ADDIS ABABA UNIVERSITY
INSTITUTE OF TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING

ADAPTATION OF STATION DESIGN PARAMENTERS FOR ADDIS ABABA LIGHT RAILWAY IN ETHIOPIAN CONTEXT

By
KALEAB TESFAYE

January, 2018
ADDIS ABABA UNIVERSITY

INSTITUTE OF TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING

ADAPTATION OF STATION DESIGN PARAMENTERS FOR ADDIS ABABA LIGHT RAILWAY IN ETHIOPIAN CONTEXT

By
KALEAB TESFAYE

A thesis submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Degree of Master of Science in Civil Engineering

Advisor
MATIAS KABTAMU

January, 2018

ADDIS ABABA UNIVERSITY

INSTITUTE OF TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING

ADAPTATION OF STATION DESIGN PARAMENTERS FOR ADDIS ABABA LIGHT RAILWAY IN ETHIOPIAN CONTEXT

By
KALEAB TESFAYE

January, 2018

A thesis submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Degree of Master of Science in Civil Engineering

Name and Signature of Members of the Examining Board

Name	Title	Date	Signature
Ato Matias Kabtamu	Thesis Advisor	_____	_____
_____	Internal Examiner	_____	_____
_____	External Examiner	_____	_____

Declaration

I declare that, this thesis is my original work undertaken as part of a programme of study at Addis Ababa University, Institute of technology. All views and opinions expressed there in remain the sole responsibility of the author, and do not necessarily represent those of the Institute.

Kaleab Tesfaye

Signature: _____

Date: _____

This thesis has been submitted for examination with my approval as a thesis advisor.

Matias Kabtamu

Signature: _____

Date: _____

Acknowledgements

This thesis has been comprehended and completed with unreserved assistance and guidance of keen individuals, colleagues and esteemed organizations. Hence I am so glad and no word when I express my gratitude to those who have played significant and pertinent role in my graduate career.

First, I would like to express deepest gratitude to my advisor *Ato Matias Kabtamu* for his constant motivation, commitment, guidance, support, supervision and constructive suggestion throughout this thesis work. Next, I want to thank *Eng. Abdulsetar Siraj* a lot for suggesting valuable comments to keep the research on track.

The last but not certainly the least, I gratefully acknowledge the staffs and employee of Ethiopia Railway Corporation Addis Ababa Light Railway, Ethio-Djibouti Railway and Ethiopia Railway Corporation for providing me the necessary, timely, reliable information and data for the input of this thesis work at the time of organization.

Table of Contents

Lists of Tables

Lists of Figures

Acronyms and Abbreviations

- LRT: light rail transit
- A.A.L.R.T: Addis Ababa light railway transit
- APTA-American Public Transportation Association
- WMATA: Washington Metro Politian Area of Transit Authority
- VTA: Valley transportation Authority
- ADAAG: Americans with Disabilities Act Architectural Guidelines
- RTD: Regional Transit way Guidelines Technical Report
- OSHA: Occupational Safety and Health Administration
- RPR: Regional passenger rail
- RRT: Rail rapid transit
- HSR: high speed rail
- QRA: Quantitative Risk Assessment
- LRV: light railway vehicle
- TCRP: Transit cooperative research program
- VCE: Vertical Circulation Element
- ARMA: American railway engineering and maintenance way of association
- ERC: Ethiopian Railway Corporation
- TSI: Technical Specifications for Interoperability
- CCLRT: Central Corridor Light Rail Transit
- TOD: Transit Oriented Development

Abstract

Station is a basic production unit of railway transportation, integrating technical equipment relating to transportation. For the last couple of years investigations have been conducted in Ethiopia in railway site selection. One of that is the Addis Ababa light railway, where two alternative rights of way are seen. That is north- south corridor and East –west corridor of Addis Ababa which is about 34km.

An important subject in the planning of a new railway line is the design of the railway stations since they affect the capacity, flexibility and the safety of the rail transport system. The main objective of paper is to investigate how stations can be designed to align with the proposed high speed railway concepts on the line of the light railway based the topography, demography, climatic and economic conditions of the country. The focus in the report is to adapt parameters of station design and investigate how they are affected by the high speed railway concepts. This paper consists of a literature study similar to the subject. The knowledge gained is then used to suggest possible station platforms, station safety. Some aspects of station design that are investigated in the literature study are platforms, platform safety issues, necessary dimensions of platforms and stations.

It is concluded that the spacing of station and dimension of station (base width and length, plate form of station) is optimized in consideration of satisfying all passengers and the optimization analysis is need in estimation of cost of station. Therefore, sizing station is critical and designers should err on the side of safety when determining the size of the station.

Key Words: Light Rail Way, Station Design, Platform and Safety.

Chapter 1 Introduction

In every aspect of transportation land, water air, station have been played a very critical and paramount role to render the state- of the- art quality service to the passenger in need. Among land transport sector a country with huge number of population, rail way service out-rightly helps to move significant type of community from one place to another in short time span. Accordingly, this paper try to figure out and pin- point those important issues to the station design parameter related to rail way transportation.

The design of station is an important step in railway engineering. It's not only related to the station design. What's more, stations are the key links to generating integrated transportation capacity and are one of the most basic infrastructures to meet the need of service quality in railway transportation. The station yard undertakes the receiving and sending of train and intercity transit train. It has numerous tracks and the works are complex.

The station design all in all should meet and include the adjustment of transportation and operations in peak hours suffice the need of technical operation that assure improving and upgrading of the service quality.

According to the character and feature of technical operation, the stations can be classified into three types in passenger traffic line, i.e.

- ✓ the overtaking station,
- ✓ the intermediate station, and
- ✓ the originating train departure arrival station;

In addition mixed passenger and freight railway station can be classified into five types, such as

- ✓ Crossing station,
- ✓ overtaking station,
- ✓ the intermediate station,
- ✓ district station and
- ✓ Marshaling station.

Moreover the passenger and freight traffic volume station can also be classified into four types for passenger traffic lines, i.e.

- ✓ super-large station,
- ✓ large station,
- ✓ medium station, and
- ✓ small sized station; and

➢ Six types for passenger and traffic lines, i.e.

- ✓ super class station,
- ✓ Class-I,
- ✓ Class-II,
- ✓ Class-III,
- ✓ Class-IV and
- ✓ Class- V stations.

Taking the above fact in to account and reviewing history at eye-glass, Introducing railway in Ethiopia transport industry is not a new idea. It is known before 100yrs at the time of Atse Menlik an emperor who was tried to modernize and civilized the countries by bringing the technology existed at the time any cost. The first train came to city was diesel traction, narrow gauge (1m) rail which covered only very specific route and limited service. But, currently after long period of time with bilateral cooperation of

Ethiopian government and the Chaina government, railway which is electrically power traction, standard gauge (1.435m) rail is under construction in the four corridors of Ethiopia.

This research would like to see Addis Ababa light railway station designs specifically. Public transfer stations are evolving into multi-functional public areas, attracting much more people. A lot of extra trips are made by public transport, causing the system to reach its capacity, especially during peak periods. Not only does the number of vehicles increase and does their occupancy degree grow, also congestion occurs in the transfer station itself. Unlimited expansions of the necessary transfer area are not an option: inner city areas must contain many different functions and public transport is just one of them. By adding more functions, the number of processes increases, their complexity increases and the design process also becomes more complex. (W. Daamen Delft University of Technology, Department of Civil Engineering, the Netherlands)

Stations consist of three elements;

1. **Platform (concourse)** area where passengers walk to and from the trains and where passengers queue in anticipation of boarding trains.
2. **The transition plaza**, a space necessary to facilitate the movement of patrons from the parking areas or other means of access (modal access) to the platform and from the platform to their modal access.
3. **The multi-modal access** is defined as the choice of transit used by a patron to access the station, i.e. car, bus, bike or walk.

The basic design criteria for stations are as follows:

- Meet set back from centerline of track and dynamic envelope requirements for clearances at the platforms.
- Meet requirements of ADA, ADAAG and ANSI 117.1, NFPA 130, and Part IV DOT, 49 CFR Parts 27, 37 and 38.
- Adhere to railway codes, guidelines for platform safety requirements.
- Minimum platform and transition plaza areas are defined by the crush load of the train consist x2 x5 sf. Length of the platform is determined by the length of the train consist plus 50 feet of tangent section at each end.
- Coordinate platform and transition plaza with bus, kissing ride, parking ride, pedestrian and bike access.

The transition plaza is a space described as an area necessary to facilitate the movement of patrons from the parking areas or other means of access to the platform. The transition plaza is where patrons can obtain, tickets, view public information systems and wait for pick-up. In many instances the transition plaza also acts as a side loading platform, and should be held to the same clearance and lighting requirements as a platform.

Coordinate platform and transition plaza design with neighboring community. Community involvement is necessary to establish a sense of place of the station in the community and to develop a design for shelters, windscreens and other elements. As a part of the community development, RTD, its design team and community planners could facilitate a plan to develop transit-oriented development (TOD) adjacent to the mass transit site. This is only viable if, the governing body has zoning ordinances in place that allow a mixed use TOD to occur. TOD however needs to occur with a balance toward providing a convenient and

pleasant experience for the (RTD Design Guidelines & Criteria Light Rail Design Criteria November 2005)

Station is a basic production unit of railway transportation, integrating technical equipment relating to transportation.

It helps to provide different type of service related to Passenger traffic service and goods traffic service, such as passengers boarding and alighting, goods consignment, goods loading and unloading, goods delivery and safekeeping, etc.

At time of design the station the first important thing is to distribute the large station according to the distribution and topology of cities along the route of line, and then distribute medium and small station based on the plane location. Passenger station building shall coordinate with urban planning and the general layout diagram of the station and shall be convenient for passenger passing. The station building shall be placed near residential area and to the best shall be erected at the middle part so that the passengers alighting and boarding may be as convenient as possible.

The passenger station building shall keep a certain distance from the central line of the nearest track, so more tracks may be added at the building side. Generally, distance between outer wall of the building edge and platform edge should be set; when condition is unfavorable, a shorter distance can be adopted, but it shall never be shorter than the main platform width.

Relation between platform and building

The scale of station building is subject to the largest number of the passengers waiting for trains at one time. Intermediate station building scales are mostly medium or small,

and generally fixed design is adopted. Common capacity of small station building may be 50, 100, 200 and 400 persons.

Length of platforms

- length of the platform shall be set a300~500m, subject to the recent passenger amount and train length and enlargement needs.
- When passenger amount is relatively small and the train is relatively short, the platform length may be reduced properly.

Width of platforms

- Width of the platform shall be determined subject to the largest alighting and boarding person, luggage vehicle type, size of buildings and facilities set in the platform when the passenger train stops by the station platform.
- The main platform width within the range of station building from the outer wall edge of the building ledge to the platform edge shall be no less than 6m, and other part shall be no less than 4m.
- Single-track railway intermediate platform width shall be no less than 4m and double track railway shall be no less than 5m. When overpass facilities are provided the platform shall be widened as needed.

Height of platform

The height of passenger platform can be divided into 3 types; they are

- ✓ high platforms,
- ✓ middle platform and
- ✓ low platform.

Limited by the gauge the platform next to the main line and line for overload freight trains shall be 300mm higher than the rail surface, other platforms may be 500mm higher than the rail surface. High platform that is 1,100mm higher than the rail surface is needed only under special circumstance.

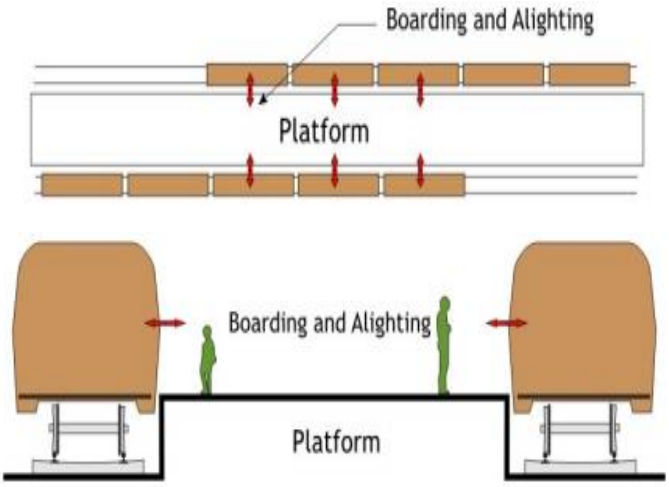
For water drainage, the surface of platform slope shall be designed a cross slope no bigger than 2% toward the platform edge.

Passenger platform

There are two types of passenger platforms,

- ✓ basic and
- ✓ intermediate platforms, as shown in Fig.1

Intermediate platform shall be set between Track II and 3 and two station tracks away from main platform, so that application may be more effective and maintenance may be more convenient (if it is set between Track l 1 and II, sleeper change may be very difficult). When passenger amount is not very large, it is not needed to provide intermediate platform.



