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Assessing the Effectiveness of Circulation and Spatial Coordination for Traffic Control in Bus Terminals

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Abstract:

Bus terminal is one of the latest strategies employed at solving urban transportation problems both inter and intra state. Bus terminal is a designated place where bus starts or ends its schedule route. It is a traffic nodal point in transportation which connects different traffic mode between states, cities and towns. This study aims to stipulate effective circulation and spatial coordination strategies either through design or planning that will enhance traffic control and effective functioning of bus terminal. In order to understand and evaluate the circulations in bus terminals, the study seeks to investigate sources of circulations in bus terminals, spatial arrangements and allocation of spaces in existing bus terminals. It also evaluates circulation for both pedestrian and vehicular method adopted in existing bus terminals and general maintenance culture of existing bus terminals. In order to present this research, the study based its methodology on review of existing literatures and case studies. The researcher studied nine (9) existing terminal facilities in a bid to critically analyze existing situations in bus terminals and invariably study their approach in circulation and spatial coordination to control traffic in the terminals.

Keywords: Transportation, bus terminal, space, circulation, coordination, traffic control

1. Introduction

Circulation plays a significant role in transportation systems, and it facilitates the smooth movement in space. A successful bus terminal design has adequate circulation and coordination of the spaces. Passengers and vehicular movements are put into consideration to control traffic in the bus terminal, for maximum security, comfort, and safety of users (Humg, Steven, Ming, & Wang, 2013). Transportation is crucial to a nation's economy; it provides access to human natural resources and promotes trade, contributing to a nation's wealth and power. A well-functioning and sustainable city can be achieved by strengthening its public transportation system (Ching, 2007). Throughout history, the economic, wealth and power of tribes, communities, or nations were tied to efficient modes of transportation.

However, public transportation system such as bus terminal, are prone to traffic congestion, and there is an increase in the explosive rate of urbanization of towns and cities, which therefore places intense pressure on urban infrastructures, particularly, transportation system and results in difficulty in achieving migration, particularly to the nodal centers of metropolitan area. This increase population, the reason been that transportation forms the link between different activities within the cities (Humg, Steven, Ming, & Wang, 2013). To promote traffic control through adequate circulation and spatial coordination in bus terminals. The study focused on how effective circulation and space organization is in existing bus terminal design to enhance travel efficiency, traffic control, travel time, comfort, and security of passengers and freight ⁽¹⁰⁾

2. Circulation in Bus Terminals

Areas of the terminal include a variety of pedestrian activities within the same general space. People may be walking through, standing in line to buy tickets, waiting to meet someone, and shopping within the same space. Portions of these spaces may also be of little use to pedestrians, such as a corner beyond the significant flow of pedestrians or concentrations of other activities ⁽¹³⁾ The level of services for passengers queuing and waiting is taken into consideration, and these thresholds were developed based on common pedestrian space, personal comfort, and degrees of internal mobility with average area per person and average interpersonal space (distance between people).

There are several criteria for pedestrian walkways in transit facilities. These affect the level of service, and these levels of service are based on common pedestrian space and average flow rate. The average speed and volume-to-capacity ratio are shown as additional criteria ⁽⁴⁾ Within the passenger terminal area, access facilities should ease the transfer of passenger flows from the available access modes, too, from, and through the terminal itself, and vice versa. These facilities include curbside loading and unloading, curbside baggage check-in where this is permitted, shuttle services to parking lots and other terminals, and loading and unloading areas for cars, buses, taxis, limousines, and rapid surface modes. Passengers move physically through the terminal system using the internal circulation system, which should be simple to find and

follow and also easy to negotiate. The airside interface is designed for secure and easy boarding of the aircraft. Internal circulation is handled by corridors, walkways, people movers, moving belts, ramps, and tramways. ⁽⁹⁾

2.1. Spatial Arrangements of Bus Terminals

Spatial organization is the arrangement of physical and human objects on the Earth's surface. The photographic process of spatial organization uses concepts such as location, distance, direction, density, and arrangement (linear, grid-like) to capture spatial relationships. Points, lines, areas, and volumes are the four geometric features with which spatial organization can be easily described. ⁽²⁾ There are five distinct types of a spatial organization as elaborated by ⁽³⁾ and they include:

