obvious presence of staff enhances a pleasant stay [8].

2.2 Passenger Characteristics

A better understanding of factors that influence individual travel behaviour can reveal changes in preference and attitude, provide insights to existing travel patterns, improve transport planning, prepare for future infrastructure needs and services, and help better infrastructure design and implement sustainable and

inclusive transport policies that will meet transportation goals [3]. Transport attributes, such as travel cost and trip distance, external factors such as urban form and land use and socio-demographic characteristics are all critical determinants of transport mode choice [12]. Gender, household composition, income and car ownership are the most significant socio-demographic factors in influencing travel behaviour. However, gender is often the least understood socio-demographic variable [13]. According to Ruger (2019), the characteristics of passengers affecting station design include;

- Age
- Gender (including pregnant women)
- Luggage
- People of small stature (including children)
- Arrival rate
- Passenger group size (People moving with children)
- Passengers with disability (visual, hearing and communication impaired, limb impairment)

These characteristics will have an effect on passenger flow, ticketing system, safety and relevant information to improve the service quality and other necessary infrastructure within the station.

3.0 STATION INFRASTRUCTURE

Passengers are fairly pragmatic about what facilities should be provided at railway stations. Different passengers expect the railway station to be equipped with facilities and services which meet their basic expectations and enhance the train travel experience. The basic services and infrastructure for a station to serve its sole purpose are described in the following section with how they are influenced by passenger characteristics.

3.1 Train information

Real time information is rapidly becoming a baseline expectation for customers using railway transportation. Passengers expect information to be readily available within station premises [14]. A Human centred station navigation system is a critical tool in increasing passenger confidence, which will promote ease of access and manoeuvebility which in turn will reduce the opportunity for criminal activity and congestion. Current safeguarding initiatives are also designed to help vulnerable people feel more safe, secure and confident about asking for assistance if required [11]. Careful consideration should be made for the location of announcement systems and ensuring that speakers are placed frequently throughout the station to reach all public areas is vital, rather than relying purely on high volume. High volumes can cause pain and disorientation to some users [10]. The station should contain appropriate navigation and wayfinding signage which is also accessible to those with additional permanent or temporary needs in respect of cognitive, mental or physical impairment [11]. At the very least, staffed booking offices and information points as well as appropriate remote help points should be able to provide this information in line with customer expectations. [10] [15]. Systems for the delivery of information should be in working order and communicating accurate and timely information in an intelligent manner. Passengers expect to also have the means to call for assistance at all times, and points of information should be strategically such assistance to be relevant, timely and accurate as shown in figure 2. Station staff should be visible and stationed at key positions within the station, helpful and reassuring presence, particularly in times of disruption and during hours of darkness [6] [11].

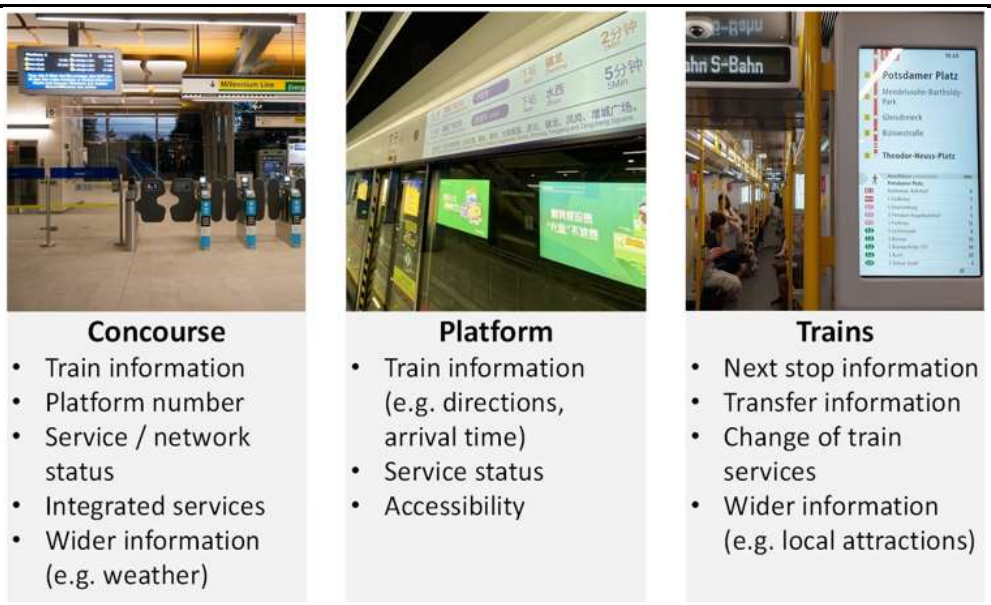

Figure 2: Critical positions for information accessibility [14]