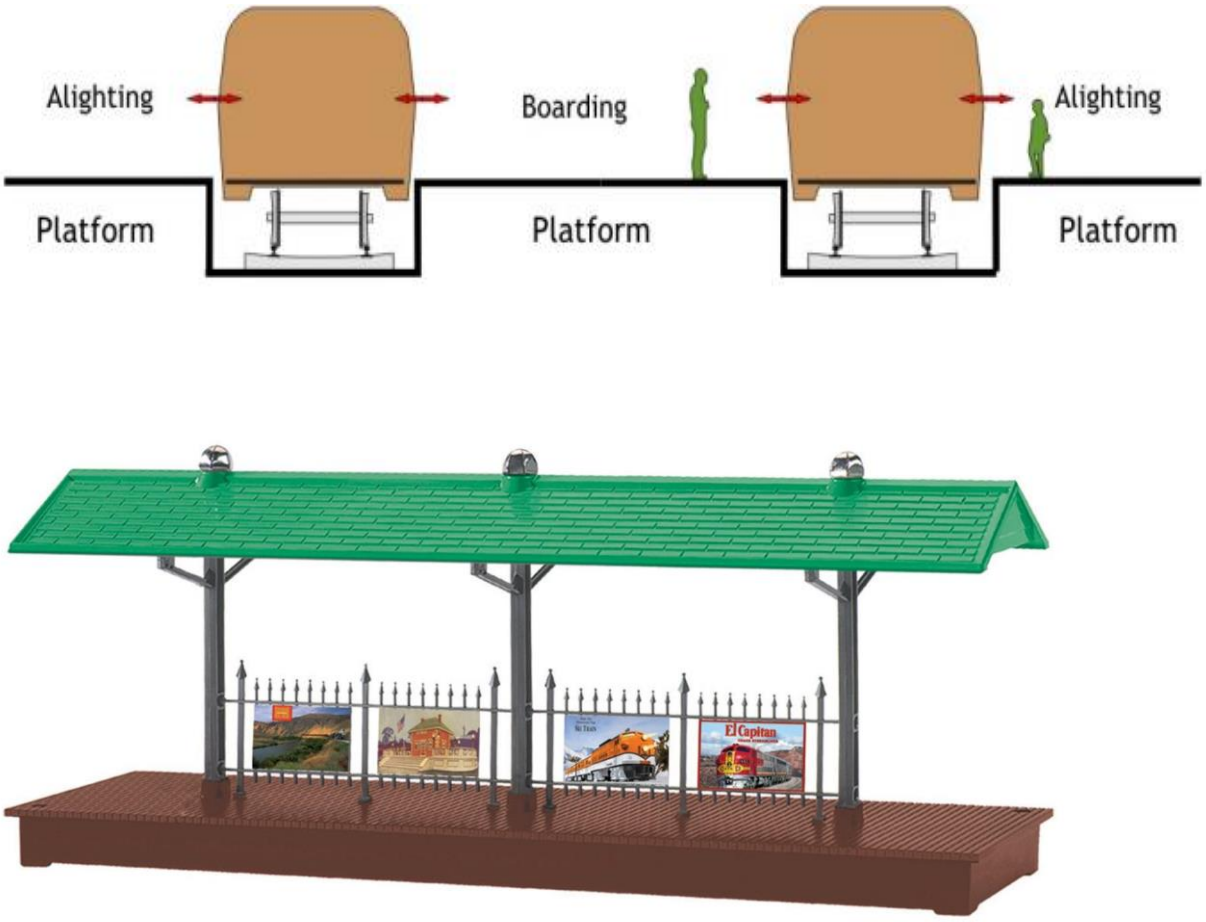


Figure 1:Passenger platform

1.1 Statement of the problem

Design of railway station based on Ethiopian context can solve the upcoming problem of railway station encounter in railway station management and operation in Addis Ababa light railway.

The railway is constructed between left hand side (LHS) & right hand side (RHS) of the highway (i.e. in the median), as the arriving and departure of rails can cause many problems. Design this station based on the site and environmental condition is very important.

Therefore it is very vital to design railway station based on Ethiopian context so that we can minimize significantly risk concerning issues. And accordingly we can provide state-of the-art convenient very efficient, safe and accessible railway station to the community.

1.2 Objectives and Significant of the study

As briefly explained in previous pages the railway technology is not a new idea for the country but the light railway, standard gauge railway is a recent and new technology and phenomena so in this thesis paper tries to provide and address some useful guidelines for the design of station for the light railway especially for Addis Ababa.

Addis Ababa city population is growing fast accordingly the movement of the community from one place to other increase as well. For the same case, light railway need to alleviate and resolve the transportation problem of Addis Ababa so the railway station design must accommodate the loading and unloading of passengers in peak hours.

In addition the station design must be safe and comfortable for all passengers like old peoples, children's, disable passengers etc. Hence, our thesis aims to deal on these objectives.

1.3 Objective

1.3.1. General objective

1. Selecting basic facilities needed in railway station design for Addis Ababa light railway
2. Adaptation of station design parameters based on Ethiopia context basically for Addis Ababa light railway

1.3.2. Specific objective

1. Adaptation of Site selection requirement for station
2. Adaptation of parameter for platform and switches
3. Assess, Evaluate and Adaptation of Passenger safety on platforms

1.4 Methodology and organization of the study

Various railway station design codes approaches have been reviewed and evaluated to Adopt design of railway stations in Ethiopian context based on Ethiopia climatic, population, topography and safety condition by compromising codes.

Only codes with standard gauge (1.435m) are considered. .

In our research development, we use the China code in station building and station site selection because most reasons in these codes are climatically and population wise are similar to Ethiopia.

In station design safety standards adaptation we use AREMA code and Indies code because this codes give detail parameter on safety that is updated continuously.

The research methodologies for this study incorporate the following major task that is related with the design of light rail way station.

- ➢ Literature review
- ➢ Basis for the selection of light railway station design parameters
- ➢ Comparison on standards
- ➢ Adaptation
- ➢ Conclusions and recommendation for future work are presented

Chapter 2 Literature Review

Like so much in present day society, the railroad was the result of industrial revolution although the idea of a special track for hauling goods dates back about 2000 years. Railways that fit Lewis's definition, that is *"railway is a prepared track which so guides the wheels of the vehicles running on it that they cannot leave the track"*, existed as far back as the 6th century BC; the Greek Diolkos was a railway with a track made from stone, 6km in length across the Peloponnese, used for transporting ships until the 9th century AD – an extraordinarily long period [Coulls, 1999].

After a mid of 20th century rationalization of the rail network began and the following activities were taken to compete with other massive mode of transportation [Coulls, 1999].

- Steam locomotives were avoided and replaced with full electrification of the lines.
- Modernization of passenger coaches
- Safety system upgrading
- Freight wagons were also highly improved with the introduction of high capacity and with box containers and fully braked units.

Definition

The Transportation Research Board (Transportation Systems Center) defined "light rail" in 1977 as *"a mode of urban transportation utilizing predominantly reserved but not necessarily grade-separated rights-of-way. Electrically propelled rail vehicles operate singly or in trains. LRT provides a wide range of passenger capabilities and performance characteristics at moderate costs."*

Light in this context is used in the sense of "intended for light loads and fast movement", rather than referring to physical weight. The infrastructure investment is also usually lighter than would be found for a heavy rail system.

The American Public Transportation Association (APTA), in its Glossary of Transit Terminology, defines light rail as:

"...a mode of transit service (also called streetcar, tramway, or trolley) operating passenger rail cars singly (or in short, usually two-car or three-car, trains) on fixed rails in right-of-way that is often separated from other traffic for part or much of the way. Light rail vehicles are typically driven electrically with power being drawn from an overhead electric line via a trolley [pole] or a pantograph; driven by an operator on board the vehicle; and may have either high platform loading or low level boarding using steps."[1]

The basic concepts of light rail were put forward by H. Dean Quin by in 1962 in an article in Traffic Quarterly called "Major Urban Corridor Facilities: A New Concept". Quin by distinguished this new concept in rail transportation from historic streetcar or tram systems as:

- having the capacity to carry more passengers
- appearing like a train, with more than one car connected together
- having more doors to facilitate full utilization of the space
- faster and quieter in operation

In addition "Track Design Handbook for Light Rail Transit Second Edition (1-5)", says that LRT itself is a broad spectrum and ranges from single unit streetcars running in mixed traffic within city streets at speeds as slow as 25 mph [40 km/h] and even lower up through multiple car trains running on a totally exclusive guide way at speeds of 60 mph [100 km/h] or faster.

Light rail lines are distinct from metro rail systems (often called "heavy rail"). The latter are always entirely in exclusive rights-of-way, are usually designed to handle long trains of vehicles (6to 10 cars per train is common) and have a relatively high absolute minimum operating speed along the revenue route (usually 45 mph [72 km/h] or higher). By contrast, LRT trains can operate in shared rights-of-way; very seldom exceed three cars per train and speeds as low as 10 mph [16 km/h] are tolerated in revenue service track.

If there is any one single characteristic that defines "light rail," it is likely the ability of the vehicle to operate in mixed traffic in the street when necessary.

Stations

Mobility on rails is acknowledged to be one of the most sustainable means of transportation between cities and towns. Therefore, a railway station's location in a built environment and its degree of accessibility is essential to reach as many travelers as possible.

Passenger traffic service and goods traffic service, such as passengers' boarding and alighting, goods consignment, goods loading and unloading, goods delivery and safekeeping, etc are the major type of service render by rail way transport.

The quality of Building station affects overall performance, as well as the life expectancies of other railway system. The station design should meet the adjustment of transportation and operations in peak hours, meet the need of technical operation, assure the tracing and improve the service quality.

Figure 2:-Boarding and alighting

The station scale and traffic ability should meet the requirement of long-term passenger distribution and operation management; meanwhile, it should be accord with the requirement of passenger emergency evacuation under accidental conditions.

In the premise of satisfying certain functions, the station had better to be in minimum dimension as well as considering local climate condition, so as to fully reveal the characteristic of traffic functions, such as simple, fast, aesthetic, and identifiable, etc. Since most areas along the railway line are well-developed sections in a city, the station construction should take the effect on existing and planning traffic network, ambient environment, traffic, architecture into consideration, and emphasis the feasibility of the construction.

In station design the Design themes are written in "Guide to Station Planning and Design" as follow

Usability: The movement of passengers, public transport vehicles and non-users through a station can be complex. It is important to plan and design safe, secure, legible and accessible spaces that make the use of our stations easy, attractive and accessible for all users.

Operability: Effective planning, management and operation of stations is essential to realize a positive outcome for users and operators. Operability includes consideration of service coordination, operating costs, integrated ticketing, maintenance, safety and servicing.

Quality: Integrated, high quality station environments will improve all aspects of a station user's experience. Design of high quality facilities is based on a combination of performance, accessibility and function, all of which form an essential part of a user's

experience while remaining adaptable and able to meet with the changing needs of passengers and function.

Value: Planning and design of stations must deliver good value for money, give due considerations to environmental and ecological impacts and consider wider opportunities for regeneration and development.

Light rail stations are typically 180 to 400 ft (55 to 120 m) long. Various platform configurations are possible, including center, side, or split on opposite sides of an intersection. Stations may be on-street, off-street, along a railroad right-of-way, or on a transit mall. High and low platforms have been used, although the trend in recent years has been the increasing use of an intermediate height for platforms that is approximately 14 in. (0.35 m) above the top of the rail to match the floor height of low-floor light rail vehicles. Light rail stations usually include canopies over part of the platform, limited seating, and ticket vending machines. Fare collection on light rail systems is typically by the proof-of-payment system, so stations do not have fare gates or barriers. (TCRP Report 90, Volume 2,(R9) provides guidance on designing bus way stations.(7-4))

Amtrak states that: The track and platform arrangement at a station site is one of the most critical elements determining the operational efficiency and capacity of the station, and the sitting of new stations must carefully consider the future requirements for tracks and platforms. Track and platform planning include determining the number and lengths of platforms needed, their spacing, and access to them, which is based on:

- The ridership at the station (the number of trains per day serving the station and daily passengers);
- The service type or types at the station-Long Distance, State Corridor, HSR, or a combination of these types;

- ➢ The train consists associated with each service (which determines platform lengths);
- ➢ Whether the ROW is dedicated to passenger rail only, or is shared with freight; and
- ➢ Whether the station is through-service stations as well as a terminal

2.1. Facilities Required at Railway Stations

B.Arch. thesis Monday, September 21, 2009 says: A railway station is the gate-way through which people find their way into a town or community. First impression is a lasting one and hence there is the Importance of a well-designed station building and its surroundings, which should match with other civic amenities. While service is the main consideration, the type and finish of a station building should be, as far as practicable, in keeping with the best standard of civic amenities available in that area. A big passenger station should provide facilities corresponding to anticipated demands during at least the first 25 years of its life with provision for future expansion.

