Pedestrian Flow and Capacity Analysis at Railway Stations

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ABSTRACT

Enormous growth of population has been observed in recent years and the number of passengers is traveling by the Indian railway has been increased significantly during the pilgrim season due to rapid urbanization. Pedestrian traffic is an important aspect of traffic handled by the Indian railways, because of competitive tariffs with other modes of transports, the comfort of travel, and speed of connectivity. The present study is carried out in the Kerala state railway stations under the categories of A1(NSG2), and A (NSG3) which has the highest annual passenger of boarding and alighting are recorded. Pedestrian flows are taken with the help of recorded video graphic footage on the railway station premises. The studies carried out in the pedestrian parameters and estimate the capacity of pedestrian flow involve a variety of pedestrians such as era, sexuality, belongings carried by the pedestrian, schedule of a train as well at entry and exit passageway of stairways with the help of Indo-HCM 2017 and NFPA 130, 2020 also to analyses the level of service of a pedestrian with the fundamental diagrams of the pedestrian flow vs speed, speed vs density, flow vs density, and space vs speed are developed. The discoveries of this study are expected to be fruitful for civic bodies, railway protection force, policymakers, the public, and other stakeholders to design a solution working on the idea of world elegance railway stations.

Keywords: Passenger, Stairway and platform, Speed, Pedestrian flow.

1 INTRODUCTION

Road users have become a crucial component of the transport system as any individual's journey starts & finishes by walking. Over recent decades, the use of the rail transit system as a safe and efficient means of transport has become increasingly common in metropolitan cities around the world. Rail transit services attract loving feedback due to its higher availability, convenience, protection and reliability (Liu et al., 2017). Rail by train has been more favourable and has grown in importance and prestige. Another of the reasons found with regard to the quality qualities of public transport and attracting as many passengers as possible is the development of rail transportation. Passenger traffic is a significant part of rail traffic Brahmbhatt et al. (2015). Due to various affordable tariffs, convenience and speed of transport, rail travel is a chosen mode of travel for a large part of the population to travel to fulfil their business, social and religious obligations. The Indian Railways (IR) with the expansion of its system and services across the country is a significant mode of transport of person and material over vast distances. In Kerala, railway lines are graded on the basis of annual revenue for passengers (Holloway & Tyler, 2013). A1-category railway stations get the highest average receipts for trains and thus the flow of passengers is higher relative to the other groups. Passengers are faced with a number of problems due to poor or inadequate services offered by train, in particular high-passenger rail. The architecture and configuration of the station affect the actions of the commuter. The station area typically consists of

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entrances, exits, transit/departure platforms, station amenities (fee device monitor, counter info, etc.) as well as connectivity amenities (stair, elevator, subway, FOB, etc.).

1.1 Objectives

- To analyse the level of service of pedestrian
- To study the fundamental diagrams of passenger flow at stairways and passageway of all entry and exit of various platforms in the railway station premises

1.2 BACKGROUND

(Soltani et al., 2012) has proven the effect of new regulations and design requirements on the safety element of public transport terminals for the disabled. The key target demographic for this research comprised of impaired passengers, particularly at KL Central and Klan Central Stations. This basic transport systems were badly built for disabled people in both research paper regions. In this report, it is observed that traveling to and from the airport, boarding and lighting is the most important part that needs to be discussed in this study. Result indicates that there is a need for a large amount of initiative on the part of government agencies and a massive demand for the renovation of the existing facilities, In order to make the disabled people feel more welcomed in society and to improve their inclusion and accessibility within the communities in Malaysia. (Asadi-Shekari et al., 2014) the Pedestrian Experience Survey is becoming increasingly relevant in an urbanizing world where walking is increasingly promoted. Scientists and designers shall assess the efficiency of the connect using steps established as a level of service to offer guidelines on appropriate or desired requirements. A range of techniques are being used to evaluate the pedestrian level of service (PLOS), including a wide variety of considerations and with considerable discussion ass to what should or should not be used. Earlier analysis has modified the methods used to evaluate the automotive LOS for PLOS. Collaboratively, certain considerations could be categorized in the following areas: convenience, safety & mobility. The most widely used considerations were: the width of the footpath; the obstruction of the traffic flow; the speed and volume of the motor vehicle; the width of the shoulder; and barriers such as on-street parking. Even so, several of the variables used have still not been theoretically studied and virtually neither of the methods in use has been tested for cross accuracy.

