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THE IMPORTANCE OF GOOD CIRCULATION IN RAILWAY TERMINALS AND STATIONS

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ABSTRACT

Terminal buildings are among the key components of modern railway transportation systems. In the design of railway terminals/stations, one of the key issues that confront architects and engineers is how to achieve effective circulation for passengers and goods at the point of interchange between the different modes of transportation systems. Therefore, the aim of this article was to assess the importance of effective circulation spaces with a view to identifying the attributes of internal and external circulation spaces and elements that can promote easy flow of pedestrian traffic in railway passenger terminals/stations. This article further addresses pedestrian circulation conditions, as well as observing features of good circulation space/element on rail terminals and good railway terminal circulation designs. The focus of the interior station circulation analysis is on pedestrian facilities directly affected by the terminal designs, including public space within the railway station (train hall, connecting passageways, vertical circulation and street entrances), and the street connector linking the terminal buildings to the existing streets and other subway stations.This implies that in order to achieve effective circulation spaces, architects and engineers should pay adequate attention to these aspects in the design and development of circulation spaces in railway terminals.

***Keywords**: Circulation Spaces; Railway Terminals; Railway Stations; Terminal Designs*

1.0 INTRODUCTION

Rapid, or heavy, rail transit is the highest capacity urban transit mode. Operating on exclusive rights of way, and grade-separated from motor vehicle traffic, rapid rail typically operates underground in subways or above ground on elevated lines. Unlike buses and light rail transit –

which passengers can board or alight at relatively simple, austere stops or stations – subways and elevated lines stop only at grade-separated stations where passengers must move to and from track platforms, ticketing areas, and adjacent streets. These stations are frequently complex pieces of engineering and architectural design in their own rights, where tens of thousands of people move, wait, transfer, and sometimes shop in a single day. This article examines the importance of ease of movement of people through railway terminals or stations.

Because many subway and elevated transit stations have been in service for decades, they often must accommodate in the same physical space more passengers than they originally were designed to handle. Thus, transit station designers and transit operators not only must devise strategies to provide safe and comfortable movement of passengers through transit stations, they also must implement these strategies within an environment of physical and financial constraints. Therefore, an important goal of this article is to explain the importance of transit system managers, planners, and designers in providing optimal passenger flow in railway terminals or stations.

2.0 Circulation in Buildings

According to Bitgood (2010), circulation in buildings is a term that describes the movement of people through a space. It is also the pathways taken by the users of a space, whether the users move through a space in the manner which was intended by the designers and the circulation pattern and approach taken by the users. The concept of circulation denotes the manner in which buildings and the spaces in them are designed to aid ease of human flow in the building (Yang, 2017). It also refers to the pathways through a building's floor layout, from which the users of the space experience the architecture of the building. In view of this, circulation networks in any building are considered to be key components of the building, except the structure is to be used solely as a monument. This is because it is the circulation network, which comprises circulation elements that enables users to gain access into and experience and exist from buildings. From the review of literature, circulation in buildings can be divided into two main types; namely, internal circulation and external circulation (Onugha, Ibem and Aderonmu, 2016). On the one hand, internal circulation deals with the movement of the users within the building envelope. On the other hand, external circulation is concerned with the movement around the exterior parts of the building; the landscape, the pedestrian and vehicular pathways and other external spaces. These two components are very important aspects of design of passenger terminals. This is due to the volume of pedestrian traffic that flows into, within and out of the building while travelling by any mode of transport (road, rail, water, air etc.) and other users of the spaces within and around the building (Bernal, 2016).

3.0 Circulation Spaces in Passenger Terminals

Architecturally speaking, in the design of buildings, a circulation space is usually situated between larger spaces in a building, through which the movement of people to and from another space in the building can be achieved (Kocabas, 2013).They are spaces which are internal to the structure of buildings, yet external to the principal rooms. Circulation spaces in buildings are comprised of two categories. The first are spaces that facilitate horizontal circulation (linear movement) within the building and such spaces are referred to as horizontal circulation spaces (Onugba et al, 2016). This circulation spaces are located within and around a building and provide connections between major spaces within the same floor level or on the external ground level of the building. Examples of building elements that facilitate horizontal circulation within buildings include entrances, foyers or receptions, lobbies, lounges, ramps and travellators (Onugba et al, 2016).