2.1.1. Centralized Organization

A dominant, central space is generally being observed around centralized organization. A prominent secondary space is generally being set up around its perimeter. It may or may not be situated inside the space. ⁽¹⁴⁾

2.1.2. Linear Organization

A separate and divergent linear space is generally being observed around linear organization. Series of similar spaces in terms of function generally form this type of organization. Different size, form and function of spaces create linear organization. An exterior exposure is being noticed around each space along the sequence. ⁽¹⁴⁾

2.1.3. Radial Organization

A radial organization consists of a central space from which several radial organization is a demonstrative plan that extended upto its context. The central space of a radial organization is, in most cases, regular in form. However, difference occurs in case of individual requirements of function and context· the straight arms, for which the central space is the hub, may differ from one another. ⁽¹⁴⁾

2.1.4. Clustered Organization

Physical proximity is the main idea behind this type of organization. It relates its spaces to one another. It consists of repetition, cellular spaces that perform similar functions and also share natural visual characteristics such as shape, and orientation. ⁽¹⁴⁾

2.1.5. Grid Organization

Positions in space and relationships are related to one another by a three-dimensional grid pattern or field. A point of intersections created by two grids, which are usually perpendicular sets of parallel lines, carefully planned into the third dimension. The grid pattern is transformed into sets of modular and repetitive units of space. ⁽¹⁴⁾

2.2. Spatial Consideration in Architecture

Space can be organized into patterns in buildings so that they relate to each other. It provide a cohesive structure to the design. The spatial relationships between forms promote interaction of users ⁽¹⁶⁾

2.2.1. The volume of Space

At the stage between mass and space, architectural form is observable. Both an area of concern as well as the form of the spatial volume is being noticed in case of planning and reading.

2.2.2. Impact of Space

Several scales of symbiotic relationship of the forms of mass and space found. At each stage, the impact of space on a building should be considered alongside the forms.

2.2.3. Space as a Figure in Building

Arrangement of parts of walls as the positive elements of a plan is generally being noticed at the scale of a building. Shape and form as the background of the wall is generally being observed. ⁽²⁾

2.3. Spaces Required In the Planning of Terminal Facilities

Improving the transportation system is an integral factor that contributes to the success of a convenient transfer and movement of passengers within terminal space. At critical junctions of the route network, interchange facilities which are typically located at services or modes intersect. The planning and designing terminals must consider two perspectives: the operators and the users. ⁽⁵⁾ The design of a bus terminal on all levels should include almost these spaces or even more for an effective functioning ⁽¹⁸⁾

- Bus parking spaces
- Public parking spaces
- Public seating and waiting area
- Ticketing facilities
- Dispatch offices
- General administrative offices

- Rental spaces
- Baggage room
- Drivers lounge
- Restrooms
- Restaurants
- Maintenance facilities
- Transit lodge (for overnight lodging)
- Shopping facilities.

2.4. Pedestrian Consideration for Bus Terminal Design

The most recent approach to the design of pedestrian spaces has been the use of the level-of-service concept. Based on this concept, a qualitative evaluation is made of human convenience at various traffic concentrations, and this is translated into appropriate design parameters. Consideration in a Terminal design includes the first Interaction of pedestrians with traffic. Pedestrian facilities include walkways, crosswalks, curb ramps for the disabled, and grade separations. There is a high pedestrian concentration in urban areas that majorly focus on walkways to ensure their safety. ⁽⁸⁾

2.5. Vehicular Consideration in Bus Terminals

2.5.1. Bus Geometrics

Bus geometrics, or the physical dimensions and maneuverability of the bus, determine the width of roadways, shapes of platforms, column spacing, ceiling heights, and other aspects of bus-level design. The insignificant detail of the right-side loading of buses often restricts terminal design possibilities. Swept Path When a bus usually turns, it always turns about a point that is somewhere on the centerline of the rear axle. The turns required to accomplish the movement and positioning of buses are variable and differ considerably with the equipment encountered. ⁽¹⁹⁾