(Shah et al., 2013) this research focuses on the conduct of pedestrian traffic at Vadodara Railway Station in Gujarat State, India. For the study, four separate stairways with different physical dimensions attached to the platform and FOB were considered. For various sizes of stairs, flow velocity-space and density plots display different trends but usually similar patterns. The research discusses the features of the pedestrians observed mostly during span of 15 minutes before and after the arrival of the train, taking into account the age, gender, state of loading and the time of day. The result reveals that pedestrians travel faster in the afternoon or throughout the day relative to the night and the presence of pedestrians with baggage has a potential influence on the reduction of the pedestrian's average walking speed. The research results include a stronger overview of the characteristics of let pedestrian movement through taking into account that limited length including its train's arrival period when a significant volume passenger numbers travel within the Context of India.

IRC 103 (2012) IRC guidelines specifications for each pedestrian facility is provided. In the case of footpaths, both horizontally and vertically, a minimum walking space of 1.8 m width x 2.2 m height should be free of any obstructions. An additional 1 m can be attached to the specified 4 m width for footpaths in retail areas. Dead Width is considered this additional width. For drainage purposes, cross falls should only be supported where absolutely appropriate and should be a limit of 1:50. The specifications while including the kerbs are the overall

the height of the pavement, including the kerb, must not exceed 150 mm from the road surface. the walking surface and the top paving. The median can be up to a height of 250 mm or covered by accident blockers. Undetectable a potential width of 10 mm may be projected onto the footpath by obstacles placed below 2.20 m. It is important to prevent protruding elements. Bicycle stands should be placed on a base that is elevated.

2 DATA COLLECTION

In order to observe the passenger flow parameters, video-graphic survey data is the most appropriate one, therefore recorded CCTV footage data of multiple stairways leading to the entry and exit area connected to the station platform and FOB was collected from Palakkad and Trivandrum Central railway stations premises in mid-December to January, 2019 – 2020. Selected trains on the special day and the duration were selected to catch pedestrian traffic due to restricted survey permission of after the arrival of train in station premises Number of passengers observed from the respective railway stations is tabulated in Table 1.

Table 1. Observed number of passengers from study area.

Location (Railway Station)	Palakkad	Trivandrum Central
Time of survey based on train arrival and departure	6.00 am to 3.00 pm	7.30 am to 8.30 pm
Number of trains observed	6	4
Number of samples taken	1243	2351

3 DATA ANALYSIS

The passenger flow characteristics of different railway stations were analyzed in this chapter. Passengers were analyzed based on various properties such as their age, gender and luggage carrying. Passenger flow analysis with respect to time in peak hour was analyzed (Bivina et al., 2018). Based on the flow parameters observed, fundamental relationship between the passenger flow parameters was developed.

3.1 Passenger Composition

Passenger composition was analyzed for the two different railway stations based on the microscopic parameters such as gender, age and luggage carrying. Overall male passengers are observed more compared to female category and the highest is observed in Trivandrum Central railway stations and that is of 82 percent. While considering the age parameter passengers was classified as below 15 years, between 16 to 30 year, 31 to 60 years and greater than 61 years for analyzing age wise classification. For all the two railway stations passengers in the middle age group was found to be dominant, around 49 percent of the passengers observed is between 16 to 30-year age group. While considering the luggage carrying property, since it is public transportation area passengers arrive and depart for many purposes such as educational, work purpose, leisure trip etc. therefore almost the majority of passengers have luggage with them.

