TRAIN TERMINAL, ASOPROCHONA (TEMA)

BY

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DECLARATION

I hereby declare that this submission is my own work towards the PG-DIP and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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DEDICATION

This design thesis is dedicated to the almighty God who has given me the grace and strength to go through this architectural programme. It is also dedicated to my parents Mr. Thomas kweku Ansah and Mrs Jane Ansah and my siblings for their immense support.

ACKNOWLEDGEMENT

This design report was prepared with the assistance of some kind-hearted individuals and organizations and I would like to express my profound appreciation to them.

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I would also like to extend my gratitude to the station master of Asoprochona Train Station, Mr. Wood, the area engineer of the Accra Train Station and all the staff.

ABSTRACT

Over dependence on road transportation for both inter and intra cities coupled with over-population in major cities in Ghana such as Tema has resulted in heavy vehicular traffic on roads, increased road accidents, lose of precious time in traffic and increase in fuel consumption.

Government as part of its long term plan to curtail this problem is carrying out an expansion and modernization of the existing rail network from southern Ghana to the north. This will help link Ghana to neighboring countries such as Burkina Faso, Mali etc. This has made it necessary to construct modern train stations and terminals where freight and passengers can be handled in the transportation process.

This vision and desire by government and Ghana Railway Company has led me to choose and design a modern train terminal in Tema-Asoprochona. This facility is expected to serve as a place where passengers and freight originate, terminates or are handled in the transportation process. It is also expected to serve as a catalyst for development along the beach area south west of Sakumono, where the facility will be constructed.

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CHAPTER ONE

1.1 Introduction

Railway transportation is one of the most important catalysts for development. It is a prerequisite for economic growth and poverty reduction. Research shows that an effective railway transportation system can reduce costs and comparative distances between trading partners, increasing trade effectiveness and maximizing existing industrial investments and production outputs. People rely on train transport to get to workplaces, school, market, health clinics e.t.c. Mines and manufacturers also rely on rail transport to get their products to markets and ports.

The Ghana Railway Company Limited is the operator of railways in Ghana. Ghana's railway network is 950 km of mostly single track rail of 1.067m gauge located in the southern part of country. In 1965, it carried 2.3 million tons of freight and 8 million passengers at the time that it was financially sound. However due to certain factors such as ineffective management, the changing world economy, sharp drops in commodity prices,encroachment,competition from the road sector among others in 1985, the rails position as a prominent transport mode went down. The lower revenue it was recording resulted in;

1. default on loan payments
2. Poor maintenance
3. Drop in service quality
4. Loss of customers

There are however efforts to revive the railway operations in the country. (source: www.ghanarailway gazette .com).

1.2 Problem statement and justification

Populations in urban areas are increasing at astronomical rates. Accra and Tema being two major cities in Ghana are no exception. By 2025, the population of Ghana is expected to be 38 million with more than 60% of the people being urban residents. (source: UNHabitat, 2002).

A large number of people commute between Accra and Tema everyday to do business, work, school, shop etc which has resulted in;

1. Heavy vehicular traffic on roads in both cities
2. Lateness to workplace leading to decrease in productivity

3. Increase in fuel consumption
4. Environmental pollution
5. High cost of constructing new roads.

To solve this problem, a relatively cheap, safe, comfortable, environmental friendly and fast alternative means of transportation has to be put in place to complement road transportation. Rail transport, if well developed will go a long way to alleviate these problems.

The state of passenger railway transportation and its supporting facilities in Accra and Tema municipalities are unable to accommodate the anticipated volumes of passenger traffic. A modern and effective railway terminal coupled with modern rolling stock will go a long way to ease the traffic problem in the region and revamp the passenger train transport system in and outside the region.

1.3 Objectives

The project seeks to provide

1. a train terminal that serve as an effective transit point for the anticipated volumes of passenger traffic in and outside Tema
2. a facility that will serve as a catalyst for further development on the Asoprochona –Tema beach road.
3. more opportunities to increase the local job base through retail outlets, offices, and service oriented business spaces
4. a better identity of the community to outsiders through iconic architecture.

1.4 Scope

This thesis intends to;

1. Study the history and operations of the Ghana Railway Company
2. Establish the basis for providing a train terminal in Asoprochona –Tema
   Propose the design of a new train terminal in Asoprochona which includes
   1. The main terminal building
   2. Ancillary facilities

1.5 Target group

This facility will cater for adults, children the physically challenged, the able etc

1.6 Client

1. The ministry of transportation
2. Ghana railway company limited

1.8 Financiers

The government has awarded a US 1.4 billion dollars concession for the Eastern railway to M/S Peatrack a, foreign company.

The agreement covers the design, building, operating, and transfer for the construction, expansion and operation of a modern rail network between Accra – Tema and Paga for a period of 35 years. Phase one of the project involves the rehabilitation of the existing Tema – Accra – Nsawam suburban railway

It has also secured a US 5 million dollar loan from OPEC to rehabilitate the 30km Accra – Tema rail line to revamp commuter rail transportation service within the Accra – Tema metropolis.

(source: Ministry of Harbours And Railways, November 2005).

CHAPTER TWO

2.0 Literature Review

2.1 Background of Railways

For historical reasons, the current rail network only serves the main traffic corridors in the seaboard third of the country, although this is the main area of economic activity.

The first lines were built to support and develop mining interests following the discovery of gold-bearing rocks in the Ashanti region, 200 km inland from the coast. The need to move construction equipment inwards and minerals out led to the construction of an initial 66 km route from Sekondi to Tarkwa in 1898 to 1901. Construction north of Tarkwa proved easier and the following 200 km to the country's second city of Kumasi was completed by 1903. After gold was discovered at Prestea, a 29 km branch from Tarkwa was opened in 1908. (source: Railway Gazette International- David Brice, June 2008).

Work began in 1909 on a 304 km line to link the capital Accra with Kumasi, but this was not completed until 1923. Rather than minerals, this line was predicated on the development of cocoa, rubber and timber traffic. Its opening also completed a very circuitous through route between Accra and Sekondi. With the very basic port facilities at Sekondi proving inadequate to handle growing mineral exports, a new deep-water port was opened in 1928 at Takoradi, 6·5 km to the southwest. All railway operations were transferred to the new terminus apart from the extensive workshops which remain near Sekondi. (source: Railway Gazette International- David Brice, June 2008).

Subsequent additions included the 157 km Central Provinces line opened in 1923 from Huni Valley to serve further mineral deposits at Kade, and the important 73 km branch from Dunkwa to serve bauxite mines at Awaso, prompted by heavy demand for aluminium to build aircraft during World War II. In 1953 an 82 km link was opened between the Kade branch and the Accra - Kumasi line at Kotoku, shortening the Accra-Takoradi journey by 268 km. The following year saw the completion of a 23 km branch from Achimota Junction, north of Accra, to the port at

Tema, which is now becoming increasingly important. (source: Railway Gazette International- David Brice, June 2008).

For administrative purposes the railway is divided into three sectors :

- Western Line: Takoradi - Kumasi and branches to Awaso and Prestea;
- Central Line: Huni Valley - Kotoku and the Kade branch;
- Eastern Line: Accra - Kumasi and the branch to Tema.

The railway is built to 1 067 mm gauge, with a maximum axleload of 16 tonnes. The first line between Takoradi and Dunkwa was built very cheaply and is plagued by severe curvature north of Tarkwa, although some consideration has been given to re-alignment to ease operations. All lines are single-track except for a 30 km double-track section between Takoradi and Manso. Semaphore signalling was originally installed, but is now only operational on the double-track section. Solar-powered colour-light signaling, funded by the World Bank, replaced the mechanical equipment on the Western Line, but the cost of spares soon became prohibitive and the system has now been abandoned. Likewise, the single line token apparatus has fallen into disuse, and train operation and crossing arrangements on the rest of the network are controlled using paper tickets. (source: Railway Gazette International- David Brice, June 2008).

The safety of train operations is a major concern for GRC, because of the lack of secure signalling, but also the very poor condition of the track and the mineral wagons which convey the bulk of present freight traffic. These vehicles are in continual service, and require a much higher standard of maintenance than they currently receive. Derailments are frequent, caused by bad track or poorly-maintained vacuum brakes and running gear.

2.1.1 The Management and Organization

The Railway organization started in 1901 as a department of Gold Coast Civil Service. Its headquarters was located at Sekondi where construction of Ghana's rail system began in 1898.

The headquarters was later moved to Takoradi in 1934, when a new Administration Block was completed along with the Tadoradi harbour in 1927. With the building of the harbour, the railway and the harbour came under the joint administration of Railway and Harbours Administration. (source: Railway Gazette International- David Brice, June 2008).

A succession of expatriate civil servants headed the railway as "General Manager and Harbours Authority" until 1960 when the first Ghanaian head of the then Locomotive, (now Mechanical/Electrical Engineering) Department was appointed to the post.

The Railway and Harbours Administration became a statutory corporation on 1st July 1972, with the passing of the Railway and Ports Act 1971 (Act 358). The Corporation was governed by a ten-member Board of Directors, which included the General Manager. (source: Railway Gazette International- David Brice, June 2008).

On 1st July, 1977, the Supreme Military Council (SMC) passed the Ghana Railway Corporation Decree (SMCD 95) and the Ghana Ports Authority Decree (SMCD 96) which separated the railway from the Ports and established them as two distinct bodies-corporate under separate administrations.

In August 1982, the Board of Directors, gave way to an interim Management Committee (IMC) of seven under the Chairmanship of the General Manager. Again, in December 1984, a Joint Consultative committee (CC) was set up to replace the IMC, as an advisory body. The post of General Manager was changed to Managing director in May 1985. (source: Railway Gazette International- David Brice, June 2008).

In February 1995, the Board of Directors was re-constituted and now the Railway company has a ten-member board.

On 7th March 2001, Railway company was issued with a Certificate of Incorporation by the Registrar of Companies, and is now known as Ghana Railway Company Limited. This is to allow for private sector participation and investments into railway operations.

Executive control of the organisation is vested in the Managing Director who is assisted by two Deputy Managing Directors, one for administration and Operations (DMD-A/O) and the other for Engineering (DMD-E). The day to day management of its business falls under the jurisdiction of Heads of Department, who variously report to the Managing Director and his deputies. The railway network is divided into three areas, i.e. Tarkwa, Kumasi and Accra, headed by Area Managers. The Area Managers are responsible for the administrative control and co-ordination of work in the areas. (source: Railway Gazette International- David Brice, June 2008).

2.1.2 Vision

To be a modern and efficient nationwide rail transport provider with links to the neighbouring countries.

2.1.3 Company Charter

1. honesty
2. customer oriented
3. maintenance of good corporate image
4. total quality management practices
5. high sense of commitment and dedication to duty
6. communicative environment
7. research and development for continuous improvement
8. incentive and motivation policy
9. a first choice place of work for its employees

(source: Railway Gazette International- David Brice, June 2008).

2.1.4 Assets-current state of the system

The assets developed and acquired to achieve the current capacity are briefly described as under:-

a. Track

The Ghana Railway Corporation operates a network with a route length of 647 kilometres of metric gauge. For operational purposes, the network is divided into Western, Eastern and Central Lines. The Western Line with a route length of 340 kilometres links

Tadoradi Port to Kumasi and Awaso and is by far the busiest. Tae 350 kilometres stretch from Accra- Tema to Kumasi makes the Eastern line, while the Central line covering a distance of 199 kilometres links together the Western and Eastern lines to create a pattern like the letter "A". Altogether, the total track length is about 1,300 kilometres.

(source: Railway Gazette International- David Brice, June 2008).

Western line, the principal export corridor, is equipped with 80 lbs and 90 lbs rails on the main line and 75 lbs and 60 on the Awaso and Prestea Branch lines respectively. Eastern and Central lines are equipped with a mixture of 60 lbs and 80 lbs rails. Except few areas where steel trough sleeper are used, the track is constructed with treated wooden sleepers on crushed stone ballast all obtained locally.

b. Locomotives

The locomotives being used on the railway system is diesel-electric. In the early years of its establishment, steam locomotives were used. However, since the early 1980's, the steam locomotives have all been phased out and GRC now operates mostly Diesel-Electric locomotives. Presently, there are about 60 locomotives in service on the System.

(source: Railway Gazette International- David Brice, June 2008).

c. Coaches/wagons

Altogether, there are some 652 wagons/coaches in service. The coaches which were delivered in 1986 are being rehabilitated.

(source: Railway Gazette International- David Brice, June 2008).

d. Staffing

Back in 1978, GRC had a staff complement of over 11,000. A staff reduction plan drawn together with the World Bank saw the level falling to the present figure of around 4,000. There are plans to rationalize staffing levels further, with a view to reducing operating costs, and thereby improve the competitiveness of the Railway. (source: Railway Gazette International- David Brice, June 2008).

e. Training

The Ghana Railway Company gives priority attention to staff training and development. The Company has a Central Training Institute where its staff is trained. Overseas training courses are occasionally organized for Senor and Middle level Management and Technical staff. Local Training outside Railway is also organized for the staff.

2.1.5 Performance.

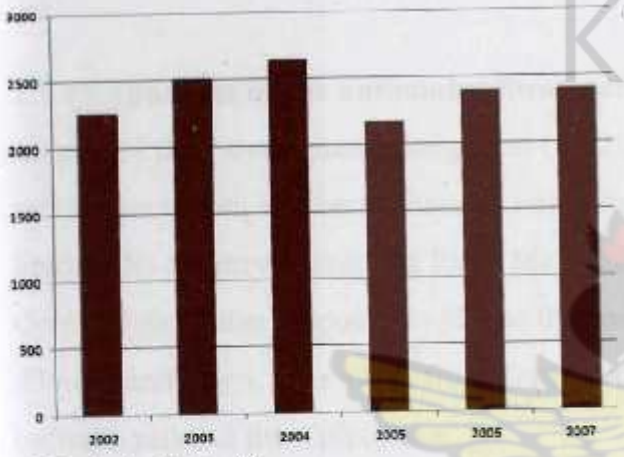


Fig .1 Freight traffic

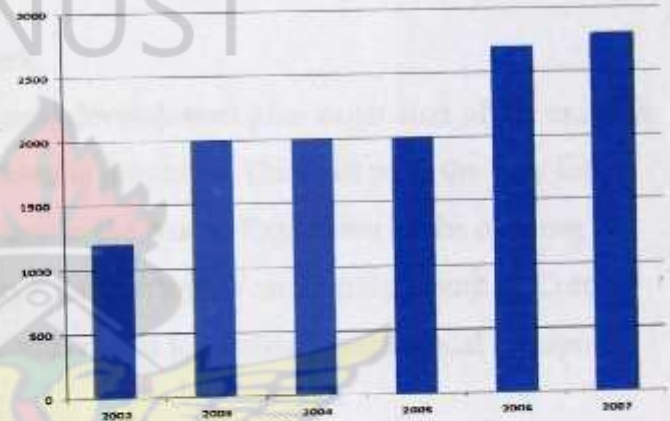


Fig. 2 passenger traffic

(source: Railway Gazette International- David Brice, June 2008).

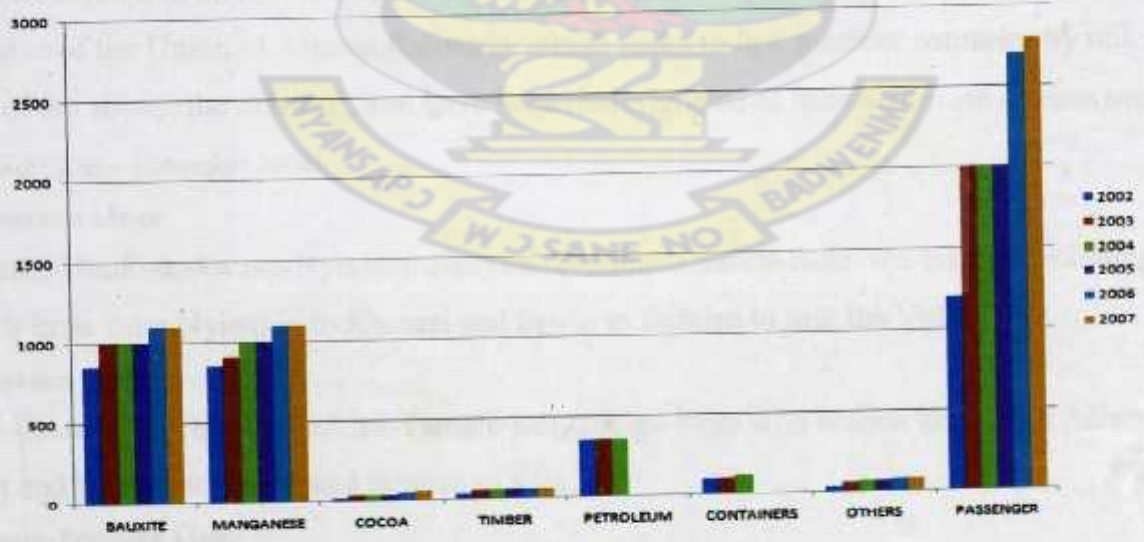


Fig 3 Freight and passenger traffic. (source: Railway Gazette International- David Brice, June 2008).

The graphs above show that

1. Bauxite and manganese which form the main commodities transported by rail has an annual average growth rate of 4.9%.
2. There is an annual average growth rate of 8.3% of passengers who commute by train.
3. Freight forms 55% of total rail transport while passenger forms 47%.
4. There is a faster growth rate in the volume of passenger traffic than the individual commodities transported on the railway.

   People have over the years come to appreciate the numerous advantages associated with travelling by train.
5. Passenger transportation has very high prospects in Ghana if given the necessary attention.

2.1.6 Expansion of the national railway network

As part of the Government's long-term (10-20 years) development plan expansion of the existing rail network from southern Ghana to northern Ghana is proposed. This will pave the way for linking the country to Burkina Faso, Mali and Niger in the North. Expansion of the existing Central line is also proposed to link to the country's Eastern and Western neighbours of Cote d'Ivoire and Togo, as is a link from Tem to Akosombo so as to facilitate multimodal transport between rail and the Volta Lake.

The expansion is in line with the objectives of the Economic Community of West African States (ECOWAS) to link all member states by rail. It will also facilitate the achievement of the broad objective of the Union of African Railways, which seeks to link member countries by rail. In view of the above, the existing lines have been re-designated as follows: (source : African business Journal-August – November 2004).

a. Western Line:

Takoradi-Dunkwa-Awaso-Nyinahin-Sunyani-Techiman-Sawla-Bole-Wa-Hamile including branch lines from Nyinahin to Kumasi and Sawla to Fufulsu to link the Volta Lake.

b. Eastern Line:

Accra-Kumasi-Techiman-Fufulsu-Tamale-Bolgatanga-Paga with branch lines from Achimota to Tema and Tamale to Yendi and Bosuso to Kibi.

c. Trans-Ecowas Line:

Aflao-Tema-Kotoku-Tarkwa-Prestea-Omape.

Tema-Akosombo Line

The expansion programme will include improvement and modernisation of the existing network. The total cost is estimated at US$1,655.24 million. (source : African business Journal-August – November 2004).

It is planned to engage private sector participation under a Build Operate and Transfer (BOT) arrangement, however it is still early days considering feasibility studies still need to be conducted to access viability before the projects can be taken to market. Steps have been taken in this regard on the Accra-Kumasi-Techiman-Fufulsu-Tamale-Bolgatanga-Paga line. Ghana has signed a protocol agreement with Burkina Faso and a joint committee has been set up that will meet every six months. The two countries have submitted a joint request to the African Development Bank (AFDB) for funding of the initial feasibility study. Should funding be received from AFDB, studies should begin before the end of next year. (Source: African business Journal-August – November 2004).

2.2 ECONOMIC CONSIDERATIONS

2.2.1 Proposed Western Line

This line passes through the forest areas within the Brong-Ahafo, Western, and parts of the Ashanti Regions, where a lot of agricultural products like foodstuffs, cocoa and timber are produced.

Currently about 40% of the retail cost of food is attributed to transportation costs. In addition, a large percentage of foodstuffs produced in the rural areas rot due to non-availability of a cheaper means of transport to convey it to consuming centres like Accra, Kumasi and Sekondi-Takoradi. The construction of the line will also serve as a catalyst for the exploitation of mineral deposits such as diamonds, gold, limestone and bauxite located along the line. The line will also link the Upper West and Brong-Ahafo regions to Takoradi, thus facilitating the movement of goods (exports/imports) between the North and the South.

By linking this line to Burkina Faso, Mali and Niger, import and export of their commodities through the Takoradi Port will be facilitated. The branch lines from Sawla to Fufulsu will also promote the development of multimodal transport between rail, road and the Volta Lake. (Business Journal African, August- November 2004).

2.2.2 Proposed Eastern Line

This line will link the Upper East and the Northern regions to the South. The line passes through the forest areas of the Eastern and Ashanti regions where a lot of agricultural products such as foodstuffs, cocoa and timber are produced. Livestock, as well as sheanuts, cotton and rice are produced in the two Northern regions.

As already mentioned, the construction of the line will reduce food prices in the consuming centres. Mineral deposits like bauxite, limestone, diamond and gold are located along this line, and the construction of this line will serve as a catalyst for the exploitation of these mineral deposits.

In addition to linking the Northern part of the country to the Port of Tema, and the proposed inland port at Boankra, the line - which passes through Buipe - will contribute to the development of multimodal transport between rail, road and the Volta Lake. It will also link the country to its hinterland neighbouring countries of Burkina Faso, Mali and Niger thus facilitating export and import of their commodities through Ghana's ports. (Business Journal African, August-November 2004).

2.2.3 Proposed Trans-Ecowas Line

The construction of this line will pave the way to link Ghana with her Eastern and Western neighbours of Cote d'Ivoire and Togo.

2.2.4 Proposed Tema-Akosombo Line

This line will link the Tema port to the Volta Lake at Akosombo to facilitate multimodal transport between rail and the Volta Lake.

2.2.5 Development of Accra-Tema suburban rail network

2.2.6 Track

The project will involve modernization of the existing lines and construction of new lines. The existing and the proposed lines are:

i. Existing lines

Accra - Nsawam

Tema - Achimota-Accra

Accra - James Town

ii. Proposed lines

Accra - Dodowa

Accra - Kasoa

Accra - Dansoman

Accra - La-Teshie Nungua - Tema

The gauge for both the existing and the proposed lines will be 1435mm

(source : African business Journal-August – November 2004)

Existing & Proposed Railway Network

Fig 4existing and proposed rail network (Source:Business Opportunities in Ghana forum-Nov 2007)

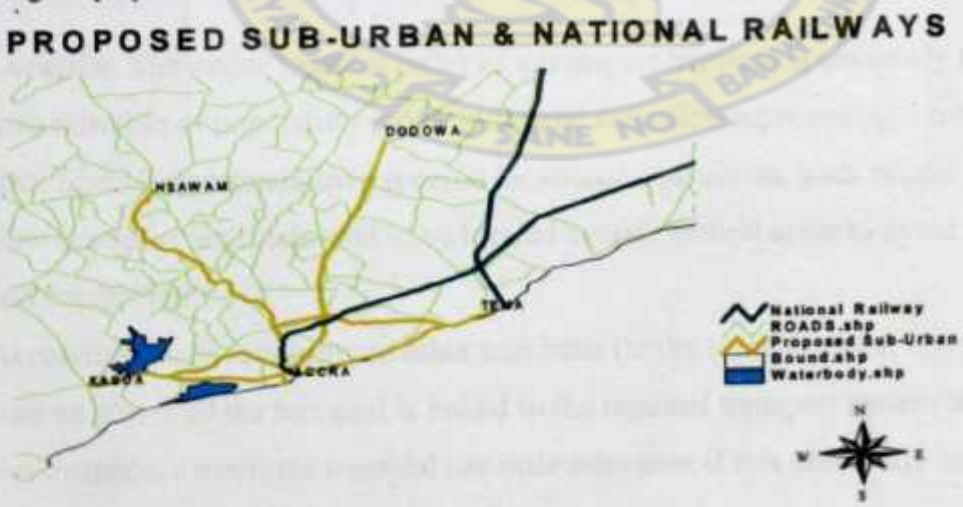


Fig 5 Proposed sub-urban and national railways(Source:Business Opportunities in Ghana forum-Nov 2007)

2.3 Definition of terminal

Terminal refers to a location where freight and passengers originates, terminates, or is handled in the transportation process. Terminals are central and intermediate locations in the movements of passengers and freight. They usually have facilities to accommodate the traffic they handle.

A train terminal is a station at which, since it lies at the very end of a line of railway, all arriving trains must perforce terminate their journeys, and from which they can consequently depart only following a reversal. Key advantage is that it permits travelers to reach all of the platforms without the need to cross any track. Very often a terminus is the final destination of trains but this is not always the case.

Terminals may be points of interchange within the same modal system and which insure a continuity of the flows. Terminals, however, are also very important points of transfer between different modes of transportation. Busses, cars, bicycles etc deliver people to train stations, trucks haul freight to rail terminals, and rail brings freight to docks for loading on ships.

One of the main attributes of transport terminals, international and regional alike is their function of bringing people or goods to a particular place. They serve as obligatory points of passage having invested on their geographical location which is generally intermediate to commercial flows. Thus, transport terminals are either created by the centrality or the intermediacy of their respective locations. Three major attributes are linked with the importance and the performance of transport terminals:

- **Location**. The major location factor of a transport terminal is obviously to serve a large concentration of population and/or industrial activities, representing a terminal's market area. Specific terminals have specific locational constraints, such as port and airport sites. New transport terminals tend to be located outside central areas to avoid high land costs and congestion.
- **Accessibility**. Accessibility to other terminals (at the local, regional and global scale) as well as how well the terminal is linked to the regional transport system is of importance. For instance, a maritime terminal has little relevance if it is efficiently handling maritime

traffic but is poorly connected to its market areas through an inland transport system (rail and road).

- **Infrastructure**. The main function of a terminal is to handle and transship freight or passengers. Infrastructure considerations are consequently important as they must accommodate current traffic and anticipate future trends and also technological and logistical changes.

2.4 CHANGING ROLES OF RAILWAY TERMINI IN CITIES

Railway stations have a very long history of about 170 years which can be divided into three major phases.

2.4.1 Phase 1

The first phase began in Britain when the first steam railway was opened for passengers in the first half of the 19th century between Liverpool and Manchester. Steam railways which was a technological advancement over stagecoaches and horse-drawn carts, were usually sited at the city's edge. This meant that people had to ride in horse-drawn carriages to continue their journeys within the urban areas.

The earliest stations and termini usually simple wooden structures and consisted of a single building and roofed platform without incorporating other facilities.

By the latter parts of the 19th centuries more varied architectural styles, waiting rooms, refreshment rooms, complicated internal spaces and later railway hotels were being incorporated in the design of train stations and termini. It is clear that in this first phase the role of the railway station as a city's gateway had changed to the additional role of being centres where travelers as well as local people converged. (source: Ideas of Node and Place in the changing roles of railway Termini in cities).

2.4.2 Phase 2

What triggered the second phase is the transport revolution in Britain which occurred in 20th century which saw the electrification of the steam railways and the first underground railway network constructed.

The untidiness and discomfort of the existing stations triggered trouble, inefficiencies and inconveniences for the electrified railway system as the existing rail stations were built to serve steam-driven locomotives. This and the world wars resulted in the closures and demolitions of several train stations around Europe.

Also the invention of the petrol vehicles which were as a result of the transportation revolution saw the beginning of a combination of road and air transportation which made rail travel more and more unpopular. (source: Ideas of Node and Place in the changing roles of railway Termini in cities).

2.4.3 Phase 3

This phase started from the early 1970s until the early 1980s. as a result of increased road traffic due to urbanization, railway transportation was reconsidered as the cheapest,cleanest,fastest and safest means of land transportation from one place to the other. Since then rail transportation has always been included, alongside other transport modes in transportation policies for several cities. (source: Ideas of Node and Place in the changing roles of railway Termini in cities).

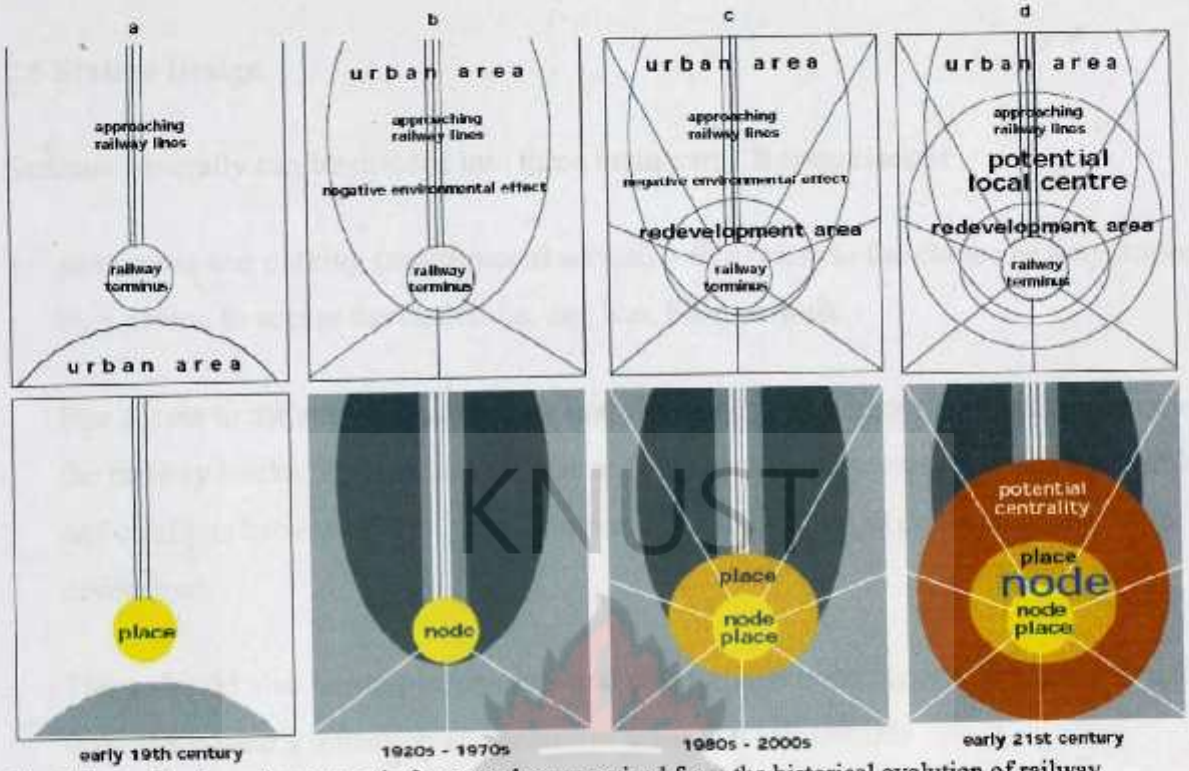


Fig 6 The node-place diagrammatic framework summarized from the historical evolution of railway termini. (source: Ideas of Node and Place in the changing roles of railway Termini in cities).

A. Depicts an archetype of the railway terminus from the 19th to the early 20th century characterized by an isolated location at the edges of the city. It represents railway termini in their earliest years when they were kept at the city periphery.

B. can be seen to be isolated nodes of the transportation network located within declining urban settings. In this second phase, when the cities grew beyond the terminus locations, railway termini had become major transit nodes as they were well interconnected with other modern modes of transport.

C. depicts the railway termini that are currently to be redeveloped as node and place embedded within the urban setting.

B. depicts the future potential of railway terminus areas as rejuvenated local centres. The newly redeveloped districts at railway termini would benefit from the efficient transport connection that encourages a large number of people to

converge as well as to pass through the areas where multiple activities are provided, both inside and outside the terminus buildings.

2.5 Station Design

Stations generally can be divided into three main parts. It comprises of

1. site access and parking (multi-modal access) - this refers to the choice of transit used by a person to access the station i.e. car, bus, bike, or walk.

   Bus access to the station must ensure that situations where buses are required to cross the railway tracks. Bus and automobile access should be separated wherever possible and conflicts between buses, trains, automobiles, bicycles and pedestrian should be minimized.

   There should also be simple, obvious and comfortable passengers' circulation to and from the station's transition and platform areas. To achieve this

   i. Unnecessary turns and dead ends should be avoided.
   ii. Enough space for circulation should be provided to avoid bottlenecks
   iii. Cross circulation at fare collection and decision points should be avoided
   iv. Enough space should be provided for long queues at fare collection areas so that traffic is not blocked.
   v. Separate facilities for entering and leaving the station should be separated.
   vi. Grade changes should be minimized as much as possible.
   vii. Pedestrian through zones should be free of obstructions such as phone booths, ticket machines, advertising systems, seating etc.
   viii. Adequate sight distance and visibility along pedestrian routes should be ensured.
   ix. At least two points of access/exit from the platform should be provided

   (Light Rail Design Criteria, November 2005)

Bicycle access and facilities should be located to minimize conflicts with pedestrian and vehicular traffic. Also it should be easier to monitor bicycle storage areas from the station's entrance or the street to promote security. The bicycle racks can also be located on the transition plaza but separated from places where people gather.

2. Transition plaza – this refers to the space or area necessary to facilitate the movement the movement of people from the parking or other means of access to the platform. In this place a person can buy tickets, view public information systems and wait until they are picked up.

Fig 7 Unobstructed circulation station concourse. (source Design Guide for Disable- code of practice, version 1.July 2008)

The following are some of the design criteria for the transition plaza.

1. The transition zone should be big enough to cater for passenger volumes during peak and off-peak periods.
2. Ticket vending machines, information systems etc should be located near to the line of travel without impeding the flow of passengers to the platform.
3. Ticket sale points should be able to serve a large number of passengers in a short period of time.

Fig 8 A typical ticket gate (source Design Guide for Disable- code of practice, version 1 July 2008)

3. Platform

2.6 Railway platform (facts and description)

A railway platform is a section of pathway, alongside rail tracks at a train station, metro station or tram stop, at which passengers may board or alight from trains or trams. Almost all stations for rail transport have some form of platforms, with larger stations having multiple platforms. The term platform is most commonly used for designated areas where trains stop. Technically speaking, the term platform actually refers to physical continuous sections of platform area. So such a physical platform may contain several designated platforms.