The facilities required at stations consist of the following main groups:

(i) Passenger requirements: Such as

- ➢ waiting rooms and retiring rooms,
- ➢ refreshment rooms and tea stalls,
- ➢ enquiry office and reservation office,
- ➢ bath rooms and toilets,
- ➢ drinking water supply arrangements

- platforms and platform sheds and
- Approach roads.

(ii) ***Traffic requirements*:** Such as

- goods sheds and goods platforms,
- station buildings,
- Station Master's office and other offices,
- signals and signal cabins,
- reception and departure lines and sidings,
- brake down trains and arrangements for the same and
- Station equipment's etc.

(iii) *Locomotive, Carriage and Wagon requirements*:

- Such as Locomotive Shed,
- watering or fueling facilities,
- Inspection pits, etc.

2.2 Site selection for station

"Washington Metropolitan Area Of Transit Authority May 2008" indicated in its document the purpose of the Station Site and Access Planning Manual is to provide clear, concise design guidelines for station site and access planning, for use by WMATA, local jurisdictional planners, related government agencies, and WMATA Joint Development partners with interests in planning transit facilities at both new and existing Metrorail stations or proposing development at stations. The primary objective of the Manual is to illustrate how station site facilities should be planned to optimize pedestrian and

vehicular access to the station for all modes of arrival, with focus on physical design and operational issues.

"AREMA SECTION 6.3" Also says: In planning a passenger station it is important to devise a coordinated arrangement between the track layout and the station proper which will, at reasonable cost, provide maximum convenience, expedition, and economy in rendering all the platform services. Particularly at high traffic stations, it is extremely desirable that baggage, mail and express trucks shall not ordinarily have to traverse or occupy platform space being used for the accommodation of passengers. Determination of the type of platform (i.e. combined or separate trucking and passenger) best suited to a particular situation is dependent upon the character and volume of the various kinds of traffic handled, the type of station (i.e. stub, through or loop), the location and type of approaches to the platforms for the various kinds of traffic, the relation of the various approaches to each other, the relative lengths of platforms and trains, space available for station track and platform development, and the method of operation. Because there are so many variables involved, final conclusion as to the best arrangement can only be reached with a thorough study.

The chinese code says (p43) "The allocation of passenger stations shall be determined in considerations of the city size, significance, district, passenger traffic to transfer and conditions of existing equipment for passenger transport, which shall be combined with urban planning and connected with urban traffic systems."

Station Area Locations "Vta Transit Sustainability Policy 2007" indicates the location, functionality, safety, and visual appearance of Station Areas are critical to attracting and maintaining transit riders in any location. Accordingly, when there are competing proposals for new stations that have similar characteristics (e.g. ridership, operations),

agencies that can show they are proactively working to improve the public perception of transit and access to Station Areas shall receive priority considerations.

2.3 Station area and facilities design

The Chinese code (p45) The arrangement of passenger station buildings shall match with urban planning. The passenger station buildings in a through type station should be set on the one side of city center. The passenger station buildings in a stub-end type station should be set at the end of platform or on the one side of tracks.

The physical design of Station Areas (including platform length and width, location of vertical transport, shelters, information signs, and ticket machines) is based on, among other aspects:

- Expected travel demand during the peak.
- Maximum operable length of trains serving the station.
- Role of the station in the network (whether it is a origin/destination, terminal, or transfer station).
- Level of connectivity to other transit modes.
- Surrounding development and community themes.
- Potential for station expansion and growth.

All design elements must at a minimum meet the criteria for its respective operator (e.g. Caltrain or ACE).

2.4 Platform

Platform is a place where passengers walk to and from the trains and where passengers queue in anticipation of boarding trains. The transition plaza, a space necessary to facilitate the movement of passengers from the parking areas or

other means of access (modal access) to the platform and from the platform to their modal access.

"Indian Manual of Standards and Specifications for Railway Stations (p82)": says the platform area is where customers access trains. The platform area must facilitate multiple customer circulation functions: circulation along the platform, boarding and alighting trains, queuing at the platform edge while waiting for a train, queuing at VCEs, runoff at VCEs, and waiting at benches or rest areas. Because of these complex—and often conflicting—circulation characteristics, overcrowding on the platform may create uncomfortable or dangerous situations where customers are crowded near the platform edge. Therefore, sizing station platforms is critical and designers should err on the side of safety when determining the size of the station platform.

According to "RTD Design Guidelines & Criteria" The following presents fundamental criteria that are intended to produce efficient and passenger-sensitive platforms.

- All platforms shall be designed to conform with the ADAAG, including detectable warning strips on platform edges.
- Platform length for both center and side platforms shall accommodate a four-car train and have a minimum length clear of approach ramps of 360 ft(10.73m).unless approved otherwise by RTD.
- The nominal horizontal gap between the platform edge and the edge of vehicle floor shall be 6 inches (0.15m). On tangent tracks, the platform edge is located 55 inches (1.397m) from track center line with a tolerance of +0.50(0.0127m) inches vertically and 0.0 inches horizontally.

Fare collection on light rail systems is typically by the proof-of-payment system, so stations do not have fare gates or barriers. Referee (TCRP Report 90, Volume 2,(R9) provides guidance on designing bus way stations.(7-4)

In order to make the platform safe and simple AREMA recommend in "Platform Dimensions (2001)" Part "Platform Lengths are Based Upon Car Length, Plus Number of cars and a margin of 40 feet(12.2m) for braking. Actual platform lengths will vary according to site constraints and train operational requirements. Platforms will vary in length depending on the service being provided and whether or not the station is served by either diesel or electric type motive power. Minimum platform lengths may vary from 210 lineal feet (64m) in length (3 cars for diesel, 2 cars for electric) to 890 lineal feet (271.17m) (11 cars for diesel). Along some lines platform lengths may be longer.

RTD recommended that Platform length for both center and side platforms shall accommodate a four-car train and have a minimum length clear of approach ramps of 360 ft (109.73m).unless approved otherwise by RTD.

As the LRT station is build in the median of the highway it must be accessible easily. AREMA recommended in "Platform Access (2001)"part Passenger access to the platform area may be through the station and at other points away from the station itself. Stairways, handicap accessible ramps and elevators may need to be provided in order to accommodate both arriving and departing passengers. Access points to the platform should be clearly visible and/or signed in order to allow for swift and safe passenger movement to and from trains. At stations where tunnels are used to access platforms, tunnel widths should be wide enough to accommodate the largest peak flow of passengers and void of obstructions. When tunnels are used for platform access, tunnel ramps must be designed for handicap access. In the event adequate space is not available, elevators may be used for handicap access**.**

Platform width shall be determined subject to the largest alighting and boarding person, luggage vehicle type, size of buildings and facilities set in the platform when the passenger train stops by the station platform.

AMTRAK says that (p88) determination of platform width is a balance between accommodating the peak passenger load and the physical constraints. In other words, wider platforms will generally be preferred over narrower ones as being safer, better able to handle service baggage vehicles, and able to provide for growth in passenger volume.
CCLRT Design Criteria (pge 11) says The desired minimum platform width for LRT platforms should be 20 feet for center platforms (preferred) and 13 feet (12 feet absolute minimum per for side platforms. Platform width should include space for a safety barrier along the platform edge opposite the track when there is a grade difference of two feet, six inches or greater, or adjacent to a roadway.

Platform height refers to the height of a railway platform Above Top of Rail (ATR).there are a large number of incompatible standards for platform heights and train floor heights. When raised platforms are in use, the train width must also be compatible, to avoid both large gaps and mechanical interference which causes equipment damage

Differences in platform height (and platform gap) can pose a risk for passenger safety. Platform ramps, steps, and fillers together with hazard warnings such as "mind the gap" are used to reduce risk and enable access. Platform height affects the loading gauge (the maximum size of train cars), and must conform to the structure gauge physical clearance specifications for the system. Tracks which are shared between freight and passenger service must have platforms which do not obstruct either type of railroad car

According to AREMA Platforms are also defined based on height from top railway

- high level platforms,
- middle level platform
- low level platforms,

Based on placement relative to railway

- side platforms and
- Island platforms.

Each platform type is also governed by minimum standard platform dimensions such as shown in the following chart.

Table 1: Standard platform dimensions

Low level platform	8” above top of rail
High level platform	5’-6’ from center line adjacent track to edge of platform
Side platform width	Minimum 10”-0”
Island platform width	Minimum 15”-0”

NOTE: Minimum may vary according to individual railroad standards, state and/or regulatory requirements.