Of key importance to users of buildings are entrances. Notably, entrances are parts of a building that facilitate access to the building or from a space to another space within the building. They are also referred to as the entry points of a building. In view of their role in buildings, entrances should be designed with adequate consideration given to all possible users of the building. Closely related to entrances are foyers, which are also circulation spaces within a building, located at the entrance, which connects the entrance point of the building to other spaces within the building. It can also be described as a transition space in the building and is usually referred to as an entrance hall, hallway, receiving area, entryway or vestibule (Stefan, 2012). According to (Kocabaş 2013), the foyer starts at the entrance door and helps the users of the building to understand how to get to other spaces within the building. Further, corridors and lobbies are also linear circulation pathways in buildings that provide a link between various spaces within the building. In public buildings such as passenger terminals, the internal doors generally open in the direction of thecorridors and lobbies (Kocabaş 2013). In fact, Lacey(2004) explained that the main purpose of corridors is to convey information about a building to users and to assist them move around the interior spaces of the building.

There are also lounges, which are horizontal circulation spaces within a building that serves as a repose or relaxation space for the users of the building and provide a link between other spaces in the building. In passenger terminals, it is a space in which travelers prior to the commencement of their journey to their respective destinations, sit and relax while waiting for their journeys to begin.

The second category of circulation spaces is those that which facilitate vertical circulation (up and down movement) within the building and are referred to as vertical circulation spaces. This comprises all circulation spaces and design elements within a building that provide a means of upward and downward movement for users of buildings, from one floor level to another. The placement of vertical circulation design elements within a building is of vital importance because these circulation elements not only influence the floor layout of each floor they link, but also determine the layout of each floor level. Put succinctly, they control access from one floor to the other in buildings (Hernandez, 2010).

A number of spaces and elements facilitate vertical circulation within buildings. They include; staircases, ramps elevators, escalators and lifts. The staircase is a very common vertical circulation element in buildings. They are designed and constructed to help users move from one floor level to another within the building. Structurally, they are composed of a series of steps, with level landings situated at specific positions, spanning between floors in a building of more than one floors (Onugba et al, 2016). The ramp also serves the same function as the staircase, but it is structurally different from a staircase by having no risers and threads. Whereas both the staircase and ramps are architectural design elements, elevators, escalators and lifts are electrically-powered vertical circulation installations in buildings and are not included in the current study. The same is applicable to travellators, which are conveyor transport belts that can serve as either a horizontal circulation element or as a vertical circulation element in buildings (Connor Pincus Group, 2015).

4.0 Circulation on Railway Terminals/Station

Why people choose to travel by private car rather than by public transit is of major concern to transportation planners and transit operators. For some reluctant would-be riders, the answer might be summed up by the words of Berra (2010)whom when asked why he no longer patronized a popular St. Louis nightspot: “Nobody goes there anymore. It’s too crowded.” Passenger crowding on rail transit and in stations may not only decrease the attractiveness of transit for potential riders, it can also create unsafe conditions in stations as passengers’ risk being pushed onto tracks. Passengers forced to occupy space intended as a buffer along the platform edge are placed in harm’s way. Moreover, excessive station crowding can also prevent passengers from entering and exiting transit vehicles quickly and safely. If passenger volumes are so high that flow through stations is significantly obstructed, emergency evacuations may be impeded as well, risking health and safety. Beyond safety, crowding in transit stations can also reduce average vehicle speeds (and hence system capacity) by increasing vehicle dwell times due to protracted passenger boarding and alighting. Rail is the highest-capacity transit mode, and rail transit stations frequently experience high levels of pedestrian congestion, typically during the morning and afternoon rush hours, but also related to special events – such as festivals, parades, and sporting events – that attract large crowds of riders. Occasionally, extreme events such as natural or humanmade disasters, such as an earthquake, fire, or terrorist attack that require the complete evacuation of transit facilities, may also result in high levels of pedestrian congestion. In addition to walking and waiting, passengers also frequently purchase and validate their tickets, buy newspapers or food from concessions, ask for information at kiosks, or stop to consult maps. Thus, transit station congestion can take place in walking areas such as stairways, escalators, and elevators, and also in waiting areas such as platforms (especially during train boarding and alighting times). Point areas (Figure 1) such as station entrances and exits, ticketing machines, turnstiles/fare gates, and concessions may also experience congestion and queuing.