Where spoken information cannot be accessed via a public address system at a station, passengers expect provision of an alternate information system, so as to acquire the same information audibly at the station. Clear announcements of departures, giving information about time, platform and destination, should be given as they are particularly valuable for blind and partially sighted passengers, and are a reassurance to all [10] [16]. Generally, real-time information in stations becomes more focused on service delivery to ensure that customers receive the most relevant information they need to support their journey [14]. Help points should be designed so that visually impaired people can find, recognise and use them. Based on the study of human behaviour, the Operators should ensure that the help point can be located easily and does not impede pedestrian traffic [2].

The station signage should be able to convey information which in turn will assist passengers with decision-making, therefore factors such as clarity, visibility, safety, accessibility, applicability and style are important elements to take into account in signage design based on customer behaviour [17]. Good signage communicates with passengers effectively by using clear messages, appropriate shape and size, recognisable symbols and infographics, legible typefaces or fonts and clearly contrasting colours [14]. A study conducted on 28 CoMET and Nova metros highlighted the major guidelines involved in signage design. This was done by exploring six key objectives as shown in figure 3.

Figure: Selected factors involved in signage design [14]

Observation of customer behaviour enabled the operators to carry out enhancements within stations to improve clarity, visibility and legibility of signage. This has led operators to explore various approaches to complement their static signage with new types of dynamic information to encourage greater passenger awareness and decision-making [1] [14]. This includes dynamic information for crowd control, passenger flow, and incident response, leading to an increased use of digital signage, and other mobile applications. This has allowed Passenger communications to undergo a revolution in the last decade, allowing passengers and train operators to pass information to one another, and amongst themselves [14].

3.2 Stairways

Collection and dispersal of passengers on railway platforms take place through stairways and foot over bridges. Design of these vital elements needs to incorporate the behavior of pedestrian flow to ensure desired level of service as well as safety in case of emergency [3]. Pedestrian flow characteristics are influenced by number of attributes of the pedestrian like age, gender, physical dimensions, luggage carried, group size, activity while walking, purpose in addition to the other attributes such as space availability, direction of movement and schedule of train as well [2] [18].

A study was conducted in India at Vadodara railway station premises to determine passenger characteristics at staircases. The required pedestrian data was extracted by noting down pedestrians entering the trap area [18]. At the time of arrival and departure of trains, pedestrian arrived at the platform and moved with speeds higher than the normal speed irrespective of age. Immediately after the train came to a halt, it was noticed that the alighting passengers moved towards the staircase in large numbers creating congestion for few moments at the entry of the stairway influencing individual movement. Pedestrians with luggage or holding a child were observed to require more space and affect pedestrian flow within the stairway. Overtaking was also found to rarely occur in normal conditions. Pedestrians moving in groups were observed to match their walking speed. This scenario affects the whole pedestrian flow within the staircase. At times, passengers were noticed to wait on the stairways for the incoming train and this has a great contribution in reduction of usable space of the staircase hence affecting the pedestrian movement [1] [10] [18]. A survey conducted in South Africa indicated that it is necessary to identify the arrival rates of the boarding passengers assigned to the particular train in the design of staircases. The arrival rates have an influence on the congestion level within the staircase. From the operational nature of Bonteheuwel station as a transfer station, the passenger arrival rate analysis was noticed to be influenced by transferring passengers from other platforms [19]. The staircases are to have handrails so as to assist passengers in movement up and down the staircase. This is a key feature derived from different characteristics of passengers. Older passengers will require balance assistance as they use the staircase. The rails will also aid passenger control moving up and down the staircase and will also aid in avoiding serious injuries when passengers fall by providing a place to hold on to, in case they slip [11] [20]. According to the Transport Infrastructure Manual (2020), Railway station stairs must:

- Have uniform rise heights and not exceed 2.5m total rise in any flight.
- Integrate a landing no less than 1.2m (1.5m preferred), including intermediate landings.
- Include a slip resistant surface, steps must have a co-efficient of friction of greater than 0.5.
- Include run-off distances for queuing and runoff distances.
- Have an intermediate handrail at the centre of the stairway where stairways exceed 4m in width. Have handrails on both sides of the stair.

