KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI.

COLLEGE OF ARCHITECTURE AND PLANNING

FACULTY OF ARCHITECTURE AND BUILDING TECHNOLOGY

DEPARTMENT OF ARCHITECTURE

TEMA RAILWAY STATION

(INTER-MODAL TRANSPORT SYSTEM)

BY:

HARRY ASANTE-ODAME

AUGUST, 2009.

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A postgraduate design thesis presented to the Department of Architecture in partial fulfillment of the requirement for the award of Postgraduate Diploma in Architecture.

BY:

HARRY ASANTE-ODAME

AUGUST, 2009.

DEDICATION

To my parents, Mr and Mrs. Asante

DECLARATION

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

Date: 18th September, 2009. Signed: ....

ASANTE-ODAME Harry

(STUDENT)

I declare that I have supervised this thesis project and confirm that it has been wholly undertaken by the student and as such have my permission to present it for academic assessment.

Date: 19th Sept. 2009 Signed: ....

Mr. Ben ODAME

(SUPERVISOR)

Date: .... Signed: ....

Prof. G.W.K. Instiful

(Head of Department)

ACKNOWLEDGEMENT

"Be gone unbelief, my savior is near.

And for my relief will surely appear.

By prayer let me wrestle and he will perform:

With Christ in the vessel, I smile at the storm"

---- MHB 511 -John Newton (1725—1807) ----

My sincerest gratitude to God Almighty, maker of Heaven and Earth for His guidance and protection throughout these years of formal education.

This project has come to a successful conclusion owing to the enormous contribution of some great personalities which cannot be sidelined as far as this project is concerned. Due acknowledgement therefore goes to the following individuals and institutions.

My first and foremost appreciation goes to my able supervisor in person of Mr Ben Odame (Department of Architecture, KNUST) for his intuitive guidance and assistance to produce such a comprehensive document.

My second appreciation goes to the late Mr Ebenezer Abaitey of blessed memory, my first supervisor for the advice and support he gave me and my other colleagues at the early stages of the project. May his soul rest-in-peace.

Many thanks to Mr Nii (Chief Engineer- Accra Railway Station) for granting me and my colleagues permission to carry out studies on the station and also to Mr Gordon (Senior Draughtman) for the relay of information to us in the pursuance of our agenda.

I am also highly indebted to Ayitey Aryee (Former student-Department of Architecture, KNUST), for making available relevant data for my review and site analysis.

The pursuance of this agenda would have come to not without the timely assistance of Architect James Frimpong-Asante (Land Economy, KNUST). God richly bless him.

Finally, I wish to express my profound gratitude to Justice Offei Nketiah, Desmond Opoku and Miss Celestine Kpende for their support. To all who assisted in diverse ways, may the good Lord bless you all abundantly.

TABLE OF CONTENTS **PAGE**

CHAPTER TWO

2.0 LITERATURE REVIEW

CHAPTER THREE

3.1 PROFILE OF TEMA

3.2 THE SITE

3.3 SITE CHARACTERISTICS

LIST OF TABLES

LIST OF FIGURES

CHAPTER FOUR

ABSTRACT

Novelty characterized the Victorian period. It is the period best known for inventions, for remarkable technological advances and engineering technology. The speed of change throughout the period was phenomenal, a movement best encapsulated by the arrival of the steam engine-the locomotive by Richard Trevithick (a British engineer and inventor-1804 in England).

Suddenly it was possible to travel great distances at speeds hitherto unimaginable. Within decades of the first train, a recognizable railway network sprang up. An iron spider's web, it quickly spread out, connecting up most of the country, dissolving distances. People and goods could now move easily around, and with them ideas. As travelling is now relatively cheaper, most can afford to experience the new railways and their destinations.

The population's sense of places is now transformed. No longer tied to a locality, people can move as they wished, changing jobs, towns, religious denomination and status. And this excitement and flux is reflected in the magnificent railway architecture dating from the 1830s onwards.

The design thesis focuses on the reinstating of the country's railway through a proposal for the redesign of a new station at Tema Municipality to cater for the numerous transportation problems associated with the city. This proposal was made after a detailed study of the population dynamics, commercial activities as well as futuristic programmes stipulated for the Tema community.

There was therefore the need to make a bold decision, hence the design of a magnificent structure to serve as node to attract attention and urban development within the Tema municipality. The decision to relocate the station to a new site was crucial, thus, owing to the old site's state and size as against the anticipated volume of traffic in the foreseeable future.

The design evolves out of a purely futuristic architecture with inorganic forms to express movement, dynamism and aggression (a peculiar characteristic of Futurism style of architecture). However, the peripheral warehouses and container terminal informed the decision of wide spanning and roofing making it an icon of Tema township.

CHAPTER ONE

1.1 Introduction

About 5000yrs ago prior to the advent of the motor car, cities were pedestranized. One could only transport people and goods by foot or the assistance of animals (beast of burden) which were most times very cumbersome and unreliable. The advent of the motor car followed by the successful invent of the locomotive steam engine therefore brought much relief to travelers more especially the transportation of goods and services.

Over the years, this invention has undergone series of transformation all with the attempt to make transportation more efficient, convenient and faster.

The railway transportation has developed. Today, Tokyo, London, Berlin and many cities can boast of the efficacy of the railway opening the country for economic development.

The development of railways in most of the developing countries was necessitated by the efforts of the colonial Governments to tap the natural resources of these countries. Ghana is no exception and in her case the railways are concentrated in the south where most of her natural resources are located, dating back as far as 1901.

Ghana's shortly after its independence had the railway as its hub of economic activities. It was focused within the confines of the southern half of the country (noted for its economic viability), which played a crucial role in the evacuation of commodities destined for exports, enhancing social and economic progress. In the peak of performance, the Ghana Railway Corporation now Ghana Railway Company (certificate issued on 7th March, 2001), lifted over two million tons of freight and carried a total estimate of eight million passengers in a year. However, the performance of the railway begun to slide downwards, reaching as low as 350,000 tons freight and a few hundreds of passengers by 1983. This occurred due to a combination of some negative extenuating factors.

Deterioration of the network was marked by frequent derailments, poor maintenance practices, declining traffic and low employee morale. By the beginning of 1983, the whole rail network had collapsed.

Ghana Railways currently has a very small share of the national transport market, with 4% of freight, mainly bulk minerals, and less than 1% of passengers. This project is therefore focused on getting Ghana back to the steel and ascertaining how best specifically Tema (a suburb of Accra, Ghana's Capital Town) could solve its numerous problems associated with road transport by the use of the rail.

Tema is gradually growing in terms of population (209,000-year 2005 census) and the question is ..... *Will the existing roads match up with the population demand of tomorrow?*

1.2 Problem Statement

Coming from a purely freight oriented motive the country saw an economic boom from the haulage in the railway industry spanning the early nineteenth century to the late 90's.

Population density is increasing, accommodation is increasing, economic activities are also booming but one thing is certain, the road networks remains static and inorganic, thus, irrespective of how building accommodation and residents increases, the same road has to cater for it.

This phenomenon therefore poses a great challenge for urban planners and designers since projections for future demography seems to be failing and does not reflect ground values. This therefore explains for the rampant high incidence of motor accidents coupled with traffic jams on our roads.

As a result of migrant activity, coupled with Tema been the industrial nerve of the country, there has been an increase in population in the municipality. It has fully grown to residential community having a permanent and temporal (workers, visitors) population of over 506,400 (census 2000) and 12,000 respectively commuting daily to transact business. Goods and services have to be transported; the road networks are getting choked by the end of the day. Will the railways do the magic?

1.3 Objectives

The objectives of this project are as follows:

1. To design a railway station with all the operational needs of the Ghana Railway Company and infrastructure to ensure sustained smooth running of the station.
2. To create a facility with the objective of making profit, reduce losses and offer employment opportunities.
3. To provide a railway station with the capacity to handle anticipated volumes of passenger and freight traffic in the foreseeable future.
4. To design a station with the capacity to provide services equivalent/ more in quality and quantity to the motor car.

1.4 Scope of Study

The scope of this project embodies:

i. Administrative Area
ii. Travelling Area
iii. Commercial Area
iv. Productive Car Parking (private and public)
v. Ancillary facilities.

1.5 Justification

The transport sector takes up about 70% of the country's annual consumption on petroleum products and about 20%-55% of the country's pollution particles released to the atmosphere come from Transport Sector. (OECD 2001).

This implies that a measure to cut down or divert energy consumption to another form of operation (railway transport) could go a long way to reduce the countries total energy needs and environmental problems respectively. Currently the country is suffering from fuel crisis which puts accession on the need to rejuvenate the railways, reducing the consumption level to as low as 30%.

1.6 Target Group

The facility is to be purposely designed to meet the needs of all classes and age group within and without the municipality. These include:

- Aged citizens
- Adults in the working field.
- School going Children
- Physically disabled ---sight, hearing, limbs.
- Visitors, transitory and tourists

1.7 Client

- Tema Development Corporation
- Ghana Railway Company Limited
- Ministry of Ports, Harbours and Railways

1.8 Client's Brief

- Operational offices with Administrative Offices
- A station building with all the Traveling and Ancillary facilities.

1.9 Funding of proposed project.

It is proposed by the Ghana Railway Company Limited to engage the full partnership of the following stakeholders for the purposes of funding the railway operations.

- ***Ghana Government.***
    - $US90 million has been committed by the government towards railway rehabilitation in the country's western and eastern regions,
    - Funding has come from OPEC to the amount of U$ 5 million and from the Government of Ghana (U$ 500,000).)
-

- ***Private Sector Involvement:***
    - Canadian International Development Agency (CIDA)
    - Chinese manufacturer Tanshang Locomotive is to supply new diesel multiple-unit suburban trains for service in Ghana. Voith Turbo will equip each set with eight motor-transmission units,

Other sources of finance for its activities include funding from donor countries, grants, plough back profit and loans.

1.10 Anticipated Challenges/limitations.

The following challenges are likely to be encountered.

- Political Influence
- Lack of Education and awareness on the part of users
- High capital cost in the acquisition of Rolling stocks
- Controversy over timetable and fare system
- Meeting the needs of all classes of people and age.

1.11 Methodology

For the purposes of raising a good base to buttress the project, data was gathered from both primary and secondary sources.

Primary data refers to information directly collected from workers and officials in the railway Company (Accra-Tema to be precise) and other agencies directly involved in the management of the industry.

The other source of data collection, thus the secondary source was through published data; newspapers, journals, books, reports, the internet and magazines from the Ghana Railway Company and Ghana Statistical services. Unpublished reports of students who had embarked on similar projects for the time past were also source with due permission and acknowledgement.

CHAPTER TWO

LITERATURE REVIEW

2.1 HISTORICAL DEVELOPMENT OF RAILWAY TRANSPORTATION IN GHANA.

The development of railways in most of the developing countries was necessitated by the efforts of the colonial Governments to tap the natural resources of these countries. Ghana is no exception and in her case the railways are concentrated in the south where most of her natural resources are located.

The first railway was constructed to link the gold mining town of Tarkwa to the port of Sekondi in 1901. This was to carry the gold to the port for onward shipment to overseas countries.

The line was later extended to the mines at Obuasi in 1902 and then to Kumasi in October 1903 to maintain a peace keeping colonial garrison after the Yaa Asantewaa war of 1900.

In 1905 a line was constructed from Accra to Kanyeasi to carry cocoa from the Eastern Region to the Port of Accra. This was later extended to Kumasi in July 1923, also to carry cocoa and general traffic. This line forms the present Accra-Kumasi railway.

After four years of silence, constructional work started again and in 1927 a line was constructed to link Huni valley, through Oda to Kade in the diamond area of the Birin Valley. This line also carried considerable quantities of timber and cocoa to the Sekondi port.

A branch line from the Sekondi-Kumasi line had by 1912, been taken to another gold mining town (Prestea).

The introduction of motor transport around the nineteen thirties (1930's) halted further construction of the railways until 1942 when due to war-time requirements, a branch line was taken from Dunkwa to Awase to exploit the bauxite resources.

The construction of a new harbour at Takoradi called for a line to link Sekondi and Takoradi in 1928.

Between 1954 and 1956, the Volta River Project necessitated a link between the central and eastern provinces lines at Achiase and Kotoku. Within the same period a line was constructed between Achimota Junction and the new harbour at Tema.

Ghana's railway system currently has a total length of 947 kilometres made up of the Western, central and Eastern lines and some short branch lines. As shown on figure 2.1, (green lines-central, red- eastern and yellow- western line) this system connects the cities of Accra, Koforidua, Kumasi and Takoradi-Sekondi with many stops along the line (all halt stations are shown on the map). The railway extends through the five regions of the southern Ghana but not to the regions in the Northern and some eastern parts of the country. Ghana Railways is headquartered in Takoradi. The railway network is based on a single-track system of metric gauge, except for the 30-kilometre Takoradi-Manso section which is double track. This is further explained in figure 2.1 below:

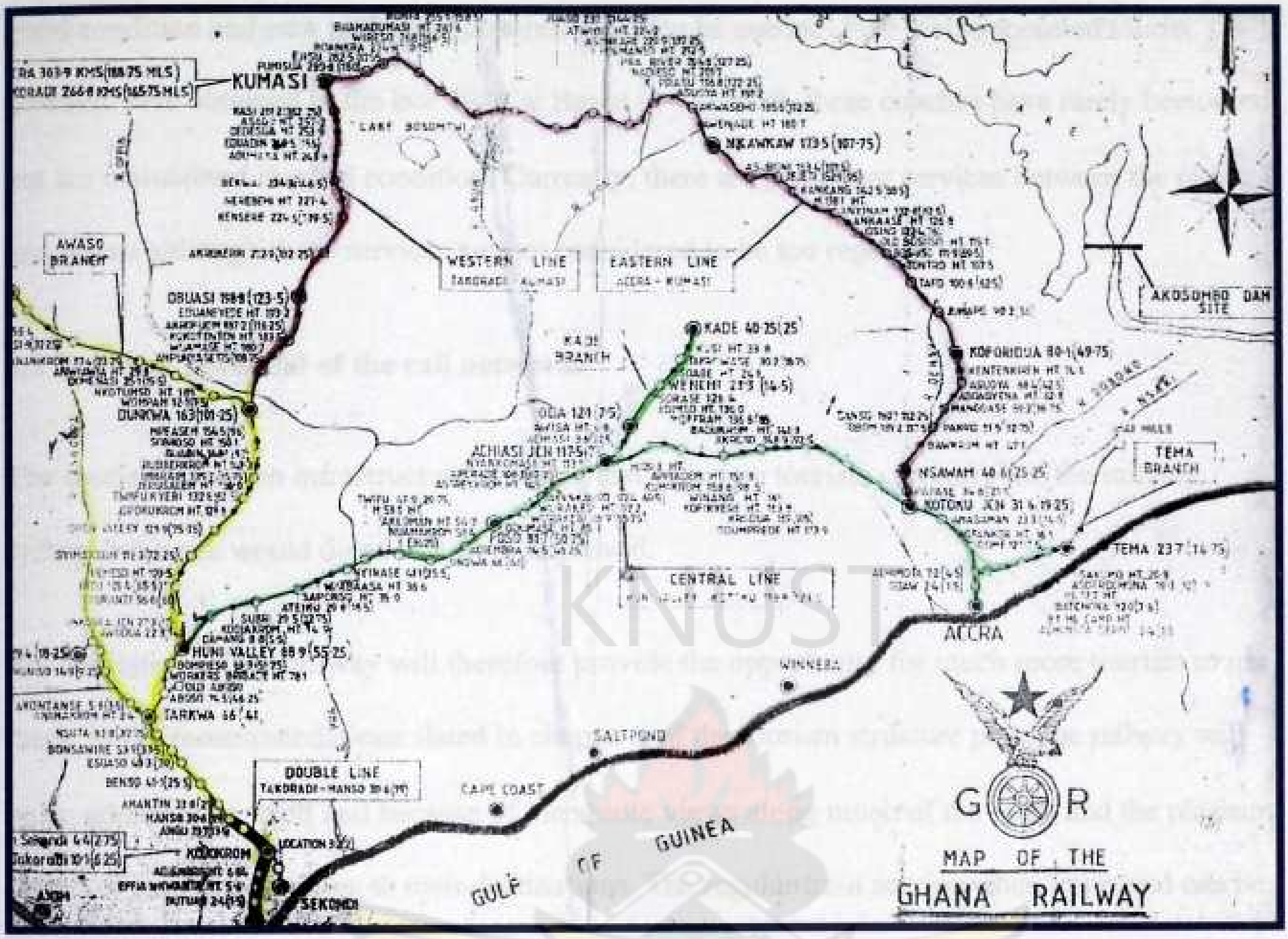


Figure 2.1 The three main lines. (Central, Eastern and Western)

The railway system dating from the late 19th and early 20th centuries, has been undergoing rehabilitation work since 1985. The first stage of the project rehabilitation involved 197 kilometres of tracks, signal and communication system on the Western line. The second and third stages to be completed in 1996, involved the central and Eastern as well as Western lines. Train stations are generally antiquated and required upgrading.

Present locomotives are generally old but three new locomotives were purchased in 1995 and 14 more are planned to be received. There is a total stock of 159 of various types of passenger coaches, most of which are in effective service. However, many of these are not in particularly good condition and new passenger coaches will also be needed. Five well-appointed tourist coaches were obtained in the late 1980's. Based in Takoradi, these coaches have rarely been used but are maintained in good condition. Currently, there are passenger services between the cities and towns although these services are not considered to be too regular.

2.2 Tourism Potential of the rail network.

The tourist survey on infrastructure revealed that very few tourists currently use the railway system but more would do so if it were improved.

Rehabilitation of the railway will therefore provide the opportunity for much more tourists to use them. In the recommendations slated in chapter 5 of the tourism structure plan, the railway will be an attraction in itself and because of the scenic views along much of the route and the pleasant means of tourists travelling to their destinations. The regular train service when improved can be used by tourists utilizing the passenger coaches. Especially important is to utilize the existing tourist coaches. These can be used both for regular tourist service and for charter coaches service depending on the need. Special charter coach service organized for tour groups as part of their tour package could be promoted as an interesting touristic experience.[1]

When the present railway rehabilitation programme is completed and traffic volume increases as it is expected to, consideration can be given to extending the railway system to Akosombo which would provide a link from the port to the dam area for conveyance of freight. This link would also serve tourists wishing to visit Akosombo from Accra. Commuter services are currently under construction since its abandonment and its maintenance problems. If commuter services could be resumed soonest, it would ease the traffic congestion in the major cities.

2.3 Summary on the evolution and construction of the Railway

The following is the development history of Ghana's Railway System:-

1898: Construction began from Sekondi on the West Coast of Ghana.

1901: First section of line to Tarkwa, a distance of 66km completed.

1902: Second Section, Tarkwa-Obuasi, 133km from the Coast completed.

1903: Final section, Obuasi-Kumasi, of the Western Line which covers a distance of 267km from the coast was opened.

1912: First section of Eastern Line, from Accra to Mangoase was opened. 29km Branch line, Tarkwa-Prestea was completed.

1923: Rail Line from Accra reached Kumasi, completing a thorough-but-circuitous route of 571km from Sekondi to Accra via Kumasi.

1927: Branch line 158km long from Huni Valley to Kade was opened to serve the Central Region and part of Eastern Region.

1944: Dunkwa-Awaso branch line 73km was completed.

1954: Achimota Junction-Tema line, 16.5km was opened.

1956: 81km link from Central Line at Achiase to Kotoku on the Accra-Kumasi line was opened. The line was put into full operational use on 3rd June, 1957. The construction of the Achiase-Kotoku line established a direct route of 320km from Takoradi to Accra via Achiase Junction.

2.3 Performance

a. 1903 – 1983

In the early post-independence period, the railway was the hub of economic activity in its corridors of operations. It played a crucial role in the evacuation of commodities destined for exports thereby enhancing social and economic progress. At the peak of its performance, the railway lifted over two million tons of goods traffic and carried some eight million passengers in a year. Thereafter, the performance of the railway started to slide downwards, reaching a low of some 350,000 tons by 1983. This occurred due to a combination of negative factors.[2]

b. Recent Performance 1984-2001

Performance of freight and passenger traffic has changed with time. In earlier times, the network conveyed substantially more traffic, about 2 million tonnes of goods traffic and 8 million passengers, but by 1983, goods haulage slumped to an all-time low of about 350,000 tonnes. General decline in the economy and the physical deterioration of the network were largely to blame for the fall in traffic.

Following completion of rehabilitation of the Western Line in 1988, both passenger and freight traffic improved significantly but dropped in the ensuing years as a result of shortage and unreliability of mainline locomotives. With the procurement of locomotives and vans, the freight traffic increased to 743,000 tonnes in 1988 and has been increasing ever since. (See Tables IV and V)

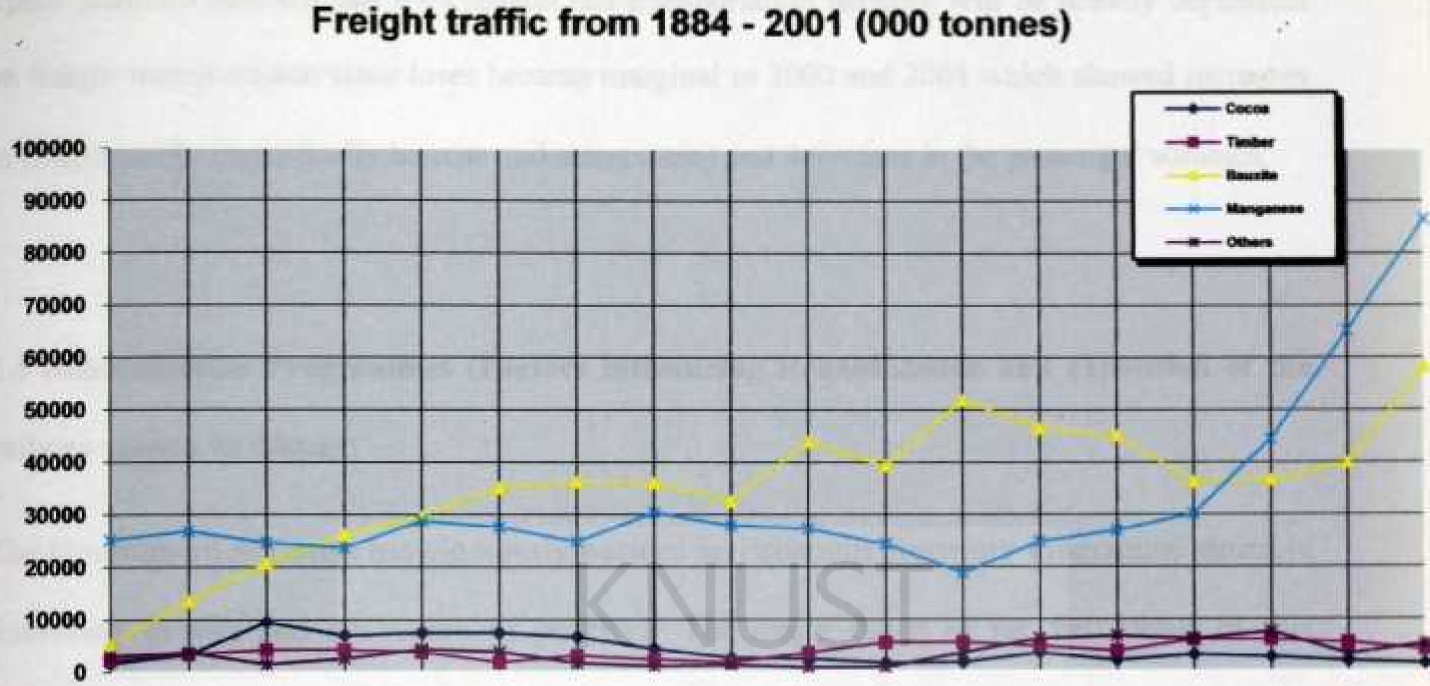


Figure 2.2 Statistics of freight traffic from 1884-2001

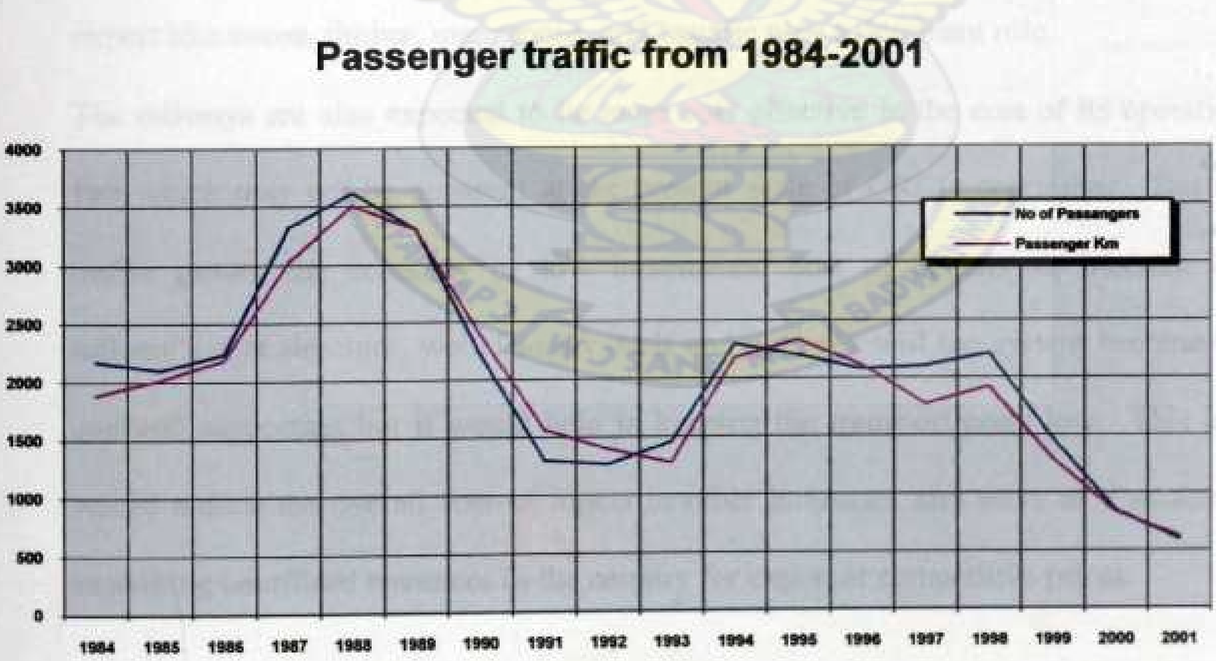


Figure 2.3 Statistics of Passenger traffic from 1884-2001

These statistics indicate that a successful rail transportation network will be heavily dependent on freight transportation since loses became marginal in 2000 and 2001 which showed increases in freight traffic (specifically bauxite and manganese) and decreases in the passenger volumes.

2.4 Rehabilitation Programmes (Factors influencing Rehabilitation and expansion of the railway system in Ghana)

The Government of Ghana has vigorously pursued an Economic Recovery Programme aimed at fomenting growth and alleviation of poverty. The major thrust of the first phase of this Programme was rehabilitation of Infrastructure, particularly within the Transport Sector. The railway network was recognized as crucial to the transport needs of the economy particularly in the following areas:

i. Firstly the rail network provides vital support to the export sector in which commodity export like cocoa, timber, manganese, and bauxite play a dominant role.

ii. The railways are also expected to be more cost effective in the area of its operations, a fact which may not be apparent at the present scale of GRC's operations. But as the traffic grows, the economy of low incremental cost of operations, inherent in the railway's cost structure, would assert itself and not only will the system become viable and self supporting but it would help in keeping the transport costs low. This in turn would reduce the overall cost of inputs in other industries and serve as a stimulus for exploiting unutilized resources in the country for export at competitive prices.

iii. Moreover, transportation by rail would result in reduction in the consumption of petroleum products because railways are more energy efficient as compared to other modes of surface transport. This is of special significance because of the country's dependence on imported petroleum products.

iv. Lastly, railways alone can provide bulk and timely movements to take advantage of special freight offers by ships visiting the country.

These are purely economic considerations and there are many social benefits too, like relative comfort and safety of rail travel, less resultant pollution, and comfortable night travel leading to saving of day time and addition to productive time, which have weighed with the government in assigning a vital role to railways in the overall scheme of meeting the transport needs of the country.

The rehabilitation of railways was, therefore, accepted as a cornerstone of the Economic Recovery Programme launched by the Government and serious efforts have been made within the framework to rebuild the lost capacity on Railways through rehabilitation of infrastructure (track, signaling and telecommunication), acquisition of locomotives, wagons and passenger coaches and the erection of modern railway stations.

The Rehabilitation Programme of Ghana Railway commenced in 1983. The total investment as at August 2002 was about US$256 million.[3]

2.5 Assets - Current State of the System

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

a. **Tracks**

The Ghana Railway Corporation operates a network with a route length of 947 kilometers of metric gauge. The Western Line with a route length of 340 kilometers links Takoradi Port to Kumasi and Awaso and is by far the busiest. The 304 kilometers stretch from Accra-Tema to Kumasi makes the Eastern line, while the Central line covering a distance of 199 kilometers links together the Western and Eastern Lines to create a pattern like the letter "A". Altogether, the total track length is about 1300 kms.

Western line, the principal export corridor, is equipped with 80lbs and 90lbs rails on the main line and 75lbs and 60lbs on the Awaso and Prestea Branch lines respectively. Eastern and Central lines are equipped with a mixture of 60lbs and 80lbs rails.

Except few areas where steel trough sleepers 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 are diesel-electric. In the early years of its establishment, steam locomotives were being used. However, since the early 1980's, the steam locomotives have all been phased out and GRC now operates mostly Diesel-Electric locomotives.

Until June 1983, GRC suffered serious Motive Power difficulties. With the delivery of twenty-six new locomotives under the third phase, the Power problem has been addressed, bringing the total locomotive fleet to 61.

c. **Coaches/Wagons**

As part of the phase three project, 100 covered steel vans were procured. Altogether, there are some 652 wagons/coaches in service. The coaches which were delivered in 1986 are being rehabilitated.