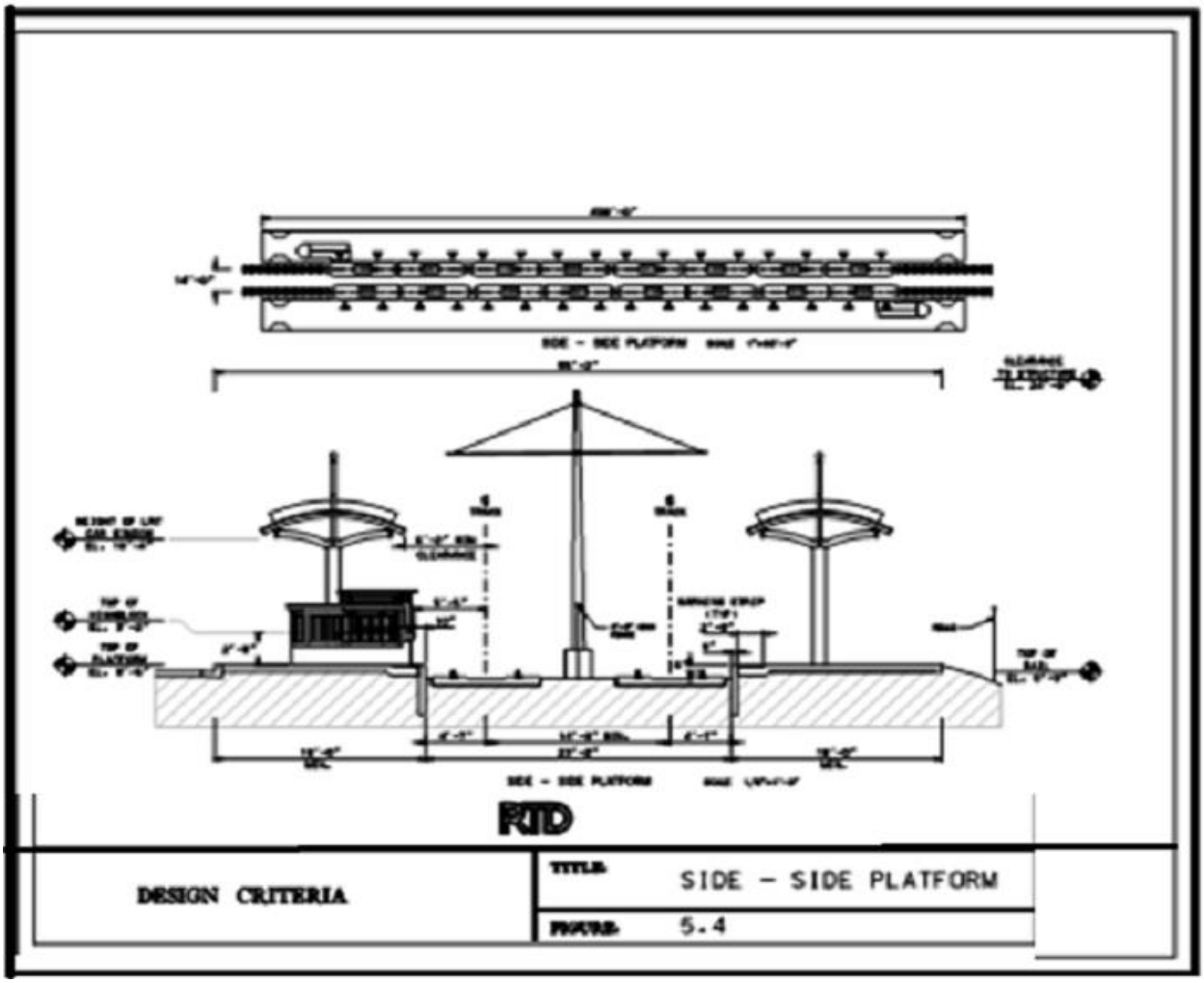


Figure 3: section on platform

Figure 4: Center platform

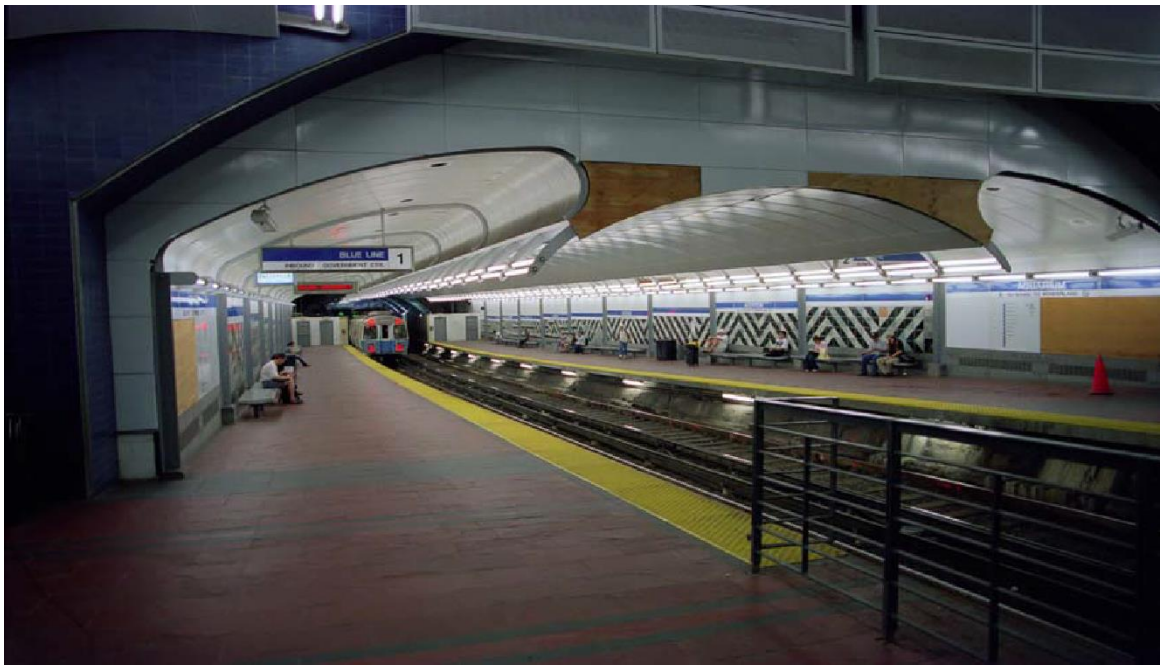


Figure 5: Side platform

2.5. Distance between tracks and plate form

Distance between tracks and plate form must be safe for the track and platform arrangement at a station site is one of the most critical elements determining the operational efficiency and capacity of the station, and the sitting of new stations must carefully consider the future requirements for tracks and platforms. Track and platform planning include determining the number and lengths of platforms needed, their spacing, and Access to them.

China code shows Building and Support Facilities in the following table

Table 2:-Distance between main building and equipment and center line of track

No	Names of buildings and equipment			Vertical distance above top of rail	Distance from center line of track
1	Edge of points and column such as columns of over pass bridge ,foot bridge, canopy and points of ordinary systems ,electrical power and	Located on the side of main track or station track		1000 and above	>2440
		Canopy columns	Location side of main track or the arrival and departure track for passing end of gauge freight trains	1000 and above	>2440
			Located on the side of the arrival and departure track and for passing end of gauge freight trains	1000 and above	>3000
		Located on the middle of outside of eater		1100 and	>3000

	lighting.etc.	station track in station yard		above	
		Location on the side of outer ladder track or shunting track		1100 and above	>3500
2	Edge of high signal	Located on the side of main track or the arrival and departure track for passing out of gauge freight train	Common	1100 and above	>3000
			Hard to reconstruct	1100 and above	>3500
		Located on the side of the arrival and departure track for passing out of gauge freight train	Common	1100 and above	>2400
			Hard to reconstruct	1100 and above	1950(reserved)
3	Edge of freight platform	Ordinary platform		1100	1750
		High platform		<4800	1850
4	Edge of passenger platform	Ordinary platform		1250	
		High platform		500	
		Low platform	Located on the side of main track or the arrival and departure track for passing out-of-gauge freight trains	300	1750

2.6 Switches turnouts

Switch: A moveable track device that allows trains to transfer from one track to another, encompassing the distance from the point of switch to the point of frog.

On Ethiopian railway standard proposed by Russia stated that

- ➢ Switch turnouts laid on station mainline tracks shall be capable of passing trains along the straight direction at a speed not less than in adjacent sections.
- ➢ Switch turnouts and fixed crossings shall comply with the approved design drawings and type of track rails. Laying of 1435 mm gauge switch turnouts shall be performed on the switch sleepers according to the standard sleepers' distribution.
- ➢ At each switch turnout the switch, the frog, the rail track between them and at the adjacent section shall be of the same type. When new turnouts are being laid the adjacent rails shall also be new; when used turnouts are being laid the adjacent rails shall have the same wear conditions as the turnout rails

Switches:

(1) All switches, frogs and guardrails shall be placed in accordance with the proper plan of the code (Track work Plans), unless otherwise specified by the railway.

(2) Switches shall be left in proper adjustment, special care being given to the bending of the stock rail.

Switch is a track structure used to divert rolling stock from one track to another.

Switch and crossing grinding that is performed on switches and crossings to restore their profile. Usually performed by a small rail grinder known as a "switch and crossing grinder". To cover the rail surface usually more than one grinding pass is required.

Switches and crossings /turnouts/set of points permit tracks to cross over each other and permit trains to switch from one track to another

Out of the total cost, 50% of the cost is for track construction such as track superstructure including switches and crossings (class slide by dreliaskassa)

High temperature that can lead to rail buckling, flooding with the potential of track washouts and snow or ice affecting switch operation are some physical impacts.

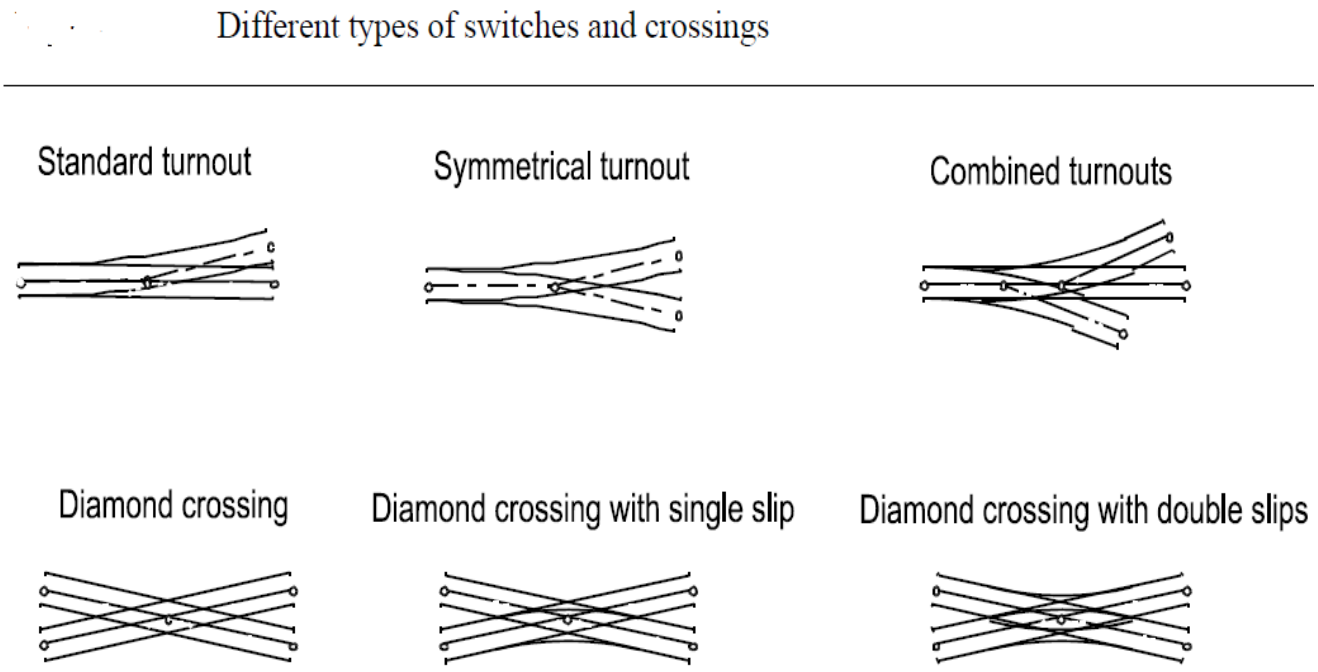


Figure 6: Types of switches

Figure 7 : Switch

2.7 Passenger safety on platforms

Some of recent accidents happen in the modern railway industry are occur due to

- ➢ human error,
- ➢ equipment fault,
- ➢ Improper technology, etc.

Figure 8: China train collision: 3 died, 60 injured June 2009

Figure 9: China two high-speed trains collided: 43 died, 211 injured July 2011

In order to avoid and minimize such kind of terrible accidents safety is the first agenda. Safety must be not jeopardized and must be the top agenda for the railway Authorities at the *design* and *implementation* stages, and in the *maintenance* and *operation.*

Safety is continuously updated and must seriously stated on codes .on AREMA and Indian codes safety is dealt nicely . this research selects the two codes in safety part

2.7.1 Safety

Safety (2007) is to prevent injuries and proscribe action upon the incidence of injury. Safety applies with equal importance to the people who provide service and the people who utilize rail transit.

Safety is part of the daily procedures and policies that apply to the following people:

Construction workers, supervisors and periodic visitors

People and vehicles adjacent or near the construction sites

- Rail maintenance-of-way, station, train, shop, yard and office workers
- Passengers and retail customers on trains and in stations
- Passengers and the public as they enter or pass by the transit system

Sources of injury are numerous and can be some of the following:

- ➢ Every day actions such as walking
- ➢ Using tools and operating machinery
- ➢ Rain, ice and snow
- ➢ Storms

SAFETY (1992) indicates Trenching (cut and cover excavation) is one of the most dangerous situations in modern construction. Since a jacking operation generally involves some form of trenching or pit construction, the jacking contractor or railway forces must strictly conform to all Federal, State and local regulations and in particular, the requirements of the Occupational Safety and Health Administration (OSHA).

Preventative measures that should be developed may include the following:

- Policies and procedures
- Initial and periodic peer review of safety training and drills
- Evacuation and treatment plans

According to The" RailCorp Design Principles [p3] " for station development list the requirements as follows

Safety: in design, construction & operation. Particularly with respect to emergency fire & life safety.

Security: Particularly crime prevention through environmental design.

Build ability: Except new stations built on entirely new lines, station construction will usually take place while stations and trains continue to operate. It is therefore critical that designs enable access, safety and customer service to be maintained throughout construction.

Maintenance & Life Cycle: the level of required maintenance (both cleaning and servicing) and the life of a building's component assemblies, parts, systems, materials, finishes or fixings (due to decay, wear and tear) can amount to many times the capital cost of the building over its functional life.

Access: Requirements for people (both the public and staff) to enter the premises with and without disabilities and other business uses.

Environment: To minimize the station impact when constructing or upgrading facilities, both during construction and as part of an ongoing public facility.

Heritage: Minimizing the impact of new station infrastructure on items of recognized heritage value.

US-based on research traffic safety shows that public transport is safer than private motor vehicles and that transportation systems that have their own infrastructure are safer than those that do not.

- Regional passenger rail (RPR) is the safest way to travel. Its casualty rate (the average number of injuries and fatalities per billion passenger miles) is little more than one-quarter the rate for motor vehicles.
- Rail rapid transit (RRT) is somewhat safer than light rail transit (LRT). RRT is almost twice as safe as motor vehicles, and LRT is more than one-and-a-half times safer than motor vehicles.
- Bus is the least safe form of public transport. Buses use the same infrastructure as motor vehicles, and therefore suffer from traffic congestion and road accidents.
- Private motor vehicles are the most dangerous form of at-grade motorized travel, with motorcycles the most dangerous of all.

There are reasons why public transport is safer than private transport.

- ➢ One is that since the capacity of public transit is higher than that of private vehicles,
- ➢ public transport use can reduce the number of distinct vehicles on the road,
- ➢ In turn decreasing the potential for accidents.

"Manual for standards and specifications for railway stations June 2009 ministry of railways (railway board) government of India" says that the objective of safety is to minimize the potential impact on passengers and minimize dependency on technology and equipment. It contains the following:

1. Station perimeter - definition of separation between station operating area and remainder of station complex which will include other structures.
2. Appropriate features to support life safety and security strategy.
3. Conformance with appropriate fire and life safety codes
4. Provisions regarding sufficient areas and means of egress to facilitate safe movement of passengers and staff at peak times, disrupted conditions and/or emergencies.
5. Provisions regarding maintaining tenable conditions during station evacuation in the event of an emergency
6. Provision of fire detection and alarm systems including fire detection systems, HPI (Help Point Intercom), and audible and visible alarms.
7. Provision of fire detection and suppression systems
8. Surveillance and access control systems
9. Central security control, monitoring and response

In addition, the manual recommended on safety management systems that can incorporate every aspect of zero level risk..