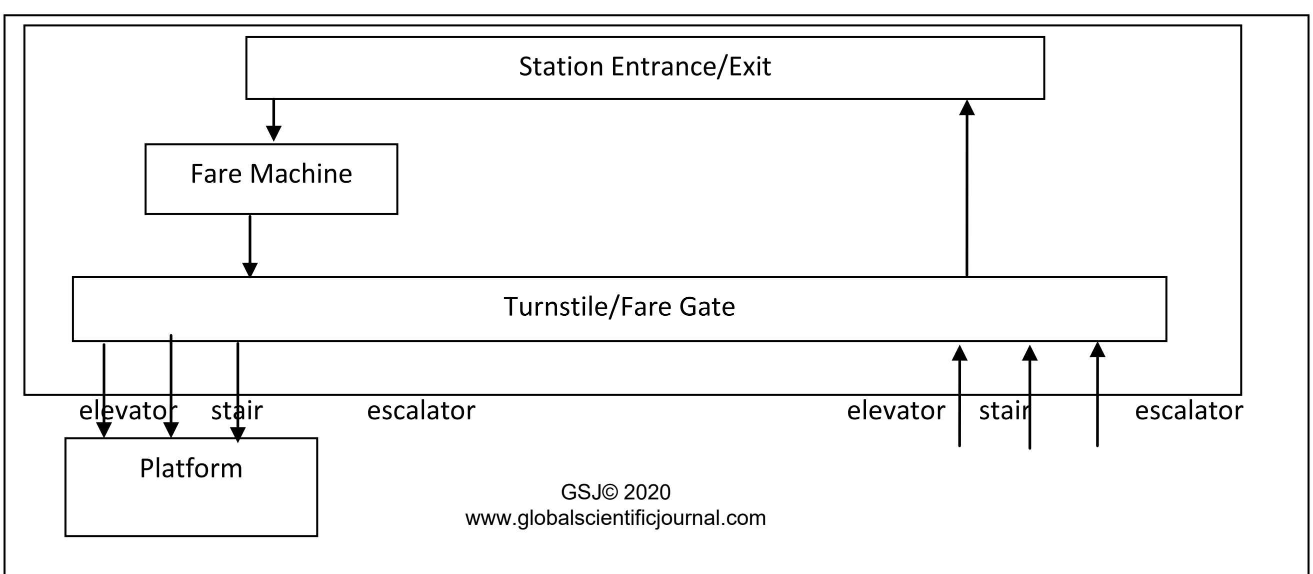
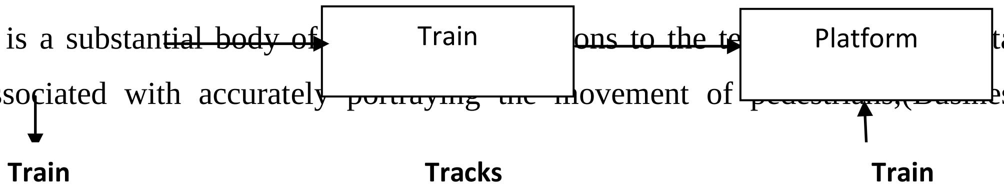


Figure 1. Conceptual Diagram of Rail Station Passenger Flow



While there is a substantial body of ... ons to the te... tational problems associated with accurately portraying the movement of pedestrians,(BusinessDay, 2018; Slack, 2017; Bernal, 2016; Ezzedine. Bonte, Kolski and Tahon, 2008) very little has been written about how these increasingly sophisticated methods are applied in practice and the context in which they are used. Some scholars have written about the use of ridership forecasts to justify new rail transit service, (Pitsiava-Latinopoulou, Zacharaki, Basbas and Politis, 2008; Bitgood, 2010; Yang, 2017) and a smaller number have written about institutional and political factors that influence transit fare policy and technology adoption (Onugba et al, 2016; Kocahas, 2013), but this work does not address how these phenomena affect station design. This report seeks to address these gaps in the literature. Pedestrian flow is defined as the number of pedestrians who pass through a cross-section of an area during a given time period. (Refer to Section III for a more detailed discussion of the relationship between flow rates and related measures of speed and density.) Pedestrian flow in rail transit stations is affected by both the numbers of pedestrians sharing the space and the spatial layout of the station – including the size and location of different station areas, how these areas are connected to one another, and the number, size, and location of the vertical circulation elements (escalators, elevators, and stairs). The maximum rate of pedestrian flow is usually constrained by the acceptable levels of passenger comfort as well as by safety considerations. (Stefan, 2012)