3.3 Lifts

Lifts shall be provided where ramps are not available. Passengers expect Lifts to be located as near as possible to any stairs. Since travel time is of great importance to passengers, It is recommended that lifts are grouped together to reduce waiting times [20]. For big stations through lifts should be fitted wherever the geography of the station allows. These have a door at either end of the lift and are much easier for wheelchair users, who do not have to turn round in the lift or back out of it, a manoeuvre which can be difficult and time consuming [21]. Passengers also expect sheltered seating to be provided close to lift entrances for waiting passengers who cannot stand for long periods. Lift doors should tonally contrast with the surrounding wall. Automatic lift doors should have reopening activators, operated by invisible beam or contact with passengers, children and assistance dogs [20]. A study which was conducted in Vienna showed that an average of 66% of passengers without luggage choose an escalator, 31.5% choose stairs and only 2.5% choose lifts as shown in figure 4 [12].

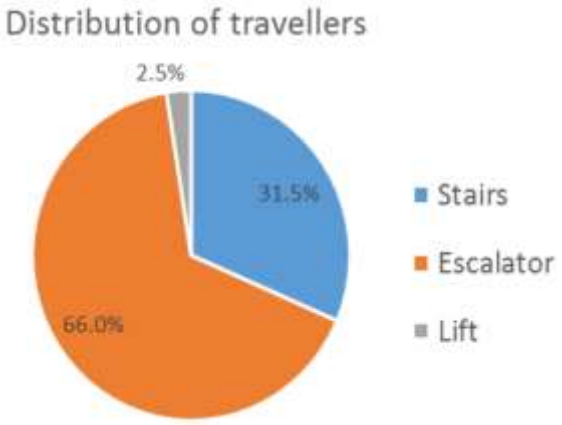

Figure 4: Distribution of passengers on preference for changing station floors [12]

Figure 5 goes on to classify passenger distribution on different ways which can be used when they alight up and down the levels of the station. Contributing factors include walking speed, age, gender and other related factors [12].

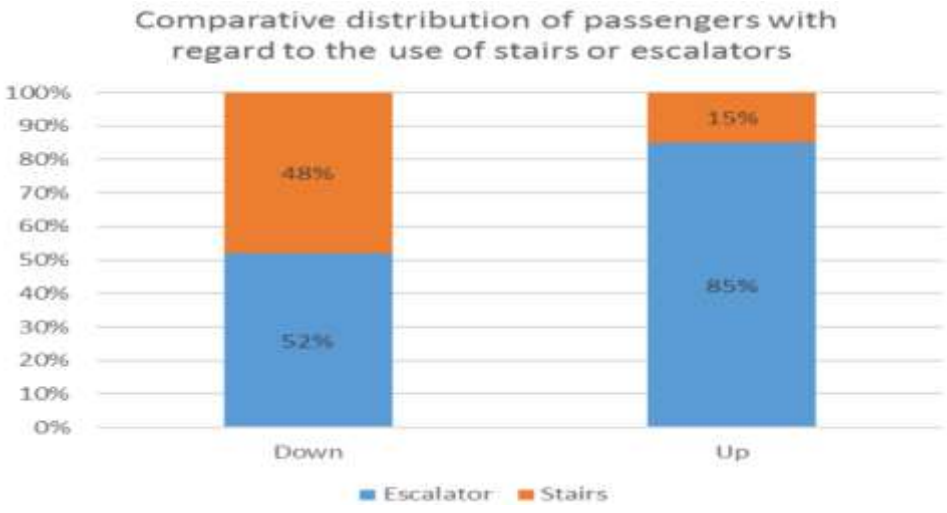

Figure 5: Distribution of passengers with regard to use of stairs or escalators [12].

3.4 Ticketing System

The ticketing system is one of the crucial points of the station. This is where passengers will access the most important services of the station. Passengers are likely to grade the station performance by the level of service of the ticketing system. Ticketing system design and positioning should cater for all passengers which are to use this system [20] [22]. Where manual ticket sales counters are to be used, information desks and customer assistance points should be provided along an obstacle free route, also taking into consideration accessibility to wheelchair users and people of small stature with an induction loop system for hearing assistance. If electronic devices are used, they should be able to display pricing information to the sales person and to the person purchasing the ticket and the summary of the above mentioned points is shown in figure 6 [14] [20].