2.6 PLANS AND PROGRAMMES

2.6.1 Expansion Programmes

Expansion of National Railway Network

As part of the Ghana Government long term development plan it is proposed to expand the existing rail network from southern Ghana to northern Ghana, This will pave the way for linking the country to our neighbouring countries like Burkina Faso, Mali and Niger in the North.

It is also proposed to expand the existing Central line to link our Eastern and Western neighbouring countries; these are La Cote d'Ivoire, Togo, Benin and Nigeria. A link from Tema to Akosombo is also proposed to facilitate internodes transport between rail and the Volta Lake.

In view of the above, the existing lines have been redesignated as follows:-

i. **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

ii. **Eastern Line:-**

Accra – Kumasi –Techiman –Fufulsu – Tamale – Bolgantanga –Paga with branch lines from Achimota to Tema and Tamale toYendi and Bosuso to Kibi

iii. **Trans Ecowas Line:**

Aflao – Tema – Kotoku –Tarkwa – Prestea – Omape

iv. Tema – Akosombo Line (See attached maps)

The expansion programme will include improving and modernisation of the existing network. The total cost is estimated at US$1,655.24 million.

PROPOSED LINES

Figure 2.4 Proposed railways line map of Ghana.

2.6.2 Sub- Urban Rail Network

In order to address the above issues Ghana Railway Company Limited (GRC) proposes to introduce commuter Rail Transportation Services within Accra-Tema Metropolis using Diesel Multiple Units (DMU).

Proposed Lines

The Project will involve the upgrading of the existing lines and construction of new lines. The existing and the proposed lines are:-

a. Existing Lines

Accra – Nsawam

Tema – Achimota – Accra

b. Proposed Lines

Accra – Kasoa

Accra – Dansoman

Accra – Dodowa

The gauges for both the existing and the proposed lines shall be 1435mm (standard guage).

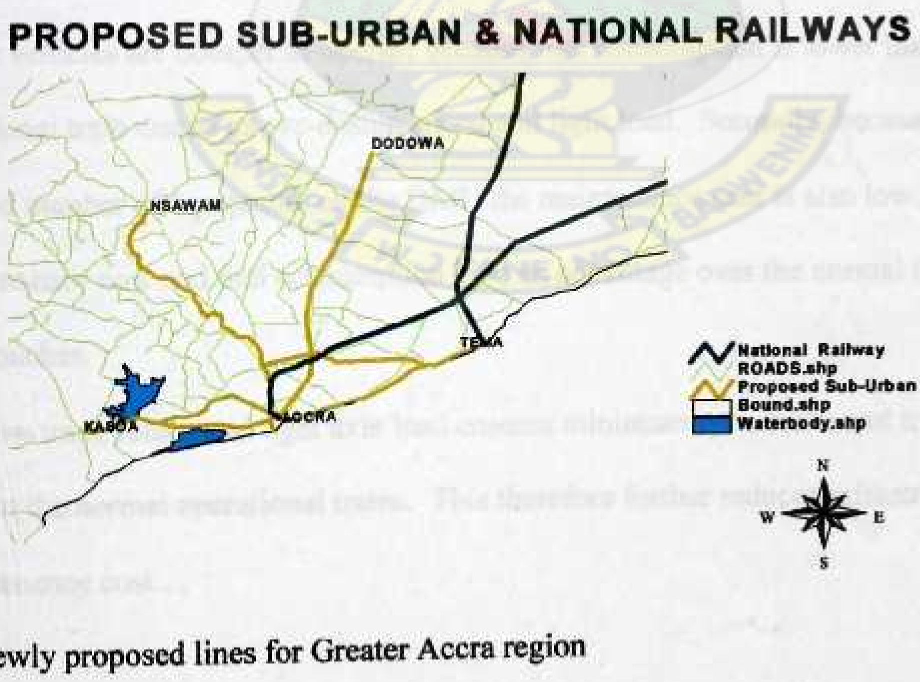


Figure 2.5 Newly proposed lines for Greater Accra region

Rolling Stock

The commuter services shall be run using Diesel Multiple Units (DMUs) instead of coaches hauled by locomotives. Each unit will consist of:

a. a diesel power (engine) with normal transmission to the wheels for traction, and,

b. trailing coaches (or cars) which may be 3 or more depending on the requirement

The DMUs have the following advantages over the ordinary locomotives and coaches:

i. Frequent stoppage at short intervals;

ii. Drastic reduction in shunting time at terminal and junction stations thus decreasing journey and turn round times

iii. DMUs provide quick acceleration and deceleration which is necessary due to the frequent stops at stations at short intervals of about one kilometer.

iv. The initial cost is very low as compared to a complete train (ie. 4 coaches of DMU will be cheaper than a complete locomotive with 4 coaches).

v. These vehicles are cheaper to operate because fuel consumption is lower than the traditional train due to its pre-design speed and light load. Secondly, because of the limited number of equipment on the DMU the maintenance cost is also low. This low maintenance cost and fuel consumption give an advantage over the normal locomotive and coaches.

vi. The low track forces and light axle load ensures minimum tyre, brake and track wear as against the normal operational trains. This therefore further reduces infrastructure maintenance cost.

vii. The DMUs have designs which incorporate standard train equipment e.g. Engine, Traction Motor, Lighting, Brake Equipment, etc. used in GRC. These are interchangeable with standard equipment on our trains for easy maintenance.

2.7 Future of Railway in Ghana

With these plans, programmes and projections, the future looks bright for the Railway in Ghana. The extension of the railway to the northern parts of the country would open up the whole country and ensure the bulk and timely movement of goods within the country. This is especially so in the case of agricultural produce from the production centers to the marketing centers, and also manufactured goods from the factories to the marketing centers.

The movement of people and goods in the country would result in cheaper transport costs and thereby make prices of goods and services affordable in the country.

[1]The proposed plans would make the existing and proposed Eastern Line very viable and contribute to the development of the Railway and reduce dependence on the Western Line which is presently the mainstay of the system. The traffic forecasts for the short to medium term plans are given in Table VII

[1] Ghana Railway Company

2.8 RAILWAY ARCHITECTURE

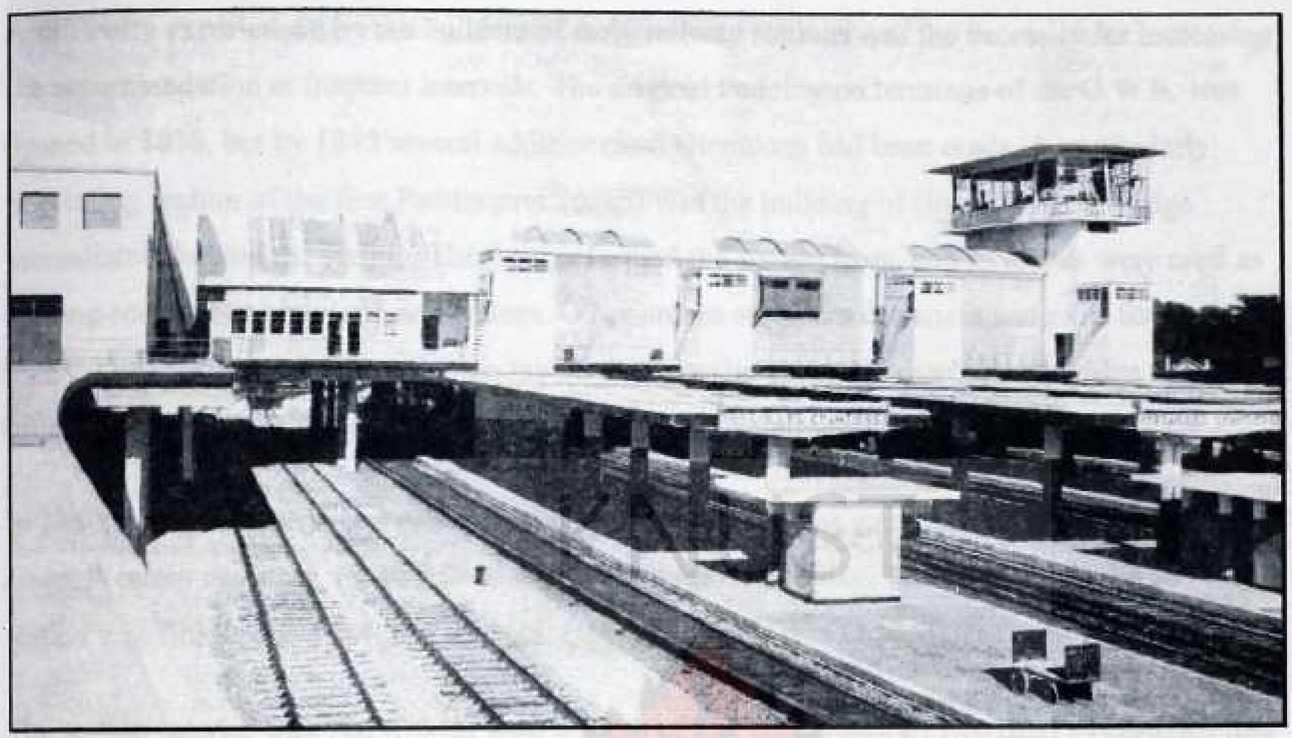
2.8.1 Designs That Combine Elegance and Utility

The primary function of any railway is admittedly to transport both passengers and goods in the minimum of time and with the maximum of safety. In modern conditions considerations of comfort also weigh heavily with the travelling public. In addition to comfort, we have the aesthetic aspect of railway work. The days of hideous stations, ugly administrative buildings, and signal cabins or bridges that spoil the landscape are rapidly passing. Modern development enlists the services of the trained architect for planning railway buildings—from the smallest signal cabin to the stately and beautiful stations to be found all over the world to-day.

Architecture has inevitably undergone many changes during the last century—conforming to public needs, popular taste, and the opportunities presented by improved methods of construction. Its application to railway work has also changed with the times; the old Victorian buildings offer a striking contrast to the imposing structures, in steel and concrete, of the post-war period.

The evolution of the modern railway station provides many outstanding instances of the architect's services to the engineer. Primarily a station was regarded as a starting-point or stopping-place for trains. The first obvious provision was one or more platforms to facilitate the entering and leaving of trains. Barriers to exclude the non-travelling public, ticket-offices—bearing little resemblance to the old coach booking-offices—and waiting-rooms followed in due course, together with roofs to cover at least part of the platforms.

Large numbers of stations, particularly in country districts, were built of wood, gradually giving place to brick buildings as additions followed increasing traffic. Most of the important terminal stations, even in the early days of railways, were generally built with lofty arched roofs. Apart from the convenience in construction, this type of roof permitted the escape of smoke from the locomotives standing at the platforms.



UNUSUAL DESIGN. A modern railway station at Versailles. The station is served by both steam and electric trains, and is on the system of the French State Railways. There are four double platforms each 1,312 ft. in length.

A natural development of the main terminus was the inclusion of the company's administration offices in the station buildings. The use of the single-span arched roof for station work has been a feature of railway architecture for many years. Examples of such roofs are to be found at St. Pancras, Cannon Street and other London stations. Frequently the roof is divided into three arches, as at King's Cross Station, London, and in recent times at Milan, one of the most remarkable stations in the world.

In former days a station roof would serve a double purpose—to protect the premises from the weather and also to collect water for use in the locomotives. An interesting example of this practice was the old station at Selby, Yorkshire, built in 1835. This station cost £10,300 to build, and is still in existence, although now used exclusively for goods traffic. In its original form the station comprised a series of sheds over the lines with offices and warehouses adjoining. The trussed timber roofs of the sheds were in three parts, supported on hollow cast-iron columns. It was through these columns that the rain-water for the locomotives drained into underground tanks. Selby Station, together with the Leeds terminus of the old Leeds and Selby Railway, had no platforms or waiting-rooms, and each station served for both goods and passenger traffic.

A difficulty experienced by the builders of early railway stations was the necessity for increasing the accommodation at frequent intervals. The original Paddington terminus of the G.W.R. was opened in 1838, but by 1845 several additions and alterations had been made. A particularly interesting feature of the first Paddington Station was the building of Bishop's Road bridge immediately behind the station. This bridge formed the station front, and its arches were used as waiting-rooms, booking-hall, and offices. Other arches served as entrances and exits for carriage roads. The goods depot at Paddington lay on the opposite side of Bishop's Road bridge to the original passenger station, which was in use for some twelve years.

In 1850, however, traffic had grown to such an extent that plans were put in hand by Brunel, the Great Western engineer, for Paddington Station as it exists to-day. The main portion of the station was finished in 1854, and the total cost of the work was £650,000.

The station interior was 700 ft. long with a width of 238 ft., divided by two rows of columns into three spans of 68, 102 and 68 ft. At two points the main building was crossed by 50 ft. transepts, accommodating large traversing frames for moving locomotives or rolling-stock from one track to another. The supporting columns were bolted down to large masses of concrete and the roof was carried by wrought iron arched ribs, covered partly with corrugated iron, and partly with glass. The station of 1854 was in use without extension for more than fifty years. Brunel was assisted in the ornamental details of the work by the nineteenth-century architect. Sir Matthew Digby

DORIC COLUMNS are embodied in this entrance to Euston Station, one of the L.M.S. London termini, which is a fine example of neo-classic architecture. The arch was completed in 1839 at a cost of £35,000. The stone was brought from Bramley Fell quarries in Yorkshire.

A feature of the station decoration was the iron scroll work at the western end, which was not removed until the early part of 1935. At the eastern end was built the Great Western Hotel. Under the hotel are entrances to the London Underground Railways.

The design of railway stations has led to the adoption of an infinite variety of types, depending on local circumstances and requirements. Considerations of space have led to some rather unusual arrangements in railway-station planning. At Sydenham Station on the Southern Railway suburban line the down platform does not face the up platform, which is built farther south, on the opposite side of an over-bridge carrying a roadway The south end of the down platform is not connected with the north end of the up platform except by the road bridge. The station has been built in this curious shape because of the lack of building land opposite either platform. The situation of a station is generally governed by the proximity of a town or village to the line, and the site chosen is naturally as close as possible to a main road,

Where a road crosses the railway, a very popular position for the main station buildings is on the road bridge, with long ramps leading down to the platforms below.

The design of any station depends mainly on the requirements of its position and the convenience of the buildings both for the use of the railway staff and of the travelling public.

The design of the large stations, particularly where the frontage of the street is occupied by a large railway hotel, has usually followed the architectural tendency of the period. The Georgian and Victorian styles of building are exemplified in the older railway stations and hotels of Great Britain, but new construction has shown a decided tendency to strike a modern note.

Many notable examples of modern architecture are exemplified in station buildings both in Britain and abroad. An example of construction in reinforced concrete is to be found on the Northern Railways of France at Lens. Interesting features of this station are its concrete clock tower and the twin pylons that carry the telegraph wires. The cross-ties of these pylons above and below the insulator bars produce an effect reminiscent of the bead-frames used by children in the earliest stages of their mathematical education

THE CENTRAL TERMINAL AT BUFFALO is one of the most modern buildings on the line of the New York Central Railroad between New York and Chicago. The station is a 436 miles rail journey from the east coast of America.

France also provides another fine example of modern architecture in the station at Versailles, the severity of the curved facade being relieved by the arched windows that incorporate double swing doors giving access to the spacious booking-hall. The single span arched roof is glazed in a lace pattern with square and circular panes of glass, giving a pleasing effect. One end wall, above the ticket office windows, displays a huge map of Western France.

Facing the entrance doors is a fine clock, without numerals, flanked by rectangular indicators providing particulars of train departures and arrivals. The galleries leading from the booking-hall to the platforms are designed on the same generous lines with walls panelled for the display of artistic posters depicting places served by the station.

Many remarkable stations have been built in recent years in the London district to serve the ever-lengthening tentacles of the Underground Railways. Some of these stations are in almost rural surroundings, and the architects have taken every advantage of an opportunity to combine the practical with the artistic in evolving their design.

Some fine stations were built on the Southgate Extension of the London Underground Railways, each having similar points in style and decoration but differing widely in general design to suit local conditions.

The construction of these stations was carried out in steel and reinforced concrete, with walls of brick. All the concourses are lined with glazed tiles with variations of colour to give pleasant contrasts.

A feature of these stations is the provision of a relief shaft, to mitigate the effect of the draught caused by trains entering or leaving the platforms. The station below ground is connected by a shaft to a louvered tower. As a train enters, the air blast is forced up the relief shaft instead of subjecting passengers on the platform to a miniature tornado. Similarly a train leaving the station draws air in through the tower to fill the partial vacuum created underground.

An interesting problem arises in connexion with this "suction" effect in the wake of a fast train—nobody can have failed to notice the swirl of paper and dust caused by the flash of an express through a station. With great increases of speed it is probable that station roofs will have to be re-designed to obviate their being damaged by the force of these artificial cyclones.

A FRENCH SIGNAL CABIN of artistic design at St. Denis, four miles north of Paris, on the lines of the Northern Railways of France.

Southgate Station resembles other modern stations on the Piccadilly line, having wide entrances with direct communication between booking-hall and platforms, and well-arranged equipment.

The main station building, however, is circular with a wide canopy, above which is a continuous, but smaller, ring of metal-framed clerestory windows. The canopy is lighted from below at night-time by a box-light carried round the building. The concrete roof is supported on small steel columns. A concrete encased steel column supports the centre of the roof, surmounting which is a lantern, topped by a spun copper ball.

The lantern comprises a series of concrete rings with glazed bronze frames between them. Lamps behind these windows illuminate the station at night-time. In addition to this lantern, however, there are two illuminated concrete masts that rise from polygonal kiosks on either side of the station. Each mast carries the bull's-eye emblem of the Underground Railways.

Station architecture has in the past conformed as far as possible to the general style of the town that is served by the railway. This is particularly true of such countries as Belgium, where the railway station will often closely resemble the buildings surrounding it.

Where a town has a medieval tradition the station buildings will, when possible, be built in the form of a castle, with battlemented walls, even the clock tower appearing as a loopholecl turret. A station with a distinctly medieval aspect is that at Ghent St. Pierre on the Belgian State Railways, where the motor cars in the forecourt provide a striking contrast to the castle-like walls of the booking-hall and administration offices.

One of the most notable examples of railway construction that conforms to local tradition is the L.M.S. bridge over the river at Conway. The bridge is built in the same style as the adjacent Conway Castle, and thus harmonizes with its surroundings.

MODERN ARCHITECTURE is typified by this Great Western signal box at Cardiff West. Signals and points are power operated. The three-floored box has steel framework with red-brick filling. The ground floor contains the switchboard, transformers and rectifiers. The first floor has the relay racks and other equipment. The top floor is the operating room with an interlocking frame having 339 levers

Battlemented walls and turrets are frequently employed by railway architects as decorative features of tunnel mouths, and many fine examples exist in the country districts of Britain.

Bridges, especially those built of iron or steel, have generally been regarded as being within the province of the engineer. Some bridges and viaducts do, though, represent the very best in the architecture of both the past and the present.

The simplest brick or masonry bridge employs one of the earliest architectural devices—the arch. Naturally the number of arches was increased as requirements demanded, and in due course the size of the arches was augmented with improved methods of construction. The use of reinforced concrete has resulted in some single-arch bridges of remarkable beauty that do full justice to their surroundings, whether over deep ravine or mountain torrent.

BOUNDS GREEN STATION on the Piccadilly line. This station is on the extension from Finsbury Park to Arnos Grove which was opened in September 1932. A feature of this station in North London is a relief shaft to ease the effect of draughts caused by trains entering and leaving.

Long viaducts, too, have a charm of their own and generally display features of real architectural merit. Many of the finest bridges and viaducts in existence were built more than half a century before steel and concrete came into general use. The employment of reinforced concrete, however, does not imply that the bridge or building will present too severe an appearance in surroundings that call for artistic treatment Concrete structures are often faced with stone, coloured brickwork or even marble.

It is not on stations and bridges alone, however, that the skill of the architect is expended. Many of the humbler, yet no less essential, railway structures are the subject of much thought and careful planning by the architect. Signal cabins, for example, have undergone revolutionary changes in recent years. Many fine types of signal box have been evolved in Britain and abroad. A striking example of the application of modern design to a signal cabin can be seen at St. Denis on the Northern Railway of France. This is a concrete structure with rounded ends, the whole of the upper story being of glass surmounted by an overhanging roof carrying framework for the reception of telegraph wires.

ARNOS GROVE is another station of modern design on the Piccadilly line. The construction of the station was carried out chiefly in steel and reinforced concrete. The floors are of concrete or rubber according to the position.

An additional bay is built out from the side of the cabin nearer the track, affording an uninterrupted view of both up and down traffic. This bay, in common with the rest of the upper story, is provided with a railed balcony.

With the use of concrete for constructional work, formerly done by the engineer, the architect has been called upon to design water-towers and other structures for the railways' locomotive departments A well-designed water-tower in reinforced concrete is far in advance, architecturally, of the iron tank supported on girders or set in unrelieved brickwork.

In all railway buildings the requirements of the engineer must be given very careful consideration. Particularly is this so in the design of such structures as engine "round-houses." These buildings must be so arranged that the largest number, of locomotives can be accommodated in a given space a circular plan is often adopted with tracks radiating in a manner similar to the spokes of a wheel from a central turn-table. Thus, a main doorway is provided so that an incoming locomotive can be run on to the turntable, which is revolved until the engine is in a position to leave the table for its "stall."

A feature of round-house design is the provision of chimneys fitted with large "aprons" that take the smoke away from the locomotives through the roof.

SOUTHGATE STATION on the Arnos Grove to Enfield section of the Piccadilly line was opened in March, 1933. In general planning it follows the design of the other modern stations on this tine. Escalators lead to sub-surface stations.

Signal-cabins, water-towers and engine-houses all provide excellent examples of architecture applied to the requirements of the engineer. Railway stations, however, are designed primarily to enable the largest numbers of passengers to enter or leave their trains in the shortest possible time. The fact that modern stations are pleasing to the eye is incidental to their usefulness in coping with large crowds.

An interesting illustration of this aspect of station design is to be found in the London Underground Railway buildings described earlier on this page. Staircases are made as wide as possible with a central dividing rail. Walls are curved inwards, where bookstalls or shops line the concourses, to avoid obstruction. An outward curve is given to walls where crowds of passengers must move in a continuous stream. Other means are also adopted to facilitate passenger movement. For example, the escalator treads are coloured alternately dark and light, so breaking up the incline of the moving stairway, and decreasing the possibility of passengers "missing their step" when hurrying to the trains

THE INTERIOR OF LIVERPOOL STREET STATION with its iron columns and girder work is typical of many London termini. The station was formerly the terminus of the Great Eastern, and was opened in February, 1874. The terminus occupies an area of sixteen acres

2.9 TERMINOLOGIES IN RAILWAY STATION DESIGN

2.9.0 Introduction

There was a time (in the UK at least) when the word "station" would only ever be taken to refer to a railway station. For some reason, nowadays people insist on referring to a station as a "train station", as if there was any other sort of station. Whatever it is called, the station can often be a neglected part of the railway scene but they are the usually first point of contact the passenger has with the system and they ought to be well designed and pleasing to look at.

2.9.1 What then is a train or a railway station?

This photo shows the station at Sultan Negara in Kuala Lumpur, Malaysia, built for access to the Commonwealth Games complex. It was designed to handle large numbers of passengers, hence the wide platforms. Note that there are no columns to obstruct the platform near the edges, the platforms are straight and the whole station is protected by a large overall roof, essential in a country with a tropical climate. All utility rooms, staff amenities and ticket facilities are at ground level.

Source: **http://www.railway-technical.com**

Stations are the places where trains stop to collect and deposit passengers. Since the station is the first point of contact most passengers have with the railway, it should be regarded as the "shop window" for the services provided. It should therefore be well designed, pleasing to the eye (photo left), comfortable and convenient for the passenger as well as efficient in layout and operation. Stations must be properly managed and maintained and must be operated safely.

2.9.2 Station and Crossing Safety

There are two differing views about passenger safety at stations which have dictated station design for the last 150 years or more. For most of the world, it has been assumed that passengers (and other members of the public) will take care of their own safety when walking on or near a railway. Because of this, it is not considered necessary to segregate passengers from trains. Passengers will look out for passing trains when crossing tracks and will take care not to leave luggage, children, cars or anything else which could damage or be damaged by a train. Station design has reflected this so that platforms were often not raised very much above rail level. Passengers were forced to climb up to trains, usually with the help of a plentiful staff and portable steps carried on vehicles. Passengers were free to wander across tracks, usually at walkways specially provided for them and any road vehicles which needed to cross the line. Railways were not fenced. Only at terminals and very busy stations was any attempt at segregation made.

In the UK, railways were always fenced and passengers and the public were invariably kept away from the tracks as far as possible. Platforms were built to a level which allowed a reasonable step up into a train without help and bridges or underground passages (called "subways" in the UK) were provided to allow people to cross the line unhindered by the movement of trains. The high platform also permitted quicker loading and unloading of trains.

In the US, the rise in the popularity and numbers of automobiles was matched by a decline in the use of railroads. The decline in the use of railroads meant there was also a decline in the awareness of the public of the nature of railroads or of the power and speed of trains and the distances they required to stop. The result has been an increase in the number of crossing accidents, where cars or trucks have been hit by trains. There have also been incidents where passengers have been struck by passing trains while crossing the tracks to reach a station exit.

2.9.3 Platforms

The term platform is worth explaining. In the US, the position of a train in a station is referred to as the "track". This is very logical as the raised portion of the ground next to the track is actually the platform and may well be used by passengers boarding a train on a track along the opposite edge of the platform.

It is a feature of station design in the UK and railways designed to UK standards, that platforms are built to the height of the train floor, or close to it. This is now also adopted as standard on metro railways throughout the world. The rest of the world has generally had a train/station interface designed on the basis that the passengers step up into the train from a low level platform or even straight off the ground. To this end, passenger vehicles were usually designed with end entrances, having the floor narrower than the rest of the car body so that a set of steps could be fitted to either side of the entrance gangway. However, high platforms are now seen in many countries around the world.

Platform width is also an important feature of station design. The width must be sufficient to accommodate the largest numbers of passengers expected but must not be wasteful of space - always at a premium for station areas in expensive land districts of a city. The platform should be designed to give free visual areas along its length so that passengers can read signs and staff can ensure safety when dispatching trains. Columns supporting structures can often seriously affect the operation of a station by reducing circulating areas and passenger flows at busy times. Platform edges should be straight to assist operations by allowing clear sight lines.

2.9.4 Entrances and Exits

The entrance hall of Doncaster station, UK. The ticket office is immediately behind the camera position. The hall has a shop, a car rental office and public telephones. A train information display is mounted high on the wall and a TV screen duplicates the information below it. There is an information counter next to the shop, this being an additional service now often seen in larger stations. Flooring is designed to be easy to keep clean.

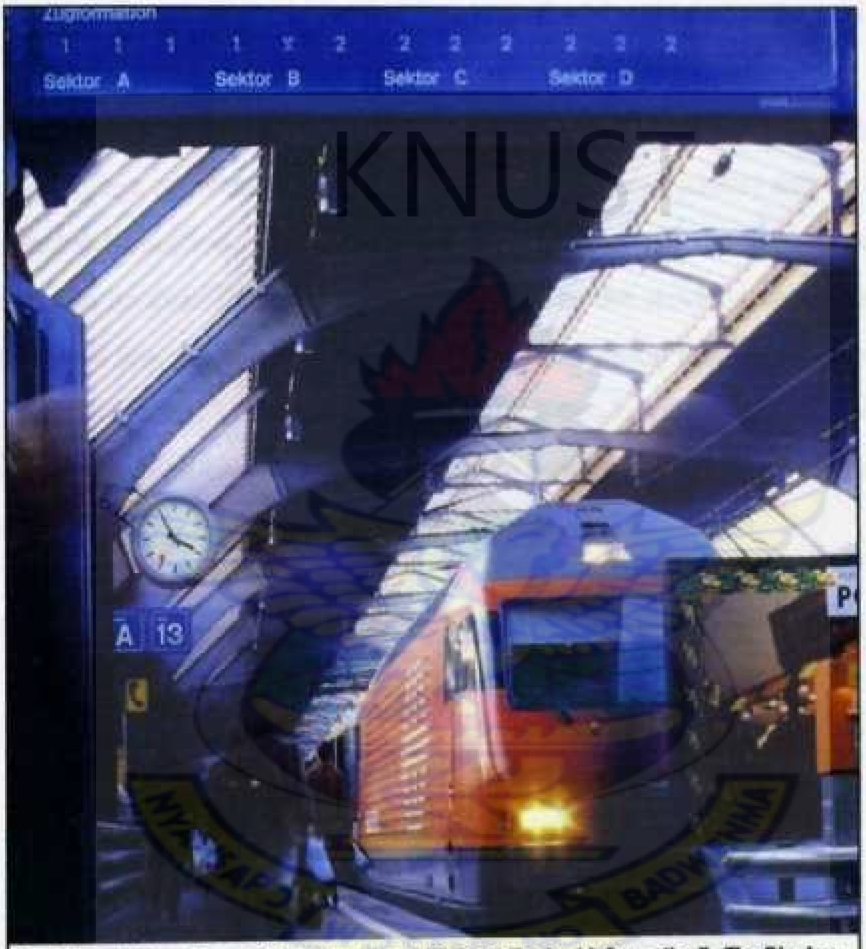
Source: http://www.railway-technical.com

Station entrances and exits must be designed to allow for the numbers of passengers passing through them, both under normal and emergency conditions. Specific emergency exit requirements are outlined in many countries as part of safety legislation or to standards set down by the railways or other organizations. These laid down standards usually define the exit flows and the types of exits allowed for, e.g. the different rates for passages, stairways and escalators.

Whatever the standards are, the entrances to a station must be welcoming to the prospective passenger. Stations must also have sufficient entrances to cater for the different sides of the railway route but the number must also take into account the cost effectiveness of each entrance. The cost of staffing ticket offices can be very considerable and the numbers of ticket offices must be managed to suit the patronage offering.