2.5.2. Roadway Ramps

Bus Roadway Widths Ten-foot-wide single lanes will suffice for 8ft-wide equipment. Eleven-foot lanes are preferable where ample terminal space is available and specially to accommodate equipment 8ft wide, the use of which steadily is increasing. Double-lane runways, enabling standing buses to be overtaken by other buses, provide a significant advantage over one-lane runways because of the increased flexibility of operations that is made possible for purpose of merely overtaking another bus or row of buses having no appreciable tail out, double-lane runway widths should be at least 20ft and preferably 22ft, mainly if extra-wide equipment is accommodated -immediately or in the future. ⁽²⁰⁾

2.6. Traffic Control in Bus Terminals

A quality way to improve transit services is by providing transit users with real-time, reliable information at bus stops and terminals. The following can be provided for users and these include conventional and automated telephone services, signs, printed and posted schedules, transit websites, changeable signs or monitors at stations and stops, and announcements). Improved technologies for predicting arrival of next vehicle have been articulated with real-time information provided to transit users. ⁽¹⁾Populations in urban areas continue to increase, particularly in central districts. Transit systems must learn to handle higher traffic loads as Multi-level transportation terminals represent a solution to this problem and have become a conversant happening in high-density areas. Hence an improved multi-level terminal operational performance is a critical task in major cities across the world. ⁽¹⁷⁾

2.7. Basic Amenities in Bus Terminus

A bus terminus is a place for assembly, discharge, or transfer of passengers at a limited number of points on a route. The size and character of other facilities at these points depend on the volume of traffic and frequency of services. The range mainly from designated stopping points, for example, bus stops to large buildings with provisions for rest, refreshment, personnel comfort, and the service and maintenance of vehicles. ⁽⁶⁾

2.7.1. Car Parking

The size of the parking depends upon the type of parking will provide at the given location. Automated car parking is suggested when the parking demand is high (>3000).

2.7.2. Bike Parking

When the parking demand is high (>35000), automated bike parking can be suggested

2.7.3. Restaurant

Restaurant is an area used for entertainment by the public as a family or friends. Depends on usage, the number of food courts and the other facilities, the size of the restaurant vary.

2.7.4. Hospital, Police Terminus

For bus terminus, railway junction, airport, and harbor for emergency and safety for the public hospital and police terminus are needed. Passenger capacity determines size.

2.7.5. Toilet

Toilet is an everyday utility in public areas for both males and females. Special types also made for disabled people.

2.7.6. Administrative Block

Ticket counter, ticket verification point, help desk, reception is available here. Other recreational facilities like halls, lodges, food coats, jewelry shops, gift shops, and some extra facilities also available. Unnecessary movements and blocking can be handled through this.

2.7.7. Passage for City Bus

With minimum width provided for platforms should be 13.3m, with a turning radius of 16.5m, it depends on the number of buses entering the bus terminus at a particular time along with the turning radius of a bus.

2.7.8. Subway Width and Height

The subway is an underground passage for the safe and secure movement of people. The height and width id generally 5.28m and 3.33m, respectively, with four steps on all sides although subway differ from place to place. **Kiss and**

2.7.9. Ride Parking

Public transportations like auto, tax other than a city bus and own vehicles for dropping the passengers. The kiss, and ride facility should be provided to reduce the walking and unnecessary movements.

2.7.10. Green Vegetation

Used by public for breathing clean air. This is the primary objective of vegetation. However, in any case, it should not affect the sight distance of buses ⁽⁶⁾

2.7.11. The Dimension of Bus Depot and Sewage

Treatment Plant: Inside the terminal area, these are the secondary factors of a bus terminus,. For utilizing the wastewater from toilets and drinking, wastewater treatment is necessary.

2.7.12. Other Factors

- Shop: depending on passenger capacity it changes.
- Sight distance: it is the eye level of a driver for the safe riding of a bus or vehicle without any obstructions. It should be less than 0.5 from a driver's eye level of 3.9 high.
- Width of the main road: Depends on the main road crossing the bus terminus the right and left turn movement of vehicles can be improved.