5.0 Features of Good Circulation Space/Element on Rail Terminals

From the review of literature, a number of features were identified as having significant influence on the effectiveness of circulation spaces in buildings. These are the physical, spatial and locational attributes of circulation spaces that allow them to serve as useful circulation spaces for human traffic. Chief amongst these features include but are not limited to: the shape/geometry of the building; location of the elements of circulation/circulation spaces; the size of these circulation elements; the shape of the circulation elements and the number of circulation elements available The geometry or shape of the building influences the circulation design within and around it. The building form is directly related to the size of the building, the size of the site and the organization of spaces i.e. the spatial arrangement in the building. This in turn has influence on the circulation pattern and how users experience the building. An increase in the size of a building leads to a direct increase in the horizontal and vertical distance users will have to cover and the time it will take them to get to the various spaces in the building. This has a direct influence on their use of the various spaces in the building while moving through them (Onugba et al, 2016). The shape of the building can also influence users' visibility of the entry point into the building and by extension their ability to easily identify the location of the reception/waiting area in the building. Another important feature that deserves consideration is the location of circulation spaces or elements in the building. This is usually a big challenge when the circulation elements within the building are located in obscure positions that make it difficult for users to easily see and use them. One of the consequences of this is that the spaces/elements become inaccessible leading to ineffective circulation networks within the building (Onugba et al, 2016). To avoid such a scenario, it is important that the location of the various circulation elements in buildings should be properly defined through the use of appropriate signage and other way finding elements. This is very important in ensuring that they can be easily be seen by users at any point within the building. The size of circulation spaces/ elements in buildings is a direct function of their locations. In fact, it is known that the size of circulation spaces determines how effective they could be in handling human traffic and facilitating easy movement of people even at peak periods. Inadequate size of circulation spaces can hamper efficient circulation network leading to congestion within and around buildings. In order to design adequate sizes of circulation spaces/ elements, authors (Onugba et al, 2016) have recommended that architects should carry out analysis of traffic flow at peak periods to determine the carry capacity of facilities and services within and around public buildings. Added to the size is the shape of the circulation spaces/ elements. The shape of circulation spaces /element also affects the use of such spaces. For instance, in order to prevent accidents while moving within and around buildings, the use of spiral staircases, staircases without risers and staircases with tapering treads are discouraged (National Disability Authority, 2012). The number of horizontal and vertical circulation elements/spaces available to users also has influence on the movement of the users through a building. The provision of more circulation elements helps to reduce human traffic congestion within the building. For instance, the provision of additional elevators/lifts in buildings helps to facilitate effective movements, taking into consideration the time taken and the distance to be covered. These additional circulation elements can also be used as escape routes/points from the building, in the case of emergencies such as fire outbreak.

6.0 Good Railway Terminal Circulation Designs

Designers must account for many types of pedestrian flows when sizing, designing, or updating an underground transit platform. These include peak commuter conditions, evacuations, special events, and off-peak conditions that occur late at night or early in the morning. While the primary factor differentiating these conditions is passenger density, other important differences, such as passenger attitudes and route familiarity, also inform the design. Ideally, a station will meet the needs of passengers in each of these contexts.

6.1 Peak Commuter Conditions

Typical peak period passenger volumes at subway stations tend to occur at the beginning and end of each workday (weekdays from 6 a.m. to 9 a.m. and from 4 p.m. to 7 p.m.), when regular commuters dominate ridership during these periods. Peak period passengers often share certain characteristics:

1. They use the same stations to reach the same destinations day after day, and are thus highly familiar with their habitual routes. As a result, they may not pay attention to wayfinding signs and instructions, relying instead on experience, including precisely where to stand on the platforms while waiting for trains.
2. They appreciate the opportunity that transit offers them to multi-task during their commutes. Thus, they may be distracted from their surroundings because of their attention to reading materials or mobile devices.
3. Particularly during the morning peak, commuters in destination stations frequently move with more urgency in order to arrive at work on time.
4. Over time, they have formed expectations of typical commuting conditions and thus may be willing to tolerate a greater degree of crowding than occasional transit riders, if such crowding is typical. However, these same commuters may also experience more frustration with service delays or other disruptions than occasional riders experience.

6.2 Evacuations

Any change to a station, including those intended to increase safety, can lead to unsafe situations if they impede the ability of passengers to quickly exit the station in the event of an emergency.

Station evacuations are extremely rare occurrences, and thus they have minimal impact on passengers' typical experience with transit. However, while failure to design for other types of pedestrian flows may result in passenger discomfort, confusion, or frustration, failure to adequately design for evacuations can result in serious injuries and deaths if crowds begin to panic. Helbing, Keltsch, and Vicsek (2002) list 63 major crowd disasters that have been documented over the past 150 years in which deaths and injuries resulted from crushing and trampling in panicked crowds. The majority of these disasters occurred in entertainment venues such as stadiums and theaters.