3.2 Passenger Flow Analysis

The stream of passengers is calculated as the number of pedestrians traveling per minute at a specific location. Based on the passenger flow the peak hour of the study locations were determined. Highest passenger flow is observed in Trivandrum Central railway stations for morning duration. Passenger flow corresponding to different minutes in the peak hour is plotted for different study areas. The time-related variance in human mobility is plotted and shown in the figure. 1 and figure. 2.

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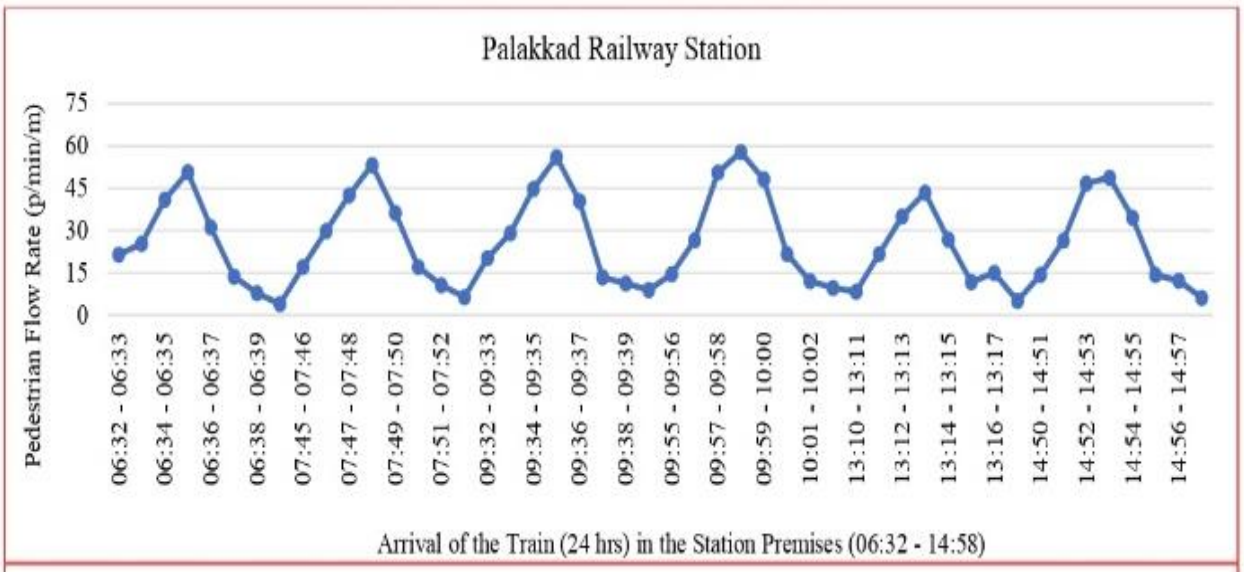

Figure 1. Palakkad railway station pedestrian flow rate.