(Source: Light Rail Design Criteria, November 2005)

2.6.1 Characteristics

A most basic form of platform consists of an area at the same level as the track, usually resulting in a fairly large height difference between the platform and the train floor. This would often not be considered a true platform. The more traditional platform is situated at an elevated level relative to the track, but often lowers than the train floor, although ideally the platform should be at the same level as the train floor. Occasionally the platform is at a higher level than the train floor. This may be the case when a train with a low floor level serves a station built for trains with a higher floor level.

2.6.2 Facilities

Part of the station facilities are usually on the platforms. Where the platforms are not situated within a station building, often some form of shelter or waiting room is provided. The protection offered by such varies greatly – some being little more than a roof with open sides, others being a closed room with heating or air-conditioning. Also there may be benches, lighting, garbage boxes and static or dynamic displays with information about the next train, delays, etc. There are often loudspeakers as part of a public address system. The PA system is often found where dynamic timetables or electronic displays are not present. A variety of information is presented, usually pertaining to departures, but often arrivals also. This concerns destinations and times, delays, cancellations, platform changes, changes in routes and destinations, the fact that for a train a supplemental fee or a reservation is required, etc.

Fig 9 Information system and tactile marking at the edge of platform (Source Design Guide for Disable- code of practice, version 1 July 2008)

2.6.3 Platform arrangement

There are three different arrangements of platforms. They are:

1. side platforms- this is where the platforms are arranged facing each other and with each catering for one mainline track.

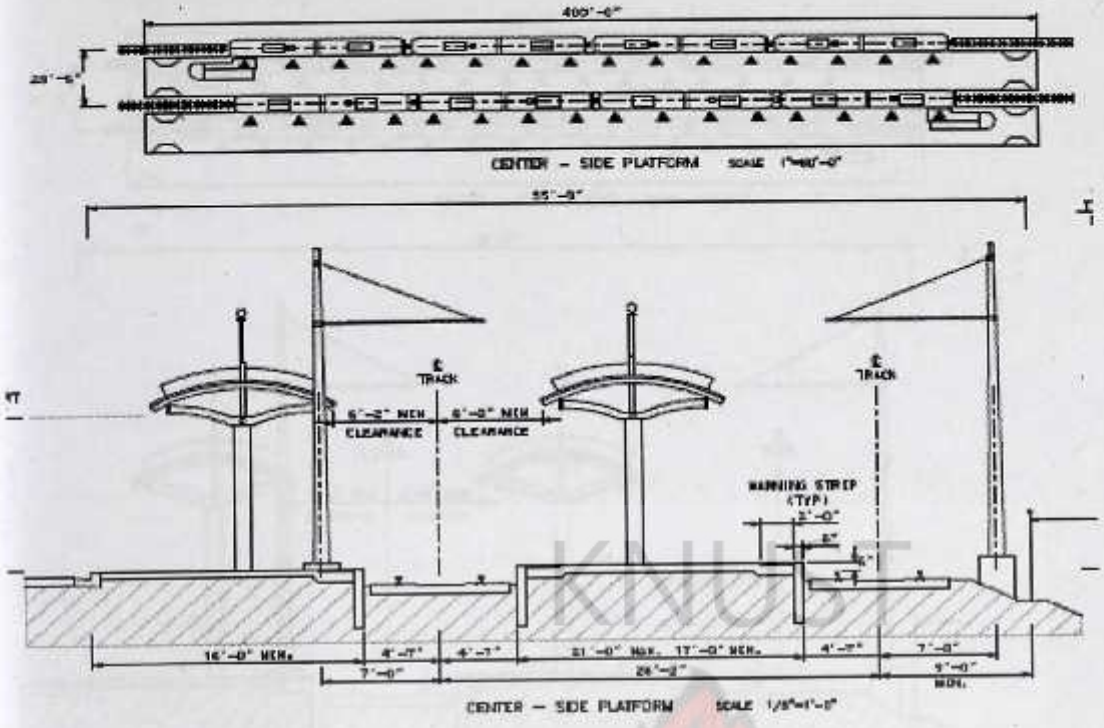


Fig 10. A typical section through a side platform (Source: Terminal Architecture and Engineering)

2. Center platform- this refers to where one platform services tracks located on each side of it. Passengers have to use a bridge or tunnel to be able to access center platforms. It is also known as island platform.

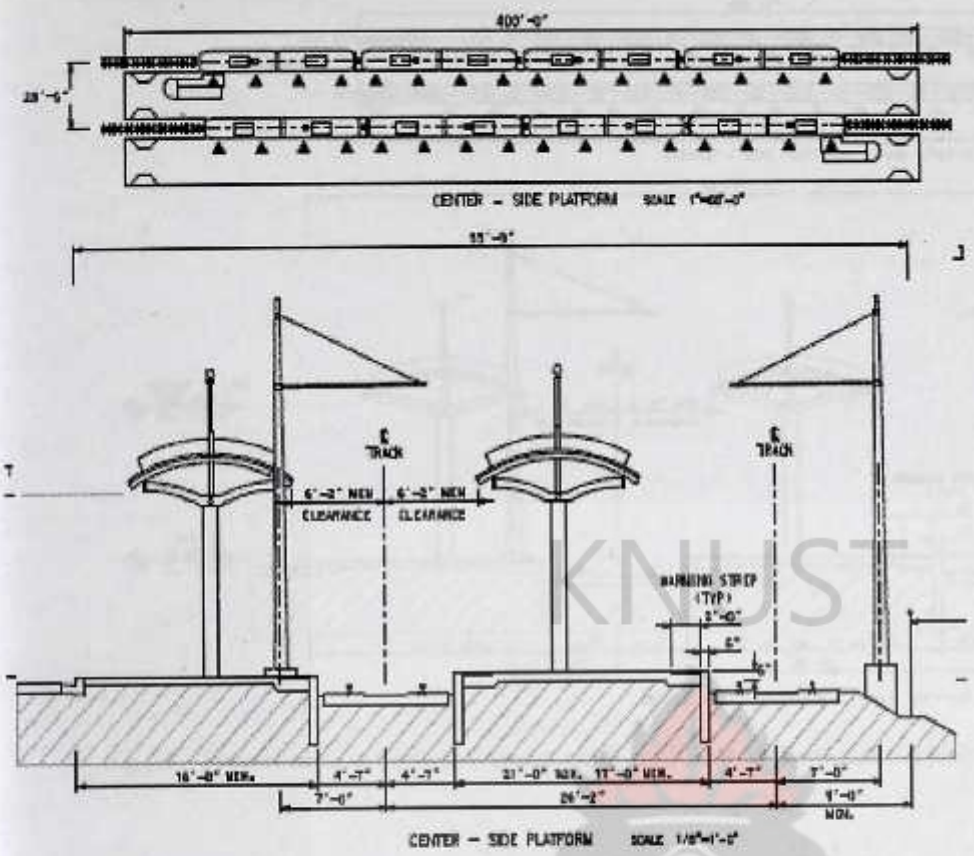


Fig 11. A typical section through a center platform (Source: Terminal Architecture and Engineering)

3. Side center platform: this kind of platform is located on just one side and a center platform provided to service the other tracks.

   The centre platform kind of arrangement offers the most efficiency in terms of use of platform space and furnishings.

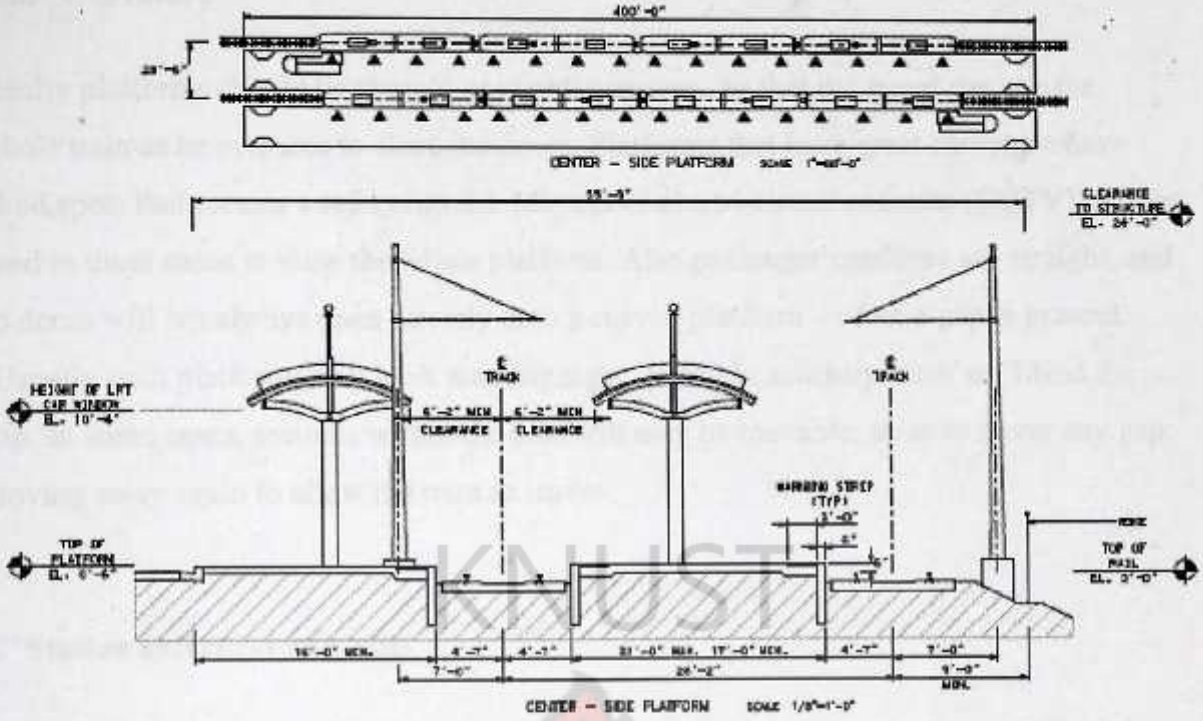


Fig 12. Typical section through a center platform (Source: Terminal Architecture and Engineering)

2.6.4 Platform safety

For platforms to be efficient and passenger sensitive the following should be ensured

1. Platforms should be designed with conspicuous warning strips on the edge of the platform to prevent accidents
2. As much as possible platforms should be clear of equipments and other obstacles.
3. Fixed objects such as furniture, advertising boards, etc should be concentrated in one area leaving enough room for circulation.
4. Clear emergency exiting from platforms should be provided.
5. Platform exits should be big enough and located to cater for estimated passenger volumes under both normal and emergency conditions.
6. As much as possible platform surface should flash with the floor of the trains interior to make boarding easier and safer.

2.6.5 Curvature

Ideally platforms should be straight or slightly convex, so that the guard can see the whole train as he prepares to close the doors. Platforms that have great curvature have blind spots that creates a safety hazard. Mirrors or closed-circuit cameras (CCTV) may be used in these cases to view the whole platform. Also passenger carriages are straight, and so doors will not always open directly onto a curved platform – often a gap is present. (Usually such platforms will have warning signs, possibly auditory, such as "Mind the gap. In some cases, sections within the platform may be movable, so as to cover any gap; moving away again to allow the train to leave.

2.7 Station entrances and exits

Station entrances and exits should be sufficient and be designed in such a way that it can cater for passenger traffic for peak and non-peak times. Its location should be easily identified and should make it easier, faster, and safer for people to escape in the event of an emergency. Doors should be wide enough and should swing in both directions.

2.7.1 Passenger flow in train stations

The station is the first and last encounters a passenger experiences when travelling by train. Passengers must of necessity access the station before boarding a train and must upon arrival exit through the station. In stations passengers travel on escalators, stairs, ramps, lifts, etc and goes through fare collection gates before and after a train ride. A general passenger flow chart with main station activities and their relationships is shown below.

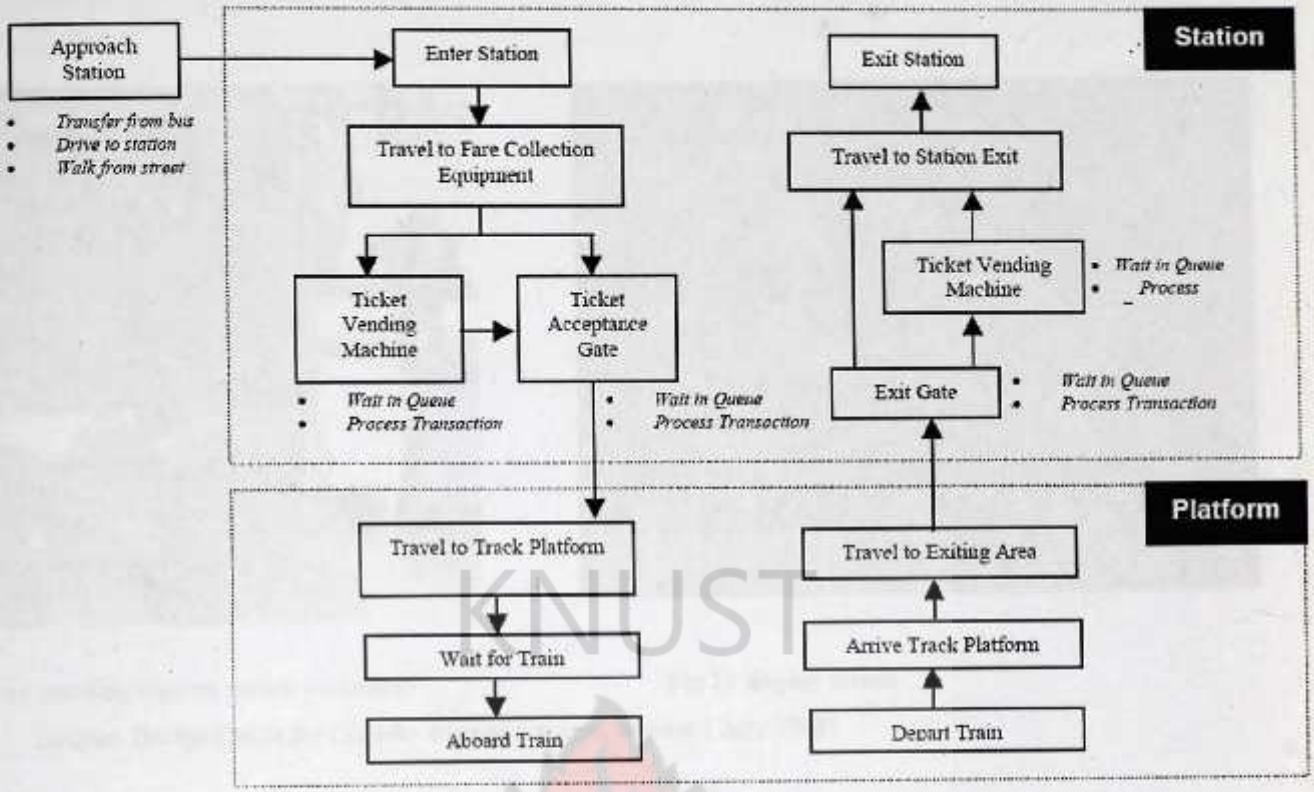


Fig 13 A typical flow chart within a train terminal (source: www.train terminal circulation)

2.7.2 Passenger information

Passenger information systems (PIS) must be a reliable means of giving information to commuters in a station. Information systems should be placed and made in such a way that information can easily communicated to people using the station. They must be updated regularly and must be visible in all weather.

There are two types of information being constant and instant. Constant information normally gives information on the services, goods and the fares of the station. The instant gives information those changes very often (daily or by minute). They usually give information concerning;

1. the time now
2. time of arrival or departure of a train
3. train destinations and stops
4. the stations served by this station

Fig 14 Free standing sign on station concourse

Fig 15 display screen

(source: Design Guide for Disable- code of practice, version 1 July 2008)

2.7. 3 Station materials and finishes

The durability, availability and aesthetic features of a train terminal have a direct relationship with its image. Because train stations are used by a large number of people daily and are usually targets of vandalism, materials used should be durable and must be easily available and replaced. Materials should also be appealing and harmonious in texture and appearance. Flooring materials should be non slip, easy to clean and replace and also fire resistant.

2.7.4 Video Surveillance in Train Stations

In recent years, public transit security concerns have increased significantly. The threat of terrorist activity has always been present, but it is a larger issue today than ever before. In train and subway stations, video surveillance systems can help to prevent such acts. Additionally, security cameras can deter crime and vandalism within stations, and provide riders with an added sense of security.

2.7.5 Station facilities

Some of the facilities provided in train terminal design are

1. ticket booths and or ticket machines
2. customer service desks
3. convenience stores
4. fast-food or restaurants
5. postal services
6. left-luggage
7. lost-and-found luggage
8. luggage carts
9. waiting rooms
10. taxi ranks and bus bays
11. driver restrooms

2.8 Technical studies

Rail gauge refers to the distance between the inner sides of the two parallel rails that make up a single railway line. There are three main types of gauges namely the standard or international, broad and narrow gauge.

Fig 16 Rail track gauge (source: Rail gauge, Wikipedia, the free encyclopedia)

Standard gauge refers to the type of rail with 1435mm distance between the inner sides of the rails. New railways are usually built to standard gauge unless there is a strong reason not to adopt it. Sixty percent of the world's railways use this type of gauge because of the following:

1. It facilitates inter- running with neighbouring railways.
2. Locomotives and rolling stock can be ordered from manufacturers' standard design and do not need to be custom built.

It is for these reasons that the existing railway lines in Ghana are being changed to make way for the standard gauge.

Fig 17. Standard gauge (source: Rail gauge, Wikipedia, the free encyclopedia)

The Broad Gauge refers to any gauge that is wider than standard gauge. They are common for cranes in docks for short distances. They are used to provide better stability.

Fig 18. Broad gauge (source: Rail gauge, Wikipedia, the free encyclopedia)

Narrow Gauge is any gauge that is narrower than the standard gauge. They cannot handle as much tonnage as the standard gauge but are less costly. They are dominant in Southern and Central Africa. The most widely used ones are the 1067mm, which is dominant in Ghana, and the 1000mm gauges.

Fig 19 Narrow gauge (source: Rail gauge, Wikipedia, the free encyclopedia)

2.8.1 Alignment of Tracks

In laying two or more tracks the critical point, which is the center to center distance between the tracks should not be less than 3300mm. Two trains are not allowed at this section of the rail lines as it may cause accidents.

Fig 20 Critical point of two tracks (source: Rail gauge, Wikipedia, the free encyclopedia)

2.8.2 Trains

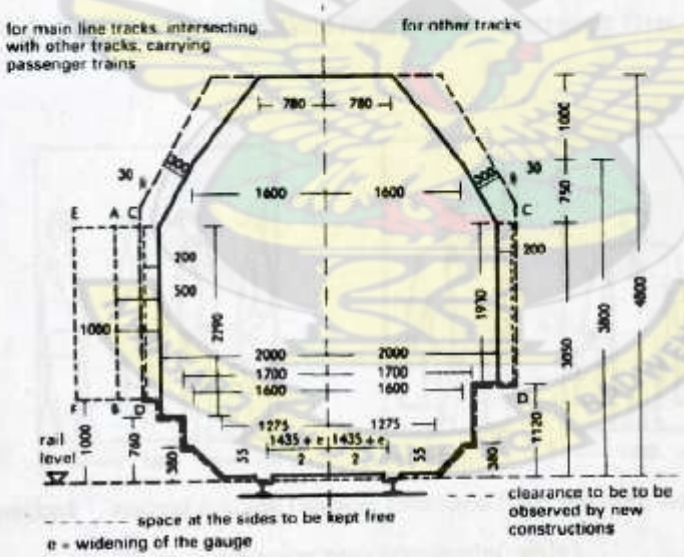


Fig 21 dimensions of a typical train coach (source: Ernst and Peter Neufert, Architects Data, third edition 2000)

Modern passenger trains have an average width of 2800mm and an average height of 4000mm.

2.8.3 Platforms

The minimum height of train platform is 500mm but the width is determined by the kind of activity there. It is better to have an unobstructed and straight platform so that the train conductor can monitor passengers embarking or disembarking from the train. Materials for the platform should as much as possible be resilient and non slip.

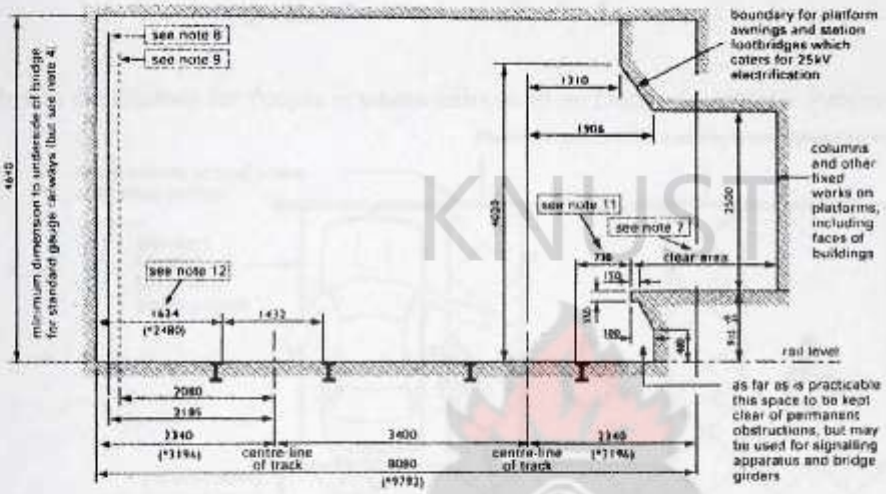


Fig 22 Platform and track details (source: Ernst and Peter Neufert, Architects Data, third edition 2000)

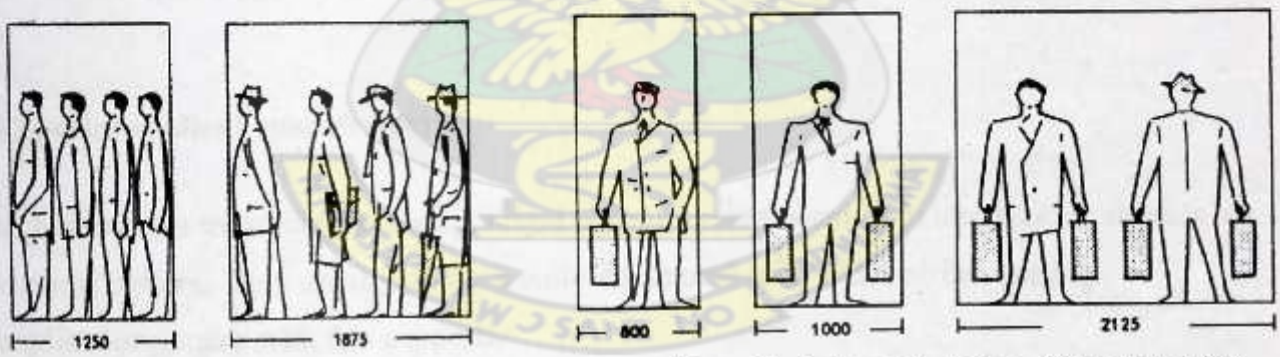


Fig 23 Closely packed normal spacing (source: Ernst and Peter Neufert, Architects Data, third edition 2000)

Space requirements(able)

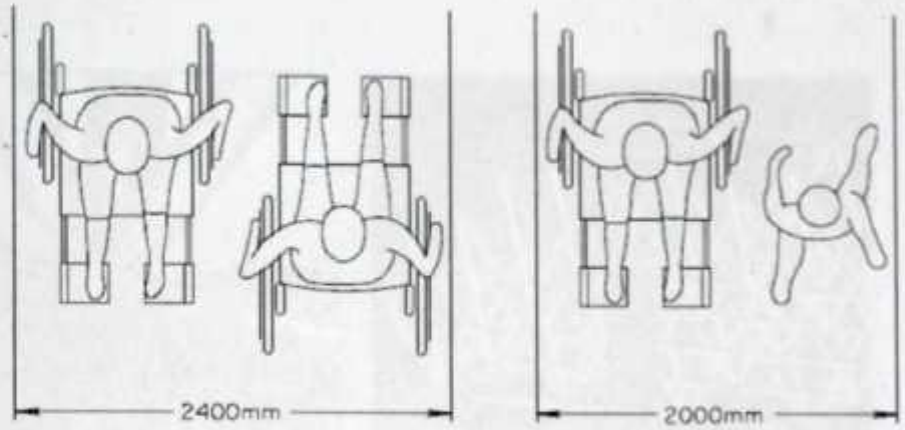


Fig 24 Minimum dimensions for people in wheelchairs (source; Design Guidelines-Parsons Brinckerhoff, July 2002)

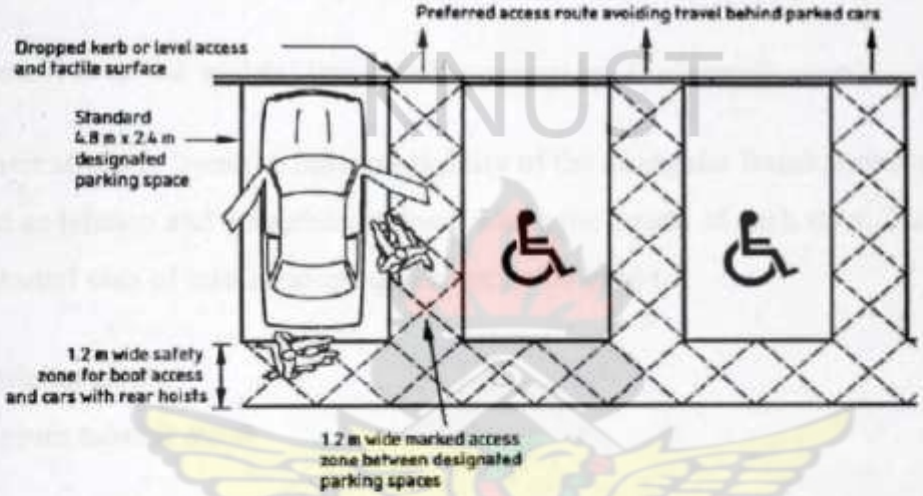


Fig 25 Access around designated off-street parking spaces (source; Design Guidelines-Parsons Brinckerhoff, July 2002)

2.8.4 Special studies (spaceframe)

A space frame is a truss-like light weight rigid structure constructed from interlocking struts in a geometrical pattern. They usually utilize a multi directional span and are often used to accomplish long spans with few supports.

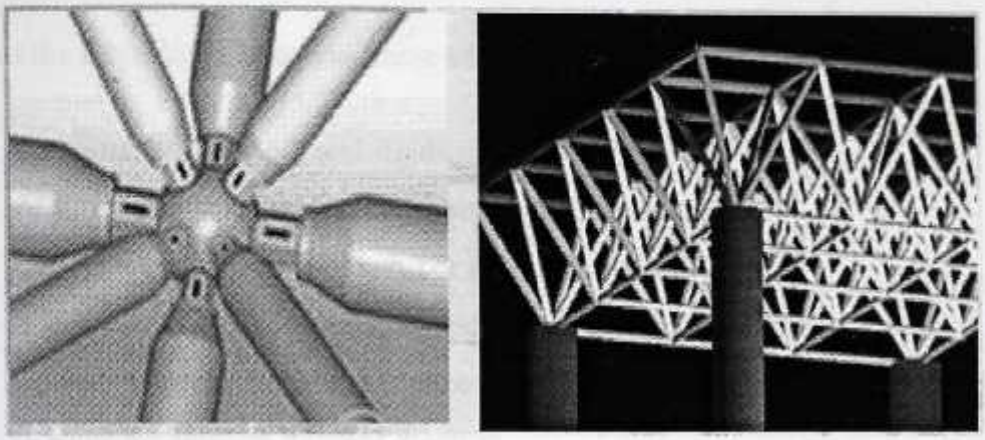


Fig 26 space frame structure and module (source: Delta structures Inc.-Guide specifications)

They derive their strength from the inherent rigidity of the triangular frame; bending moments are transmitted as tension and compression loads along the length of each strut. The simplest form is a horizontal slab of interlocking square pyramids built of:

1. Steel tubular struts
2. Aluminium tubular struts

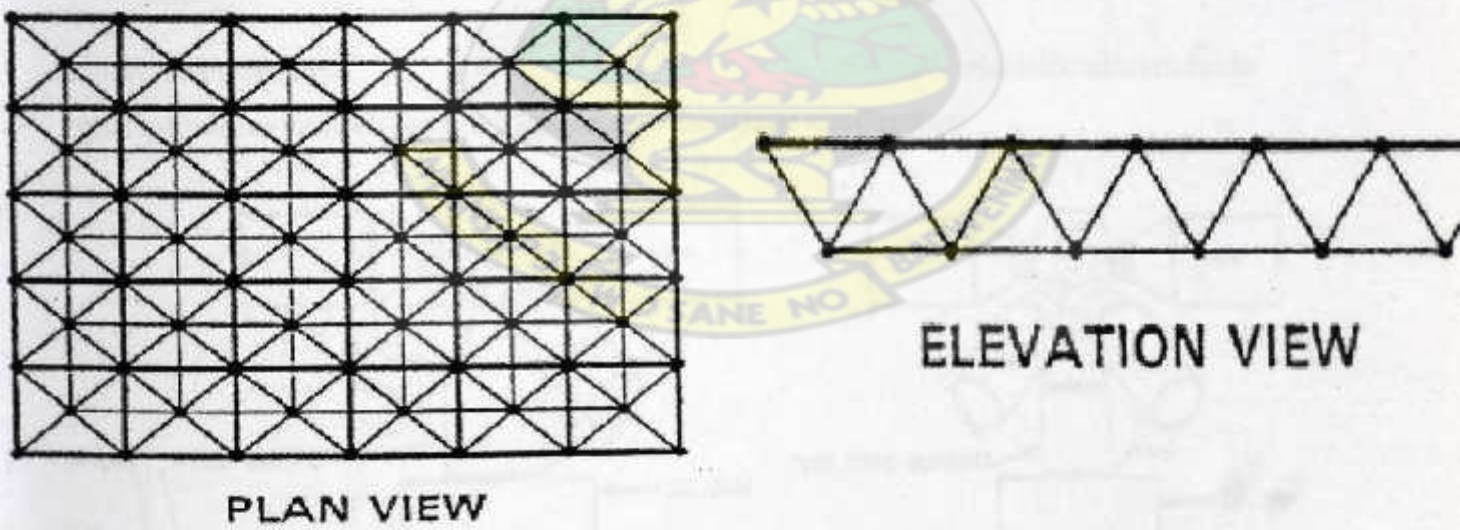
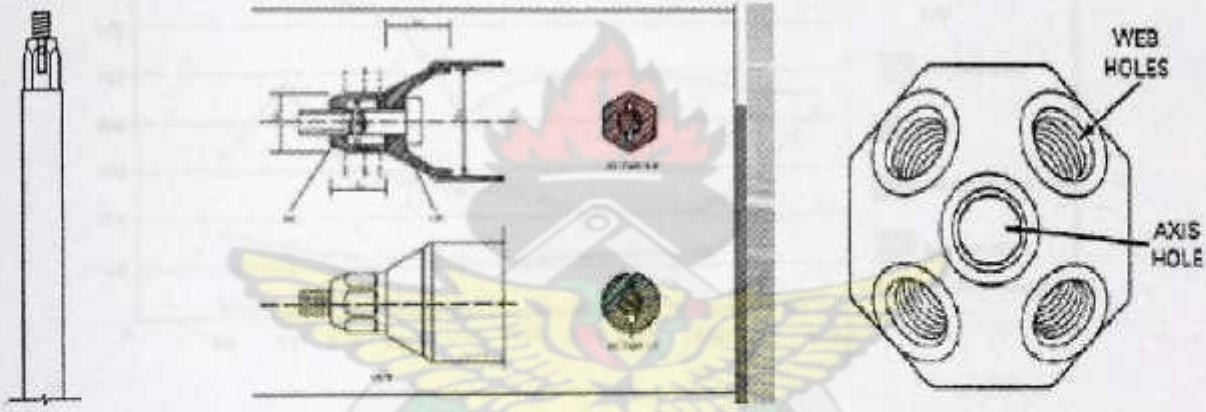


Fig 27 plan and elevation views of space frame structures (source: Delta structures Inc.-Guide specifications)

2.8.5 Advantages

Some of the advantages of space frame structures are:

1. Considerable strength and rigidity
2. Ability to have large spans without middle supports
3. Capacity to carry concentrated or non-symmetrical loads
4. It is possible to run extensive overhead services through them
5. Components can be mass produced in a standardized manner, segregated and transported to sight for straight forward erection.
6. They add to the aesthetics of buildings, especially the interior spaces.



Aluminium/steel strut steel/aluminium node

Fig 28 space frame members (source: Delta structures Inc.-Guide specifications)

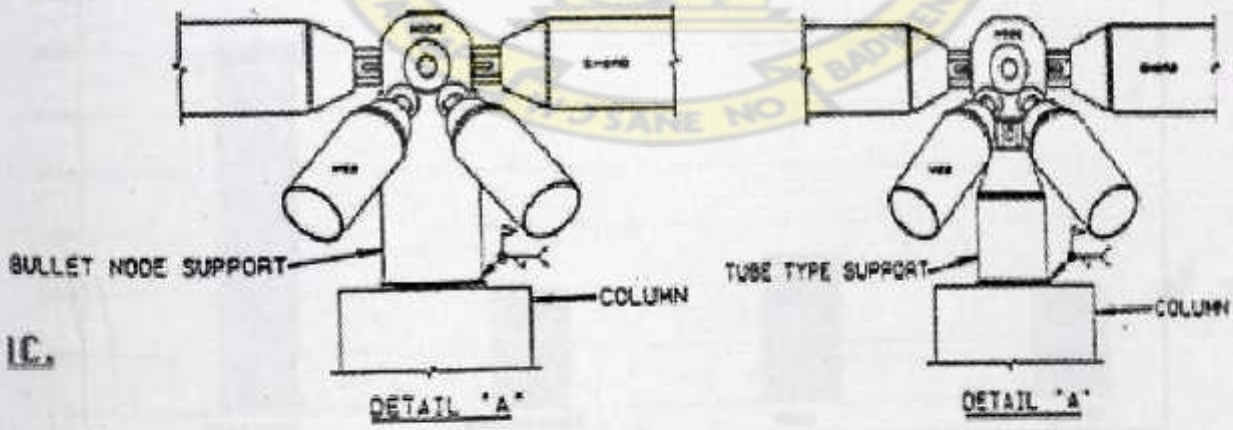


Fig 29 connection of spaceframe members (source: Delta structures Inc.-Guide specifications)

2.9 TRAFFIC STUDIES

Several people commute between Tema and other parts of the country daily. They use some of the main roads namely the Tema motorway , the Spintex road , the Accra- Tema beach road, among others. To determine the volume of daily traffic along the Tema- accra beach road corridor, a traffic count was undertaken. The graph below shows the composition and volume of traffic on the tema- accra beach road which borders my site on the south west.