2.8. Terminal Performance and Efficiency Indicators

The management of bus terminal for performance and efficiency parameters includes-

- Frequency of buses to be handled in a time period of one day
- Arrival of buses at the terminal during peak hour (handling capacity)
- Mean of alighting time and boarding time (should be minimum)
- Average idle time for bus
- Waiting time at the counters
- Collection of fees
- Complaints generated.⁽¹⁵⁾

3. Methods of Study and Organization of the Paper

This paper adopts the case study method of research to examine and discuss the situation in existing bus terminals. Case studies are used in design research to analyses a phenomenon, to generate a hypothesis, and to validate a method. However, Case studies were carried out in nine different bus terminals and summarized in a table that brings together the fundamental elements conducted during the case study, which include identifying common characteristics among the various terminals. ⁽⁷⁾

The bus terminal studied during this research was classified into two; the case study was grouped to six local bus terminals and three international bus terminals to allow for comparative study among the terminals studied. The case study carried out at the terminals was subjected to some finding such as significant sources of circulations in bus terminals, the significant spatial arrangements, and allocation of spaces within existing bus terminals, the circulation for both pedestrian and vehicular adopted by some existing terminals and the general maintenance culture of existing bus terminals.

3.1. Case Study 1. Benin Garage, Akure, Ondo State, Nigeria

The Benin garage is located around the Agbogbo area, along Benin road, Ondo State, Nigeria. It is a transitional park that links all the regions of the federation, and its an example of a private bus station in Nigeria; this bus station operates on several routes and goes as far as the Northern part of the Federation. The terminal has a loading (and offloading) bay for various vehicles, mainly cars, and buses, with few shops and kiosks for passengers, passers-by, and terminal officers to buy food and drinks. There is also a mechanical workshop in the garage to make repairs of faulty vehicles. However, there is, in existence, vast expanse of land in the location to be used.

3.1.1. Architectural Criticism

3.1.1.1. Merits

- The site is suitable for its purpose because of the location and land availability.
- There is excellent coordination of passengers.

3.1.1.2. Demerits

- The zoning and operation of the site are not organized.
- It is substandard for its purpose (being an inter-state transport terminal).
- No landscape and site planning.
- The facilities are not adequate.
- There is no coordinated terminal building.
- Inferior aesthetics.



Figure 1: Showing the Loading Bay and Parked Vehicles in the Terminal
Source: Researchers Field Survey, 2017

3.2. Case Study 2. Ondo Garage, Akure, Ondo State, Nigeria

3.2.1. Background Information

Ondo garage is a typical style of a local bus station in Nigeria, and its located in Ondo state, Ondo Road, Akure, Nigeria; it offers a wide range of service routes to the southern and western regions, and also redistribute to neighboring towns.

3.2.2. Architectural Criticism

3.2.2.1. Merits

- The site is on a location where passengers join other routes after alighting
- Site is located where there is easy accessibility for the users
- The site is enclosed enough not to obstruct moving traffic.

3.2.2.2. Demerits

- There is no adequate site planning provided for the facility
- There is no architectural design
- Also no waiting area for passengers
- Inadequate site facilities to cater to passengers needs



Figure 2: Showing the General Bus Park in the Garage with an Arrival Concourse

3.3. Case Study 3: Ikeja Bus Terminal, Lagos State, Nigeria

A comfortable environment is being provided through terminal. It is more safe, secure unlike the existing bus parks. Most of the bus parks are unhygienic with lack of facilities and wobbly vehicles.

Taxi Rank, Passenger Convenience, Operations Control Centre Waiting Areas, Ticketing Booth, Loading Bays, Information Centre, Food Court, and an ATM Gallery etc. are some facilities over here.

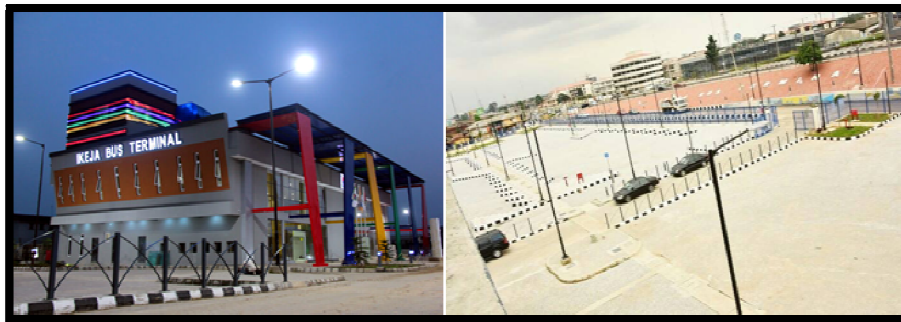


Figure 3: Showing the Terminal Building and Available Parking Spaces within the Terminal