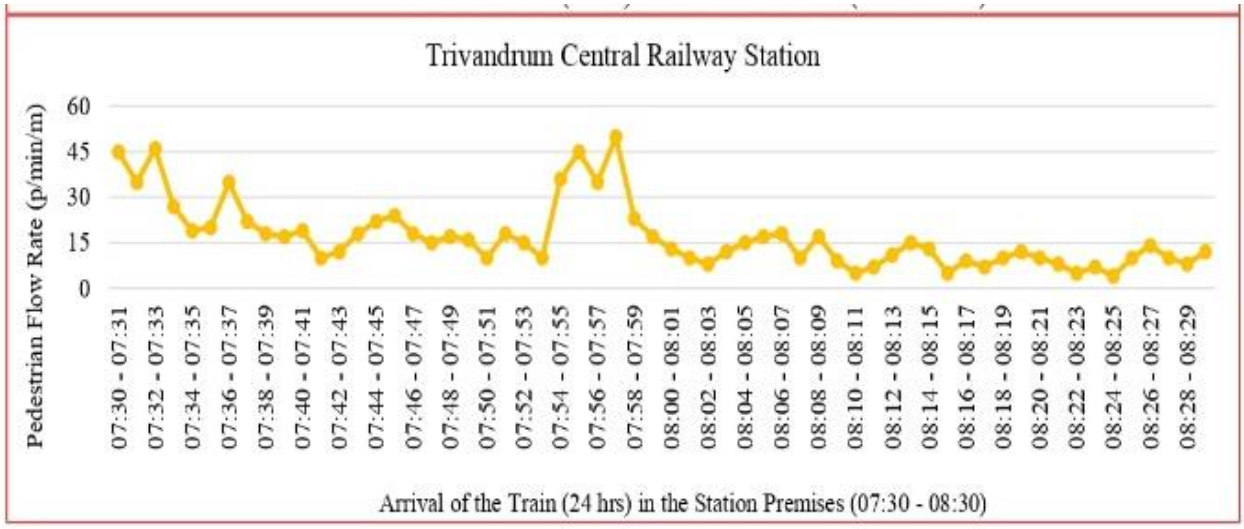

Figure 2. Trivandrum central railway station pedestrian flow rate.

In Palakkad the peak hour is estimated in the morning and the highest passenger flow is observed between 09:58 am and 09:59 am the passenger flow is reaching 60 passengers per minute. In Trivandrum Central railway station, the highest maximum flow is reaching up to 55 pedestrians per minute and it is between 7:58 am to 7:59 am.

3.3 Flow – Speed Analysis

The relationship between pedestrian velocity and flow is seen in figures 3 and 4 below. Similar to car flow curves, these curves indicate that there is room available to select higher walking rates while A few people are on a staircase (i.e. low levels of flow). Due to closer connections with pedestrians, speeds decrease as traffic increases. Transformation becomes even more difficult where a critical degree of crowding occurs, and thus flow and speed decrease.

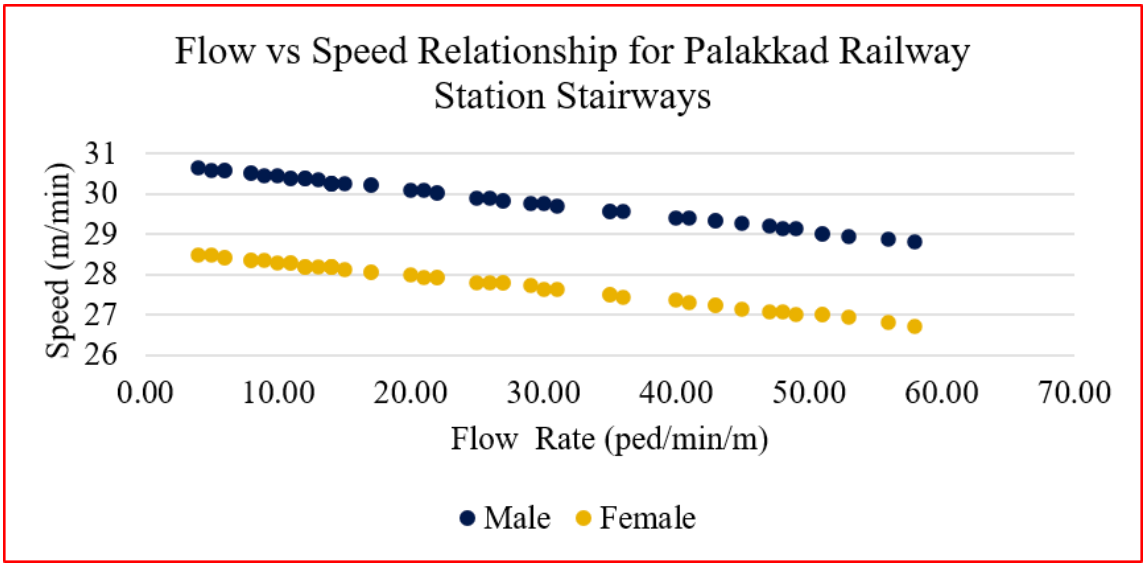

Figure 3. Palakkad railway station flow vs speed.