Fig 30. Chart showing vehicular classification (source: Department of urban roads - Ghana ,2006)

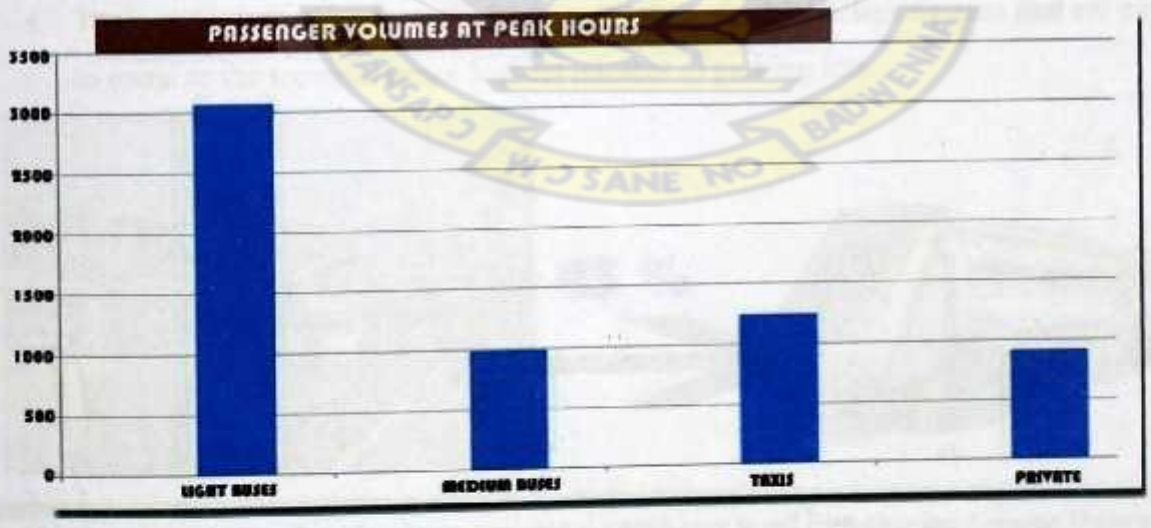


Fig 31. Chart showing passenger volumes at peak hours (source: Department of urban roads - Ghana ,2006)

AVERAGE VEHICULAR OCCUPANCY

TYPE OF VEHICLE	AVERAGE NO OF OCCUPANTS
LIGHT BUSES(TRTRO)	15
MEDIUM BUSES	31
TAXIS	3
PRIVATE CARS	2

Fig 32 Average number of vehicular occupancy (source: Department of urban roads - Ghana ,2006)

From the graphs it could be observed that

1. An average of 6216 commuters travel from Tema to other parts of the country by the beach road daily.
2. Peak passenger and vehicular volumes occur between 7-8 in the morning and 5-6 in the evening.
3. A larger percentage(49%) of people who are expected to use the terminal will come by light buses.
4. Taxis and private cars form the highest number of vehicle classification that are expected to come to the terminal hence highest number of parking lots.

Fig 33. An estimated 45% of road users are expected to switch over to rail transportation. (source: Department of urban roads - Ghana ,2006).

Statistics from the Ghana Urban roads indicate that about **45%** of commuters of both private and public transport will willingly shift to a more efficient rail transport.

A figure of 2800 commuters will be willing to shift to the rail transportation. By **2025** this figure is projected to be 4400.

A train terminal capacity of **5000** people is therefore proposed .

CHAPTER THREE

3.0 Methodology

Collection of data can be grouped into two main types namely the qualitative and quantitative. The quantitative method deals with getting answers to some particular questions. They may be in the form of filling in some numbers or ticking of boxes in response to some questions. They are mostly used when the data is based on large number of responses.

Qualitative data collection involves the exploring of issues to gain in-depth knowledge on the topic under study. These two types of data collection were employed with regard to writing this report.

1. **Interviews** : several interviews were undertaken to be able to know the current situation pertaining to transportation in Ghana, railway transportation and other issues concerning Ghana Railway Company. Interviews were conducted with Ghana Railway Company area engineer- Accra, Asoprochona train station manager and draughtmen of the Accra railway station.
2. **Internet** : since no modern and vibrant railway terminal or station exists in Ghana at the moment, most of the information concerning train terminal design and other related information were gathered from the internet.
3. **Periodicals**, books and publications: some of the information on the subject were obtained from books on train terminals and airport designs etc.

3.1 Limitations

Several limitations were encountered with regard to gathering information to prepare this report. First and foremost, getting the site maps for Tema, Asoprochona and Accra were extremely difficult.

Secondly getting information on vehicular traffic volumes for Tema over the years also proved difficult.

Lastly the non-existence of a modern train terminal or station in the country also made it difficult for me to be able to get enough information with respect to the operations of the Ghana Railway Company.

3.2 CASE STUDY

This foreign case study was done to know what is happening abroad with respect to train terminal design.

3.2.1 Union station

3.2.2 Location

Union Station is an important and a historic landmark and architectural gem located in Washington D.C within a civic precinct. It serves as a major transportation hub, retail center and tourist destination catering for the residents of the district of Columbia, tourists and commuters from both Washington D.C area and across America.

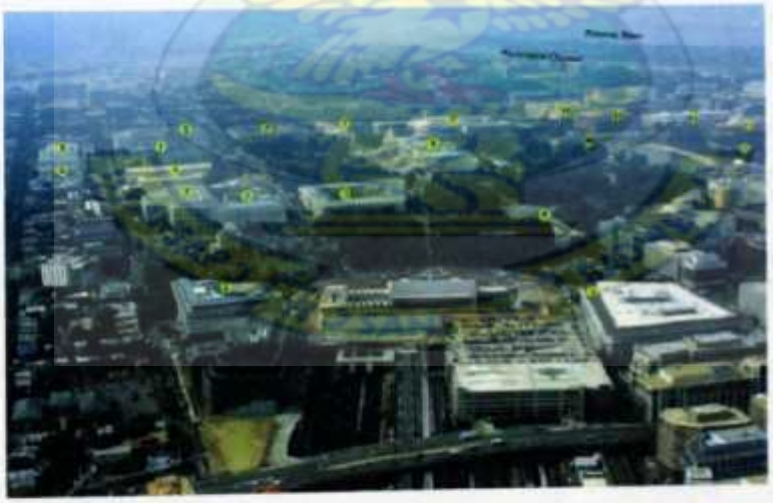


Fig 34 Picture of Union Station (outlined in red) in the urban setting(source: www.essential- architecture.com)

1. Postal museum
2. Thurgood marshall federal judiciary building
3. Senate office buildings
4. United states supreme court

5. Library of congress buildings
6. Shakespeare
7. House office buildings
8. Capital of the united states
9. Union station plaza
10. US Botanical Gardens
11. Food and Drug Administration building
12. US Department of Health and Human Services
13. Voice of America
14. American Indian Museum
15. The National mall

3.2.3 Layout

Union station made provision for the following spaces.

1. **Lower level**

Movie theatre

Food court

Car park

Retail shops

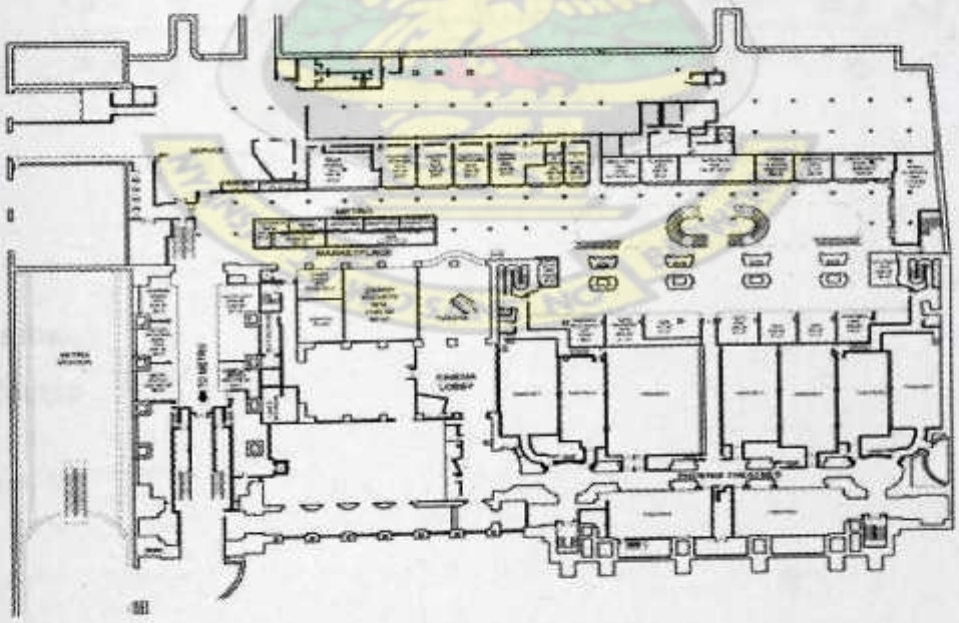


Fig 36 Lower level plan(source: www.essential- architecture.com)

2. **Street level**

Postal services
Waiting area
Information desk
Train concourse
Ticket vending machine area
Platforms
Ticket and baggage offices
Restaurant
Main hall
carriage porch
washrooms

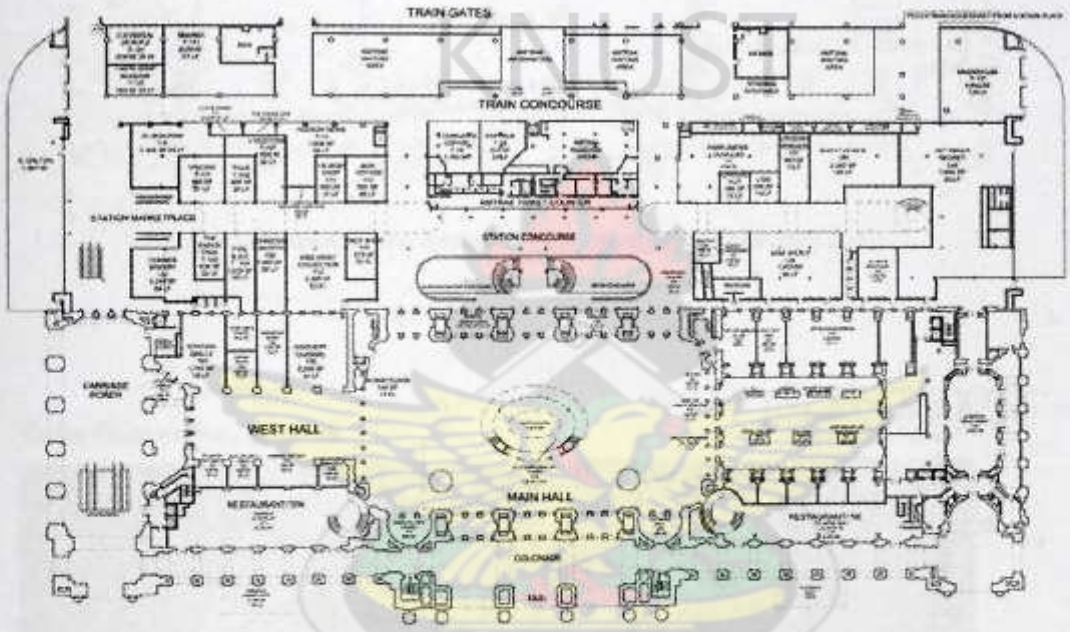


Fig 37 Street level(source: www.esscntial- architecture.com)

3. **Mezzanine.**

Shopping concourse
Retail stores
Auditorium
Café
Washrooms
Bank

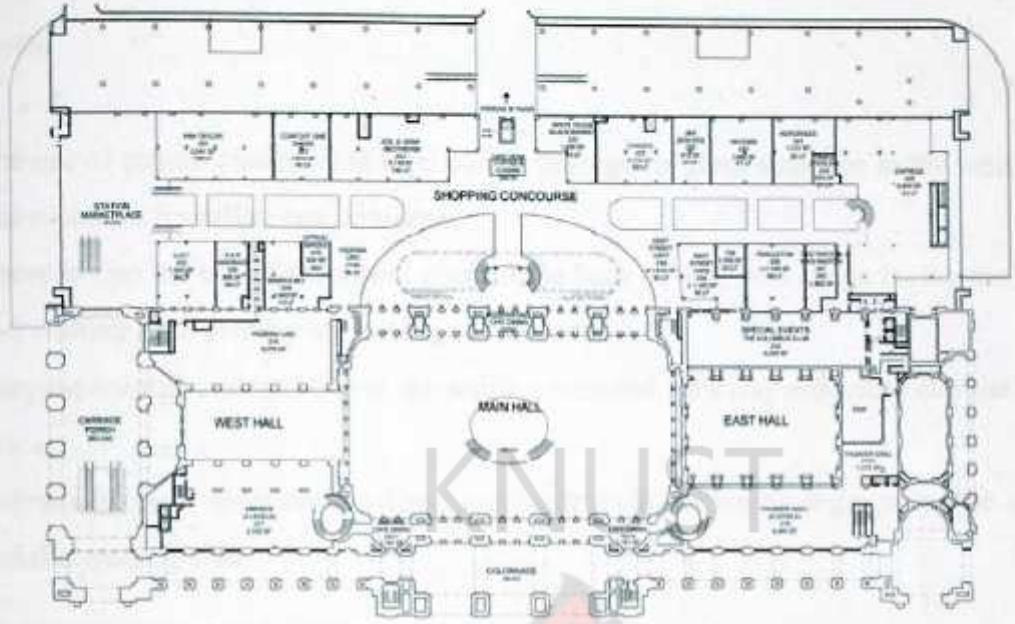


Fig 38 Mezzanine level(source: www.essential- architecture.com)

Train Concourse / Amtrak

Fig 39 View of the train concourse(source: www.essential- architecture.com)

3.2.4 Merits

1. The use of atrium ensures that light comes through its glass structure to the waiting area and creates a friendlier environment.
2. There is also the use of storefront glass at the back of the retail shops facing the walkway and waiting area thereby improving advertisement.
3. Varying colours and textures at the waiting area and walkway enhances circulation within space.
4. Balustrades have been used to direct and control circulation by segregating the walkway and the waiting area.

Fig 40 Main hall café at street level and mezzanine level dining with piece of art

(source: www.essential- architecture.com)

1. wide arched windows with glazing help to bring in natural light into the main hall
2. the mezzanine level dining at the main hall helps to save space. It however impedes circulation.

3.2.5 Bike transit centre

The new bike transit which is attached to the station is supposed to provide convenience and access for commuters. The features of the bike transit centre are

1. 1700 square feet of space enclosed in glass.
2. Lockers for up to 150 bikes
3. Bike rental, sales and store areas

Fig 41 Bicycle transit facility (source: www.essential- architecture.com)

3.3 Accra Train Station

3.3.1 Site layout

Fig 42. Layout of Accra Train Station(source: Accra Train Station, 2009)

3.3.2 Facilities provided

Fig 43. Administration of Train station(source: Author)

Fig 44. Parking Area (source: Author)

Fig 45. Platform area(source: Author)

Fig 46. Restaurant (source: Author)

Fig 47. Ticketing and weighing area (source: Author)

Fig 48. Maintenance unit (source: Author)

3.3.3 Merits

4. Goods and pedestrian portions of the station have been separated for effective circulation.
5. Facilities of the station have been laid out in such a way that there is effective ventilation and also to make maximum use of natural lighting.
6. The platform area is open. This will enhance evacuation of people in times of emergency and also helps in ventilation.
7. One style of architecture runs through the design of the whole facilities

3.3.4 Demerits

1. The station facilities are scattered all over the site. This makes way finding and circulation difficult.
2. Low platform height makes it difficult for people especially with disability to board and disembark from trains.
3. Parking areas and pedestrian walkways are not well defined.
4. Location of the station in the heart of the city centre of Accra makes it difficult for people and vehicles to access the station.

CHAPTER FOUR

4.0 Site

The site is located in Tema a city in the Greater Accra region. It is bounded on the south east by the Sakumono village and on the south west by the Accra-Tema beach road.

Fig 49 LOCATION OF TEMA

Fig 50 LOCATION OF SITE (source: Author)

Fig 51 SITE (source: Author)

4.1 Site justification

There is a growing number of people who commute between Tema and Accra daily on the beach road and a train terminal along that road will cut down drastically the increasing number of vehicles on that corridor and other major roads.

Also a train terminal along the beach road will serve as a catalyst for the springing up of other facilities (e.g. waterfront development).

Furthermore, a suburban train shuttle service is in operation on that Corridor but the facilities at the site will be unable to handle anticipated passenger volumes.

4.2 Existing site conditions and inventory

A site survey conducted on the site revealed that there are 22 structures on the site. Thirteen are temporary structures on the eastern corner of the site put up by encroachers and eight are buildings belonging to the Ghana Railway Company centrally located on the site. One of the eight structures is the station itself with facilities such as waiting area, platform, ticket counter and office and manager's office. The other buildings are accommodation facilities for the railway workers. There is an existing single railway line running through the northern part of the site.

Fig 52 View of site from the Tema – Accra Beach Road(source: Author)

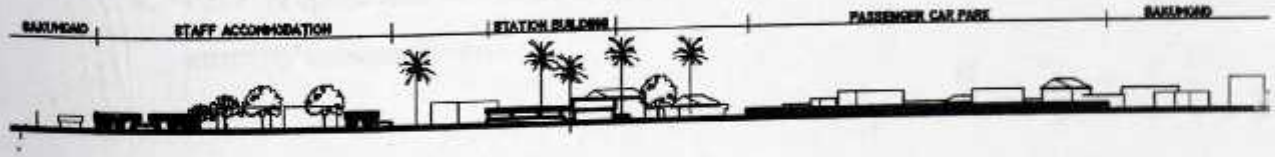
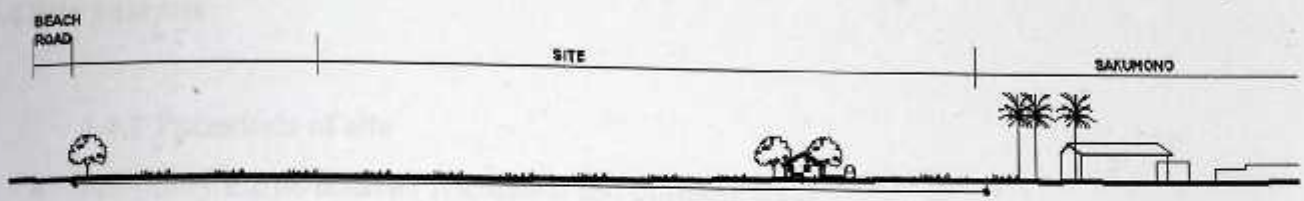


Fig 53 SECTION X-X (source: Author)



SLOPE- 1: 70 m

Fig 54. SECTION Y-Y (source: Author)

4.3 Building conditions

A study conducted on the building revealed that buildings are old and have outlived their use. The station building is small in size with an area of 120 sq meters. Materials used are;

Wall – sandcrete blocks

Roof – asbestos roofing sheet

Floor – concrete

Considering

-the small size of the station vis-a-vis the anticipated volume of passengers

-the fact that the building has outlived its use

-the fact that some carcinogenic materials were used

I propose that

1. The station building should be demolished to make way for the new terminal.
2. The worker's accommodation blocks which have the same building materials condition should also be demolished
3. Squatters should be moved from the site.
4. I also propose that two more tracks should be added to cater for sub-urban and intercity transportation.

4.4 Site analysis

4.4.1 Potentials of site

- Proximity traffic source (residential and business area)
- Site is located along a rail way line
- Proximity to a major access road to Tema (beach road)
- Site is large enough for such a facility
- Site has a gentle slope
- Most of the site's area has vegetative cover

4.4.2 Problems

- Site is a little bit removed from the city centre
- Encroachment on site by squatters
- No bridge or tunnel for people to cross the rail lines to the beach road
- Immediate areas around site not very vibrant with economic activities

4.4.3 Intervention.

- Introduce such facilities that will attract a lot of businesses and people to the terminal
- Reclaim encroached land from squatters
- Provide bridge over the rail lines

4.5 Site peripheral studies

A study of the building and conditions around the site reveal the following

1. 98% of the buildings are residential and 2% civic.
2. Civic buildings are made up of churches and a school
3. 40 % of buildings are multi- storey
4. Concrete and sandcrete blocks constitute the main building materials used.

About 750 meters on the south western side of the site is the gulf of guinea.

On the south western side of the site is the Tema – Accra beach road and the Gulf of Guinea, which is about 750 meters away.

4.6 Profile of Tema

Tema municipality is a district of Ghana in the Greater Accra Region. It consists of twenty –six communities with the most busiest and popular ones being communities 1, 2,4,7,9 and 13(Sakumono). It is a city on the Atlantic coast, east of the capital of Accra in Ghana.
It was once a fishing village but the decision to construct the new harbor in 1951 created the need for the creation of a town which would provide residential accommodation and urban amenities to the harbor and the labour for the industries associated with it. This brought the Tema Township into being. (Source; www. Ghana Web .com).

CHAPTER 5

5.1 BRIEF DEVELOPMENT

Through research and study of some train terminals in Ghana and abroad and modern trends in train terminal designs, a detailed brief was developed. The design brief is divided into:

5.1.1 Parking areas

This includes	AREA (Sq.m)
1. Long –term parking	1040
2. Short term parking	920
3. Bicycle parking	36
4. Taxi station	645
5. Service parking.	46
6. Trolley parking	59
7. Parking for disabled	108
8. Employee parking.	276
9. Lay bys	300

5.1.2Transition areas

1. Shopping areas.	500
2. Lettable office spaces	154
3. Restaurants	700
a. Kitchen	110
b . Caretaker's office	7.2
b. storage space	20
c. servery	23
d. eating areas	480
e. changing and washrooms	4.5
4. Waiting areas	3750

a. Ticketing areas 153
b. ATM and ticket vending areas 160
c. Retail shops 500
d. Kids game area 506
e. First aid 80
f. Internet cafe 300

5. Baggage section
   a. Temporal goods storage 165
   b. Baggage weighing areas 228
6. Post office
   a. Post office hall 54
   b. Parcels and sorting room 44
   c. Store 9.2
   d. Office 10

7. Washrooms 101
8. Driver restrooms 108
9. Fire control room 11
10. Waste management room 9
11. Platforms 225
12. Security room 50

5.1.3Platform areas.

a. Waiting areas 170
b. ATM and ticket machines area 45

5.1.4Administrative offices

This includes

1. Reception 15
2. General office 41
3. Conference room 20

4. Engineering and drawing office 40
5. area manager 35
6. employee restroom 36
7. personnel office 45
8. radio telephone and signal office 15
9. accounts office 30
10. CCTV room 15
11. assistant area manager 6.5
12. staff canteen 75

5.1.5 Overnight accommodation for travelers

1. reception 100
2. 21 accommodation facilities 525
3. Eating area 77

Circulation -----20% 2636

TOTAL **15817**

FLOW DIAGRAM

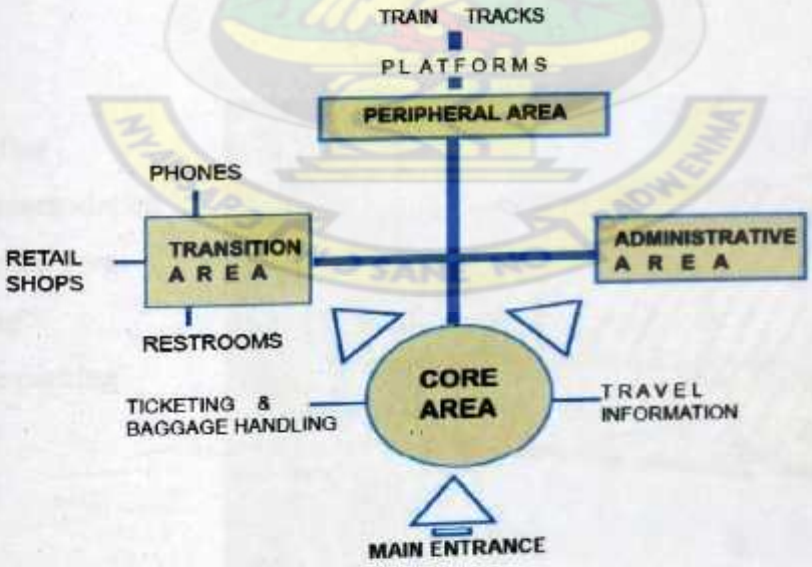


Fig 55 Flow diagram of functional elements within railway stations(source: www.train terminal circulation)

5.2 Conceptual site planning

The conceptual site planning is as a result of careful research, analysis and consideration of the relationships between the various facilities. The conditions and facilities in and around the site influenced the layout of the terminal facilities. The site was divided into quiet and noisy zones. The facilities, namely the main terminal building and the overnight accommodation facilities as well as the various the spaces contained in them had to be laid out to

1. Reduce solar ingress
2. Enhance natural ventilation
3. Make use of natural light

Several sketches were made to respond to the conditions in and around the site with regard to the conceptual site planning. Shape of the site, orientation of the site, access slope structures around the site greatly influenced the layout of the site. Fifty- one thousand of the one hundred and six thousand square meters total area of the site will be used for the design of the terminal and the accommodation facilities. The rest is allocated for future expansion. The various conceptual site layout options which were considered are shown and explained below.

5.2.1 Option 1

1---Terminal building
2--- Overnight accommodation
3---drop off and pickup area
4---customer parking
5---staff and service parking
6---greenery
7---platform area

Fig 56 option one---- Site layout (source: Author)

Merits:

1. Staff accommodation can be maintained and refurbished and used for the same purpose or as an overnight accommodation facility for travelers.

Demerits:

1. Accommodation facility is located very close to the source of noise.
2. Future expansion will affect accommodation facility.
3. Terminal building and the north eastern settlement are not properly linked.

5.2.2 Option 2

1. Terminal building
2. Shopping area
3. Staff & service parking
4. Passenger drop off and pickup.
5. customers car park
6. platform
7. soft landscape
8. lay by

Fig 57 option two --- Site layout(source: Author)

Merits:

1. People from the north east area of site can access the main terminal building directly.
2. Accommodation facility is located at a relatively quiet portion of the site.
3. Future expansion is easier.
4. Accommodation facility and the terminal building can be serviced by one service road.

Option 2 was adopted and refined. This choice is a result of the fact that the advantages of the second option outweighs that of the first option.

5.3 Description of design essentials

The station facilities were divided into three main parts

1. Intermodal access: this refers to site access and parking.

2 The station plaza – this refers to the space or area necessary to facilitate the movement the movement of people from the parking or other means of access to the platform. In this place a person can buy tickets, view public information systems and wait until they are picked up.

3 The platform. A railway platform is a section of pathway, alongside rail tracks at a train station at which passengers may board or alight from trains or trams.

5.3.1 Intermodal access:

All vehicular accesses were taken from the Accra – Tema beach road which lies on the south west of the site. Services had one access, bus and mini vans had one and short, long term, pick up and drop off sharing one access. There is also bicycle and motor cycle access on the same road. Pedestrian access was taken from the south west and north east of the site (this caters for residents in and around Sakumono area).
Vehicular and pedestrian accesses were segregated to avert conflicts and ensure effective circulation to and from the site. Special parking for the disable was provided close to the terminal building.

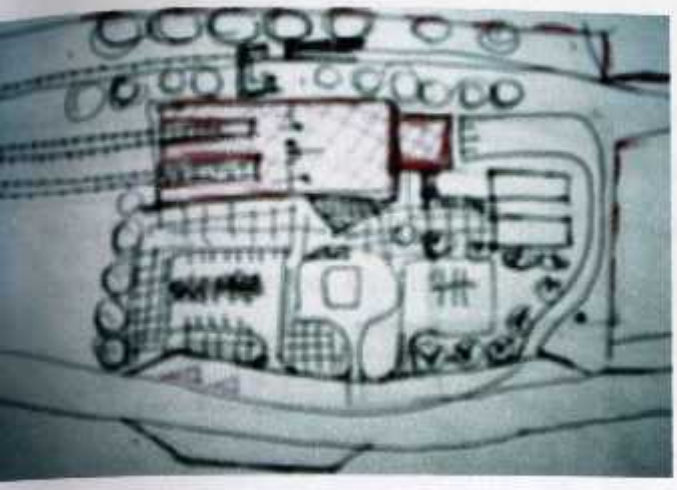


Fig 58 Site layout(source: Author)

Fig 59 3D impression. View from the north-east (source: Author)

The site layout shows all three main accesses taken from the Accra-Tema Beach road. Two bus lay bys have been provided so as to limit the number of big buses that enter the site. Pick up and drop off area has been located near the entrance. Paid short term and long term parking are located on the south western part of the site. The service access lies on the far right to service the main terminal and the overnight accommodation.

Parking meters have also been provided to generate revenue from the long term and short term parking areas. CCTV cameras have also been provided to monitor activities that take place in the intermodal access areas.

5.3.2 The transition plaza

The design form of the terminal building was dictated by the concept of bringing the train into the terminal so that passengers can experience the pleasure of viewing trains as they arrive and depart. This is reflected in the long south west and north east elevations.

The structural system adopted was space frame with tree-like vertical supports. This helps to achieve long span for free movement of people and good views. The building's functional requirements and facilities necessitated the use of wide spans, swift movement of people and baggage, good views and security. This informed the choice of space frame structure supported by tree-like columns at the waiting area and the platform. Waffle slabs with r.c column supports have been used to span wide floor areas. For the administrative offices, galvanized steel truss have been used for the roof structure.

5.3.3Circulation

The general concourse serves as a meeting point for those who arrive at the terminal. It is wide enough to accommodate heavy passenger volumes moving to and from the terminal. The foyer features a galvanized steel truss canopy that covers portions of the drop off and pickup areas and the general concourse. This is to protect passengers from the vagaries of the weather. At the entrance foyer one can have a feel of the interior space as the frontage of the terminal building is glazed. There are three access and exits to and from the transition plaza. One is for goods and baggage, one serving as the main entrance and the other for emergency exit. Upon entering the facility one can easily locate the information and ticket booths. A conscious effort was made to keep the plan very open as possible to make way finding easier. It also enhances natural ventilation and lighting.

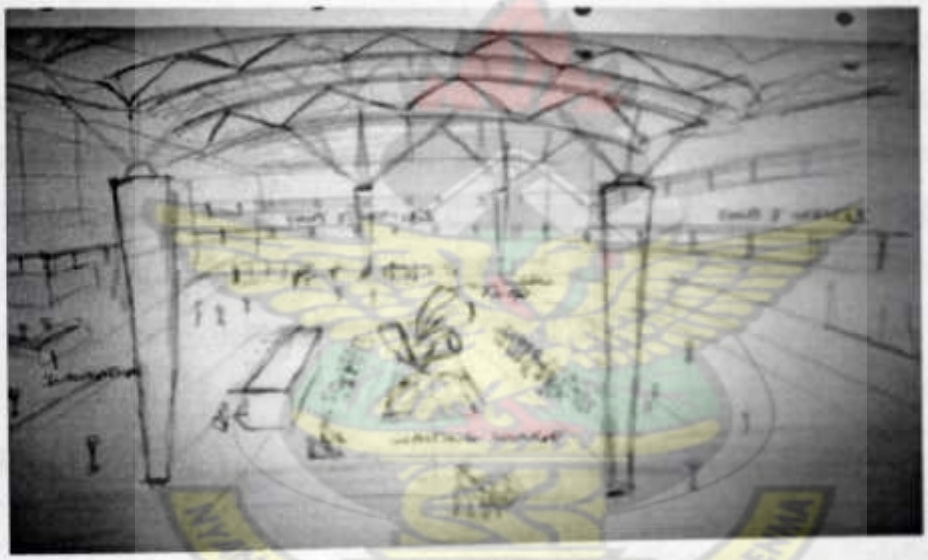


Fig 60 Interior view- The scale of the structure necessitated the need to use wide span structures to make circulation effective. The various retail spaces and offices have been located at the periphery of the site to allow free movement of air and people. Exposing the space frame members in the interior also gives the interior space an interesting ambience.
(source:author)

Considering the width and length of the building, natural ventilation and lighting became issues to tackle. To improve the two there was the need to create an opening in the roof which is open to the sky in order to admit natural light and ventilation within the space. It also creates a very pleasant ambience around the waiting lounge. Beneath the opening is a planter with sweet scented plants to enhance the ambience and collect the rain droplets during raining periods. Around the waiting area and the ticket booths are the postal services, bar, first aid, convenience shop, Atm area, ticket vending machines and phone booths. In keeping with the concept of creating the environment whereby people can enjoy viewing trains as they arrive and depart. In order to make circulation effective there is no change in the slab level within the waiting area and the platform area. Special phone booths, ticket vending machines and ATM have been provided to cater for the disable. To make it easier for people to be able to have a good view unto the platform, waiting areas have been created on the first and second floors with ice-cream stands and other retail shops surrounding them. The waiting areas are also interspersed with planters with sweet scented plants. Escalators with stairs in the middle have been used in order to attract people to the first and second floors where most of the shops and retail stands are located. Two different kinds of restaurants are available. The one on the first floor serves local dishes whiles the one on the second floor serves continental dishes. Two ramps lead people down unto platforms after going through the turnstiles on the first floor.