Figure 6: Ticketing positons and structure [20]

Queues at booking offices are likely to be experienced hence this will pose a risk to people who cannot stand for long periods. Possible solutions include provision of handrails or perch seating. Rope or chain systems should be avoided, as they do not provide a sufficient level of support and are a trip hazard for people with visual impairments [10] [11] [20]. Where ticket vending machines are used, they should be placed on an obstacle-free route at a station. The machine should be equipped with a user friendly interface enabling passengers to use them with ease. They should use technology which is in sync with the learning curve of passengers likely to use the service [11] [20]. The machines should be accessible to people which are visually impaired and reachable to a wheelchair user and people of small stature. The illuminance level along obstacle-free routes shall be adapted to the visual task of the passenger. Tickets and change should be easy to retrieve by people with limited manual dexterity. Ticket vending machines should be carefully sited, so that glare and reflections from natural or unnatural light are minimised on the screen [20] [23].

3.5 Platform

In the process of passengers utilizing the platform in the rail station, there are a number of cross streamline, opposite passengers and passengers' mutual avoidance behavior. In pedestrian intertwined areas, pedestrian traffic characteristics are complex, and may affect the pedestrian travel time, traffic capacity and service levels of the platform [24]. Most of the Passengers want a seat and when seats are in short supply they want to make sure they are first on the train. To do this they try to get as close as possible to the platform our train is arriving at. But the announcement of the platform is usually left until the incoming train arrives [23]. This creates a stand-off with the passengers guessing which platform the train will arrive at and congregating around the barriers ignoring all the calls over the public address to return to the main concourse. Whilst there are many operational reasons for this it is a constant fight against the behaviour of the crowd [23] [25]. This therefore

requires a more imaginative way in order to understand how passenger behaviour can be influenced in public spaces such as stations. The behaviour of passengers has a major influence on operational components such as passenger flows in railway stations, passenger exchange times and thus the punctuality of trains [4]. Particularly in the case of movement systems such as stairs, escalators or lifts, capacity limits can be reached with a high volume of travellers, which leads to operational irregularities. Likewise, the design of the platform including its entrances and exits in combination with sub-optimally designed vehicles can lead to undesired prolongations of hold time and thus to delays [3].

Hence it is crucial to understand passenger characteristics so as to have an insight on how passengers in stations conduct themselves under the given boundary conditions. Based on this knowledge the station operator will be able to efficiently design facilities and architectural infrastructure in railway stations which will meet the passengers' expectations [4]. Passenger distribution along the platform has a significant influence on passenger exchange time and thus on hold time and operating quality. Due to the disproportionate increase in passenger exchange time, an uneven distribution of passengers along the platform has a stronger influence on hold time [23]. A proper platform should cater for congestion which might take place when the train arrives and the design should ensure that all train doors should be utilised during boarding and de-boarding of the train. In long-distance transport, positioning on the platform depends primarily on whether or not travellers have a seat reservation. Subsequently, the selected coach class also influences the location of the positioning regardless of possible reservations [9]. This has a corresponding effect on the passenger waiting position on the platform. Particularly on peak travel days with increased passenger volume, this inevitably leads to an artificially generated and easily avoidable overloading of individual doors with correspondingly long hold times for the entire train [26]. The effect of group size should also be considered in platform design as it play a pivotal role on average walking speed. Single pedestrians are expected to walk at a faster average speed of 1.22m/s compared to those walking with one or two companions at an average speed of 1.02 and 0.92m/s respectively [19].

3.6 Shops and Supplementary Facilities

Currently, there are two distinct trends in supplementary facilities to stations. First, urban station buildings are increasingly taking the form of a complex. The second trend is that regional stations are being constructed together with local public facilities [22]. According to Ruger (2017), the supplementary facilities include;

- Restaurants,
- Bars,
- Hotels,
- Newspaper and Magazine Stands,
- Post and Telephone Services,
- Money Exchange Counters,
- Souvenir Shops,
- Pharmacies, Etc.,

Passengers require the Station building to provide these facilities as they prepare for their trip. Passengers have to stay more or less long at the station as they wait for train departure and changing of train and this plays a key role in the analysis of waiting times at the station. Waiting time has an influence on comfort and station experience hence it is felt subjectively and has to be reduced. Facilities like toilets and bathrooms should be embedded into the station design so as to improve passenger comfortability and experience [9] [16]. From studies made at the Vienna metro system, it was determined that approximately 20% of long distance travelling passengers stay more than 30 minutes at rail stations hence services to improve station experience are required during this waiting period. For this to be executed with high quality, luggage keeping services should be

provided to allow ease of movement within the station as confirmed by a study in which highlighted that almost 80% of people require luggage keeping services within the station [12] [16]. From the study, passenger preferences during their stay at the station were noted as shown in figure 7 [12].