3.3.1. Architectural Criticism

- It fits into the modern-day bus terminal design
- Properly zoned
- Good Aesthetics

3.4. Case Study 4: Station Square of Winterthur bus Terminal, Switzerland

The station square of Winterthur is on strategic location between the old cities, the train station, and an upcoming retail and office district almost 100000 people cross it every day as pedestrians at the same time. The square has different zones. Facilities include

- Waiting lounge
- Ticketing booth
- Parking lots
- Loading and offloading
- Offices
- Conference center
- Security post

3.4.1. Architectural Criticism

- The good sightlines and legible spatial management support passenger movement within the facility with intermodal movement
- The roof design admits natural light and creates natural ventilation
- Circulation routes, together with step-free access, cater to mobility-impaired passengers.
- Station Square has an iconic design and is a robust local landmark
- Clearly stated, signing and sightlines deliver simple intermodal connectivity between interchange facilities.
- Connectivity between the interchange zone and the immediate local area is also excellent - with clear sightlines to local destinations, uncluttered movement spaces, and pedestrian crossings located to meet with desire lines.
- Excellent and exciting architectural design.



Figure 4: Showing the Waiting Area, Loading, and Offloading Bay

3.5. Case Study 5: New York New Union Bus Terminal, Manhattan

The terminal has a maximum practical upward incline of the bus ramp from the mouth of Lincon tunnel to the terminal, establishes the floor elevation of the local bus level at North avenue end of the building. At the entry and exit point of buses on the long-distance level which shops downward. The structure comprises of steel structure of straight forward columns girded and beam type with allowances for slopping levels.

Facilities include

- Waiting lounge
- Ticketing booth
- Parking lots
- Loading and offloading
- Offices
- Conference center
- Security post

Pedestrian paths are usually marked out and particularly so in areas of most massive pedestrian traffic. They are easily accessible, not causing inconvenience but at a standing of extra services and time-saving. All these lead to the setup of ship fronts, restaurants, magazines, and shoeshine stand.

3.5.1. Architectural Criticism

- lounge and concourse have marble warm coat 1.35m high
- Most of the floors are of terrazzo with non-slip aggregate on slopping surface floors
- The handrails have wearing surfaces, trim and concourse column are of trust aluminum
- The exterior is of glazing and aluminum composite board
- Excellent and exciting architectural design.



Figure 5: Showing the Ticketing Booth, Loading, and Offloading Bay

4. Recommendation and Conclusion

4.1. Recommendations

Upon seeing the regeneration potentials inherent in terminals and stations design, the following recommendations are poignant for development of an active transport system:

Each state should develop its intra-state and inter-state transportation potentials to act as suitable means of transporting people and goods, as well as establish an institute to train the workforce required both in the short and long basis to operate this sector safely. The best approach to achieve this goal is for the government to encourage and assist interstates in this regard by promoting an empowering the environment in terms of setting in place appropriate policies and incentives to the state to develop an adequate and convenient road transportation sector.

Furthermore, great attention should be given to site planning and design such that bus circulation is unimpeded and separated from the users, whether pedestrians or autos. Attractive landscaping is required to bridge up the usual gap between outdoor and indoor spaces. The terminal building should be flexible in designing such that it would give room for

future expansion and re-modification. In a broader view, the complex should be visually attractive such that it favors tourism since the terminus serves the purpose of bringing people together and causing social interaction.

4.2. Conclusion

Bus terminals need a simple design arrangement that allows for smooth flow by adopting well-defined separation of activity units within and outside the building. Terminal design is, however, expected to alleviate the transport needs of the people who wish to patronize transport services for safety and security purposes. These combined socio-economic and Architectural solutions to the numerous sets back related to road transport and Bus Terminal, in particular, makes this project a highly welcome and necessary catalyst for the overall development.

Circulation spatial coordination and bus terminal involves the consideration of all facilities, which include arranging all infrastructure and planning elements with detail dimensional understanding for the effective functioning of the facilities. Also, attention should be on improving the aesthetics and visual consideration of bus terminals to improve spatial experience and comfort for users.

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