5.3.4 Information systems.

Public address systems, video surveillance systems and lighting fixtures are fixed in ceiling panels which have been dropped from the space frame. The ceiling panels are finished with fire resistant coating and serves as a buffer between the roofing material and the habitable space beneath it. There are also instant and constant types of information systems located around the waiting areas. They have been located in such a way that they do not impede the movement of travelers and goods.

5.3.5 The platform

Platforms serve as a means by which passengers embark or disembark from the train and this poses a great challenge. First and foremost, the platform design should:

1. Be wide enough to allow a lot of people to embark and disembark from the train at the same time.
2. Have resilient materials as it floor finish
3. Have safety precaution signs provided at places where necessary to minimize accidents within the platform area.
4. Be well ventilated.

The platform type chosen was two side platforms with one island platforms to cater for four different rail tracks. Waiting areas with snack and ice-cream stands have been provided on the platform. This helps to ease traffic congestion on the turnstiles when ones train arrives or depart. To make the platform very effective:

1. The platforms have been designed to have few columns so that travelers can move freely within the platform area. This called for the use of space frame structure as it can span a very wide area.
2. Conspicuous warning strips have also been provided at the edge of each platform to prevent accidents when getting onto the platform.
3. Furniture on the platform are located along the periphery of the area.
4. Emergency exit has been provided on the south western side to cater for emergency situations.
5. The platform height (700mm) ensures that it flashes with the floor of the interior of the spaces .

5.4 Services

5.4.1 Lighting and ventilation

Due to the linear nature of the site coupled with the alignment of the existing tracks the building could not be oriented in such a way that the longest sides face the true north and south. This made it necessary to provide shading devices to minimize solar ingress into the building. The shading devices are made of aluminium jalousies which are arranged in an alternating pattern. A conscious effort was made to create extensive glazing on the south west elevation to open the building up to the prevailing wind direction.

Fig 61 Alternating aluminium jalousie has been used to shade the glazing. It also creates an interesting feature on the south west elevation. (source:author)

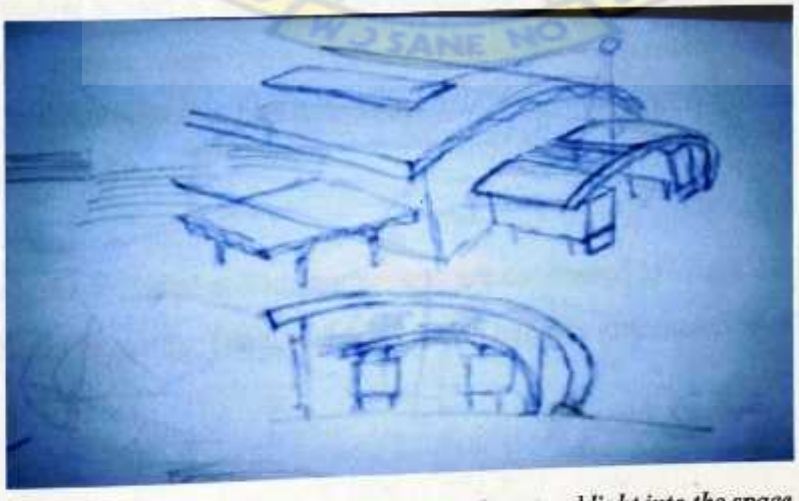


Fig 62 . Perspex at portions of the roof helps to bring in natural light into the space. (source:author)

The building employs both natural and artificial ventilation. Natural ventilation is mainly used in the public areas but augmented with artificial if the need arises. Artificial lighting and ventilation are mainly employed in the administrative shops and lettable office spaces.
Emergency lighting systems have been installed along escape routes.

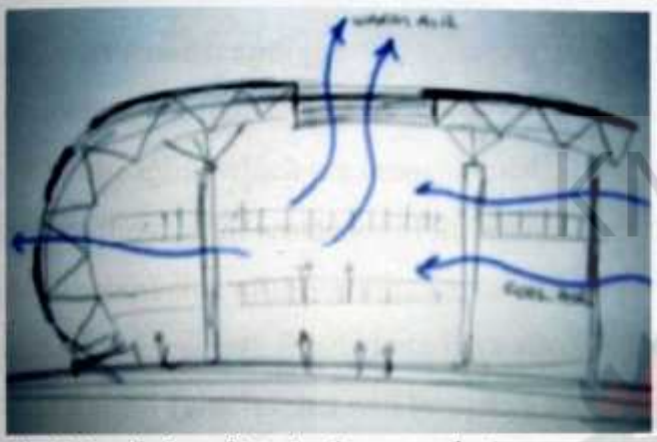


Fig63 Ventilation of interior (source:author)

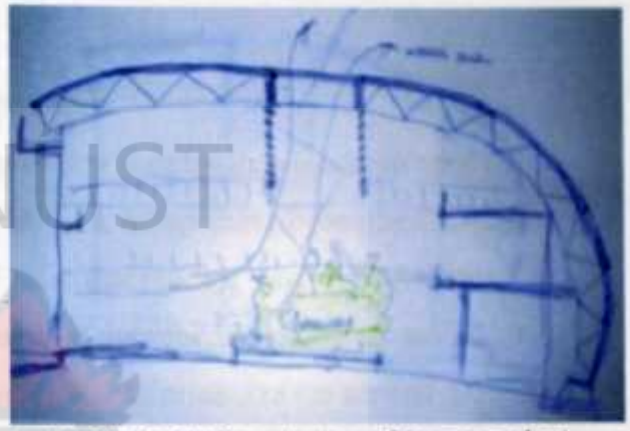


Fig 64 Detail of opening in roof (source:author)

An opening was made in the roof to enhance the ventilation within the space. Fresh air comes into the space from the south western wall, absorbs heat from the habitable space and then rises through the opening created at the top. Aluminium jalousie dropped from the spaceframe goes round the perimeter of the opening to prevent rain from getting to the waiting area.

5.4.2 Security control

Efforts have been made to ensure the safety of passengers, their goods and baggage as well as the terminal building, its fixtures and fittings. CCTV room monitors all sections of the facility including the intermodal access areas. Also the design was made in such a way that small niches where criminals can hide are nonexistent. The open nature of the plan also makes it difficult for criminal activities in the terminal to be carried out.

5.4.3 Fire control

Fire hydrants have been provided at 50m centres and are connected to75mm diameter ring pipe which is sourced from the mains. The control room also handles emergencies of this nature.

5.4.4 Surface drainage

Surface drainage is channeled through covered drains, falls by gravity and joins the main drains along the Tema- Accra beach road (yet to be constructed).soil waste is collected in septic tank located on the south eastern portion of the site. It is emptied as and when the need arises.

5.5 Landscaping

5.5.1 Soft Landscaping

Landscaping in train terminals design serve several purposes.

Soft landscaping which are drought resistant and require low maintenance has been used to enhance the overall aesthetics of the design. Trees with thick foliage have been planted at the north-eastern side of the terminal to reduce the level noise that reaches the residential area nearby (Sakumono). Shady trees have also been planted at the vehicle parking areas to provide shade for the vehicles that will be parked there. They are also to minimize the area of ground surface exposed to the sun as well as the amount of carbon dioxide that will be generated on the site.

5.5.2 Hard Landscaping

The hard landscaping elements used in the design (pavement and asphalted driveways) have been designed in such a way to well define pedestrian paths, walking patterns and vehicular circulation patterns. Interlocking pavers with colours and textures which complement the colour scheme of the terminal have been used. Garden lamps and bus shelters have also been provided at vantage points.

5.6 Costing

Typical station cost elements for two-platform stations for large intercity Stations

Station element	Capital cost (£m)	Maintenance cost (£m p.a.)
Platform	2	0.05
Canopies	0.3	0.02
Shelters	0.2	0.05
Waiting rooms	1	0.05
Ticket Halls	2	0.05
Staff Offices	1	0.03
Access	2	0.05
TOTAL	8.5	3.0

(source: Accra Train Station Design Report, K. Asomaning, June 2003)

Grand total £8500000

Considering the fact that I am designing a four-platform train terminal, the cost will be twice the the grand total figure above. The cost therefore becomes **£ 17,000,000.** When converted to Ghanaian currency taking into consideration the current exchange rate of GH¢2.35 to one British Pound, it becomes **GH¢ 40,000,000** approximately.

5.7 CONCLUSION AND RECOMMENDATIONS

5.7.1 Conclusion

Ever increasing car ownership ratios in major cities in Ghana, continuous negligence of governments, among others have led to a near collapse of the rail transportation sector.
To revamp this system of transportation, there should be conscious effort by the Ministry of Transportation, The Ghana Railway Company and other stakeholders.

The train terminal when constructed is expected to spark up further development along the beach road. It is also expected that the construction of this facility coupled with the importation of modern rolling stock will to a large extent bring back to life the rail transportation system countrywide.

5.7.2 Recommendation

The following recommendations are in respect of the project.

1. Structures on the site within 50 feet radius from the centre of the rail track should be demolished in accordance with safety regulations.
2. Road lying on the north-east side of the site should be well constructed so that people can have easy access to the facility without using the Accra-Tema beach road.
3. Train halts should be constructed along the Tema-Accra corridor to enable people board trains without necessarily coming to the terminal.

5.8 Phasing

The project should be carried out in phases as indicated below.

Phase 1.....construction of main terminal building

Phase 2.....construction of the warehouse

Phase 3.....construction of the maintenance unit

Phase 4.....construction of overnight accommodation

Phase5.....construction of staff accommodation

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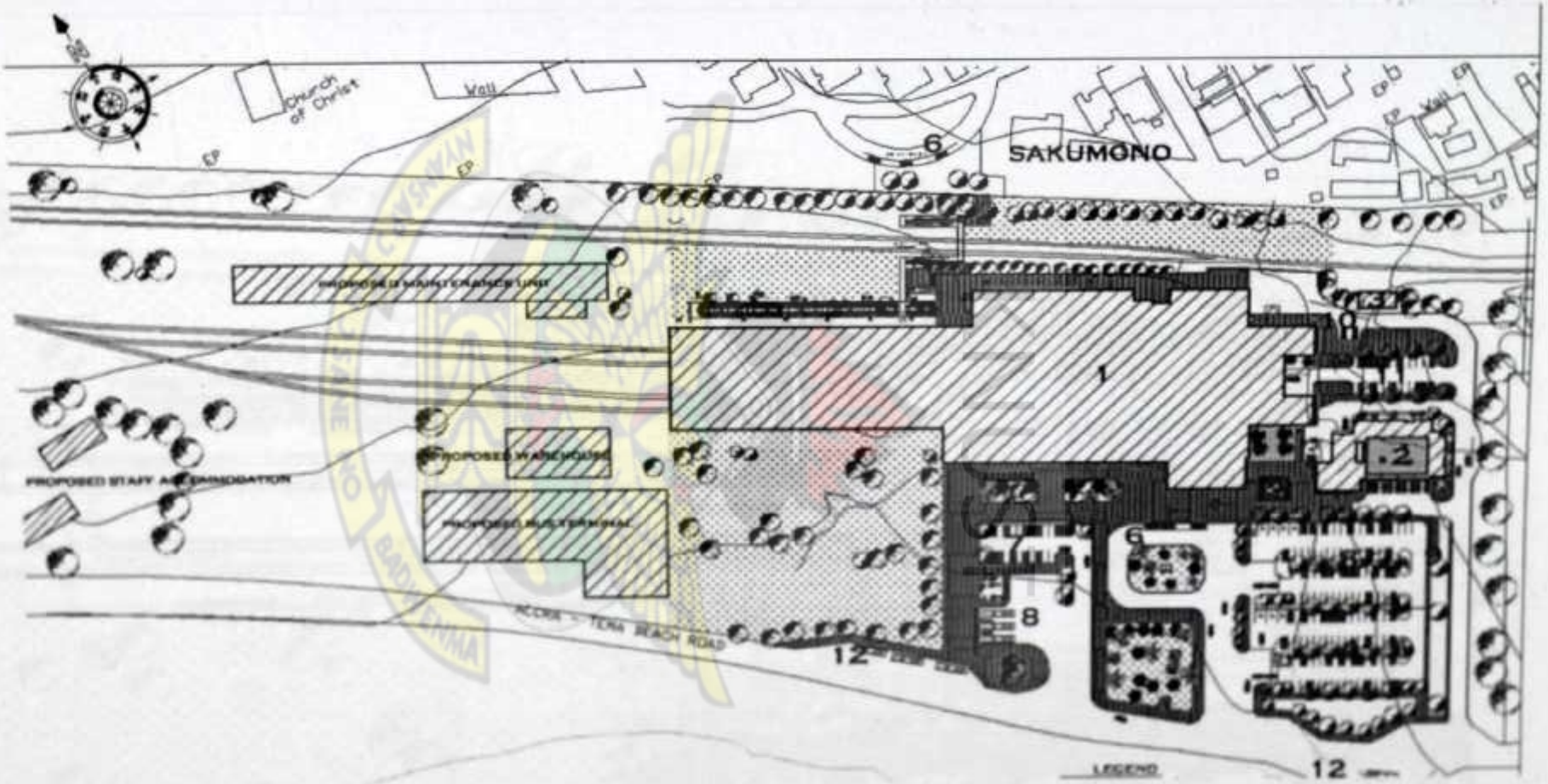
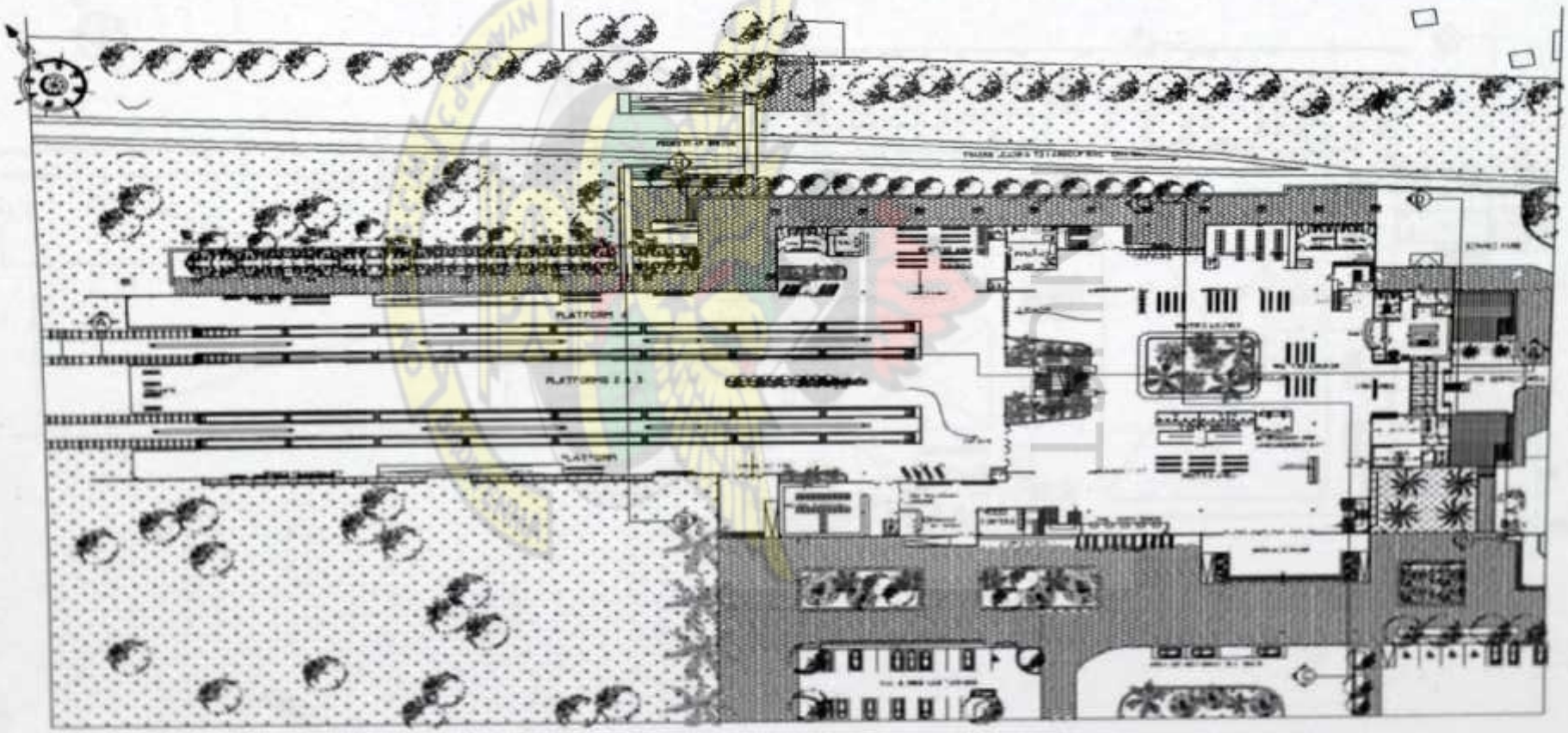
APPENDICES

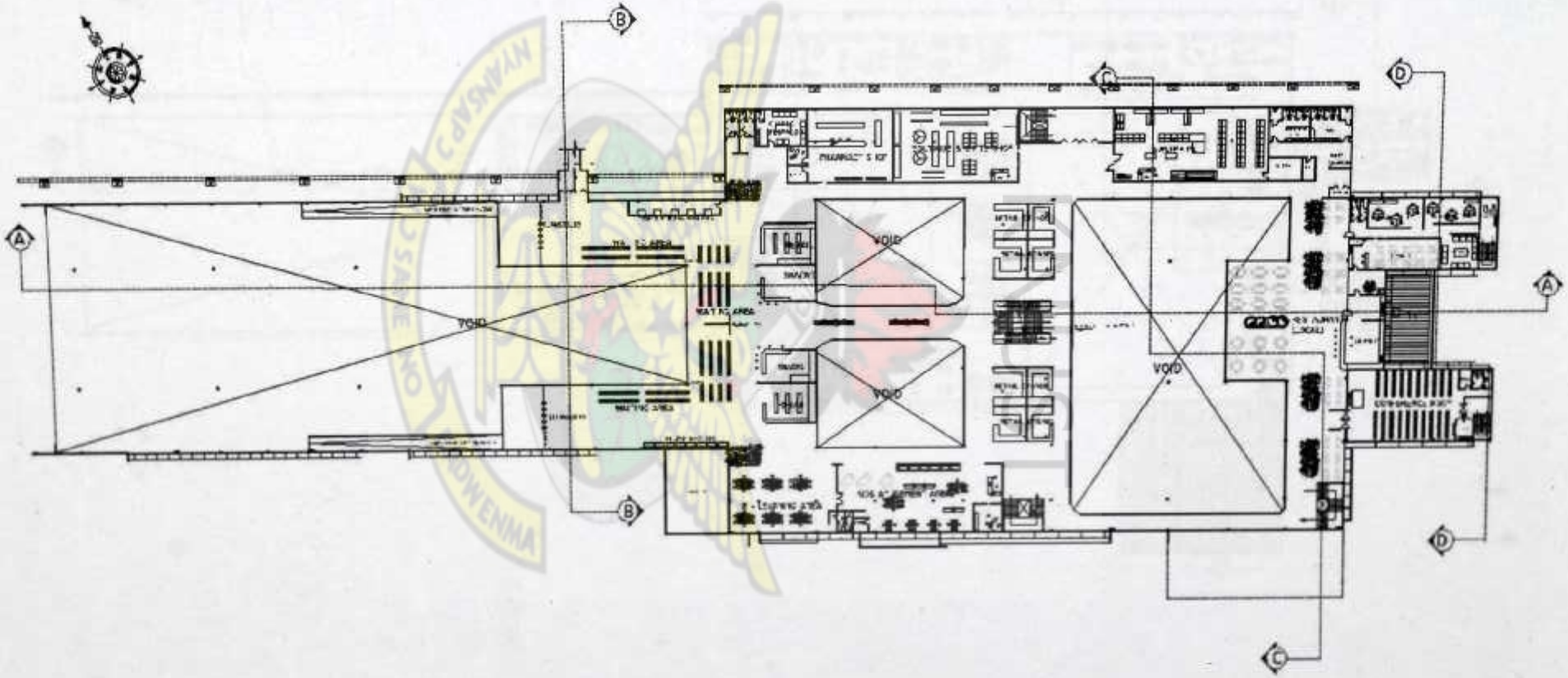
APPENDIX 1. SITE LAYOUT



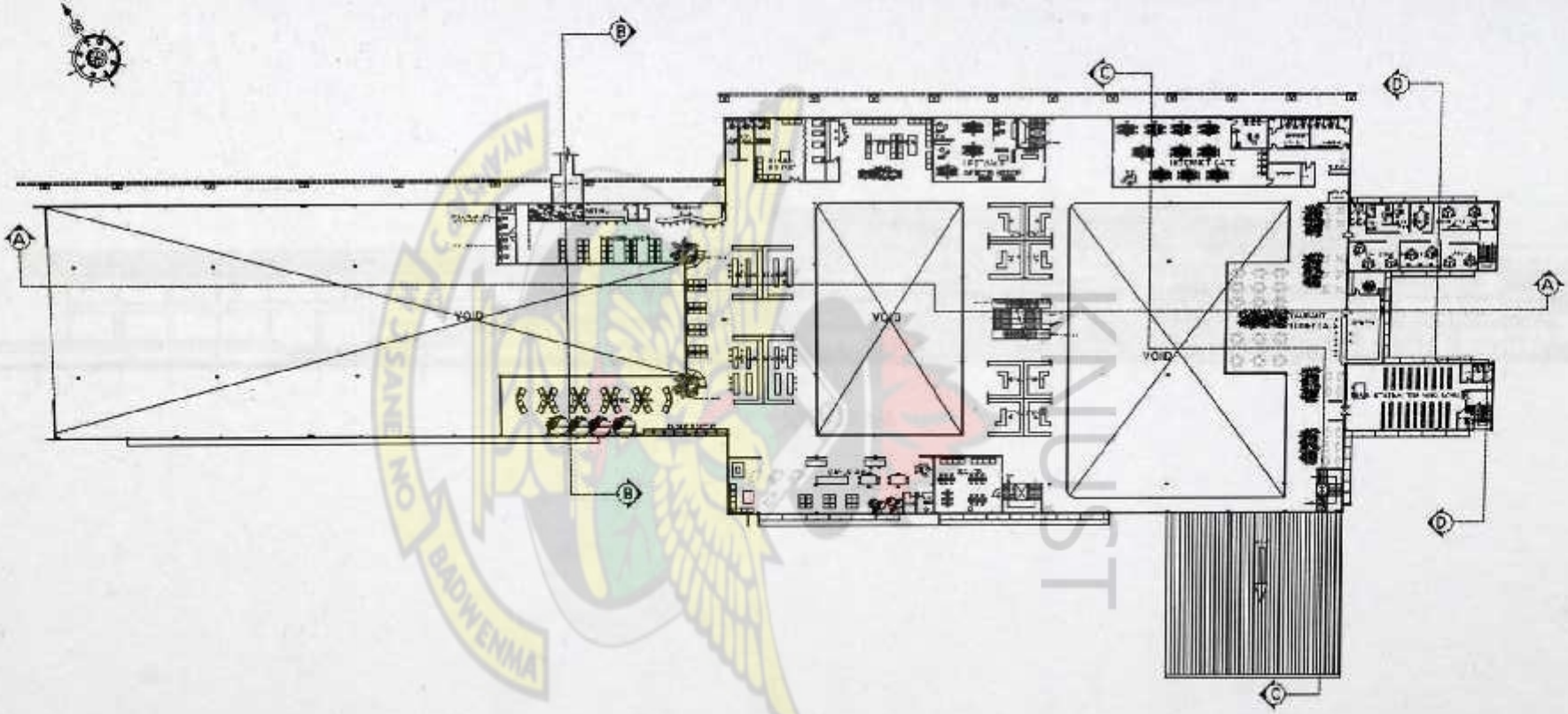
APPENDIX 2. GROUND FLOOR PLAN



APPENDIX 3. FIRST FLOOR PLAN



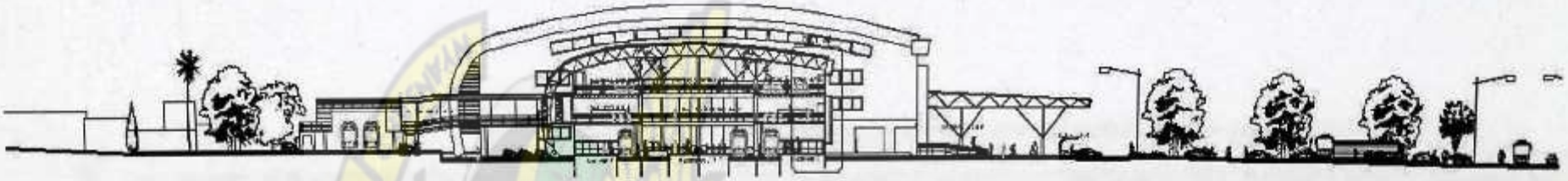
APPENDIX 4. SECOND FLOOR PLAN



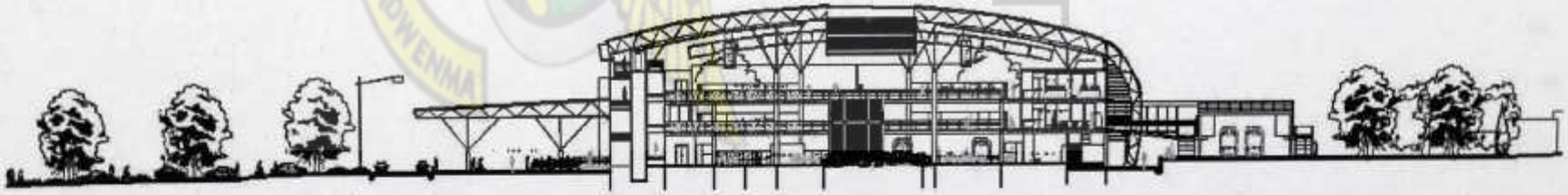
APPENDIX 5. SECTION A-A

SECTION A-A

APPENDIX 6. SECTIONS B-B AND C-C



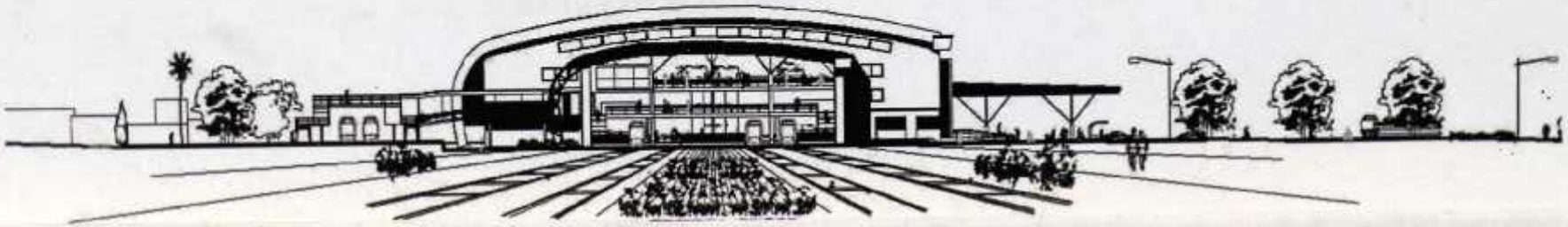
SECTION B-B



SECTION C-C

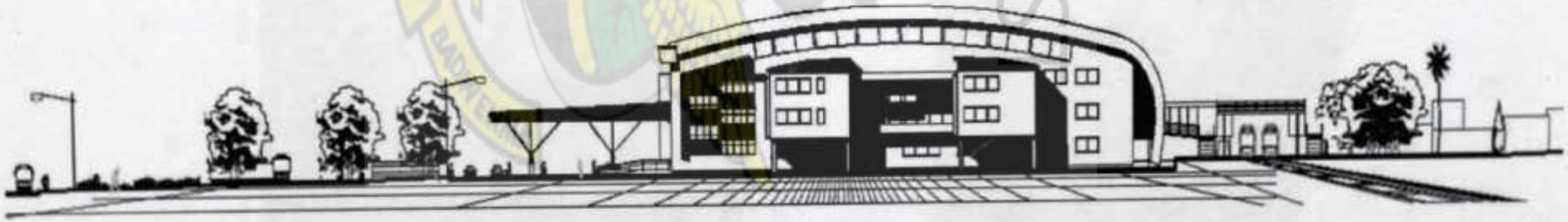
APPENDIX 7. SOUTH WEST AND NORTH WEST ELEVATIONS

SOUTH WEST ELEVATION



APPENDIX 8. NORTH EAST AND SOUTH EAST ELEVATIONS

NORTH EAST ELEVATION

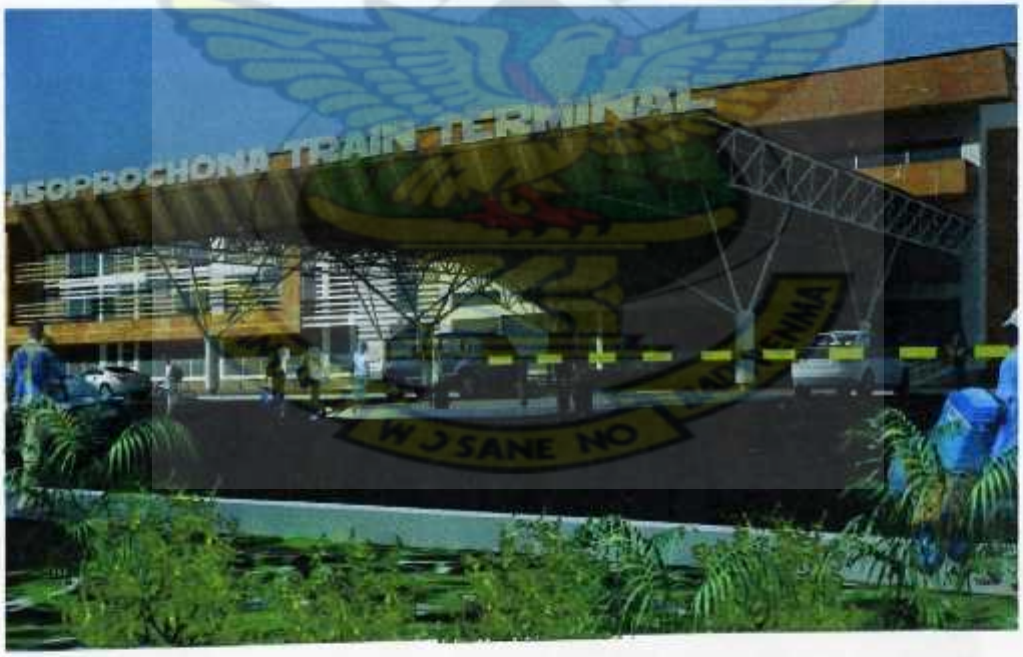


SOUTH EAST ELEVATION

View from North West

View from North East

View main terminal and overnight accommodation



View of main entrance

View of concourse showing waiting and ticketing area

View of platform area

View of retail area on second floor

View of interior of accommodation for overnight travellers

TRAIN TERMINAL, ASOPROCHONA (TEMA)

BY

Ansah James Arhin

A Thesis report submitted to the Department of Architecture,

Kwame Nkrumah University of Science and Technology in partial fulfillment of the requirements for the degree of

POST-GRADUATE DIPLOMA IN ARCHITECTURE

Faculty of Architecture and Building Technology

College of Architecture and Planning

May 2009

DECLARATION

I hereby declare that this submission is my own work towards the PG-DIP and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

Ansah James Arhin	.....	18/09/09
Student Name and ID	Signature	Date

Certified by:

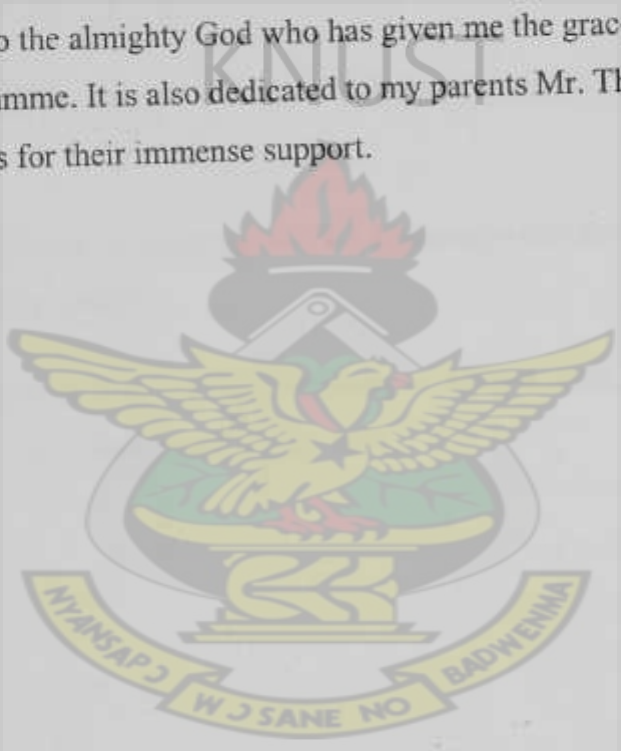
Mr. G. F. A. Olympio	.....	18-09-09
Supervisor(s) Name	Signature	Date

Certified by:

Prof. G. W. K. Intsiful	.....	.....
Head of Dept. Name	Signature	Date

DEDICATION

This design thesis is dedicated to the almighty God who has given me the grace and strength to go through this architectural programme. It is also dedicated to my parents Mr. Thomas kweku Ansah and Mrs Jane Ansah and my siblings for their immense support.



ACKNOWLEDGEMENT

This design report was prepared with the assistance of some kind-hearted individuals and organizations and I would like to express my profound appreciation to them.

First and foremost my appreciation goes to Professor G.W.K Intsiful and Mr. S.O Afram for their support and guidance.