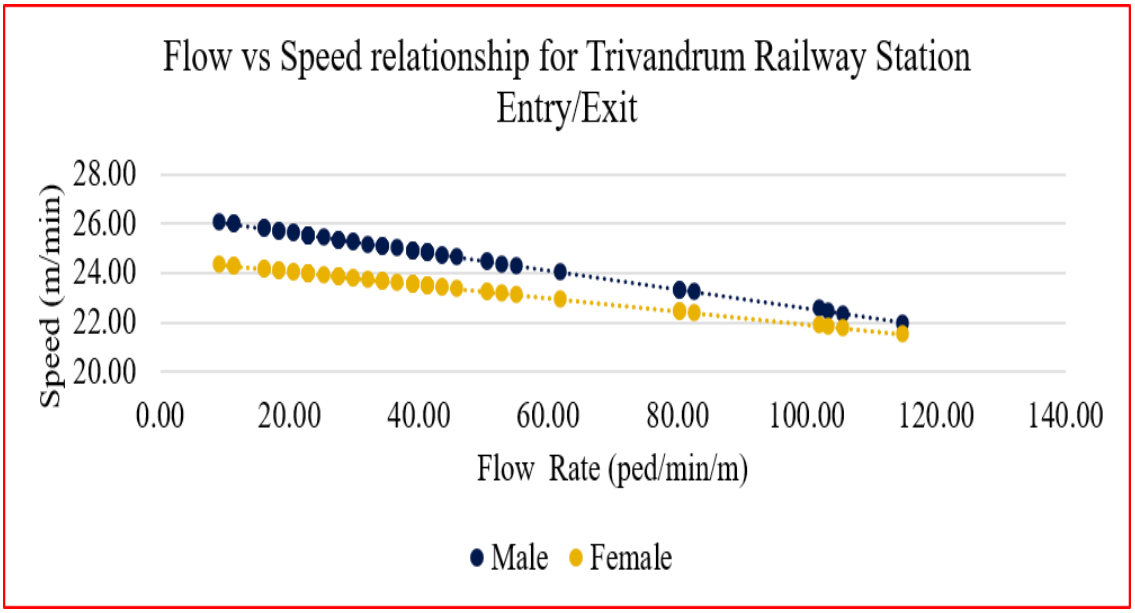

Figure 4. Trivandrum central railway station flow vs speed.

When the flow rate increase speed will be reduced due to space availability. Nominal speed found is when the flow rate is around 50 ped/min/m the Speed will be 25 - 30 m/min.

3.4 Density – Flow Analysis

Passenger flow is estimated as the number of pedestrians passing a given the flow rate is strictly the density is additive. The traffic density increases, as when the pedestrian arrival economy recovers, and, as a result, the available area for easy travel of pedestrians increases. passengers at all entrance and exit will be reduced (Dass et al., 2015). The density & flow relationships identified for the entry and exit zone at Palakkad, and Trivandrum Central Railway stations are shown in figure 5 and figure 6.