Consideration must be paid to issues like which way doors open. On the Paris Metro in 1918, a crown panicked near Bolivar station during an air raid on the city and 66 people were killed in a crush trying to get into the station for shelter. The obstacle that triggered the crush was a set of doors that only opened outwards -- normally the right direction for safety, but not when the crowd is trying to rush in! Subsequently it became Metro policy that all doors had to open both ways.

2.9.5 Passenger Information



A station designed to assist passengers with good "instant information". The Display over the platform entrance shows the location of first and second class coaches and the train is divided into sections A, B, C and D. The sections are marked by signs on the platform. The train restaurant facilities are shown between first and second class. The platform is clean and signs are not confused with too much advertising.

Source: http://www.railway-technical.com

Information systems on stations are variously referred to as a Passenger Information System (sometimes referred to as PIS) or Passenger Information Display (PID). Professional railway staff often refers to them as Train Describers. Whatever it is called, there must be a reliable way of informing the passengers where the trains are going. Passenger information systems are essential for any railway. One of the most common complaints by passengers on railways is the lack of up to date and accurate information. When asking the staff for information, passengers expect an accurate and courteous response with the latest data. There is nothing worse than the "your guess is as good as mine" response when a member of staff is asked what is happening when a train is delayed or has not appeared on time. This means that staff must have access to the latest information and they must be trained to use it properly and to pass it on to passengers.

Information displays mounted in public areas must be visible in all weather conditions (noting that some electronic displays are very difficult to see in sunlight conditions) and be updated regularly with accurate information. There are two types of information - constant and instant. Constant information can be described as that which describes the services and fares available and which changes only a few times a year or less. This information can be displayed on posters and fixed notices. There also might be special offers which can be posted from time to time. Instant information is that which changes daily or minute by minute. This is better displayed electronically or mechanically - both systems can be seen around the world.

For instant systems, it can be assumed that passengers are required to know:

- The time now
- The destination and expected time of arrival of the next train
- The stations served by this train
- Major connections requiring boarding of this train
- The position of their car - if travelling with a reserved place
- Where the train will stop - for variable length trains
- Other destinations served from this station and from which platform

A good example of passenger information displays can be seen on some Paris (France) RER stations. A large illuminated board is hung over the platform and all the stations served by the train approaching are shown by lamps lit next to the station name. The time now and the train length are also shown. Although the system is not now modern, it is very effective.

There are some information systems appearing with advertising in some form or other. This is a useful source of revenue or sponsorship but it must not be allowed to detract from the main aim of providing the passenger with train service information.

Some modernized lines are nowadays provided with bi-directional signaling. This allows trains to travel along either line at normal speeds and be fully under the control of fixed signals. This is a useful facility to have when engineering works have made one track unusable. Trains operating in either direction will then use the other track(s). For passenger information purposes, bi-directional signaling makes it necessary to have good and easily variable passenger information displays.

2.9.6 Toilets/ Washrooms/ Restrooms

For a long time the provision of toilets on railway premises has been the subject of criticism and debate, both in the industry and amongst passengers. Passengers expect to be provided with facilities and complain loudly when they are not. On the other hand, public toilets are regularly abused and vandalised in many countries and railway administrations end up paying large amounts to maintain and repair them. They can also often be used for illegal activities, such as drug related offences, sexual activities and for robberies.

Some railways, especially those in big cities, have, for many years, tried to close most of station toilets because of the cost of keeping them in a reasonable condition and because of the difficulties in policing them. The result has been an increase in the number of passengers relieving themselves in the public and sometimes in the prohibited areas of the railway, including cases where they have wandered onto the track and got themselves killed by passing trains. At the very least, these activities cause an odour and health risk nuisance.

Any railway operators responsible for stations will have to decide whether they are prepared to pay for the installation of toilets and, if they do so decide, they must be prepared for the management and maintenance of such facilities. Nowadays, it is considered good marketing to provide good restroom, baby changing and toilet facilities. They will not be cheap to provide and they will require regular inspections to ensure the safety and cleanliness of the premises. In spite of all the difficulties, toilets must be considered a requirement, if for no other reason than the public expect them. If they are installed, they must be designed to a high standard and then kept spotlessly clean throughout the day.

2.9.7 Concessions

Concessions on railway premises can be a lucrative source of income for a railway and the opportunity to provide for them should be taken wherever possible. The normal types of concessions are coffee shops, refreshment counters and small lunch rooms, plus pharmacies, dry cleaners, newspaper shops and flower shops. Some larger stations are able to provide space for so many shops that they are almost shopping malls in their own right. This is good for the railway, since it attracts customers and it provides a sense of community which would otherwise be lacking. There should, however, be limits as to what can be done and proper design in the first place and subsequent good estate management are both required to permit railway operations to continue unhindered and with safety.

Shops should not be allowed to sell dangerous goods and may be restricted in the sale of tobacco products if the railway has a no smoking policy. Some operators have excluded the sale of food within their property because they have a no eating/drinking policy. Other railways regard food/beverage sales as an important part of the marketing strategy and positively encourage restaurants to take leases on stations. Food outlets must not be allowed to generate a rubbish or vermin problem.

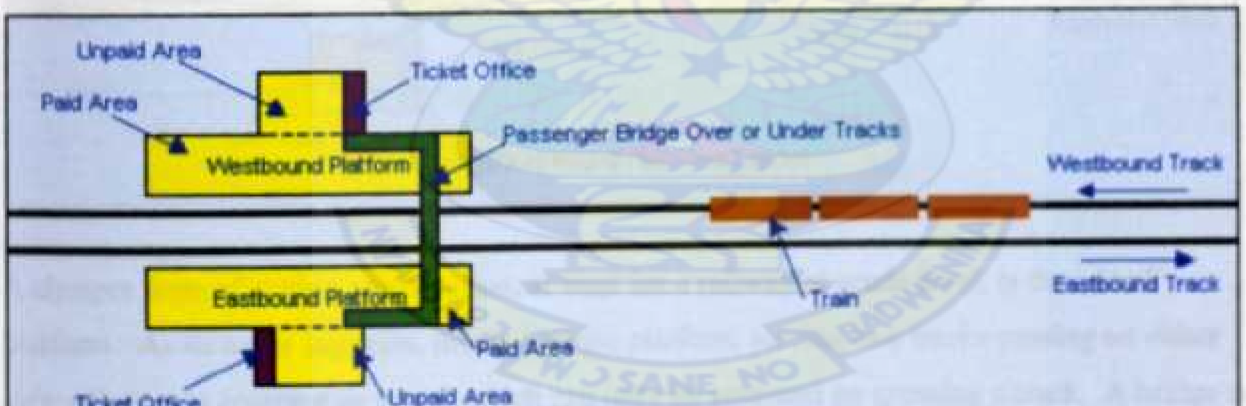
At least, operators must prevent shops from allowing passages to become obstructed with sales equipment and they must ensure that they conform to the railway's safety requirements in cooking and similar activities. Leases for shops should detail all the exclusions required and lay out clearly the safety, evacuation and training requirements for shop staff.

2.9.8. Station Design

The design of stations has developed over the years as the use of railways has first expanded and latterly declined. A new form of station design has also evolved with the introduction of metros and high capacity urban railways. A number of different types of station design are shown below and the advantages and disadvantages of each are discussed.

On a railway which requires passengers to be in possession of a valid ticket or "authority to travel" whilst on the property, the station area is divided into an "unpaid area" and a "paid area", to denote the parts where passengers should be in possession of a valid ticket. Of course, there are now many railway operators who have "open stations", which allow passenger to wander at will without a ticket. In these circumstances, in addition to a ticket office or ticket selling machines, tickets can be purchased on the train.

2.9.8.1 Side Platform Station

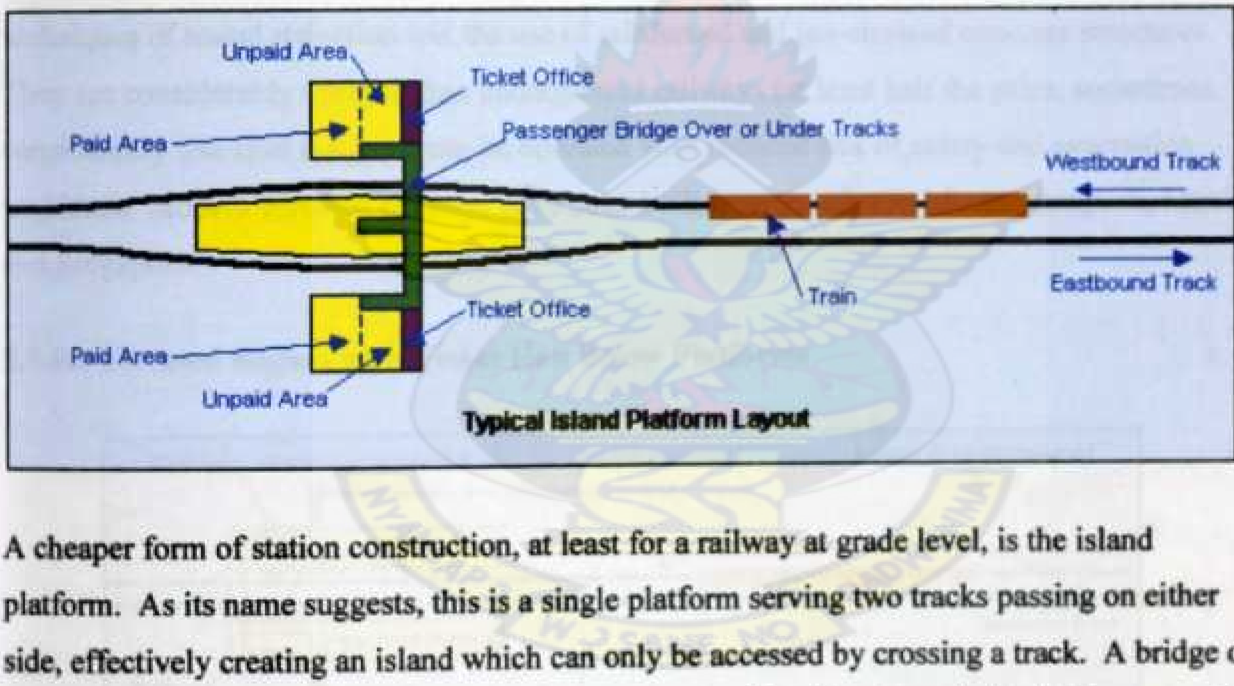


Typical Side Platform Station Layout

The basic station design used for a double track railway line has two platforms, one for each direction of travel. The series of examples in the following diagrams shows stations with right hand running as common in Europe and the Americas. Each platform has a ticket office and other passenger facilities such as toilets and perhaps refreshment or other concession. Where there is a high frequency service or for designs with high platforms, the two platforms are usually connected by a footbridge. In the case of a station where tickets are required to allow passengers to reach the platform, a "barrier" or, in the case of a metro with automatic fare collection, a "gate line", is provided to divide the "paid area" and "unpaid area".

This design allows equal access for passengers approaching from either side of the station but it does require the provision of two ticket offices and therefore staffing for both of them. Sometimes, stations with two ticket offices will man only one full time. The other will be manned as required at peak times.

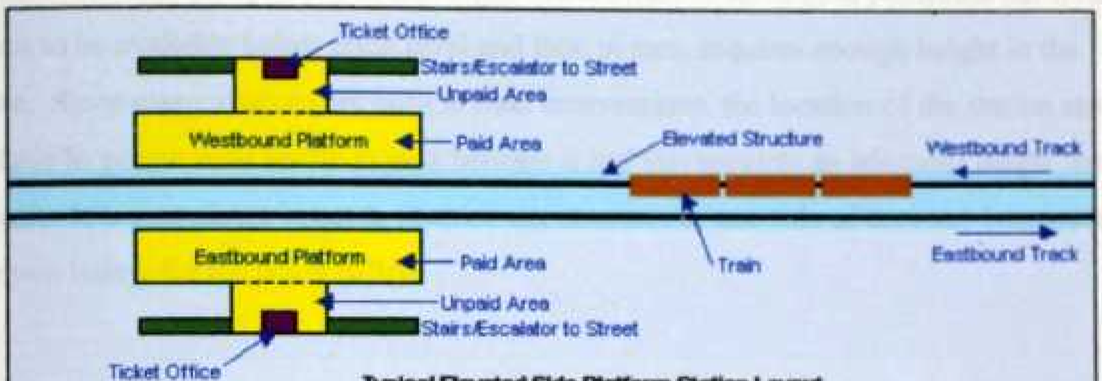
2.9.8.2 Island Platform Station



Typical Island Platform Layout

A cheaper form of station construction, at least for a railway at grade level, is the island platform. As its name suggests, this is a single platform serving two tracks passing on either side, effectively creating an island which can only be accessed by crossing a track. A bridge or underpass is usually provided. Island platforms are usually wider than single platforms used for side platform stations but they still require less area. In the example shown above, there are two ticket offices, but one can be provided if preferred. Island platforms on elevated railways do require additional construction of the viaduct structure (usually adding considerably to the costs) to accommodate the curves in the tracks needed to separate them on the approach to the platform.

8.9.8.3 Elevated Station with Side Platforms



Typical Elevated Side Platform Station Layout

Elevated railways are still popular in cities, despite their history of noise creation and generally unfriendly environmental image. The poor image has been considerably reduced with modern techniques of sound reduction and the use of reinforced and pre-stressed concrete structures. They are considerably cheaper than underground railways (at least half the price, sometimes considerably less than that) and can be operated with reduced risk of safety and evacuation problems. Modern elevated railways have been built in such cities as Miami, Bangkok, Manila and Singapore.

8.9.8.4 Elevated Station with Ticket Hall Below Platforms

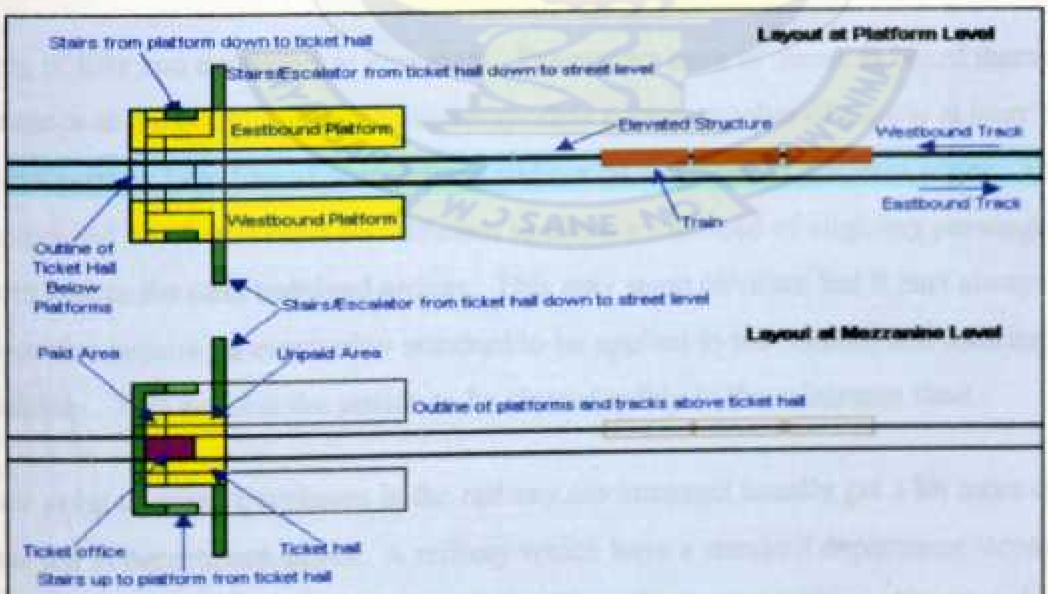


Diagram of Elevated Station with Ticket Hall Below Platforms

In the example illustrated immediately above, the ticket office and gate lines are below the platform level. This can be done to allow one ticket office to serve both platforms but it requires the space to be available below track level and this, in turn, requires enough height in the structure. Since many stations are built at road intersections, the location of the station structure might have to permit road traffic to pass beneath it and this requires an adequate height structure to be built. It is sometimes better to position the structure to one side of the road intersection to allow room below for the ticket office.

2.9.9 Lifts and Escalators

Vertical transportation at stations in city environments and on urban railways is almost as important as the horizontal transportation provided by the trains. Any station not easily accessible on the surface and which requires stairs, will nowadays, require lifts for the disabled. Stations with a height difference between levels of more than 4 to 5 metres (13-18 feet) will probably need escalators as well - certainly in the up direction. Escalators are expensive, so the number of passengers using the facility must be at a sufficient level to make them worthwhile. Both lifts and escalators are high cost maintenance items and need to be kept in good condition. They require mandatory regular safety inspections.

The siting of lifts and escalators is important. Passengers have to queue to board them so there must be space at the boarding point to accommodate a large number of people at busy times. Such areas must be kept free of obstructions and not be too close to platform edges. The number of stairways and escalators must be sufficient to allow a trainload of alighting passengers to clear a platform before the next trainload arrives. This may seem obvious, but it isn't always done. Most countries require an evacuation standard to be applied to the number and location of stairs and escalators. This enables the station to be cleared safely in the minimum time.

One other point to note. Escalators in the railway environment usually get a lot more use than those you see in department stores. A railway which buys a standard department store design escalator may find it will quickly wear out and will need constant repairs. A more robust design may be a better life cycle cost solution.

Examples of Good Station Design Features

A new underground station on the metro system of Santiago, Chile. A combination of striking architecture and subdued lighting combine to give a pleasing overall finish. The use of upper level galleries, visible to the left and right, is unusual but adds to the feeling of accessibility.

Source: http://www.railway-technical.com

Architecture

An example of a wide station platform (Cairo Metro, Egypt) designed to accommodate large numbers of passengers boarding and alighting at the same time. Note that there are no supporting columns to limit circulation or visibility on the platform. There are a few seats for waiting passengers but these are arranged to prevent a person lying down on them. Vagrants sheltering in stations in a serious problem in some cities and has to be discouraged.

Platform Design

Madrid, Spain, offers an example of a light, airy station concourse with faregate lines dividing the "paid" and "unpaid" areas. The ticket office is located in the centre of the gate line so it can be used by passengers in both areas. The lightweight steel structure over the escalators in the foreground carries CCTV cameras and loudspeakers.

Source: http://www.railway-technical.com

2.10 CLASSIFICATION OF RAILWAY STATIONS IN GHANA

In Ghana the railway stations are categorized into the volumes of traffic and freight and also on the administrative and commercial importance in relation to urban and rural centres. There are five categories namely:

1. **Type 1**- comprises of

(a) The station building

(b) District administrative offices

(c) District mechanical and civil engineering sections.

(d) Goods sheds, warehouses and signal boxes.

2. **Type 2**- comprises of

(a) The station building

(b) Sometimes locomotive running sheds and engineering workshops.

(c) Goods sheds and signal boxes

3. **Type 3**- comprises of

(a) The station building

(b) Permanent way and assistant permanent way inspector's offices

4. **Type 4**-comprises of

(a) The station building

(b) Goods shed

One person is responsible for all operational duties.

5. **Type 5**- comprises of

These are halts which serve small villages along the railway route. These halts depend on the nearest two stations in either direction for operational facilities.[5]

Owing to the project area (site) under consideration, which is a major hub of commercial activity and higher in status with respect to the countries' priorities, **Type 1** has been chosen because of its ability to accommodate the anticipated volumes traffic and freight (Thus, Tema-the largest man-made harbor of the country and that of West Africa).

CHAPTER THREE

3.1 PROFILE OF TEMA

3.1.1 Tema in perspective

Tema is a port-city located 25 Km (16 mi) east of capital city of Accra in the Greater Accra Region of Ghana, with a population 209,000 (as at the last population census conducted in the year 2005AD). It is currently having a population of 600,000 which justifies the accession of the massive increament within the last four years. It is however, anticipated that, the current figure will double within the next ten years to come.

It is a city on the Atlantic Ocean coast. It was originally a small coastal fishing hamlet along the Gulf of Guinea which grew after its construction into a deep sea man-made harbour (opened in 1962), and is currently the nation's largest sea port. It is also home to an oil refinery and is an important centre of manufacturing (thus, contains warehouses for the storage of Ghana's main exports, particularly cocoa).

The docks also contain 12 deepwater berths & oil-tanker berth, plus supporting warehouses, transit buildings, and cold-storage facilities. It is linked to the capital by railway and a highway. Tema has expanded in size due to the construction of its harbour and has since eclipsed Takoradi as Ghana's major sea port.Tema is the nearest city to the geographical position of 0 degrees latitude and 0 degrees longitude (which lies several hundred miles south in the Bight of Benin).

Fig. 3.1 **A view of the harbour**

3.1.2 Etymology

Tema originates from the Ga word ' *Tor* ', which translates to Gourd in the English language. This plant was grown in the present area and therefore the place was called ' *Torman* ' meaning tor-town or tor-city. (' *Man* ' means town or city in Ashanti). This altered and evolved with time, mainly due to the Europeans and finally became Tema. Location map in context of Ghana shown below:

Figure. 3.2 **The map of Ghana. (Area shown in red as Tema)**

Figure 3.3 Cocobod warehouses at Tema (January 2008) **Source**: Author

3.1.3 Tema as Municipal Assembly

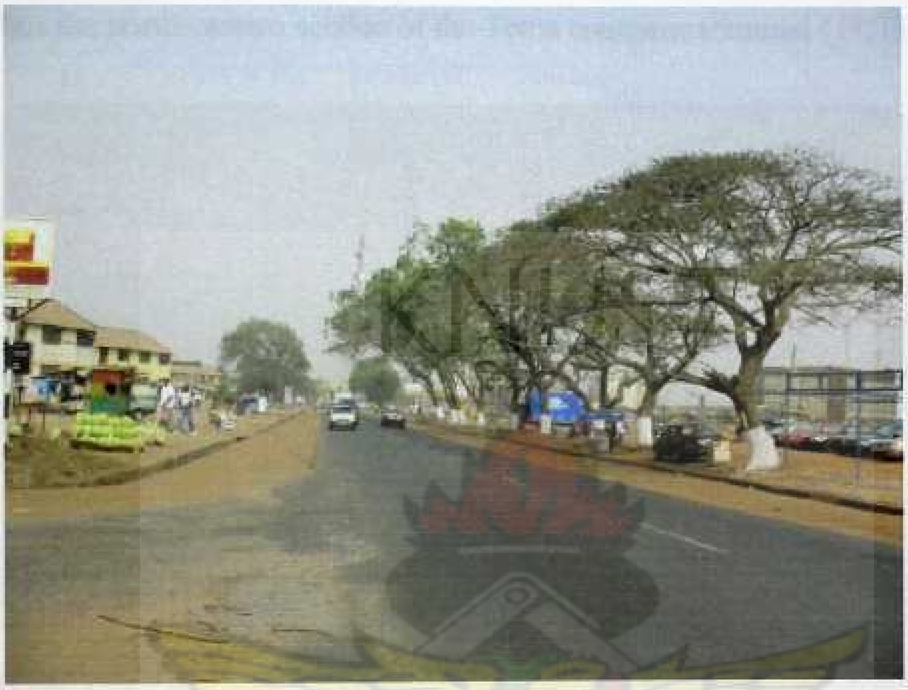
It is at the moment the administrative capital of the Tema Municipal Assembly after undergoing several development from a local council to an autonomous district council in 1974 (Tema District assembly) , and then to the status of a Municipality in December, 1990.

The municipality covers a total area of 35,959 kilometres square with 163kmsq being government land (thus, the remaining belongs to traditional authorities, stools and domestic families).

As a township, Tema is made up of several sprawling districts, known as a 'Communities', with the centre of Tema referred to as 'Community 1'. Tema is separated from Accra by

Sakumono and eastern suburbs of Accra such as Teshie and Nungua, and the districts of Sakumono and Tema are themselves kept separated by the Sakumono Lagoon.

Tema's communities are home to several major financial institutions, government departments, retailers, restaurants, and hotels & guesthouses.



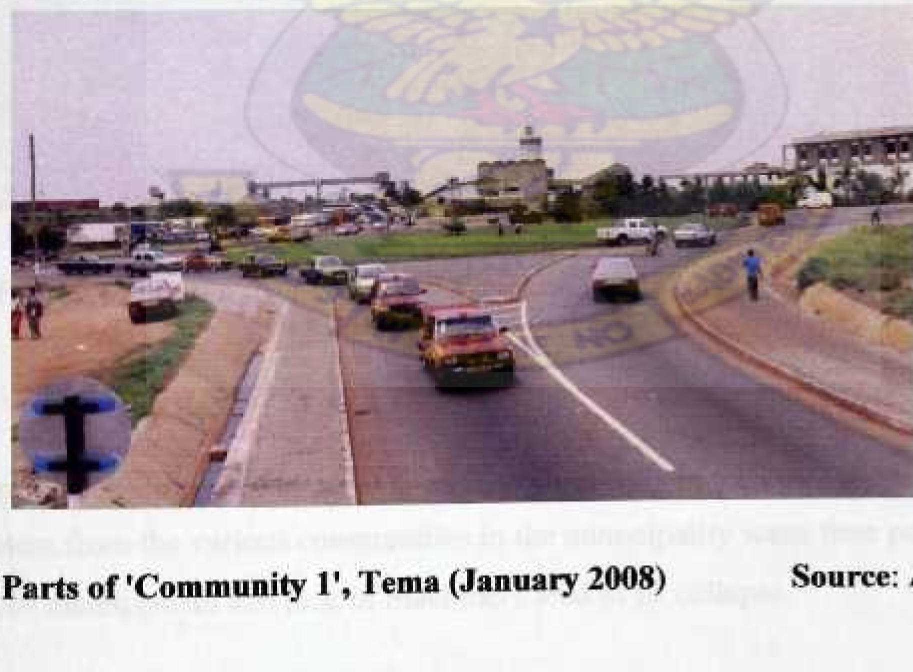


Figure 3.3 Parts of 'Community 1', Tema (January 2008) **Source**: Author

3.2 THE SITE

3.2.1 LOCATION

The site under consideration is located within the main harbour zone, few metres from the main harbour road. It lies on latitude 5'37'52.43''N and Longitude 0.0'5.89''E (the Greenwich Meridian), thus the north-eastern section of the Tema container terminal (TCT).

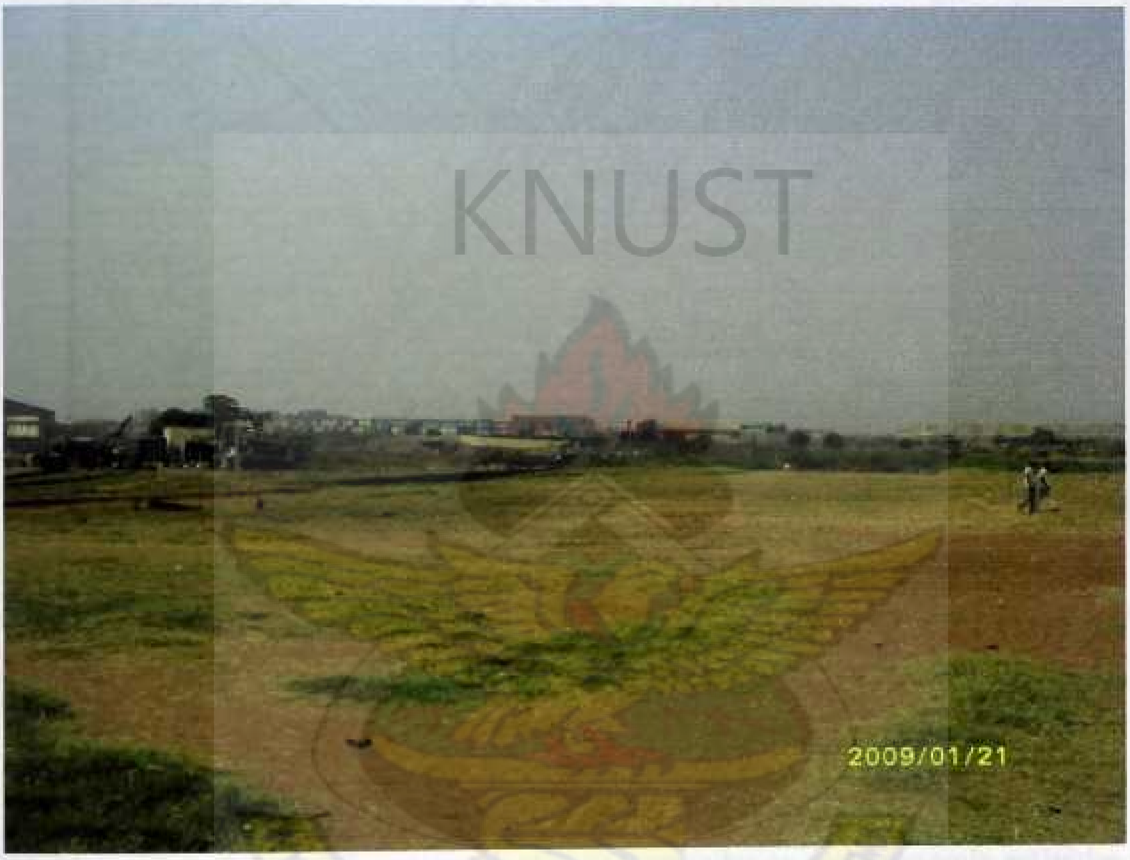


Figure 3.5 Picture of the site over-looking the container terminal. **Source**: Author

The Tema railway station used to serve as an important node in the convergence of both vehicles and commuters from the various communities in the municipality some time past, but owing to issues of poor management and lack of machinery lead to its collapse.