Secondly, I'm very grateful to Mr.G.F.A. Olympio for his dedication and guidance with respect to this design as well as the writing of this report.

I would also like to extend my gratitude to the station master of Asoprochona Train Station, Mr. Wood, the area engineer of the Accra Train Station and all the staff.

ABSTRACT

Over dependence on road transportation for both inter and intra cities coupled with over-population in major cities in Ghana such as Tema has resulted in heavy vehicular traffic on roads, increased road accidents, lose of precious time in traffic and increase in fuel consumption.

Government as part of its long term plan to curtail this problem is carrying out an expansion and modernization of the existing rail network from southern Ghana to the north. This will help link Ghana to neighboring countries such as Burkina Faso, Mali etc. This has made it necessary to construct modern train stations and terminals where freight and passengers can be handled in the transportation process.

This vision and desire by government and Ghana Railway Company has led me to choose and design a modern train terminal in Tema-Asoprochona. This facility is expected to serve as a place where passengers and freight originate, terminates or are handled in the transportation process. It is also expected to serve as a catalyst for development along the beach area south west of Sakumono, where the facility will be constructed.

TABLE OF CONTENT

CHAPTER ONE

1.1 Introduction

Railway transportation is one of the most important catalysts for development. It is a prerequisite for economic growth and poverty reduction. Research shows that an effective railway transportation system can reduce costs and comparative distances between trading partners, increasing trade effectiveness and maximizing existing industrial investments and production outputs. People rely on train transport to get to workplaces, school, market, health clinics e.t.c. Mines and manufacturers also rely on rail transport to get their products to markets and ports.

The Ghana Railway Company Limited is the operator of railways in Ghana. Ghana's railway network is 950 km of mostly single track rail of 1.067m gauge located in the southern part of country. In 1965, it carried 2.3 million tons of freight and 8 million passengers at the time that it was financially sound. However due to certain factors such as ineffective management, the changing world economy, sharp drops in commodity prices,encroachment,competition from the road sector among others in 1985, the rails position as a prominent transport mode went down. The lower revenue it was recording resulted in;

1. default on loan payments
2. Poor maintenance
3. Drop in service quality
4. Loss of customers

There are however efforts to revive the railway operations in the country. (source: www.ghanarailway gazette .com).

1.2 Problem statement and justification

Populations in urban areas are increasing at astronomical rates. Accra and Tema being two major cities in Ghana are no exception. By 2025, the population of Ghana is expected to be 38 million with more than 60% of the people being urban residents. (source: UNHabitat, 2002).

A large number of people commute between Accra and Tema everyday to do business, work, school, shop etc which has resulted in;

1. Heavy vehicular traffic on roads in both cities
2. Lateness to workplace leading to decrease in productivity

3. Increase in fuel consumption
4. Environmental pollution
5. High cost of constructing new roads.

To solve this problem, a relatively cheap, safe, comfortable, environmental friendly and fast alternative means of transportation has to be put in place to complement road transportation. Rail transport, if well developed will go a long way to alleviate these problems.

The state of passenger railway transportation and its supporting facilities in Accra and Tema municipalities are unable to accommodate the anticipated volumes of passenger traffic. A modern and effective railway terminal coupled with modern rolling stock will go a long way to ease the traffic problem in the region and revamp the passenger train transport system in and outside the region.

1.3 Objectives

The project seeks to provide

1. a train terminal that serve as an effective transit point for the anticipated volumes of passenger traffic in and outside Tema
2. a facility that will serve as a catalyst for further development on the Asoprochona –Tema beach road.
3. more opportunities to increase the local job base through retail outlets, offices, and service oriented business spaces
4. a better identity of the community to outsiders through iconic architecture.

1.4 Scope

This thesis intends to;

1. Study the history and operations of the Ghana Railway Company
2. Establish the basis for providing a train terminal in Asoprochona –Tema
   Propose the design of a new train terminal in Asoprochona which includes
   1. The main terminal building
   2. Ancillary facilities

1.5 Target group

This facility will cater for adults, children the physically challenged, the able etc

1.6 Client

1. The ministry of transportation
2. Ghana railway company limited

1.8 Financiers

The government has awarded a US 1.4 billion dollars concession for the Eastern railway to M/S Peatrack a, foreign company.

The agreement covers the design, building, operating, and transfer for the construction, expansion and operation of a modern rail network between Accra – Tema and Paga for a period of 35 years. Phase one of the project involves the rehabilitation of the existing Tema – Accra – Nsawam suburban railway

It has also secured a US 5 million dollar loan from OPEC to rehabilitate the 30km Accra – Tema rail line to revamp commuter rail transportation service within the Accra – Tema metropolis.

(source: Ministry of Harbours And Railways, November 2005).

CHAPTER TWO

2.0 Literature Review

2.1 Background of Railways

For historical reasons, the current rail network only serves the main traffic corridors in the seaboard third of the country, although this is the main area of economic activity.

The first lines were built to support and develop mining interests following the discovery of gold-bearing rocks in the Ashanti region, 200 km inland from the coast. The need to move construction equipment inwards and minerals out led to the construction of an initial 66 km route from Sekondi to Tarkwa in 1898 to 1901. Construction north of Tarkwa proved easier and the following 200 km to the country's second city of Kumasi was completed by 1903. After gold was discovered at Prestea, a 29 km branch from Tarkwa was opened in 1908. (source: Railway Gazette International- David Brice, June 2008).

Work began in 1909 on a 304 km line to link the capital Accra with Kumasi, but this was not completed until 1923. Rather than minerals, this line was predicated on the development of cocoa, rubber and timber traffic. Its opening also completed a very circuitous through route between Accra and Sekondi. With the very basic port facilities at Sekondi proving inadequate to handle growing mineral exports, a new deep-water port was opened in 1928 at Takoradi, 6·5 km to the southwest. All railway operations were transferred to the new terminus apart from the extensive workshops which remain near Sekondi. (source: Railway Gazette International- David Brice, June 2008).

Subsequent additions included the 157 km Central Provinces line opened in 1923 from Huni Valley to serve further mineral deposits at Kade, and the important 73 km branch from Dunkwa to serve bauxite mines at Awaso, prompted by heavy demand for aluminium to build aircraft during World War II. In 1953 an 82 km link was opened between the Kade branch and the Accra - Kumasi line at Kotoku, shortening the Accra-Takoradi journey by 268 km. The following year saw the completion of a 23 km branch from Achimota Junction, north of Accra, to the port at

Tema, which is now becoming increasingly important. (source: Railway Gazette International- David Brice, June 2008).

For administrative purposes the railway is divided into three sectors :

- Western Line: Takoradi - Kumasi and branches to Awaso and Prestea;
- Central Line: Huni Valley - Kotoku and the Kade branch;
- Eastern Line: Accra - Kumasi and the branch to Tema.

The railway is built to 1 067 mm gauge, with a maximum axleload of 16 tonnes. The first line between Takoradi and Dunkwa was built very cheaply and is plagued by severe curvature north of Tarkwa, although some consideration has been given to re-alignment to ease operations. All lines are single-track except for a 30 km double-track section between Takoradi and Manso. Semaphore signalling was originally installed, but is now only operational on the double-track section. Solar-powered colour-light signaling, funded by the World Bank, replaced the mechanical equipment on the Western Line, but the cost of spares soon became prohibitive and the system has now been abandoned. Likewise, the single line token apparatus has fallen into disuse, and train operation and crossing arrangements on the rest of the network are controlled using paper tickets. (source: Railway Gazette International- David Brice, June 2008).

The safety of train operations is a major concern for GRC, because of the lack of secure signalling, but also the very poor condition of the track and the mineral wagons which convey the bulk of present freight traffic. These vehicles are in continual service, and require a much higher standard of maintenance than they currently receive. Derailments are frequent, caused by bad track or poorly-maintained vacuum brakes and running gear.

2.1.1 The Management and Organization

The Railway organization started in 1901 as a department of Gold Coast Civil Service. Its headquarters was located at Sekondi where construction of Ghana's rail system began in 1898.

The headquarters was later moved to Takoradi in 1934, when a new Administration Block was completed along with the Tadoradi harbour in 1927. With the building of the harbour, the railway and the harbour came under the joint administration of Railway and Harbours Administration. (source: Railway Gazette International- David Brice, June 2008).

A succession of expatriate civil servants headed the railway as "General Manager and Harbours Authority" until 1960 when the first Ghanaian head of the then Locomotive, (now Mechanical/Electrical Engineering) Department was appointed to the post.

The Railway and Harbours Administration became a statutory corporation on 1st July 1972, with the passing of the Railway and Ports Act 1971 (Act 358). The Corporation was governed by a ten-member Board of Directors, which included the General Manager. (source: Railway Gazette International- David Brice, June 2008).

On 1st July, 1977, the Supreme Military Council (SMC) passed the Ghana Railway Corporation Decree (SMCD 95) and the Ghana Ports Authority Decree (SMCD 96) which separated the railway from the Ports and established them as two distinct bodies-corporate under separate administrations.

In August 1982, the Board of Directors, gave way to an interim Management Committee (IMC) of seven under the Chairmanship of the General Manager. Again, in December 1984, a Joint Consultative committee (CC) was set up to replace the IMC, as an advisory body. The post of General Manager was changed to Managing director in May 1985. (source: Railway Gazette International- David Brice, June 2008).

In February 1995, the Board of Directors was re-constituted and now the Railway company has a ten-member board.

On 7th March 2001, Railway company was issued with a Certificate of Incorporation by the Registrar of Companies, and is now known as Ghana Railway Company Limited. This is to allow for private sector participation and investments into railway operations.

Executive control of the organisation is vested in the Managing Director who is assisted by two Deputy Managing Directors, one for administration and Operations (DMD-A/O) and the other for Engineering (DMD-E). The day to day management of its business falls under the jurisdiction of Heads of Department, who variously report to the Managing Director and his deputies. The railway network is divided into three areas, i.e. Tarkwa, Kumasi and Accra, headed by Area Managers. The Area Managers are responsible for the administrative control and co-ordination of work in the areas. (source: Railway Gazette International- David Brice, June 2008).

2.1.2 Vision

To be a modern and efficient nationwide rail transport provider with links to the neighbouring countries.

2.1.3 Company Charter

1. honesty
2. customer oriented
3. maintenance of good corporate image
4. total quality management practices
5. high sense of commitment and dedication to duty
6. communicative environment
7. research and development for continuous improvement
8. incentive and motivation policy
9. a first choice place of work for its employees

(source: Railway Gazette International- David Brice, June 2008).

2.1.4 Assets-current state of the system

The assets developed and acquired to achieve the current capacity are briefly described as under:-

a. Track

The Ghana Railway Corporation operates a network with a route length of 647 kilometres of metric gauge. For operational purposes, the network is divided into Western, Eastern and Central Lines. The Western Line with a route length of 340 kilometres links

Tadoradi Port to Kumasi and Awaso and is by far the busiest. Tae 350 kilometres stretch from Accra- Tema to Kumasi makes the Eastern line, while the Central line covering a distance of 199 kilometres links together the Western and Eastern lines to create a pattern like the letter "A". Altogether, the total track length is about 1,300 kilometres.

(source: Railway Gazette International- David Brice, June 2008).

Western line, the principal export corridor, is equipped with 80 lbs and 90 lbs rails on the main line and 75 lbs and 60 on the Awaso and Prestea Branch lines respectively. Eastern and Central lines are equipped with a mixture of 60 lbs and 80 lbs rails. Except few areas where steel trough sleeper are used, the track is constructed with treated wooden sleepers on crushed stone ballast all obtained locally.

b. Locomotives

The locomotives being used on the railway system is diesel-electric. In the early years of its establishment, steam locomotives were used. However, since the early 1980's, the steam locomotives have all been phased out and GRC now operates mostly Diesel-Electric locomotives. Presently, there are about 60 locomotives in service on the System.

(source: Railway Gazette International- David Brice, June 2008).

c. Coaches/wagons

Altogether, there are some 652 wagons/coaches in service. The coaches which were delivered in 1986 are being rehabilitated.

(source: Railway Gazette International- David Brice, June 2008).

d. Staffing

Back in 1978, GRC had a staff complement of over 11,000. A staff reduction plan drawn together with the World Bank saw the level falling to the present figure of around 4,000. There are plans to rationalize staffing levels further, with a view to reducing operating costs, and thereby improve the competitiveness of the Railway. (source: Railway Gazette International- David Brice, June 2008).

e. Training

The Ghana Railway Company gives priority attention to staff training and development. The Company has a Central Training Institute where its staff is trained. Overseas training courses are occasionally organized for Senor and Middle level Management and Technical staff. Local Training outside Railway is also organized for the staff.

2.1.5 Performance.

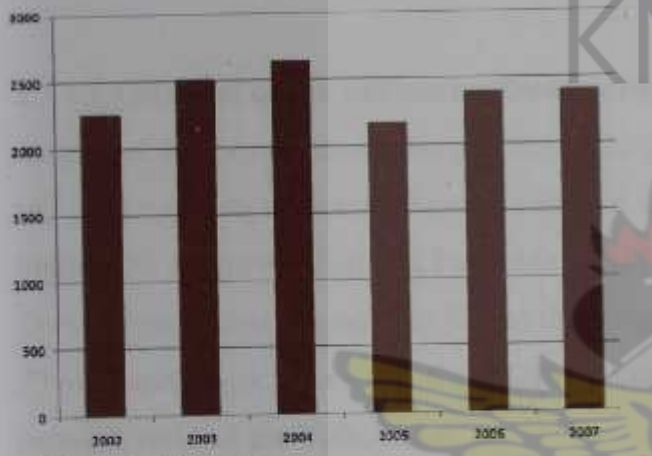


Fig .1 Freight traffic

Fig. 2 passenger traffic

(source: Railway Gazette International- David Brice, June 2008).

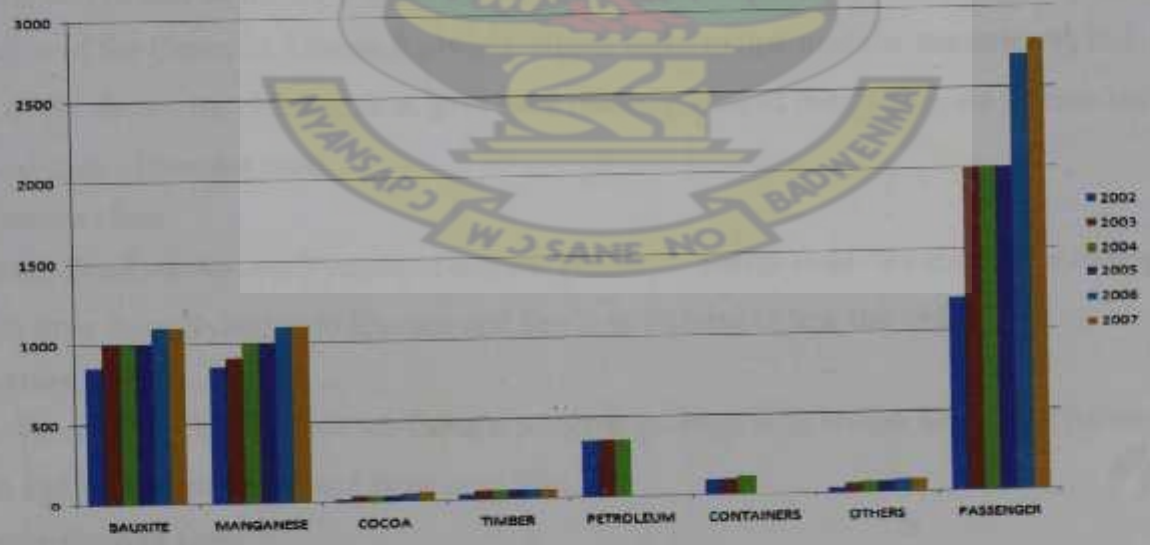


Fig 3 Freight and passenger traffic. (source: Railway Gazette International- David Brice, June 2008).

The graphs above show that

1. Bauxite and manganese which form the main commodities transported by rail has an annual average growth rate of 4.9%.
2. There is an annual average growth rate of 8.3% of passengers who commute by train.
3. Freight forms 55% of total rail transport while passenger forms 47%.
4. There is a faster growth rate in the volume of passenger traffic than the individual commodities transported on the railway.
   People have over the years come to appreciate the numerous advantages associated with travelling by train.
5. Passenger transportation has very high prospects in Ghana if given the necessary attention.

2.1.6 Expansion of the national railway network

As part of the Government's long-term (10-20 years) development plan expansion of the existing rail network from southern Ghana to northern Ghana is proposed. This will pave the way for linking the country to Burkina Faso, Mali and Niger in the North. Expansion of the existing Central line is also proposed to link to the country's Eastern and Western neighbours of Cote d'Ivoire and Togo, as is a link from Tem to Akosombo so as to facilitate multimodal transport between rail and the Volta Lake.

The expansion is in line with the objectives of the Economic Community of West African States (ECOWAS) to link all member states by rail. It will also facilitate the achievement of the broad objective of the Union of African Railways, which seeks to link member countries by rail. In view of the above, the existing lines have been re-designated as follows: (source : African business Journal-August – November 2004).

a. Western Line:

Takoradi-Dunkwa-Awaso-Nyinahin-Sunyani-Techiman-Sawla-Bole-Wa-Hamile including branch lines from Nyinahin to Kumasi and Sawla to Fufulsu to link the Volta Lake.

b. Eastern Line:

Accra-Kumasi-Techiman-Fufulsu-Tamale-Bolgatanga-Paga with branch lines from Achimota to Tema and Tamale to Yendi and Bosuso to Kibi.

c. Trans-Ecowas Line:

Aflao-Tema-Kotoku-Tarkwa-Prestea-Omape.

Tema-Akosombo Line

The expansion programme will include improvement and modernisation of the existing network. The total cost is estimated at US$1,655.24 million. (source : African business Journal-August – November 2004).

It is planned to engage private sector participation under a Build Operate and Transfer (BOT) arrangement, however it is still early days considering feasibility studies still need to be conducted to access viability before the projects can be taken to market. Steps have been taken in this regard on the Accra-Kumasi-Techiman-Fufulsu-Tamale-Bolgatanga-Paga line. Ghana has signed a protocol agreement with Burkina Faso and a joint committee has been set up that will meet every six months. The two countries have submitted a joint request to the African Development Bank (AFDB) for funding of the initial feasibility study. Should funding be received from AFDB, studies should begin before the end of next year. (Source: African business Journal-August – November 2004).

2.2 ECONOMIC CONSIDERATIONS

2.2.1 Proposed Western Line

This line passes through the forest areas within the Brong-Ahafo, Western, and parts of the Ashanti Regions, where a lot of agricultural products like foodstuffs, cocoa and timber are produced.

Currently about 40% of the retail cost of food is attributed to transportation costs. In addition, a large percentage of foodstuffs produced in the rural areas rot due to non-availability of a cheaper means of transport to convey it to consuming centres like Accra, Kumasi and Sekondi-Takoradi. The construction of the line will also serve as a catalyst for the exploitation of mineral deposits such as diamonds, gold, limestone and bauxite located along the line. The line will also link the Upper West and Brong-Ahafo regions to Takoradi, thus facilitating the movement of goods (exports/imports) between the North and the South.

By linking this line to Burkina Faso, Mali and Niger, import and export of their commodities through the Takoradi Port will be facilitated. The branch lines from Sawla to Fufulsu will also promote the development of multimodal transport between rail, road and the Volta Lake. (Business Journal African, August- November 2004).

2.2.2 Proposed Eastern Line

This line will link the Upper East and the Northern regions to the South. The line passes through the forest areas of the Eastern and Ashanti regions where a lot of agricultural products such as foodstuffs, cocoa and timber are produced. Livestock, as well as sheanuts, cotton and rice are produced in the two Northern regions.

As already mentioned, the construction of the line will reduce food prices in the consuming centres. Mineral deposits like bauxite, limestone, diamond and gold are located along this line, and the construction of this line will serve as a catalyst for the exploitation of these mineral deposits.

In addition to linking the Northern part of the country to the Port of Tema, and the proposed inland port at Boankra, the line - which passes through Buipe - will contribute to the development of multimodal transport between rail, road and the Volta Lake. It will also link the country to its hinterland neighbouring countries of Burkina Faso, Mali and Niger thus facilitating export and import of their commodities through Ghana's ports. (Business Journal African, August-November 2004).

2.2.3 Proposed Trans-Ecowas Line

The construction of this line will pave the way to link Ghana with her Eastern and Western neighbours of Cote d'Ivoire and Togo.

2.2.4 Proposed Tema-Akosombo Line

This line will link the Tema port to the Volta Lake at Akosombo to facilitate multimodal transport between rail and the Volta Lake.

2.2.5 Development of Accra-Tema suburban rail network

2.2.6 Track

The project will involve modernization of the existing lines and construction of new lines. The existing and the proposed lines are:

i. Existing lines

Accra - Nsawam

Tema - Achimota-Accra

Accra - James Town

ii. Proposed lines

Accra - Dodowa

Accra - Kasoa

Accra - Dansoman

Accra - La-Teshie Nungua - Tema

The gauge for both the existing and the proposed lines will be 1435mm

(source : African business Journal-August – November 2004)

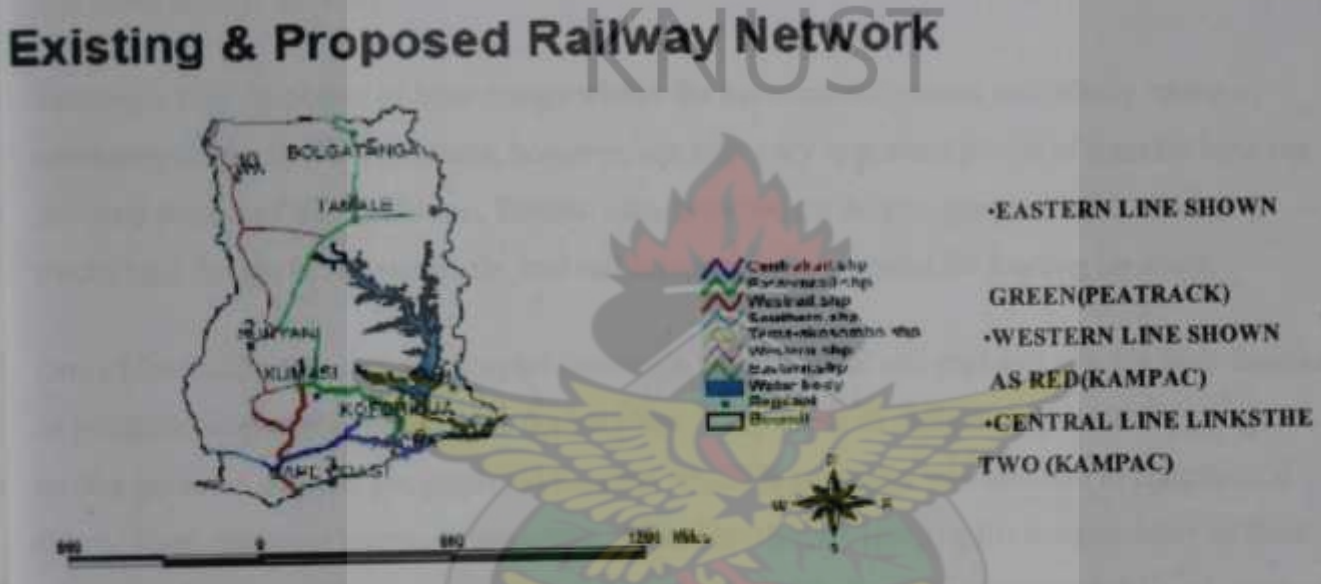


Fig 4existing and proposed rail network (Source:Business Opportunities in Ghana forum-Nov 2007)

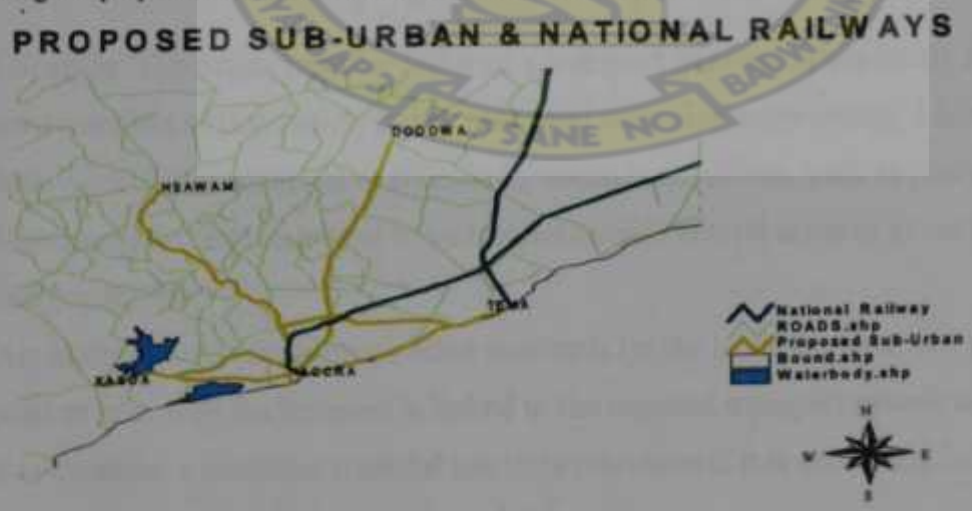


Fig 5 Proposed sub-urban and national railways(Source:Business Opportunities in Ghana forum-Nov 2007)

2.3 Definition of terminal

Terminal refers to a location where freight and passengers originates, terminates, or is handled in the transportation process. Terminals are central and intermediate locations in the movements of passengers and freight. They usually have facilities to accommodate the traffic they handle.

A train terminal is a station at which, since it lies at the very end of a line of railway, all arriving trains must perforce terminate their journeys, and from which they can consequently depart only following a reversal. Key advantage is that it permits travelers to reach all of the platforms without the need to cross any track. Very often a terminus is the final destination of trains but this is not always the case.

Terminals may be points of interchange within the same modal system and which insure a continuity of the flows. Terminals, however, are also very important points of transfer between different modes of transportation. Busses, cars, bicycles etc deliver people to train stations, trucks haul freight to rail terminals, and rail brings freight to docks for loading on ships.

One of the main attributes of transport terminals, international and regional alike is their function of bringing people or goods to a particular place. They serve as obligatory points of passage having invested on their geographical location which is generally intermediate to commercial flows. Thus, transport terminals are either created by the centrality or the intermediacy of their respective locations. Three major attributes are linked with the importance and the performance of transport terminals:

- **Location**. The major location factor of a transport terminal is obviously to serve a large concentration of population and/or industrial activities, representing a terminal's market area. Specific terminals have specific locational constraints, such as port and airport sites. New transport terminals tend to be located outside central areas to avoid high land costs and congestion.
- **Accessibility**. Accessibility to other terminals (at the local, regional and global scale) as well as how well the terminal is linked to the regional transport system is of importance. For instance, a maritime terminal has little relevance if it is efficiently handling maritime

traffic but is poorly connected to its market areas through an inland transport system (rail and road).

- **Infrastructure**. The main function of a terminal is to handle and transship freight or passengers. Infrastructure considerations are consequently important as they must accommodate current traffic and anticipate future trends and also technological and logistical changes.

2.4 CHANGING ROLES OF RAILWAY TERMINI IN CITIES

Railway stations have a very long history of about 170 years which can be divided into three major phases.

2.4.1 Phase 1

The first phase began in Britain when the first steam railway was opened for passengers in the first half of the 19th century between Liverpool and Manchester. Steam railways which was a technological advancement over stagecoaches and horse-drawn carts, were usually sited at the city's edge. This meant that people had to ride in horse-drawn carriages to continue their journeys within the urban areas.

The earliest stations and termini usually simple wooden structures and consisted of a single building and roofed platform without incorporating other facilities.

By the latter parts of the 19th centuries more varied architectural styles, waiting rooms, refreshment rooms, complicated internal spaces and later railway hotels were being incorporated in the design of train stations and termini. It is clear that in this first phase the role of the railway station as a city's gateway had changed to the additional role of being centres where travelers as well as local people converged. (source: Ideas of Node and Place in the changing roles of railway Termini in cities).

2.4.2 Phase 2

What triggered the second phase is the transport revolution in Britain which occurred in 20th century which saw the electrification of the steam railways and the first underground railway network constructed.

The untidiness and discomfort of the existing stations triggered trouble, inefficiencies and inconveniences for the electrified railway system as the existing rail stations were built to serve steam-driven locomotives. This and the world wars resulted in the closures and demolitions of several train stations around Europe.

Also the invention of the petrol vehicles which were as a result of the transportation revolution saw the beginning of a combination of road and air transportation which made rail travel more and more unpopular. (source: Ideas of Node and Place in the changing roles of railway Termini in cities).

2.4.3 Phase 3

This phase started from the early 1970s until the early 1980s. as a result of increased road traffic due to urbanization, railway transportation was reconsidered as the cheapest,cleanest,fastest and safest means of land transportation from one place to the other. Since then rail transportation has always been included, alongside other transport modes in transportation policies for several cities. (source: Ideas of Node and Place in the changing roles of railway Termini in cities).

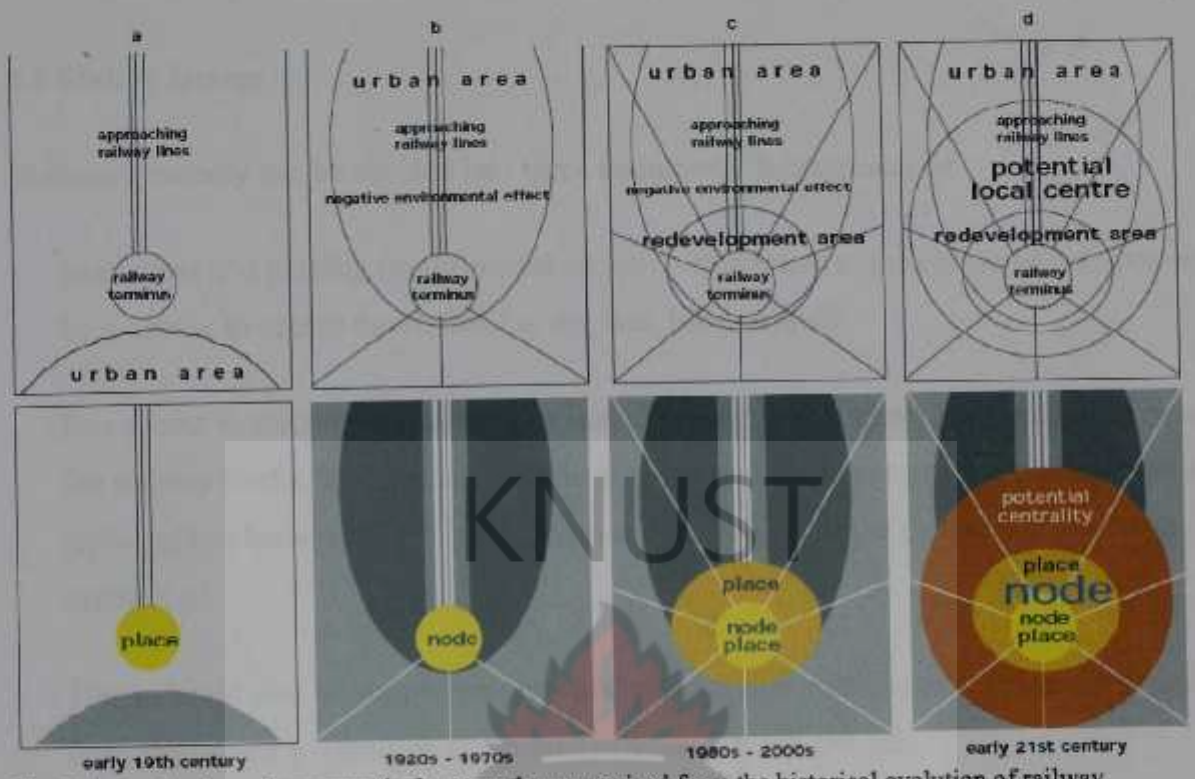


Fig 6 The node-place diagrammatic framework summarized from the historical evolution of railway termini. (source: Ideas of Node and Place in the changing roles of railway Termini in cities).

A. Depicts an archetype of the railway terminus from the 19th to the early 20th century characterized by an isolated location at the edges of the city. It represents railway termini in their earliest years when they were kept at the city periphery.

B. can be seen to be isolated nodes of the transportation network located within declining urban settings. In this second phase, when the cities grew beyond the terminus locations, railway termini had become major transit nodes as they were well interconnected with other modern modes of transport.

C. depicts the railway termini that are currently to be redeveloped as node and place embedded within the urban setting.

B. depicts the future potential of railway terminus areas as rejuvenated local centres. The newly redeveloped districts at railway termini would benefit from the efficient transport connection that encourages a large number of people to

converge as well as to pass through the areas where multiple activities are provided, both inside and outside the terminus buildings.

2.5 Station Design

Stations generally can be divided into three main parts. It comprises of

1. site access and parking (multi-modal access) - this refers to the choice of transit used by a person to access the station i.e. car, bus, bike, or walk.

   Bus access to the station must ensure that situations where buses are required to cross the railway tracks. Bus and automobile access should be separated wherever possible and conflicts between buses, trains, automobiles, bicycles and pedestrian should be minimized.

   There should also be simple, obvious and comfortable passengers' circulation to and from the station's transition and platform areas. To achieve this

   i. Unnecessary turns and dead ends should be avoided.
   ii. Enough space for circulation should be provided to avoid bottlenecks
   iii. Cross circulation at fare collection and decision points should be avoided
   iv. Enough space should be provided for long queues at fare collection areas so that traffic is not blocked.
   v. Separate facilities for entering and leaving the station should be separated.
   vi. Grade changes should be minimized as much as possible.
   vii. Pedestrian through zones should be free of obstructions such as phone booths, ticket machines, advertising systems, seating etc.
   viii. Adequate sight distance and visibility along pedestrian routes should be ensured.
   ix. At least two points of access/exit from the platform should be provided

   (Light Rail Design Criteria, November 2005)

Bicycle access and facilities should be located to minimize conflicts with pedestrian and vehicular traffic. Also it should be easier to monitor bicycle storage areas from the station's entrance or the street to promote security. The bicycle racks can also be located on the transition plaza but separated from places where people gather.