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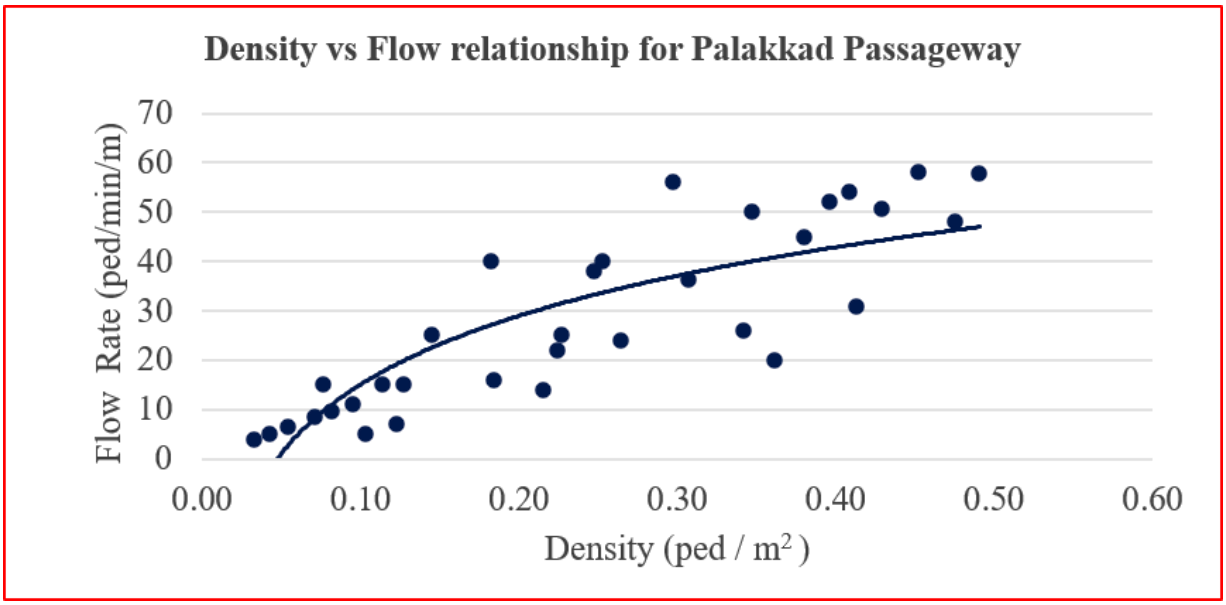

Figure 5. Palakkad railway station density vs flow.

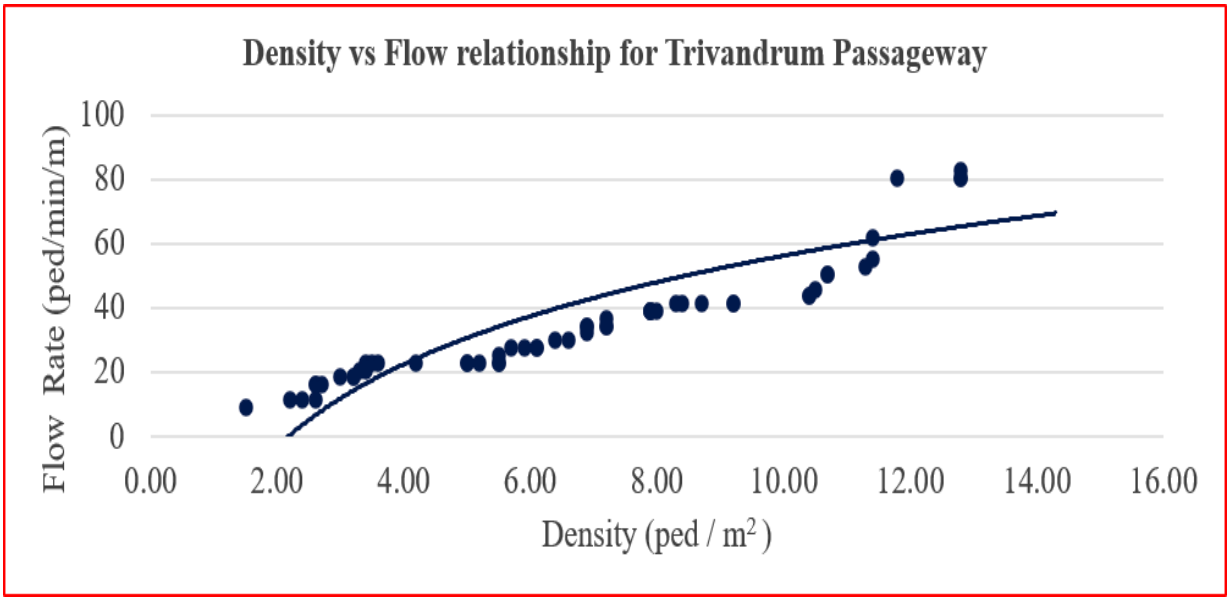

Figure 6. Trivandrum central railway station density vs flow.