3.2.2 SITE SELECTION AND JUSTIFICATION

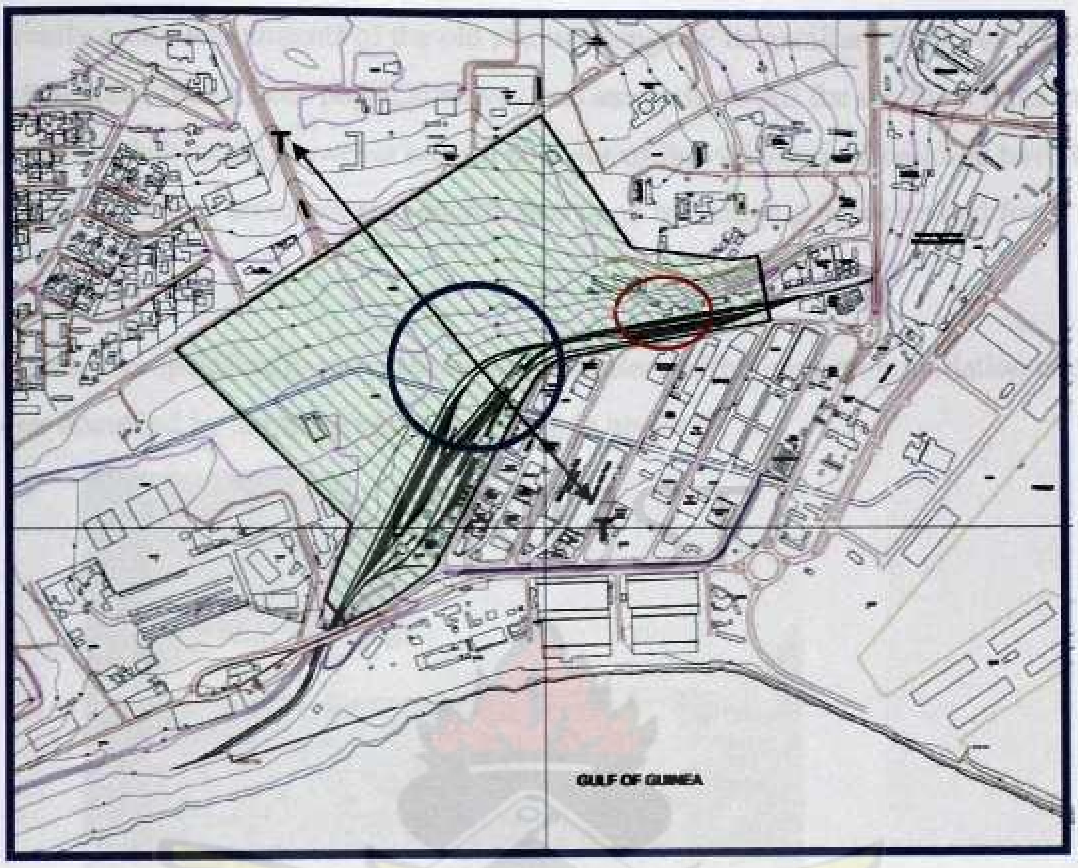


Figure 3.6 Total area shown with a black boundary (the red and blue boundaries represent the old and new site respectively).

Population is now on the ascendancy, residential accommodation and economic activities are also booming but the road networks remain static and inorganic. Migrant population in Tema is gradually increasing, whereas goods and services have to be transported, but the issue is the roads are getting choked at the end of the day.

With the current problems associated with road transport, the Government of Ghana has therefore decided to vigorously pursue an Economic Recovery Programme aiming at fomenting growth and alleviating poverty through the rehabilitation of the old railway network and incorporating new ones where necessary to meet the transportation needs of the country as a whole. Tema is one of the areas under focus which explains the cruciality of the site in question

3.2.3 SITE INVENTORY (CONDITIONS)

The site currently contains remnants of the old station alongside its ancillary facilities. They are in absolute poor state, rising from physical survey and assessment. All the facilities there are currently unsafe for habitation, however certain portions of the old terminal building have been habited by squatters. Other areas are also encroached upon by shipping agencies and food vendors.

The motel which was specifically provided to meet travelers with their accommodation needs is currently been occupied by shipping agencies owing to neglect.

Figure 3.7 View of the squatters and motel (Tema Old site) respectively. **Source**: Author

3.2.4 The Old Station

The state of the old station is not a pleasant one. Cracks have been detected on the walls and the platform. The roof of the single storey structure is currently ripping off with wide openings resulting from cracks and vagaries of the weather. The columns which support the platform roofs are also in bad state.

Figure 3.8 Picture showing the current state of the old station. **(Tema)** **Source**: Author

3.2.5 General Assessment

Upon the assessment of structures on the site, it becomes imperative to consider another area for a new station, owing to the current building's state and size as against the anticipated volume of 5000 commuters. It is also proposed that the old station is restructured and expanded into a freight zone whereas the old motel area is redeveloped into railway staff accommodation.

3.3 SITE CHARACTERISTICS

3.3.1Topography

The site is generally flat forming part of the coastal plains (0mSouth -25mNorth above sea level However, the old site which used to accommodate the old station is having portions steeply sloping, leaving a long stretch of land for the station. It is among such reasons why the newly proposed was relocated to the present area (relatively flat and broad enough to accommodate the terminal). The total harbour area is 1,650,000sqm with the site covering an area of 439,028sqm (perimeter 328 metres). There also a few isolated areas with hills not higher than 0.5metres.

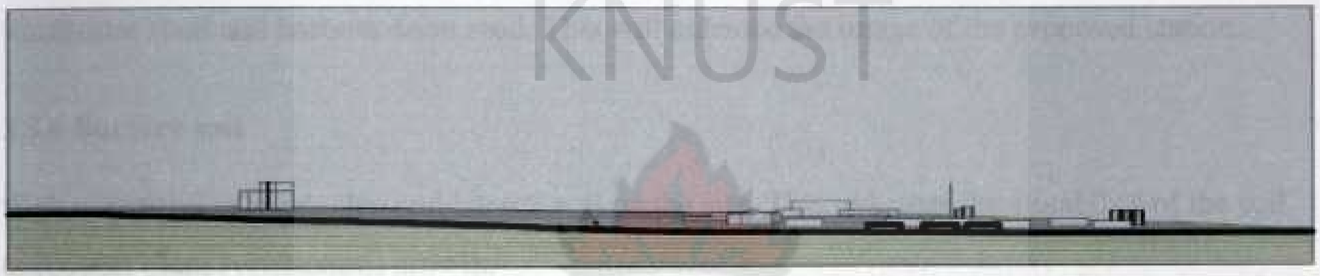


Figure 3.9 Section T-T across the site showing the slope. as shown in figure 3.6

3.3.2 Geology

Tema is generally under laid with layers of precambian rocks and Dahomeyan formation of metamorphic rocks which consist: Schists, Phyllite starolite, granite and gneiss which is studied to have high load bearing property.

3.3.3 Vegetation

Most portions of the site are fairly interspersed with lightly grown semi-deciduous trees and shrubs are present on the site. Other areas are covered with grassland whereas other portions exposed (bare with sand-loam composition).

3.3.4 Hydrology and drainage

There are few spots with water puddles as a result of concentrated clayey soil at some portions of the site. To resolve problems of drainage on site for sewage waste from the facility, cess pool is proposed to take care of soil waste and general liquid waste.

There is a discovery of an underground concrete drain at the lower end of the site leading to the shore. Careful steps are been taken to ensure design doesn't conflict with the situation.

3.3.5 Accessibility

The site has three main accesses from the boundary streets namely; Meridian road, Harbour-warehouse road and harbour-farm road. This will enhance the image of the proposed station.

3.3.6 Surface soil

High quantities of sand, clay and laterite soil on the site. This indicates the suitability of the soil to support plant (vegetation) growth.

3.3.7 Rainfall

Main annual rainfall range between 730 mm and 790 mm. The rainy season is usually from April to July (major season) and from September to November (minor season).

3.3.8 Temperature range

Temperatures are high all year with significant daily and seasonal variations. There are high temperatures from October to April. (Daily maximum and minimum temperatures of 30 degrees Celsius to 32 degrees and 22 degrees Celsius to 27 degrees Celsius respectively).

Cooler temperatures occur from May to September (Daily maximum and minimum temperatures of 27 degrees Celsius to 29 degrees and 22 degrees Celsius to 24 degrees Celsius respectively).

3.3.9 Humidity

Humidity varies from 60%-80% (or more) in the wet season to less than 30% in the dry season.

3.4 SITE ANALYSIS

ADVANTAGES ON SITE (STRENGTHS)	ADVANTAGES OFF SITE (OPPORTUNITIES)
Three accesses to the site	Presence of Offices and residential houses
The presence of green flourishing vegetation.	Availability of services and utilities lines
Existence of rail network.	Newly laid tracks towards the site
Focal point for business transactions	Good Roads circulation around site
Proximity to commuters and harbour workers	Bollard barriers preventing unlawful diversions.
Availability of services and utilities	
Relatively large and gentle sloping site	

Table 3.1 Advantages on and off the site.

DISADVANTAGES ON SITE (WEAKNESS)	DISADVANTAGES OFF SITE (THREATS)
Squatters on site	Encroachment of land
Exposed drain and utility lines	Undefined parking around site.
Hawking and vending activities on site	Obstructed views 13m High cylindrical tanks
Refuse dumping on site	Too close peripheral buildings.
Thorough fare and undefined walkways	Heavy traffic on the harbour road at peak hours

Table 3.2 Disadvantages on and off the site.

CHAPTER FOUR

RELEVANT STUDIES

4.1CASE STUDIES

4.1.1 Local Case study at Accra train station

Location

The station is located within the central business district of Accra, the capital city of Ghana.. It was purposely built to complete the western and Eastern lines at the southern part of the country (as shown in figure 2.1 , chapter 2)

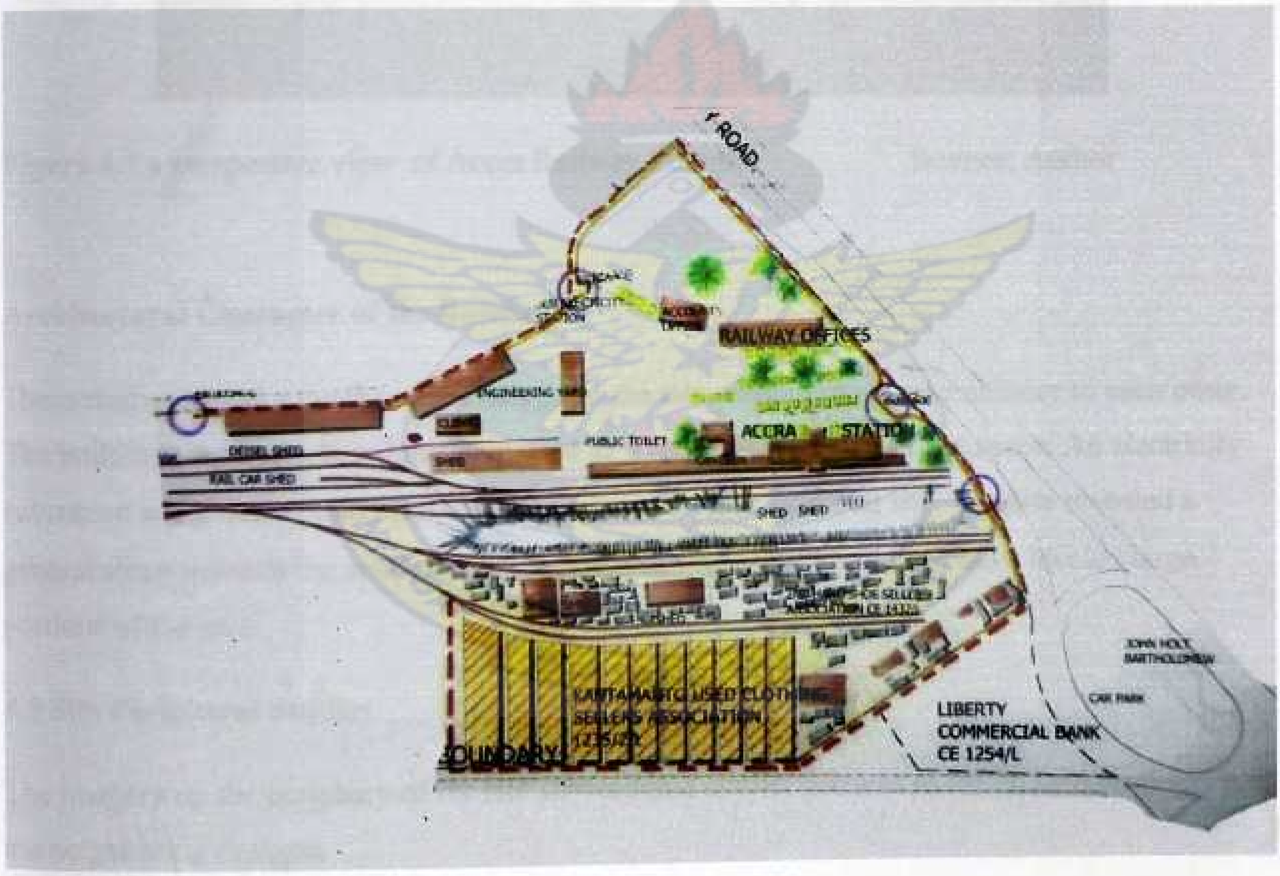


Figure 4.1 Layout of Accra Railway Station **Source**: Ghana Railway Company

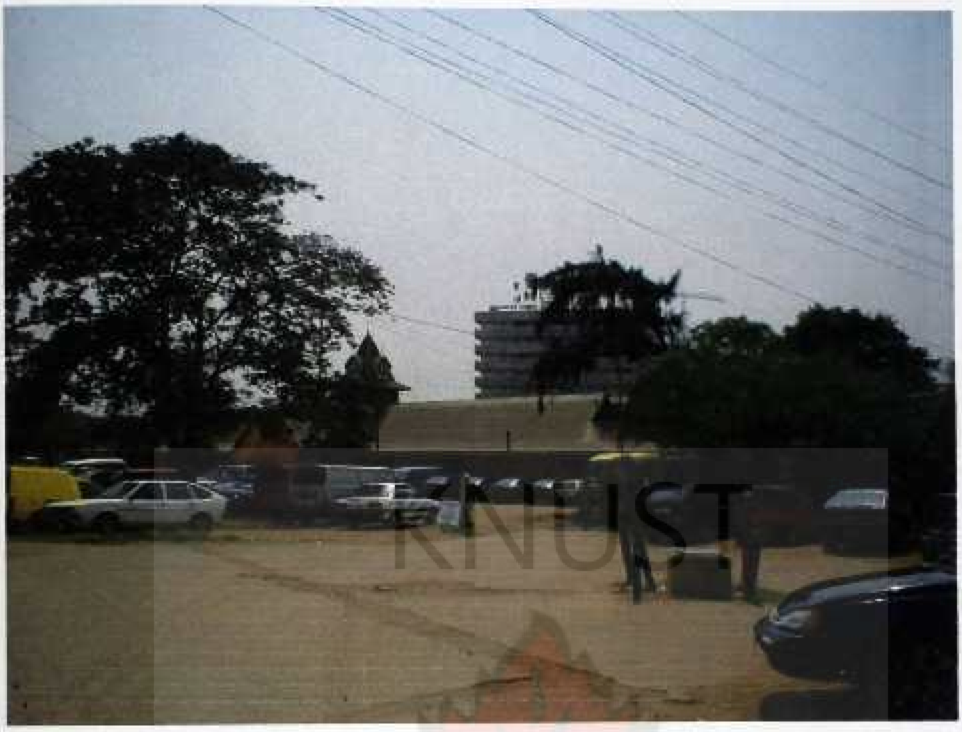


Figure 4.2 a perspective view of Accra Railway Station **Source:** Author

Architectural Character of the Building.

These studies reveal a number of buildings on the site without much resemblance to each other. The buildings seemed just to have happened as a result of the need for the space. An electricity substation and a cable radio mast are some of the services found on site. The site revealed a general slope towards the southern end but the building and the rail lines have leveled large portions of the area.

4.5 Site Peripheral Studies

The imagery on the periphery of the site shows some similar features in the architectural styles in the neighboring designs.

- They show emphasis on the horizontality of the structure by the use of horizontal bands
- Most of the structures are of urban scale, featuring a minimum of 3 floors to 9 floors in the Liberty House
- The use of concrete as the principal construction material.

Figure 4.3 an Aerial view of Accra Railway Station showing boarder structures around the site.

Source: Author

BRIEF

Administrative Offices	Ticket offices	Store Rooms	Workshop
Platform	Canteen	Phone Booth area	Maintenance area
Police Station	Car Park	General Waiting area	

Figure 4.4 pictures of the canteen , platform and waiting area **Source**: Author

Figure 4.5 Picture of the staff parking area and tick acquiring area **Source**: Author

GENERAL OBSERVATION

- The platform areas are lower, so passengers have to use stairs on the train to board and unboard. This is unfriendly to the disabled which is carefully considered the new design.
- Much of the stations land has been encroached upon making operations very difficult, Physical barriers and tight security should be ensured.
- The building is obsolete and cannot also accommodate the current and anticipated traffic.
- Most of the facilities are currently under capacity, for instance, the car park and waiting area.

4.1.2 Foreign case Study of New Wellington Station, New Zealand

Location

Wellington Railway Station is located at the Bunny Street, Wellington- New Zaland.

Coordinates-41*16'43''S 174*46'51''E. It is the southern terminus of New Zealand's North Island Main Trunk railway, Wairarapa Line and Johnsonville Line. In terms of number of services and in passenger numbers, it is New Zealand's busiest railway station.

Figure 4.6 An exterior view of the Station **Source**: http://nzrail.netfirms.com/

Brief History

When completed in 1937 the station was New Zealand's largest building, partly because it was designed to accommodate 675 head office and district railways staff.[2] The land upon which it is built is reclaimed, and it was the first major New Zealand structure to incorporate a significant measure of earthquake resistance. It was constructed by Fletcher Building as one of its first major construction projects. It was designed by New Zealander W. Gray Young, famous for his neo-Georgian styles.

When it opened, Wellington's two former stations closed: Lambton, built by New Zealand Government Railways to serve the Wairarapa line; and Thorndon, built by the Wellington and

Manawatu Railway Company to serve what became the North Island Main Trunk via Johnsonville.

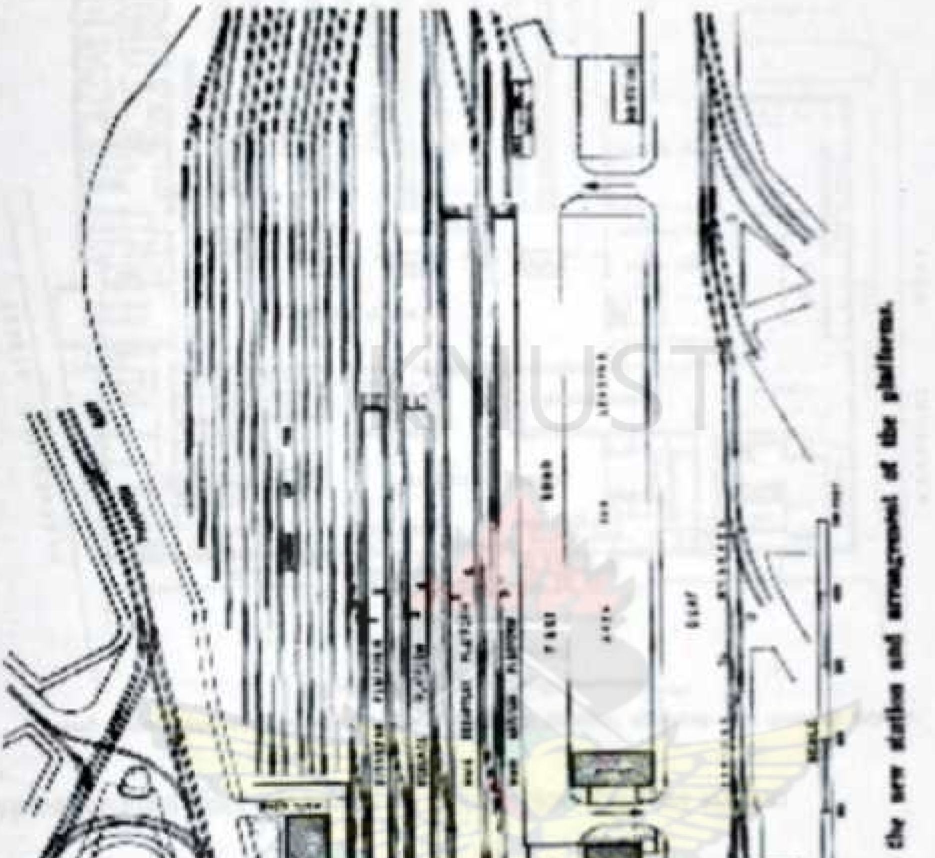
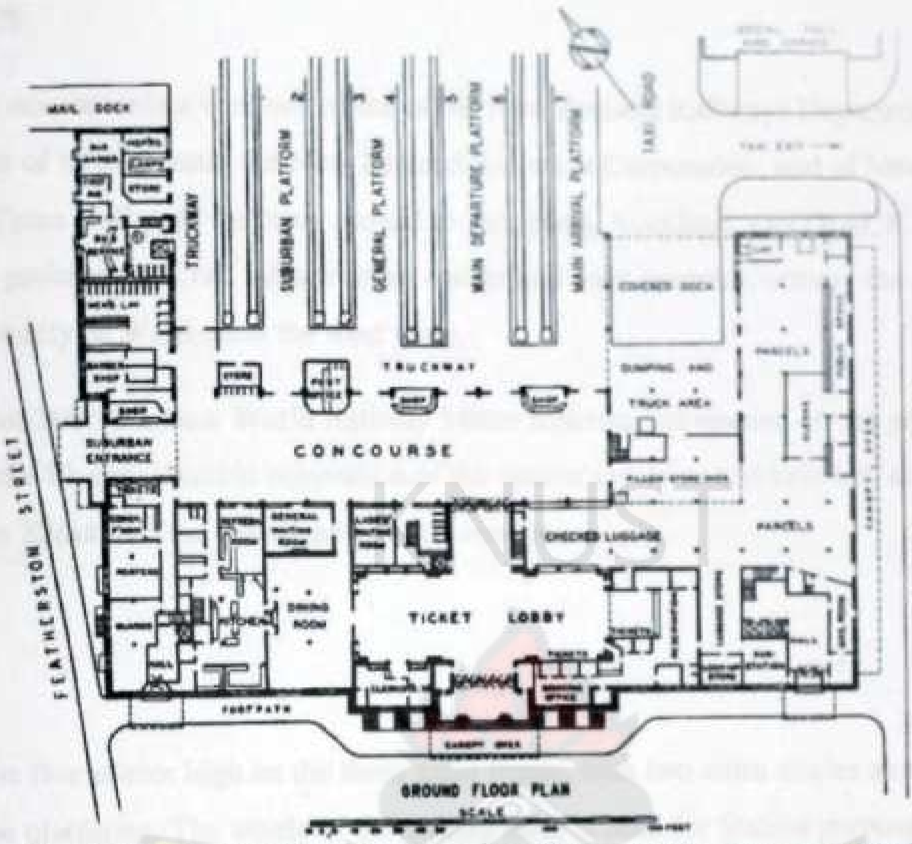


Figure 4.7 Layout showing the access to the new station and arrangement of the platforms



Ground Floor plan of Wellington's New Railway Station, showing the general layout.

Figure 4.8 a typical ground floor plan of New Wellington Railway station

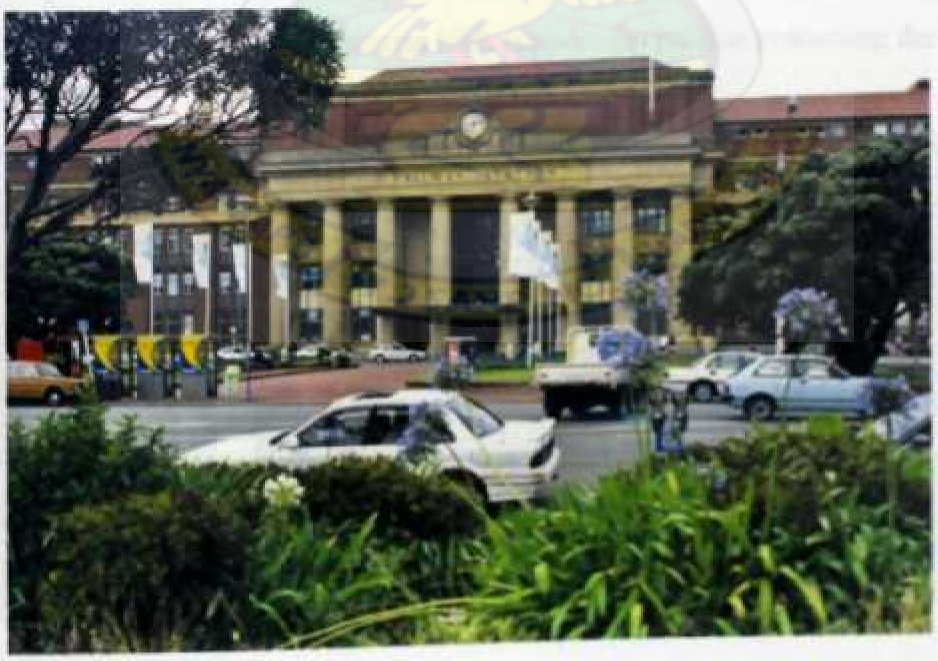


Figure 4.9 A view of the station with surrounding soft landscape.

OCCUPANTS

It was built to accommodate the head office of the New Zealand Railways Department and was the head office of its successor, the New Zealand Railways Corporation, and of New Zealand Rail Ltd and Tranz Rail until the latter moved to Takapuna, Auckland. ONTRACK and KiwiRail, the government's rail infrastructure owner and train operator, occupy the east wing, Victoria University of Wellington the west wing.

On 4 December 2006 the New World Railway Metro supermarket opened on the ground floor. This coincided with considerable renovation of the station's interior and exterior, and the closure of the Railway Kiosk and the American Hotdog vendor.

FLOORS

The building is five stories high on the three main fronts, with two extra stories along the north wall facing the platforms. The whole of the ground floor is used for Station purposes, and the whole of the upper floors, except part of the first and the sixth, for office purposes.

ENTRANCE

Eight massive columns reaching to four stories high support the portico protecting the main entrance from the weather.

Figure 4 .10 a picture of the entrance

WALL FINISHES

The building is of attractive design with base of coloured granite, exterior walls of brick and roof of Spanish mission tiles.

Figure 4.11 a picture of the interior

STRUCTURE

It has a steel frame encased in reinforced concrete and supported on groups of reinforced concrete piles. Bricks used for the outer cladding are of a special design, with slots to accommodate vertical rods reinforcing the brickwork and binding it to the structural members. It required 1.75 million bricks, plus 1500 tonnes of decorative granite and marble. The station is registered as a Category I Historic Place.

LANDSCAPE

The foreground on all three streets is laid out in lawns and shrubberies, harmonising with the architecture of the building.

Figure 4.12 the interior environment.

Figure 4.13 the platform area.

SERVICES

The station copes with large daily passenger numbers with very little alteration having proved necessary. In its first year, 7,600 passengers made 15,200 trips on 140 trains daily. Today, 22,000 passengers make 44,000 trips on 390 trains, excluding long-distance services.

BRIEF

Entrance lobby	Ticket window	Luggage counter	Station master
Traffic office	Foreman's office	Staff offices	Porter's room
Platforms	Truck ways	General waiting	Lavatories
Newspaper stall	Concourse	Telephone booths	Post office
Cafeteria	Hospital	Barber's saloon	Parcel Office

OBSERVATIONS

- Wide unobstructed spans to free movement
- Elaborate and pronounced entrance
- High volumes to give a sense of liberty
- The use of transparencies to bring in daylight
- Walls of platforms have been dirtied. (note: Use surface that is washable or resist abrasion.)

4.1.3 Lyon-Saint Exupery Airport Railway Station

Fig. 4.14 Exterior view of the Staion

Name of Facility

Lyon-Saint Exupery Airport Railway Station

Location

The station is located in Satolas, a city in France.

Design Philosophy

Light shine into the very heart of one of the darkest events in American history

Concept

The byzantine mandorla, the wings of cherubim above the ark of the covenant, the sheltering wings of the Egyptian canopic urns.

Duration of Project

1989-1994 in three phases

Essential Feactures

Main Hall-1,300 Ton Roof

Dimension- 120 X 100 Metres

Max. Height Of 40 Metres

Span- 53 Metres

Roof Concept

Abird released from a child'shand.

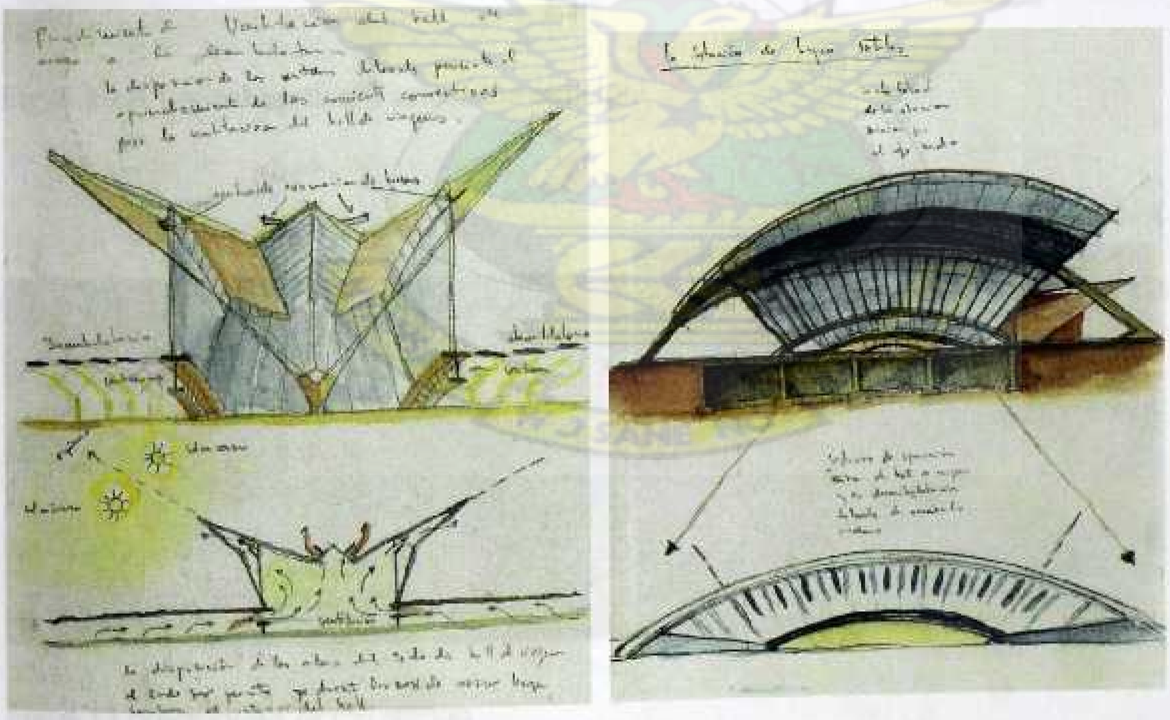


Fig. 4.15 Initial ideas

Materials

Glass, Steel, Concrete, Stone and Light.