2. Transition plaza – this refers to the space or area necessary to facilitate the movement the movement of people from the parking or other means of access to the platform. In this place a person can buy tickets, view public information systems and wait until they are picked up.

Fig 7 Unobstructed circulation station concourse. (source Design Guide for Disable- code of practice, version 1 July 2008)

The following are some of the design criteria for the transition plaza.

1. The transition zone should be big enough to cater for passenger volumes during peak and off-peak periods.
2. Ticket vending machines, information systems etc should be located near to the line of travel without impeding the flow of passengers to the platform.
3. Ticket sale points should be able to serve a large number of passengers in a short period of time.

Fig 8 A typical ticket gate (source Design Guide for Disable- code of practice, version 1 July 2008)

3. Platform

2.6 Railway platform (facts and description)

A railway platform is a section of pathway, alongside rail tracks at a train station, metro station or tram stop, at which passengers may board or alight from trains or trams. Almost all stations for rail transport have some form of platforms, with larger stations having multiple platforms. The term platform is most commonly used for designated areas where trains stop. Technically speaking, the term platform actually refers to physical continuous sections of platform area. So such a physical platform may contain several designated platforms.

(Source: Light Rail Design Criteria, November 2005)

2.6.1 Characteristics

A most basic form of platform consists of an area at the same level as the track, usually resulting in a fairly large height difference between the platform and the train floor. This would often not be considered a true platform. The more traditional platform is situated at an elevated level relative to the track, but often lowers than the train floor, although ideally the platform should be at the same level as the train floor. Occasionally the platform is at a higher level than the train floor. This may be the case when a train with a low floor level serves a station built for trains with a higher floor level.

2.6.2 Facilities

Part of the station facilities are usually on the platforms. Where the platforms are not situated within a station building, often some form of shelter or waiting room is provided. The protection offered by such varies greatly – some being little more than a roof with open sides, others being a closed room with heating or air-conditioning. Also there may be benches, lighting, garbage boxes and static or dynamic displays with information about the next train, delays, etc. There are often loudspeakers as part of a public address system. The PA system is often found where dynamic timetables or electronic displays are not present. A variety of information is presented, usually pertaining to departures, but often arrivals also. This concerns destinations and times, delays, cancellations, platform changes, changes in routes and destinations, the fact that for a train a supplemental fee or a reservation is required, etc.

Fig 9 Information system and tactile marking at the edge of platform (Source Design Guide for Disable- code of practice, version 1 July 2008)

2.6.3 Platform arrangement

There are three different arrangements of platforms. They are:

1. side platforms- this is where the platforms are arranged facing each other and with each catering for one mainline track.

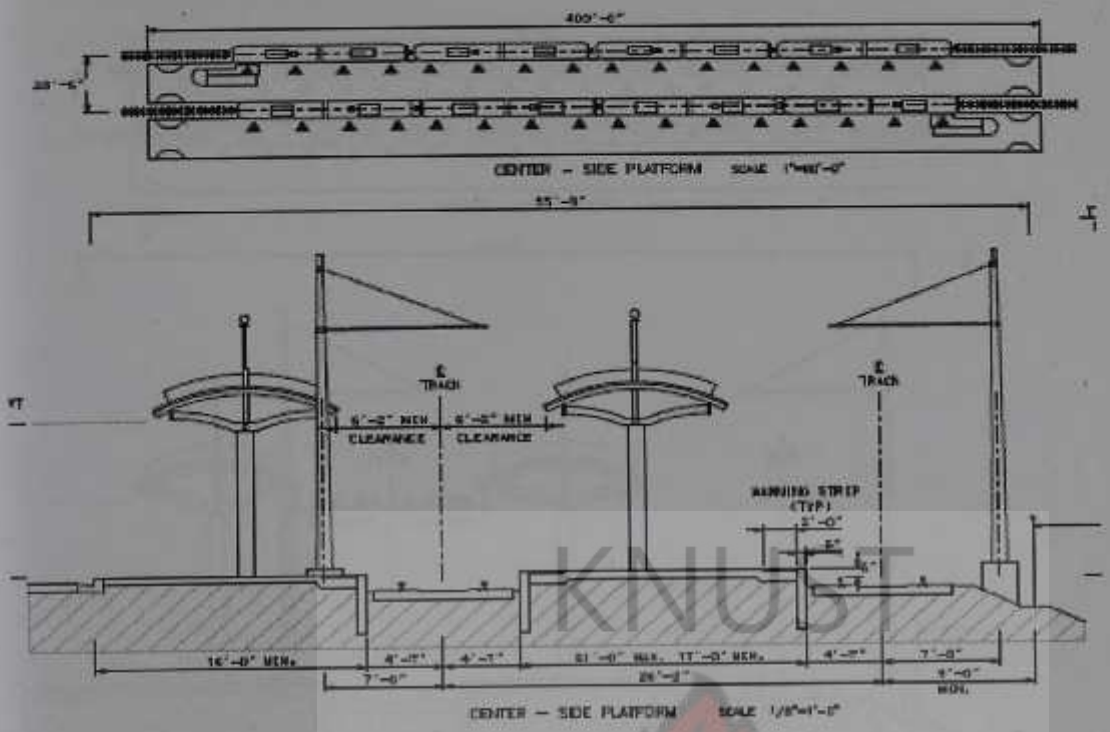


Fig 10. A typical section through a side platform (Source: Terminal Architecture and Engineering)

2. Center platform- this refers to where one platform services tracks located on each side of it. Passengers have to use a bridge or tunnel to be able to access center platforms. It is also known as island platform.

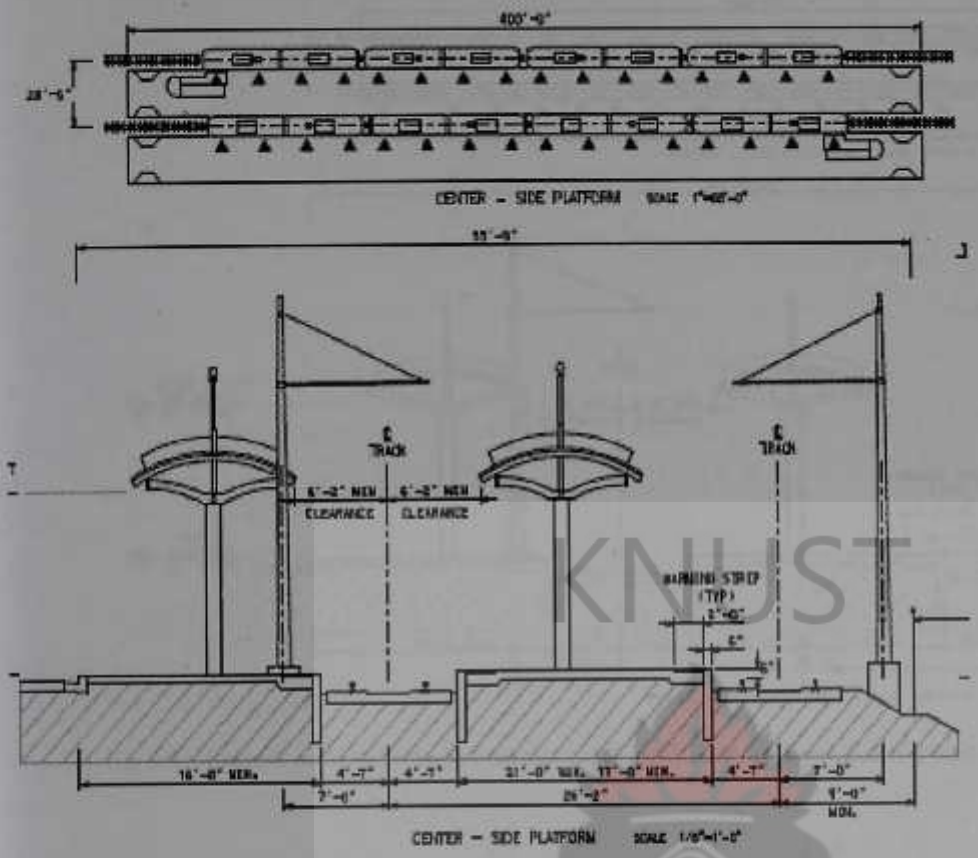


Fig 11. A typical section through a center platform (Source: Terminal Architecture and Engineering)

3. Side center platform: this kind of platform is located on just one side and a center platform provided to service the other tracks.

   The centre platform kind of arrangement offers the most efficiency in terms of use of platform space and furnishings.

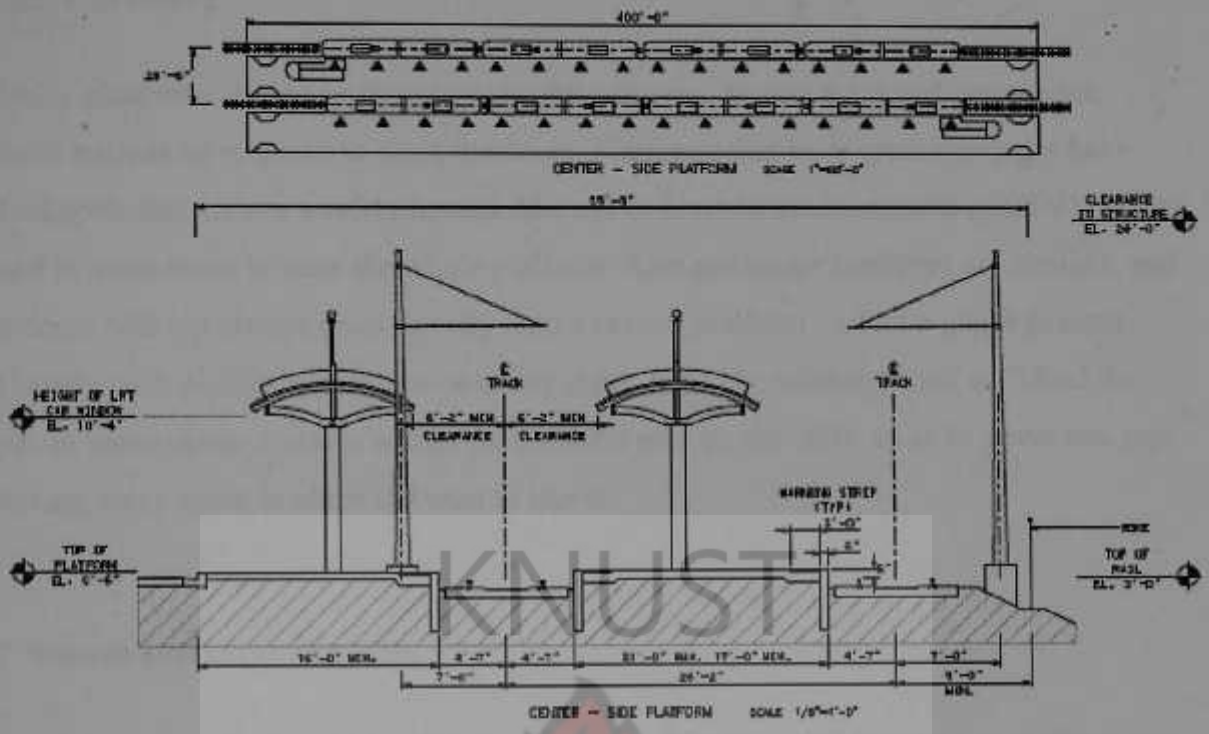


Fig 12. Typical section through a center platform (Source: Terminal Architecture and Engineering)

2.6.4 Platform safety

For platforms to be efficient and passenger sensitive the following should be ensured

1. Platforms should be designed with conspicuous warning strips on the edge of the platform to prevent accidents
2. As much as possible platforms should be clear of equipments and other obstacles.
3. Fixed objects such as furniture, advertising boards, etc should be concentrated in one area leaving enough room for circulation.
4. Clear emergency exiting from platforms should be provided.
5. Platform exits should be big enough and located to cater for estimated passenger volumes under both normal and emergency conditions.
6. As much as possible platform surface should flash with the floor of the trains interior to make boarding easier and safer.

2.6.5 Curvature

Ideally platforms should be straight or slightly convex, so that the guard can see the whole train as he prepares to close the doors. Platforms that have great curvature have blind spots that creates a safety hazard. Mirrors or closed-circuit cameras (CCTV) may be used in these cases to view the whole platform. Also passenger carriages are straight, and so doors will not always open directly onto a curved platform – often a gap is present. (Usually such platforms will have warning signs, possibly auditory, such as "Mind the gap. In some cases, sections within the platform may be movable, so as to cover any gap; moving away again to allow the train to leave.

2.7 Station entrances and exits

Station entrances and exits should be sufficient and be designed in such a way that it can cater for passenger traffic for peak and non-peak times. Its location should be easily identified and should make it easier, faster, and safer for people to escape in the event of an emergency. Doors should be wide enough and should swing in both directions.

2.7.1 Passenger flow in train stations

The station is the first and last encounters a passenger experiences when travelling by train. Passengers must of necessity access the station before boarding a train and must upon arrival exit through the station. In stations passengers travel on escalators, stairs, ramps, lifts, etc and goes through fare collection gates before and after a train ride. A general passenger flow chart with main station activities and their relationships is shown below.

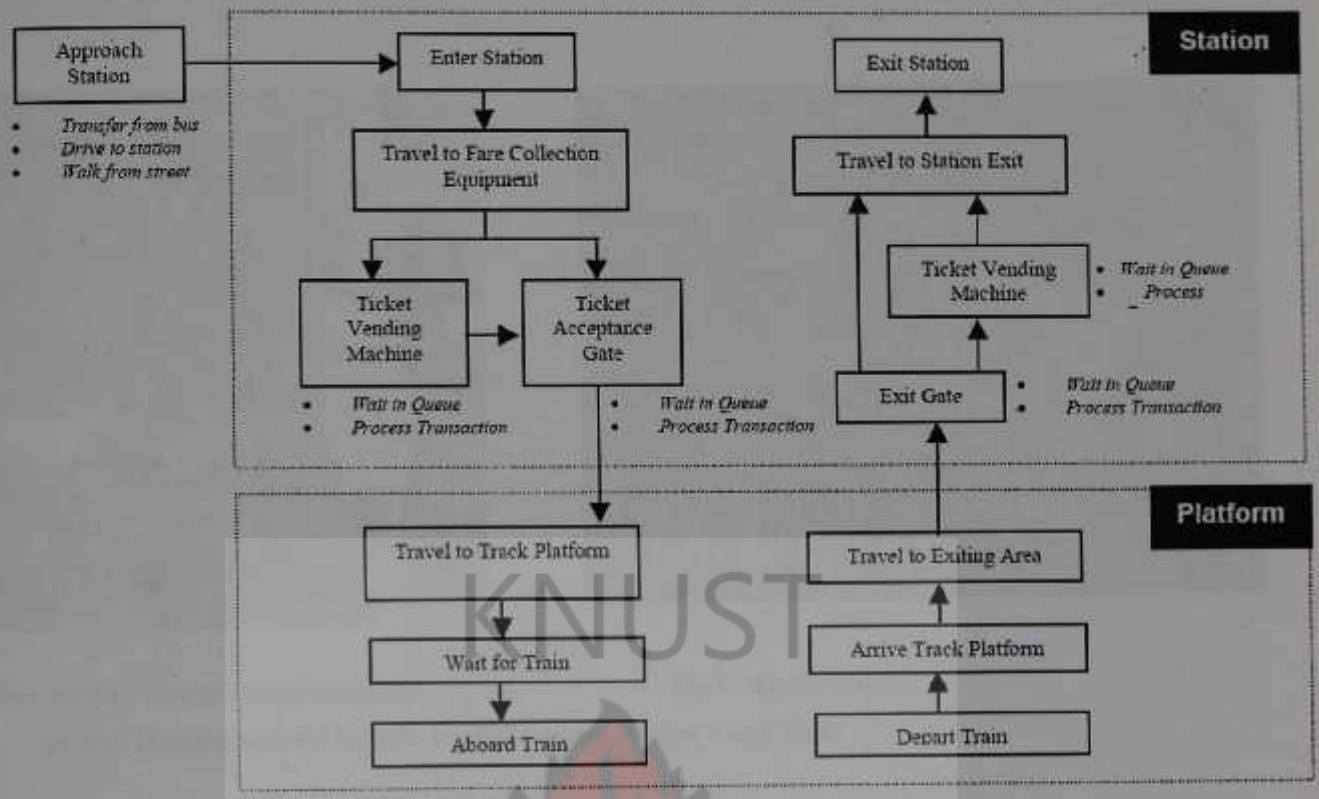


Fig 13 A typical flow chart within a train terminal (source: www.train terminal circulation)

2.7.2 Passenger information

Passenger information systems (PIS) must be a reliable means of giving information to commuters in a station. Information systems should be placed and made in such a way that information can easily communicated to people using the station. They must be updated regularly and must be visible in all weather.

There are two types of information being constant and instant. Constant information normally gives information on the services, goods and the fares of the station. The instant gives information those changes very often (daily or by minute). They usually give information concerning;

1. the time now
2. time of arrival or departure of a train
3. train destinations and stops
4. the stations served by this station

Fig 14 Free standing sign on station concourse

Fig 15 display screen

(source: Design Guide for Disable- code of practice, version 1 July 2008)

2.7. 3 Station materials and finishes

The durability, availability and aesthetic features of a train terminal have a direct relationship with its image. Because train stations are used by a large number of people daily and are usually targets of vandalism, materials used should be durable and must be easily available and replaced. Materials should also be appealing and harmonious in texture and appearance. Flooring materials should be non slip, easy to clean and replace and also fire resistant.

2.7.4 Video Surveillance in Train Stations

In recent years, public transit security concerns have increased significantly. The threat of terrorist activity has always been present, but it is a larger issue today than ever before. In train and subway stations, video surveillance systems can help to prevent such acts. Additionally, security cameras can deter crime and vandalism within stations, and provide riders with an added sense of security.

2.7.5 Station facilities

Some of the facilities provided in train terminal design are

1. ticket booths and or ticket machines
2. customer service desks
3. convenience stores
4. fast-food or restaurants
5. postal services
6. left-luggage
7. lost-and-found luggage
8. luggage carts
9. waiting rooms
10. taxi ranks and bus bays
11. driver restrooms

2.8 Technical studies

Rail gauge refers to the distance between the inner sides of the two parallel rails that make up a single railway line. There are three main types of gauges namely the standard or international, broad and narrow gauge.

Fig 16 Rail track gauge (source: Rail gauge, Wikipedia, the free encyclopedia)

Standard gauge refers to the type of rail with 1435mm distance between the inner sides of the rails. New railways are usually built to standard gauge unless there is a strong reason not to adopt it. Sixty percent of the world's railways use this type of gauge because of the following:

1. It facilitates inter- running with neighbouring railways.
2. Locomotives and rolling stock can be ordered from manufacturers' standard design and do not need to be custom built.

It is for these reasons that the existing railway lines in Ghana are being changed to make way for the standard gauge.

Fig 17. Standard gauge (source: Rail gauge, Wikipedia, the free encyclopedia)

The Broad Gauge refers to any gauge that is wider than standard gauge. They are common for cranes in docks for short distances. They are used to provide better stability.

Fig 18. Broad gauge (source: Rail gauge, Wikipedia, the free encyclopedia)

Narrow Gauge is any gauge that is narrower than the standard gauge. They cannot handle as much tonnage as the standard gauge but are less costly. They are dominant in Southern and Central Africa. The most widely used ones are the 1067mm, which is dominant in Ghana, and the 1000mm gauges.

Fig 19 Narrow gauge (source: Rail gauge, Wikipedia, the free encyclopedia)

2.8.1 Alignment of Tracks

In laying two or more tracks the critical point, which is the center to center distance between the tracks should not be less than 3300mm. Two trains are not allowed at this section of the rail lines as it may cause accidents.

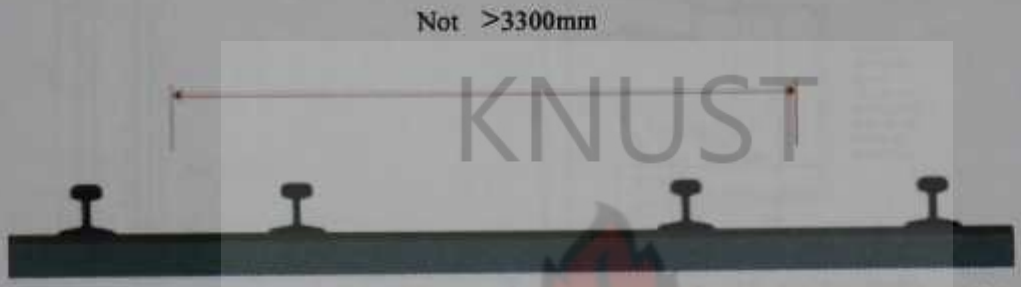


Fig 20 Critical point of two tracks (source: Rail gauge, Wikipedia, the free encyclopedia)

2.8.2 Trains

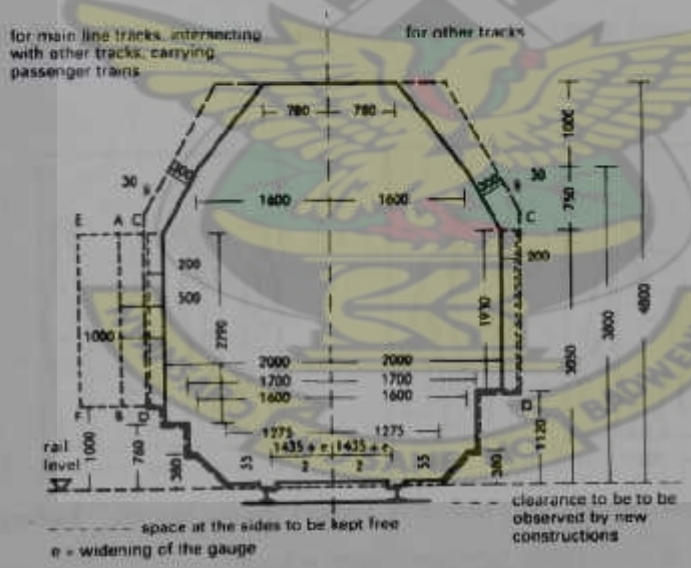


Fig 21 dimensions of a typical train coach (source: Ernst and Peter Neufert, Architects Data, third edition 2000)

Modem passenger trains have an average width of 2800mm and an average height of 4000mm.

2.8.3 Platforms

The minimum height of train platform is 500mm but the width is determined by the kind of activity there. It is better to have an unobstructed and straight platform so that the train conductor can monitor passengers embarking or disembarking from the train. Materials for the platform should as much as possible be resilient and non slip.

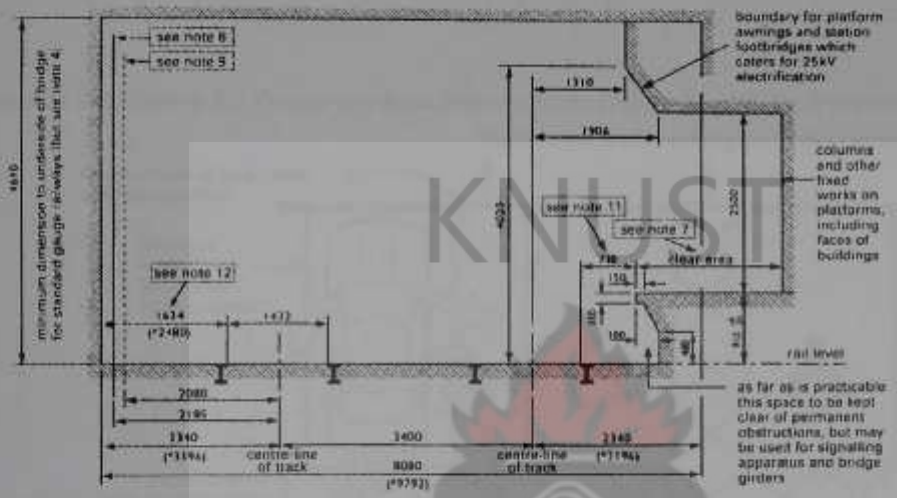


Fig 22 Platform and track details (source: Ernst and Peter Neufert, Architects Data, third edition 2000)

Fig 23 Closely packed normal spacing (source: Ernst and Peter Neufert, Architects Data, third edition 2000)

Space requirements(able)

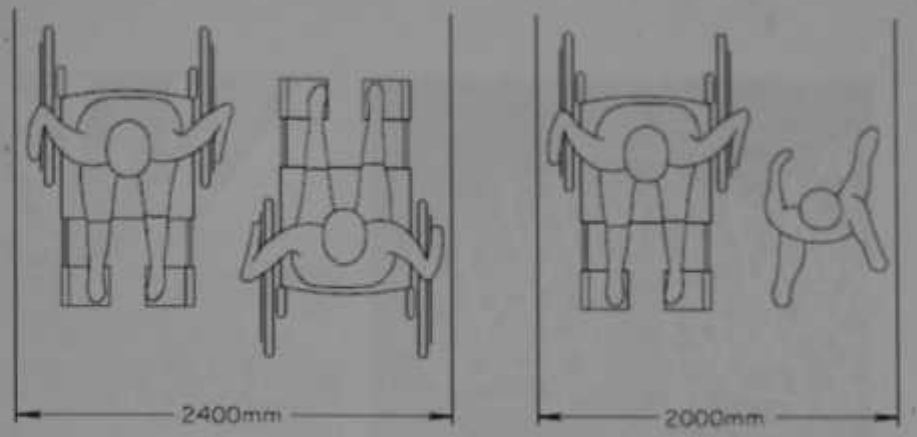


Fig 24 Minimum dimensions for people in wheelchairs (source; Design Guidelines-Parsons Brinckerhoff, July 2002)

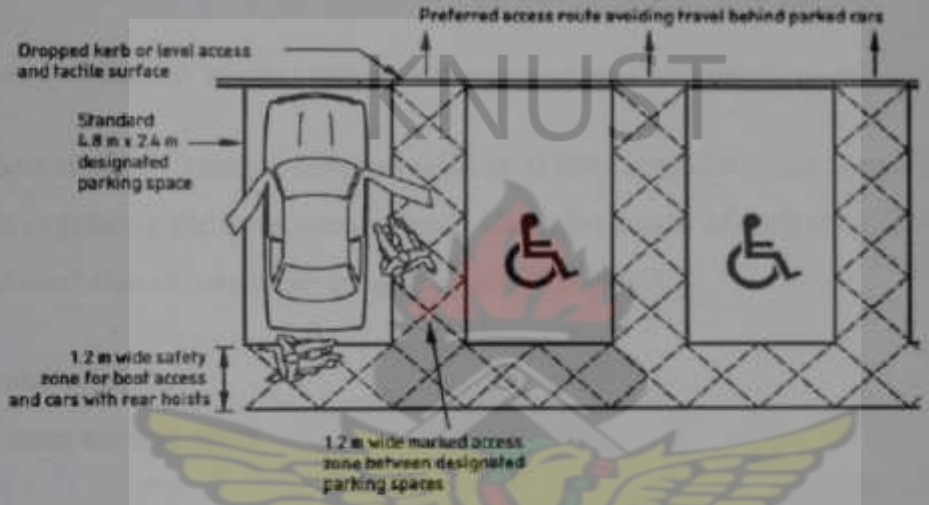


Fig 25 Access around designated off-street parking spaces (source; Design Guidelines-Parsons Brinckerhoff, July 2002)

2.8.4 Special studies (spaceframe)

A space frame is a truss-like light weight rigid structure constructed from interlocking struts in a geometrical pattern. They usually utilize a multi directional span and are often used to accomplish long spans with few supports.

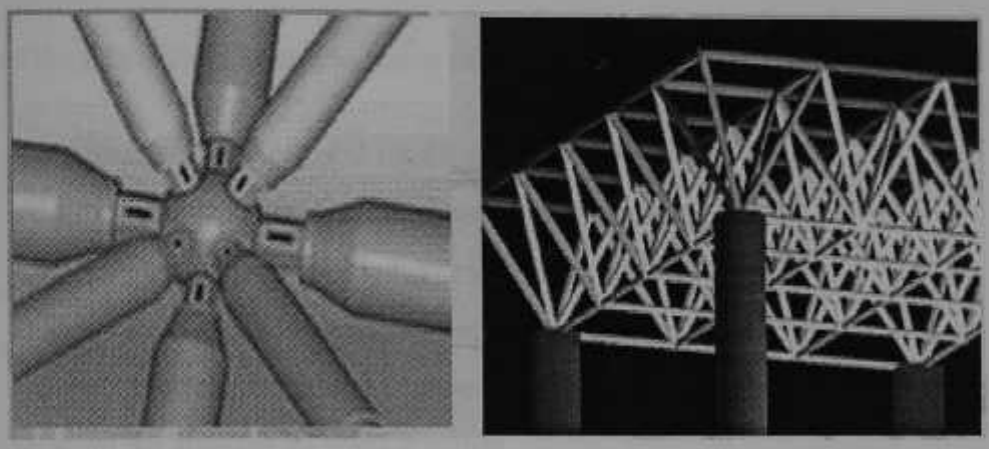


Fig 26 space frame structure and module (source: Delta structures Inc.-Guide specifications)

They derive their strength from the inherent rigidity of the triangular frame; bending moments are transmitted as tension and compression loads along the length of each strut. The simplest form is a horizontal slab of interlocking square pyramids built of:

1. Steel tubular struts
2. Aluminium tubular struts

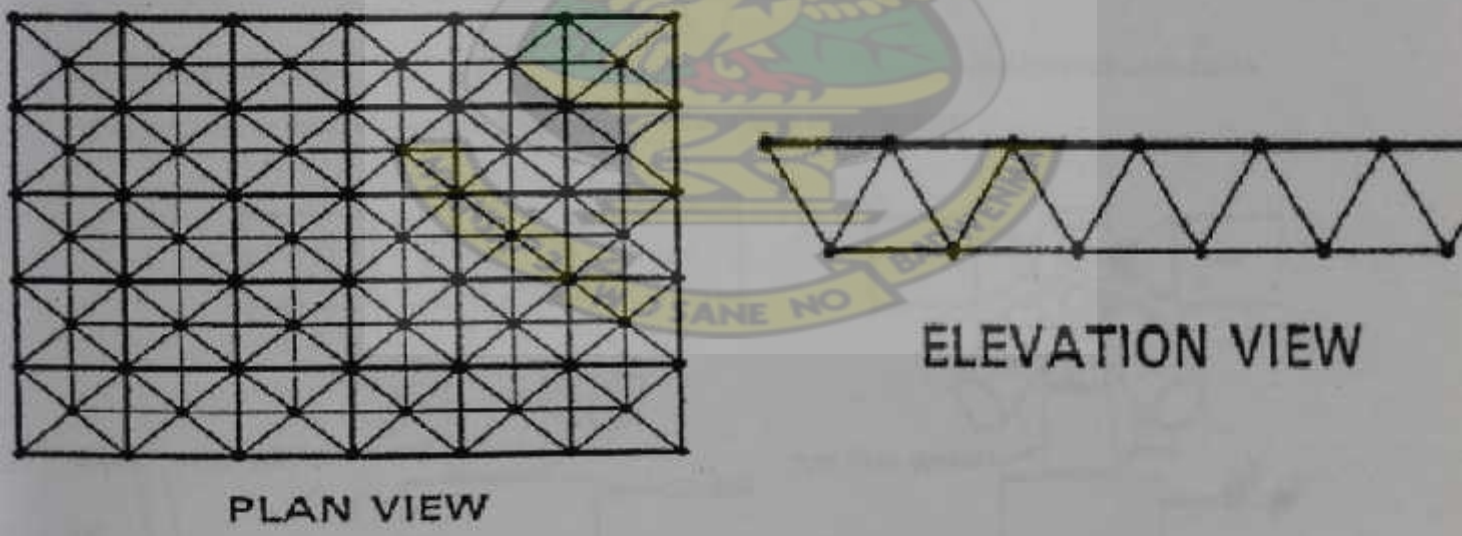
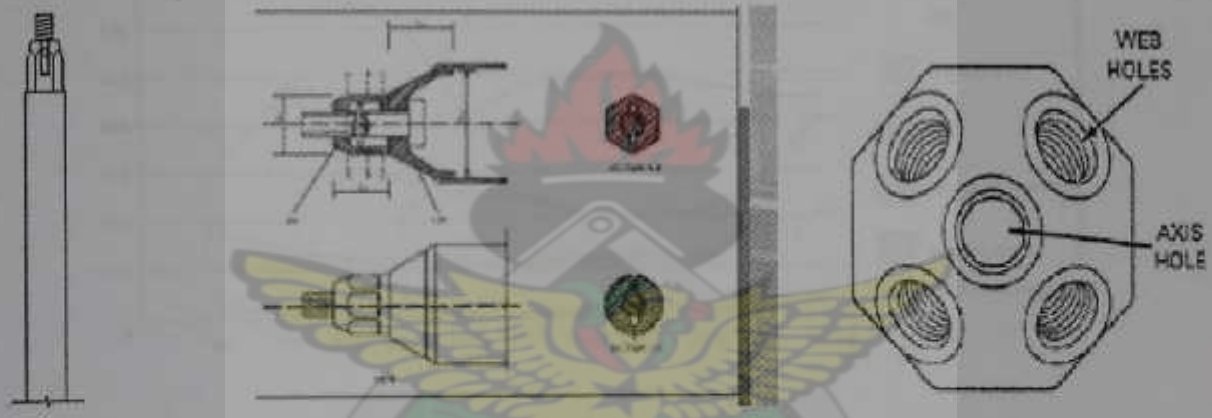


Fig 27 plan and elevation views of space frame structures (source: Delta structures Inc.-Guide specifications)

2.8.5 Advantages

Some of the advantages of space frame structures are:

1. Considerable strength and rigidity
2. Ability to have large spans without middle supports
3. Capacity to carry concentrated or non-symmetrical loads
4. It is possible to run extensive overhead services through them
5. Components can be mass produced in a standardized manner, segregated and transported to sight for straight forward erection.
6. They add to the aesthetics of buildings, especially the interior spaces.