The few documented cases of crowd disasters in subway stations have generally been associated with people rushing to enter the station (to seek shelter from weather or air raids, for example) rather than with emergency evacuations. This may be because most rail transit stations are well designed to accommodate evacuations, and/or because such evacuations are exceedingly rare. In a survey of rail passengers in Southern China, a majority claimed that they would behave calmly and follow instructions in case of an emergency, (Li et al, 2011) though this finding is a better indication of how passengers believe they should behave than of how they would actually behave. Given the rarity of actual evacuation events at transit stations, empirical studies of passenger behavior under evacuation conditions are rare.34 However, in a survey of the literature on crowd panic, Helbing et al (2002) identify nine typical features of panicked crowds:

1. Individuals become nervous and develop blind actionism;
2. People try to move faster than normal;
3. People engage in physical interactions such as pushing;
4. Crowd movement becomes uncoordinated, particularly at bottlenecks;
5. Exits become jammed;
6. Physical interactions can result in dangerously high pressures that can bend steel barriers and tear down brick walls;
7. Fallen and injured people become obstacles that impede escape;
8. People exhibit herding behavior, doing what the people around them are doing;

9. People fail to notice alternative exits or fail to use them efficiently.

6.3 Special Events

Special events such as major concerts and sporting events can be an ideal opportunity to introduce new riders to public transit because traffic and parking congestion are often so onerous at these events that passengers are more open to trying unfamiliar alternative modes of transportation that may allow them to avoid these problems. Rail transit is particularly suited to serve heavy temporal, directional, and spatial peaking, which characterizes special events. However, the unusually high passenger volumes often associated with these events can result in highly unstable crowd conditions. Boisterous sports fans may be less likely tofollow or be aware of safety procedures and instructions, making the likelihood of a crowd disaster as described above an even greater threat. While most documented crowd disasters have occurred in stadiums and theaters, (Still, 2000 and Helbing et al, 2002) when those same crowds exit the stadium and enter a transit platform, their behavior may be similarly volatile. Design volumes for evacuations are often based on passenger volumes during the peak 15 minutes of a typical weekday. However, for stations that serve large stadiums and arenas, peak special event volumes should be considered as well, even when such volumes occur only a few times each year (as at many college and professional football stadiums). As noted above, many passengers taking rail transit to special events may be first-time or occasional transit riders, meaning they are less familiar with station layouts, as well as with procedures for paying fares and boarding trains. Extra staff and/or signage are often necessary to assist such novice passengers to expedite crowd movements through stations.

6.4 Off-peak Conditions

In off-peak hours, particularly at night, the dangers associated with crowds become much less important than the dangers and perceived dangers associated with the lack of crowds: unmonitored spaces and the potential for crime. In a survey of transit passengers in Los Angeles, Iseki and Taylor found that transit riders tend to value a feeling of safety at night more highly than most other characteristics of the transit experience, such as convenience and reliability

(Hiroyuki and Brian, 2009). Women in particular are likely to feel less safe on empty train cars and platforms where there is no transit staff, regardless of the presence of security cameras and other automated surveillance systems. (Loukaitou-Sideris, Anastasia and Camile, 2009)

Elements that are intended to channel crowds and provide wayfinding, such as barrier walls, information signs, and stairways, may also obstruct the line of sight for passengers, security personnel, or cameras, making it more difficult to adequately surveil the entire platform and establishing places for potential assailants to hide. Fear of assault can be a significant source of passenger discomfort and a deterrent to transit use, regardless of whether the danger associated with such unobserved spaces is real or perceived. While passengers' feelings of safety in unmonitored spaces are not directly related to the efficient movement of passenger flows, they are important to the passenger experience. Station improvements that increase sightlines and visibility, together with passenger flows, are thus preferred to those that may improve passenger flows at the expense of sightlines and visibility.

7.0 Conclusion

Among the several featuredhighlights, the most significant ones that can enhance the effectiveness of circulation spaces in railway terminals include accessibility, the ease in which the users of the passenger terminal can access facilities within and around the building; location of the circulation element; spatial characteristics of the circulation space, its size and shape/geometry; good lighting and free air in the circulation space, the quantity of the circulation elements and the availability of signage to direct users to the various facilities in and around the passenger terminal building. Based on this discussions, it is recommended that to ensure effective spaces network in intermodal passenger terminals, architects and engineers saddled with the responsibilities of designing such facilities should give adequate attention to these aspects of circular spaces such as entrances, receptions, corridors/lobbies, ramps, staircases, roads, parking spaces and pedestrian walkways. As important components of transport system, terminal buildings must be easily accessible from outside and also provide internal spaces that can easily distribute people to the different segments of the building. This can help passengers and other users to have a good circulation experience in the course of using such facilities.

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