2.7.2 Safety Management Methods

Safety in the heavy rail transit industry involves:

1. Hazard Identification and Management
2. Quantitative Risk Assessment (QRA)
3. Design Review
4. Traceability from Initial Design to Acceptance Testing (Safety Certification) A Separate Safety Management and Reporting Function
5. Training of station staff in assessment and management of emergency condition

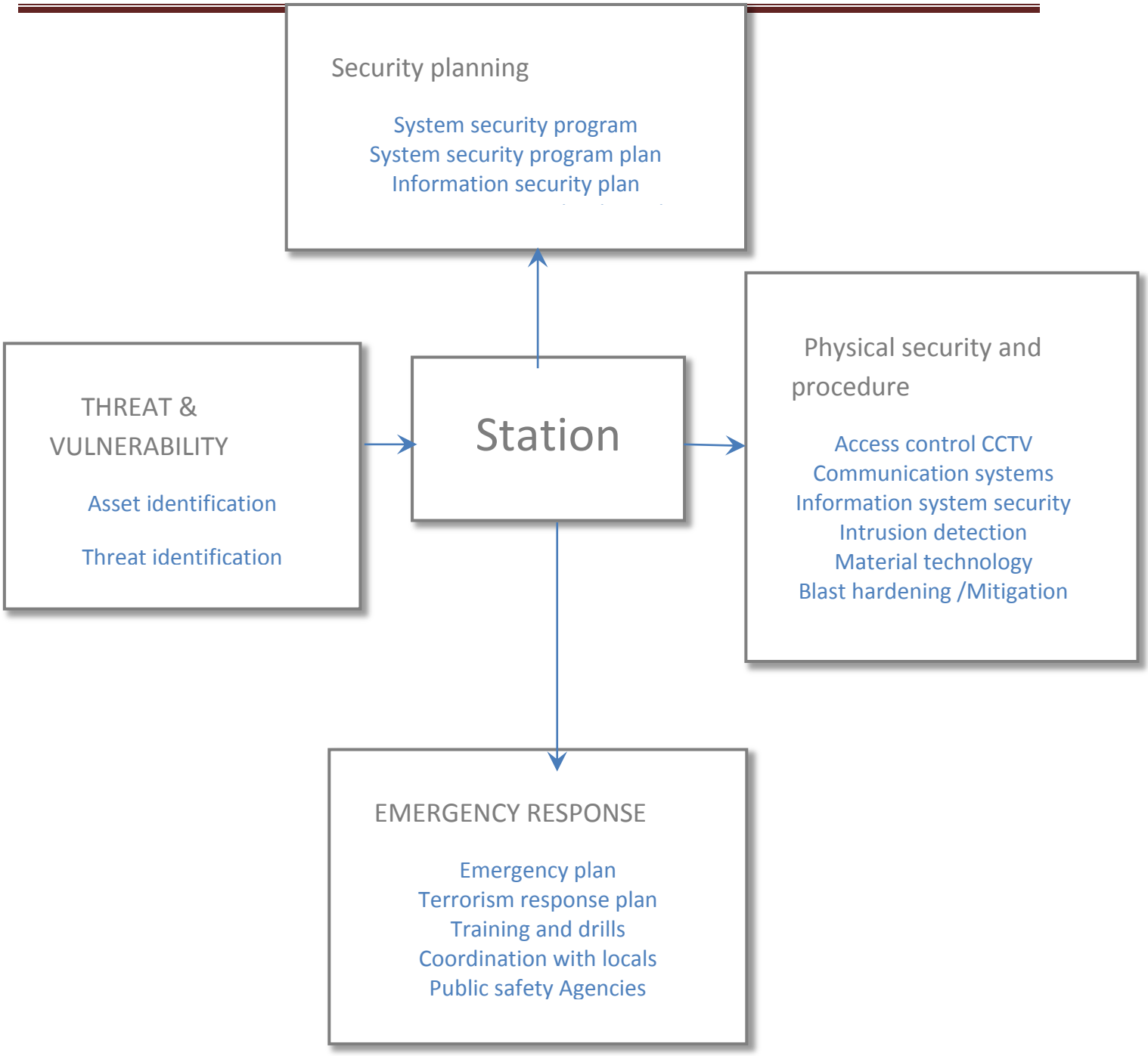


Figure 10: Security and Emergency Preparedness Planning Guide

Chapter 3 Light Railway Concept

This chapter explains the concepts of light rail way. It also describes the history of light rail way in the world and the present situation in Addis Ababa

3.1 What is Light Rail Way

Light in this context is used in the sense of "intended for light loads and fast movement", rather than referring to physical weight. The infrastructure investment is also usually lighter than would be found for a heavy rail system.

The Transportation Research Board (Transportation Systems Center) defined "light rail" in 1977 as "a mode of urban transportation utilizing predominantly reserved but not necessarily grade-separated rights-of-way. Electrically propelled rail vehicles operate singly or in trains. LRT provides a wide range of passenger capabilities and performance characteristics at moderate costs."

Figure 11: light railway

The American Public Transportation Association (APTA), in its Glossary of Transit Terminology, defines light rail as:

...a mode of transit service (also called streetcar, tramway, or trolley) operating passenger rail cars singly (or in short, usually two-car or three-car, trains) on fixed rails in right-of-way that is often separated from other traffic for part or much of the way. Light rail vehicles are typically driven electrically with power being drawn from an overhead electric line via a trolley [pole] or a pantograph; driven by an operator on board the vehicle; and may have either high platform loading or low level boarding using steps."[1]

A more modern variation, where the trains tend to run along their own right-of-way and are often separated from road traffic. Stops are generally less frequent, and the vehicles are often boarded from a platform. Tracks are highly visible, and in some cases significant effort is expended to keep traffic away through the use of special signaling, level crossings with gate arms.

Many light rail systems—even fairly old ones—have a combination of the two, with both on- and off-road sections. In some countries (especially in Europe), only the latter is described as light rail. In those places, trams running on mixed rights-of-way are not regarded as light rail, but considered distinctly as streetcars or trams. However, the requirement for saying that a rail line is "separated" can be quite low—sometimes just with concrete "buttons" to discourage automobile drivers from getting onto the tracks. Some systems such as Seattle's Link are truly mixed but closed to traffic, with trams and traditional buses both operating along a common right-of-way.

operates the same trains as Vancouver, but uses drivers. In most discussions and comparisons, these specialized systems are not considered light rail.

The situation of light rail transport in Addis Ababa

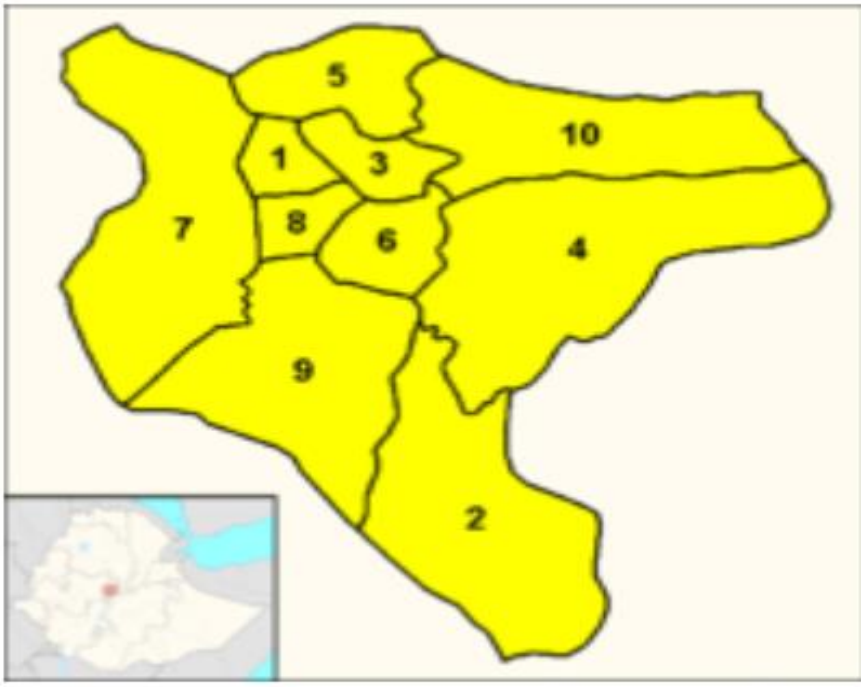
Addis Ababa's Transport problems are diverse

- –Aged Fleet,
- –Chaotic movement of mini-bus taxis
- –Environmentally unacceptable emission
- –Unsafe, Hazardous to life and property

Table 3:- Average temperature for Addis Ababa

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	dec
Average max temperature (0c)	**23**	**24**	**25**	**24**	**25**	**23**	**20**	**20**	**21**	**22**	**23**	**23**
Average temperature(0c)	**15**	**16**	**17.5**	**17.5**	**18**	**16.5**	**15**	**15**	**15.5**	**15**	**15**	**15**
Average min temperature(0c)	**7**	**8**	**10**	**11**	**11**	**10**	**10**	**10**	**10**	**8**	**7**	**7**

No	Description
1	Addis ketema
2	Akakikaliti
3	Arada
4	Bola
5	Gullela
6	Kirkose
7	Kolefakeranio



8	Ledeta
9	Nifas silk lafto
10	Yeka

Figure 12 : Addis Ababa district map

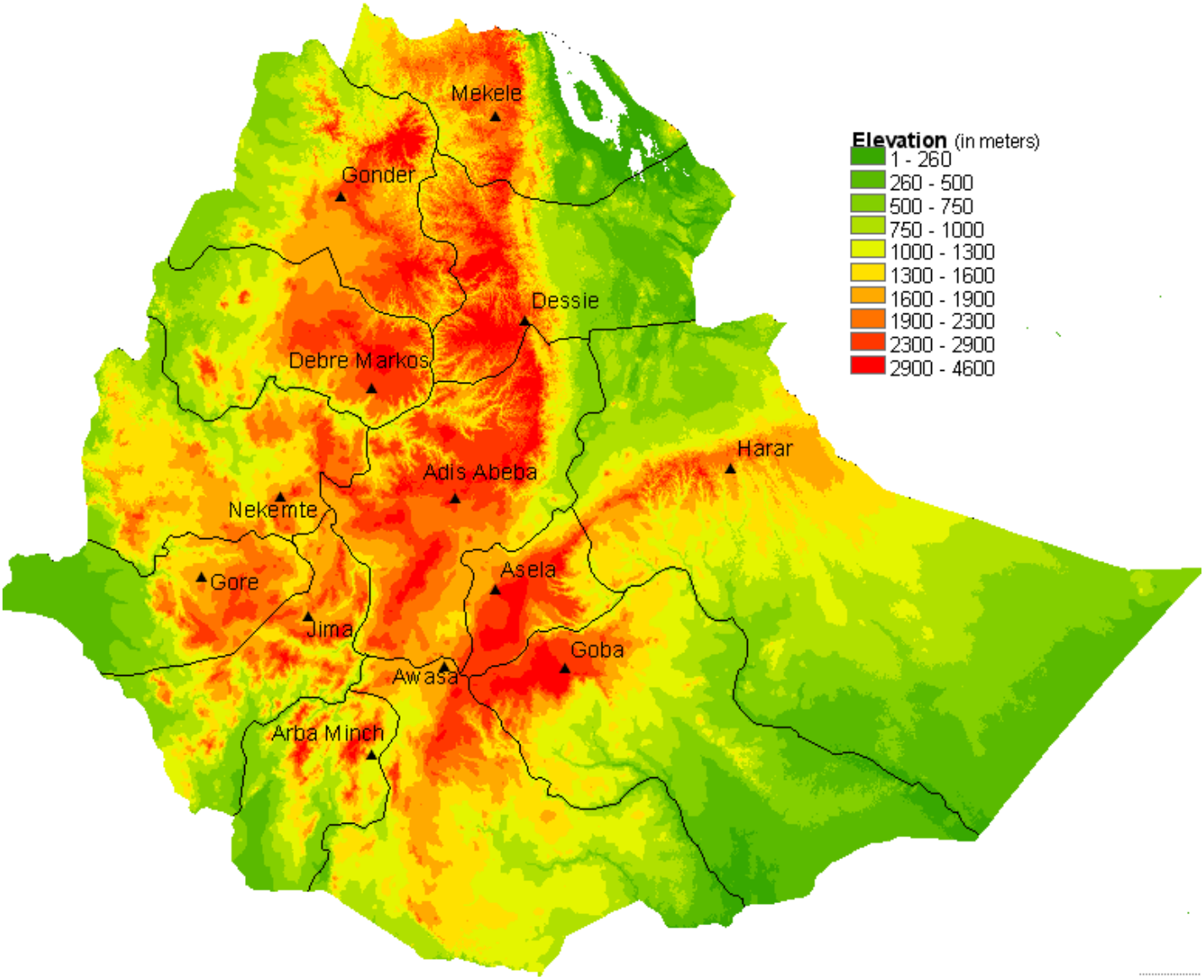


Figure 13: topographic map of Ethiopia

As we know the elevation deference of Addis Ababa is so high we should talk care in selecting rout for the rail way as much as possible. the route selected should be

- Flat us much as possible
- Must be economical i.e it should avoid large cut and fill
- Must be safe to load and unloading

The station selected should beat flat place and accommodate large peoples and should protect peoples from sun and rain at any time.