When the flow rate increase in an area density will also increase, up to when the available space area is fully occupied flow rate will decrease and queue will form. Nominal found is when the flow rate is around 60 ped/min/m congestion in the area and queue will form.

3.5 Density – Speed Analysis

A pedestrian's walking speed is a feature of flow, density, and space available. Using linear function (Olander & Eves, 2011), the relationship among speed & density (evaluated autonomously) is established for specific entry and exit stairways. Speed and density observed from the four railway stations is plotted linearly.

Relationship of speed and density is plotted for the four study areas and the corresponding in Figure 7, Figure 8 and Table 1, the R2 value are shown.

Table 1. Fundamental equations.

Railway Stations	Flow(x) vs Speed(y)	Density(x) vs Flow (y)	Density(x) vs Speed(y)
Palakkad Junction	$y = -0.0341x + 30.78$ $R^2 = 0.9985$	$y = -48.909x^2 + 135.54x$ 0.7318 $R^2 = 0.7513$	$-y = -3.8585x + 30.771$ $R^2 = 0.9949$
Trivandrum Central	$y = -0.0384x + 26.42$ $R^2 = 0.9998$	$y = -53.58x^2 + 73.35x$ 16.781 $R^2 = 0.681$	$-y = -0.2519x + 26.731$ $R^2 = 0.848$

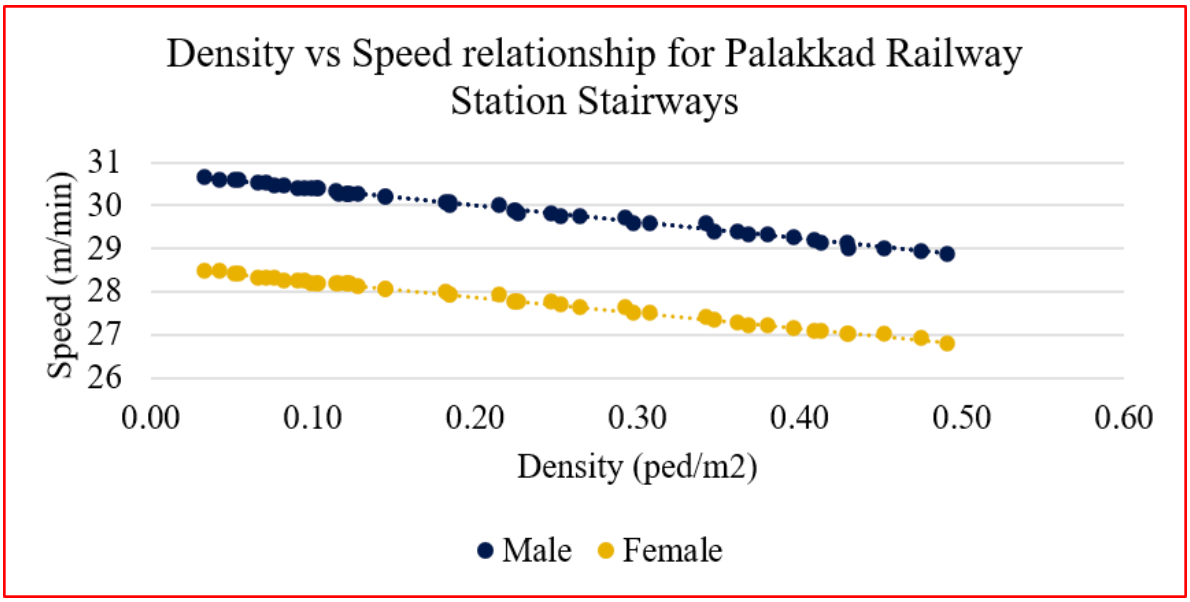

Figure 7. Palakkad railway station density vs speed.