Cost

The whole costed $ 2 Billion/ approximately 600 million Francs

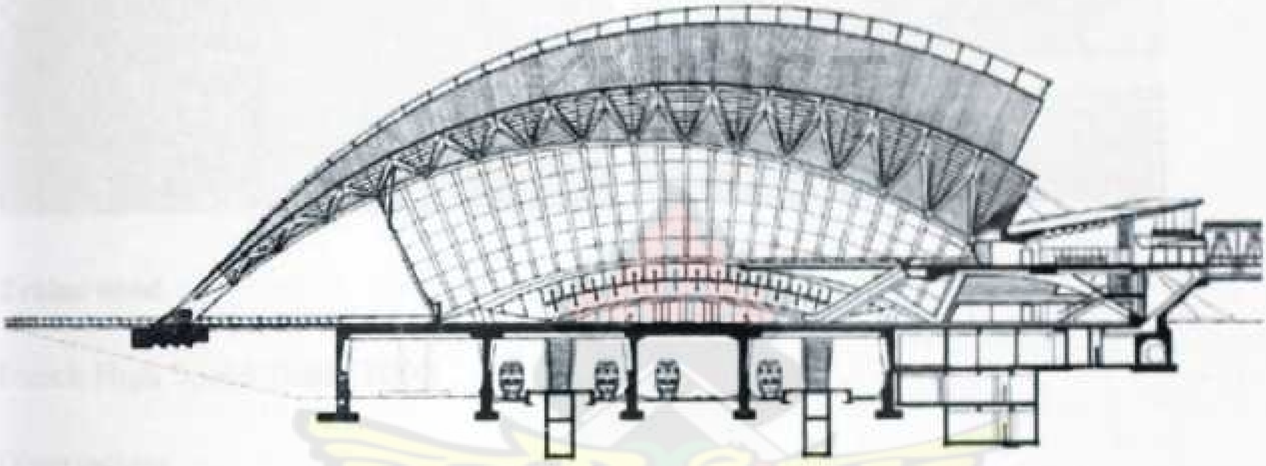


Fig. 4.16 A typical section a across the structure.

Fig. 4.17 other views of the station

Other facts

It accommodates 6-tracks with The middle two encased in a Concrete shell for trains to Pass at high speed (300km/h)


Trains used

French High Speed Train (TGV)

Observations

- Wide unobstructed spans to free movement
- Elaborate and pronounced entrance
- High volumes to give a sense of liberty
- The use of transparencies (glass) to bring in daylight
- Extensive use of concrete allows for easy
- Formation of forms and wide spanning.



BRIEF SUMMARY

Originally called the Lyon Satolas Station, this project is surely one of Calatrav's best known works. The architect was the winner of a competition organized by the Rhone-Aples Region and the Lyon Chamber of Commerce and Industry (CCIL). The competition brief called for a building that would provide smooth passenger flow while creating an exciting and symbolic "gateway to the region." The shape of this 5,600 square-metre facility, which was designed for the French national railway company (SNCF) to connect the high-speed train network (TGV) to the Lyon Airport in Satolas, is more closely related to Calatrav's sculptures than to any animal. Built at a total cost of 600 million francs in three phases, the station accommodates six tracks, with the middle two encased in a concrete shell for trains that pass through at high speeds (300km/h).

A 180-metre long steel connecting bridge linking the facility to the airport terminal gives the plan a shape that might bring to mind a stingray as much as a bird. Its essential feature remains the main hall with its 1,300-ton roof, measuring 120 X 100 metres, and a maximum height of 40metres and a span of 53 metres.

4.2 TRAFFIC STUDIES

4.2.1 Transport situation in Tema.

Statistics show that an average of about 60,000 people (approximately 10% of the population of Tema) commutes to Accra and back daily. Majority of the people commute through light buses (trotro) closely followed by commuters who use private cars.

According to a survey conducted by the Department of Urban Roads- Tema there is evident of a major road traffic crises in the near future should the situation be left in its current state. There are plans to elevate the already mentioned major road to a dual-carriage way. All these are efforts by the government of the day to curb this shortfall. Notwithstanding, the existence of a competitive rail transport, will not only serve as an alternative form of transport but will expedite and eventually cause the switch of commuters from the roads.

It is however imperative to note that if a viable railway network was to be put in place, the number of commuters who travel via the private cars could be slashed to a comprehensive 10-20% and thereby drastically solving the current crises on these two major roads.

Type of vehicle	Average no. of occupants(Ω)
Light Buses (Trotro)	15
Medium/ Heavy Buses	31
Taxis	3
Private Cars	2

Table 4.1 showing average occupancy of the various vehicles used.

TYPE OF VEHICLE	FREQUENCY (No. of vehicle)		TOTAL	NO. OF OCCUPANTS
	AM	PM		
Light Buses (Trotro)	868	1470	2338	35070
Medium/ Heavy Buses	119	152	271	8401
Taxis	1985	2629	4614	13842
Private Cars	3742	4285	8027	16054
TOTAL				**73367**

Table 4.2 Table showing the total number of vehicle plying the Accra-Tema road after bridge, near community 3 daily, and its corresponding occupancy.

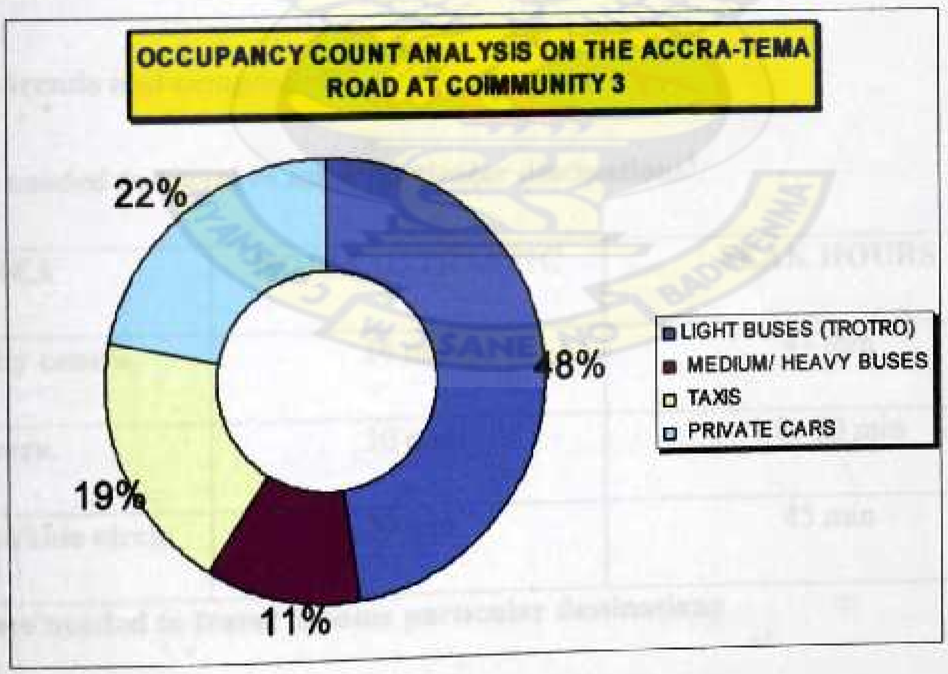


Figure 4.18 Occupancy count analysis on the Accra-Tema Road (community 3)

4.2.2 Vehicular classifiation

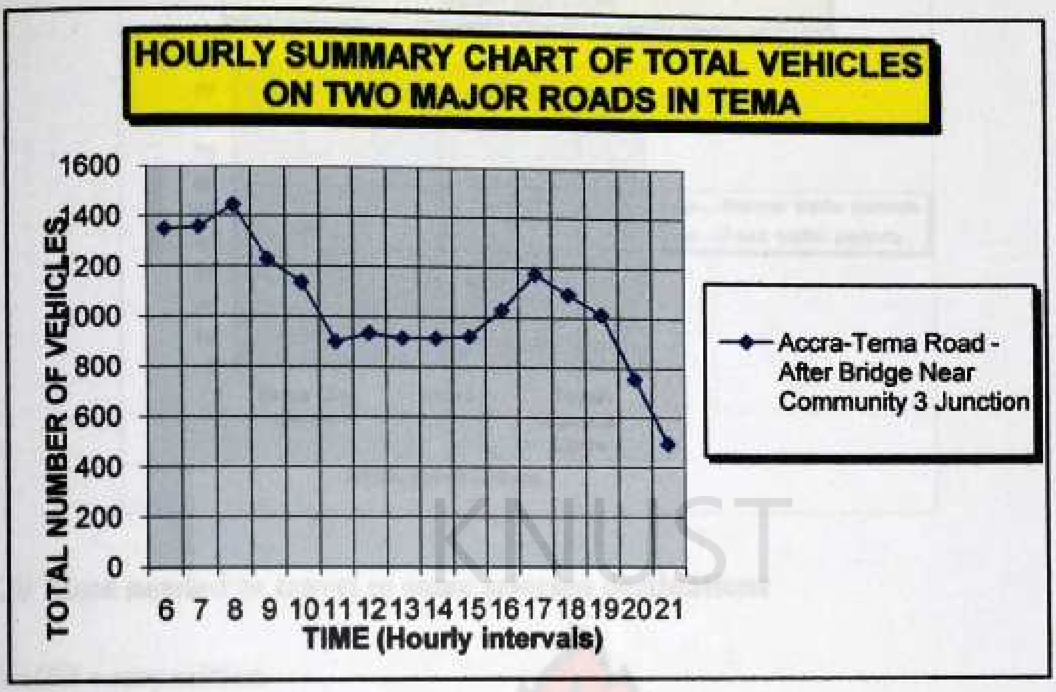


Figure 4.19 Hourly Summary chart of total vehicles on Accra- Tema Road (Com 3)

The Accra-Tema road after the bridge near community three junction is the busiest of the two due to the consistence of its use by motorist.

4.2.3 Traffic trends and composition

4.2.3.1 Time needed to travel to some particular destinations[1]

AREA	NORMAL TRAFFIC	PEAK HOURS
Tema city centre	10 min	45 min
Accra	30 min	1 hr 30 min
Tetteh Quarshie circle	20 min	45 min

Table 4.3 **Time needed to travel to some particular destinations**

[1] Report on Traffic Count Analysis: Department of Urban Roads, Tema.

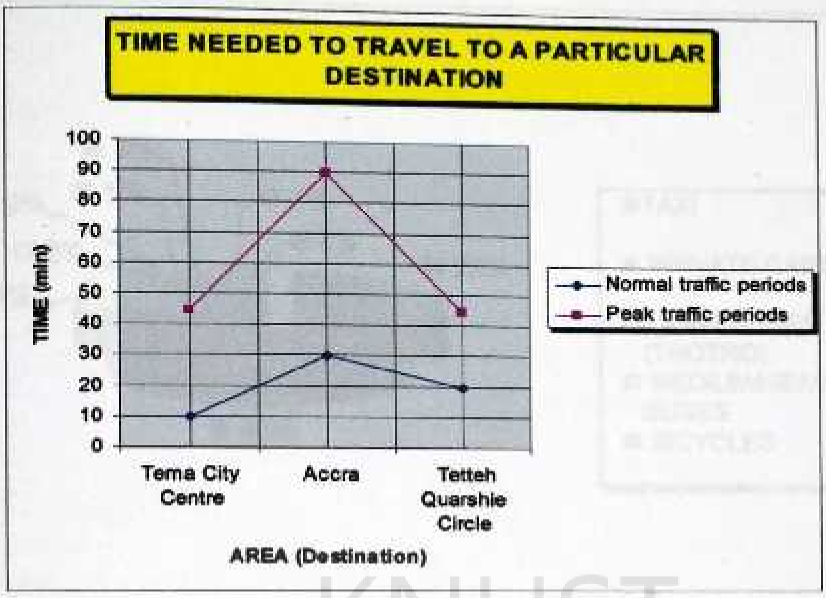


Figure 4.20 **Time needed to travel to some selected destinations**

4.2.3.2 Traffic composition

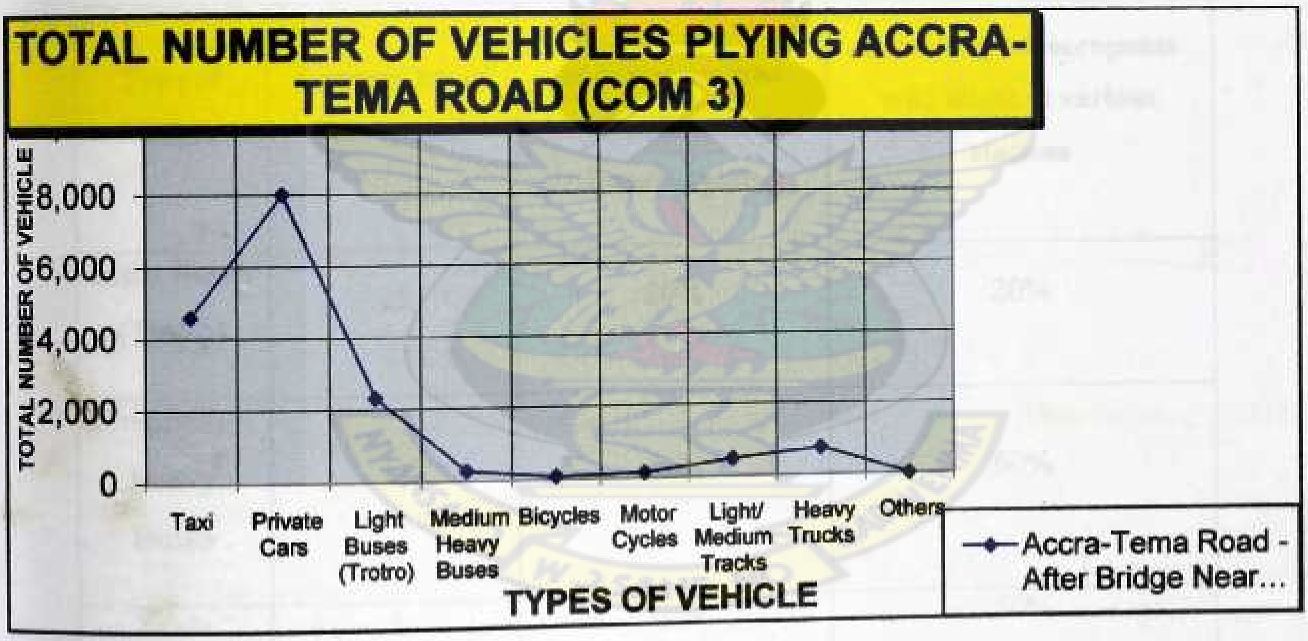


Figure 4.21**Total number of vehicles plying Accra-Tema Road (Com 3)**

The insufficiency of a reliable mode of public transport on these major roads has caused a rise in the use of private cars. Currently, 48% of vehicle that ply these routes are private cars. As compared to the other modes of transport this is on the high side.

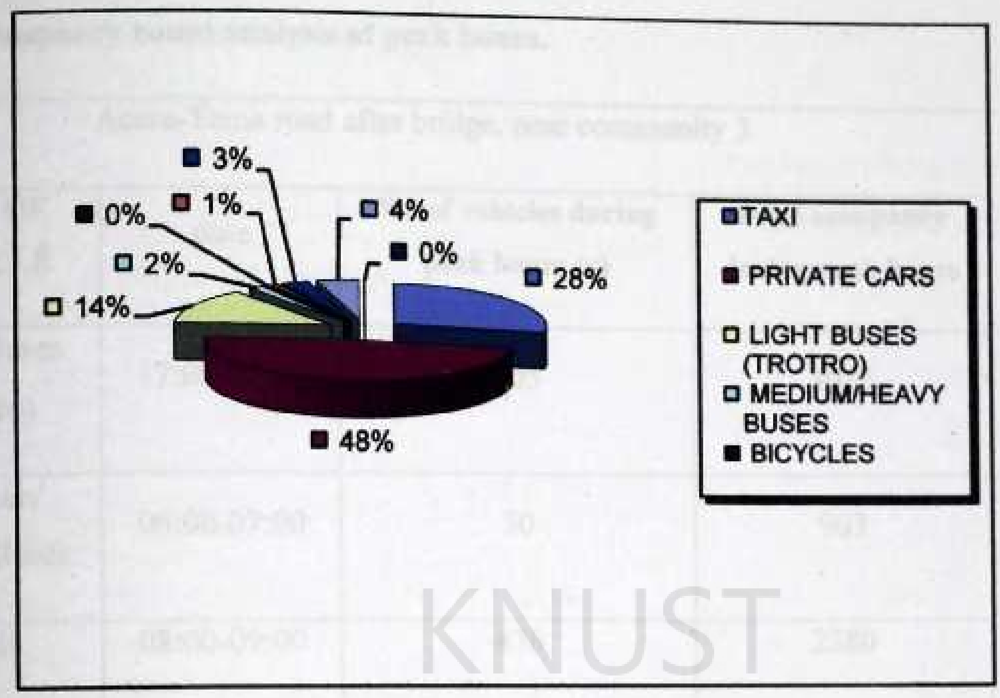


Figure 4.22 Statistics on Vehicles that ply the Tema road at peak hours

Type of vehicle	Average no. of occupants	Average percentage of occupants who travel to destination without alighting	Percentage of occupants who alight at various stations
Light Buses (Trotro)	15	80%	20%
Medium/ Heavy Buses	31	40%	60%
Taxis	5	50%	50%
Private Cars	2	100	-

Table 4.4 The average vehicular occupancy including crew was found at peak hours[2]

[2] Report on Traffic Count Analysis: Department of Urban Roads, Tema.

4.2.3.3 Occupancy count analysis at peak hours.

Accra-Tema road after bridge, near community 3.			
TYPE OF VEHICLE	**time**	**No. of vehicles during peak hours (v)**	**Total occupancy during peak hours**
Light Buses (Trotro)	17:00-18:00	205	3075
Medium/ Heavy Buses	06:00-07:00	30	903
Taxis	08:00-09:00	476	2380
Private Cars	07:00-08:00	701	1402
total			**7760**
Gross total			**21173**

Table 4.5 **Occupancy count analysis at peak hours.**

4.2.4 Characteristics of Vehicular/ passenger flow

- The total number of people who travel in Tema at peak hours is 21,173
- A greater number of commuters travel via light buses (trotro) than any other mode of transport, due to the frequent stops along the routes to its destination
- The figures above show that the private cars aside of being the highest number on these roads have one of the lowest occupancy levels.
- At peak hour 35% of both light Buses (Trotro) and taxis carry passengers to the various communities and destinations in the municipality. Also, statistics show that 20% and 30% of medium/ heavy buses and private cars respectively do not travel beyond the boundaries of Tema at peak periods.

Total no. of vehicles at peak hours (Z) = r+v

Type of vehicle	Total no. of passengers at peak hours (Z)	Passengers who commute beyond the boundaries of Tema	Passengers who travel to destination without alighting
Light Buses (Trotro)	10335	6718	5374
Medium/ Heavy Buses	3042	2434	974
Taxis	4960	3224	1612
Private Cars	2836	1985	1985
total	21173	14361	9945

Table 4.6 Total no. of vehicles at peak hours.

[3]The crew (i.e. the drivers and the bus conductors) on Light Buses (Trotro), Medium/ Heavy Buses, and Taxis cannot be classified as passengers. Thus from the above table a figure of 2668 being the crew on these three vehicle types would be deduct from the total figure of 9945.

This gives us a figure of 7277 passengers at the peak hours of the day.

4.2.5 Proposals

The township of Tema despite being a harbour and an industrial city is fast developing into a residential setting. Yearly thousands of people commute to settle in Tema due to its proximity to

[3] Ayitey Ayee, (2006) Tema Railway Station, KNUST

the capital city and its growing residential development. The population of Tema is however, set to double in the next decade if this trend continuous.

Currently the number of people who travel at the peak hours of the day is **7277**. Statistics show that about **45%** of commuters of both private and public transport will willingly shift to a more efficient rail transport. This thereby gives us a gross figure of **3274.65** commuters during peak hours.

By 2015, it is envisaged that the population of Tema which currently stands at 600,000 might reach one million. This will undoubtedly have a strain on the transportation system in Tema. In the event of this, a futurist figure of **4000** passenger capacity terminal is proposed, targeting both intracity and intercity commuters.[3]

4.3 TECHNICAL STUDIES

4.3.1 The Train

The average height of the existing trains used by the Railway Corporation is approximately 3665mm. leaving a gap of about 250mm between the train and the platform. The coaches and wagons also offer the same dimensions.

Present modern trains average about 4000mm leaving no gap between the train and the platform.

The major changes are:

1. in the Form and shape
2. An increase in height

And they are designed to be

1. light weight
2. Fast i.e. High speed ranging between 220-550km/h and modern railway technology is
    a. slabtruck
    b. central operated (computerized)

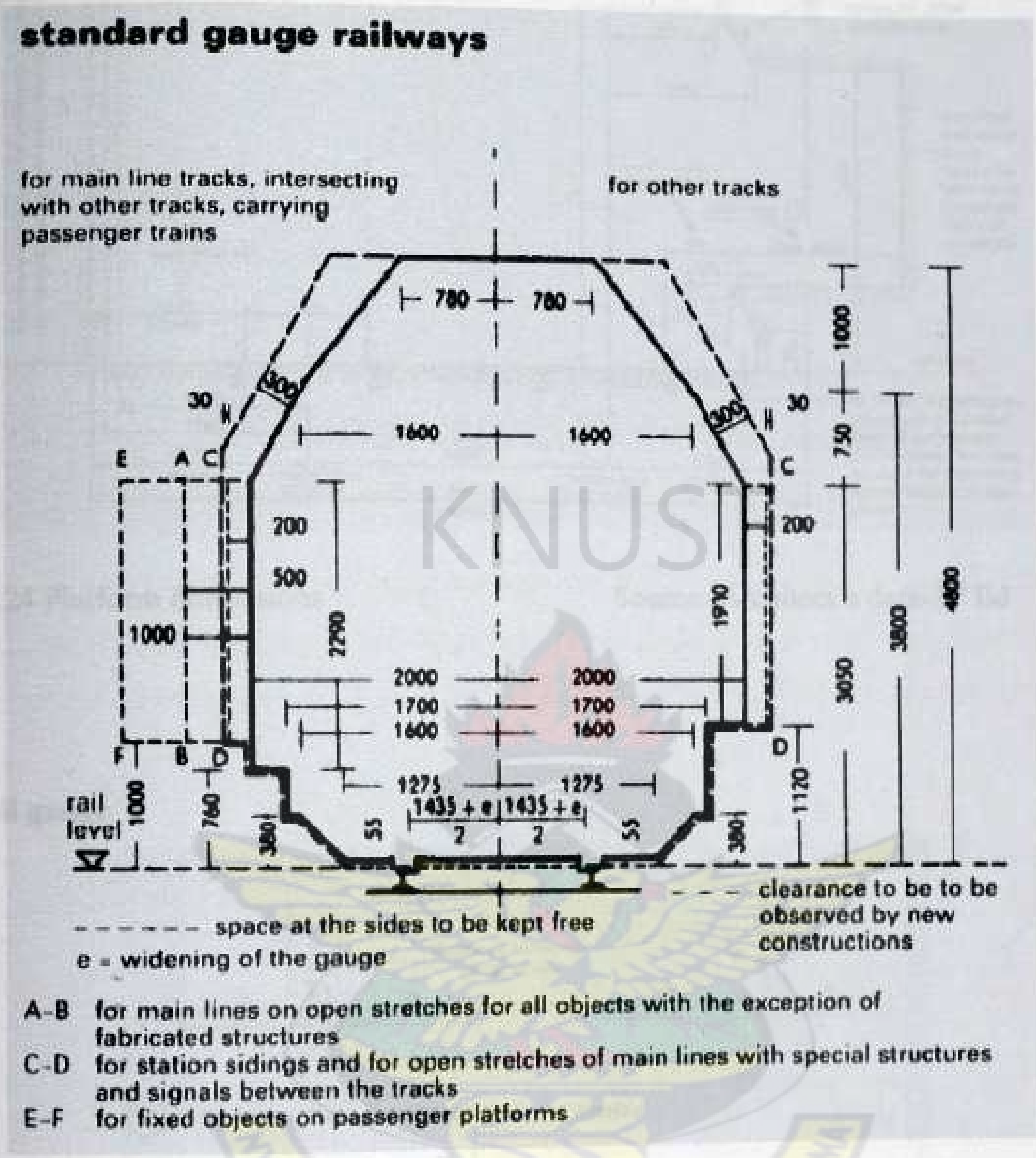


Figure 4.23 Train dimensions Source: Architect's data-3rd Ed

4.3.2 The platform

Platform heights vary from country to country, and can be as small as 0.38m. However, access to the platform must not involve passengers having to cross the track. This requires tunnels or bridges, which should have a width of 2.5-4.0m, if there is circulation in both directions; 4.00-8.00m is desirable. Steps on bridges or in tunnels should be the same width as the bridge or tunnel

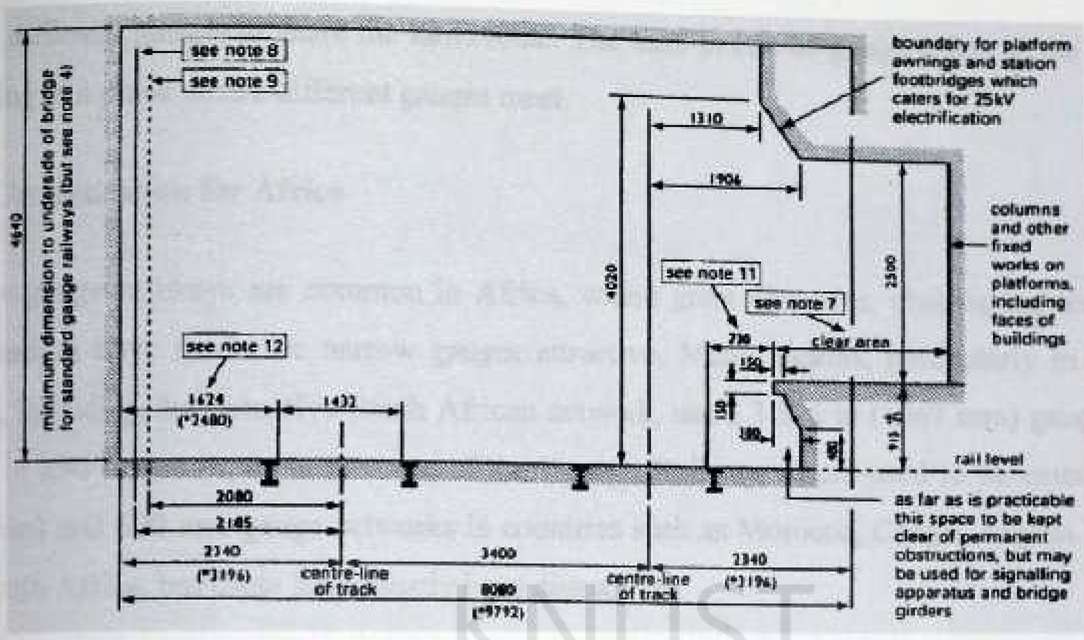


Figure 4.24 Platform dimensions Source: Architect's data-3rd Ed

4.3.3 Rail gauge

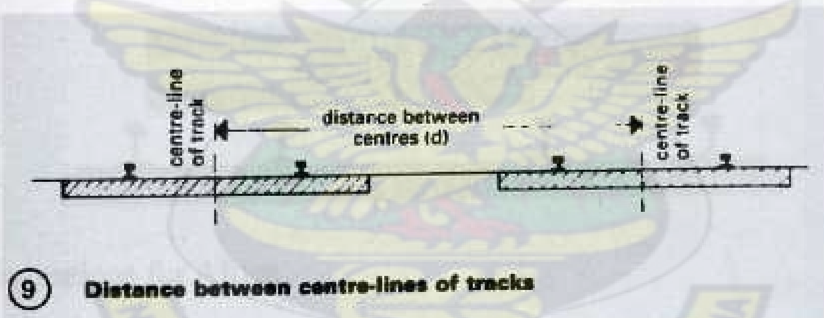


Figure 4.25 Distances between centre-lines of tracks Source: Architect's data-3rd Ed

Rail gauge is the distance between the inner sides of the two parallel rails which make up a railway track. Sixty percent of the world's railways use a gauge of 1435 mm (4 ft 8½ in), which is known as the **standard or international gauge**. Rail gauges wider than standard gauge are called **broad gauge (1495mm-2140mm)**, and rail gauges smaller than standard are called narrow gauge. Some stretches of track are built to a dual gauge: that is to say that three (or sometimes four) parallel running-rails are laid in place of the usual two, in order to allow trains of two different gauges to share the same route. The term **break-of-gauge** refers to the situation obtaining at a place where different gauges meet.

4.3.4 Configuration for Africa

Narrow-gauge railways are common in Africa, where great distances, challenging terrain and low funding have made the narrow gauges attractive. Many nations, particularly in southern Africa, including the extensive South African network, use a 3 ft 6 in (1067 mm) gauge. Metre gauge is also common, as in the case of the Uganda Railway. There used to be extensive 2 ft (610 mm) and 600 mm gauge networks in countries such as Morocco, Congo, Angola, Namibia and South Africa, but these have mostly been dismantled.