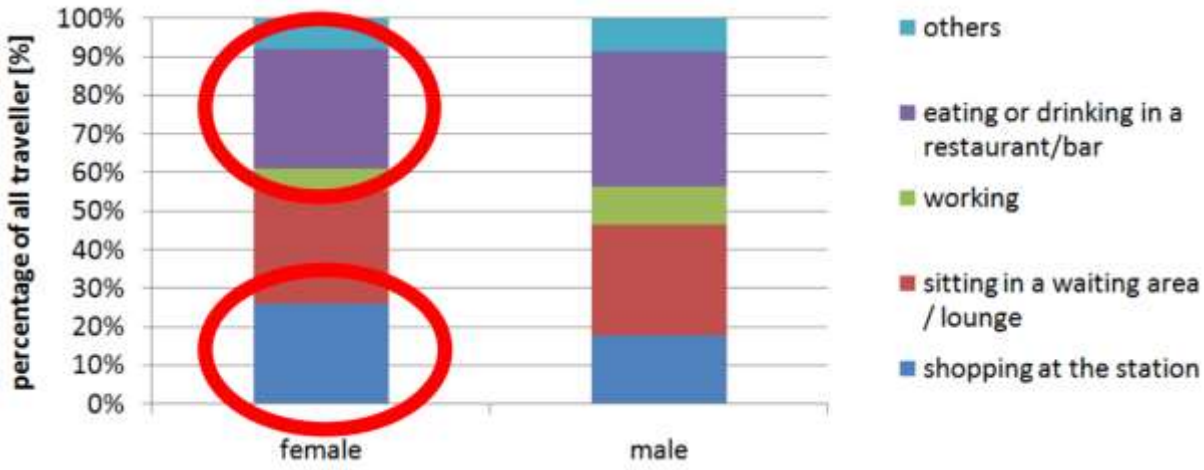

Figure 7: Passenger preferences during station stay [12]

3.7 Safety, Security and Emergency

Safety and security are primary needs of travelers, especially when it comes to Public Transportation. This recommends to transport operators and planners that, in order to increase the attractiveness of public transportation, it is of great importance to ensure adequate safety and security conditions, even before a convenient, efficient, and comfortable service. Passengers using the train service should feel safe and secure within station premises [5] [15]. A condition of being protected from danger or harm caused by intentional or unintentional events should be instilled within the station so as to promote ridership as passengers will feel comfortable within station premises. Fear of not being safe and secure affects mobility patterns. In fact, a sense of insecurity could force individuals to adopt some mobility behaviors in contrast with the travel choices they would really like to make [6] [15].

Safety is based on the end user perception. This is a crucial aspect as it will affect passenger attraction and ridership. Research highlights that passengers feel unsafe at night. This is largely felt by the females and hence gender should be taken into consideration during station design so as to make them feel safe [13] [15]. Examples of accidents are falls, collisions, and slips, while criminal acts include harassment, assault, theft, and robbery. However, it is not just a matter of protection from injury or crime, because even simple rude behaviors, such as bumping, shoving, and cursing, can escalate into something worse [27]. Station closure causes disruption due to unplanned operational situations hence operators must close the entrances or exits of a rail station. In emergencies, passengers cannot properly utilise station facilities. A station closure can strongly affect both the service and demand of the rail transit system [22] [28]. Congestion and panic may cause significant changes in passenger flow demand at the closed stations and nearby stations. The affected passengers will be forced to alter their planned origin station or destination station, hence stations should be able to accommodate extra passengers without congestion and overload of station infrastructure and services being experienced. [28] [28].

4.0 CONCLUSION

From the literature above, it is clear that for an operator to provide relevant services to rail users, the design should be centred on the behaviour and perception of the end user. Passenger characteristics and behavior mapping plays a pivotal role in the design of station facilities. This approach is very effective in aiding station

operators to offer services which are in sync with user requirements in a cost effective manner. Incorporation of passenger characteristics during station design will also play a pivotal role in attracting new customers. Consideration of these factors will support design optimisation and improve capacity utilisation within stations.

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