Aluminium/steel strut steel/aluminium node

Fig 28 space frame members (source: Delta structures Inc.-Guide specifications)

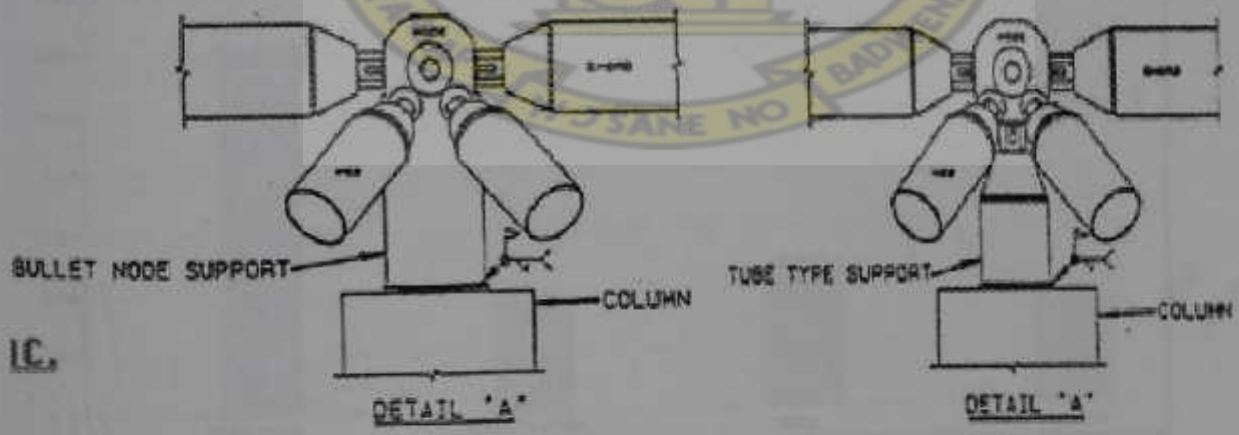


Fig 29 connection of spaceframe members (source: Delta structures Inc.-Guide specifications)

2.9 TRAFFIC STUDIES

Several people commute between Tema and other parts of the country daily. They use some of the main roads namely the Tema motorway , the Spintex road , the Accra- Tema beach road, among others. To determine the volume of daily traffic along the Tema- accra beach road corridor, a traffic count was undertaken. The graph below shows the composition and volume of traffic on the tema- accra beach road which borders my site on the south west.

Fig 30. Chart showing vehicular classification (source: Department of urban roads - Ghana ,2006)

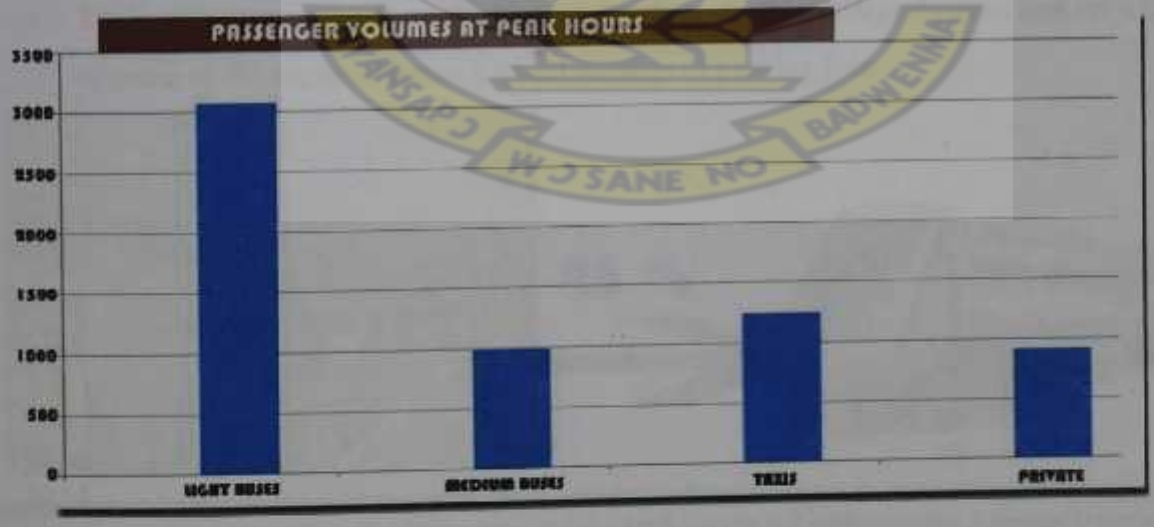


Fig 31. Chart showing passenger volumes at peak hours (source: Department of urban roads - Ghana ,2006)

AVERAGE VEHICULAR OCCUPANCY	
TYPE OF VEHICLE	AVERAGE NO OF OCCUPANTS
LIGHT BUSES(TRTRO)	15
MEDIUM BUSES	31
TAXIS	3
PRIVATE CARS	2

Fig 32 Average number of vehicular occupancy (source: Department of urban roads - Ghana ,2006)

From the graphs it could be observed that

1. An average of 6216 commuters travel from Tema to other parts of the country by the beach road daily.
2. Peak passenger and vehicular volumes occur between 7-8 in the morning and 5-6 in the evening.
3. A larger percentage(49%) of people who are expected to use the terminal will come by light buses.
4. Taxis and private cars form the highest number of vehicle classification that are expected to come to the terminal hence highest number of parking lots.

Fig 33. An estimated 45% of road users are expected to switch over to rail transportation. (source: Department of urban roads - Ghana ,2006).

Statistics from the Ghana Urban roads indicate that about **45%** of commuters of both private and public transport will willingly shift to a more efficient rail transport.

A figure of 2800 commuters will be willing to shift to the rail transportation. By **2025** this figure is projected to be 4400.

A train terminal capacity of **5000** people is therefore proposed .

CHAPTER THREE

3.0 Methodology

Collection of data can be grouped into two main types namely the qualitative and quantitative. The quantitative method deals with getting answers to some particular questions. They may be in the form of filling in some numbers or ticking of boxes in response to some questions. They are mostly used when the data is based on large number of responses.

Qualitative data collection involves the exploring of issues to gain in-depth knowledge on the topic under study. These two types of data collection were employed with regard to writing this report.

1. **Interviews** : several interviews were undertaken to be able to know the current situation pertaining to transportation in Ghana, railway transportation and other issues concerning Ghana Railway Company. Interviews were conducted with Ghana Railway Company area engineer- Accra, Asoprochona train station manager and draughtmen of the Accra railway station.
2. **Internet** : since no modern and vibrant railway terminal or station exists in Ghana at the moment, most of the information concerning train terminal design and other related information were gathered from the internet.
3. **Periodicals**, books and publications: some of the information on the subject were obtained from books on train terminals and airport designs etc.

3.1 Limitations

Several limitations were encountered with regard to gathering information to prepare this report. First and foremost, getting the site maps for Tema, Asoprochona and Accra were extremely difficult.

Secondly getting information on vehicular traffic volumes for Tema over the years also proved difficult.

Lastly the non-existence of a modern train terminal or station in the country also made it difficult for me to be able to get enough information with respect to the operations of the Ghana Railway Company.

3.2 CASE STUDY

This foreign case study was done to know what is happening abroad with respect to train terminal design.

3.2.1 Union station

3.2.2 Location

Union Station is an important and a historic landmark and architectural gem located in Washington D.C within a civic precinct. It serves as a major transportation hub, retail center and tourist destination catering for the residents of the district of Columbia, tourists and commuters from both Washington D.C area and across America.

Fig 34 Picture of Union Station (outlined in red) in the urban setting(source: www.essential- architecture.com)

1. Postal museum
2. Thurgood marshall federal judiciary building
3. Senate office buildings
4. United states supreme court

5. Library of congress buildings
6. Shakespeare
7. House office buildings
8. Capital of the united states
9. Union station plaza
10. US Botanical Gardens
11. Food and Drug Administration building
12. US Department of Health and Human Services
13. Voice of America
14. American Indian Museum
15. The National mall

3.2.3 Layout

Union station made provision for the following spaces.

1. **Lower level**

Movie theatre

Food court

Car park

Retail shops

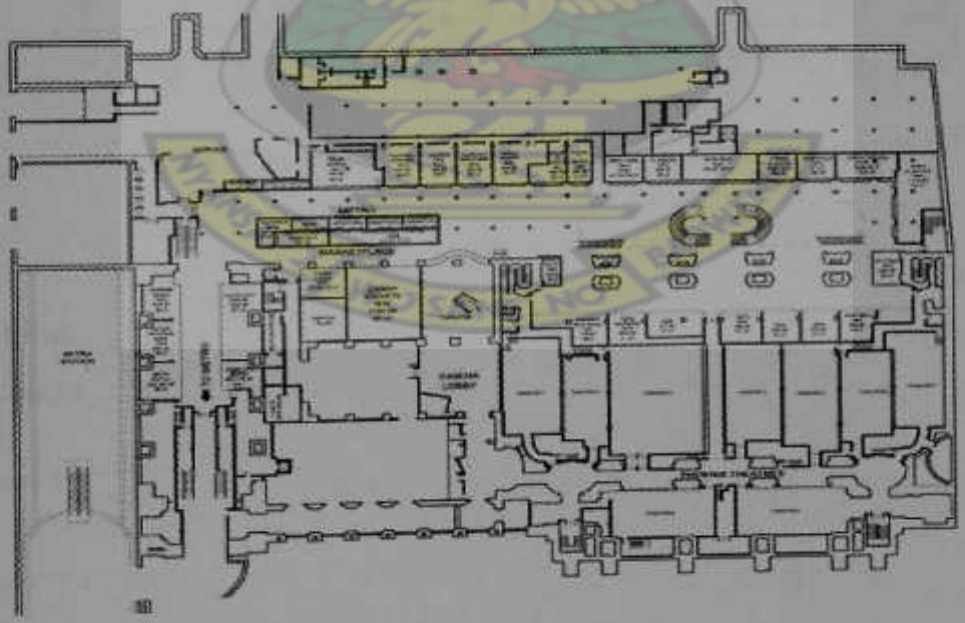


Fig 36 Lower level plan(source: www.essential- architecture.com)

2. **Street level**

Postal services
Waiting area
Information desk
Train concourse
Ticket vending machine area
Platforms
Ticket and baggage offices
Restaurant
Main hall
carriage porch
washrooms

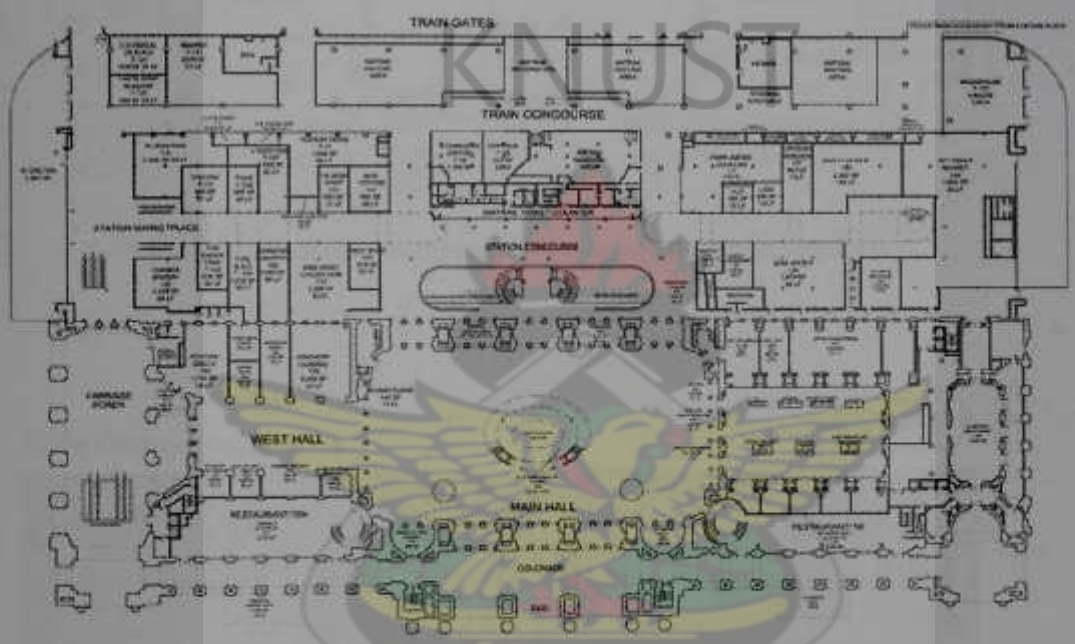


Fig 37 Street level(source: www.esscntial- architecture.com)

3. **Mezzanine.**

Shopping concourse
Retail stores
Auditorium
Café
Washrooms
Bank

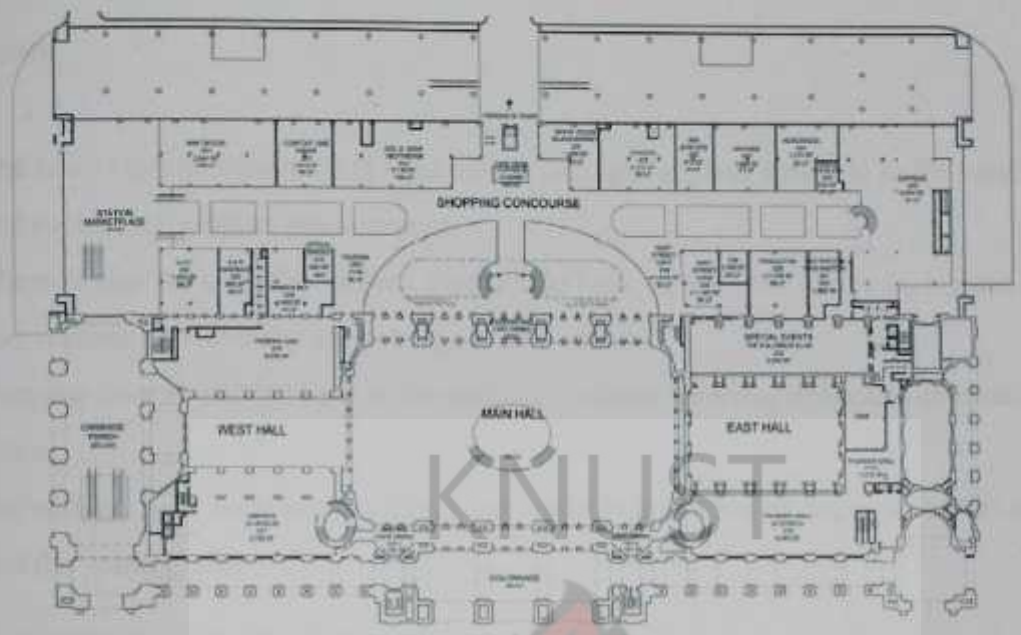


Fig 38 Mezzanine level(source: www.essential- architecture.com)

Train Concourse / Amtrak

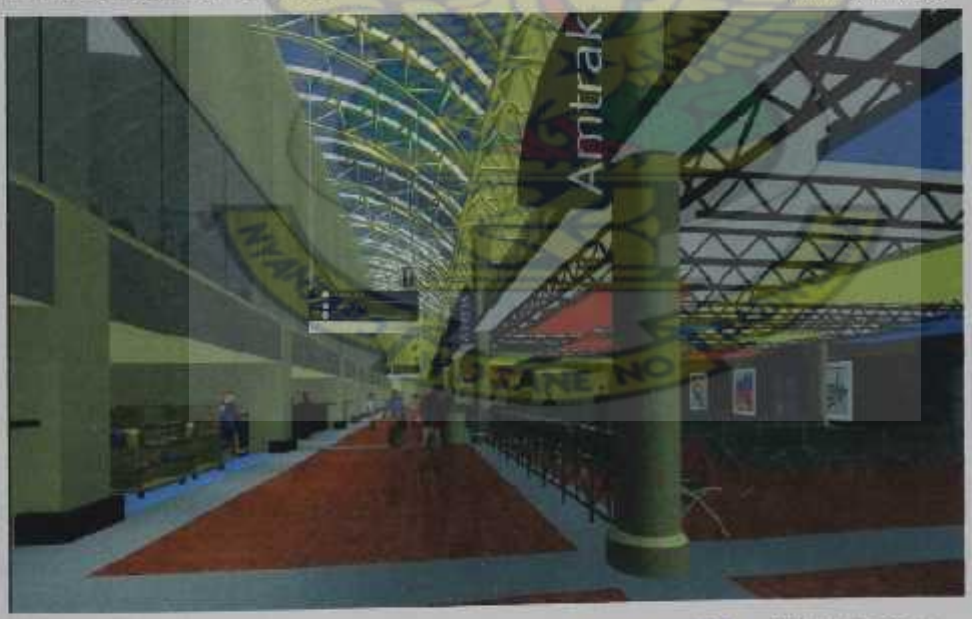


Fig 39 View of the train concourse(source: www.essential- architecture.com)

3.2.4 Merits

1. The use of atrium ensures that light comes through its glass structure to the waiting area and creates a friendlier environment.
2. There is also the use of storefront glass at the back of the retail shops facing the walkway and waiting area thereby improving advertisement.
3. Varying colours and textures at the waiting area and walkway enhances circulation within space.
4. Balustrades have been used to direct and control circulation by segregating the walkway and the waiting area.

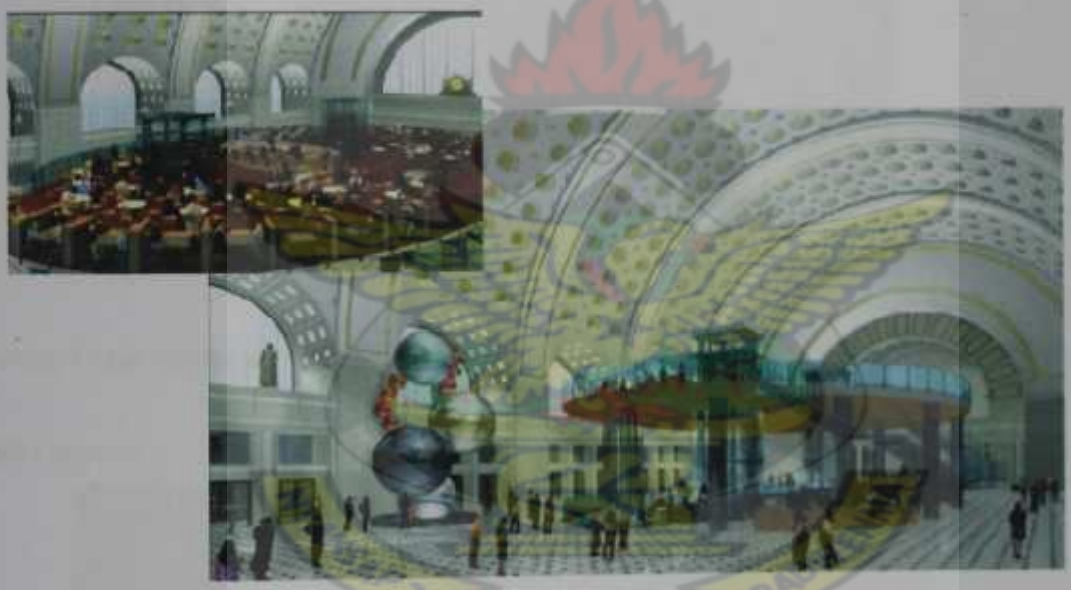


Fig 40 Main hall café at street level and mezzanine level dining with piece of art

(source: www.essential- architecture.com)

1. wide arched windows with glazing help to bring in natural light into the main hall
2. the mezzanine level dining at the main hall helps to save space. It however impedes circulation.

3.2.5 Bike transit centre

The new bike transit which is attached to the station is supposed to provide convenience and access for commuters. The features of the bike transit centre are

1. 1700 square feet of space enclosed in glass.
2. Lockers for up to 150 bikes
3. Bike rental, sales and store areas

Fig 41 Bicycle transit facility (source: www.essential- architecture.com)

3.3 Accra Train Station

3.3.1 Site layout

Fig 42. Layout of Accra Train Station(source: Accra Train Station, 2009)

3.3.2 Facilities provided

Fig 43. Administration of Train station(source: Author)

Fig 44. Parking Area (source: Author)

Fig 45. Platform area(source: Author)

Fig 46. Restaurant (source: Author)

Fig 47. Ticketing and weighing area (source: Author)

Fig 48. Maintenance unit (source: Author)

3.3.3 Merits

4. Goods and pedestrian portions of the station have been separated for effective circulation.
5. Facilities of the station have been laid out in such a way that there is effective ventilation and also to make maximum use of natural lighting.
6. The platform area is open. This will enhance evacuation of people in times of emergency and also helps in ventilation.
7. One style of architecture runs through the design of the whole facilities

3.3.4 Demerits

1. The station facilities are scattered all over the site. This makes way finding and circulation difficult.
2. Low platform height makes it difficult for people especially with disability to board and disembark from trains.
3. Parking areas and pedestrian walkways are not well defined.
4. Location of the station in the heart of the city centre of Accra makes it difficult for people and vehicles to access the station.

CHAPTER FOUR

4.0 Site

The site is located in Tema a city in the Greater Accra region. It is bounded on the south east by the Sakumono village and on the south west by the Accra-Tema beach road.

Fig 49 LOCATION OF TEMA

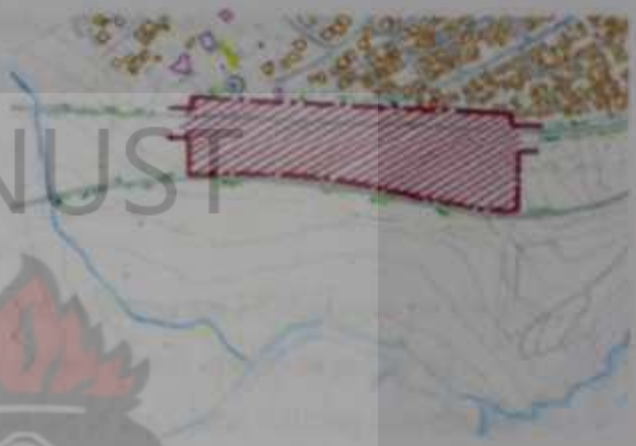


Fig 50 LOCATION OF SITE (source: Author)

Fig 51 SITE (source: Author)

4.1 Site justification

There is a growing number of people who commute between Tema and Accra daily on the beach road and a train terminal along that road will cut down drastically the increasing number of vehicles on that corridor and other major roads.

Also a train terminal along the beach road will serve as a catalyst for the springing up of other facilities (e.g. waterfront development).

Furthermore, a suburban train shuttle service is in operation on that Corridor but the facilities at the site will be unable to handle anticipated passenger volumes.

4.2 Existing site conditions and inventory

A site survey conducted on the site revealed that there are 22 structures on the site. Thirteen are temporary structures on the eastern corner of the site put up by encroachers and eight are buildings belonging to the Ghana Railway Company centrally located on the site. One of the eight structures is the station itself with facilities such as waiting area, platform, ticket counter and office and manager's office. The other buildings are accommodation facilities for the railway workers. There is an existing single railway line running through the northern part of the site.

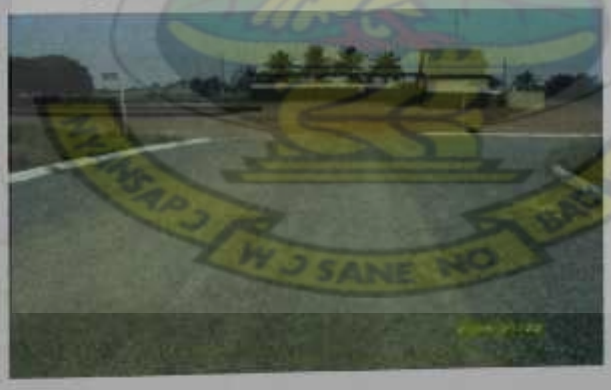
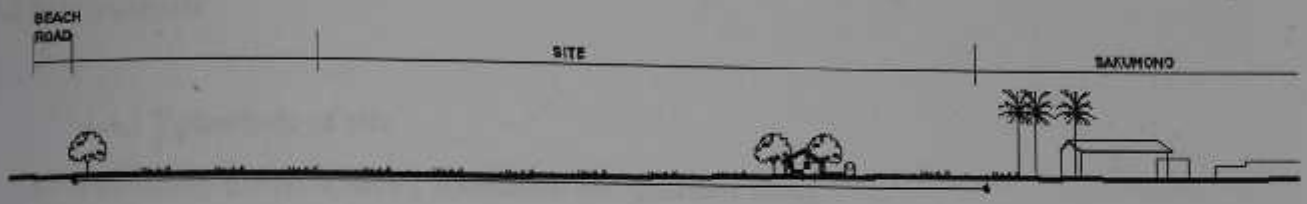


Fig 52 View of site from the Tema – Accra Beach Road(source: Author)

Fig 53 SECTION X-X (source: Author)



SLOPE- 1: 70 m

Fig 54. SECTION Y-Y (source: Author)

4.3 Building conditions

A study conducted on the building revealed that buildings are old and have outlived their use. The station building is small in size with an area of 120 sq meters. Materials used are;

Wall – sandcrete blocks

Roof – asbestos roofing sheet

Floor – concrete

Considering

-the small size of the station vis-a-vis the anticipated volume of passengers

-the fact that the building has outlived its use

-the fact that some carcinogenic materials were used

I propose that

1. The station building should be demolished to make way for the new terminal.
2. The worker's accommodation blocks which have the same building materials condition should also be demolished
3. Squatters should be moved from the site.
4. I also propose that two more tracks should be added to cater for sub-urban and intercity transportation.

4.4 Site analysis

4.4.1 Potentials of site

- Proximity traffic source (residential and business area)
- Site is located along a rail way line
- Proximity to a major access road to Tema (beach road)
- Site is large enough for such a facility
- Site has a gentle slope
- Most of the site's area has vegetative cover

4.4.2 Problems

- Site is a little bit removed from the city centre
- Encroachment on site by squatters
- No bridge or tunnel for people to cross the rail lines to the beach road
- Immediate areas around site not very vibrant with economic activities

4.4.3 Intervention.

- Introduce such facilities that will attract a lot of businesses and people to the terminal
- Reclaim encroached land from squatters
- Provide bridge over the rail lines

4.5 Site peripheral studies

A study of the building and conditions around the site reveal the following

1. 98% of the buildings are residential and 2% civic.
2. Civic buildings are made up of churches and a school
3. 40 % of buildings are multi- storey
4. Concrete and sandcrete blocks constitute the main building materials used.

About 750 meters on the south western side of the site is the gulf of guinea.

On the south western side of the site is the Tema – Accra beach road and the Gulf of Guinea, which is about 750 meters away.

4.6 Profile of Tema

Tema municipality is a district of Ghana in the Greater Accra Region. It consists of twenty –six communities with the most busiest and popular ones being communities 1, 2,4,7,9 and 13(Sakumono). It is a city on the Atlantic coast, east of the capital of Accra in Ghana.
It was once a fishing village but the decision to construct the new harbor in 1951 created the need for the creation of a town which would provide residential accommodation and urban amenities to the harbor and the labour for the industries associated with it. This brought the Tema Township into being. (Source; www. Ghana Web .com).

CHAPTER 5

5.1 BRIEF DEVELOPMENT

Through research and study of some train terminals in Ghana and abroad and modern trends in train terminal designs, a detailed brief was developed. The design brief is divided into:

5.1.1 Parking areas

This includes	AREA (Sq.m)
1. Long –term parking	1040
2. Short term parking	920
3. Bicycle parking	36
4. Taxi station	645
5. Service parking.	46
6. Trolley parking	59
7. Parking for disabled	108
8. Employee parking.	276
9. Lay bys	300

5.1.2Transition areas

1. Shopping areas.	500
2. Lettable office spaces	154
3. Restaurants	700
a. Kitchen	110
b . Caretaker's office	7.2
b. storage space	20
c. servery	23
d. eating areas	480
e. changing and washrooms	4.5
4. Waiting areas	3750

a. Ticketing areas 153
b. ATM and ticket vending areas 160
c. Retail shops 500
d. Kids game area 506
e. First aid 80
f. Internet cafe 300

5. Baggage section
   a. Temporal goods storage 165
   b. Baggage weighing areas 228
6. Post office
   a. Post office hall 54
   b. Parcels and sorting room 44
   c. Store 9.2
   d. Office 10

7. Washrooms 101
8. Driver restrooms 108
9. Fire control room 11
10. Waste management room 9
11. Platforms 225
12. Security room 50

5.1.3Platform areas.

a. Waiting areas 170
b. ATM and ticket machines area 45

5.1.4Administrative offices

This includes

1. Reception 15
2. General office 41
3. Conference room 20

4.	Engineering and drawing office	40
5.	area manager	35
6.	employee restroom	36
7.	personnel office	45
8.	radio telephone and signal office	15
9.	accounts office	30
10.	CCTV room	15
11.	assistant area manager	6.5
12.	staff canteen	75

5.1.5 Overnight accommodation for travelers

1.	reception	100
2.	21 accommodation facilities	525
3.	Eating area	77
	Circulation -----20%	2636
TOTAL		15817

FLOW DIAGRAM

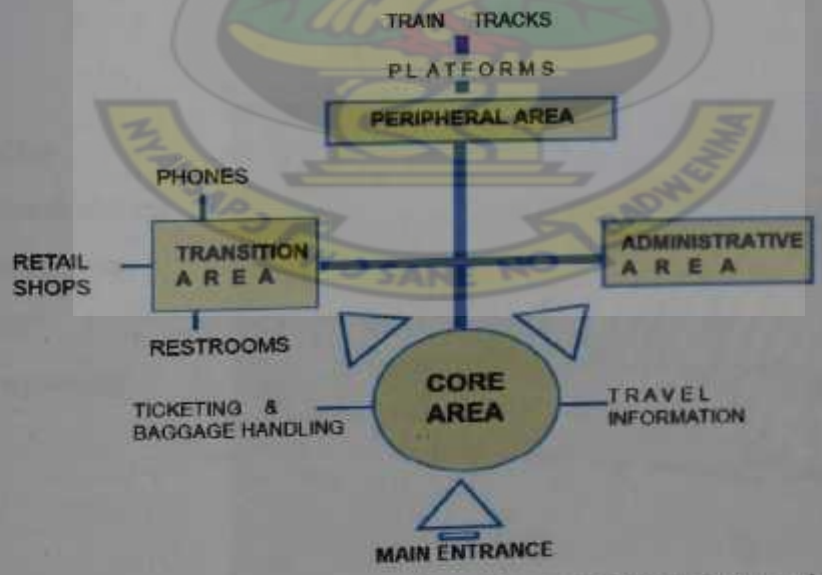


Fig 55 Flow diagram of functional elements within railway stations(source: www.train terminal circulation)

5.2 Conceptual site planning

The conceptual site planning is as a result of careful research, analysis and consideration of the relationships between the various facilities. The conditions and facilities in and around the site influenced the layout of the terminal facilities. The site was divided into quiet and noisy zones. The facilities, namely the main terminal building and the overnight accommodation facilities as well as the various the spaces contained in them had to be laid out to

1. Reduce solar ingress
2. Enhance natural ventilation
3. Make use of natural light

Several sketches were made to respond to the conditions in and around the site with regard to the conceptual site planning. Shape of the site, orientation of the site, access slope structures around the site greatly influenced the layout of the site. Fifty- one thousand of the one hundred and six thousand square meters total area of the site will be used for the design of the terminal and the accommodation facilities. The rest is allocated for future expansion. The various conceptual site layout options which were considered are shown and explained below.

5.2.1 Option 1

1---Terminal building
2--- Overnight accommodation
3---drop off and pickup area
4---customer parking
5---staff and service parking
6---greenery
7---platform area

Fig 56 option one---- Site layout (source: Author)

Merits:

1. Staff accommodation can be maintained and refurbished and used for the same purpose or as an overnight accommodation facility for travelers.

Demerits:

1. Accommodation facility is located very close to the source of noise.
2. Future expansion will affect accommodation facility.
3. Terminal building and the north eastern settlement are not properly linked.

5.2.2 Option 2

1. Terminal building
2. Shopping area
3. Staff & service parking
4. Passenger drop off and pickup.
5. customers car park
6. platform
7. soft landscape
8. lay by

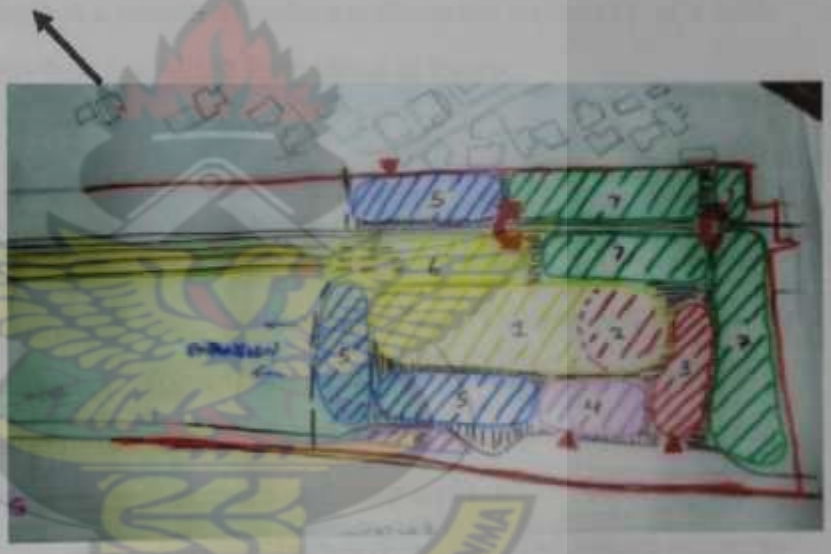


Fig 57 option two --- Site layout(source: Author)

Merits:

1. People from the north east area of site can access the main terminal building directly.
2. Accommodation facility is located at a relatively quiet portion of the site.
3. Future expansion is easier.
4. Accommodation facility and the terminal building can be serviced by one service road.