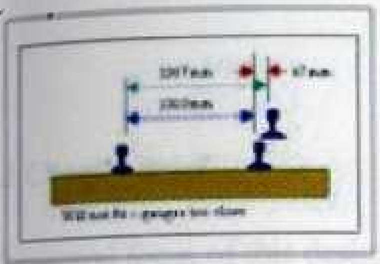
Because Africa is fragmented politically, railways built by governments tend not to link up with each other, each country's lines connecting its outlands with its own port. Incompatible gauges are therefore not obvious. For example, a link from Nigeria to Cameroon would join 1067 mm to 1000 mm.

Figure 4.26 Configurations for Africa

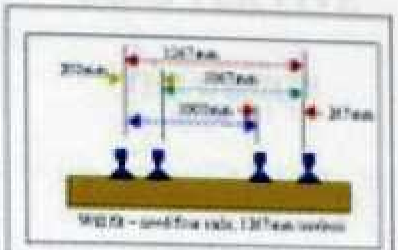
Proposal for Africa - a four rail system to support triple gauge (4 ft 8½ in, (1435 mm), 3 ft 3.375 in, (1000 mm) in and 3 ft 6 in (1067 mm) gauge), thus allowing system unification in Africa.

[1]1067 mm and 1000 mm gauges found in Africa are too close to allow 3-rail dual gauge. 4-rail dual gauge is required. With a little care, the sleepers for this dual gauge configuration can be made to support triple gauge, including the standard gauge of 1435 mm, at little extra cost.

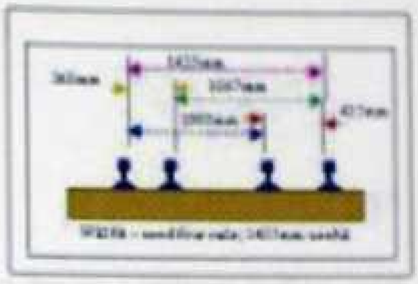
1



1000 mm and 1067 mm gauges are too close to allow 3-rail dual gauge



1000 mm and 1067 mm gauges can be commoned with 4 rail dual gauge



1000 mm and 1067 mm gauges can be commoned with 4 rail dual gauge with bonus 1435 mm gauge

An advantage of the four-rail dual gauge track is that the four rails combined to give some of the greater strength of two rails of double the weight. The allows the old rails to be reused to some extent, instead of being scrapped and used for fenceposts.

Comparison of standard gauge (blue) and one common narrow gauge (red) width.

Also, another way to bring the rails to the international level is to standardize all existing gauges. Standard-gauge railroads have a greater haulage capacity and allow greater speeds than the narrow-gauge system can ever hope to attain.

CHAPTER FIVE

THE DESIGN

5.1 Client's Brief

The central focus of this design project as stated by the client is to design a railway station with all the operational needs of the Ghana Railway Company. This involves , the administrative area, travelling centre, a commercial facility, a productive car parking and ancillary facilities.

Because the design was within the urban setting, a careful consideration was sought to ensure that :

- Urban development is enhanced and harmonized,
- Special performance requirement of the facility and the users are met as far as the facility is concerned.

A design needs to have strong contextual references so it's not just a design idea that plopped down on a landscape. The existing fabric of that community, the sense of place, what's around the site, must be considered so the result isn't arbitrary, but reinforces the strength of that community.

The scope of the design is therefore broken down into the following as a developed brief for design consideration and accommodation schedule:

5.2 DESIGN BRIEF/ SCHEDULE OF ACCOMMODATION

- PRODUCTIVE CAR PARKING
    - Taxi and Bus Rank
    - Drop off zone
    - Short Term Parking
    - Long Term Parking
    - Employee Parking
    - Service Parking

- Trolley parking
- Bicycle parking

- OPEN LANDSCAPE SPACES

- THE STATION BUILDING

Administrative Offices for the following

- Station staff
- Clerical staff
- Area manger and staff
- Area traffic manger and staff
- Area personnel manager and staff
- Chief engineer (civil and electrical), assistant engineer and drawing office
- Chief train inspector
- Senior internal auditor and Accounts staff
- Statistical Department
- Radio telephone offices
- Signal clerical staff
- Sectional controller
- Station Masters Office
- Baggage Section/ Weighing Section
- Storage Cabinets & Lockers

- Operations – Control Room
  - Accident Centre
  - Control Room
  - Wagon Cell
  - Platform area
- Conference room
- Departmental offices
- Commercial – Ticket sales point

- Entrance foyer
- Concourse
- Waiting areas
- Observation galleries
- Telephone booths
- Post and Parcel office
- Storage facilities
- Lavatories
- Local and exotic Restaurants / Kitchens
- Bar
- Shopping arcade -Shops, Internet Cafes,
- E-toy learning centre
- Museum of Ghana's Railway History
- Security Points
- Banking Facilities
- First Aid Centre
- Pharmacies
- Crime unit
- Waiting Lounge And Phone Booths
- Engineering Yard & Workshops
- Refueling dump

SPECIAL FACILITIES

- Advertisement
- Signal area
- Announcement bay

ANCILLARIES

- Plant room (generator set)

- Air-conditioning room
- Fire control unit
- Waste management unit

5.4 PLANNING AND DESIGN

"If you take the example of the modern stations in Switzerland- in Zurich or Basel, for example- you get feeling that you are in a shopping mall".

-Santiago Calatrava-

What sort of building must a train station be then? It must therefore be wide to house the grand diesel multiple engines and their steel tracks, sheltering the disorganized bustle of all the arriving and departing passengers, their baggage and sometimes even their livestock.

"In the early 1800's, no single space compared in the scale and height with the archetypal cathedral. Although serving a much humbler purpose, railway stations needed to be built to a similar scale"[1]

5.4.1 Visibility And Orientation

Passengers want to see staff and be seen by staff. Passengers want a clear view through public spaces and be sure of where they are going. Visibility deters the vandal and the thief. However extensive glazing brings with it the problem of making TV screens unreadable.

The maximum value is obtained through locating staffed areas where they permit a view over greatest number of passengers for the greatest proportion of their time on the station

With this background the arrivals and the departures found on the ground floor of the design is an open floor area with very few partitions giving visibility for both the passengers, staff and security. Seating is however arrange to allow some privacy within the open area by providing segregated seating interspersed with lockers and petty shops

5.4.2 Space Planning

There are three main aims in the planning of space within stations:

a. The avoidance of congestion
b. The resilience to surges in demand of train service
c. Capacity for evacuation

Good initial space planning will help station to function efficiently throughout their lives:

- Stations design should promote both the free flow of passengers through public areas and reasonable comfort in waiting areas, whilst promoting a feeling of security
- Designs should promote optimal use of spaces, such as shared routes to different areas and platforms
- Adequate space must be provided for all activities, without conflict.
- Stations design should naturally lead passengers past facilities (such as timetable posters and ticket-selling facilities) in a logical manner.
- Routes should be obvious and direct, requiring minimal walking distances.

Having this in mind the proposed design has generous and open areas for circulation. This gives the shortest routes from outside to the platforms to board trains. Ticket stands, help desks, security, lavatories and shops have been catered for en route to the platforms.

5.4.3 Planning For Hazards

Stations may be faced with a number of types of hazards. Fire is usually the greatest; however, flooding, leakage from water mains and sewers, derailments and other hazards must be considered.

Hence:

- Environments should be as fuel free as possible to minimize the risk of fire starting and spreading. Areas may be segregated by fire-resistant partitions
- External services, including water, electricity should be diverted to separate them from station premises, of compartmented to contain any leakage.

- Suitable monitoring systems, alarms and fire suppression equipment should be installed to give sufficient warning and protection that there is time for stations to be evacuated in emergency.
- Maximum travel distances to a means of escape for this kind of building are 30m in unsprinklered situations and 45m for sprinklered buildings
- Minimum corridors width will be 1250mm with a minimum of 4 doors opening in the direction of exit travel and capable of being opened manually.

In response to this, wide accesses are provided from the waiting area and the platforms to aid easy evacuation during emergency situations. In case of fire, the openness of the floors allows very little smoke build up which improves passenger visibility and the decreases the incidence of choking on smoke and facilitating easy evacuation.

5.4.4 Customer Focused Design

For a terminal to run successfully it is essential for the operator to know who its customers – and their customers are, what they need, and be able to service their needs

The starting point of this exercise was to understand passengers better – who they are and what they find important in their journeys through this terminal. I also wanted to understand which groups are the most demanding of quality service and how that related to their expectations of the design. I was also interested in what passengers found to be the most important aspects of their journey and its correlation with their satisfaction and experience. I also reviewed where there were special needs, both in terms of wheelchair access, and difficulties in hearing and sight.

The passengers were classified under 6 main groups: business executives, students, workers, shoppers, traders, and tourists, with special considerations for physically disabled, parent with child and senior citizens.

The summary conclusions are that 43 percent of our passengers are female, seven percent have special needs, and what passengers generally find most important are way finding, staff helpfulness, reliability and punctuality of service. The most demanding passengers are the middle income workers who use the service more than twice a day.

Once I understood and established these needs I needed to understand what aspects of the design response were most closely related so that I could deliver against these needs.

Ramps and lifts are used to help the physically challenged overcome vertical barriers in moving from floor to floor. A gradient of 1 in 12 is used for the ramps to enable wheelchair users to move safely without need for any assistance. This also caters for passengers with loads who may conveniently use provided trolleys to assist. Controls of lifts are placed at such a level to allow wheelchair user control.

With considerations of peculiar needs of religious passengers, sanitary facilities are provided for ablutions and space for prayer for Moslems in transit.

Two levels of restaurants are provided for divergent needs of passengers considering income levels and choice of dishes. Thus a chop bar, an exquisite restaurant and a moderate eating area are made available. The freight zone features a place for the temporary keeping of livestock. A convenient play pen is provided to assist "parent with child" situations during waiting times

5.6 Functional Diagrams

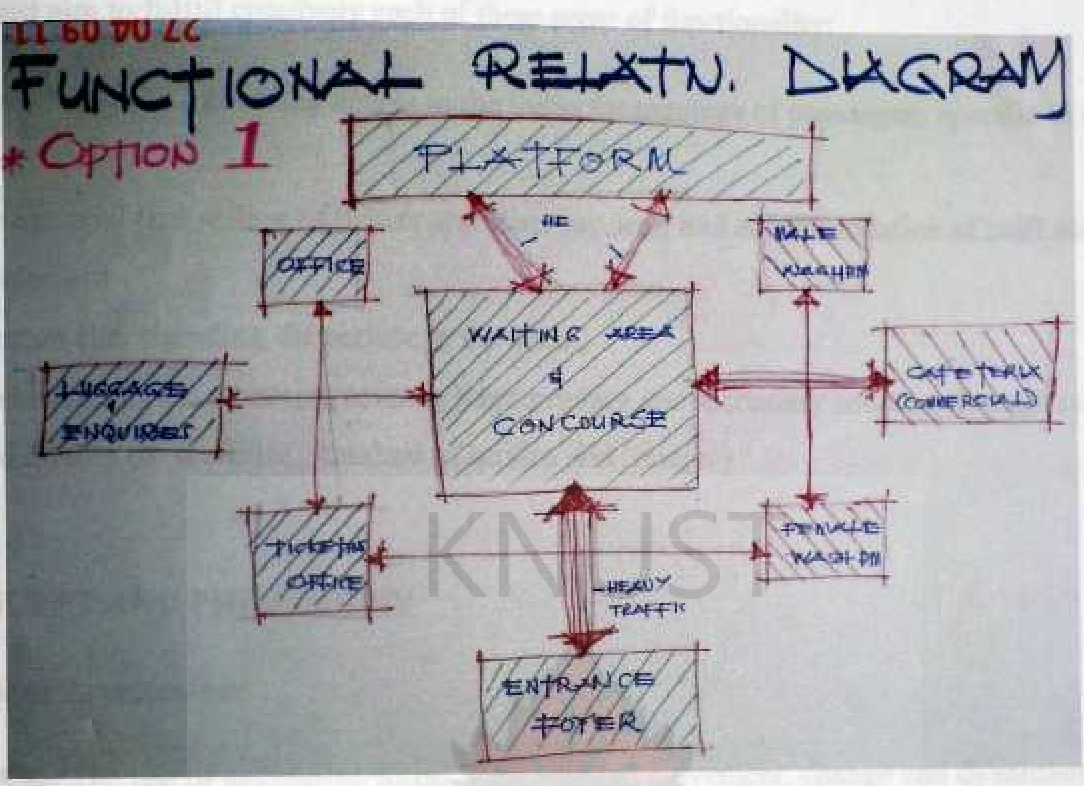


Figure 5.1 OPTION ONE

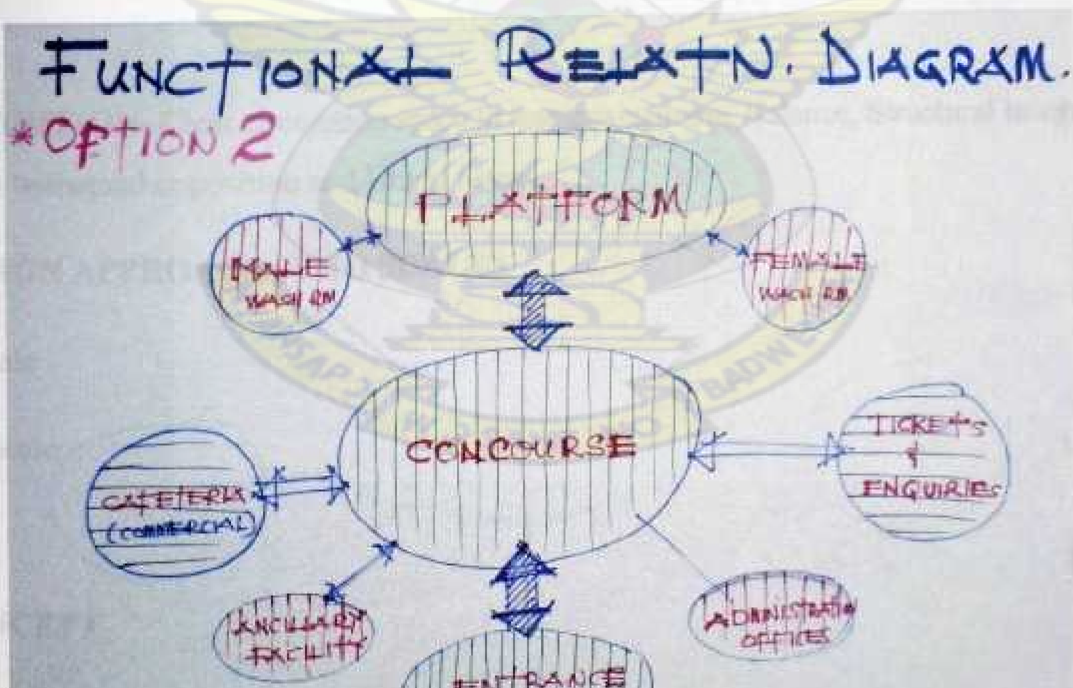


Figure 5.1 OPTION TWO

When functioning to their full capacity stations will function broadly in four areas. The design process must aim to fulfill creatively each of these areas of functionality:

- Circulatory (i.e. providing access to the trains for numbers of passengers specific to each site).
- Operational (i.e. selling of tickets and other services, and accommodation of staff and equipment
- Beacon (i.e. signaling the service in the street)
- Commercial (i.e. attracting revenue from primary and secondary sources, through range and quality of facilities, standard of service and 'image')

5.6 CONCEPT AND PHILOSOPHY

5.6.1 Style of Architecture

FUTURISM- The use of aggressive forms. Representing movement, change and dynamism in present times.

5.6.2 DEFINITION- Clear circulation space to transact business, Balance, Structural integrity, capacity to withstand opposition and lateral forces.

5.7.3 DESIGN APPROACH- TWO SCALES

Human Scale

Machine Scale

5.6.4 CONCEPT

Concourse

Entrance Lobby

Platforms

Rolling Stock

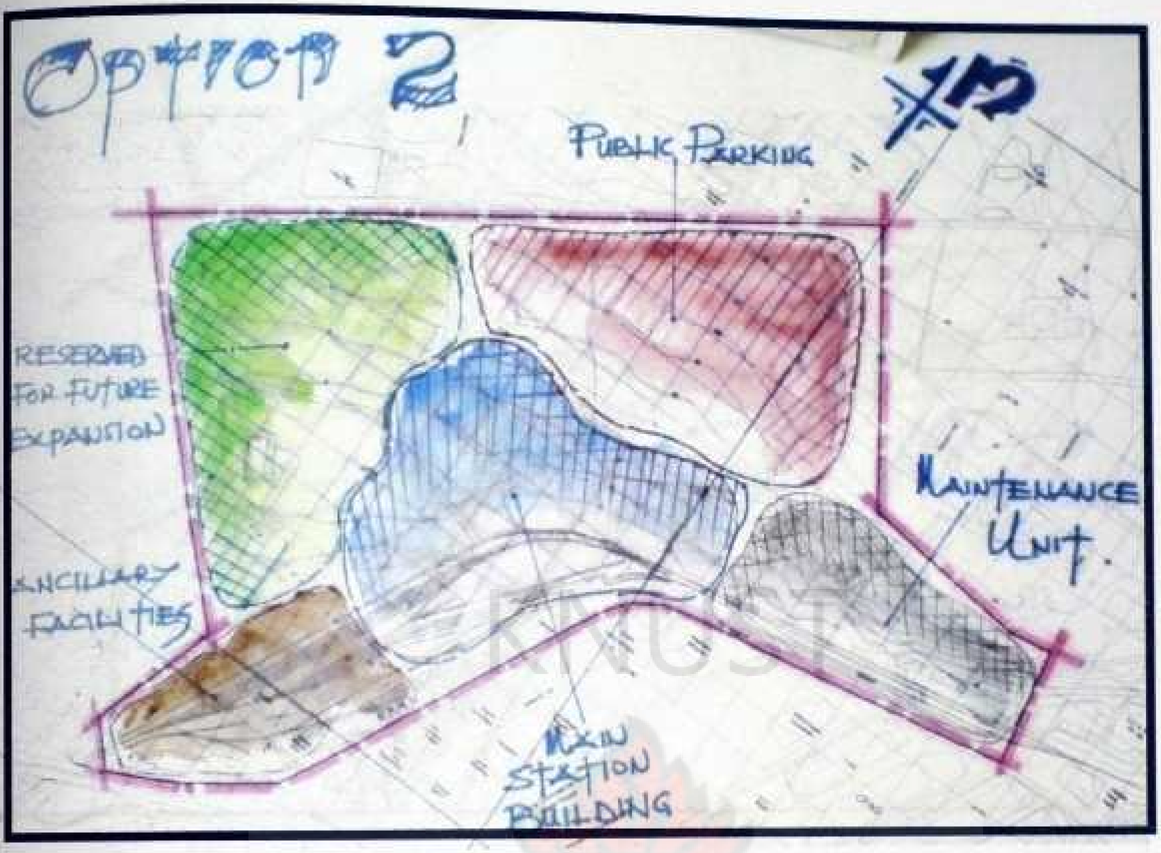
Escalators and elevators

Considerations – safety and security, ventilation, lighting, solar ingress, utilities

5.6.5 MATERIALS- concrete, steel and glass.

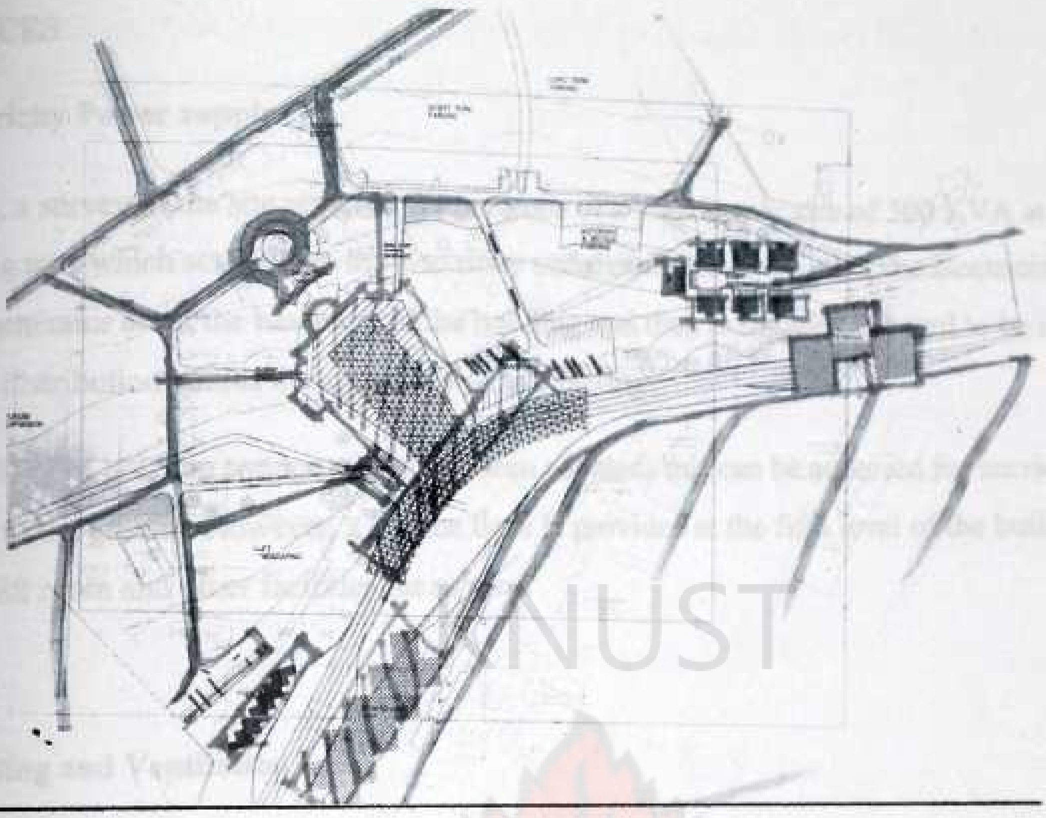
5.7 SITE PLANNING AND LAYOUT

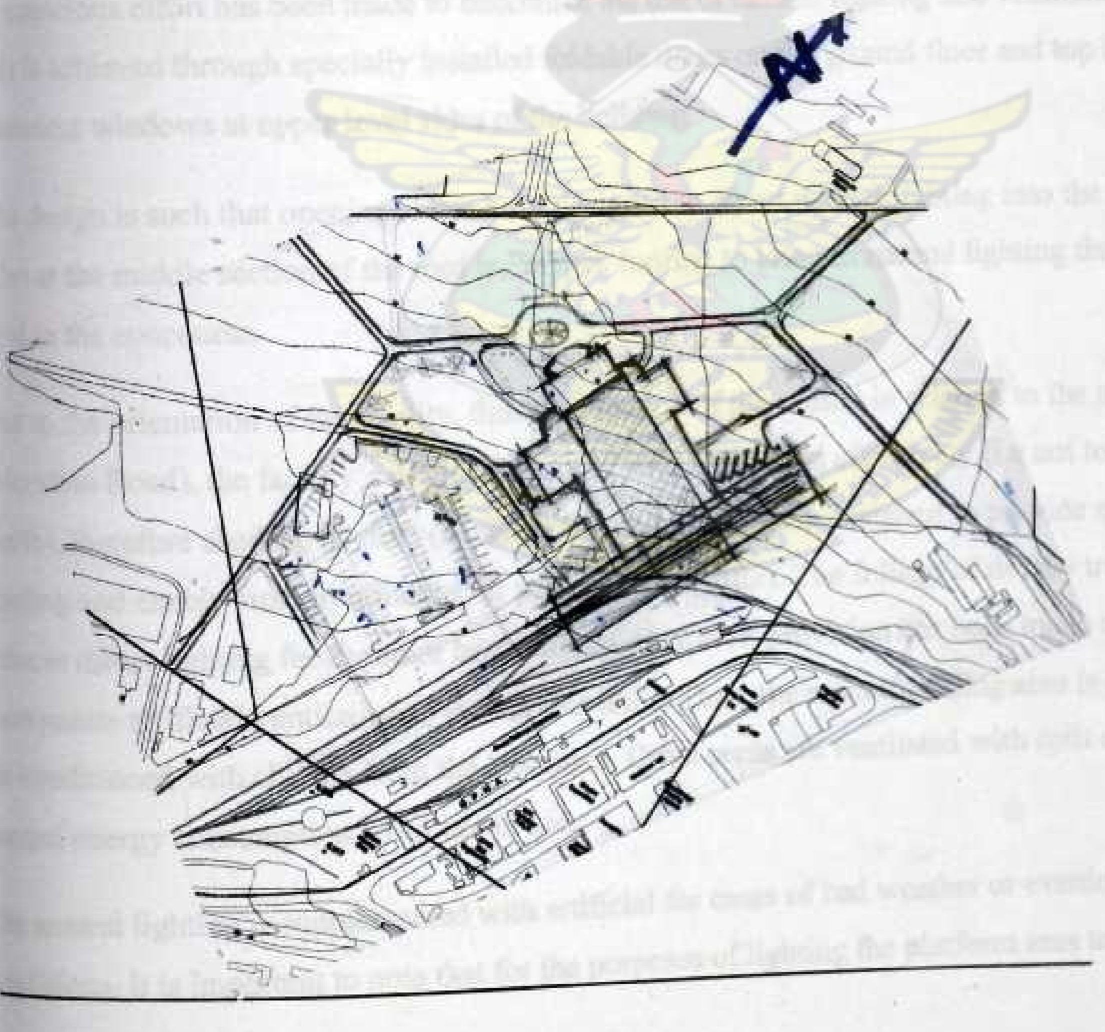
OPTION ONE



OPTION TWO

OPTION THREE





5.8 SERVICES

5.8.1 Electricity Power supply

Fortunately, a survey of the site revealed the presence of a transformer size of 500 KVA at the warehousing area which steps down the electricity and distributes to the site. The electricity is taken to a generator set at the basement of the building and then to the switch board to be sent to the various distribution boards throughout the entire facility.

The technology of hoisting service panels has been adopted; this can be accessed for service by lowering it to the ground. However, a service floor is provided at the fifth level of the building to access the lift room and other facilities for service.

5.8.2 Lighting and Ventilation

A conscious effort has been made to maximize the use of natural lighting and ventilation, and this is achieved through specially installed foldable doors on the ground floor and top hung casement windows at upper level sides of the building.

The design is such that openings have been designed to direct natural lighting into the station. Also at the middle section of the roof is Perspex roofing to bring in natural lighting through the void to the concourse.

Due to the orientation of the facility, thus the location of the station in relation to the major street (Meridian Road), the facility's orientation could not be achieved effectively (i.e not to the true North), therefore shading devices (concrete fins) have been also designed to provide maximum shading and enable cross ventilation for passengers' comfort. The foliage of nearby trees also reduces direct lighting for the solar heat buildup. However, provision has been made to incorporate artificial ventilation to the various units. Thus, the main travelling area is centrally air-conditioned with chillers from the basement. Other areas are ventilated with split units to control energy consumption when not in use.

The natural lighting is supplemented with artificial for cases of bad weather or evening conditions. It is important to note that for the purposes of lighting the platform area and the some portions of the station, a study was made into the generation of motive power from the rails through the acceleration of the trains (gravity power generation).

Emergency lighting has been provided for escape routes, to illuminate fire alarm call points and firefighting equipment.

Security lighting especially in the public parking and around the complex including the fringes of the street have been provided for whilst amenity lighting in the form of spot lights in the garden and the façade of the building.

5.8.3 Information Systems

For purposes of effectively monitoring activities within the facility, the whole building is departmentalized and centrally controlled by a system. The entrance, concourse and pedestrian areas have signages, public address systems and display units to keep commuters informed on their navigation throughout the entire facility.

The same mechanisms are installed at the exterior of the station to direct commuters and relay information where necessary.

Information systems in the concourse and lobbies are: information panels of the system, system map, neighbourhood and location map.Which are integrated with lighting and utility services. There is availability of bilingual services to the advantage of the traveling public. Hearing aids have also been made available within the station for the people with disability and this will be administered by special people.

5.8.4 Security Control

Aside the use of security personnel to curb malpractice within the station and its immediate environs, closed-circuit televisions (CCTV) has been installed with a 24 hour surveillance system.

There has also been an effort to individually control the various units of activities within the whole building envelope to ensure security at each section of the facility. This is achieved by physical barriers to every zone. For instance, Turnstiles has been used to isolate the paid areas from the unpaid areas. All entry points controlled and carefully monitored. And provision has been made for future use of walk- through scanners.

5.8.5 Fire

There is a fire service unit within the facility for emergency dealing with security, fire fighting, maintenance etc. and the fire fighting within the system involves the sprinkler system, heat and smoke detectors and fire exit points.

Fire hydrants have been also provided at 50metres centers (maximum distance) and are serviced by 75mm diameter ring pipe from the 100mm diameter mains. This supported also by a sprinkler system which is activated at temperature.

5.8.6 Surface drainage

Surface drainage is generally underground in covered drains with the provision of grills intermittently to take away rain water. The lawns have also been provided with subterranean drain pipes to help drain it effectively.