3.3 Features of Addis Ababa light rail transit (A.A.L.R.T)

- ➢ Normal track gauge=1435mm
- ➢ Maximum service speed=80km/hr
- ➢ Maximum grade, typical=50%
- ➢ Capacity = 15000 pphpd, total 60000pph
- ➢ Reliability
  - Initial injection of lrvs=41 with 286pasengercarrying capacity
  - Headway=60min initially and can be reduces to 90sec at ultimate capacity
  - Over 98% reliability factor
  - Working hour,16-18 hours /day
- ➢ affordability
  - for based on passenger –km coverage
  - considerate of paying capacity of resident
- ➢ comfort/environment
  - pleasant and attractive

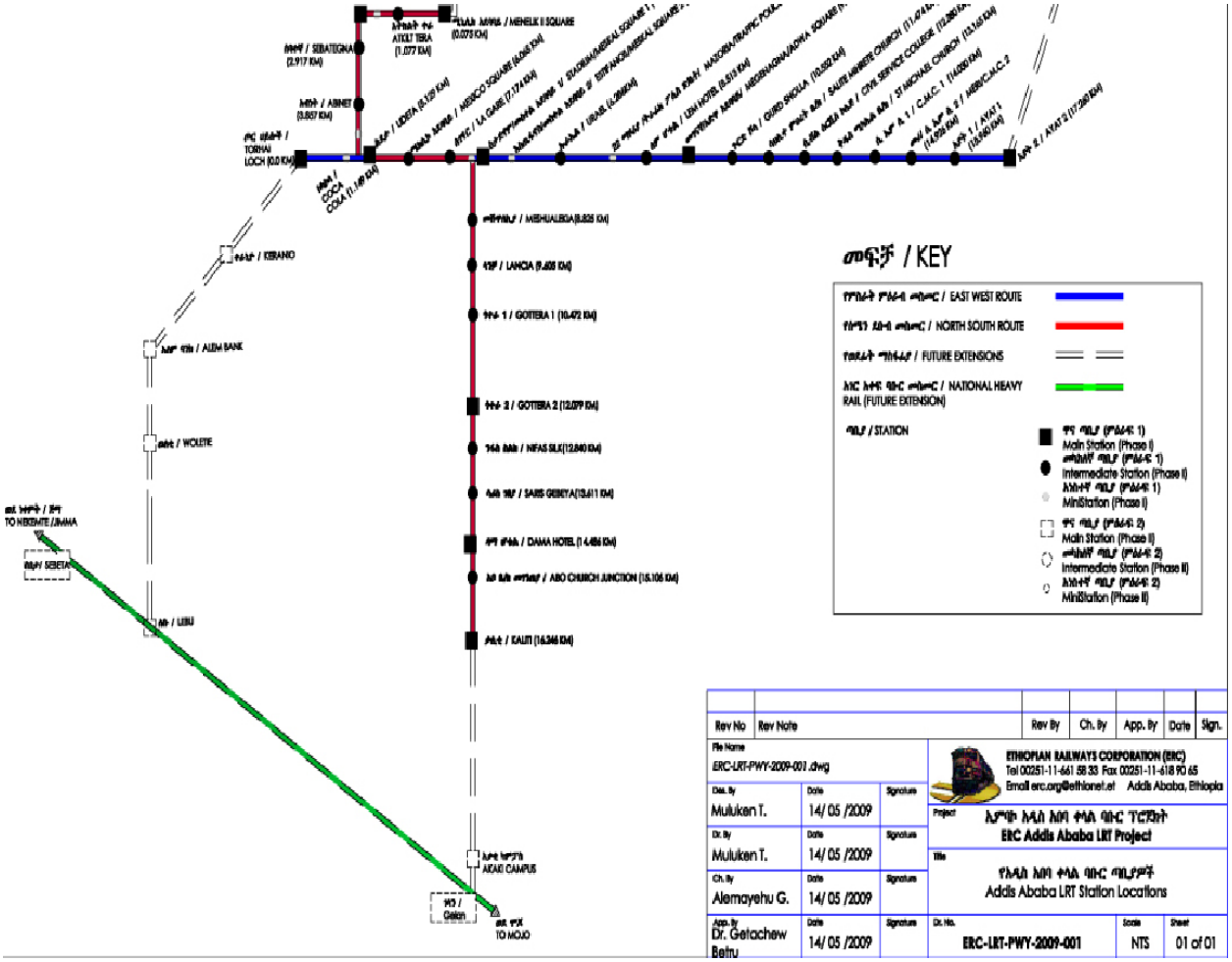


Figure 14: Areal map of Addis Ababa light railway

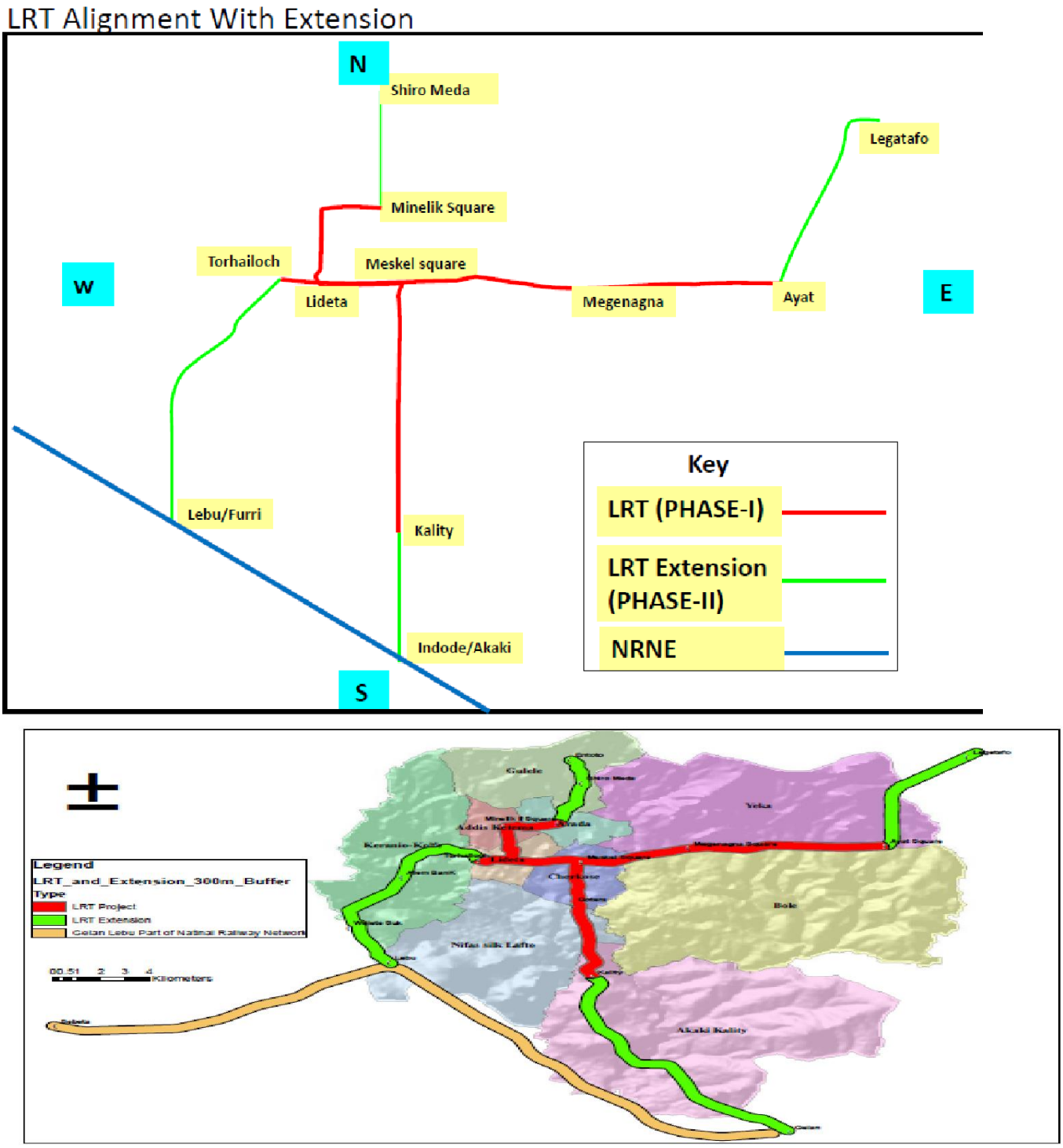


Figure 15: Future areal map of Addis Ababa light railway

Chapter 4 Basis for the selection of light railway station design parameters

This chapter gives general description of Addis Ababa (Ethiopia), which are needed to select station design parameters for Addis Ababa light railway.

The bases for selecting station design parameters are

- topographic conditions,
- climatic condition,
- Ethiopia economy, and
- Compatibility (operability) of station design standards with other neighboring countries.

Hence, this basis of selection parameters are used for the adaptation of Addis Ababa light railway station design parameters

4.1 Topographic conditions of Addis Ababa

- Ethiopia is a country of great geographical diversity with high and rugged mountains, flat topped plateaus, deep gorges incised river valleys and rolling plains. Such diversity of terrain leads to wide variations in climate, soil, natural vegetation, and settlement pattern.
- The dominant features of the topography of Ethiopia are the highland, the lowland and the rift valley regions. The highland covers 56% of the total area with an average elevation ranging from 2000 meters to 3000 meters above sea level and the lowland covers 44% of the total area commonly associated with the border line of the country.

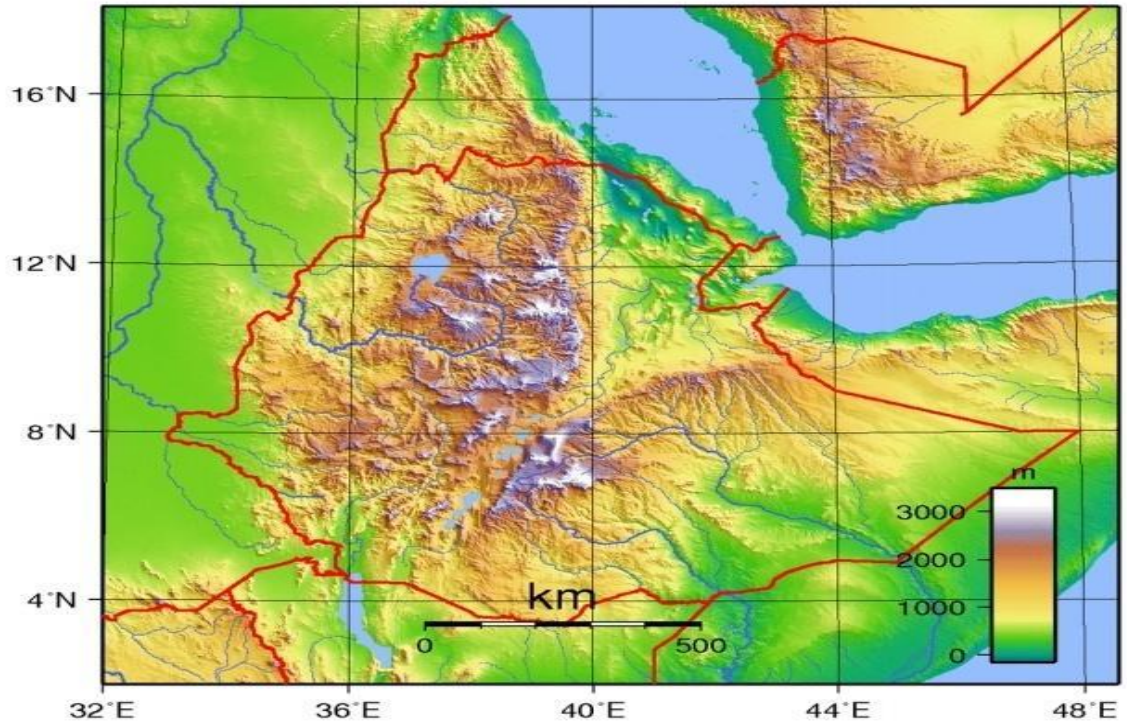


Figure 10: topographic map of Ethiopia

Addis Ababa lies at an altitude of 2,300 meters and is a grassland biome, located at 9°1′48″N 38°44′24″E ,9°1′48″N 38°44′24″E Coordinates:. The city lies at the foot of Mount Entoto and forms part of the watershed for the Awash. From its lowest point, around Bole International Airport, at 2,326 meters above sea level in the southern periphery, the city rises to over 3,000 metres in the Entoto Mountains to the north.

As we know the elevation difference of Addis Ababa is so high we should talk care in selecting rout for the rail way as much as possible.

The route selected should be

- Flat us much as possible
- Must be economical i.e it should avoid large cut and fill
- Must be safe to load and unloading

The station selected should fit flat place and accommodate large peoples and should protect peoples from sun and rain at any time.

4.2. Climatic condition

Addis Ababa has a humid subtropical mild summer climate that is mild with dry winters, mild rainy summers and moderate seasonality. This climate is usually found in the highlands of some tropical countries. (Köppen-Geiger classification: Cwb).

According to the Holdridge life zones system of bioclimatic classification Addis Ababa is situated in or near the subtropical moist forest biome.