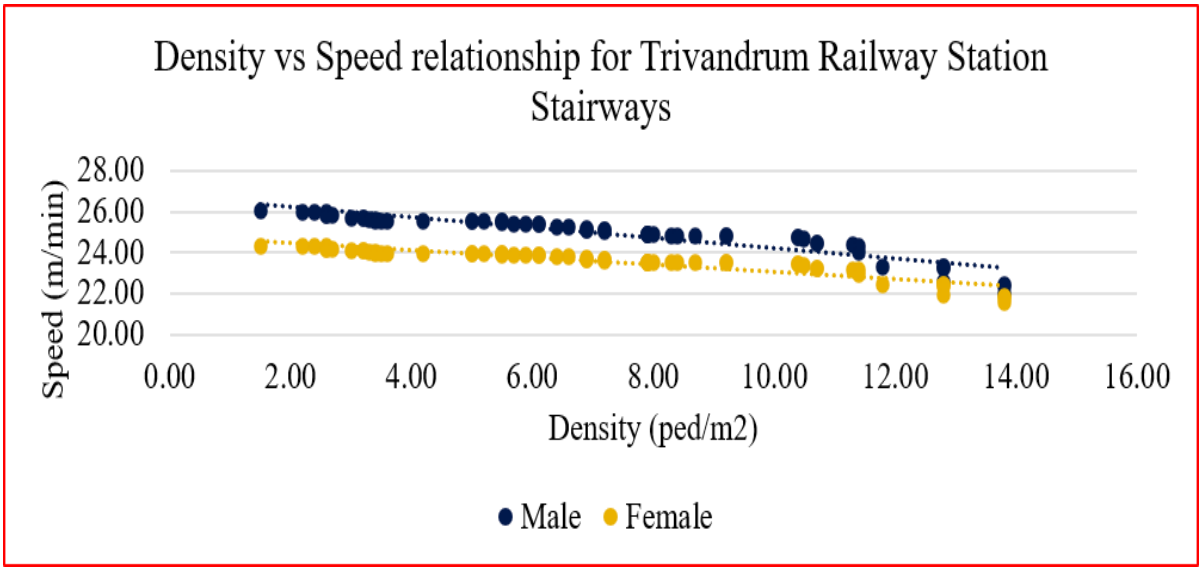

Figure 8. Trivandrum central railway station density vs speed.

When the density increases in an area speed will decrease, when the space area is fully occupied congestion and queue will form. Due to space availability speed of pedestrian changes. It is observed that when the speed is 30 m/min the density of passenger is very less that is less than 1 ped/m^2.

3.6 Pedestrian flow characteristic relationships

For all locations, the speed-density connection was found to be stable, so for all locations, the density-flow, flow-speed & density-speed module relationships were found to be quadratic (MURALEETHARAN et al., 2004). Such relationships are listed in table 1.

3.7 Pedestrian Level of Services

As a primary measure of performance, the Indo-HCM uses pedestrian space, including average speed & flow rate as secondary measurements. In order to provide a decent LOS, it is important to provide enough space for both moving and queuing pedestrian flows. Conversely, LOS is perceived to be pedestrian convenience, ease, privacy awareness & safety (Ministry of Railways, 2013). Appropriate metrics of LOS take into account unique limits on traffic flow, such as stairways and waiting pedestrians to explore roads. We're beginning to study about the stairways under LOS. Table 2 provides the pedestrian LOS requirements provided by (Indo-HCM, 2017).

Table 2. Pedestrian level of services.

Railway Stations	Flow (ped/min/meter)	PLOS	Speed (meter/min)	PLOS
Palakkad Junction	25.90	C	28.84	D
Trivandrum Central	39.53	C	24.23	E

4 CONCLUSIONS AND FUTURE SCOPE OF WORK

Present study concludes the following points,

- This analysis demonstrates average walking speed including its pedestrians for all 2 places at each group. That being said, the variation varies from person to person, sex and common waiting including its pedestrians.
- By analyzing the facilities provided in the railway stations, chengannur railway station lacks many facilities which are required for A category railway stations
- Average walking speed of passengers is obtained high in Kottayam railway station and it is of 39.57 m/min
- In developing the fundamental relationship between passenger flow parameters, better model is obtained for four railway station between speed and density.

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