An underground sump has also been created to accommodate surface drain for treatment; this is to be recycled for use in washroom, landscaping and other non-drinkable utilities

The use of pneumatic pump on the site facilitates the flow of water coupled with natural gravity. Soil waste has been channeled to a septic tank (Cess pool)

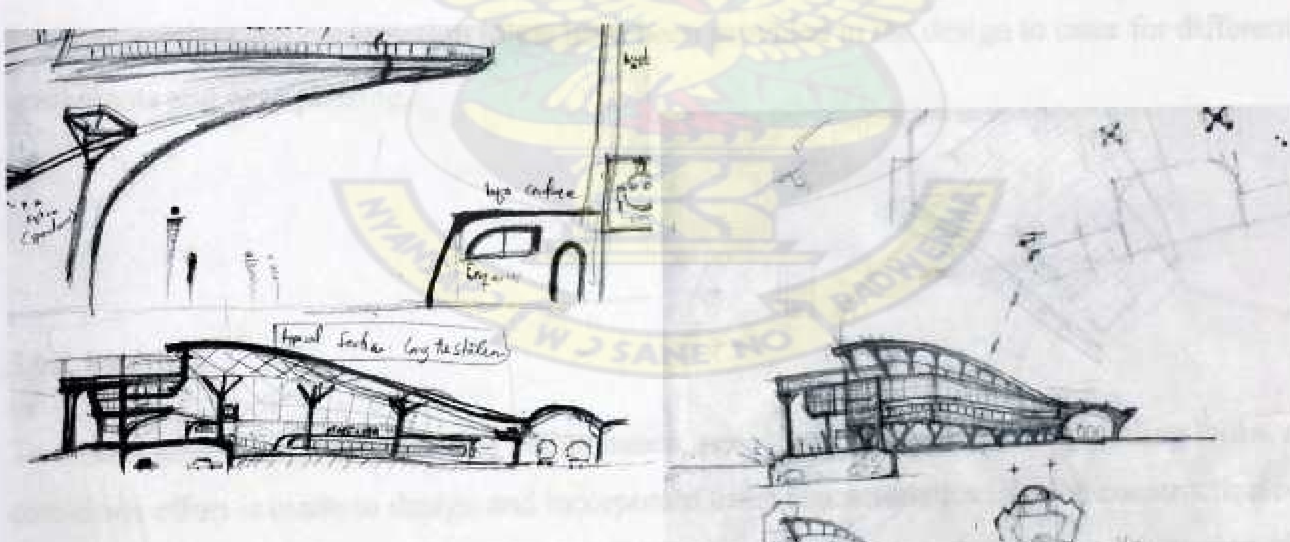
5.8.7 Communication

Telephone services are also available to all and sundry. For instance, the concourse area has been provided with telephone booths to aid travelers in contacting relatives and friends or even lodge complains when the need arises. The distribution panels point by the telecommunication distributes it to a centre where the managers, chief administration, chief engineer, the accountant and the deputy managing director all have direct lines. Other offices all have intercom-system.

5.9 CONSTRUCTION TECHNOLOGY

The structure itself is an architectural expression of the station. It creates a most distinguished contribution to the development of concrete, metal and glass.

The construction method to be used is basically that of steel space frame for the roof and support system of the platform area, and the use reinforced concrete for the main station building.



The choice of steel is to introduce light weight structure and to allow for greater adaptability in case of alterations.

Concrete was also chosen as a principal construction material because:

- mass: giving a robust structure to absorb braking force of trains
- stiffness: innate stiffness requiring fewer cladding joints
- fire resistance: easily achieving 2 hours standard
- noise insulation: its ability of absorb noise
- fatigue resistance: less sensitivity to live loads

The choice of the structural grid has been influenced by the user requirements of various spaces. Such that for the use of mass transit system, large grid centers are more often advisable to create expanse and freeness of space. The use of 10m grid for the whole design and the grid changing at the platform area to suit the tracks i.e. a standardized track of 1465mm and platform design with the minimum width of 6m.

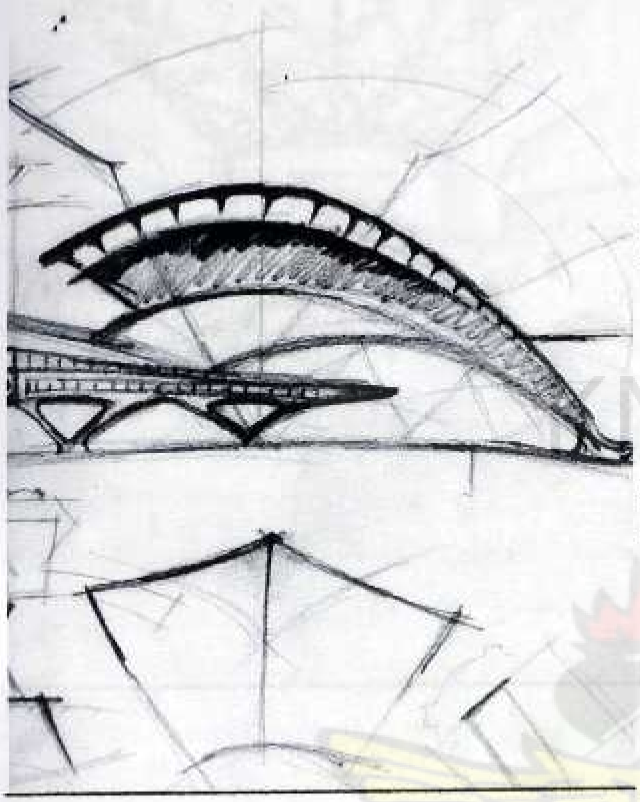
For the columns, they are in insitu cast concrete and beams and they have been designed such that the services within the structure are passed. The 800mm diametre reinforced columns are placed at 12m centres but are grided. This is an advantage of the space frame system over the conventional truss system of spanning.

Expansion joints and construction joints have been provided in the design to cater for differential settlements and easy phasing.

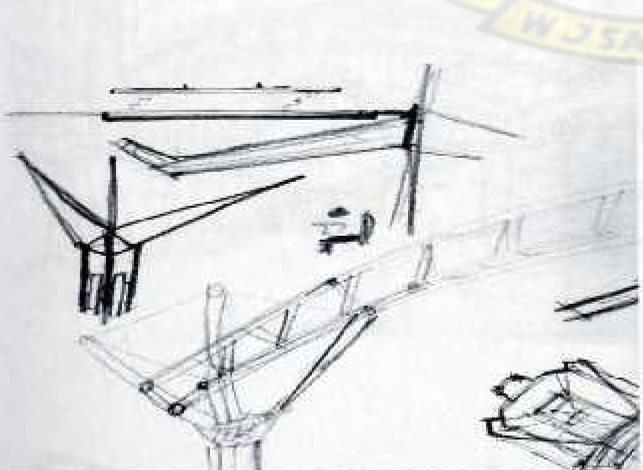
5.9.2 Finishes

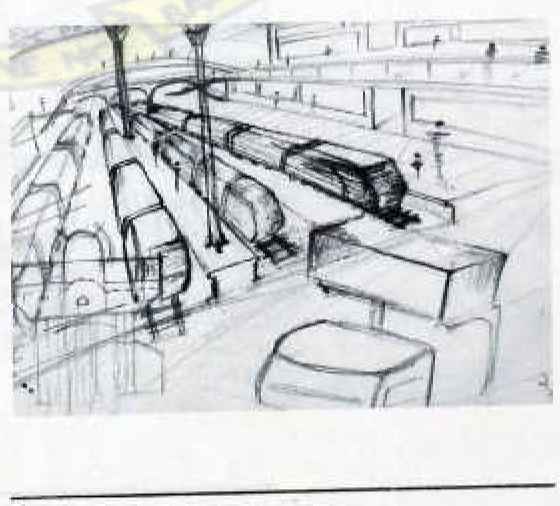
To ensure safety, durability, ease of maintenance, resistance to abrasion and appealing looks, a conscious effort is made to design and incorporate these characteristics into the construction of the various surfaces of the station. The floors have been designed such that there are zoning of floors to provide an articulated field which diffuses the boundaries of the spaces in the station. These are zoned by the use of change in textures and colours. This will enable commuters orientate themselves upon arrival.

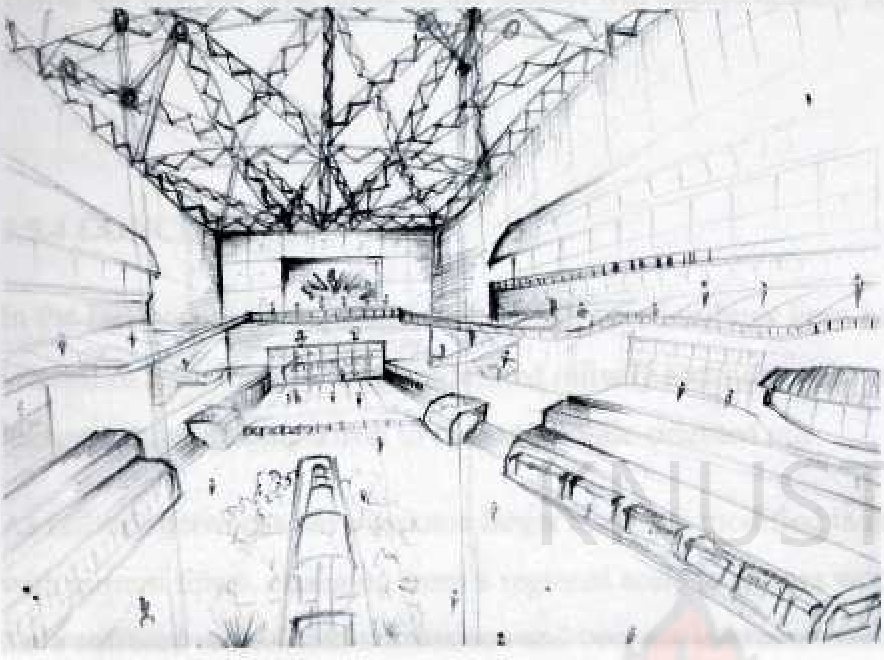
Walls are finished with abrasion proof finish to prolong the life span before replacement. Generally, surfaces of facilities are carefully selected and installed to aid in maximum vision especially with cases of display units, televisions and information panels.

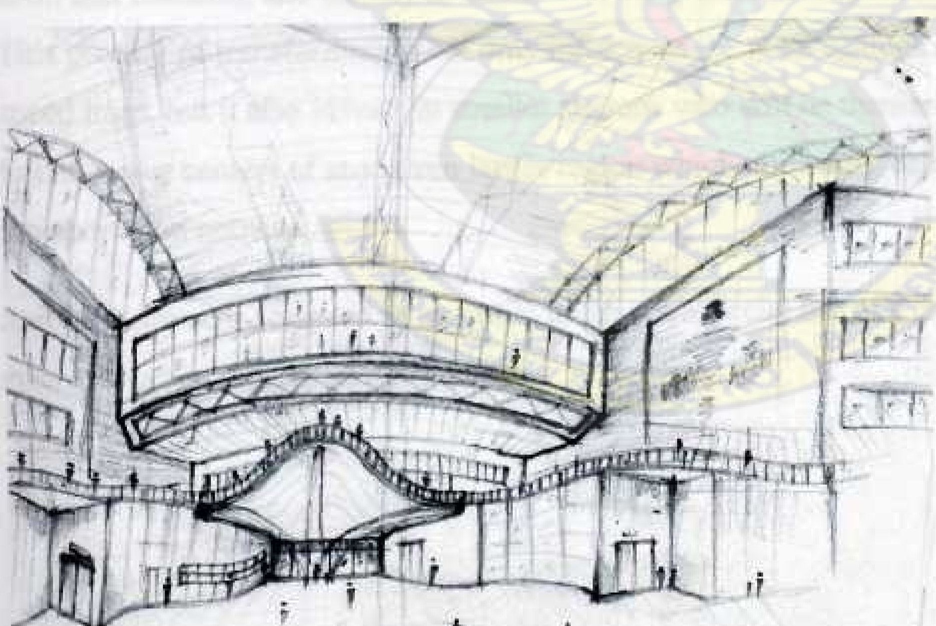


The materials chosen for the floor finish are heavy duty, durable and non slip. Also light coloured materials have been chosen to reflect light and help create a brighter atmosphere.









5.9.3 COSTING

Using the cost per area method, the project will approximately cost about $3.5 billion to complete.

5.9.4 CONCLUSION

In the last twenty years, the advent of high speed railway lines has renewed public interest in train travel and has redefined railway architecture as an important infrastructure in comparison to the automobile-oriented one.

As railway networks have become larger and have modified themselves to keep up with current times, changing from a regional scale to a more worldwide one, stations have suffered radical transformations and become interconnected knots of a network that crosses national borders.

The aim of this present work is to underline how these railway network changes have influenced, with the passing of time, the "object station," changing its composition, its form and function, and its way to relate with the greater metropolitan area.

This process of transformation not only influences the great stations crossed by high speed lines, but it also invests in smaller stations who will be themselves, in the future, nerve centers of any given larger region which ultimately belongs to the global transportation network.

Railways are now accepted as essential to the commercial life of a city, they are regarded as a means of urban regeneration.

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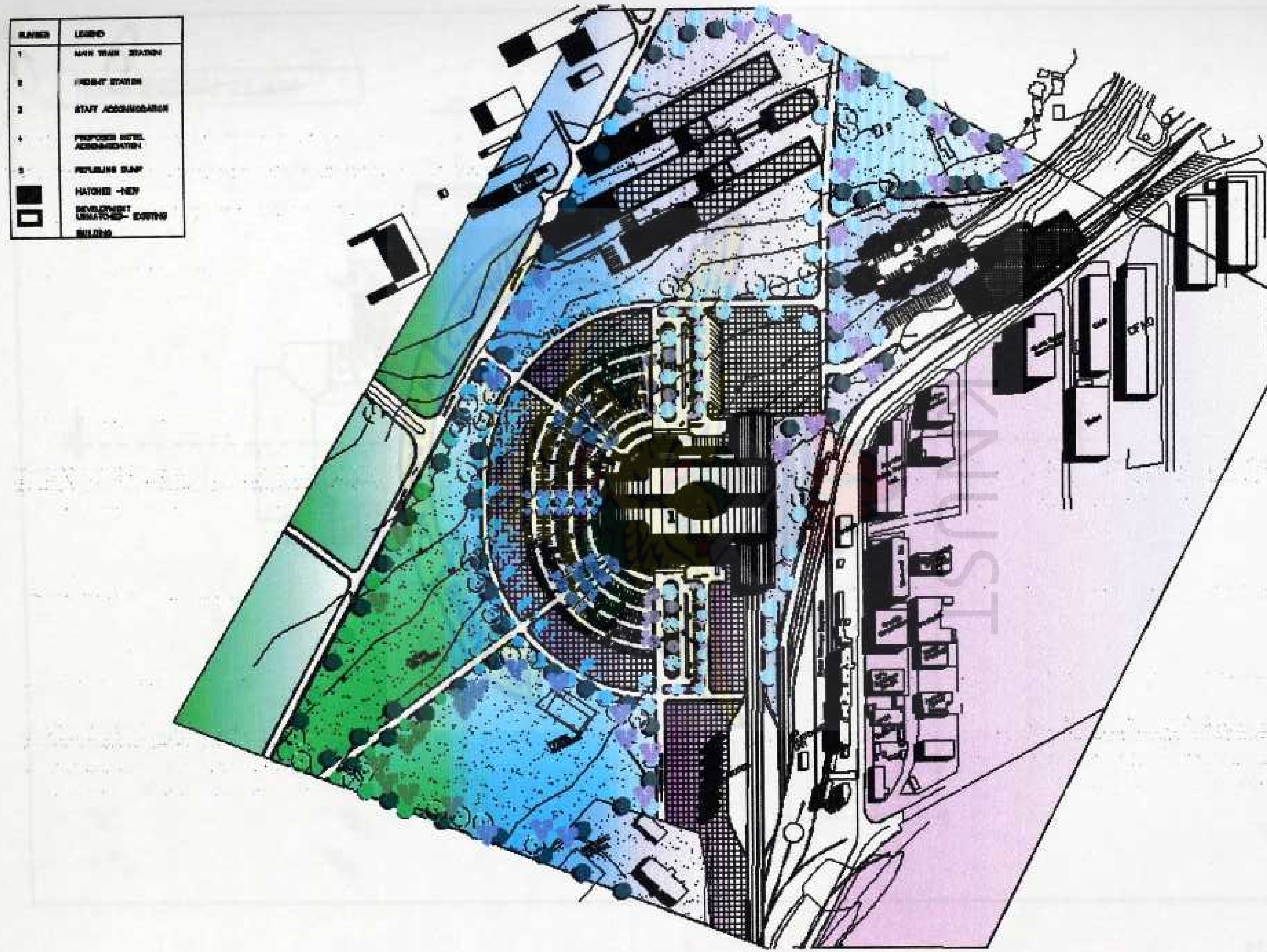
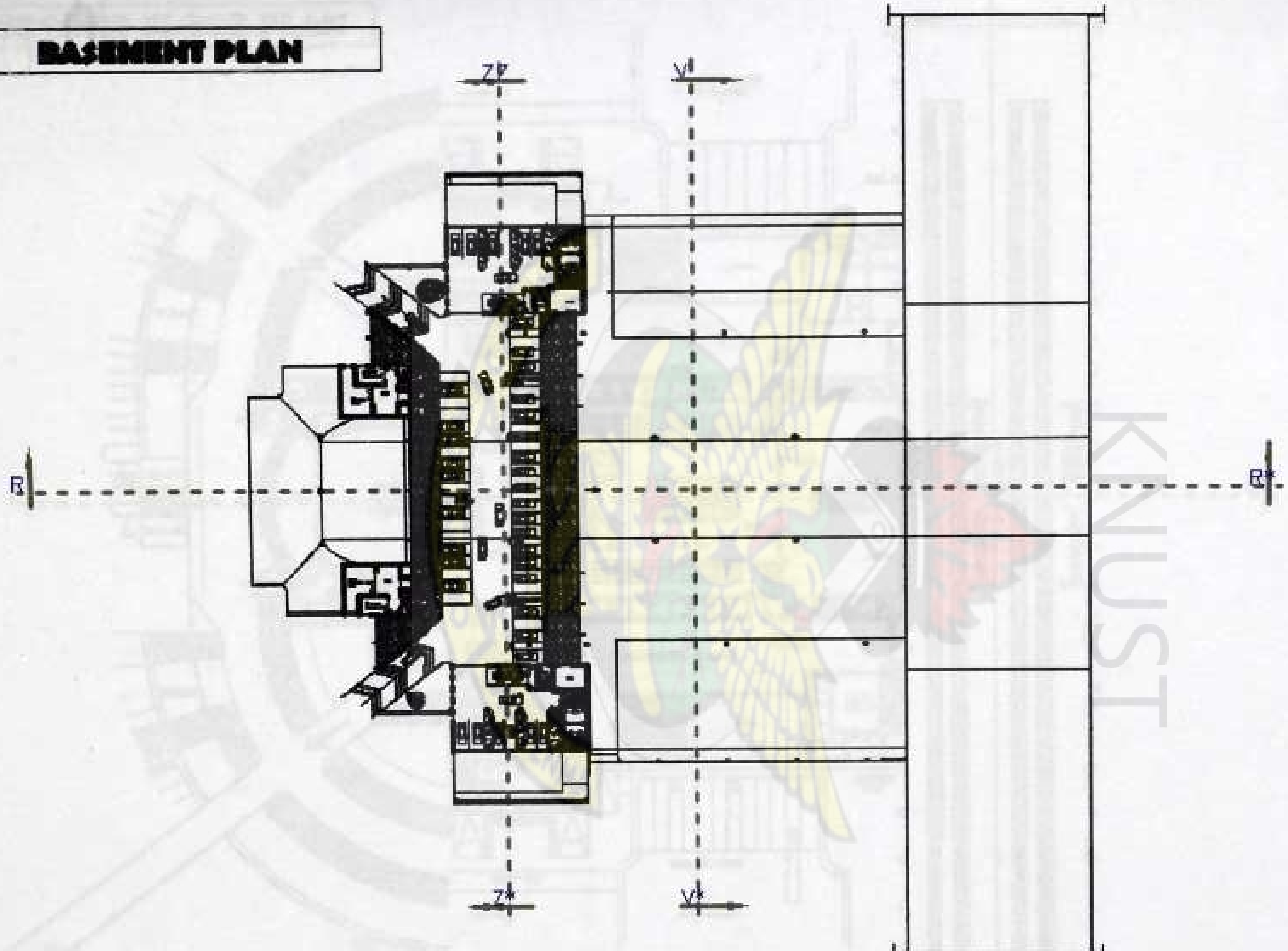
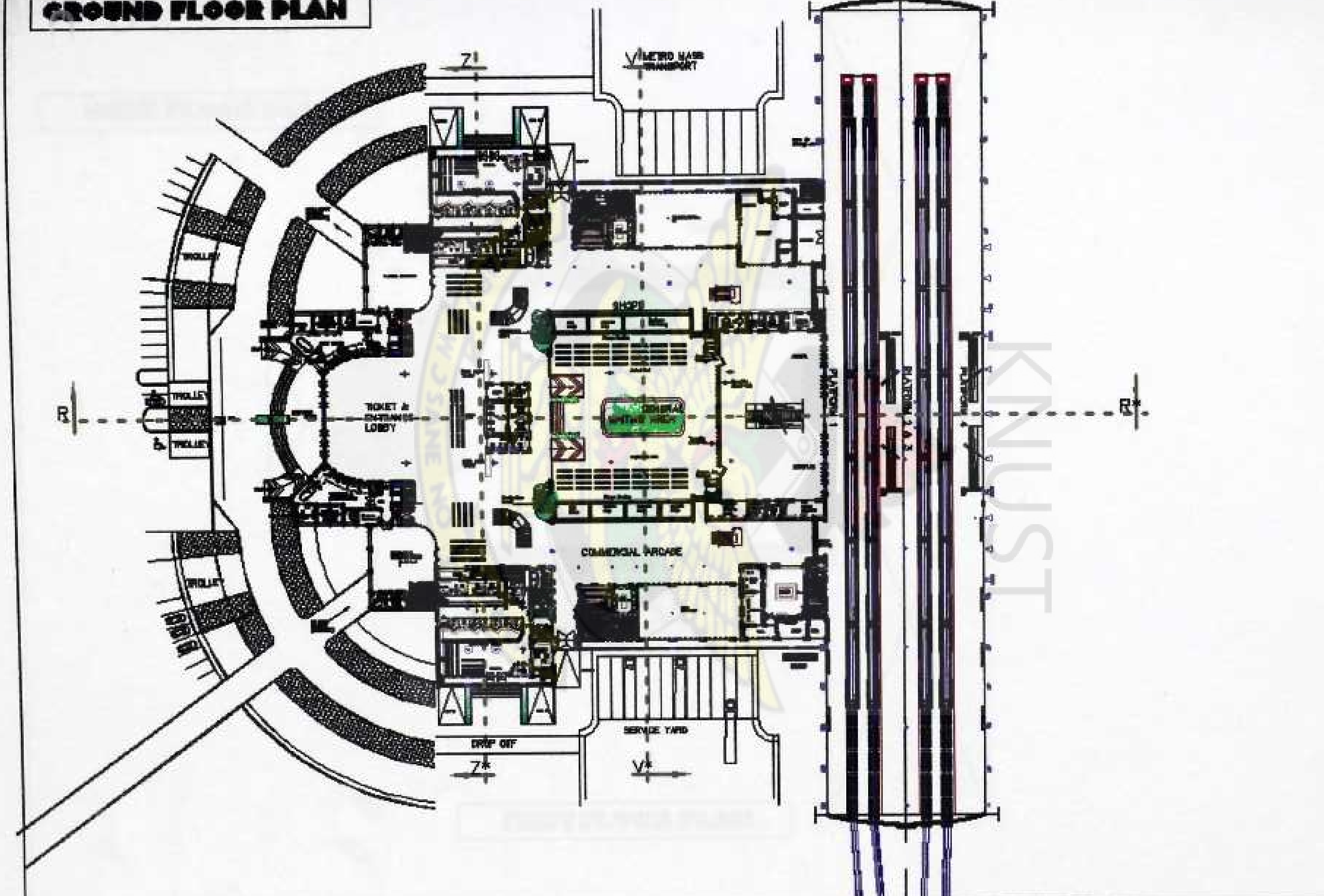
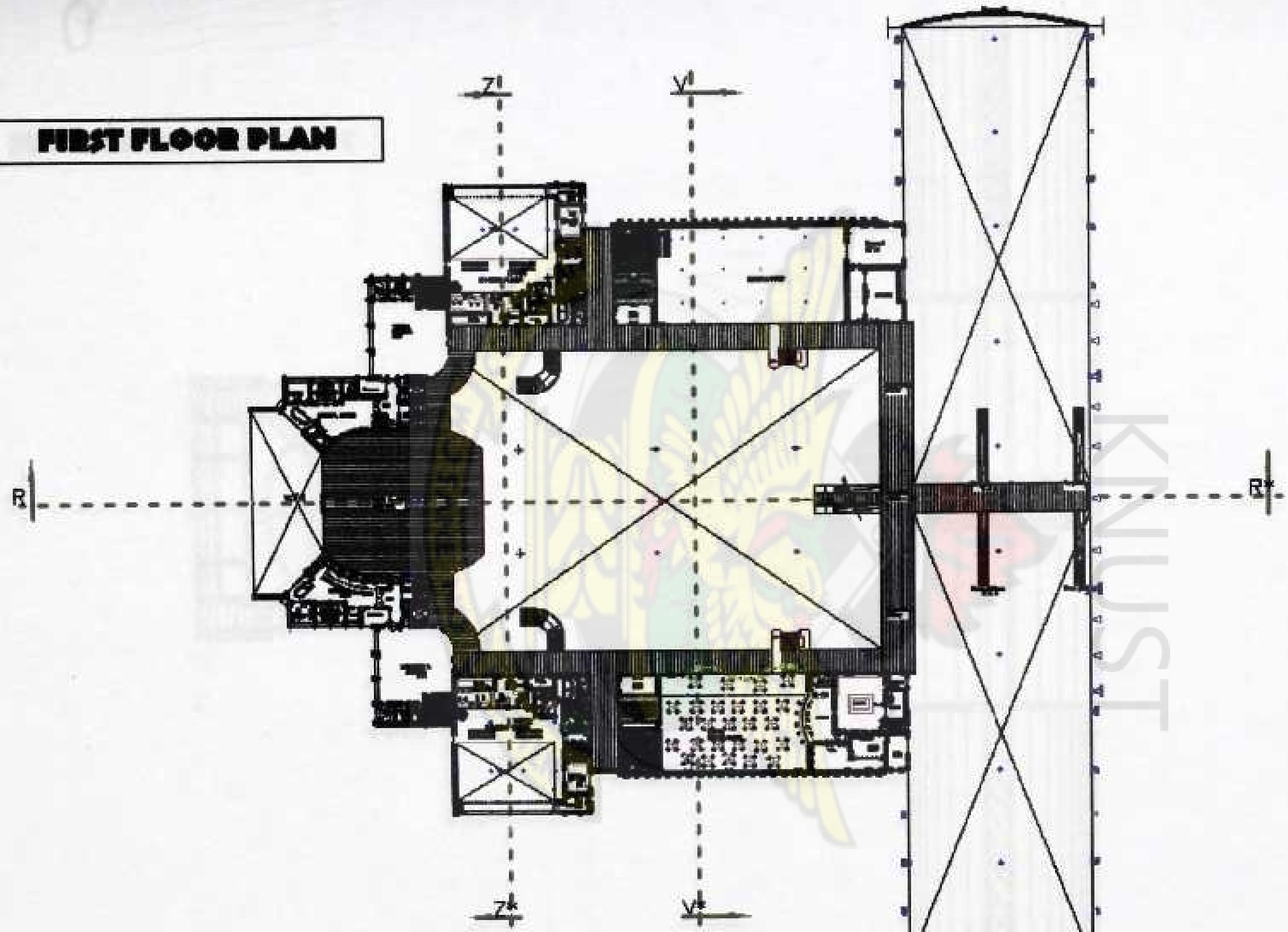

LEGEND
1 MAIN TRAIN STATION
2 FREIGHT STATION
3 STAFF ACCOMMODATION
4 PROPOSED HOTEL ACCOMMODATION
5 REFUELING DUMP
HATCHED - NEW DEVELOPMENT
UNHATCHED - EXISTING BUILDING