Option 2 was adopted and refined. This choice is a result of the fact that the advantages of the second option outweighs that of the first option.

5.3 Description of design essentials

The station facilities were divided into three main parts

1. Intermodal access: this refers to site access and parking.

2 The station plaza – this refers to the space or area necessary to facilitate the movement the movement of people from the parking or other means of access to the platform. In this place a person can buy tickets, view public information systems and wait until they are picked up.

3 The platform. A railway platform is a section of pathway, alongside rail tracks at a train station at which passengers may board or alight from trains or trams.

5.3.1 Intermodal access:

All vehicular accesses were taken from the Accra – Tema beach road which lies on the south west of the site. Services had one access, bus and mini vans had one and short, long term, pick up and drop off sharing one access. There is also bicycle and motor cycle access on the same road. Pedestrian access was taken from the south west and north east of the site (this caters for residents in and around Sakumono area).
Vehicular and pedestrian accesses were segregated to avert conflicts and ensure effective circulation to and from the site. Special parking for the disable was provided close to the terminal building.

Fig 58 Site layout(source: Author)

Fig 59 3D impression. View from the north-east (source: Author)

The site layout shows all three main accesses taken from the Accra-Tema Beach road. Two bus lay bys have been provided so as to limit the number of big buses that enter the site. Pick up and drop off area has been located near the entrance. Paid short term and long term parking are located on the south western part of the site. The service access lies on the far right to service the main terminal and the overnight accommodation.

Parking meters have also been provided to generate revenue from the long term and short term parking areas. CCTV cameras have also been provided to monitor activities that take place in the intermodal access areas.

5.3.2 The transition plaza

The design form of the terminal building was dictated by the concept of bringing the train into the terminal so that passengers can experience the pleasure of viewing trains as they arrive and depart. This is reflected in the long south west and north east elevations.

The structural system adopted was space frame with tree-like vertical supports. This helps to achieve long span for free movement of people and good views. The building's functional requirements and facilities necessitated the use of wide spans, swift movement of people and baggage, good views and security. This informed the choice of space frame structure supported by tree-like columns at the waiting area and the platform. Waffle slabs with r.c column supports have been used to span wide floor areas. For the administrative offices, galvanized steel truss have been used for the roof structure.

5.3.3Circulation

The general concourse serves as a meeting point for those who arrive at the terminal. It is wide enough to accommodate heavy passenger volumes moving to and from the terminal. The foyer features a galvanized steel truss canopy that covers portions of the drop off and pickup areas and the general concourse. This is to protect passengers from the vagaries of the weather. At the entrance foyer one can have a feel of the interior space as the frontage of the terminal building is glazed. There are three access and exits to and from the transition plaza. One is for goods and baggage, one serving as the main entrance and the other for emergency exit. Upon entering the facility one can easily locate the information and ticket booths. A conscious effort was made to keep the plan very open as possible to make way finding easier. It also enhances natural ventilation and lighting.

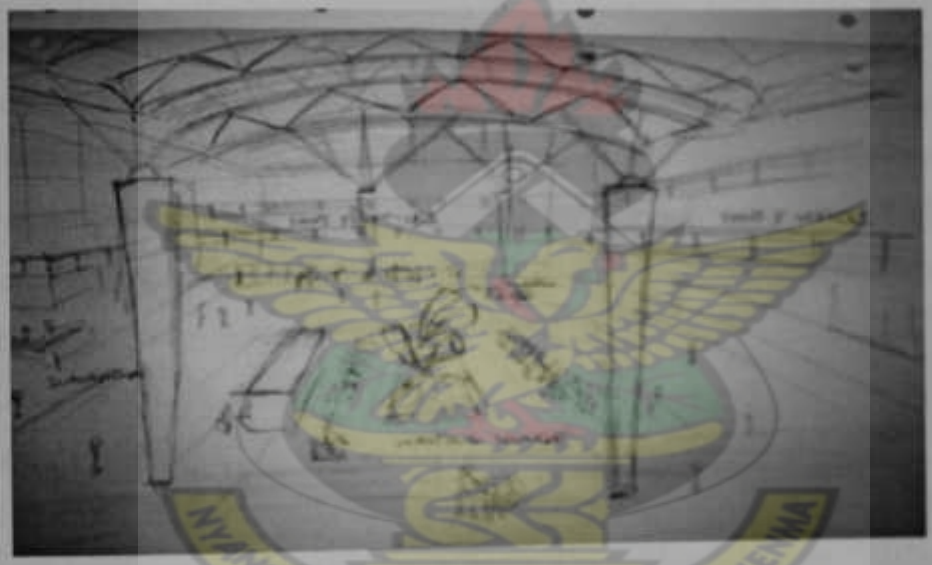


Fig 60 Interior view- The scale of the structure necessitated the need to use wide span structures to make circulation effective. The various retail spaces and offices have been located at the periphery of the site to allow free movement of air and people. Exposing the space frame members in the interior also gives the interior space an interesting ambience.

(source:author)

Considering the width and length of the building, natural ventilation and lighting became issues to tackle. To improve the two there was the need to create an opening in the roof which is open to the sky in order to admit natural light and ventilation within the space. It also creates a very pleasant ambience around the waiting lounge. Beneath the opening is a planter with sweet scented plants to enhance the ambience and collect the rain droplets during raining periods. Around the waiting area and the ticket booths are the postal services, bar, first aid, convenience shop, Atm area, ticket vending machines and phone booths. In keeping with the concept of creating the environment whereby people can enjoy viewing trains as they arrive and depart. In order to make circulation effective there is no change in the slab level within the waiting area and the platform area. Special phone booths, ticket vending machines and ATM have been provided to cater for the disable. To make it easier for people to be able to have a good view unto the platform, waiting areas have been created on the first and second floors with ice-cream stands and other retail shops surrounding them. The waiting areas are also interspersed with planters with sweet scented plants. Escalators with stairs in the middle have been used in order to attract people to the first and second floors where most of the shops and retail stands are located. Two different kinds of restaurants are available. The one on the first floor serves local dishes whiles the one on the second floor serves continental dishes. Two ramps lead people down unto platforms after going through the turnstiles on the first floor.

5.3.4 Information systems.

Public address systems, video surveillance systems and lighting fixtures are fixed in ceiling panels which have been dropped from the space frame. The ceiling panels are finished with fire resistant coating and serves as a buffer between the roofing material and the habitable space beneath it. There are also instant and constant types of information systems located around the waiting areas. They have been located in such a way that they do not impede the movement of travelers and goods.

5.3.5 The platform

Platforms serve as a means by which passengers embark or disembark from the train and this poses a great challenge. First and foremost, the platform design should:

1. Be wide enough to allow a lot of people to embark and disembark from the train at the same time.
2. Have resilient materials as it floor finish
3. Have safety precaution signs provided at places where necessary to minimize accidents within the platform area.
4. Be well ventilated.

The platform type chosen was two side platforms with one island platforms to cater for four different rail tracks. Waiting areas with snack and ice-cream stands have been provided on the platform. This helps to ease traffic congestion on the turnstiles when ones train arrives or depart. To make the platform very effective:

1. The platforms have been designed to have few columns so that travelers can move freely within the platform area. This called for the use of space frame structure as it can span a very wide area.
2. Conspicuous warning strips have also been provided at the edge of each platform to prevent accidents when getting onto the platform.
3. Furniture on the platform are located along the periphery of the area.
4. Emergency exit has been provided on the south western side to cater for emergency situations.
5. The platform height (700mm) ensures that it flashes with the floor of the interior of the spaces .

5.4 Services

5.4.1 Lighting and ventilation

Due to the linear nature of the site coupled with the alignment of the existing tracks the building could not be oriented in such a way that the longest sides face the true north and south. This made it necessary to provide shading devices to minimize solar ingress into the building. The shading devices are made of aluminium jalousies which are arranged in an alternating pattern. A conscious effort was made to create extensive glazing on the south west elevation to open the building up to the prevailing wind direction.

Fig 61 Alternating aluminium jalousie has been used to shade the glazing. It also creates an interesting feature on the south west elevation. (source:author)

Fig 62 . Perspex at portions of the roof helps to bring in natural light into the space. (source:author)

The building employs both natural and artificial ventilation. Natural ventilation is mainly used in the public areas but augmented with artificial if the need arises. Artificial lighting and ventilation are mainly employed in the administrative shops and lettable office spaces.
Emergency lighting systems have been installed along escape routes.

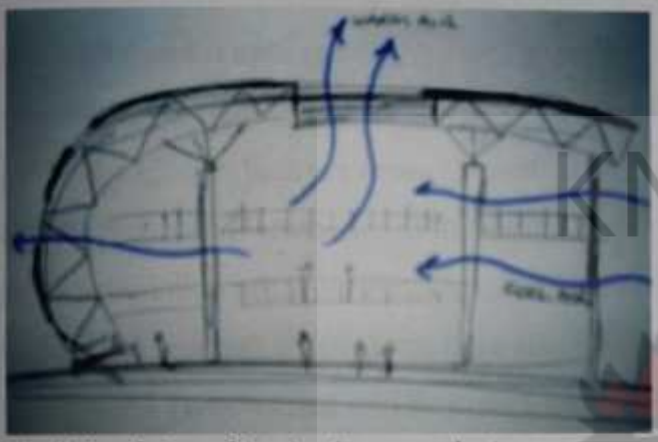


Fig63 Ventilation of interior (source:author)

Fig 64 Detail of opening in roof (source:author)

An opening was made in the roof to enhance the ventilation within the space. Fresh air comes into the space from the south western wall, absorbs heat from the habitable space and then rises through the opening created at the top. Aluminium jalousie dropped from the spaceframe goes round the perimeter of the opening to prevent rain from getting to the waiting area.

5.4.2 Security control

Efforts have been made to ensure the safety of passengers, their goods and baggage as well as the terminal building, its fixtures and fittings. CCTV room monitors all sections of the facility including the intermodal access areas. Also the design was made in such a way that small niches where criminals can hide are nonexistent. The open nature of the plan also makes it difficult for criminal activities in the terminal to be carried out.

5.4.3 Fire control

Fire hydrants have been provided at 50m centres and are connected to75mm diameter ring pipe which is sourced from the mains. The control room also handles emergencies of this nature.

5.4.4 Surface drainage

Surface drainage is channeled through covered drains, falls by gravity and joins the main drains along the Tema- Accra beach road (yet to be constructed).soil waste is collected in septic tank located on the south eastern portion of the site. It is emptied as and when the need arises.

5.5 Landscaping

5.5.1 Soft Landscaping

Landscaping in train terminals design serve several purposes.

Soft landscaping which are drought resistant and require low maintenance has been used to enhance the overall aesthetics of the design. Trees with thick foliage have been planted at the north-eastern side of the terminal to reduce the level noise that reaches the residential area nearby (Sakumono). Shady trees have also been planted at the vehicle parking areas to provide shade for the vehicles that will be parked there. They are also to minimize the area of ground surface exposed to the sun as well as the amount of carbon dioxide that will be generated on the site.

5.5.2 Hard Landscaping

The hard landscaping elements used in the design (pavement and asphalted driveways) have been designed in such a way to well define pedestrian paths, walking patterns and vehicular circulation patterns. Interlocking pavers with colours and textures which complement the colour scheme of the terminal have been used. Garden lamps and bus shelters have also been provided at vantage points.

5.6 Costing

Typical station cost elements for two-platform stations for large intercity Stations

Station element	Capital cost (£m)	Maintenance cost (£m p.a.)
Platform	2	0.05
Canopies	0.3	0.02
Shelters	0.2	0.05
Waiting rooms	1	0.05
Ticket Halls	2	0.05
Staff Offices	1	0.03
Access	2	0.05
TOTAL	8.5	3.0

(source: Accra Train Station Design Report, K. Asomaning, June 2003)

Grand total £8500000

Considering the fact that I am designing a four-platform train terminal, the cost will be twice the the grand total figure above. The cost therefore becomes **£ 17,000,000.** When converted to Ghanaian currency taking into consideration the current exchange rate of GH¢2.35 to one British Pound, it becomes **GH¢ 40,000,000** approximately.

5.7 CONCLUSION AND RECOMMENDATIONS

5.7.1 Conclusion

Ever increasing car ownership ratios in major cities in Ghana, continuous negligence of governments, among others have led to a near collapse of the rail transportation sector.
To revamp this system of transportation, there should be conscious effort by the Ministry of Transportation, The Ghana Railway Company and other stakeholders.

The train terminal when constructed is expected to spark up further development along the beach road. It is also expected that the construction of this facility coupled with the importation of modern rolling stock will to a large extent bring back to life the rail transportation system countrywide.

5.7.2 Recommendation

The following recommendations are in respect of the project.

1. Structures on the site within 50 feet radius from the centre of the rail track should be demolished in accordance with safety regulations.
2. Road lying on the north-east side of the site should be well constructed so that people can have easy access to the facility without using the Accra-Tema beach road.
3. Train halts should be constructed along the Tema-Accra corridor to enable people board trains without necessarily coming to the terminal.

5.8 Phasing

The project should be carried out in phases as indicated below.

Phase 1.....construction of main terminal building

Phase 2.....construction of the warehouse

Phase 3.....construction of the maintenance unit

Phase 4.....construction of overnight accommodation

Phase5.....construction of staff accommodation

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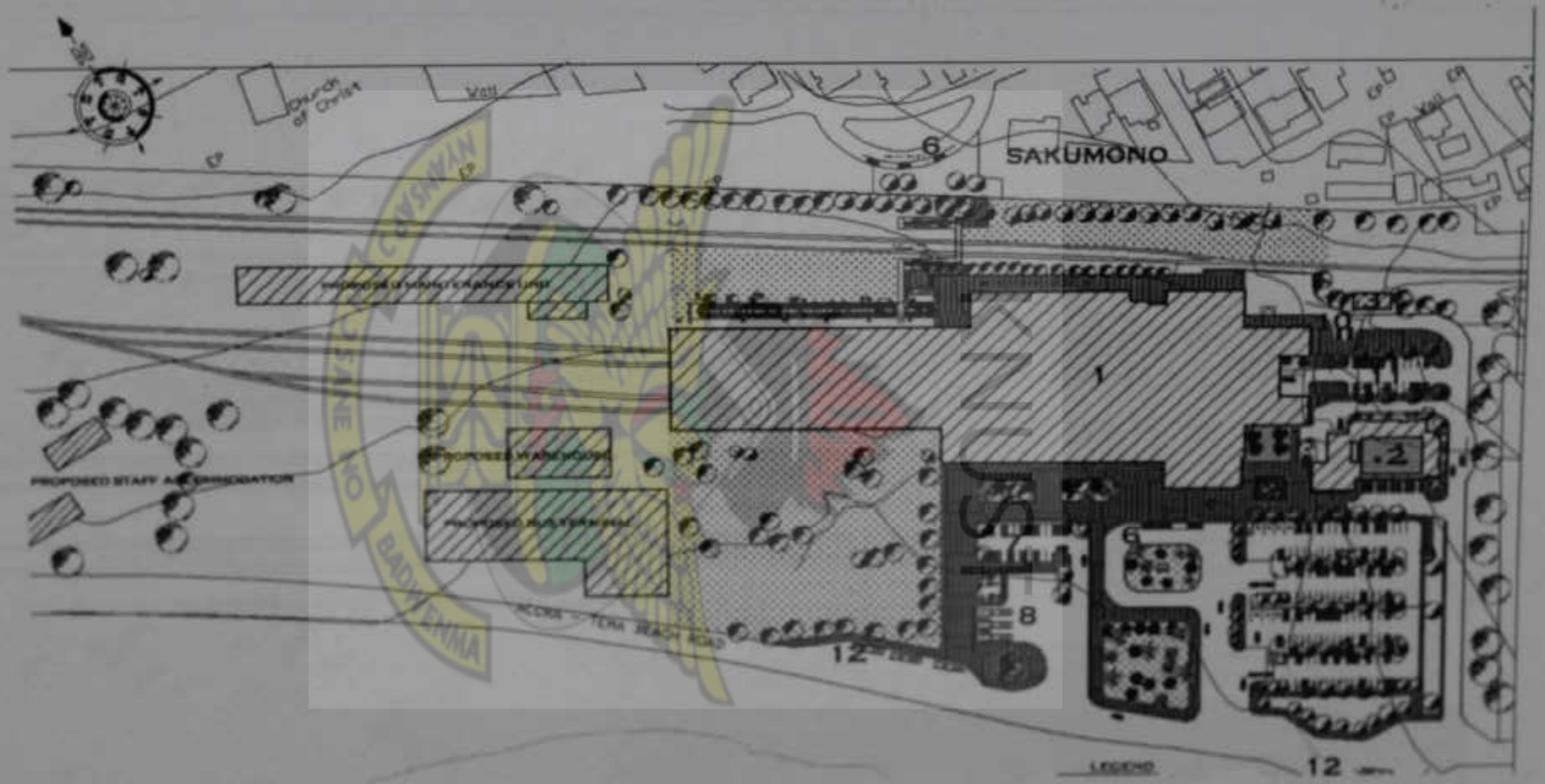
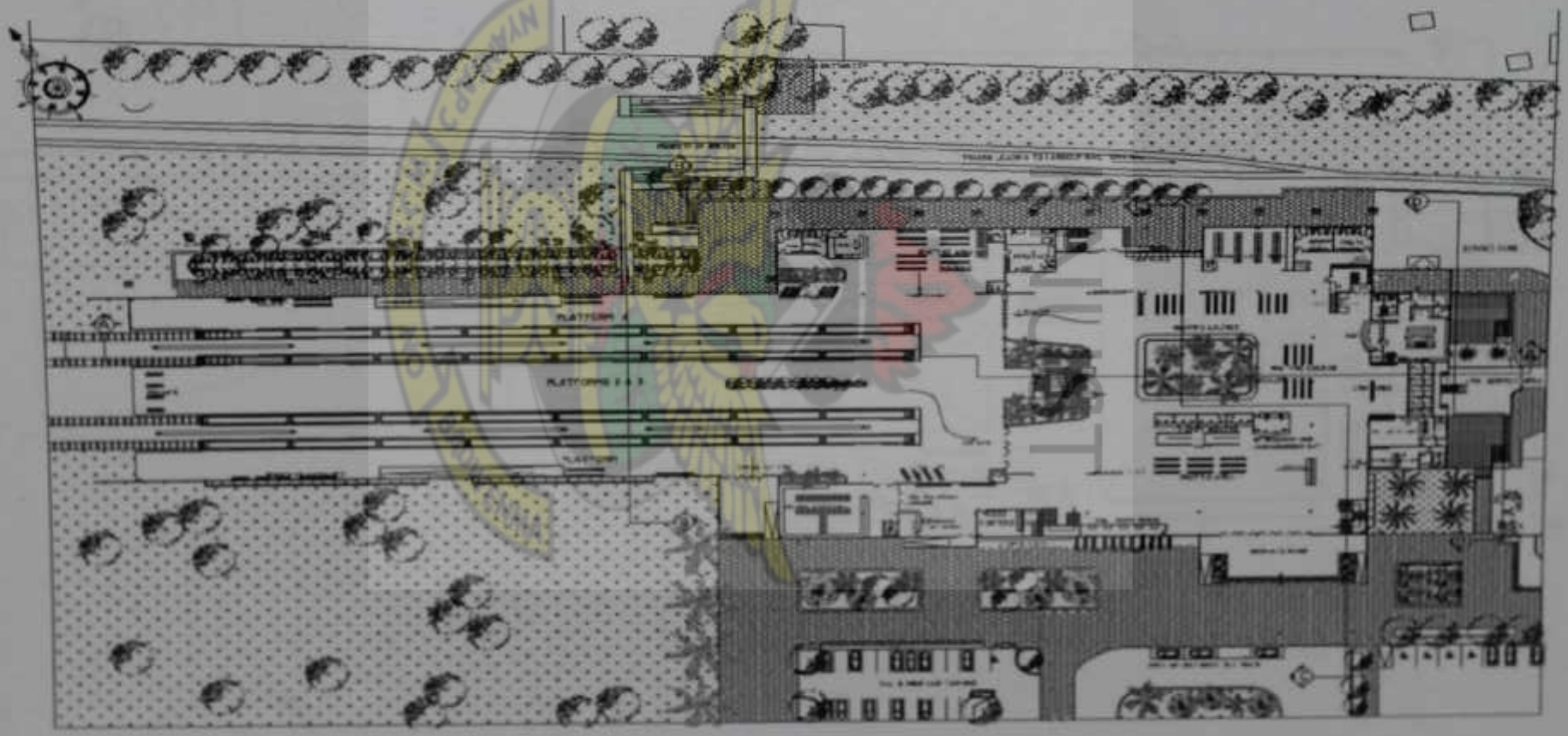
APPENDICES

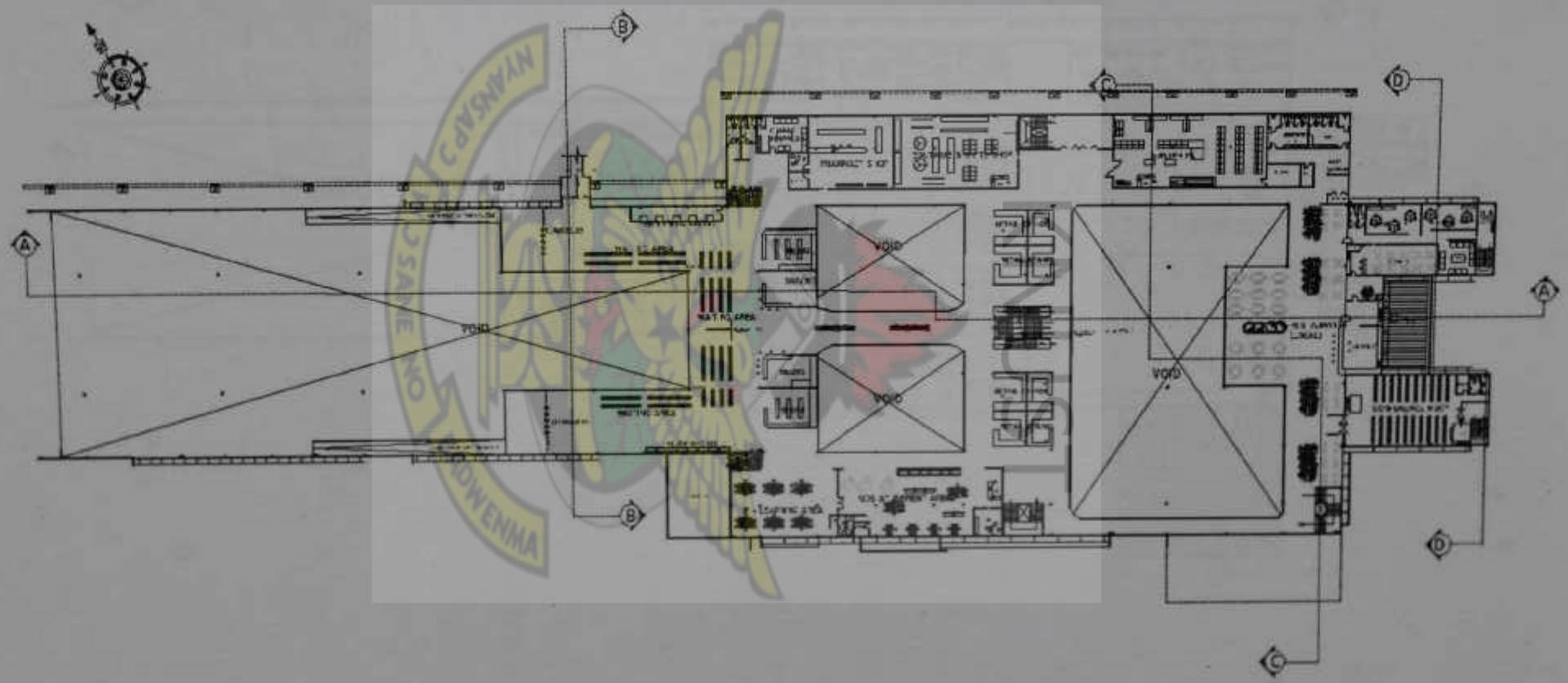
APPENDIX 1. SITE LAYOUT



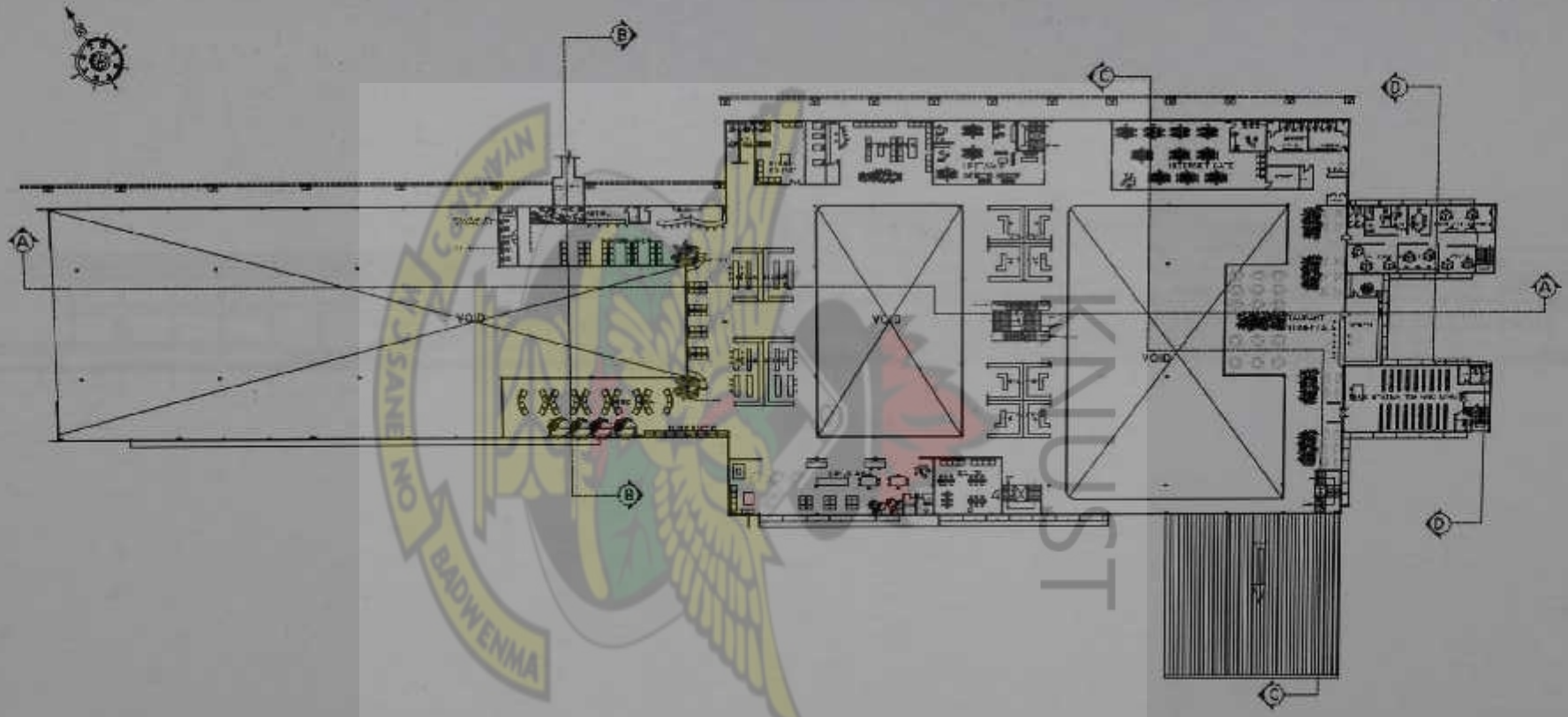
APPENDIX 2. GROUND FLOOR PLAN



APPENDIX 3. FIRST FLOOR PLAN



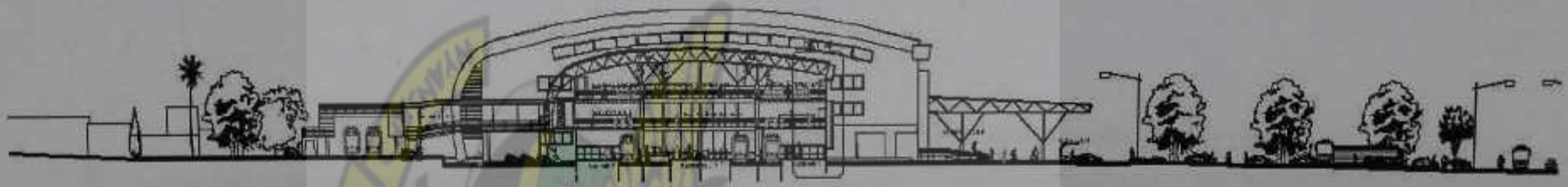
APPENDIX 4. SECOND FLOOR PLAN



APPENDIX 5. SECTION A-A

SECTION A-A

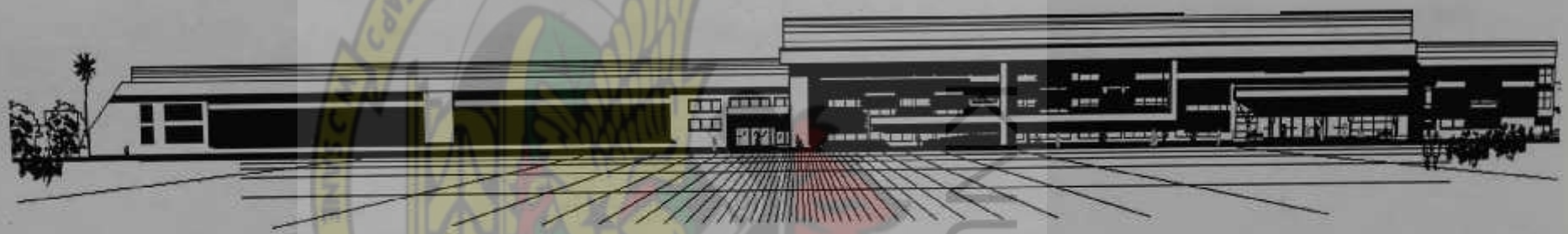
APPENDIX 6. SECTIONS B-B AND C-C



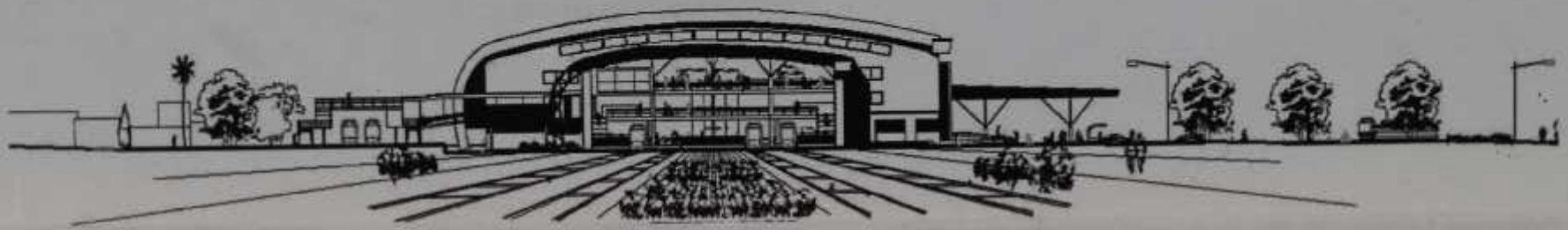
SECTION B-B

SECTION C-C

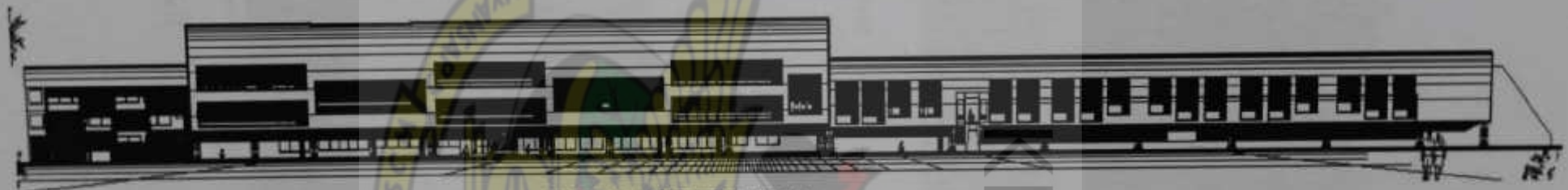
APPENDIX 7. SOUTH WEST AND NORTH WEST ELEVATIONS



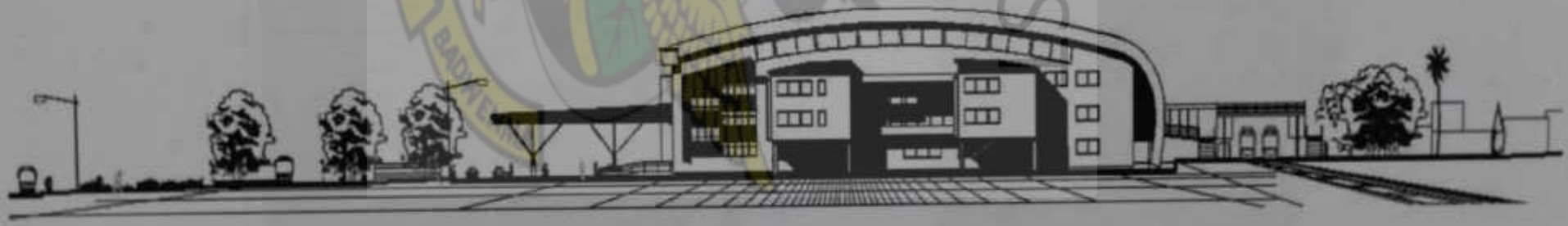
SOUTH WEST ELEVATION



APPENDIX 8. NORTH EAST AND SOUTH EAST ELEVATIONS



NORTH EAST ELEVATION



SOUTH EAST ELEVATION

View from North West

View from North East

View main terminal and overnight accommodation

View of main entrance

View of concourse showing waiting and ticketing area

View of platform area

View of retail area on second floor

View of interior of accommodation for overnight travellers