The city has a complex mix of highland climate zones, with temperature differences of up to 10 °C (18 °F), depending on elevation and prevailing wind patterns. The high elevation moderates temperatures year-round, and the city's position near the equator means that temperatures are very constant from month to month.

Mid-November to January is a season for occasional rain. The highland climate regions are characterized by dry winters, and this is the dry season in Addis Ababa. During this season the daily maximum temperatures are usually not more that 23 °C (73 °F), and the night-time minimum temperatures can drop to freezing. The short rainy season is from February to May. During this period, the difference between the daytime maximum temperatures and the night-time minimum temperatures is not as great as during other times of the year, with minimum temperatures in the range of 10–15 °C (50–59 °F). At this time of the year the city experiences warm temperatures and a pleasant rainfall. The long wet season is from June to mid-September; it is the major winter season of the country. This period coincides with summer, but the temperatures are much lower than at other times of year due to the frequent rain and hail and the abundance of cloud cover and fewer hours of sunshine. This time of the year is characterized by dark, chilly and wet days and nights. The autumn which follows is a transitional period between the wet and dry seasons.

The highest record temperature was 32 °C (90 °F) August 27, 1996, while the lowest record temperature was 0 °C (32 °F) on November 23, 1999.[30]

Table 4:- Average temperature for Addis Ababa

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	dec
Average max temperature (0c)	**23**	**24**	**25**	**24**	**25**	**23**	**20**	**20**	**21**	**22**	**23**	**23**
Average temperature(0c)	**15**	**16**	**17.5**	**17.5**	**18**	**16.5**	**15**	**15**	**15.5**	**15**	**15**	**15**
Average min temperature(0c)	**7**	**8**	**10**	**11**	**11**	**10**	**10**	**10**	**10**	**8**	**7**	**7**

4.3. Ethiopia economy

Ethiopian economy is largely an agro based economy. It contributes almost 45.9% during 2006/07 fiscal year, to the national production and provides employment to more than 80% of the working population. The industry is in nascent stage. The domestic construction industry contributes 47% of the industry contribution in GDP. The services sector is growing with business opportunities in trade, banking and tourism.

The International Monetary Fund (IMF) ranks Ethiopia as among the five fastest growing economies in the world. After a decade of continuous expansion (during which real GDP growth averaged 10.8% per annum), in 2013/14 the economy grew for its 11th consecutive year posting 10.3% growth. Over the 12 months from July 2013 (the country's fiscal year runs from July-July), all of the economy's main sectors performed well. Agriculture (which represents 40.2% of GDP) grew by 5.4%, industry (14% of GDP) expanded by 21.2% and services (46.2% of GDP) rose by 11.9%. This positive growth should continue for the coming two years, although constraints on private sector development could slow its momentum.
Supported by a slowdown in global commodity prices, the Government of Ethiopia succeeded in containing annual consumer price inflation to 7.1% in December 2014 (down from 39.2% in 2011) by pursuing a tight monetary policy and using base money as its nominal anchor. Fiscal policy focuses on strengthening domestic resource

mobilization and reducing domestic borrowing with the goal of maintaining macroeconomic stability. A strong fiscal stance, particularly through measures to improve tax administration and enforcement, contained the fiscal deficit to 2.6% of GDP in 2013/14, although this was up from 1.9% of GDP the previous year

With a large domestic market and promising economic prospects, Ethiopia has the potential to become a regional economic powerhouse, but persistent state intervention in the relatively closed economy has suppressed the growth of economic freedom over the past five years. Since 2011, Ethiopia's economic freedom has expanded by a modest 1.0 point.

4.4. Demography

Based on the 2007 census conducted by the Ethiopian national statistics authorities the population of Addis Ababa is 3,384,569 million; all of the population are urban inhabitants. For the capital city 662,728 households were counted living in 628,984 housing units, which results in an average of 5.3 persons to a household.

In the previous census, conducted in 1994, the city's population was reported to be 2,112,737, of whom 1,023,452 were men and 1,089,285 were women. At that time not all of the population were urban inhabitants; only 2,084,588 or 98.7% were.

According to the 2007 national census, 98.64% of the housing units of Addis Ababa had access to safe drinking water, while 14.9% had flush toilets, 70.7% pit toilets (both ventilated and unventilated), and 14.3% had no toilet facilities.[35] In 2014, there were 63 public toilets in the city, with plans to build more.[36] Values for other reported common indicators of the standard of living for Addis Ababa as of 2005 include the following: 0.1% of the inhabitants fall into the lowest wealth quintile; adult literacy for men is 93.6% and for women 79.95%, the highest in the nation for both sexes; and the civic infant mortality rate is 45 infant deaths per 1,000 live births, which is less than the nationwide average of 77; at least half of these deaths occurred in the infants' first month of life.

In railway station design we should consider the population Aged Fleet , Chaotic movement of mini-bus taxis in loading and unloading of passengers, disability and flow of passengers in peak time.

Chapter 5 Discussion on Different Standards and Experience

Following the discussion on economic aspects of station locations and track and platform technical aspect are made based on the standards of different countries and as stated in literatures. Ethiopian Railway Corporation reports, feasibility studies and researches presented by different companies

5.1 Discussion on Station Site selection

In station site selection different standards and experience state that the allocation of passenger stations shall be determined in considerations of passengers easily and safely access, city size, significance, district, passenger traffic to transfer, conditions of existing equipment for passenger transport. Visual appearances of Station areas are critical to attracting and maintaining transit riders in any location.

"AREMA SECTION 6.3" Also says: In planning a passenger station it is important to devise a coordinated arrangement between the track layout and the station proper which will, at reasonable cost, provide maximum convenience, expedition, and economy in rendering all the platform services. Particularly at high traffic stations, it is extremely desirable that baggage, mail and express trucks shall not ordinarily have to traverse or occupy platform space being used for the accommodation of passengers. Determination of the type of platform (i.e. combined or separate trucking and passenger) best suited to a particular situation is dependent upon the character and volume of the various kinds of traffic handled, the type of station (i.e. stub, through or loop), the location and type of approaches to the platforms for the various kinds of traffic, the relation of the various approaches to each other, the relative lengths of platforms and trains, space available for station track and platform development, and the method of operation. Because there are so many variables involved, final conclusion as to the best arrangement can only be reached with a thorough study.

The Chinese code says (p43) "The allocation of passenger stations shall be determined in considerations of the city size, significance, district, passenger traffic to transfer and conditions of existing equipment for passenger transport, which shall be combined with urban planning and connected with urban traffic systems."

Station Area Locations "Vta Transit Sustainability Policy 2007" indicates the location, functionality, safety, and visual appearance of Station areas are critical to attracting and maintaining transit riders in any location. Accordingly, when there are competing proposals for new stations that have similar characteristics (e.g. ridership, operations), agencies that can show they are proactively working to improve the public perception of transit and access to Station Areas shall receive priority considerations

5.2 Discussion on Platform Selection

In platform selection of railway station we see different standards and experience the standards we consider are Indian Manual of Standards and Specifications for Railway Stations, RTD Design Guidelines & Criteria, AREMA (2001)

The platform area must facilitate multiple customer circulation functions: circulation along the platform, boarding and alighting trains, queuing at the platform edge while waiting for a train. Overcrowding on the platform may create uncomfortable or dangerous situations where customers are crowded near the platform edge.

Therefore, sizing station platforms is critical and designers should err on the side of safety when determining the size of the station platform.

5.2.1 Platform Dimensions

Station platforms are an important part of the infrastructure of any railway system and proper design can give great assistance to good operation

Amtrak says in its Station Program and Planning Guidelines : Where there are multiple platforms provide flexibility to accommodate different services Level boarding requires straight (tangent) platforms to achieve the Minimum gap between platform edge and the car deck—so the platform lengths specified here assume absolute straight alignment Length and height are related to equipment, while width is typically related to capacity or passenger volume If the preferred platform length is not initially accommodated or built, plan the station location and track layout to allow for future extension of the Platform to a greater length without requiring reconfiguration of the building or platform.

Platform Length

According to AREMA (2001) Platforms will vary in length depending on the service being provided and whether or not the station is served by either diesel or electric type motive power. Minimum platform lengths may vary from 210 lineal feet (64m) in length (3 cars for diesel, 2 cars for electric) to 890 lineal feet (271.27m) (11 cars for diesel). Along some lines platform lengths may be longer.

RTD recommended that Platform length for both center and side platforms shall accommodate a four-car train and have a minimum length clear of approach ramps of 360 ft (109.73m).unless approved otherwise by RTD.

Amtrak says in its Station Program and Planning Guidelines states that the platform lengths specified here assume absolute straight alignment Length.

Table 5: PLATFORM LENGTH

Service type	Proffered all location	Minimum off NEC	Minimum -NEC
Acela regional	17.78	N/A	13.97
North east regional	25.4	10.795	21.59
State corridor	17.78	7.62	17.78
Long distance	30.48	13.97	21.59

Platform length for high-speed railway services will be modified to accommodate full-length level boarding for lengthened acela express and new HSR fleets

Platform Width

Width of the platform shall be determined subject to the largest alighting and boarding person, luggage vehicle type, size of buildings and facilities set in the platform when the passenger train stops by the station platform.

AMTRAK says that (p88) determination of platform width is a balance between accommodating the peak passenger load and the physical constraints. In other words,

wider platforms will generally be preferred over narrower ones as being safer, better able to handle service baggage vehicles, and able to provide for growth in passenger volume

Table 6 : Platform Width

Platform	Preferred width(m)	Minimum width(m)
center island	0.6096	0.508
Side w/baggage loading	0.381	0.3048
Side w/passenger loading	0.3048	0.254

CCLRT Design Criteria (pge 11) The desired minimum platform width for LRT platforms should be 20 feet for center platforms (preferred) and 13 feet (12 feet absolute minimum per for side platforms. Platform width should include space for a safety barrier along the platform edge opposite the track when there is a grade difference of two feet, six inches or greater, or adjacent to a roadway.

Platform Height

Platform height refers to the height of a railway platform Above Top of Rail (ATR). There are a large number of incompatible standards for platform heights and train floor heights. When raised platforms are in use, the train width must also be compatible to avoid both large gaps and mechanical interference which causes equipment damage.

Differences in platform height (and platform gap) can pose a risk for passenger safety. Platform ramps, steps, and fillers together with hazard warnings such as "mind the gap" are used to reduce risk and enable access. Platform height affects the loading gauge (the maximum size of train cars), and must conform to the structure gauge physical clearance specifications for the system. Tracks which are shared between freight and passenger service must have platforms which do not obstruct either type of railroad car.

Table 7: platform height from top of the railway

	HIGH LEVEL(mm)	Middle level (mm)	Low level(mm)	Remark
CHINA	1250	550	380	1250mm is common
POLAND	760-1060		550	
IRAN	760	550	380	
SOUTH KOREA	1150	550	<550	All metro platforms are 1150mm
RUSSIA	1100	550	200	
JAPAN	1250			
BELGIUM	760			

The European Union Commission issued a TSI (Technical Specifications for Interoperability) on 30 May 2002 (2002/735/EC) that sets out standard platform heights for passenger steps on high-speed rail. These standard heights are 550 mm and 760 mm

Based on experience and researcher: In 1981, the *Transit Journal* published by the American Public Transit Association suggested that light rail platform heights have been standardized to "slightly over 3 feet." (914 mm) and is very similar to the UK 915 mm platform height standard.

Some of the effects of this include the problem of a single height platform when multiple types of railcars (with different platform heights) use a station

Differences in platform height (and platform gap) can pose a risk for passenger safety. Platform ramps, steps, and platform gap fillers together with hazard warnings such as "mind the gap" are used to reduce risk and enable access. Platform height affects the loading gauge (the maximum size of train cars), and must conform to the structure gauge physical clearance specifications for the system. Tracks which are shared between freight and passenger service must have platforms which do not obstruct either type of railroad car.

To reduce station construction costs, many train systems use a low platform, and require passenger cars with internal stairs up to the train floor.

5.2.2 Distance between tracks and platform

The track and platform arrangement at a station site is one of the most critical elements determining the operational efficiency and capacity of the station, and the sitting of new stations must carefully consider the future requirements for tracks and platforms. Track and platform planning include determining the number and lengths of platforms needed, their spacing, and Access to them.

Amtrak's standard offset for 15 and 48 inch ATR platforms is 5'7" from the centerline of the track.

Amtrak's standard offset for 8 inch platforms is 5'1" from the centerline of the track, although other offset dimensions, determined by host railroads and states, may also be required for 8 inch

Table 8: Track-platform distance

Code	Track-platform distance(M)
European	1.65
CHINA	1.75
AREMA	1.7
EUROPEAN	1.65

Chapter 6 Adaptation

As we know the elevation deference of Addis Ababa is so high we should talk care in selecting rout for the rail way as much as possible

the route selected should be

- Flat us much as possible
- Must be economical i.e it should avoid large cut and fill
- Must be safe to load and unloading

The station selected should be placed at straight, flat and accommodate large people

6.1 Adaptation of Site Selection Requirement for Station

The allocation of passenger stations shall be determined in considerations of the

- city size,
- significance,
- district,
- passenger traffic to transfer and
- conditions of existing equipment for passenger transport,

This shall be combined with urban planning and connected with urban traffic systems.