BASEMENT PLAN

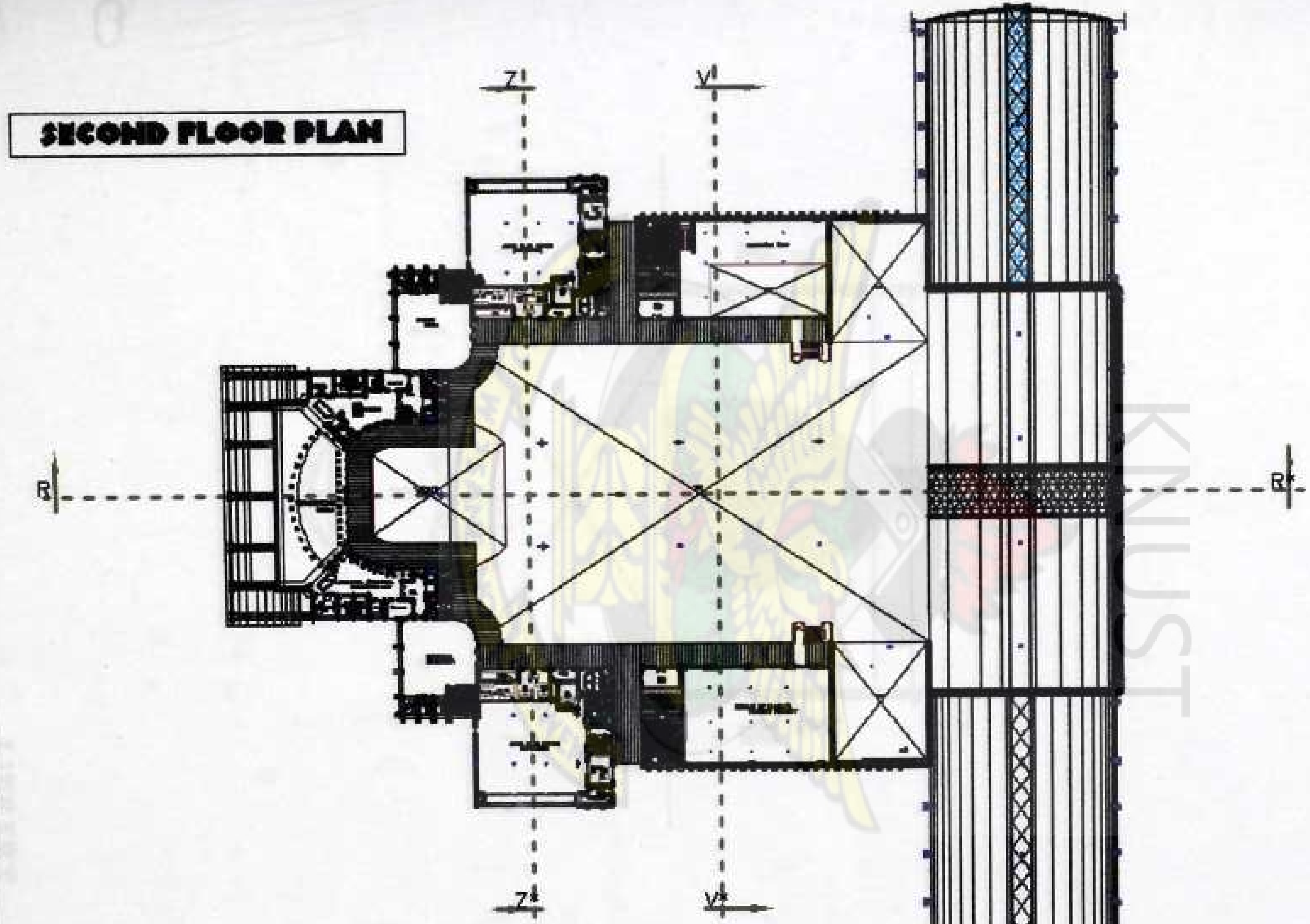


GROUND FLOOR PLAN



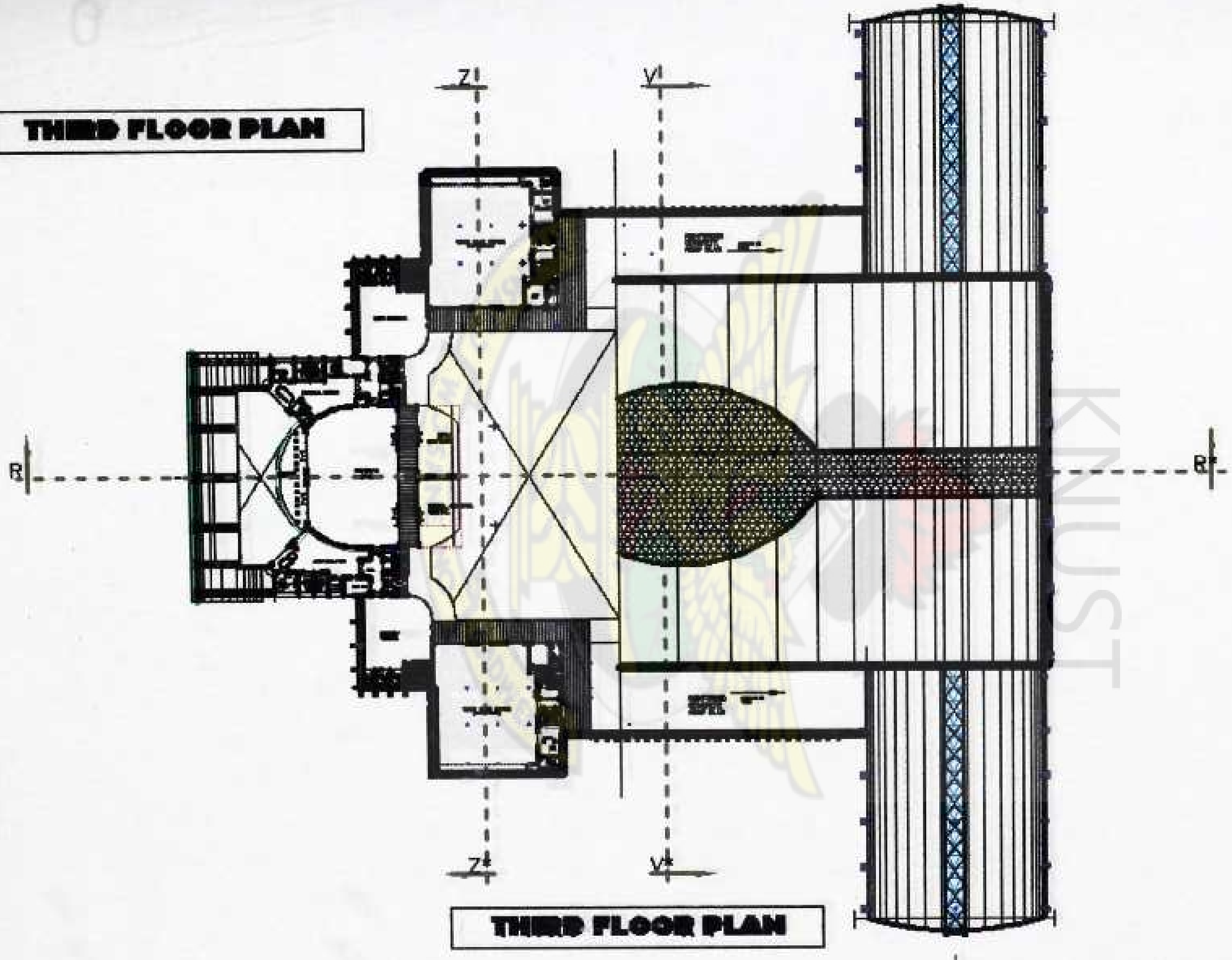


FIRST FLOOR PLAN



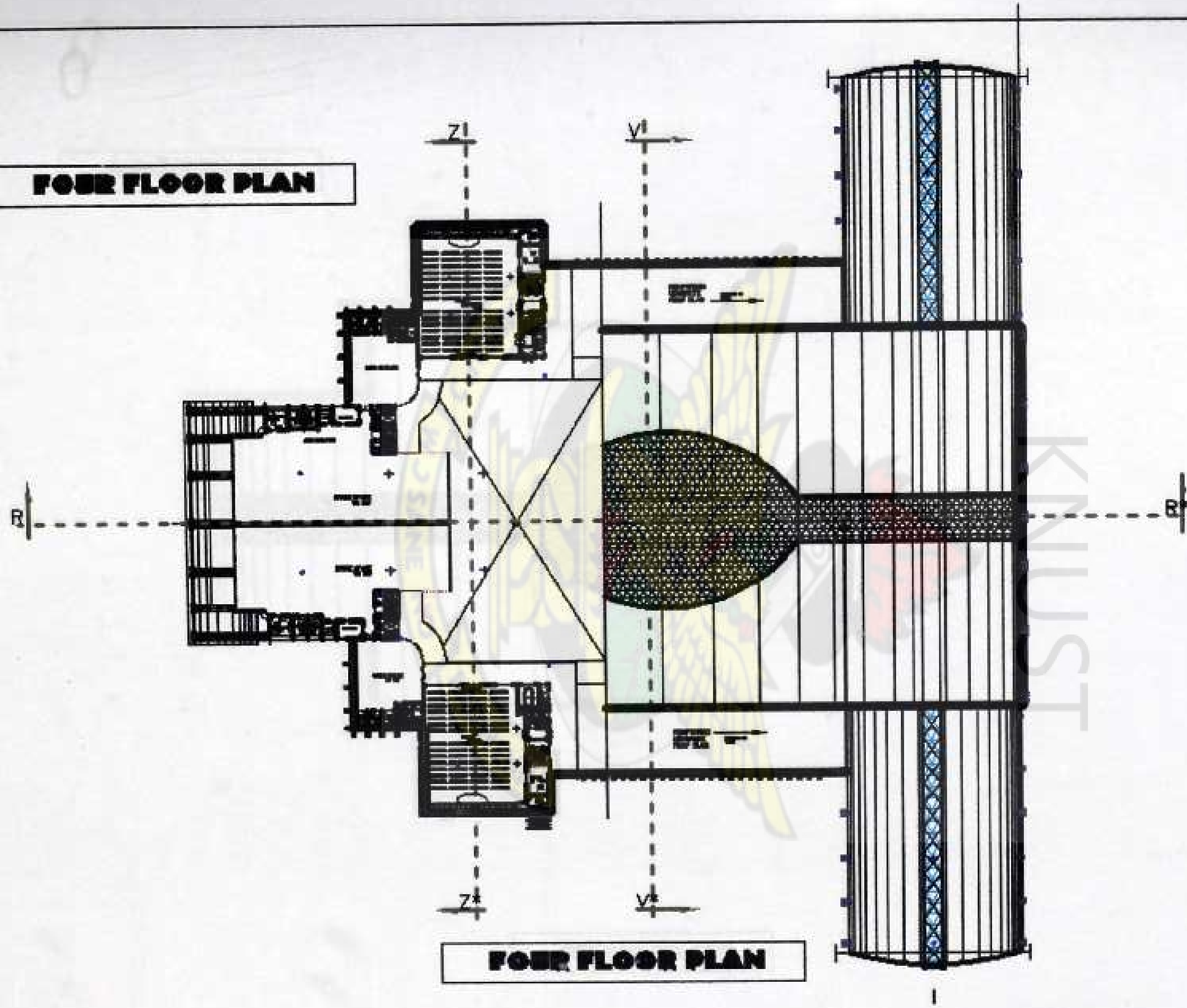
SECOND FLOOR PLAN

THIRD FLOOR PLAN

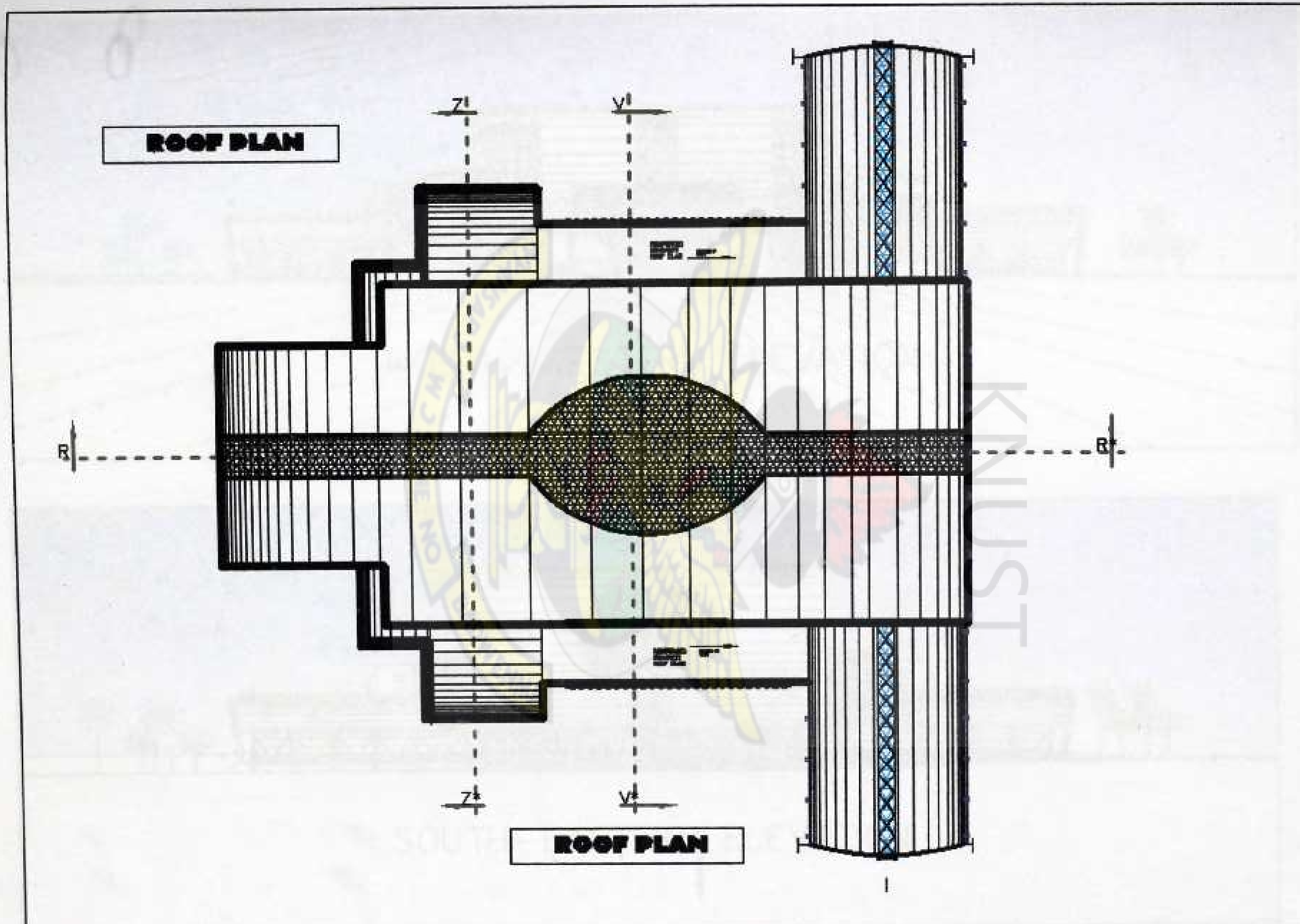


THIRD FLOOR PLAN

FOUR FLOOR PLAN



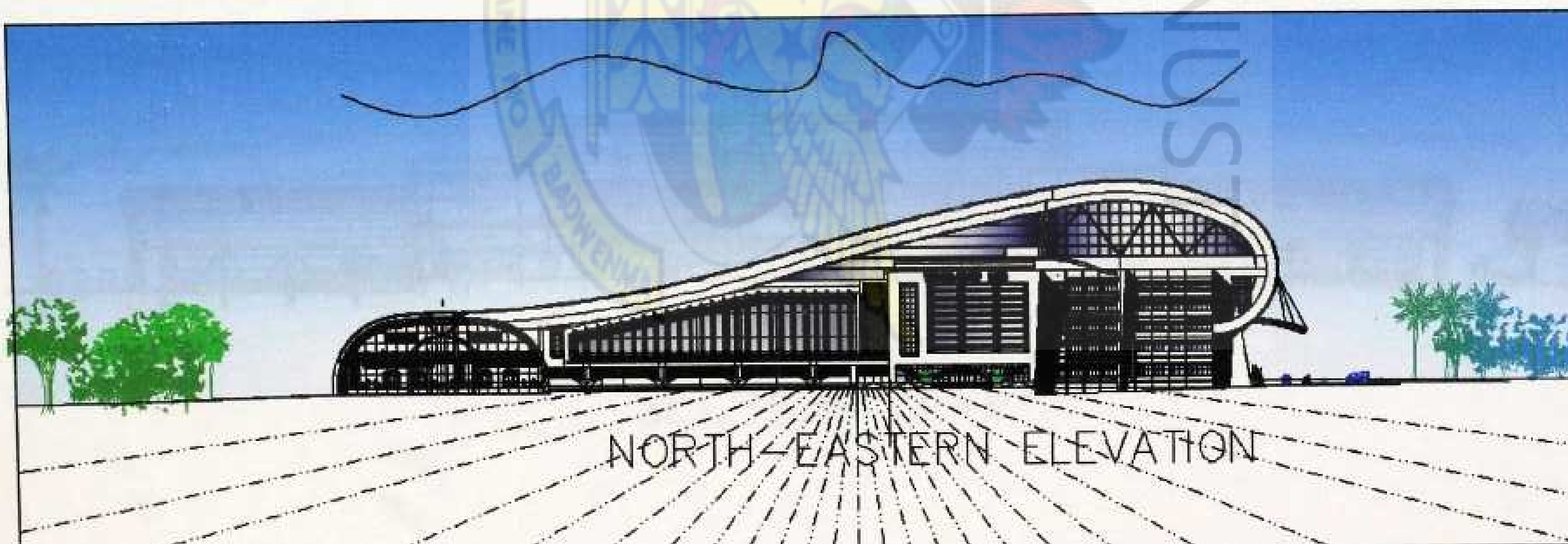
FOUR FLOOR PLAN

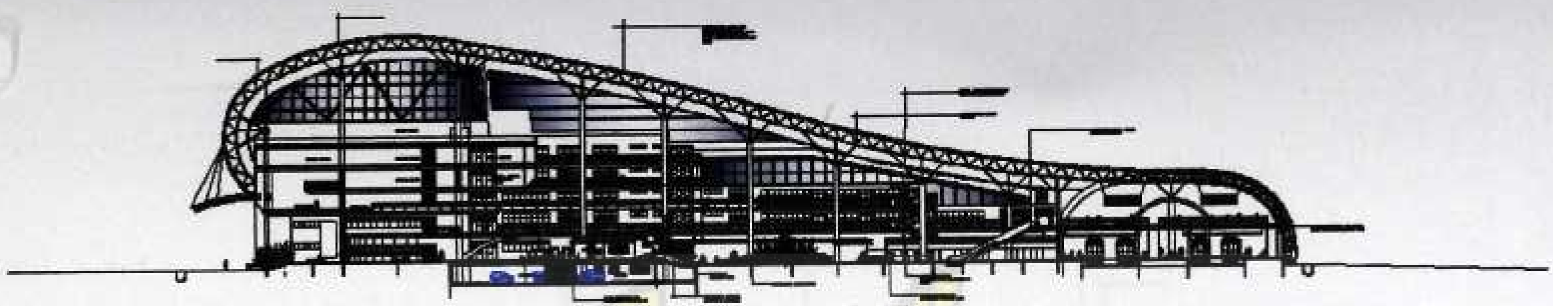

ROOF PLAN
Z
Z*
V
V*
R
R*
ROOF PLAN


NORTH-WESTERN ELEVATION

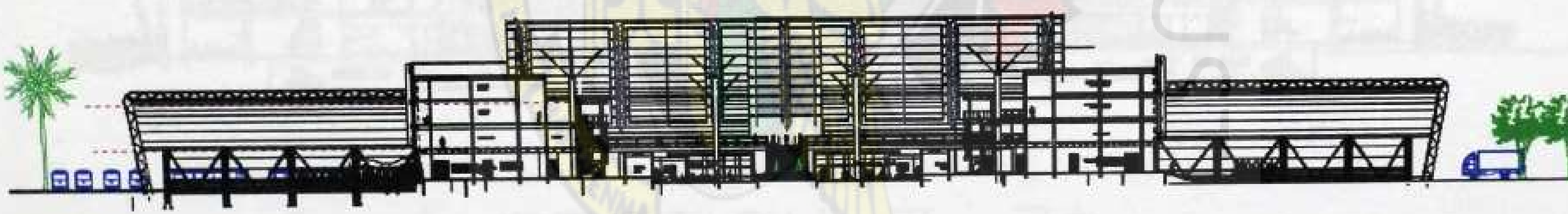

SOUTH-EASTERN ELEVATION


SOUTH-WESTERN ELEVATION


NORTH-EASTERN ELEVATION



SECTION R–R*



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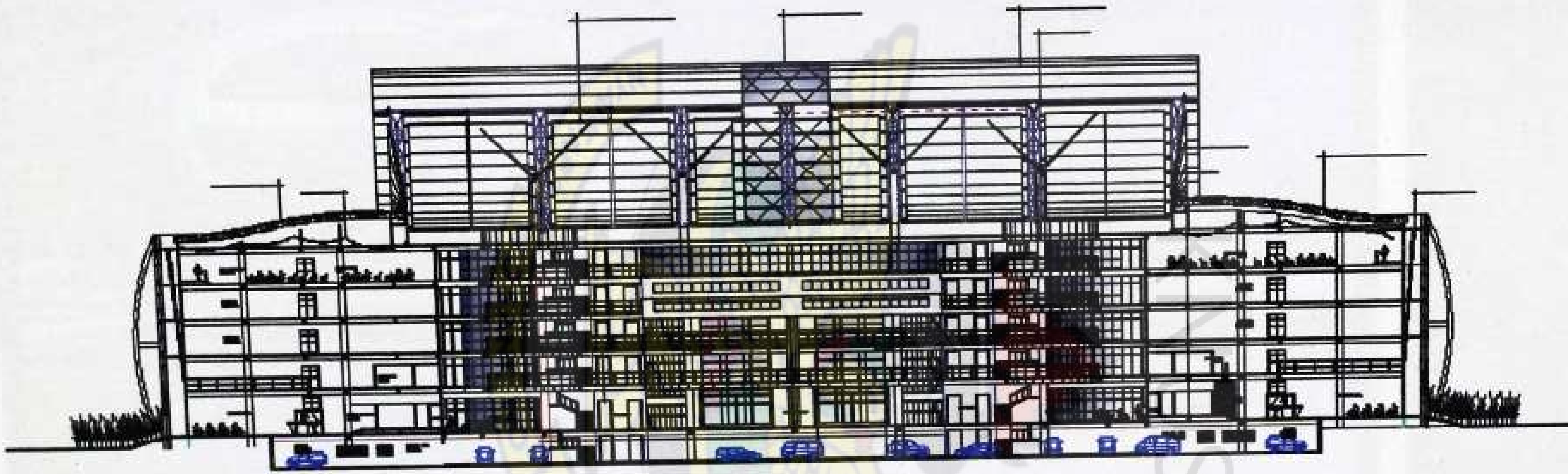
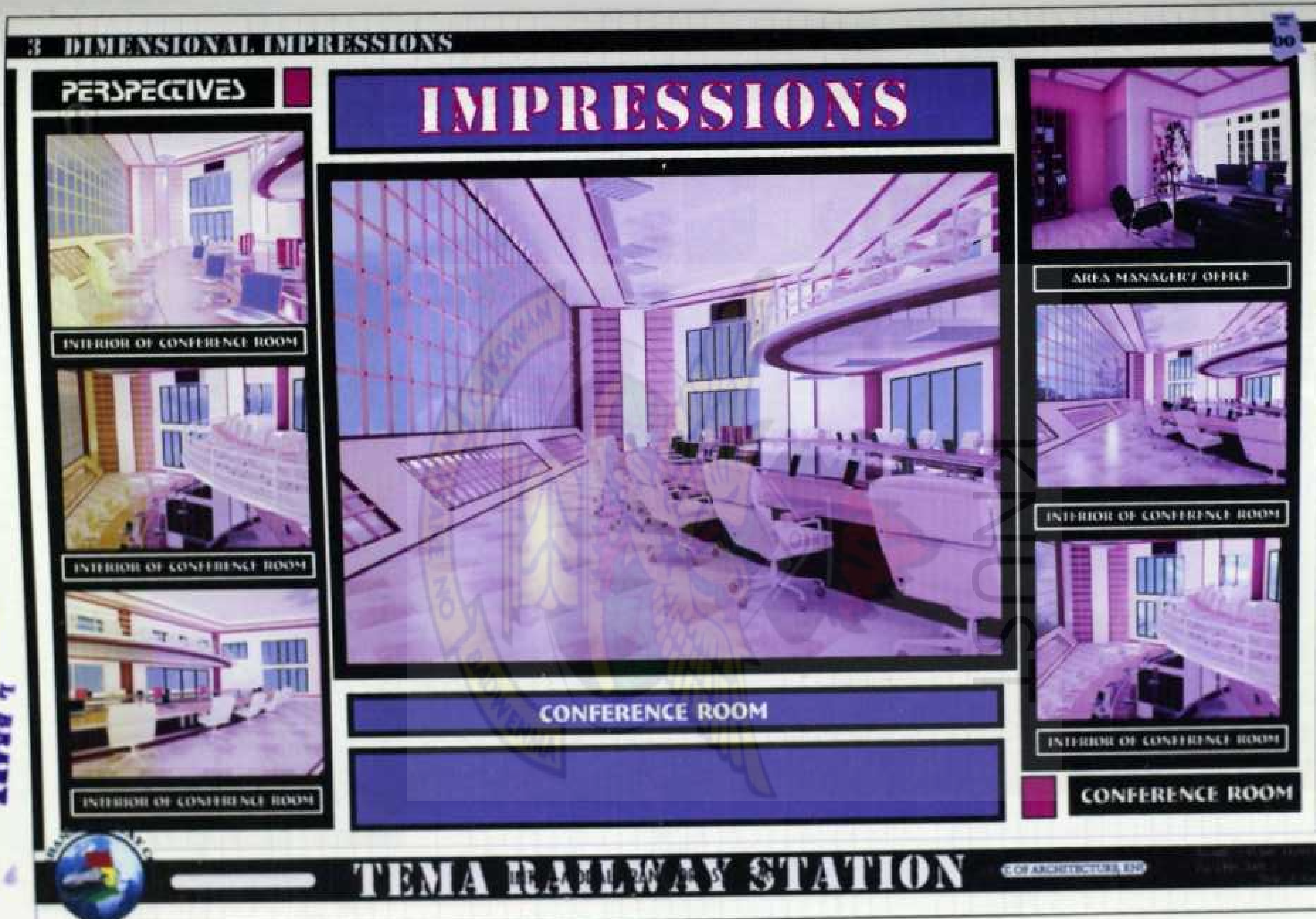


SECTION Z-Z*


3 DIMENSIONAL IMPRESSIONS
PERSPECTIVES
IMPRESSIONS
INTERIOR OF CONFERENCE ROOM
INTERIOR OF CONFERENCE ROOM
INTERIOR OF CONFERENCE ROOM
CONFERENCE ROOM
AREA MANAGER'S OFFICE
INTERIOR OF CONFERENCE ROOM
INTERIOR OF CONFERENCE ROOM
CONFERENCE ROOM
TEMA RAILWAY STATION

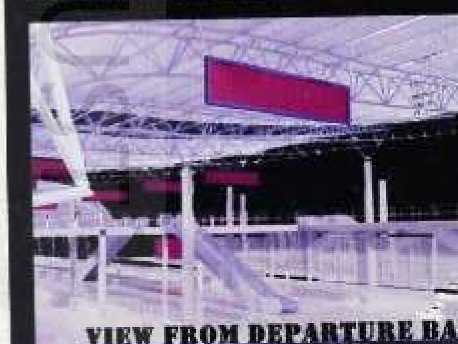
3 DIMENSIONAL IMPRESSIONS

INTERIOR OF TRAVELLING AREA

TEMA RAILWAY STATION

DEPT. OF ARCHITECTURE, KNUST

PLATFORM



BOARDING PLATFORM

TEMA RAILWAY STATION

3 DIMENSIONAL IMPRESSIONS

PERSPECTIVES

IMPRESSIONS

INTERIOR OF THE BANKING HALL

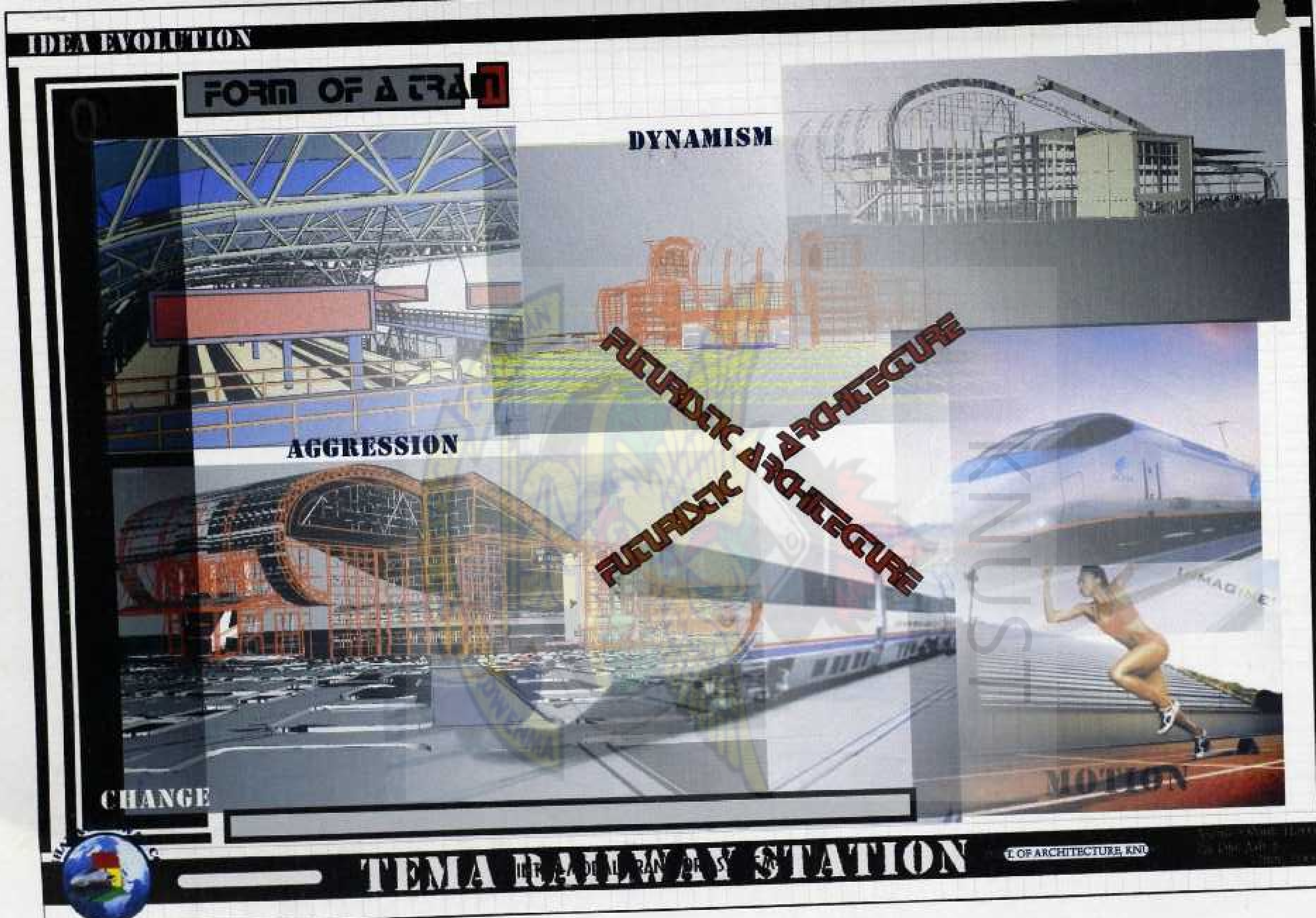
INTERIOR OF CONFERENCE ROOM

INTERIOR OF CONFERENCE ROOM

VIEW OF THE BANKING HALL FROM ENTRANCE

BANKING HALL

TEMA RAILWAY STATION


IDEA EVOLUTION
FORM OF A TRAIN
DYNAMISM
AGGRESSION
FUTURISTIC ARCHITECTURE
FUTURISTIC ARCHITECTURE
MOTION
CHANGE
TEMA RAILWAY STATION