In adaptation of site selection

- The location,
- functionality,
- safety, and
- Visual appearances of station areas are critical to attracting and maintaining transit riders in any location.

Proactively working to improve the public perception of transit and access to station areas shall receive priority considerations.

The topography, temperature, density of population and cost of construction are seen in adapting code for railway station of Addis Ababa light rail way.

The physical design of Station Areas (including platform length and width, location of vertical transport, shelters, information signs, and ticket machines) is based on, among other aspects:

- Expected travel demand during the peak.
- Maximum operable length of trains serving the station.
- Role of the station in the network (whether it is a origin/destination, terminal, or transfer station).
- Level of connectivity to other transit modes.
- Surrounding development and community themes.
- Potential for station expansion and growth.

Stations may be

- On-street,
- off-street,
- along a railroad right-of-way, or
- on a transit mall.

Light rail stations usually include

- Canopies over part of the platform,
- limited seating, and
- Ticket vending machines.

6.2. Platform dimension Selection

Sizing station platforms is critical and designers should err on the side of safety when determining the size of the station platform. In selecting station dimension we must give attention for

- Safety
- Nice and easily accessible for loading and unloading of all kind passengers.
- Speed of train

Various platform configurations are possible,

- Center platform
- Side platform
- Split on opposite sides of an intersection.

Sizing station platforms is critical and designers should err on the side of safety when determining the size of the station platform.

It is necessary to provide platform for conventional passenger trains at stations along shared corridors since the criteria of the vehicles (length, floor height, location of the doors, etc.)

Generally, platforms have different functions and characteristics during departing and arriving peak conditions. For the arriving peak, the platform must have sufficient area and vertical access facilities for passengers to quickly move through it. During the departing peak, the platform acts as a storage area for passengers waiting for a train and as a movement space for passengers distributing themselves along the platform.

Platform length

Station platform length depends on the longest train running on that section. It should accommodate the full length of a typical train consist and allow for maximum flexibility. While the minimum required platform length will vary depending on the type of rail service provided. Therefore, platform lengths should be standardized as much as possible both within the individual station, and across multiple stations serving.

Plat form length must minimize the construction cost i.e must be economical avoid large earthwork cut and fill and must accommodate the maximum arriving and departure of passengers

In order to make the plate form safe and economical "Platform lengths are based upon car length, plus number of cars and a margin for braking.

Plat form length(m)=car length(m)*no of cars +braking distance(m)

Recommended the Addis Ababa light railway station plat form length shown in the table

Table 9: Platform length

	Minimum(m)	Maximum(m)	remark
Platform length	64m	270	For both side and center platform

✶ Along some lines platform lengths may be longer based on speed.

Platform width

Width of the platform shall be determined subject to the largest alighting and boarding person, luggage vehicle type, size of buildings and facilities set in the platform when the passenger train stops by the station platform

At stations where tunnels are used to access platforms, tunnel widths should be wide enough to accommodate the largest peak flow of passengers and void of obstructions. When tunnels are used for platform access, tunnel ramps must be designed for handicap access. In the event adequate space is not available, elevators may be used for handicap access**.**

The dimension of the platform width will need to be ascertained to ensure that sufficient space is provided on platforms to allow:

a) Passenger circulation to, from and along the platform;

b) Operational and passenger facilities where provided;

c) Passengers to wait for trains in relative comfort and provide protection from the weather (including sun, wind, rain

Recommended Addis Ababa light railway station plat form width shown in the table

Table 10: platform width

Platform	Preferred width(m)	Minimum width(m)
center island	0.6096	0.508
Side w/passenger loading	0.3048	0.254

Platform height

Platform height refers to the height of a railway platform Above Top of Rail (ATR)

When raised platforms are in use, the train width must also be compatible, to avoid both large gaps and mechanical interference which causes equipment damage.

Differences in platform height (and platform gap) can pose a risk for passenger safety. Platform ramps, steps, and fillers together with hazard warnings such as "mind the gap" are used to reduce risk and enable access. Platform height affects the loading gauge (the maximum size of train cars), and must conform to the structure gauge physical clearance specifications for the system.

In most standards Selection of intermediate height platform is become common now days by taking continuous data on field and through experience. And it become safe, nice and easily accessible for loading and unloading of all kind passengers.

In different codes recommend plat form height are above 550mm.

Recommended Addis Ababa light railway station plat form height shown in the table

Table 11:- Adapt platform height from rail

	HEIGHT OF PLAT FORM FROM TOP OF RAIL			
	high level (mm)	Middle level (mm)	Low level (mm)	remark
Platform height	1150	550	390	

6.3. Distance between tracks and platform

Based on experience and china code distance between track and platform is adapted in the table as follows

Table 12: Track – platform distance

	Ordinary level ATR	High Level ATR
Edge of passenger platform	1.75 m	1.75 m

Chapter 7 Conclusion and Recommendation

7.1. Conclusion

This research tries to set guidelines for station design of the railway system of Ethiopia basically Addis Ababa light railway station design. The standard guidelines for station design elements can be done according to the country topographical condition, population condition and economic criteria,

Due to source constraints and limitations the present research work did not cover and address several important aspects of station design parameters information on light railway station. However taking the same in to account here below are the key point that figure it out to be considered while setting station.

- On the basis of the light rail, the station position should be decided by referencing to surrounding environment, city planning, and facilities on both sides. Meanwhile, the entrance and exit of the station should be reasonably designed according to station types and actual passenger flow, so as to bring convenient, safe, and fast services to the passengers. Moreover, the station position should be accommodated with urban traffic.

- Station types, scale and layout should be reasonably designed for achieving the target of "Safe, Reliable, Economic, and Applicable". On the condition of passenger satisfaction, operation management, and operation safety, the station scale should be constructed in a minimum degree for achieving optimal cost performance.

- The spacing of station and dimension of station (platform width and length) is optimized in consideration of satisfying all passengers and the optimization analysis is need in estimation of cost of station. Dimensioning station is critical and designers should err on the side of safety when determining the size of the station platform.
- Railway station platform shall be determined subject to the largest alighting and boarding person, luggage vehicle type, size of buildings and facilities set in the platform when the passenger train stops by the station platform.

This research is a major part on the railway concepts presented in the Addis Ababa light Railway investigations and the alternatives have different number of stations and different design speed. The speed limits on stations will also vary and require different safety measures at different stations.

From the literature study it was concluded that there are many different aspects to consider when designing a railway station. Some of them are extensively affected by the high speed rail concept compared to a conventional railway concept while other aspects are more or less unaffected.

7.2. Recommendation for Future Works

The present work has attempted to standardize guidelines for station deign parameters (station facilities, platform); and a little about corresponding safety system. However, due to data constraints the present research work did not cover detail information on railway station system.

In view of this work, it would be desirable to consider the following recommendations for the future work for the development of modern railway system in Ethiopia.

- Full scale experiments should be set up and carried out in Ethiopia to determine the optimum (sufficient) amount for railway station to make the station safer and satisfy all kind of passengers. Therefore, a railway station's location in a built environment and its degree of accessibility is essential to reach as many travelers as possible
- Since many of the possible problems with the station are connected to water, the drainage systems need a special concern and detailed study.

- The safety issues related to mechanical problems such as signaling failure, equipment failure and train control failure should be taken as a critical issue in future station studies. And in addition the contribution of track structure failures to safety problem in railway system needs a detail investigation.
- The station plane design should be coordinated with surrounding urban roads and architecture planning; and the passages, the entrance and exit, and air pavilion should be located reasonably for maximally attracting passengers.
- In the premise of satisfying certain functions, the station had better to be in minimum dimension as well as considering local climate condition, so as to fully reveal the characteristic of traffic functions, such as simple, fast, aesthetic, and identifiable, etc.

Finally ,to be in place the best arrangement of station with the state of art technology that serve efficient and comfortable service to the public a thorough research and continuous study involving all stakeholder is very indispensable and mandatory.

References

[1] American Railway Engineering and Maintenance Way of Association

[2] China Code

[3] EEthiopian railway corporationPremier Design

[4] Willem- Jan Zwaenburg,;Litep-Epfl,Conference Paper Strc 2007,7th Swiss Transport Research Conference , Monte Verita/Ascona,Septemeber12-14.2007

[5]Transit Capacity and Quality of Service Manual—2nd Edition

[6] W. Daamen Delft University of Technology, Department of Civil Engineering, The Netherlands

[7] ToveAndersson And David Lindvert Master of Science Thesis in the Master's Programme Infrastructure and Environmental Engineering Department of Civil and Environmental Engineering Division of geo-engineering 2013

[8] Road And Traffic Chalmers University Of Technology Göteborg, Sweden 2013

[9] Track Design Handbook for Light Rail Transit Second Edition

[10] Regional Transit way Guidelines Technical Repor"RTD Design Guidelines & Criteria" May 2011

[11] Yehualaeshet Jemere (msc. Ceng) Chief Officer, Construction and Project Execution Department July, 2012

[12] "Washington Metro Politian Area Of Transit Authority May 2008"VTA Transit Sustainability Policy 2007

[13] RailCorp Design Principles [p3]

[14] B.Arch. thesis: Monday, September 21, 2009

[15] Manual For Standards And Specifications For Railway StationsJune 2009 Ministry Of Railways (Railway Board) Government Of India

[16] Rail way case study at corby station

[17] Australasian Transport Research Forum 2011 Proceedings 28 - 30 September 2011, Adelaide, Australia Publication website: http://www.patrec.org/atrf.aspx Estimating the user benefit of rail station lifts By Neil Douglas Neil Douglas is Manager of Douglas Economics

[18] Land scape guide lines for historical railway station by Hamilia BT Ahmed

[19] Merced to sacramento High speed train project ,Merced Public Workshop Presentation April 20, 2010

[20]Stop, Station, and Terminal Capacity May 4, 2004 ,portland state university

[21]The High Speed Railway Station of the future - How to achieve it? Ir. Rudolf Mulder – DHV
[22] Railway- technology.com, International Trade Fair for Transport Technology Innovative Components, Berlin, 2014.
[23]Bonnett C.F., (2005). Practical Railway Engineering, 2nd edition. Imperial College Press, Singapore
[24]Bourdon L., (2005). Railway Safety Management Systems: Experiences to Date and Lessons Learned. Presentation to IRSC 2005, Transport of Canada
[25]ERC, (2011). The National Railway Network of Ethiopia, http://www.erc.gov.et/ index.php/projects/national-railway-network-of-ethiopianrne.html. Ethiopia Railway Corporation
[26] S. Samanta and M.k.Jha, Transaction of the Wessex Institute, 2014.
[27] EPC Turnkey Contract between Ethiopia Railway Corporation and China Railway Group limited, Addis Ababa – Djibouti Railway project Lot 1 & 2: Sebeta- Adama-Mesio, Ethiopia, 2011.
[28] Kenneth Button and Aura Reggiani, Transportation and Economic Development Challenges, USA, 2011.
[29]David Little Field, Metric Hand Book; Planning and Design Data, USA and Canada, 2012
[30]AbiiTsige, (2009). The Africa regional review on transport, Addis Ababa, UN Economic Commission for Africa
[31]Blunt E., (2009). Ethiopia looks to revive past railway glories; http://news.bbc.co.uk/2/hi/8110012.stm
[32]Bonnett C.F., (2005). Practical Railway Engineering, 2nd edition. Imperial College Press, Singapore
[33]European Railway Agency, (2010). Railway safety performance in the European Union
[[34]Noh H.M., Y.O. Cho and J.B. Wang, (2010). The Development of a Railway Safety Assessment Program in South Korea, Proceedings of the 2010 Joint Rail Conference
[35]Coulls A., (1999). Railways as World Heritage Sites, International Council on Monuments and Sites
[36]Light Rail Technology Overview & Analysis Peter TopalovicLesleaLottimer Mary-Kaye Pepito April 2009 Final Revision
[37]California High-Speed Train Project Technical Memorandum International Rail Standards Comparison Tm 7.3

[38] David Little Field, Metric Hand Book; Planning and Design Data, USA and Canada, 2012.
[39] Public Transport Services, PTS Standards 129003 Railway stations – Platforms, Australia, 2013.
[40]Prof. Dr.Padma Bahadur Shahi, Railway Engineering: Introduction, India,2007
[41] Gareth Powell, Station Planning Standards and Guidelines, London, 2012
[42] Anoop K.Agrawal, G.L.Goel and R.N.Gupta, Design Parameters of High Speed Corridor, India, 2007.
[43] RSSB, Guidance on Station Platform Geometry GI/GN7616, London, 2010

Appendices

Diagram of typical Ground station

Diagram of typical Ground station

Diagram of typical elevated station

Design of the Urael area

Design of the Mexico round about